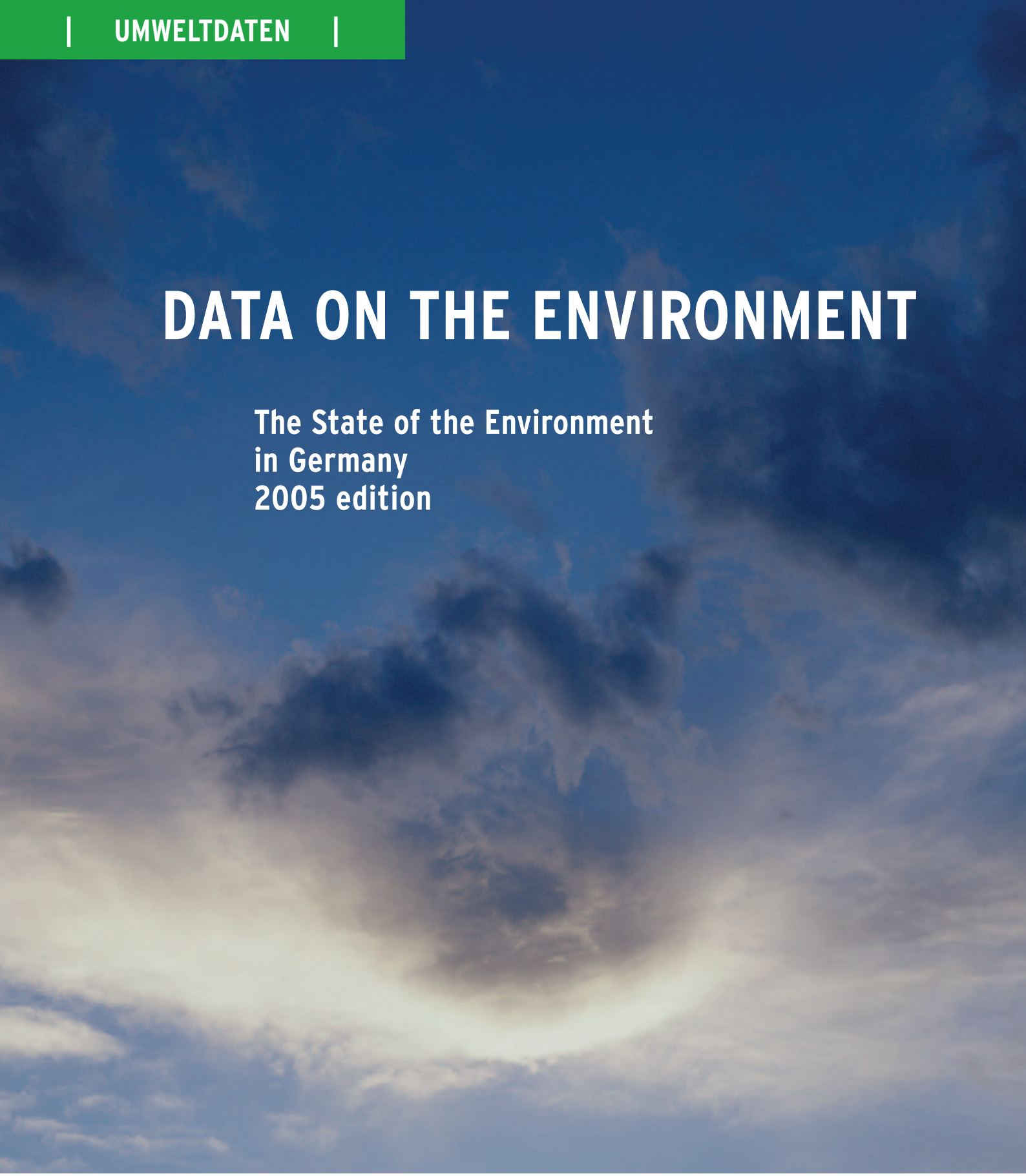
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DATA ON THE ENVIRONMENT

The State of the Environment in Germany 2005 edition

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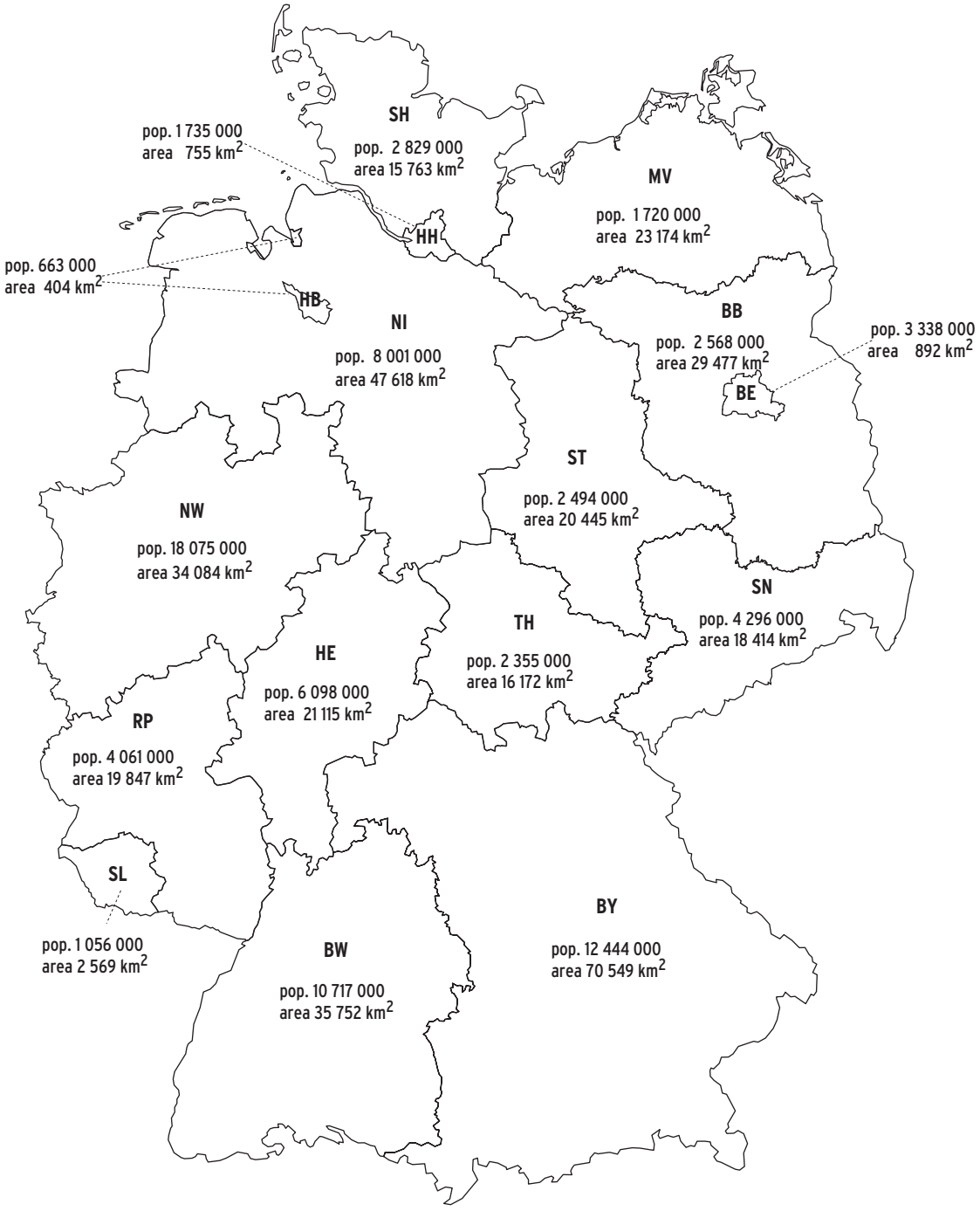
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Federal Republic of Germany



D: Total population: 82.5 million (31.12.2004)
Total area: 357 thousand km² (31.12.2003)

BW:	Baden-Württemberg	HE:	Hesse	SN:	Saxony
BY:	Bavaria	MV:	Mecklenburg-West Pomerania	ST:	Saxony-Anhalt
BE:	Berlin	NI:	Lower Saxony	SH:	Schleswig-Holstein
BB:	Brandenburg	NW:	North-Rhine Westphalia	TH:	Thuringia
HB:	Bremen	RP:	Rhineland-Palatinate		
HH:	Hamburg	SL:	Saarland		

Source: Federal Statistical Office



Foreword

How high is the quality of Germany's water, soil, and air? To what extent do environmental influences damage health? With this "Data on the Environment 2005" edition, the Federal Environment Agency presents a comprehensive and detailed account of the current state of the environment. The documented changes made to "Data on the Environment" since 1984 are significant and we can learn from these. For one, the illustrations, tables, and figures reveal the achievements of a consistent national and international environmental and health protection policy. It is also important to keep abreast of environmental protection developments and not to become complacent. Hardly anyone believed that it would again be possible to bathe in the major rivers when the first "Data on the Environment" was published. Air quality has also greatly improved in Germany since then. At the same time, it is unlikely that anybody would have identified the pace and extent of land consumption or climate change that we recognize today. Both developments accurately anticipated the tasks of Data on the Environment during the 1990s. The implication of these developments is: A foresighted, precautionary environmental policy requires up-to-date, reliable data. Only a comprehensive synopsis of the state of the environment in Germany and forecasts on possible developments enable an assessment of national and international progress in terms of common environmental goals. Establishing the origins of major environmental nuisances also allows us to evaluate the effectiveness of environmental policy.

This report includes new material not contained in its seven predecessors: It is oriented towards supporting the particular area protected under the 6th European Environment Action Programme – in other words, human health – and therefore divided into sections covering climate, environment, health and quality of life, environmental media and ecosystems, and the sustainable use of natural resources and waste management.

The advantage: There is no separate accounting of the environmental aspects of health, water, soil, air, nor of economic or cross-sectional activities. Rather, these problems are integrated into the current version as far as is possible.

This also allows for an improved depiction of political efforts for sustainable development in terms of the basis of our lives. Not only are environmental hazards from various economic sectors – such as agriculture or industry – shown, but appropriate space is also devoted to the instruments and measures employed under the concerned sectoral policies for dealing in a circumspect manner with natural resources so as to protect global ecosystems and human health.

The availability of representative data largely determines the thematic selection in the current edition of "Data on the Environment". It is based mainly on statistics provided by the Federal Government and the *Länder* in accordance with the Statistics Act on Managing Environmental, Agricultural and Water Resources as well as on surveys carried out by business associations. The description of environmental quality is predominantly based on Federal Government measuring network programmes and specialist information from the *Länder* under the Federal Government/*Länder* administrative agreement on environmental data exchange.

Limited space in the printed edition of "Data on the Environment 2005" has led to many tables being abridged. However, in order to provide the readers with complete information, the book is accompanied by a CD-Rom containing uninterrupted time periods and other additional information. The Federal Environment Agency also provides electronic information with "Data on the Environment Online" under the Internet address www.umweltbundesamt.de/umweltdaten, which updates many of the themes dealt with in this book on an annual basis. The agency therefore meets the requirements of the

Environmental Information Act which demands that access to currently available environmental information be simplified for the public by way of electronic communication.

"Data on the Environment" is the result of a 20-year tradition of close cooperation between many Federal Government and Land bodies and relevant organizations. Without this it would not have been to possible amalgamate the multi-faceted spectrum of environmental information into one complete work. In particular, we would like to thank the Federal Statistical Office, the Federal Nature Conservation Agency, the Federal Office for Radiation Protection, the Federal Office of Consumer Protection and Food Safety, the German Federal Institute for Risk Assessment, the German Weather Service, the Federal Office for Building and Regional Planning, the Federal Institute of Hydrology, the Federal Maritime and Hydrographic Agency, the Federal Agency for Food, Agriculture and Consumer Protection, the *Länder* working groups, and the organisations and government departments, who all contributed to the success of this report with texts, data, and advice.

I wish you an informative read.



Prof. Andreas Troge
(President of the Federal Environment Agency)

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I CLIMATE CHANGE AND CLIMATE PROTECTION

I 1 Greenhouse gases in the atmosphere and global effects

There is growing evidence that climate change is occurring and having effects. The greenhouse effect caused by mankind (anthropogenic) accounts for about 60–70 % of these effects, while natural processes play a far more limited role. Since the beginning of the Industrial Age, human beings have been emitting greenhouse gases into the atmosphere, primarily as a result of their energy-intensive lifestyle. A primary factor has been the burning of fossil fuels, but also non-energetic production processes contribute to the growing concentration of greenhouse gases in the atmosphere. The climate change thus induced is already clearly identifiable as a rise in global temperatures.

I 1.1 Atmospheric greenhouse gas concentrations

The most important trace gases in the atmosphere responsible for the natural greenhouse effect are water vapour (H_2O), carbon dioxide (CO_2), ozone (O_3), nitrous oxide (laughing gas, N_2O) and methane (CH_4). Those gases released by human activities over and above natural trace element emissions, cause the additional anthropogenic greenhouse effect. Apart from the gases listed above, the following are also involved: chlorofluorocarbons (CFC), halons, perfluorocarbons (PFC, especially CF_4 and C_2F_6), sulphur hexafluoride (SF_6), hydrochlorofluorocarbons (HCFC), hydrofluorocarbons (HFC) and to a limited extent water vapour emitted by aircraft in the upper atmosphere.

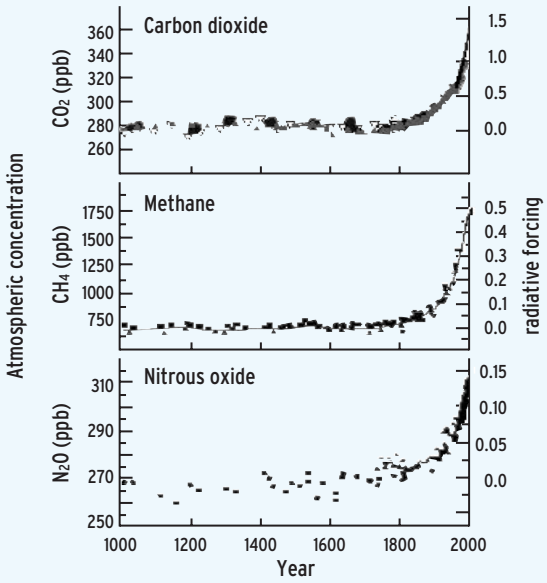
The anthropogenic greenhouse effect is further strengthened by the fact that the absolute content of water vapour in the atmosphere increases as the temperature of the air and the oceans rises. This, in turn, causes the temperature to rise once more (positive feedback).

Aerosols that get into the atmosphere counteract the warming caused by the greenhouse effect.

Carbon dioxide (CO_2)

The concentration of CO_2 has risen by about 30 % since 1750 and now exceeds a value of around 370 ppmv (Fig. I 1.1-1). The current CO_2 concentration has not been reached before in the past 420 000 years, nor, probably, in the last 20 million years. The current annual rate of increase is the highest in the last 20 000 years.

Fig. I 1.1-1: *Atmospheric greenhouse gas concentrations*



Source: *Intergovernmental Panel for Climate Change 2001*

Around three-quarters of anthropogenic emissions in the last 20 years can be traced to the burning of fossil fuels.

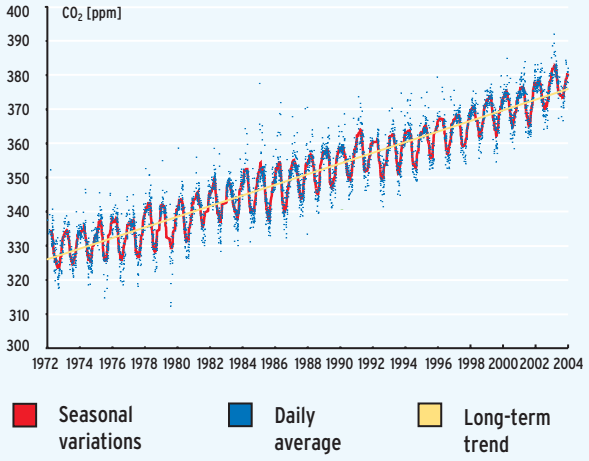
In the last two decades, the annual rise in the concentration has been about 0.4 %. During the 1990s, the annual rise in the concentration varied between 0.2 % and 0.8 %.

This trend has been documented since 1958 through measurements regularly taken in Hawaii, on Mauna Loa. The measurements taken at the Federal Environment Agency's (UBA) stations, e.g. the Schauinsland station (Fig. I 1.1-2), show the same trend.

Methane (CH_4)

Since 1750, the CH_4 concentration has risen by around 150 % to over 1760 ppbv (Fig. I 1.1-1). The current concentration is the highest in the last 420 000 years. The annual increase in the concentration slowed somewhat and partly stagnated in the 1990s as compared to the 1980s. Man is responsible for a little more than half of current CH_4 emissions (fossil fuels, agriculture and waste management).

Fig. I 1.1-2: *Atmospheric CO_2 concentration at the UBA's Schauinsland measuring station 1972–2004*



Source: *Federal Environment Agency 2004*

Stabilising the CH_4 concentration at the current level would require an 8 % reduction in global anthropogenic CH_4 emissions.

Nitrous oxide (N_2O)

Since 1750, the N_2O concentration has risen by around 17 % and is still rising (Fig. I 1.1-1). The current concentration is the highest ever in the last 1 000 years. Around one third of the emissions are man-made (agriculture and the chemical industry).

Stabilising the N_2O concentration at the current level would require a reduction of over 50 % in anthropogenic emissions.

Chlorofluorocarbons (CFC)

The ozone depletors with the highest Global Warming Potential (GWP) are: CFC-11, CFC-12 and CFC-113. Concentrations of these gases are stagnating or falling, but some halons are still rising.

Sulphur hexafluoride (SF_6)

SF_6 is the greenhouse gas with the highest known specific GWP. Once emitted into the atmosphere, it takes around 3 200 years before high-energy UV radiation breaks down the highly stable molecules in the upper atmosphere. Measurements have shown that the atmospheric SF_6 concentration has risen by two orders of magnitude since its industrial production began in 1953 (Fig. "Rise in tropospheric SF_6 concentration").

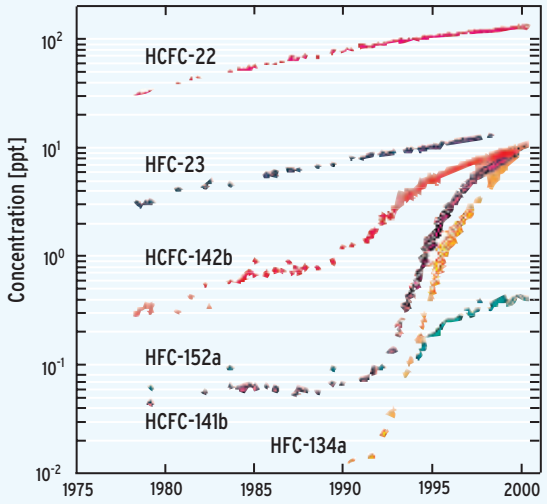
Perfluorocarbons (PFC)

PFC also have an extremely stable molecular structure, which gives atmospheric residence times of up to 50 000 years. Atmospheric measurements have shown that about half of the CF_4 currently in the atmosphere is of natural origin [1]. However, since the mid-1950s the increased use of the gas in industry has increased the atmospheric CF_4 concentration. Similar trends have been observed for C_2F_6 and other PFC (Fig. "Atmospheric CF_4 concentration" and Fig. "Atmospheric C_2F_6 concentration").

Halogenated hydrocarbons (HFC)

The key HFC in technical use are HFC 23, HFC 134a and HFC 152a. Between 1978 and 1995, the rise in HFC 23 concentration was almost linear, from 2 to 10 ppt. Over the last 10 years, due to its increasing use, the concentration of HFC 134a has risen exponentially from almost zero to almost 10 ppt [2]. Owing to its relatively low atmospheric persistence, the increase in concentration of HFC 152a has been less dramatic than that of the other two gases, and has remained below 1 ppt (Fig. I 1.1-3).

Fig. I 1.1-3: *Atmospheric concentration of HFC 23 and HFC 152a plus some other HCFCs*



Source: *Intergovernmental Panel for Climate Change 2001*

Other substances

The Earth's radiation balance is also affected by sulphate aerosols, formed from sulphur dioxide and dust (e.g. from volcanoes or forest fires). Increasing concentrations of aerosols tend to mitigate the temperature rise caused by greenhouse gases. In the troposphere, sulphate aerosols can increase cloud formation and cloud reflectivity.

Owing to the inconsistent distribution of aerosols in the atmosphere (higher concentrations in industrial areas such as Central Europe), their effects are expected to be primarily regional.

Other aerosols likewise affect the climate, although in their case uncertainties as to the various effects are greater than for sulphate aerosols. Of particular significance is soot, which absorbs visible light and so warms the air. It is also known for its toxicity.

I 1.2 Climate change and its effects

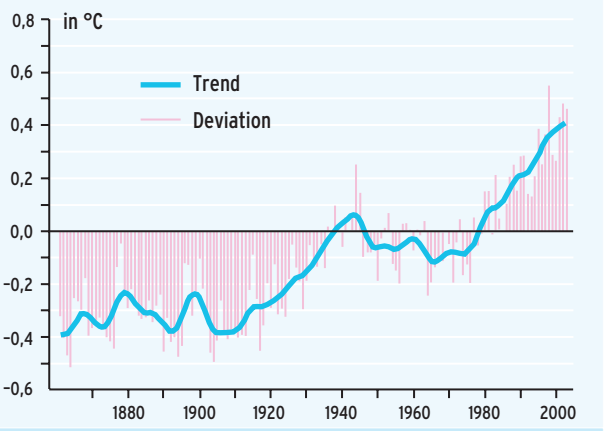
During recent years, new and more robust findings have been presented which show that most of the warming observed during the last 50 years can be attributed to human activities [3]. Both comparisons of observed global temperature change with model simulations and detailed statistical studies of long-term time series for global temperature lead to the conclusion that human influence is a key factor in global warming.

I 1.2.1 Global climate change

Climate change in the last 100 years

Since 1861, when systematic meteorological recording began, the global mean surface temperature has risen by 0.7 (+/–0.2) °C [3], [9]. (Fig. I 1.2.1-1).

Fig. I 1.2.1-1: *Deviation of global mean air temperature at ground level from the long-term average (1961–1990) in the period 1861–2003*



Source: *World Meteorological Organization 2003*

Up until the mid-1970s, the rate of warming was 0.6 °C per century, but since 1976 the temperature has risen around three times more rapidly [4].

During the 20th century, the northern hemisphere experienced the greatest rise in temperature in 1000 years. Since measurements began, the decade from 1990–1999 was globally the warmest decade yet, and the ten warmest years have occurred since 1989. Within this trend, 1998 was globally the warmest year of all, followed by 2002 and 2003 [5].

During the last 100 years, global sea levels have risen by around 0.1 to 0.2 m.

In the 20th century, the European climate changed as follows: Average ground-level temperature rose by 0.95 °C. Winter temperatures (+1.1 °C) rose more sharply than summer temperatures (+0.7 °C). The 1990s was the warmest decade of the century.

Night temperatures rose faster than day temperatures, probably due to increased cloud cover.

Precipitation in northern Europe increased by 10–40 %, while some areas in southern Europe became up to 20 % more arid. In most parts of Europe, the changes are most marked in the winter [6].

Anticipated climate change up to 2100

The anthropogenic greenhouse effect is causing changes to the climate system whose future extent and impact can only be estimated in computer models, due to the complex interaction between a multitude of factors. Some of the main climate changes that we can expect during the 21st century [3] are the following:

- It is feared that, by the year 2010, temperatures will rise between 1.4 and 5.8 °C. This level of temperature change would be greater than all the natural fluctuations in temperature observed over the last centuries. They are occurring at a speed unprecedented during the last 10 000 years.
- The sea level reacts more slowly to climate change due to its enormous capacity to absorb heat. However, once change has occurred, it will remain in place for many centuries. It is thought that a rise of between 10 and 90 cm will occur by the end of the 21st century.
- Many climate models also suggest dramatic changes in global and regional precipitation. Areas already suffering from water shortage may become even more arid. Climate researchers anticipate that there will be more extreme meteorological events, more heavy rainfall, higher daily maximum temperatures, fewer days with frost, a decrease in the diurnal temperature range, and more frequent dry spells during the summer across the continents.
- Some consequences of climate change can already be seen, for example glaciers thinning, permafrost soils thawing, trees blossoming earlier, and alterations in the breeding and migratory behaviour of birds. These processes cause major damage to the stability of ecosystems.

Evidence of regional impacts is more difficult to present, and liable to greater uncertainty.

These key changes to the European climate have been derived from scenario calculations:

- Mean temperature rises between 1990 and 2100 by 2–6.3 °C, with the greatest rises expected in southern (Spain, Italy, Greece) and north-eastern (western Russia) Europe [6].
- More frequent hot summers, particularly in southern Europe,
- Winters continue to get warmer more rapidly than summers (except for southern Europe) [6],
- Widespread increases in annual precipitation of 1–2 % per decade in north-eastern Europe, with a possible corresponding fall of up to 1 % per decade in precipitation over southern Europe. The differences between North and South will be especially noticeable in the summer (north-eastern Europe: up to +2 % per decade, southern Europe: up to −5 % per decade).

It is expected that southern Europe, above all, will suffer from the negative effects of climate change, with increases in desertification, drought and forest fires, especially in Mediterranean regions.

As well as these gradual climate changes, there may also be rapid changes in the climate system that can be referred to as abrupt climate changes. The result will be climate change that occurs rapidly and is accompanied by serious effects. Based on the current state of knowledge, it is felt that it is quite unlikely that such events will occur during the coming decades. However, the actual risk of an abrupt climate change occurring is difficult to assess, as the processes involved are non-linear and the critical limits are not precisely known. Examples of possible abrupt climate change events include:

- Collapse of thermohaline circulation (disruption of the Gulf Stream) due to the warming or dilution of the salty waters of the North Atlantic,
- Disintegration of the West Antarctic ice shield accompanied by the sea level rising by several metres,
- Accelerated melting of the Greenland ice sheet bringing with it an irreversible melting process,
- Increased risk of permafrost soils thawing and thus releasing large amounts of methane due to increasing warming,
- Additional releases of carbon dioxide, reinforces climate change through the destruction of large areas of the rainforest, e.g. in the Amazon region.

To prevent dangerous, anthropogenic damage to the climate system, the global increase in temperature needs to be restricted in the long-term to around 2° Celsius above its pre-industrial level, as shown, for example, in the WBGU's (German Advisory Council on Global Change) Special Report [7]. More recent scientific findings, such as those presented by the IPCC Workshop on Climate Sensitivity [8], indicate that it would very likely only be possible to fall short of this temperature limit if the greenhouse gas concentration could be stabilised at 400 ppm CO_2 equivalent. To achieve this level of stabilisation, global emissions can only be allowed to go on increasing for at most another 10 to 20 years, after which they need to be reduced to below half of the current level by 2050. According to the WBGU's Special Report [7], there will need to be marked reductions not just of carbon dioxide, but also of the other greenhouse gases (particularly methane, nitrous oxide and the fluorinated compounds) and other substances that have an indirect impact on climate (e.g. soot).

Based on fair burden-sharing, the industrialised countries would need to cut their greenhouse gas emissions by 80 % of the 1990 level by 2050.

I 1.2.2 Climate trends in Germany

The climate system is subject to both natural and anthropogenic (man-made) impacts. Natural impacts include, for example, volcanic and solar activity, and atmospheric and ocean circulation mechanisms such as ENSO (El Nino/Southern Oscillation) and NAO (North Atlantic Oscillation). During recent years, climate research has presented new and more robust findings that show that most of the warming that has been observed during the last 50 years can be attributed to human activities [3].

It is easier to prove anthropogenic influence on the global climate than on a regional scale, such as for Germany. This is due to the wider variance in regional climate parameters, whereby the human contribution can be obscured by natural fluctuations. Significant climate changes are now also identifiable at regional level, including in Germany, based on research into trends, seasonal variations and the extrema of climate parameters. The basis for these investigations are grid fields showing mean daily average temperatures and precipitation levels for all months since 1901, which have been interpolated from all available data from climate and precipitation measuring stations in Germany and taking into account regression relationships with topographical parameters). From these data, time series of area averages were calculated for Germany for seasons and the year.

Trends in air temperature

Globally, the last decade of the 20th century was also the hottest worldwide, and Germany was no exception. Nine of those years plus all the years so far in the

21st century were hotter than the long-term annual average temperature (8.3 °C), while six of the 10 warmest years also fall within this period. The warmest year since 1901 was 2000 (9.9 °C) (Fig. I 1.2.2-1).

Overall, annual average temperatures show a rising trend of 0.8 °C in 100 years, which is statistically significant with a 5 % probability of error (Tab. I 1.2.2-1). However, this rise is not equally distributed across the time series. To a large extent, it is based on a rise prior to 1911 and a very warm period since 1988.

The rise in temperature also varies throughout the different seasons.

The spring temperatures only show a relatively weak, statistically insignificant increase. In this case, too, the years since 1990 have been particularly warm. Five of them (in descending order: 2000, 1993, 1990, 1999, 2003) are amongst the 10 warmest since the start of the 20th century.

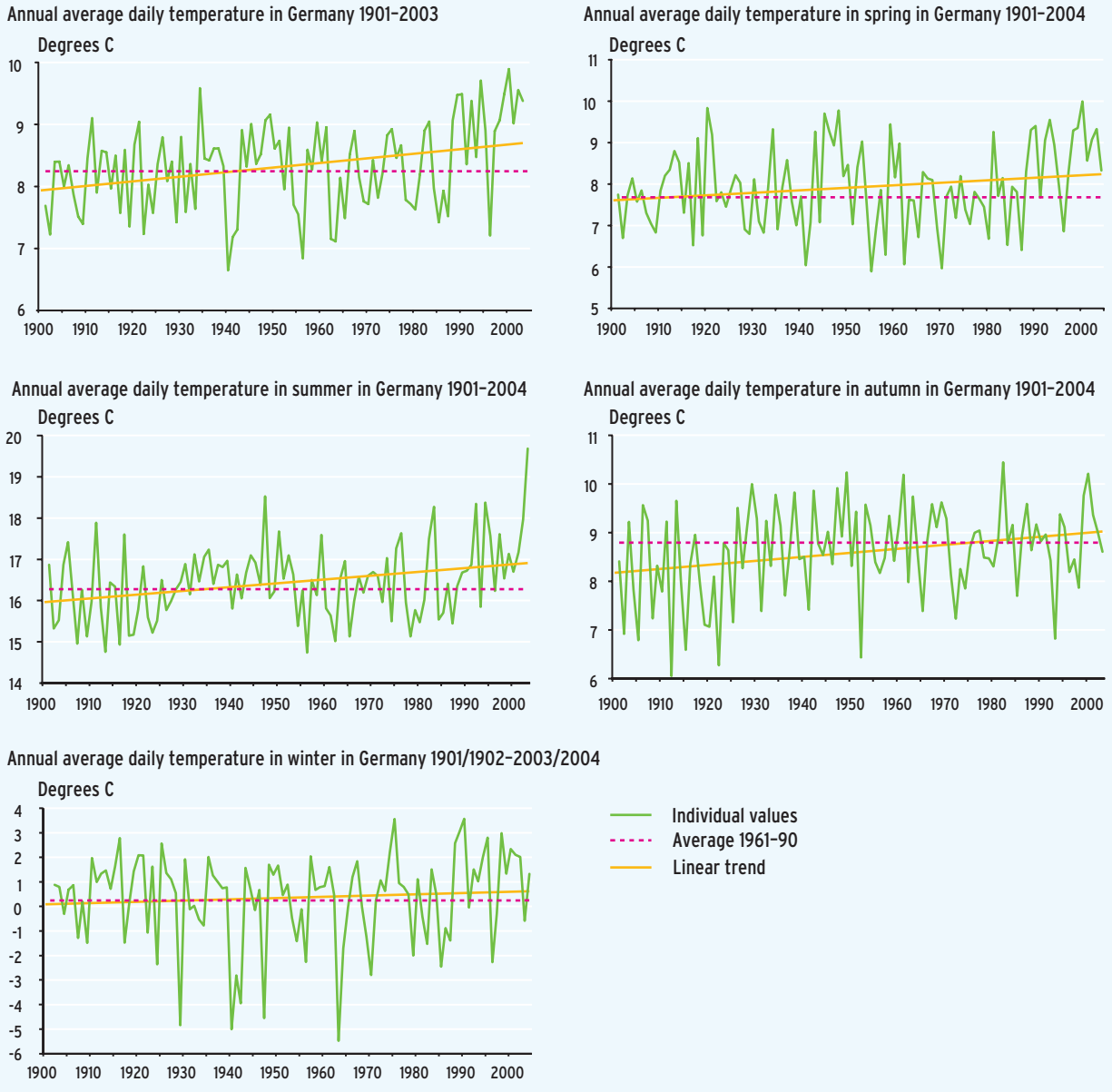
Summer contributes far more than spring to the trend in annual average temperatures. Here, there is a statistically significant increase of around 0.9 °C,

Tab. I 1.2.2-1: *Linear trends in air temperature between 1901 and 2003*

95 % (at least) statistically significant trends are shaded	
Spring (March, April, May)	0.6 °C
Summer (June, July, August)	0.9 °C
Fall (September, October, November)	0.9 °C
Winter (December, January, February)	0.5 °C
Year	0.8 °C

Source: *German Weather Service 2004*

Fig. I 1.2.2-1: *Annual average daily temperature in Germany*



Source: *German Weather Service 2004*

caused mainly by a rise in temperatures since 1955. The highest point to date in this trend was the summer of 2003, which was over one degree warmer than all the previous summers since 1901. Amongst the summers since 1990, only the temperatures of 1993 and 1996 were below the average. Five of the ten warmest summers occurred during this period (2003, 1994, 1992, 2002, and 1997).

Autumn also shows a marked, statistically significant rise in temperature, though it is mainly based on a sudden warming between 1922 and 1929. Autumnal temperatures have remained highly stable since then.

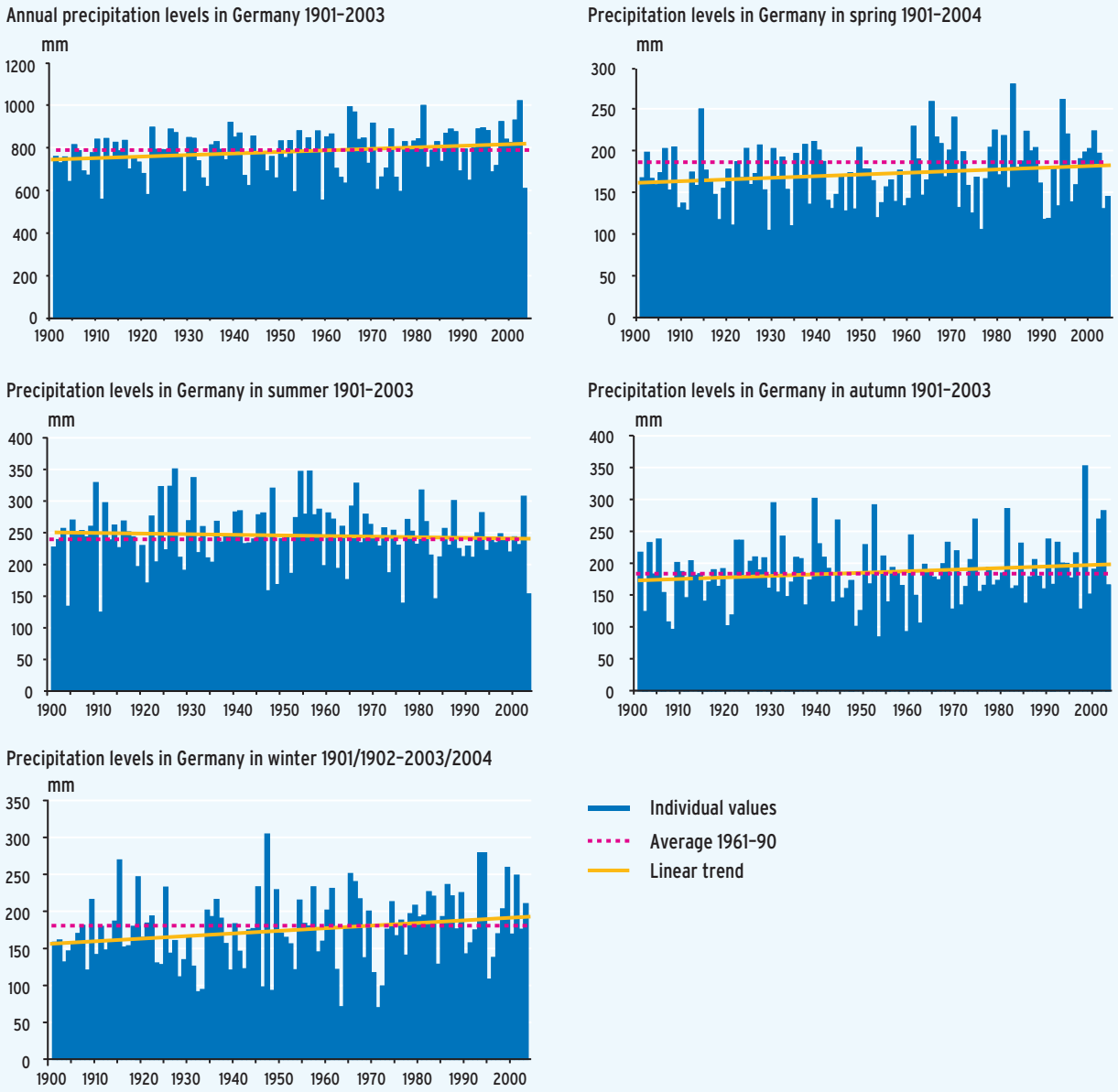
Overall, there is no upward trend in winter. The time series is characterised by an accumulation of particularly cold winters and the absence of any very warm winter during the middle part of the 20th century. However, the winters after 1990 were also very mild. Eleven of those fifteen winters were warmer than average. Four of them (1989/1990, 1994/95, 1997/98 and 1999/2000) are amongst the 10 warmest of the century.

Trends in precipitation

The time series of area averages of annual precipitation in Germany exhibits only a slight rise, due mainly to the lack of especially high annual precipitation in the first 20 years of the 20th century However, since 1990, the years 2002, 2001, 1993 and 1994 are amongst the 10 rainiest years since 1901.

As with temperature, this trend is not equally distributed across the seasons. It largely rests on an in-

Fig. I 1.2.2-2: *Average annual precipitation levels in Germany*



Source: *German Weather Service 2004*

crease in winter precipitation. Spring and autumn also exhibit a slight upward trend, while a small decrease in precipitation may be seen in summer.

The rising temperatures are likely causing an increase in water vapour content in the atmosphere. Thus, most simulated calculations show more intensive water circulation with heavier precipitation. Nonetheless, it is not yet possible to draw reliable conclusions about regional and seasonal variations (Tab. I 1.2.2-2 and Fig. I 1.2.2-2).

Tab. I 1.2.2-2: *Linear trends in precipitation between 1901 and 2003*

95 % (at least) statistically significant trends are shaded	
Spring (March, April, May)	+21 mm
Summer (June, July, August)	−9 mm
Fall (September, October, November)	+25 mm
Winter (December, January, February)	+37 mm
Year	+76 mm

Source: *German Weather Service 2004*

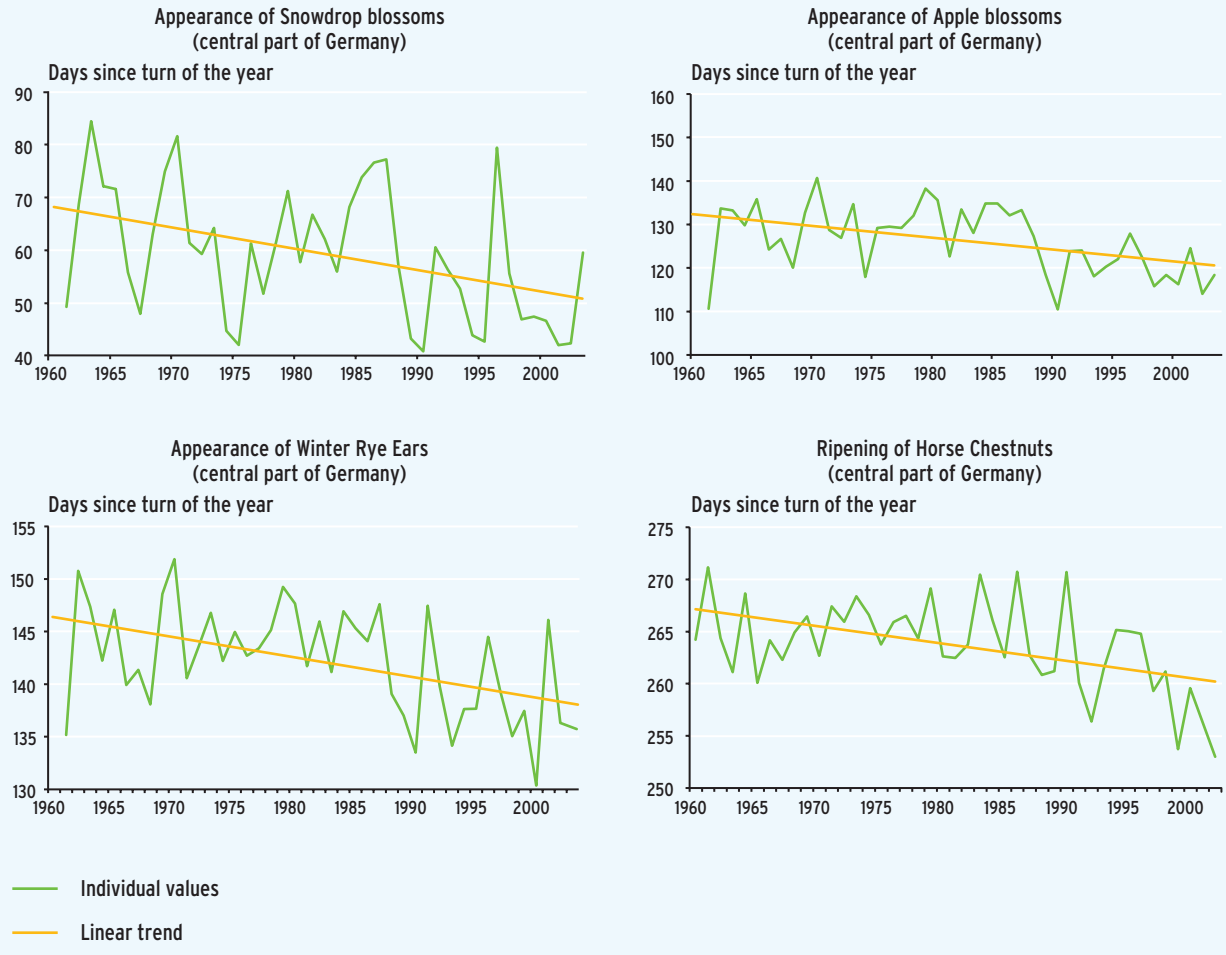
Climate effects on flora and fauna

Climate change in Germany, and in Europe, has become so significant that the first effects on flora and fauna can be observed. For example, apple trees and snowdrops are blossoming earlier (almost 5 days/decade), and forest trees in many European countries are putting out leaves earlier (approx. 5 days/decade). Many songbirds are staying for almost a month longer as compared to 1970. These phenomena prove that altered temperature levels cause changes to when seasons begin and how long they last.

The phenological spring phase is beginning earlier. There has, however, been no major trend towards retardation of autumn phenological phases. Unlike the spring phases, whose beginnings are determined largely by the temperature, the connections with climatological parameters are weaker and more complex for autumn. As well as the temperature, the precipitation in the summer months is also significant here, and non-climatological influences such as the occurrence of plant diseases and pest infestations also play an important part (Fig. I 1.2.2-3).

[1] Harnisch, J. et. al.: Tropospheric Trends for CF4 and C_2F6 since 1982 derived from SF6 dated stratospheric air. Geophysical Research Letters 23, 1996

Fig. I 1.2.2-3: *Start of phenological phases in Germany*



Source: *German Weather Service 2004*

[2] Oram, D. E. et. al.: Atmospheric measurements and emissions of HFC-23 (CHF3). Geophysical Research Letters 25, 1998
[3] Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report TAR, 2001
[4] World Meteorological Organisation (WMO), Press Release, WMO-No 702, 2003
[5] Parry, M. L. (Ed.): Assessment of Potential Effects and Adaptations for Climate Change in Europe. Summary and Conclusions. The Europe Acacia Project. Jackson Environment Institute, University of East Anglia, Norwich, United Kingdom, 2000
[6] EEA Report No 2/2004
[7] Special Report 2003 of the WBGU (German Advisory Council on Global Change): Thinking beyond Kyoto – climate protection strategies for the 21st Century
[8] IPCC Working Group I: Workshop on Climate Sensitivity. Ecole Normale Superieur; Paris, France, 26–29 July 2004, Workshop Report, September 2004, Boulder, Colorado, USA (http://ipcc-wg1.ucar.edu/meeting/CSW/product/CSW_Report.pdf)
[9] WMO statement on the status of global climate in 2003; Climatic Research Unit, University of East Anglia and Hadley Centre, The Met Office, UK

I 2 Greenhouse gas emissions

In order to quantify the impact the different greenhouse gases have on the climate, the quantities released are weighted differently according to the level of their potential to affect the climate.

The so-called GWP (Global Warming Potential) is used as the weighting factor. In calculating this factor, the most important considerations are the absorption of thermal radiation as a function of wave length and the atmospheric lifetime of the respective gases. The GWP value of CO_2, which is used as reference substance, is set at one (Tab. I 2-1).

I 2.1 Global trends

I 2.1.1 Properties and emissions of the most important greenhouse gases

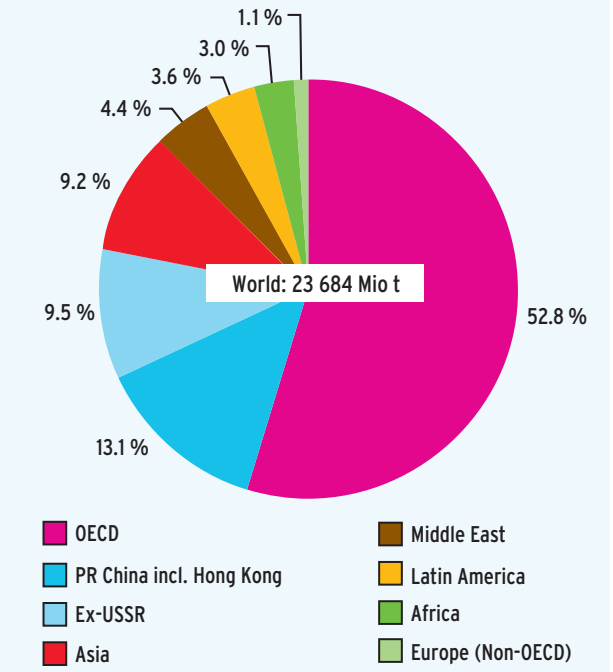
The contributions of emitting processes to the anthropogenic greenhouse effect are universally estimated as follows: combustion of fossil fuels ca. 50 %, chemicals industry (CFC, PFC and halons) approx. 20 %, forest clearance and timbering ca. 15 %, agriculture and other (methane from cattle and rice farming or from landfill sites, nitrous oxide from fertiliser use) approx. 15 %.

Carbon dioxide (CO_2)

The most important climate gas in terms of quantity is carbon dioxide (CO_2). According to calculations by the International Energy Agency (IEA), energy-related human activities worldwide release over 23 billion tonnes CO_2 into the atmosphere annually [1].

These calculations are based on figures for primary energy consumption and use a universal method for all countries, which can mean that the IEA figures deviate from the data calculated by member states themselves (Tab. I 2.1.1-1 and Fig. I 2.1.1-1).

Fig. I 2.1.1-1: *Shares of global energy-related CO_2 emissions 2001*



Source: *International Energy Agency 2003*

The most important CO_2 sinks are the oceans. In the terrestrial biosphere, particularly in forests, photosynthesis extracts CO_2 from the atmosphere in the order of 120 billion t annually, but this is returned to the atmosphere via decomposition through microbes. If vegetation cover remains constant, the amounts of CO_2 extracted and returned remain roughly similar. However, large-scale clearance of forest areas produces massive CO_2 emissions. On the other hand, nitrogen depositions, CO_2 fertiliser effects and cultivation measures increase the amount of CO_2 stored in biomass, particularly in industrialised countries. These processes actually produce a net absorption of CO_2 of around 2.57 +/–3.67 Gt CO_2 a^{-1}.

Methane (CH_4)

In the IPCC report of 2001, global anthropogenic emissions of CH_4 in 2001 are estimated to be 347 million tonnes, which would amount to an approximately 20 % share in the anthropogenic greenhouse effect. Methane is formed by anaerobic decomposition of organic material. The largest natural sources of methane are wetlands (marsh gas), while the most significant anthropogenic sources are rice and live-

Tab. I 2-1: *GWP values of the most important climate gases to be used in line with UNFCCC report procedures*[1)]

	Chemical Formula	Atmospheric Persistency in Years	GWP Value
Carbon dioxide	CO_2	Variable	1
Methane[2), 3)]	CH_4	12	23
Nitrous oxide[3)]	N_2O	114	296
Hydrofluorocarbons			
HFC – 23	CHF_3	260	12 000
HFC – 32	CH_2F_2	5	550
HFC – 41	CH_3F	2.6	97
HFC – 43 – 10mee	$CF_3CHFCHFCF_2CF_3$	15	1 500
HFC – 125	CHF_2CF_3	29	3 400
HFC – 134	CHF_2CHF_2	9.6	1100
HFC – 134a	CH_2FCF_3	13.8	1 300
HFC – 152	CH_2FCH_2F	0.5	43
HFC – 152a	CH_3CHF_2	1.4	120
HFC – 143	CHF_2CH_2F	3.4	330
HFC – 143a	CF_3CH_3	52	4 300
HFC – 161	CH_3CH_2F	0.3	12
HFC – 227ea	CF_3CHFCF_3	33	3 500
HFC – 236cb	$CH_2FCF_2CF_3$	13.2	1 300
HFC – 236ea	CHF_2CHFCF_3	10	1 200
HFC – 236fa	$CF_3CH_2CF_3$	220	9 400
HFC – 245ca	$CH_2FCF_2CHF_2$	5.9	640
HFC – 245fa	$CHF_2CH_2CF_3$	7.2	950
HFC – 365mfc	$CF_3CH_2CF_2CH_3$	9.9	890
Perfluorocarbons			
PFC – 14	CF_4	50 000	5 700
PFC – 116	C_2F_6	10 000	11 900
PFC – 218	C_3F_8	2 600	8 600
PFC – 31 – 10	C_4F_{10}	2 600	8 600
PFC 41 – 12	C_5F_{12}	4 100	8 900
PFC – 51 – 14	C_6F_{14}	3 200	9 000
PFC – 318	$c\text{-}C_4F_8$	3 200	10 000
Sulphur hexafluoride	SF_6	3 200	22 200
Fluoroethers			
HFE – 125	CHF_2OCF_3	150	14 900
HFE – 134	CHF_2OCHF_2	26.2	6 100
HFE – 143a	CH_3OCF_3	4.4	750
HFE – 235da2	$CHF_2OCHClCF_3$	2.6	340
HFE – 245fa2	$CHF_2OCH_2CF_3$	4.4	570
HFE – 254cb2	$CH_3OCF_2CHF_2$	0.22	30
HFE –7100	$C_4F_9OCH_3$	5	390
HFE – 7200	$C_4F_9OC_2H_5$	0.77	55
H-Galden 1040x	$CHF_2OCF_2OC_2F_4OCHF_2$	6.3	1 800
HG – 10	$CHF_2OCF_2OCHF_2$	12.1	2 700
HG – 01	$CHF_2OCF_2CF_2OCHF_2$	6.2	1 500

UNFCCC: United Nations Framework Convention on Climate Change
[1)] Mass-related and related to a time horizon of 100 years: (typical uncertainty range as per IPCC ± 35%)
[2)] The GWP value of methane includes the indirect effects of tropospheric ozone formation and stratospheric water vapour formation
[3)] Persistency values for methane and nitrous oxide include the indirect effects of emissions of these gases

Source: *Intergovernmental Panel for Climate Change 2001*

stock farming, extraction and distribution of natural gas and crude oil, mining and landfill. The most important reaction which decomposes methane is photochemical conversion to CO_2 and H_2O involving OH radicals formed in the atmosphere.

Nitrous oxide (N_2O)

Global annual emissions of N_2O are estimated by the IPCC 2001 report to be around 6.9 million tonnes, or about 6 % of the anthropogenic greenhouse effect. Microbial decomposition of nitrogen compounds in the soil, which can occur naturally or as a result of human activity (principally nitrogen fertilisers), is the major global source of N_2O. Nitrogen compounds can enter the soil directly or via water and the atmosphere. Direct emissions of N_2O into the atmosphere occur in industry, primarily during production of adipic acid (a raw material used in plastics manufacturing, solvents and soften-

Tab. I 2.1.1-1: *Worldwide energy-related CO_2 emissions*

	Emissions 1990	Emissions 2001	Change over 2001 1990	Share of the worldwide emissions 2001	Emissions 2001 per capita	Emissions 2001 through primary energy consumption
	Mio t	Mio t	%	%	t/capita	t/TJ
OECD	**11 012**	**12 511**	**+ 13.6**	**52.8**	**11.0**	**56.1**
Canada	430	520	+ 20.9	2.2	16.7	49.9
Mexico	292	359	+ 22.9	1.5	3.6	56.4
USA	4 826	5 673	+ 17.6	24.0	19.8	59.5
Japan	1 019	1 132	+ 11.1	4.8	8.9	51.8
Korea	226	436	+ 92.9	1.8	9.2	53.5
Australia	260	370	+ 42.3	1.6	19.0	76.4
New Zealand	22	33	+ 50.0	0.1	8.5	43.0
Austria	57	67	+ 17.5	0.3	8.2	51.8
Belgium	107	120	+ 12.1	0.5	11.6	48.5
Czech Republic	154	119	–22.7	0.5	11.6	68.5
Denmark	51	51	0.0	0.2	9.4	60.9
Finland	55	60	+ 9.1	0.3	11.6	42.5
France	353	385	+ 9.1	1.6	6.3	34.6
Germany[1]	**964**	**850**	**–11.8**	**3.6**	**10.3**	**57.8**
Greece	71	90	+ 26.8	0.4	8.2	75.0
Hungary	71	56	–21.1	0.2	5.5	53.0
Iceland	2	2	0.0	0.0	7.2	15.0
Ireland	30	43	+ 43.3	0.2	11.2	68.8
Italy	400	425	+ 6.3	1.8	7.3	59.0
Luxembourg	11	8	–27.3	0.0	19.1	52.5
Netherlands	157	178	+ 13.4	0.8	11.1	54.9
Norway	29	38	+ 31.0	0.2	8.4	34.2
Poland	344	293	–14.8	1.2	7.6	77.1
Portugal	40	59	+ 47.5	0.2	5.9	57.1
Slovakia	56	39	–30.4	0.2	7.3	50.2
Spain	207	286	+ 38.2	1.2	7.1	53.5
Sweden	51	48	–5.9	0.2	5.4	22.5
Switzerland	42	44	+ 4.8	0.2	6.1	37.3
Turkey	129	188	+ 45.7	0.8	2.7	61.9
United Kingdom	560	541	–3.4	2.3	9.2	54.9
Europe (Non-OECD)	387	254	–34.4	1.1	4.4	61.1
Africa	541	720	+ 33.1	3.0	0.9	33.4
Asia	1 254	2 179	+ 73.8	9.2	1.1	45.1
PR China[2]	2 290	3 113	+ 35.9	13.1	2.4	64.2
Ex-USSR	3 345	2 240	–33.0	9.5	7.8	57.1
Latin America	599	842	+ 40.6	3.6	2.0	44.7
Middle East	585	1 045	+ 78.6	4.4	6.2	64.0
World[3]	**20 652**	**23 684**	**+ 14.7**	**100.0**	**3.9**	**56.4**

[1] Deviations from German government's data due to IEA's own calculation method
[2] Including Hong Kong
[3] Excluding international transport (758.2 Mio t)

Source: *International Energy Agency 2003*

ers), and to a lesser extent from catalytic converters in motor vehicles. Photochemical processes decompose N_2O only when it reaches the stratosphere.

Fluorinated chemicals

Alongside the halons, chlorofluorocarbons and hydrochlorofluorocarbons (CFC and HCFC), which are regulated in the Montreal Protocol, fluorinated greenhouse gases also include these substances' chlorine-free substitutes, i.e. hydrofluorocarbons, perfluorocarbons (PFC) and sulphur hexafluoride (SF_6).

CFC, HCFC, halons and HFC are exclusively anthropogenic, and used to be (to some extent they still are) emitted during the use of aerosol propellants, foams and insulating materials, coolants in refrigerators and air conditioning systems, and fire extinguishers. In addition, the production of HCFC 22 also releases large quantities of HFC 23.

The main source of PFC emissions (above all CF_4, C_2F_6 and C_3F_8) is electrolysis, in the production of primary aluminium and semiconductors. Emissions of SF_6 arise primarily from its use in the production

of non-ferrous metals, gas-insulated switching systems and sound-proof windows.

Owing to their high specific absorption of infrared radiation and (in some cases) atmospheric retention time, the GWP of fluorinated chemicals is far higher than that of CO_2, CH_4 and N_2O. This is reflected in the fact that the HFC, PFC and SF_6 which were not regulated in the Montreal Protocol were included in the Kyoto Protocol in 1997 for the reduction in emissions of climate gases.

Emissions of HFC, which have been used as a substitute for CFC since the 1990s, have increased sharply in recent years. Global emissions of HFC 134a rose from virtually zero in 1990 to approx. 32 000 t in 1996. Emissions of HFC 23 from HCFC production were approx. 7 300 t worldwide in 1995. Measurements of the rising atmospheric concentrations of PFC make it possible to calculate PFC emissions: In 1995 about 10 500 t CF_4, 2 000 t C_2F_6, 700 t C_3F_8 and 1 000–2 000 t c-C_4F_8 were released into the atmosphere [2].

Atmospheric measurements have also been used to calculate SF_6 emissions: global emissions in 1996 were approx. 6 300 t SF_6.

Since the majority of HFC and SF_6 produced is used in more or less closed systems (refrigeration, foam, electrical switches, etc.), these stored gases are emitted with a delay of up to 50 years. Unless captured and destroyed or recycled at the end of the products' lifetime, this represents a significant potential source of emissions.

I 2.1.2 United Nations Framework Convention on Climate Change

Since the 1992 "United Nations Conference on Development and the Environment" in Rio de Janeiro, over 180 countries have signed the Framework Convention on Climate Change (UNFCCC), thereby establishing the basis for global climate protection.

Article 2 describes the convention's aims as "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." The UNFCCC commits industrialised countries to reducing their emissions of carbon dioxide and other greenhouse gases not regulated in the Montreal Protocol to 1990 levels by the year 2000. That objective was achieved.

The key purpose of all the Conferences of the Parties (COP) to date has been to further develop their climate protection commitments. At the first COP in 1996, the Berlin Mandate was adopted, empowering signatories to negotiate contractual regulations. This was finalised at the third COP (1997), in the form of the Kyoto Protocol, in which the developed nations commit themselves to reducing total emissions of the six major greenhouse gases (CO_2, CH_4, N_2O, HFC, PFC and SF_6) by at least 5 % relative to 1990 or 1995 by 2008–2012. Since the third COP, negotiations have focused on implementation details, such as the instruments to assist in reaching the targets and monitoring compliance.

The Marrakech Accords (7th COP) achieved a breakthrough – 178 countries came to an agreement on the provisions for implementing the Kyoto Protocol. For the accord to come into force, it needed to be ratified by at least 55 countries that jointly comprised at least 55 % of the industrialised countries' greenhouse gas emissions in 1990. With Russia on board, 150 countries, including Germany, who represent over 60 % of the industrialised countries' greenhouse gas emissions, have now (29.04.2005) ratified the Kyoto Protocol. The Kyoto Protocol entered into force on 16th February 2005.

The main emitter of greenhouse gases, the USA, have rejected the Kyoto Protocol.

The cost of tapping emission reduction potential varies from country to country. The flexible mechanisms of the Kyoto Protocol allow for this problem. In the framework of emissions trading, which began at EU level on 1st January 2005, implementation of the Linking Directive allows certificates to be generated for emission-reducing projects carried out under the Clean Development Mechanism and Joint Implementation , i.e. for projects beyond the borders of the EU. The Kyoto mechanisms are only permitted to be used by countries that have ratified the Kyoto Protocol and that have, by 1st January 2007 at the latest, fulfilled the methodological and substantive requirements for the establishment of a national system and for international reporting on their greenhouse gas inventories.

These instruments include international emissions trading (See Chapter I 6), Joint Implementation (JI) and the Clean Development Mechanism (CDM).

The purpose of international emissions trading is to reduce emissions where this can be done in the most cost-effective manner.

The basic principle underlying both JI and the CDM is the same – an investor carries out a project in a host country which reduces emissions and receives emission credits for doing so. Joint Implementation envisages projects between industrialised countries, while the Clean Development Mechanism relates to joint projects between industrialised and developing countries. A pre-condition for issuing emission credits is that the emission reductions are carried out in addition to measures that would have been taken with or without the project. This is verified using a reference scenario and, where necessary, other criteria. The reference scenario specifies which emissions would have occurred if the project had not been implemented.

With the Kyoto and Marrakech agreements, the United Nations have for the first time agreed absolute and legally binding limits on the amount of greenhouse gases that can be emitted. An important fact is that the Kyoto Protocol already provides for the updating of the commitments.

I 2.2 Trends in the European Union (EU-15)

I 2.2.1 Greenhouse gas emissions

The European Union contributes some 15 % to global energy-related CO_2 emissions. In the years between the year used as the basis for the calculations and 2002, the European countries reduced total emissions of the six greenhouse gases referred to in the Kyoto Protocol (CO_2, CH_4, N_2O, HFC, PFC, SF_6) by 2.9 %.

According to estimates carried out for the European Commission, in 2002 the EU member states emitted ca. 64 million tonnes of HFC, PFC and SF_6 in CO_2 equivalent. Around 78 % of this was attributable to HFC, and 14 % to SF_6. Projections indicate a 75 % rise in emissions of these substances to around 117 million tonnes CO_2 equivalent by 2010, mainly due to increased emissions of HFC (Tab. I 2.2.1-1, Fig. I 2.2.1-1, Fig. I 2.2.1-2, and Tab. "Greenhouse gas emissions in the EU-15" and Tab. "Greenhouse gas emissions of emitter sectors in the EU").

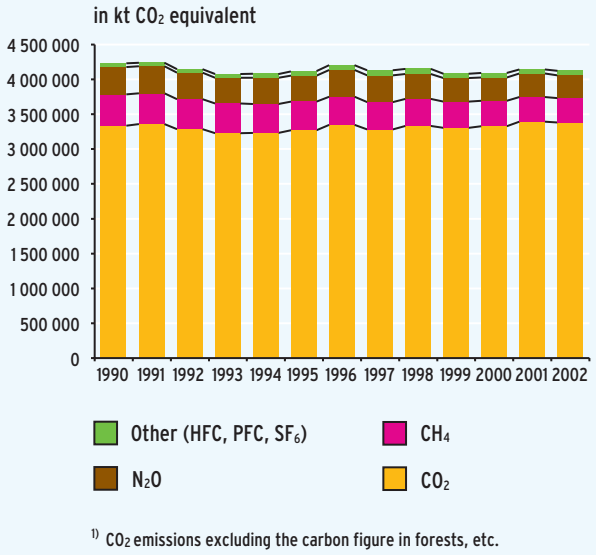
Tab. I 2.2.1-1: *Greenhouse gas emissions of the EU-15 member states in Mt CO_2 equivalent*[1)]

	1990	1995	2000	2002
Austria	78	79	81	85
Belgium	146	155	150	150
Denmark	69	77	68	68
Finland	77	76	75	82
France	565	560	558	554
Germany	**1 249**	**1 101**	**1 016**	**1 016**
Greece	105	110	130	135
Ireland	53	58	68	69
Italy	509	525	544	554
Luxembourg	13	10	10	11
Netherlands	211	225	213	214
Portugal	58	67	78	82
Spain	285	316	385	400
Sweden	72	74	68	70
United Kingdom	743	686	648	635
EU-15	**4 231**	**4 119**	**4 090**	**4 123**

1) Excluding the carbon figure in forests, etc.; Deviation from German government's data for Germany due to the details used here

Source: *European Environment Agency 2004*

Fig. I 2.2.1-1: *Greenhouse gas emissions in the European Union (EU-15)*[1)]



1) CO_2 emissions excluding the carbon figure in forests, etc.

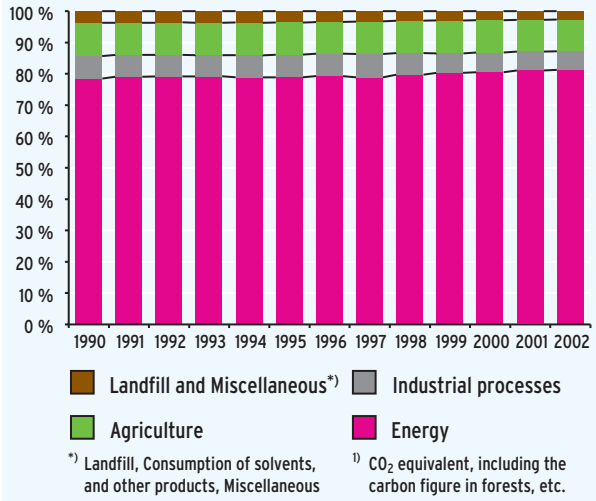
Source: *European Environment Agency 2004 a*

I 2.2.2 Reduction targets and measures in the European Union

Working from Article 2 of the UNFCCC (Para. I 2.1.2) in 1996 for the first time the Environment Council further defined the term "dangerous anthropogenic interference" with the aim of limiting the global rise in temperature to 2° Celsius. Since then, this target has been repeatedly reaffirmed, including in March 2005 by the Environment Council and the European Council.

Against this background, and based on the Kyoto Protocol, the European Union undertook to reduce emissions of the six greenhouse gases CO_2, CH_4, N_2O, HFC, PFC and SF_6 by 8 % compared with 1990 by 2008–2012. Under the burden-sharing arrangement, Member State contributions (reduction or limitation of the increase in emissions) were agreed as follows:

Fig. I 2.2.1-2: *Greenhouse gas emissions in the most significant emitter sectors in the European Union (EU-15)[1)]*



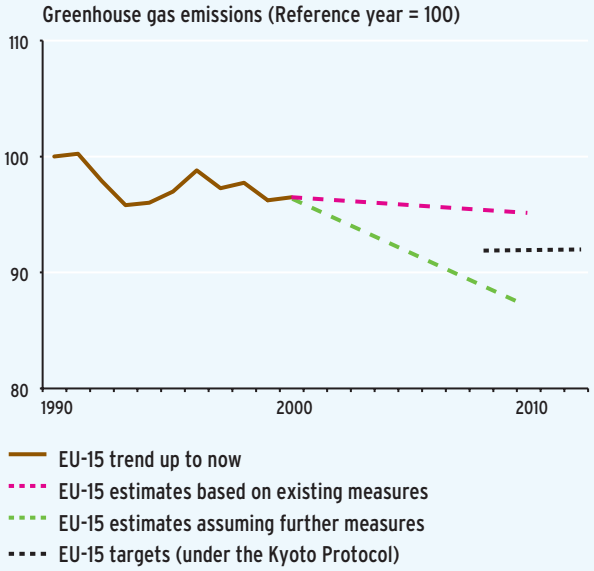
Source: *European Environment Agency 2004 a*

Belgium	– 7.5 %
Denmark	– 21.0 %
Germany	– 21.0 %
Finland	0 %
France	0 %
Greece	25.0 %
Great Britain	– 12.5 %
Ireland	13.0 %
Italy	– 6.5 %
Luxembourg	– 28.0 %
Netherlands	– 6.0 %
Austria	– 13.0 %
Portugal	27.0 %
Sweden	4.0 %
Spain	15.0 %
Total EU	**– 8.0 %**

The European Environment Agency indicated in its report "Analysis of greenhouse gas emission trends and projections in Europe 2004" [3] of December 2004 that the measures adopted so far by the EU member states (EU-15) to reduce their greenhouse gas emissions are, by their own estimates, insufficient to fulfil the EU's commitments as laid down in the Kyoto Protocol. Based on the environment policy measures already taken at national or international level, and given the anticipated increase in emissions in some EU member states, it is expected that by 2010 emissions will only be reduced by 1.0 % compared to the base year. Only Sweden and the United Kingdom are currently fulfilling their burden sharing targets. Germany is still around 2.5 percentage points short of doing so. However, European emissions trading, which began on 01.01.2005, plus further domestic measures in the households and transport sectors which were defined under the National Climate Protection Programme 2005, such as support measures and energy efficiency improvements in the buildings sector, technical improvements to vehicles and fuels, and innovative propulsion systems and climate protection projects (Joint Implementation and Clean Development Mechanism) could ensure that Germany meets its reduction target.

If the other policies and measures planned by the EU-15 member states are taken into account, emissions could be reduced by 7.7 % within the EU-15 by 2010. However this assumes that some member states over-fulfil their target (Finland, France, Greece, Ireland, Sweden, and the United Kingdom). Without the special efforts of these countries, it is projected that the EU's additional planned measures will only achieve a reduction of 5.4 % by 2010 (Fig. I 2.2.2-1).

Fig. I 2.2.2-1: *Greenhouse gas emission trends and projections in the European Union (EU-15)*



Source: *European Environment Agency 2003*

I 2.3 Trends in Germany

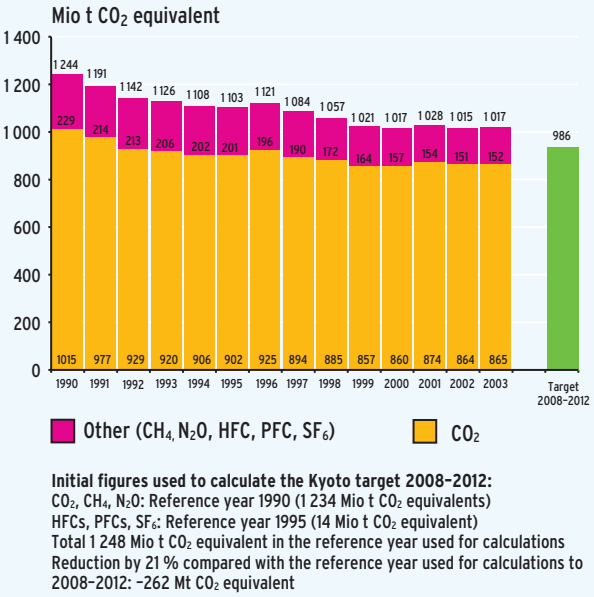
I 2.3.1 Greenhouse gas emissions

Greenhouse gas emissions in Germany 1990–2003

Emissions of greenhouse gases in Germany have been significantly reduced since 1990. Compared with the reference year of the Kyoto Protocol, total emissions expressed as CO_2 equivalent fell by around 230 million tonnes, or 18.5 % up to 2003 (CO_2, CH_4, N_2O: reference year 1990; HFC, PFC, SF_6: reference year 1995). Compared with the reference year, Germany is still 2.5 % short of achieving the Kyoto target. Germany is, therefore, very close to meeting its objective, but it needs to continue its

efforts, particularly to reduce CO_2 (Fig. I 2.3.1-1, Tab. I 2.3.1-1 and Tab. I 2.3.1-2).

Fig. I 2.3.1-1: *Emissions in Germany of the six greenhouse gases named in the Kyoto Protocol*



Source: *Federal Environment Agency 2005*

Carbon dioxide emissions are very largely caused by stationary and mobile combustion processes. CO_2 emissions fell in the first half of the 1990s due to the restructuring processes in the new *Länder* (economic restructuring, the accompanying increase in energy efficiency, switching to lower-emission fuels, decommissioning ageing equipment). In 1996, 2001 and 2003, in response to weather conditions, CO_2 output rose once more, but was again offset in the following years.

In response to improvements in waste recycling, falls in coal extraction and a reduction in animal stocks in the new *Länder*, methane emissions fell continually prior to 2003. In addition, modernisation of the mains gas supply and the shift to liquid and gaseous fuels in smaller furnaces reduced emissions.

In 1990, nitrous oxide was still being emitted primarily by agriculture and industry, in more or less equal parts. When the two adipic acid (a raw material used in plastics manufacturing, solvents and softeners) producers in Germany took action to cut their emissions, N_2O emissions from the industrial process sector fell significantly in the second half of the 1990s (Fig. I 2.3.1-2).

In the 1990s, HFC were increasingly used as a substitute for the ozone depleting greenhouse gases HCFC and CFC. This caused emissions of HFC to increase steadily during the second half of the 1990s.

Since 1995 (the reference year for achieving the Kyoto target), **PFC emissions** have fallen by 66 %.

Up until 1995 emissions of **sulphur hexafluoride** rose due to its increased use as a gas fill in acoustic windows and car tyres, but subsequently fell. By 2002/03, emissions stood at 61 % of those in 1995 (reference year for achieving the Kyoto target) (Fig. I 2.3.1-3 and Tab. "Change in greenhouse gas emissions over the previous year").

Greenhouse gas emissions by source category

With over 80 %, **energy** consumption, whether by power stations or transport, is by far the most signif-

Tab. I 2.3.1-1: *Emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990*

	Unit	1990	1995	2000	2001	2002	2003
Directly active greenhouse gases							
CO_2	Mio t	1 015	902	860	874	864	865
CH_4	kt	6 290	4 996	3 948	3 777	3 642	3 582
N_2O	kt	279	261	201	202	199	205
HFC[1)]	kt	3 510	6 360	6 630	8 130	8 247	8 247
CF_4	t	355	224	72	69	76	76
C_2F_6	t	42	32	24	18	20	20
C_3F_8	t	0	1	14	15	16	16
SF_6	t	166	276	168	139	176	176
Emissions of directly active greenhouse gases in CO_2 equivalent	**kt**	**1 243 692**	**1 102 763**	**1 016 636**	**1 027 829**	**1 015 351**	**1 017 511**
Indirectly active greenhouse gases							
NO_x (as NO_2)	kt	2 846	2 000	1 634	1 560	1 493	1 428
NMVOC	kt	3 534	2 248	1 697	1 592	1 494	1 460
CO	kt	11 212	6 581	4 913	4 561	4 300	4 155
Aerosol formation							
SO_2	kt	5 326	1 937	636	643	611	616

[1)] *in CO_2 equivalent*

Source: *Federal Environment Agency 2005*

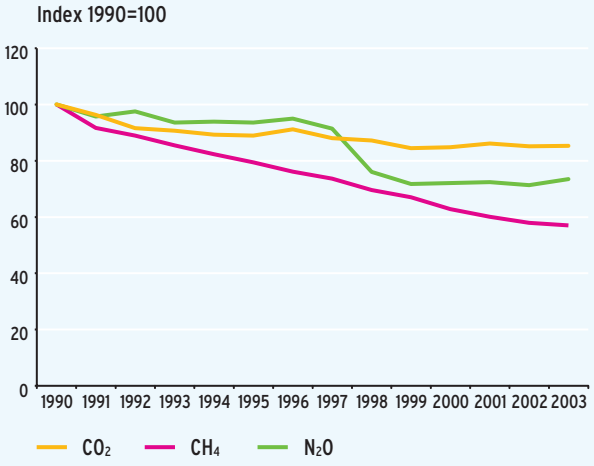
Tab. I 2.3.1-2: *Change in greenhouse gas emissions compared with the reference year of the Kyoto Protocol*

	Reference year	Emissions[1] in reference year	%	1991 +/- %	1995 +/- %	2000 +/- %	2001 +/- %	2002 +/- %	2003 +/- %
Directly active greenhouse gases									
CO_2	1990	1 015 031	100	−3.8	−11.1	−15.3	−13.9	−14.9	−14.8
CH_4	1990	6 290	100	−8.3	−20.6	−37.2	−40.0	−42.1	−43.1
N_2O	1990	279	100	−4.2	−6.4	−28.0	−27.7	−28.5	−26.3
HFCs	1995	6 360	100		0.0	4.2	27.8	29.7	29.7
CF_4	1995	224	100		0.0	−67.8	−69.0	−66.2	−66.2
C_2F_6	1995	32	100		0.0	−25.7	−43.4	−38.9	−38.9
C_3F_8	1995	1	100		0.0	1 136.1	1 165.1	1 269.2	1 269.2
SF_6	1995	288	100		0.0	−41.7	−51.7	−39.1	−39.1
Emissions of directly active greenhouse gases in CO_2 equivalent		**1 247 881**	**100**	**−4.6**	**−11.7**	**−18.5**	**−17.6**	**−18.6**	**−18.5**

[1] *Figures for CO_2, CH_4, N_2O, NO_x (as NO_2), NMVOC, CO, SO_2 in kt, for CF_4, C_2F_6, C_3F_8, SF_6 in t, for HFC in t CO_2 equivalents*

Source: *Federal Environment Agency 2005*

Fig. I 2.3.1-2: *Trend of CO_2, CH_4 and N_2O emissions in Germany*



Source: *Federal Environment Agency 2005*

icant source of greenhouse gas emissions. Because of the above-average success in making reductions in other areas, the relative importance of this source category is constantly rising. The trend is closely linked to the evolution of CO_2 emissions.

With almost 9 %, **agriculture** is the most significant of the other source categories. The evolution of CH_4 and N_2O emissions largely follows the trend in livestock numbers.

In the **industrial sector**, measures to cut emissions – particularly in adipic acid production – have led to a significant fall. The trend in HFC emissions has been in the opposite direction. In 2003, industrial processes contributed a share of under 5 % to total emissions.

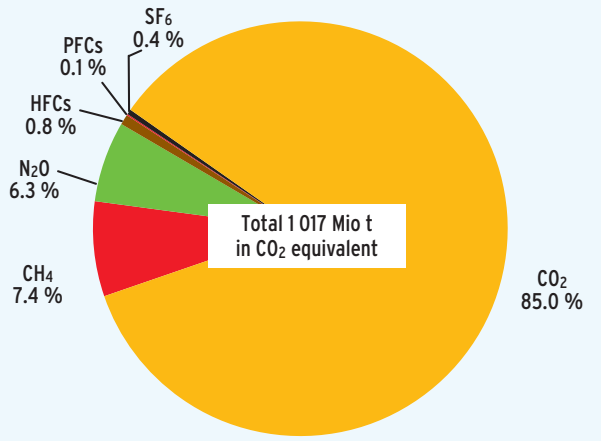
The most significant relative reduction in greenhouse gas emissions occurred in **waste management**, where improved waste recycling led to a continuous fall in methane emissions (Chapter X). Waste was increasingly recycled during the 1990s, which reduced landfill emissions in particular. By 2003, emissions had been reduced by almost two-thirds to below 1.5 % of all emissions.

Emissions from **product use** are not as prominent. A value was specified for the medicinal use of nitrous oxide in anaesthetics in 1990, which is being updated from that point (Fig. I 2.3.1-4, Fig. I 2.3.1-5 and Tab. I 2.3.1-3).

Reference scenario greenhouse gas emissions in Germany according to the Enquete Commission "Sustainable Energy Supplies"

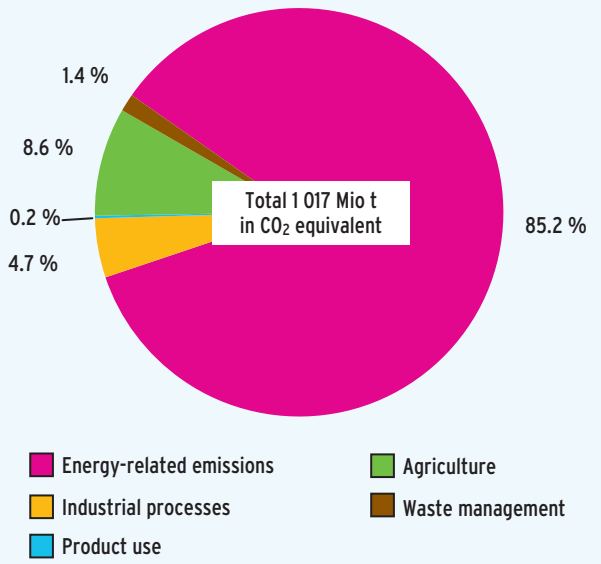
An important prerequisite before scenarios can be drawn up for the trend in greenhouse gas emissions in the future is to have some idea of where past and future anticipated trends in demographic, social,

Fig. I 2.3.1-3: *Greenhouse gas shares of the emissions (calculated in CO_2 equivalent) 2003*



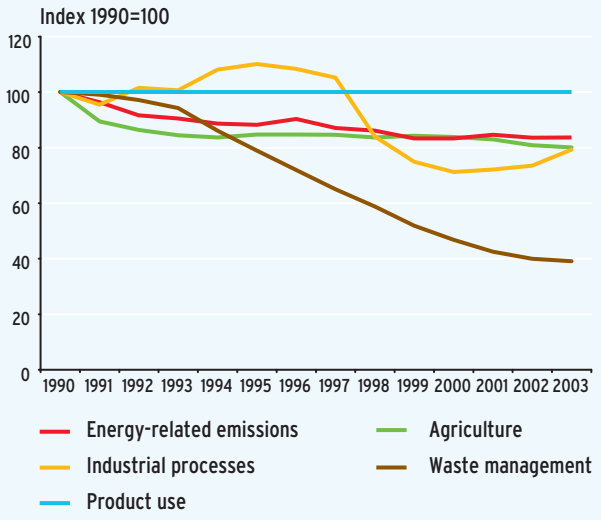
Source: *Federal Environment Agency 2005*

Fig. I 2.3.1-4: *Source category shares of greenhouse gas emissions (calculated in CO_2 equivalent) 2003*



Source: *Federal Environment Agency 2005*

Fig. I 2.3.1-5: *Trend in emissions of the six greenhouse gases named in the Kyoto Protocol in Germany by source category*



Source: *Federal Environment Agency 2005*

economic, technical and political factors could lead to in the long-term. The study commission of the 14th Bundestag, "Sustainable energy supplies under conditions of globalisation and liberalisation", presented a reference scenario in its final report that predicts the effects of the German government's climate protection policy measures over the long-term up until 2050.

Assumptions in the reference scenario

The reference scenario assumes that the population will fall to 68 million between 2000 and 2050, that at the same time the average living expectancy per resident will grow by almost 50 %, and that gross domestic product will increase by a factor of 2.4. For the 2000 to 2050 period as a whole, a basic annual price increase by 1.7 % has been assumed for crude oil, 1.9 % for natural gas and 0.9 % for coal. Up to 2030 the figure for passenger kilometres will rise to around 1 140 billion, and then fall, particularly in terms of motorised passenger transport. In 2050, road haulage figures in tonne-kilometres will be around twice as high as in 2000.

The following energy and environmental policy assumptions were made for the reference scenario. Of domestic anthracite and brown coal, at least another 750 PJ and 1,400 PJ will be used by 2010, and around 500 PJ and 1 400 PJ by 2020; after that no figures are given for either of these domestic fuels. For renewable energy sources, rising shares of net energy consumption are specified for the entire period under scrutiny, as well as minimum shares of primary energy consumption for the years up to 2020. In line with the agreement between the German government and nuclear power station operators, as well as the amendment to the atomic energy law, the use of nuclear power will be phased out. From 2002, new buildings have to conform to an energy conservation ordinance. It is assumed that these requirements will be further tightened as the energy conservation ordinance is updated in years to come. The guidelines and updated versions of this ordinance are also applied to the modernisation of existing building stocks.

Results of the reference scenario

Between 1990 and 2050, both CO_2 emissions and greenhouse gases emissions in general will see a reduction in the order of 30 % (Tab. I 2.3.1-4). CH_4 emissions will fall sharply (–87 %), and the 14 % decrease in N_2O emissions will seem poor in comparison. The relative reduction in emissions during the period 1990 to 2050 is especially marked in industry (–48 %) and in the combined area households, commerce, trade and services (around –37 %). The weakest fall is in transport, whose emissions by 2030 actually far exceed the 1990 level. Of the absolute greenhouse gas emission reductions between 1990 and 2050 of around 320 million tonnes CO_2 equivalent, the energy sector is responsible for 130 million tonnes, or around 40 %. It is followed by industry and the combined area of households, commerce, trade and services, each with around 82 million tonnes, or over a quarter. The transport sector, on the hand, contributes only 26 million tonnes, or a good 8 %.

The reference scenario maintains past policy and consumer behaviour. Its results – apart from the fig-

Tab. I 2.3.1-3: *Emissions in Germany of the six greenhouse gases named in the Kyoto Protocol by source category in kt CO_2 equivalent*[1)]

Source category	Chemical	1990	1995	2000	2001	2002	2003
Energy-related	CO_2	988 859	876 060	834 599	850 357	841 106	841 692
Emissions	CH_4	37 339	26 805	18 788	16 398	15 798	15 397
	N_20	10 419	11 057	10 261	10 021	9 736	9 444
Total		**1 036 617**	**913 922**	**863 648**	**876 776**	**866 640**	**866 533**
Share of total emissions		*83.3 %*	*82.9 %*	*85.0 %*	*85.3 %*	*85.4 %*	*85.2 %*
Industrial processes	CO_2	26 172	26 152	25 493	23 505	22 771	23 676
	CH_4	335	332	385	371	358	407
	N_20	23 484	24 991	5 549	7 342	7 861	10 373
	HFCs	3 510	6 360	6 630	8 130	8 247	8 247
	PFCs	2 696	1 759	790	723	786	786
	SF_6	3 967	6 633	4 018	3 325	4 197	4 197
Total		**60 165**	**66 227**	**42 864**	**43 396**	**44 220**	**47 686**
Share of total emissions		*4.8 %*	*6.0 %*	*4.2 %*	*4.2 %*	*4.4 %*	*4.7 %*
Product usage	CO_2	–	–	–	–	–	–
	CH_4	–	–	–	–	–	–
	N_20	1 922	1 922	1 922	1 922	1 922	1 922
Total		**1 922**	**1 922**	**1 922**	**1 922**	**1 922**	**1 922**
Share of total emissions		*0.2 %*	*0.2 %*	*0.2 %*	*0.2 %*	*0.2 %*	*0.2 %*
Agriculture	CO_2	–	–	–	–	–	–
	CH_4	60 720	51 623	49 187	49 580	48 266	47 649
	N_20	48 350	40 734	42 222	40 898	39 948	39 679
Total		**109 070**	**92 357**	**91 409**	**90 478**	**88 214**	**87 328**
Share of total emissions		*8.8 %*	*8.4 %*	*9.0 %*	*8.8 %*	*8.7 %*	*8.6 %*
Waste management	CO_2	–	–	–	–	–	–
	CH_4	33 705	26 153	14 549	12 960	12 054	11 767
	N_20	2 213	2 182	2 244	2 297	2 300	2 275
Total		**35 918**	**28 335**	**16 793**	**15 257**	**14 355**	**14 042**
Share of total emissions		*2.9 %*	*2.6 %*	*1.7 %*	*1.5 %*	*1.4 %*	*1.4 %*
Total emissions		**1 243 692**	**1 102 763**	**1 016 636**	**1 027 829**	**1 015 351**	**1 017 511**
Substance's	*CO_2*	*81.61 %*	*81.81 %*	*84.60 %*	*85 %*	*85.08 %*	*85.05 %*
share of	*CH_4*	*10.62 %*	*9.51 %*	*8.16 %*	*7.72 %*	*7.53 %*	*7.39 %*
total emissions	*N_20*	*6.95 %*	*7.33 %*	*6.12 %*	*6.08 %*	*6.08 %*	*6.26 %*
	HFCs	*0.28 %*	*0.58 %*	*0.65 %*	*0.79 %*	*0.81 %*	*0.81 %*
	PFCs	*0.22 %*	*0.16 %*	*0.08 %*	*0.07 %*	*0.08 %*	*0.08 %*
	SF_6	*0.32 %*	*0.60 %*	*0.40 %*	*0.32 %*	*0.41 %*	*0.41 %*

[1)] CO_2 emissions excluding sinks (e.g., forests)

Source: *Federal Environment Agency 2005*

ures determined by the study commission itself – are heavily influenced by the assumptions made about future demographic and economic trends. In 2010, the German reference scenario is 37 million tonnes, or 4.5 percentage points, away from the target of reducing greenhouse gas emissions by 21 % by 2008/2010 compared to the 1990 reference year's values (not adjusted by temperature). When compared with estimated values for 1990 adjusted by temperature, there is a shortfall of almost 20 million tonnes or around 2.5 percentage points.

I 2.3.2 Targets and measures to reduce greenhouse gases

Targets for reducing greenhouse gases

Within the European Union's burden-sharing scheme, Germany has undertaken to cut emissions of the six greenhouse gases referred to in the Kyoto Protocol by 21 % between 2008–2012 in comparison to the 1990 reference year. By 2003 a reduction of 18.5 % had been achieved. Nonetheless, further efforts are required to ensure that the target agreed internationally is actually achieved. Moreover, climate protection policy cannot come to an end in 2012, either at international or national level. Medium- and long-term targets are needed to prevent global warming increasing by more than 2 °C over pre-industrial levels. The setting of medium- and long-term targets will also provide planning security for investors. Therefore the German government has stipulated, in the 2002 coalition agreement, the 2004 progress report on the national sustainability strategy and the 2005 National Climate Protection Programme, that Germany will reduce its greenhouse gas emissions by 40 % by 2020 compared to the 1990 reference year, as long as the EU countries

Tab. I 2.3.1-4: *Trends in CO_2 and greenhouse gas emissions in the study commission's reference scenario*

	1990	1995	1998	2010	2020	2030	2050
Energy-related CO_2 emissions				**Mio t**			
Energy production, conversion	440.5	379.4	367.5	337.6	355.9	367.4	339.3
Industry	169.7	127.1	118.4	112.7	107.8	101.4	88.4
Households, CTS	218.7	197.5	198.6	186.0	184.9	176.8	139.8
Transport	158	172.6	176.7	188.3	181	170.3	133.4
Total	**986.8**	**876.5**	**861.1**	**824.6**	**829.6**	**815.9**	**700,8**
				1990 = 100			
Energy production, conversion	100	86	83	77	81	83	77
Industry	100	75	70	66	64	60	52
Households, CTS	100	90	91	85	85	81	64
Transport	100	109	112	119	115	108	84
Total	**100**	**89**	**87**	**84**	**84**	**83**	**71**
Energy-related GGE[1)]				**Mio t CO_2-equivalent**			
Energy production, conversion	477.8	408.6	395.7	360.7	375.1	378.1	348.3
Industry	171.8	128.5	119.9	113.9	109	102.7	89.6
Households, CTS	223.4	200.4	201.3	188.1	187	178.8	141.4
Transport	162.5	178.8	182.8	192.6	184.9	173.9	136.2
Total	**1 035.6**	**916.3**	**899.6**	**855.3**	**856**	**833.5**	**715.5**
				1990 = 100			
Energy production, conversion	100	86	83	75	78	79	73
Industry	100	75	70	66	63	60	52
Households, CTS	100	90	90	84	84	80	63
Transport	100	110	113	119	114	107	84
Total	**100**	**88**	**87**	**83**	**83**	**80**	**69**

[1)] THG = GGE = greenhouse gas emissions
Note: Figures for 1990 to 2000 not adjusted for temperature; figures from 2010 adjusted for temperature. The model data for the years 2010 to 2050 can, therefore, only be compared with the historic data to a limited extent.

Source: *Enquete commission "Sustainable energy supplies under conditions of globalisation and liberalisation" 2002*

agree to reduce European emissions by 30 % during the same period.

To achieve these general climate protection targets, the German government has also set further specific targets for reducing greenhouse gas emissions.

- In the agreement between the German government and German industry to reduce CO_2 emissions and promote cogeneration, German industry agreed to cut CO_2 emissions by 45 million tonnes by 2010 compared to 1998.
- The maintenance, modernisation and upgrading of cogeneration plants aims at total reductions of 23 million tonnes CO_2 per year, but no less than 20 million tonnes CO_2 per year up to 2010 when compared to the reference year.
- Renewable energies should be contributing at least 12.5 % to power supplies by 2010 and at least 20 % by 2020. By the middle of the century, renewable energies should be covering around half of all energy consumption.
- The share of renewable energy in the primary energy balance should be doubled to 4.2 % by 2010 compared with 2000.
- Energy productivity is to be doubled by 2020 compared to 1990. In order to implement the European emissions trading system, the legislature has stipulated, in § 4 Para. 2 of the 2007 Allocation Act, emission targets for Germany which require the targets for the allocation period 2008–2012 to be re-examined in 2006.

Measures for reducing greenhouse gases

Measures to reduce greenhouse gas emissions focus on energy saving, improving energy efficiency and developing renewable energies.

The private households and transport sectors are at the centre of the 2005 National Climate Protection Programme since emissions trading should ensure that goals are achieved in the industry and energy industry sectors. The following measures are anchored in the 2005 National Climate Protection Programme:

- Private households:
  - Public information, advice and innovation (including developing the German Energy Agency (dena) as a centre of expertise for energy efficiency, broadly-based public information campaigns, developing the BMVBW departmental research and energy saving contracting in the heating sector).
  - Promotional activities (including schemes of the German KfW banking group for the buildings sector and a marketing incentives scheme for biomass and solar energy.

  - Legal measures (including the passing of the 2006 EnEV (Energy Saving Ordinance) and energy performance certificates).
- Transport:
  - Incentive mechanisms for reducing transport intensity and increasing energy efficiency in the transport sector (including evolving the truck toll into a road-pricing scheme, volume-neutral fiscal support for low consumption cars, introducing emission-linked landing fees at German airports).
  - Technical improvements to vehicles and fuels and the promotion of alternative fuels and innovative propulsion systems (including replacing conventional fuels with biofuels, upgrading the ACEA support for the automotive industry in reducing specific CO_2 emissions in new vehicles, substituting F-gases in mobile air-conditioning systems).
  - Public information about traffic behaviour that protects resources (including reinforcing the "New Driving" campaign").

The German cabinet has commissioned the "CO_2 Reduction" inter-ministerial working group to issue, yearly in the future, a progress report on the development of the national greenhouse gas balance, especially with regard to the achievement of the climate protection targets. The report is to be based on reporting done to the EU in line with Art. 3 of the Monitoring Directive and on the National Inventory Report. The cabinet has also asked the "CO_2 Reduction" working group to present another report in 2008 aimed at updating the Climate Protection Programme. This report is, where appropriate, to set out recommendations for modifying existing measures or the need for further measures. On the one hand, the report is to review current decisions with a view to drawing up a consistent, cost-effective set of measures, taking into account the extent to which targets are being achieved. On the other hand, it is to present recommendations for refining the German government's climate protection policy against the background of the national sustainability strategy and the development at European and international levels.

[1] Key World Energy Statistics, International Energy Agency (IEA), 2003
[2] Harnisch, J.: Atmospheric Perfluorocarbons: Sources and concentrations. Proceedings of the Second International Symposium on Non-CO_2-Greenhouse Gases. Nordwijkerhoud, 8.–10th September 1999.
[3] European Environment Agency: Analysis of greenhouse gas emission trends and projections in Europe 2004 – Draft. Technical Report No. 7/2004, Kopenhagen 2004; available from the Internet at http://reports.eea.eu.int/technical_report_2004_7/en. More detailed information on the climate protection measures of the European Union is also available here.

I 3 Ecological tax reform – a cross-cutting measure for climate protection

Energy-consuming activities are amongst the most significant emission source sectors. Therefore energy taxation is an economic instrument aimed at providing incentives for energy conservation and speeding up economically feasible innovation in energy technology.

Energy taxes in Germany are primarily levied through a mineral oil tax and the electricity tax introduced in 1999. The mineral oil tax applies to motor and heating fuels, and its rates were increased in April 1999 in the first stage of the environmental tax reform. Further tax increases for electricity and vehicle fuels were passed between 2000 and 2003, and for heating fuels in January 2003 (Tab. I 3-1).

Tab. I 3-1: *Mineral oil and electricity tax rates under the environmental tax reform (ETR)*

Fuel[1]		No ETR to 31.03.1999	Stage 1 from 01.04.1999	Stage 2 from 01.01.2000	Stage 3 from 01.01.2001	Stage 4 from 01.01.2002	Stage 5 from 01.01.2003
Petrol (unleaded)[2]	EUR/1000 l	501.07	531.74	562.42	593.10	623.80	654.50
	DM/1000 l	980.00	1040.00	1100.00	1160.00	1220.05	1280.09
Diesel[2]	EUR/1000 l	317.00	347.68	378.36	409.03	439.70	470.40
	DM/1000 l	620.00	680.00	740.00	800.00	859.98	920.02
Light heating oil	EUR/1000 l	40.90	61.36	61.36	61.36	61.35	61.35
	DM/1000 l	80.00	120.00	120.00	120.00	119.99	119.99
Natural gas	EUR/MWh	1.84	3.48	3.48	3.48	3.48	5.50
(heating fuel)	DM/MWh	3.60	6.80	6.80	6.80	6.80	10.76
Heavy heating oil	EUR/1000 kg	15.34/28.12	15.34/28.12	17.90	17.90	17.89	25.00
	DM/1000 kg	30.00/55.00[3]	30.00/55.00[3]	35.00	35.00	34.99	48.90
Electricity	EUR/MWh		10.23	12.78	15.34	17.90	20.50
	DM/MWh		20.00	25.00	30.00	35.01	40.09

The highlighted rates indicate the currency stipulated in the laws (up to 2001 in DM, from 2002 in EUR).

[1] Mineral oil and electricity taxes for major fuels (without exceptional regulations)
[2] from 01.11.2001 low-sulphur, from 01.01.2003 sulphur-free
[3] For heat generation/for electricity generation, each to 31.12.1999

Source: *Federal Ministry of Finance 2005*

The medium-term phased increase in tax rates allows energy users to plan for the future, and has so far created economic incentives for energy conservation. About 90 % of the increased revenue from energy taxes is returned to businesses and individuals via a reduction and stabilisation of state pension contributions, increasing net incomes and reducing costs to employers. The environmental tax reform therefore makes labour cheaper, and energy use more expensive, bringing benefits for both the environment and employment simultaneously. The remaining part of the tax revenue is being used to promote renewable energies, modernise energy consumption in buildings and for budget consolidation.

The environmental tax reform has led to an employment increase of up to 250 000 jobs, to 20 million tonnes of savings in CO_2 emissions, and to an 18.7 billion EUR increase in tax revenues in 2003.

The environmental tax reform provides some tax relief for specific sectors, such as manufacturing industry, agriculture and forestry, aimed at avoiding a loss of competitiveness arising from the increase in energy taxes. They include the following regulations for electricity tax and heating fuels taxes:

Manufacturing industry

- Since January 2003, manufacturing industry, agriculture and forestry have received a rebate of 40 % (previously 80 %) on the standard tax rates for electricity, heating oil and gas, provided that a base rate of 512,50 EUR per year is exceeded for electricity and for gas and heating oil.
- The manufacturing industry receives compensation. Companies whose energy tax burden exceeds savings in social security contributions can, upon application, be reimbursed for up to 95 % of the excess amount. In practice, this equates to a tax rate of 3 % of the standard tax rate.
- There are also a number of special arrangements motivated by environmental considerations:

Transport

- Since January 2004, power for trams and trolley buses has been taxed at the reduced rate of 11.42 EUR/MWh.
- Motorised buses, railways, and minibuses providing regular services have, since 2004, received mineral oil tax rebates of 5.4 cents per litre of petrol or diesel.
- Biofuels are completely exempted from the mineral oil tax until the end of 2009. Natural gas, which is relatively environmentally-friendly, has been given an extremely favourable tax rate which will be in effective until 2020. So has liquid gas, effective until 2009 due to its higher carbon content.
- Since 1st January 2003, fuels with a sulphur content of over 10 mg/kg are taxed an additional 1.53 cents per litre.

Power generation

- Electricity autoproduction and contracting of up to 2 MW are exempt from the electricity tax.
- Combined Heat and Power (CHP) plants with a monthly or annual efficiency of at least 70 % are completely exempt from the mineral oil tax; a plant that uses at least 60 % of the energy content of the mineral oil in the form of heat or mechanical energy is exempt from the “eco-tax” rate.
- Highly efficient electricity generation plants such as those with gas-steam turbine systems with a net electrical efficiency of at least 57.5 % are exempt from the mineral oil tax for five years if they are put into permanent operation by 10th September 2007.

Ecological financial reform

To avoid limiting incentives for climate protection to energy taxation alone, the German government has begun to make the “eco-tax” into a more comprehensive ecological financial reform. Its aim is to introduce a subsidy policy that supports climate protection, and to take environmental protection issues into consideration in all state expenditure and schemes. The German government is focusing on removing the following subsidies that are harmful to the environment:

- The grants for German hard coal, which stood at 5.7 billion EUR in 1996, are being reduced to 2.7 billion EUR per year by 2005. By 2012, these subsidies are to amount to 1.83 billion EUR per annum.
- On 1st January 2004, the tax deduction for an employee’s journeys between home and the workplace fell from 36 cents up to 10 kilometres and 40 cents from the 11th kilometre to a uniform 30 cents per kilometre.
- The home owner grant, which likewise generates traffic and encourages the consumption of land, fell by half for new buildings from 2004. This subsidy, which costs billions, has been completely removed since the beginning of 2006.
- The 50 % reduced tax rate for inefficient night storage heaters that were put into service before 1st April 1999 has risen to 60 % as of 1st January 2003 and will be completely phased out from 1st January 2007.

I 4 Source sector: Energy and measures

Energy supply and energy consumption are cross-sector activities, so this chapter precedes the sector-specific chapters. Energy is used to provide light and heat, operate machinery, and exchange information. Final energy consumption (i.e., the energy available to end consumers after the primary fuel has been converted) is divided up according to sectors (industry; households; trade; commerce and services; road transport; other transport). In addition, there is non-energetic consumption, e.g., crude oil used in plastics manufacture, and consumption and losses in energy transformation, essentially the production of energy and fuels. Total consumption and losses in all the sectors is termed primary energy consumption, and is equal to the energy contained in the fuels used.

I 4.1 Contribution to the greenhouse effect

Energy-related CO_2 emissions are derived from German national energy balances, which are based on statistics from all areas of the energy industry. The fossil fuel burning area includes stationary sources with combustion-related emissions. The items in the energy balance are: use in transformation (public thermal power plants, industrial thermal power plants, heat and power stations, and district heating stations), energy consumption in the transformation area (own consumption) and final energy consumption.

During the period 1990 to 2002, energy-related CO_2 emissions fell by around 15 % (Tab. I 4.1-1). The reduction in emissions is mainly due to a decrease in the use of coal, which has twice as much carbon content as natural gas. In 1990, CO_2 emissions from lignite use were still 35 % of all energy-related CO_2 emissions and in the years up to 2002 fell by around 47 %. CO_2 emission from from firing of hard coal fell by 13 % in the same period. The CO_2 emissions resulting from the use of gas as a fuel, however, rose by 29 %.

Tab. I 4.1-1: *Energy-related CO_2 emissions by fuel in Germany (in Mio t)*

	1990	1995	2000	2002
Black coal	182.5	177.5	168.1	158.2
Lignite	343.3	191.7	172.7	182.3
Mineral oil[1)]	313.3	336.8	312.8	306.7
Gas[2)]	143.0	165.8	175.5	184.9
Other	2.2	1.5	2.0	2.1
Total	**984.3**	**873.3**	**831.1**	**834.2**

[1)] Excluding aircraft fuel consumption for international air traffic, including liquid gas and refinery gas
[2)] Natural gases, plus coke oven gas, town gas and blast furnace gas

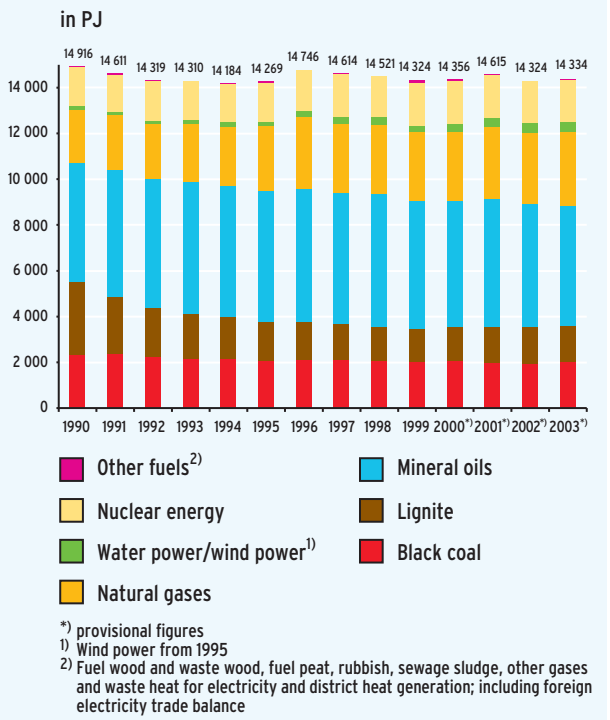
Source: *Working Group on Energy Balances 2003*

I 4.2 Energy consumption

I 4.2.1 Energy consumption by fuel

In spite of economic growth, **primary energy consumption** in Germany has been falling since the early 1990s (Fig. I 4.2.1-1). Consumption has fallen by around 4 %. Deviations from the general downwards trend during those years are mainly attributable to the impact of weather conditions. The energy demand for heating rises significantly during a cold winter.

Fig. I 4.2.1-1: *Primary energy consumption by fuel (by the efficiency level method)*



Source: *Working Group on Energy Balances 2004*

Over 14 300 PJ of primary energy were consumed in Germany during 2003. Around 37 % mineral oil, 23 % natural gas, 14 % coal, and 11 % lignite were employed in meeting the demand for primary energy. Nuclear energy provided 12.5 % of the primary energy demand. Although the percentage of renewable energies (including hydro energy, wind power, geothermal energy, biomass, and solar energy) has risen significantly since 1990, it was still only 3.3 % in 2003 (2004: 3.6 %, Fig. I 4.4.1-1).

Since 1990, the greatest changes to the fuel mix have been the halving of the use of lignite and a rise of almost a third in the consumption of gas.

In order to allow a direct international comparison, primary energy consumption in Germany is calculated using the physical energy content method (also called the efficiency method). According to this

method – used by most international organisations (IEA, EUROSTAT, ECE) – the primary energy for the generation of electricity is deduced from end energy. The efficiency of nuclear plants is assumed to be 33 %, for hydro energy, wind power, solar energy and electricity imports 100 %. Thus, for example, 1 kWh electricity generated by wind power corresponds to a primary energy equivalent of 1 kWh. With the partial substitution method – used in Germany until 1994 – the primary energy equivalent for electricity generated by the energy sources mentioned above is stated as fuel substituted by the electricity generation of the respective energy source in conventional power plants. The physical energy content method tends to calculate a higher primary energy share for nuclear energy and lower shares for other sources. Thus, in 2003, for example, the share of renewable energies was 5.5 % of primary energy demand by the partial substitution method, but only 3.3 % by the physical energy content method [1].

[1] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Ed.), BMU Environmental Policy: Renewable Energy in Figures – National and International Trends, June 2005

Tab. I 4.2.1-1: *Primary energy demand in the study commission's reference scenario*

	1990	2000	2020	2050
Primary energy demand by fuel in PJ				
Black coal	2 306	1 920	1 860	1 559
Lignite	3 201	1 547	1 470	1 438
Nuclear energy	1 668	1 849	912	0
Mineral oils	5 238	5 478	5 206	3 799
Natural gases	2 316	3 025	3 450	3 376
Electricity import balance	3	9	8	0
Hydro energy	58	73	89	92
Wind power	0	33	96	225
Biomass, waste	126	233	472	574
Solar, environment	0	13	57	310
Total	**14 916**	**14 180**	**13 621**	**11 372**

Note: Figures for 1990 to 2000 not adjusted for temperature: figures from 2010 adjusted for temperature. The model's data for 2010 to 2050 can, therefore, only be compared with the historic data to a limited extent.

Source: *Enquete commission "Sustainable energy supplies under conditions of globalisation and liberalisation" 2002*

Forecast for 2050

Making predictions is always subject to great uncertainty. But as a guideline, we shall first describe the trend that will theoretically emerge if there are no fundamental new shifts in energy policy. This forecast draws on results from a report of the study commission of the 14th Bundestag, "Sustainable energy supplies under conditions of globalisation and liberalisation", Bundestag publication 14/9400, which have been updated on behalf of the Federal Environment Agency. Since it is unlikely that this trend will actually occur, it is amended by changes that are essential to achieve the climate protection targets.

The study commission's reference scenario continues past policy and consumer behaviour, while corresponding assumptions are made with respect to demographic and economic trends in Germany, living space requirements, fuel mix, cost of energy technologies and transport. Its findings are strongly influenced by the assumptions about future demographic and economic developments.

The findings shown in Table I 4.2.1-1 take into account all political measures implemented or adopted by late 2003.

In the reference scenario, primary energy consumption falls by 20 % to 11 370 PJ by 2050, because energy efficiency in electricity generation and other energy transformation sectors has improved and because the population has decreased. However, mathematical effects also contribute to the drop in primary energy demand. On the one hand, the share of renewable energies calculated using the physical energy content method (physical energy content 100 %) rises to over 10 % by 2050 while, on the other hand, nuclear energy, assessed at a physical energy content of only 33 % here, is reduced to zero.

In the reference scenario, the study commission's national emission reduction targets of 40 % and 80 % for 2020 and 2050 respectively are both missed.

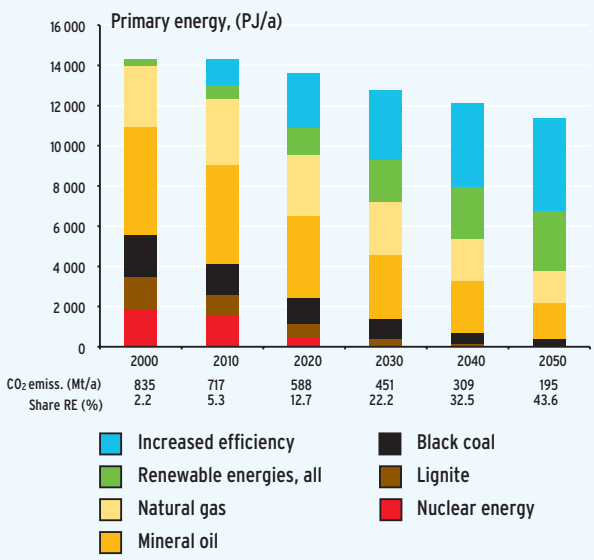
To achieve these reduction targets, energy policy has to make greater efforts. Working from the study "Long-term scenarios for sustainable energy use in Germany", commissioned by the Federal Environment Agency, a current scenario describes how there could be a combination of an increased use of renewable energies, a major improvement in energy efficiency and greater use of cogeneration. With better efficiency measures, primary energy consumption could be cut back to 6 755 PJ by 2050, and the renewable energies share in 2050 would be 44 % (Fig. I 4.2.1-2). The study shows how the emission reduction targets can be achieved while respecting nature conservation issues.

I 4.2.2 Energy consumption by source category

Primary energy consumption by sector

In 2003, almost two-thirds of the entire primary energy demand went to the final energy sectors and 7 % was used for non-energetic purposes. Almost 30 % of primary energy consumption is losses and own consumption in the generation and provision

Fig. I 4.2.1-2: *Primary energy demand structure in the future scenarios – forecast for 2050 (physical energy content method)*



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004*

of useful energy (e.g., electricity) and other secondary energy sources, such as vehicle fuels, in the energy transformation sector itself (Tab. I 4.2.2-1).

Final energy consumption by sector

During the last few decades, final energy consumption in the different sectors has been characterised by major changes. Within the final energy sectors, the significance of industry has fallen sharply. Its share of all final energy consumption sank from almost a third in 1990 to just 25.2 % in 2003. In contrast, the share of private households (from 25.1 % in 1990 to 30 % in 2003) and transport (from 25.1 % in 1990 to 28.2 % in 2003) has risen significantly. Nevertheless, mainly due to the impact of the eco-tax, the trend in the transport sector has, for the first time in the history of the Federal Republic of Germany, experienced a change with respect to absolute fuel consumption and CO_2 emissions, so that its share has begun to fall again during the last four years (Tab. I 4.2.2-2).

I 4.3 Energy efficiency and energy provision

Electricity supply in Germany

Electricity is used in a wide variety of applications and can be generated from any fuel.

Consumption of electricity in Germany grew by about 6 % between 1990 and 2002 (Tab. I 4.3-1 and Tab. I 4.3-2). During this period, the mix of the fuel types used changed considerably. During the last decade there was a decline in the use of coal to generate electricity; the use of lignite for electricity generation fell by 21 % by 2000, but then rose slightly again, by 7 % by 2003. Since 1990, the use of coal to generate electricity has fluctuated, without any clear trend emerging, and by 2003 was 2 %

Tab. I 4.2.2-1: *Primary energy demand (PED) by energy sector 1990–2003 (figures in PJ)*

	by physical energy content method[1]					
Energy sector	**1990**	**1995**	**2000*)**	**2001*)**	**2002*)**	**2003*)**
Final energy sector:						
Oth. mining and proc. trades[2]	2 977	2 473	2 411	2 375	2 321	2 323
Transport	2 379	2 614	2 751	2 693	2 673	2 595
Households	2 383	2 655	2 602	2 850	2 709	2 764
Trade, commerce, and services[3]	1 749	1 579	1 447	1 548	1 503	1 524
Final energy consumption	**9 488**	**9 321**	**9 211**	**9 466**	**9 206**	**9 206**
Transformation sectors:						
Consumption and losses[4]	4 470	3 985	4 049	4 097	4 081	4 120
Non-energetic consumption[5]	958	963	1 096	1 052	1 037	1 008
Total PES	**14 916**	**14 269**	**14 356**	**14 615**	**14 324**	**14 334**

1) Physical energy content method assumption: The energy content from non-fossil, non-nuclear, and non-geothermal sources, and from imported electricity, is assumed to be equal to the energy content of the electricity. The IEA assumes an efficiency of 33 % for nuclear and 10 % for geothermal when calculating the energy content for these two energy sources.
2) Industry
3) Including military installations
4) Losses through energy transformation, e.g., in power plants, refineries, briquette factories, incl. conduction losses and statistical differences
5) e.g., fuel as raw material in the chemical industry
*) provisional figures
Deviations in totals due to rounding

Source: *Working Group on Energy Balances 2004*

Tab. I 4.2.2-2: *Sector share of final energy consumption in percent*

	1990	1995	2000*)	2003*)
Oth. mining and proc. trades	31.4	26.5	26.2	25.2
Transport	25.1	28.1	29.8	28.2
Households	25.1	28.5	28.3	30.0
Trade, commerce, and services[1)]	18.4	16.9	15.7	16.6

[1)] 1990 to 1994 including the statistical differences for electricity shown in the energy balances
*) provisional figures
Deviations in totals due to rounding

Source: *Working Group on Energy Balances (AGEB) 2004*

above the 1990 figure. The use of fuel oil fell by 33 %, but gas use rose by 17 %. The share of renewable energy in all the electricity consumption was 3.4 % in 1990, but by 2002 this had risen by 230 % and in 2004 by 270 %, so that in 2004 its share of electricity consumption was 9.3 %. The use of nuclear power rose by around 8 %, and its share of all fuel use grew by 3 %. In 2002, of all the fuels in use, coal still had the largest share, with around 51 % of electricity production, a figure which was 56 % in 1990.

The energy used to generate electricity in the study period fell by around 1 % despite there being a 6 % increase in the amount produced. This means that the average level of efficiency in electricity generation rose from 36.5 % (1990) to around 39 % (2002). On average, power plants using fossil fuels improved their efficiency from 37 % in 1990 to 39 % twelve years later (Tab. I 4.3-3).

Power plants and networks in Germany

The power plant locations map (Fig. I 4.3-1) shows power plants connected to the national grid, industrial power plants, and plants supplying traction power with a gross capacity of 100 MW or above, based on an internal UBA power plants file. A power plant or generating unit gross capacity is the capacity at the generator terminal.

High-tension (380 kV and 220 kV) power lines are also shown.

To ensure electricity supplies, providers operate peak load power plants which can be brought online when required, for example in the early morning, when demand from households, factories, and public transport is especially high. The distribution of power plants is essentially determined by local site specific factors.

- Lignite-fired power plants, as typical base load generators, operate in the immediate vicinity of

Tab. I 4.3-1: *Trends in gross electricity production in Germany from 1990 to 2002*

Fuel	1990	1995	2000*)	2002*)
	Billion kWh			
Hydro energy[1)]	19.7	25.2	27.7	26.0
including: Regenerative	16.5	21.6	25.5	23.9
Nuclear energy	152.5	154.1	169.9	164.8
Black coal		147.1	143.1	135.0
Lignite		142.6	148.3	159.0
Natural gas	377.7[2)]	41.1	49.2	54.0
Fuel oil		9.1	5.5	6.0
Other		16.1	20.8	19.4
Wind power	0.0	1.5	9.5	16.8
Total gross electricity production	**549.9**	**536.8**	**573.4**	**581.0**
Export/import balance	0.8	4.8	3.0	0.7
Gross electricity consumption	550.7	541.6	576.4	581.7

*) provisional figures
[1)] Including pump storage stations
[2)] Total of black coal, lignite, natural gas, heating oil and others

Source: *Working Group on Energy Balances (AGEB) 2003 a*

Tab. I 4.3-2: *Trends in the use of fuels for electricity generation in Germany between 1990 and 2003*

Fuel	1990	1995	2000*)	2003*)
	Petajoule			
Black coal	1 270	1 332	1 269	1 298
Lignite	1 795	1 455	1 424	1 539
Other solid fuels	65	70	85	91
Fuel oil	109	72	38	73
Gases including:	435	433	472	510
natural gas	332	341	357	410
Hydro energy/ wind power[1)2)]	89	105	126	158
Nuclear energy	1 663	1 681	1 849	1 802
Total	**5 426**	**5 148**	**5 263**	**5 471**

*) provisional figures, as of 04.10.2004
[1)] Calculations based on the chemical energy content method
[2)] Wind power from 1995

Source: *Working Group on Energy Balances (AGEB) 2004*

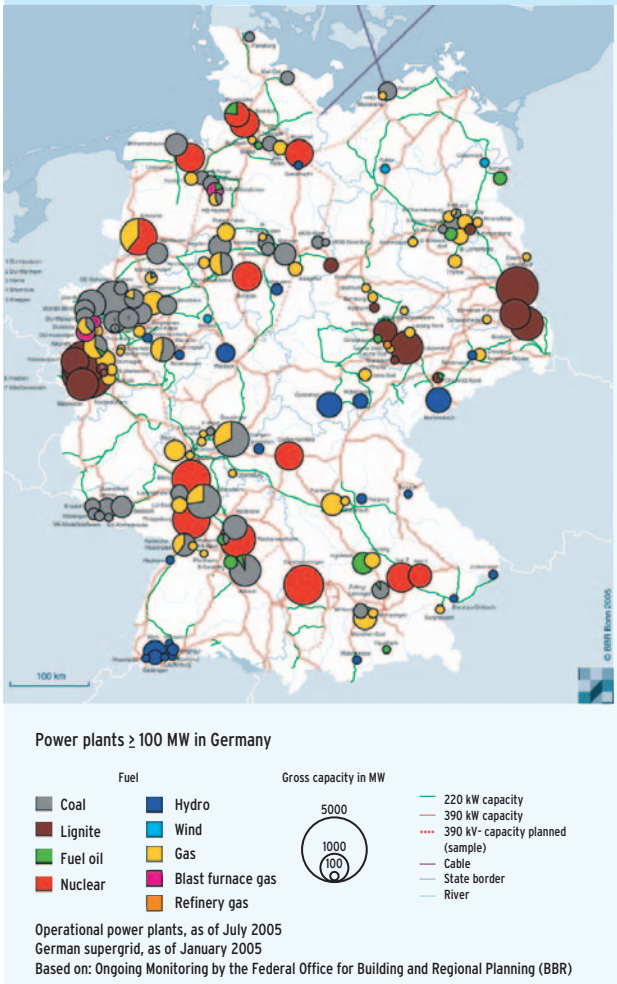
Tab. I 4.3-3: *Electricity production: Specific fuel use and overall utilisation level from 1990 to 2002*

	Unit	1990	1991	1995	2000*)	2002*)
Fossil fuel	MJ/kWh	9.7	9.7	9.4	9.0	9.1
power stations	%	37.0	37.0	38.1	40.1	39.4
Nuclear power	MJ/kWh	10.9	10.9	10.9	10.9	10.9
stations[1)]	%	33.0	33.0	33.0	33.0	33.0
Hydro,	MJ/kWh	3.6	3.6	3.6	3.6	3.6
wind[2)]	%	100.0	100.0	100.0	100.0	100.0
All power	MJ/kWh	9.9	9.9	9.6	9.2	9.2
stations	%	36.5	36.5	37.5	39.2	39.2

*) provisional figures
[1)] Nuclear energy is calculated using procedures habitual throughout the world, with an assumed physical energy content of 33 %.
[2)] Hydro energy produced regeneratively, like electricity generated from wind, is calculated using procedures habitual throughout the world, with an assumed implicit physical energy content of 100 %.

Source: *Federal Ministry of Economics and Technology (BMWA)*

Fig. I 4.3-1: *Power plants and electricity grid*



Source: *Federal Environment Agency 2005 g*

lignite resources, in the Rhineland, Bavarian, Helmstedt, Lausitz, and central German (near Leipzig) coalfields.

- Hydroelectric power plants mostly generate base load power, mostly with a gross minimum load of between 100 kW and 50 MW. They are concentrated along rivers in southern and southwest Germany. In contrast, pumped storage power plants use water to store energy to meet peak demand.
- Nuclear power plants generally produce base load power, and are concentrated in the old *Länder* except for North Rhine-Westphalia. A site need only be in the vicinity of a large river due to the large requirement for cooling water. Once the nuclear power plants at Lubmin and Rheinsberg are decommissioned, no more electricity will be generated from nuclear energy in the new *Länder*. In the old *Länder*, the Stade nuclear power plant on the Lower Elbe was prematurely withdrawn from the grid in compliance with the law of 27th April 2002 passed to terminate the use of nuclear energy in the commercial generation of electricity in a methodical fashion.
- Coal-fired power plants are usually moderate-load generators, and operate in the Ruhr and Saar coalfields, in coastal regions and along inland waterways, as coal can thus be transported cheaply.
- Gas-fired and gas-steam power plants, used for moderate and peak loads, are becoming increasingly important, and can be found all over Germany.
- Oil-fired power plants are used almost exclusively to meet peak demand and therefore generate very little electricity in total.
- Wind power systems, mostly concentrated in coastal areas and flat areas, are widely distributed and therefore not shown on the map.

It should also be emphasised that action has been taken to improve the environmental acceptability of power supply in the new *Länder* by replacing ageing substation equipment, installing modern wiring to optimise system operations, and by removing or replacing many 220 kV transmission lines with the 380 kV voltage level which suffers less losses.

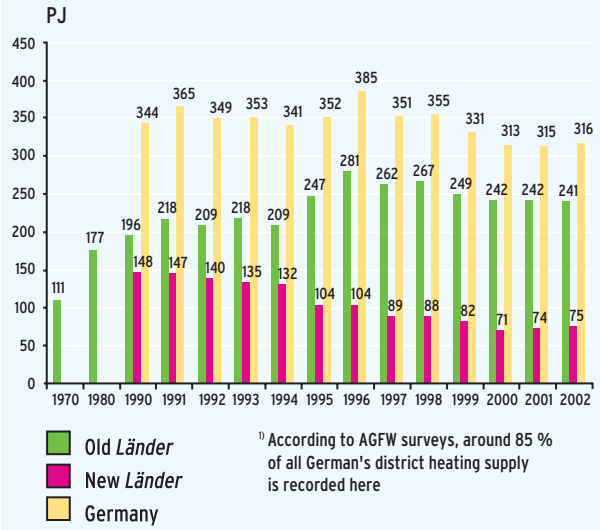
Support for combined heat and power plants

In a conventional power plant, only 30–45 % of the physical energy content in the fuel is converted to electricity. Heat is discharged unused into the air or water. Combined heat and power (CHP) plants make far better use of the fuel used than conventional power plants, as electricity and heat is produced and used together. If it is used for heating or cooling by nearby end users, 80–90 % of the fuel physical energy content can be recovered. These CHP plants may function as district heating stations, or supply single buildings, settlements or industrial installations. Decentralised systems are increasingly used to supplement conventional, centralised electricity supplies; more electricity is to be generated where the process heat can be used directly for heating and cooling purposes.

Of the district heating input into the network (Fig. I 4.3-2), almost 80 % comes from environmentally-friendly CHP and around 2 % from waste industrial heat. In particular, the potential still remains to expand the supply of district heating from CHP plants. The CHP share of all the electricity generated currently amounts to a mere 9 %.

In order to promote CHP share of energy production, in recent years, the German government has passed various laws and concluded agreements aimed at protecting the climate and saving resources. The most important mechanisms are the Combined Heat and Power Act of 12 May 2000 protecting electricity generation from CHP (KWKG

Fig. I 4.3-2: *District heating supply – Network supply*[1)]



Source: *District Heating Association*

2000), the 19 May 2002 Act to maintain, modernise, and expand CHP (KWKG 2002), and specific regulations for CHP assisted by natural gas under the environmental tax reform. The KWKG 2000 prevents the reduction of the CHP inventory that would, without legal protection, have occurred as a consequence of the electricity market being liberalised.

The KWKG 2002 is directly related to the agreement – made in 2001, applicable from 19 December 2003, and supplementing the 9 November 2000 climate agreement – between the government of the Federal Republic of Germany and German industry to reduce CO_2 emissions and promote CHP. Under the terms of this agreement, the energy industry undertook to reduce emissions by up to 45 million tonnes CO_2/annum by 2010. This contribution is to be achieved by maintaining, modernising, and expanding the use of CHP plants, with a target of reducing emissions by a minimum of 23 million tonnes CO_2/annum compared to 1998, but no less than 20 million tonnes CO_2/annum by 2010. This target is also anchored in the German sustainability strategy. The KWKG 2002 is aimed at helping Germany to achieve around half of the target reduction for CHP, i.e., about 5 million tonnes CO_2 by 2005 and 10 to 11.5 million tonnes CO_2 by 2010.

However, expert opinion at the Institute for Applied Ecology indicates that the legally-backed modernisation of CHP plants in the public supply sector and the development of small CHP plants will, at best, give Germany a CO_2 emission reduction of approx. 4 million tonnes by 2010 [1].

[1] Federal Environment Agency (UBA) "Climate Protection in Germany to 2030", Climate Change Series 3/2005

I 4.4 Renewable Energies

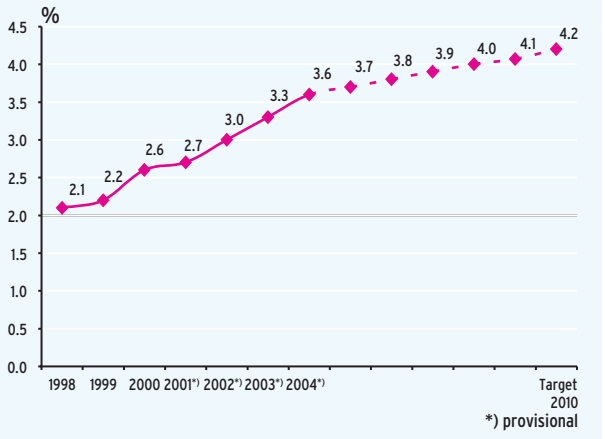
Energy-related impacts on the environment, in particular climate damage and the continuing consumption of non-renewable energy resources, are forcing people in industrialised countries to cut back on their energy consumption in every area. Alongside energy saving and the efficient use of energy (e.g., CHP, Chapter I 4.3), there is the option of making greater use of renewable energy sources that will be available for the long-term. This would considerably reduce the energy-related impact on the environment. The major requirement is to bring forward the use of solar, biomass, and geothermal energy, and wind and hydro energy.

I 4.4.1 Renewable energies' contribution to the supply of primary energy and electricity

Renewable energies' share of the primary energy demand

Recent years have seen an upward trend in the use of renewable energies. In 2004, they had a 3.6 % share of all the primary energy consumption (based on the efficiency method). This comprised 1.7 % of electricity production, 1.6 % of heat generation and 0.3 % of fuel consumption. It seems that this trend will continue, supported as it is by the amendment to the Renewable Energy Sources Act (EEG) and the marketing incentives scheme (MAP) for biomass and solar energy, both of which have improved conditions for marketing and paying for renewable energies in the electricity and heating market. In 2002, the German government set a target of doubling the share of renewable energies by 2010 compared with 2000 to at least 4.2 % of the primary energy demand (Fig. I 4.4.1-1).

Fig. I 4.4.1-1: *Renewable energy's share of the primary energy demand*

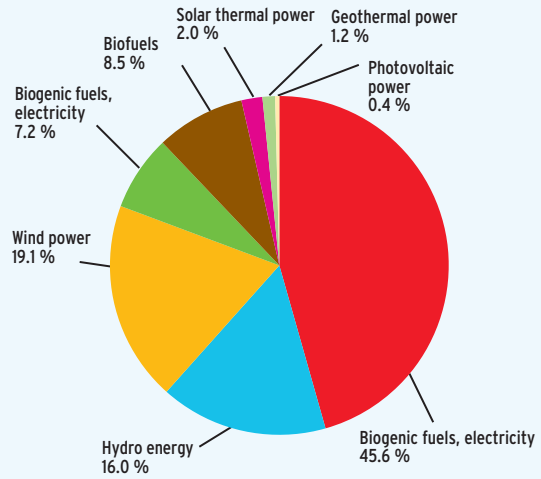


Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2005*

The use of renewable energies to generate electricity, heat, and fuels has risen sharply, from 75.9 Terawatt hours (TWh) in 1997 to 130.9 TWh in 2004 (Tab. I 4.4.1-1).

In 2004, around half of all the final energy for electricity, heat, and fuel from renewable energies was generated from biomass, followed by wind power (over 19 %) and hydro energy (around 16 %) (Fig. I 4.4.1-2). In terms of heat generated from renewable energies, biomass (mainly wood) has a 93 % share. Hydro energy (44 %) and wind power (40 %) were particularly significant in the generation of electricity from renewable energies.

Fig. I 4.4.1-2: *Energy supplied from renewable energies in 2004*



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2005*

Renewable energies' share of the electricity supply

In 2004, electricity suppliers and private plant operators produced around 55.8 TWh of electricity from hydro energy, wind power, biomass, and solar energy (photovoltaics) (Tab. I 4.4.1-2).

In recent years, the use of wind power in particular has contributed to the growth in renewable energies. In 2002 alone, wind power plants with a total capacity of around 3 200 megawatts (MW) were installed, while the figures for 2003 and 2004 were around 2 600 MW and 2 020 MW respectively. This took the total wind power capacity up to around 16 600 MW in 2004. In 1990, the figure was scarcely 50 MW. Thus, wind power has replaced hydro energy as the most important source of renewable energy for electricity production. A modern wind power system with a generator capacity of 1.5 megawatts can, depending on the wind available, generate an average of 3 million kWh of electricity each year. This equates to the average annual consumption of 850 households. At the same time, emissions that would otherwise have occurred through the use of conventional energies are avoided. For every kilowatt hour of electricity generated by wind power plants rather than coal, the emission of about one kilogram of carbon dioxide can be avoided.

In 2004, electricity generated from renewable energies was already around 9.3 % of all electricity supplied (Fig. I 4.4.1-3). Given the dynamic growth in recent years, the German government's targeted expansion, which in the 2002 national sustainability strategy and the amended EEG of 21 July 2004 specified that electricity generated from renewable energies should have a minimum 12.5 % share of Germany's electricity supply by 2010 and at least 20 % by 2020, appears to be achievable.

With respect to the ambitious goal of doubling renewable energies' share between 1990 and 2010, the rates at which gross electricity production is increasing also need to be monitored. During the last 14 years, gross electricity consumption in Germany has risen more sharply than electricity generation from renewable energies (Tab. I 4.4.1-2). This means that the rise in gross electricity consumption was not offset by the growing share of renewable energies. On the other hand, if renewable energies had not been promoted, CO_2 emissions would have fallen far less or even risen. This trend illustrates that sustainable energy supplies cannot be achieved without efficient electricity production (i.e., CHP) and use (i.e., idling losses) and electricity savings (i.e., sufficiency) (Tab. I 4.4.1-3).

Tab. I 4.4.1-1: *Chronological trend in energy supplied from renewable energies and installed capacity from 1990 to 2004*

in GWh	1990	1992	1994	1996	1998	2000	2002	2004
Total electricity production	18 463	20 378	23 018	23 219	26 321	38 629	45 830	55 826
Total heat generation	N/A	N/A	N/A	N/A	53 854	57 026	58 064	63 937
Total fuels	N/A	52	258	517	1 033	2 583	5 683	11 171
Total energy supplied	**18 592**	**20 648**	**23 627**	**25 670**	**81 209**	**98 239**	**111 574**	**130 934**

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2005*

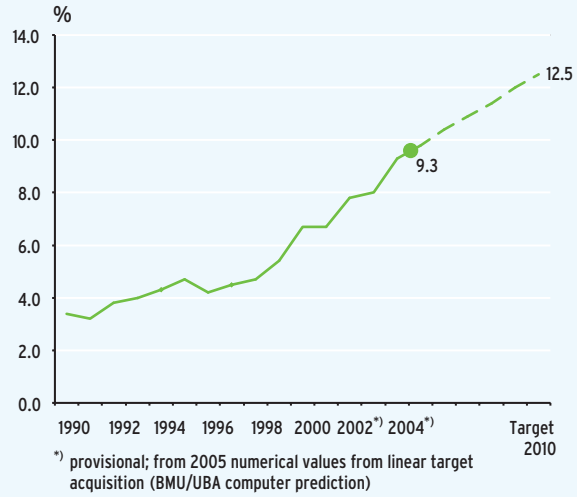
Tab. I 4.4.1-2: *Electricity production from renewable energies and gross electricity consumption in Germany*

Year	Electricity production from renewable energies	Gross electricity consumption	Share electricity production renewable energies of gross electricity consumption
	TWh	TWh	%
1990	18.5	550.7	3.4
1991	17.5	539.6	3.2
1992	20.4	532.8	3.8
1993	21.2	527.9	4
1994	23	530.8	4.3
1995	25.4	541.6	4.7
1996	23.2	547.4	4.2
1997	24.5	549.9	4.5
1998	26.3	556.7	4.7
1999	29.9	557.3	5.4
2000	38.6	578.1	6.7
2001	39	582.8*	6.7
2002	45.8	584.0*	7.8
2003	47.6	596.0*	8
2004	55.8	600.0*	9.3

*Provisional figures

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2005 a*

Fig. I 4.4.1-3: *Renewable energy's share of electricity production*



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2005*

The use of renewable energy sources replace the limited fossil and nuclear fuels. The Working Group on Renewable Energies Statistics (AG EE Stat) has calculated that, in 2004, Germany avoided around 70 million tonnes of CO_2 emissions by using renewable energies to generate electricity and heat. This calculation is based on an in-depth analysis of the displacement of fossil fuels by the different categories of renewable energy in a report by the Fraunhofer Institute for Systems and Innovation Research (ISI).

I 4.4.2 Instruments and measures to promote renewable energies

Renewable Energy Sources Act (EEG)

Directive 2001/77/EC of the European Parliament of 27 October 2001 on the promotion of electricity produced from renewable energy sources in the electricity market defines the target of increasing renewable energies' share of total Community electricity consumption to 22 %. Germany committed to renewable energies having a share of at least 12.5 % of the electricity produced. This is in line with the German government's national target. The Renewable Energy Sources Act of 20 March 2000 (EEG

Tab. I 4.4.1-3: *Emissions avoided by using renewable energies in 2004*

Greenhouse gas/air pollutant		Emissions avoided (kt)			
		Electricity	Heat[4)]	Biogenic fuels	Total
Greenhouse effect[1)]	CO_2	52 168	14 613	4 004	70 785
	CH_4	0.7	0.5	3.1	4.3
	N_2O	1.8	0.1	−4.4	−2.5
	CO_2equivalent	52 723	14 661	2 772	70 156
Acidification[2)]	SO_2	28.7	9	7.4	45.1
	NO_x	32.9	5.6	1.8	40.3
	SO_2equivalent	51.6	13	−2.7	61.9
Ozone[3)]	CO	16.7	19	0.7	36.4
	NMVOC	0.7	0.7	1.1	2.5
	Dust	1.6	0.2	0.1	1.9

Electricity generated from hydro, wind, biomass, solar energy, and geothermal energy: 55 826 GWh
Heating generated from biomass, solar energy, and geothermal energy: 63 937 GWh
Biogenic fuels (biodiesel, rapeseed, bioethanol): 11 463 GWh

1) Other greenhouse gases (SF_6, PFC, HFC) not included here
2) Other air pollutants with elevated potential for acidification (NH_3, HCl, HF) are not given here, but included in the calculation of the SO_2equivalent factor
3) Precursors for ground-level ozone
4) Based on final energy, only spatial heating and central hot water supplies in private households, heating mix excluding renewable energies in 2002

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2005*

2000) was already in place to support achievement of this target. In the 21 July 2004 amendment, which came into force on 1 August 2004, both this target and that of achieving a share of at least 20 % by 2020 are explicitly stated as being a purpose of the Act. Other provisions of Directive 2001/77/EC were also transposed into national law. As part of the transposition of Directive 2001/77/EC, one of the provisions of the Environmental Audit Act was also changed.

The EEG obliges grid operators to give immediate priority to connecting plants that generate electricity from solar, water, and wind power, geothermal energy, and biomass, to give priority to purchasing and transmitting the electricity thus generated, and to pay minimum tariffs for it.

Funding schemes

Funding schemes serve to bring renewable energies to the market more quickly:

The marketing incentives scheme for renewable energies is financed using the tax revenues from renewable energies within the environmental tax reform. It particularly encourages growth based on the use of renewable energies in the heating sector – solar-thermal plants, plants that burn solid biomass, and use deep geothermal energy, and local heating networks linked to biomass and geothermal projects, but also small biogas and hydro energy systems. In 2003, the scheme made funds of 190 million EUR available. 2004 saw 200 million EUR available for subsidies and allowances in relation to low-interest loans, a figure which is to rise to 230 million EUR per year by 2006.

The scheme that ran between 1999 and 2003 for funding photovoltaic power plants – the so-called 100 000 Roofs Solar Power Programme – and the EEG led to the installation of over 300 MWp of photovoltaic capacity in Germany. This meant that by late in 2003, there was 350 MWp of photovoltaic capacity in all. On 1 January 2004, this funding scheme was fully compensated by improved supply rates in advance of the EEG amendment that was already being put in place (2nd Act to change the EEG, the so-called Photovoltaic Preliminary Act).

I 5 Source sector industry, commerce, trade and services and measures

Industry and the commerce, trade and services group of sectors (CTS) are treated as one here, as they are similarly affected by significant climate protection policy instruments and measures. The CTS sector, which was categorised as a small consumer up to 1995, comprises small- and medium-sized enterprises such as trades, retail businesses, crafts, agriculture, the building trade, and private services. All public buildings and facilities are also included in this sector.

I 5.1 Contribution to the greenhouse effect and resource consumption

In 2001, industry had an approximately one-quarter share of final energy consumption and therefore is a significant area of activity for climate policy. By far the largest proportion of the coal, oil and gas consumed, whose CO_2 emissions are allocated directly to industry, were attributable to the need for process heat (Tab. I 5.1.1).

Tab. I 5.1-1: *Structure of final energy supply in industry by application area 2001 in %*

Application purpose	Coal, Mineral Oils, Gases	District Heating	Electricity	Final Energy, Total
Process heat	86.6	50	25.7	66.4
Spatial heat	12.5	50	0.4	9.7
Mech. Energy	1	0	64.6	21.0
Lighting	0	0	5.1	1.6
Information and communication	0	0	4.3	1.3
Total	**100**	**100**	**100**	**100**

Source: *Federal Environment Agency 2005 a*

In terms of electricity, the main demand was for mechanical energy, followed by process heat. District heating was less important in comparison. In 2002, the German Bundestag study commission "Sustainable energy supplies under conditions of globalisation and liberalisation" highlighted energy saving potential and development opportunities for these areas of application. The greatest potential for savings lies with the thermal cross-application technologies, where up to 30 % of the current energy demand (1998) could be saved. In 2001, industry's share of all of the final energy sectors' total electricity consumption was around 43 % (Working Group on Energy Balances [AGEB] 2002), which is why effective measures to save electricity are required in this application area.

The commerce, trade and services sector (CTS) still took an approx. 16 % share of all final energy consumption in 2002.

I 5.2 Cross-sectoral climate protection policy measures in industry and the CTS sector

The measures agreed to in 1998 to reduce CO_2 emissions include, alongside sector-specific measures, cross-

sectoral measures such as the energy saving ordinance (EnEV), which also affects households, and the environmental tax reform for all consumption sectors.

The **Act to Update the Environmental Tax Reform** raises the reduced eco-tax rates for electricity, heating oil, and natural gas for enterprises in the manufacturing, agricultural, and forestry sectors from the former 20 % to 60 % of standard rates. The tax on natural gas for heating and liquid gas is to be increased by around 63 %, and that on heavy fuel oil by around 72 %. The peak adjustment for energy-intensive enterprises has also been lowered. The newly-designed eco-tax is intended to provide a financial incentive to reduce the demand for energy and related CO_2 emissions in industry and the CTS sector. Falling emissions will be more apparent in the CTS sector than in industry, as around 50 % of energy consumption is accounted for by gas and heating oil, which is why raising the reduced "eco-tax" rates will be a significant incentive.

The **energy saving ordinance (EnEV)** that came into effect on 1 February 2002 applies not only to households but also to buildings in the industrial sector and CTS, and replaced the 1994 thermal protection regulation and the heating installation regulation. The permitted energy demand for new buildings will be cut by 30 % from the level allowed previously. All new buildings must obtain an energy demand certificate. Energy improvements in the building stock are intended, particularly when buildings are being renovated and heating systems renewed. The amendment to the energy saving ordinance seeks to provide more clarity and legal security when working with the EnEV (Chap. I 7).

The Fraunhofer Institute for Systems and Innovation Research (ISI) believes that if the ordinance is 80 % successful, there will be a reduction of direct CO_2 emissions in the industrial sector of approx. 2 million tonnes CO_2 by 2010 as a consequence of the energy saving ordinance. Their calculations took spatial heating to constitute 15 % of industrial fuel demand and assumed a 25 % reduction in the energy demand of new buildings per year between 2002 and 2010.

As spatial heating's share (approx. 65 %) is considerably higher in the CTS sector, the estimated emission savings of 5.2 million tonnes CO_2 in the CTS sector are likewise far greater.

I 5.3 The voluntary commitments and agreements of German industries

In the second Climate Protection declaration by German industry as of 9 November 2000, various industrial associations stated their willingness to reduce their specific emissions of all six greenhouse gases referred to in the Kyoto Protocol by 35 % until 2012 in comparison with 1990 (the Chapeau Declaration). German industry agreed that it would make additional efforts by 2005 to achieve a specific CO_2 reduction of 28 % in comparison to 1990. Elsewhere in the Declaration, the German government and German industry assume that this will result in the total emission volume falling by a further 10 million tonnes CO_2 by 2005 and a further 10 million tonnes CO_2 equivalent by 2012 compared with the voluntary commitments made previously.

The figures shown in Tab. I 5.3-1, "Data monitoring industry's voluntary commitment by individual sector", reflect around 83 % of the energy-related CO_2 emissions recorded by the national inventory. Due to the variety of data sources (official and sector-related statistics), they are somewhat blurred, but nonetheless succeed in indicating the direction in which CO_2 emissions are going. The trend for the period 1990 to 1999, both in terms of the overall total and most sectors, is towards a decrease in direct CO_2 emissions. Overall, direct CO_2 emissions in the sectors monitored fell by approx. 16 %. If only energy-related CO_2 emissions are considered, the decrease is 16.6 %. Industry's CO_2 emissions outside of the public power supply are 26.4 %, and within the public power supply 10.7 %. However, indirect emissions have risen and largely been displaced to the public power supply.

Specific CO_2 emissions, too, declined more or less sharply during the last ten years in all sectors except black coal mining. In most sectors, the fall in direct specific emissions is more pronounced than that in all specific emissions. As early as 1999, most sectors had already achieved a situation that comes very close to the commitments made for 2005 and 2012. Only a few sectors still needed to make greater emission reductions to achieve their objective (Tab. I 5.3-2).

I 5.4 Measures to promote industrial cogeneration

Cogeneration is useful wherever there is a simultaneous requirement for thermal and mechanical energy for the user's own requirements (Chap. I 4.3). Electricity prices for industrial customers determine, to a great extent, the cost-effectiveness of industrial cogeneration plants. Thus the generation of electricity and heat using industrial cogeneration systems fell sharply after the electricity market was liberalised and cheaper electricity became available for industrial consumers between 1995

Tab. I 5.3-1: *Monitoring data relating to industries' declaration of voluntary commitment (SVE), for individual sectors*

Association	SVE collection efficiency	CO_2 emissions direct			CO_2 emissions indirect[1]			Reference quantities		
		1990	1998	1999	1990	1998	1999	1990	1998	1999
		Mio t CO_2 or Mio t CO_2eq.						per reference quantity		
Association of German hard coal mining (GVdSt)	100 %	9.44	4.14	3.83	5.33	8.35	7.64	69.76	40.66	39.24
Potash Association	99 %	4.21	1.07	1.03	0.55	0.01	0.01	52.10	37.08	36.57
Sugar Industry Assocation	100 %	2.29	2.23	2.39	0.04	−0.05	−0.04	23.44	25.77	26.79
Textile Industry Association	95 %	2.90	1.60	1.68	2.90	2.21	2.12	100.00	69.30	66.30
German Paper Manufacturers Assocation	85–90 %	9.26	7.72	7.54	5.17	5.82	6.23	12.77	16.31	16.74
Mineral Oil Industry Assocation (incomplete declaration from refineries)[2]	>99 %	23.10	k.A.	20.70	k.A.	k.A.	k.A.	100.10	k.A.	112.70
Chemical Industry Association	99 %	41.01	24.88	23.75	24.52	24.55	24.49	99.30	111.40	116.00
Glass Industry and Mineral Fibre Industry Association	87.6 %	4.01	3.65	3.48	2.37	2.81	2.85	6.14	7.24	7.47
Fireproofing Industry Assocation	65 %	0.42	0.19	0.18	0.16	0.11	0.11	1.50	1.14	1.06
Ceramic Tiles and Slabs Assocation	80 %	0.48	0.34	0.38	0.22	0.15	0.14	1.24	1.02	1.02
German Brick Industry Association	90–95 %	1.92	1.66	1.75	0.49	0.59	0.60	15.82	19.71	19.44
Assocation of German Cement Works	96.6 %	10.48 15.00	7.56 15.40	7.25 15.61	2.40	2.43	2.50	33.34	34.68	36.57
German Lime Industry Association	95 %	3.05	2.53	2.45	0.17	0.16	0.16	7.13	6.62	6.63
Steel Industry Association	88.2 %	61.64	53.77	49.75	8.24	8.29	7.96	33.45	34.56	33.75
Metals Industry Association (NF metals)	80 %	2.77	2.71	2.65	11.82	11.25	11.47	6.14	7.23	7.31
Electrical Engineering and Electrical Industry Association	k.A.	k.A.	1.56	1.41	k.A.	k.A.	k.A.	48.89	53.25	55.63
Association of German Electric Power Stations	99 %	289.00	266.00	258.00	–	–	–	431.3	458.1	460.0
Total CO_2		480.9	397.0c	403.8	64.37	66.69	66.23			
Total energy-related CO_2		465.9	381.6c	388.2	64.37	66.69	66.23			
Total energy-related CO_2 excl. electricity supply		176.9	115.6[3]	130.2	–	–	–			
For information: energy-related CO_2 according to the national inventory										
Energy industry and industry		609.4	484.8	467.2						
For information: non-energy-related CO_2 according to the national inventory										
Total		27.7	25.6	26.0						
Mineral products		24.7	23.1	23.5						
Other processes		3.0	2.5	2.5						
Declaration of Voluntary Commitment record for energy-related CO_2		76 %	79 %	83 %						
Declaration of Voluntary Commitment record for non-energy-related CO_2 (total)		54 %	60 %	60 %						
Record for non-energy-related CO_2 mineral products		61 %	67 %	66 %						

[1] Net external power supply calculated using the public supply emission factor for 1990
[2] (still) no data available for indirect emissions from the voluntary commitment or monitoring
[3] Any comparison with 1990 and 1999 unhelpful due to different classification (data missing for mineral oil refineries)

Source: *Federal Environment Agency 2005 b*

and 1999. According to the agreement between the Federal Government and German industry to reduce CO_2 emissions and promote cogeneration, the electricity suppliers are to reduce CO_2 emissions by 9 million tonnes CO_2 within the area covered by law to promote cogeneration. Various studies indicate vast development potential in the industrial sector, and that new cogeneration plants should be able to achieve the target reduction of 9 million tonnes by 2010. This is supported by the environmental tax reform, which raised electricity prices and improved the cost-effectiveness of CHP plants.

I 6 Emission trading

Emissions trading objectives

Emissions trading goes back to the so-called Kyoto Protocol of 1997. The Kyoto Protocol is an international climate protection treaty that was launched in Kyoto (Japan) whereby 39 industrialised countries committed themselves to an average 5 % reduction in emissions of climate-damaging gases – such as carbon dioxide – by 2008/2012 as compared to the level of 1990. Emissions trading is one of the Protocol's instruments to achieve this goal at the lowest

Tab. I 5.3–2: *Change in specific CO_2 emissions (per reference quantity) from industries' voluntary commitment*

Association	Spec. Emissions 1998 from 1990	1999 from 1990
Association of German hard coal mining (GVdSt)	45 %	38 %
Potash Association	−68 %	−69 %
Sugar Industry Assocation	−15 %	−12 %
Textile Industry Association	−5 %	−1 %
German Paper Manufacturers Assocation	−27 %	−27 %
Mineral Oil Industry Assocation	N/A	−20 %[2]
(incomplete declaration from refineries)[1]	N/A	−20 %[3]
Chemical Industry Association[4]	−33 % −29 %	−37 %[5] −46 %[6]
Glass Industry and Mineral Fibre Industry Association	−14 %	−18 %
Fireproofing Industry Assocation	−31 %	−29 %
Ceramic Tiles and Slabs Assocation	−16 %	−10 %
German Brick Industry Association	−25 %	−21 %
German Lime Industry Association	−25 % −12 %	−31 %[5] −17 %[7]
Assocation of German Cement Works	−10 %	−13 %
Steel Industry Association	−14 %	−18 %
Metals Industry Association (NF metals)	−19 %	−19 %
Electrical Engineering and Electrical Industry Association	N/A	N/A
Association of German Electric Power Stations	−13 %	−16 %

[1] Analysis of CH_4 emissions based on the national inventory, as data on the net external power supply was unavailable, no separate entry was possible for direct emissions
[2] CO_2 emissions
[3] CO_2 and CH_4 emissions
[4] Trend in N_2O emissions based on the national inventory
[5] Energy-related CO_2 emissions
[6] Energy-related CO_2 and N_2 emissions
[7] Total CO_2 emissions

Source: *Federal Environment Agency 2005 b*

possible cost. The Kyoto Protocol entered into force on 16 February 2005, after its ratification by Russia.

In the Kyoto Protocol the European Union committed itself to cutting its average emissions by 8 % by the year 2008/2012 compared to the level of 1990. To meet this objective, the member states work independently in some areas by adopting national climate protection measures, while working in close collaboration in other areas. The most significant joint climate protection measure is the drawing up of the European emissions trading scheme for companies. The directive of the European Parliament and Council on a system for trading greenhouse gas certificates in the Community (2003/87/EC) came into effect on 25 October 2003. On this basis trading in emissions for combustion plants as well as larger installations in the energy-intensive sectors began in the EU on 1 January 2005.

The emissions trading system is an economic instrument for reducing the output of the carbon dioxide climate gas in a cost-effective manner. Through this system, a tonne of CO_2 is given a value determined by the market. Emissions trading creates incentives for investing in low-CO_2 technologies and for using low carbon fuels.

The principle behind emissions trading

Through emissions trading, climate protection occurs where it can be implemented at lowest cost. It enables a trade that is both ecologically effective and economically efficient. The economic sectors participating in emissions trading are given an emissions budget for a certain period (the trading period) which shows the emission reduction objective specified for that period. Emission allowances are provided free of charge to the operators involved, in line with fixed rules – in Germany, the Allocation Act 2007 (ZuG 2007). If companies' carbon dioxide emissions are lower than their allocated emission allowances – for instance as a result of their reducing their CO_2 emissions – unused allowances can be traded. Alternatively, companies can purchase allowances on the market if it is more expensive to take their own reduction measures. On 30 April of each year, operators of installations have to hand in emission allowances for the amount actually emitted during the previous year. Companies that do not meet their reduction requirements and fail to purchase sufficient emission allowances are liable to tough sanctions. 40 EUR per tonne of carbon dioxide have to be paid during the first period 2005 to 2007. The amount of missing emission allowances still has to be surrendered in the following year.

Other cost-effective measures for climate protection

Apart from trading amongst themselves, companies have other ways of reducing emissions. In this regard and since climate protection projects can be more cost-effective in other than in one's own country, the Kyoto Protocol allows for project-based "flexible mechanisms". The EU's member states and Parliament have adopted an understanding whereby EU companies can incorporate environmentally-friendly, project-based activities outside their own country into the mandatory CO_2 emissions trading scheme. This was laid down in the "Linking Directive", an EU directive that amends the emissions trading Directive. The amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol project mechanisms (the Linking Directive) has been in force since 13 November 2004. It gives operators participating

in the EU emissions trading scheme the option of meeting part of their climate protection targets through international partnership projects:

- projects in developing countries by the "Clean Development Mechanism" (CDM)
- projects in other industrialised countries through "Joint Implementation" (JI) as of 2008.

Emissions trading participants

Various parties are involved in emissions trading. To obtain emission credits, operators of installations submit applications for allocation. The emission data provided are assessed and certified by independent verifiers. In Germany, the German Emissions Trading Authority (DEHSt) at the Federal Environment Agency (UBA) receives the applications, scrutinizes the details, calculates the allocations based on the rules of the Allocation Act 2007 (ZuG 2007) and issues the allowances. Once a year, the companies participating in the scheme submit emission reports that also have to be verified by experts.

Registry and trading

The registry is an important element of the emission trading system. The function of the registry is comparable to that of a land and property registry. Comparable to the manner in which a land and property registry deals with the purchase of land, the registry shows the ownership of emission allowances. The EU emission trading directive requires that the registry must be operated electronically. Germany has developed a registry based on the French 'Seringas' software. It is operated by the German Emissions Trading Authority (DEHSt) at the Federal Environment Agency (UBA).

The EU emissions trading directive states that any individual or company can open an account in the registry of the German Emissions Trading Authority (DEHSt) and trade in emission allowances. The DEHSt manages all German trading accounts electronically.

The trading itself (i.e., the buying and selling) is, on the other hand, not the responsibility of the state, but is done directly between the companies licensed to trade in emissions, and via exchanges or private trading platforms.

Monitoring reports and surrendering of emission allowances

The emissions trading system rules that participating companies have to surrender emission allowances that correspond with the value of their actual carbon dioxide emissions. Therefore, a report on the carbon dioxide emissions has to be submitted each year. The operator submits an monitoring report for the installation participating in the trading scheme to the responsible regional authority by 1 March for the previous year. This report is reviewed by an independent verifier and is the basis for the annual surrendering of emission allowances at the DEHSt. Thereafter, emission allowances corresponding to the value of the installation's actual emissions of the previous year have to be surrendered by 30 April.

Launching the emissions trading scheme in Germany: The Greenhouse Gas Emissions Trading Act (TEHG), the National Allocation Plan (NAP) and the Allocation Act 2007 (ZuG 2007)

The Greenhouse Gas Emissions Trading Act is the framework of emissions trading in Germany and came into force on 15 July 2004. It transposes the EU directive on the European system for trading greenhouse gas emission allowances (2003/87/EC) into German law.

The EU directive states that the member states have to draw up national allocation plans which specify the size of the total amount of CO_2 emission allowances to be allocated. The national allocation plans also define the rules and criteria for the allocation. The German cabinet agreed on the Allocation Plan on the due date of 31 March 2004 and presented it to the EU Commission for notification. It constitutes the basis for the trade in emissions in Germany.

The National Allocation Plan 2005–2007 consists of two components. The Macro Plan determines the total amount of CO_2 that installations of the energy and industry sector which are subject to the emissions trading scheme may emit. These fixed overall emission quantities for trading purposes are known as "caps". The Macro Plan also includes the maximum total quantity of carbon dioxide emissions for the other sectors (i.e., transport, household, commerce, trade, and services) as well as the quantity of emissions for the other greenhouse gases covered by the Kyoto Protocol. For the first trading period (2005 to 2007) a total budget of 495 million tonnes CO_2 per year is allocated to installations that are subject to the emissions trading system. There is an additional reserve of 3 million tonnes CO_2 per annum for new entrants.

The Micro Plan regulates the specific allocation of emission allowances to the individual installations involved. The emission trading sector's contribution to climate protection as well as the amount of

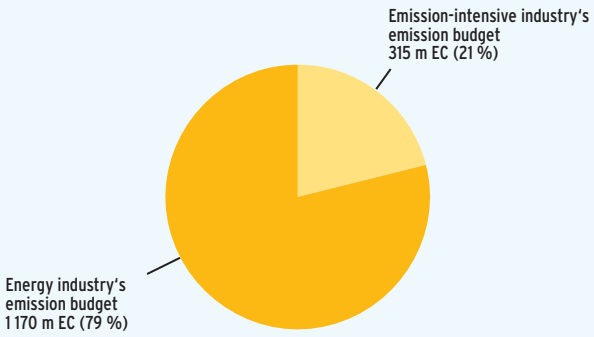
emissions that are allocated according to specific rules are included in the so-called compliance factor. The compliance factor, specifies the extent to which the energy-related emissions are to be reduced in contrast to the base period of 2000 to 2002. The compliance factor is set at 0.9709 for the first allocation period, which equates to a requirement to reduce emissions by 2.91 % over the base period.

The German Bundestag anchored most of the content of the National Allocation Plan in the Allocation Act 2007 (ZuG 2007), which came into force on 31st August 2004. The German government pinned down further allocation rules in the Allocation Ordinance 2007 (ZuV 2007). This came into force on 1 September 2004, along with the Emission Trading Cost Regulation (EHKostV 2007).

Distribution of emission allowances

In Germany, a total of 1,849 installations (as of 20 December 2004) of the energy producing industry and emission-intensive industry participate in the emissions trading scheme in the first trading period (2005 to 2007). A total of 1,485 million emission allowances were issued for the coming three years. In detail, 1,170 million allowances were issued to the energy industry, and 315 million to the participating installations of the emission-intensive industry (Fig. I 6-1).

Fig. I 6-1: *Distribution of emission credits by activity*

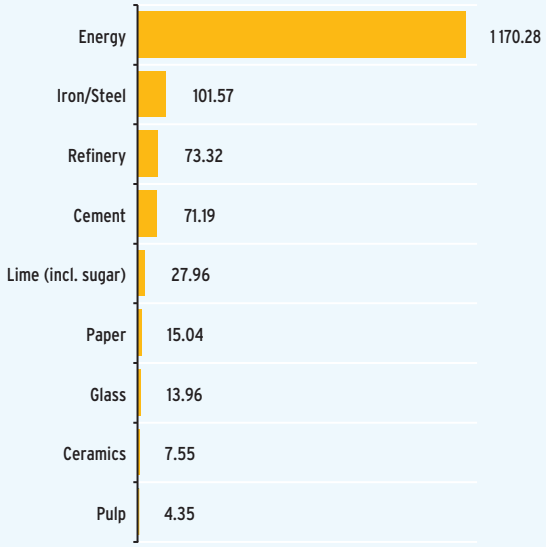


Source: *Federal Environment Agency 2005 c*

Distribution of quantities

Participation in the emissions trading system is defined in the EU's emissions trading directive and in the national Greenhouse Gas Emissions Trading Act (TEHG). Currently in Germany, the participants are those operating large energy plants (with a thermal output of over 20 megawatts) and emission-intensive industrial plants. Almost four-fifths of the emission allowances for the first trading period are allocated to installations used for generating and transforming energy (Fig. I 6-2).

Fig. I 6-2: *Allocations by activity (in millions of emission credits)*



Source: *Federal Environment Agency 2005 c*

Plant distribution by *Länder*

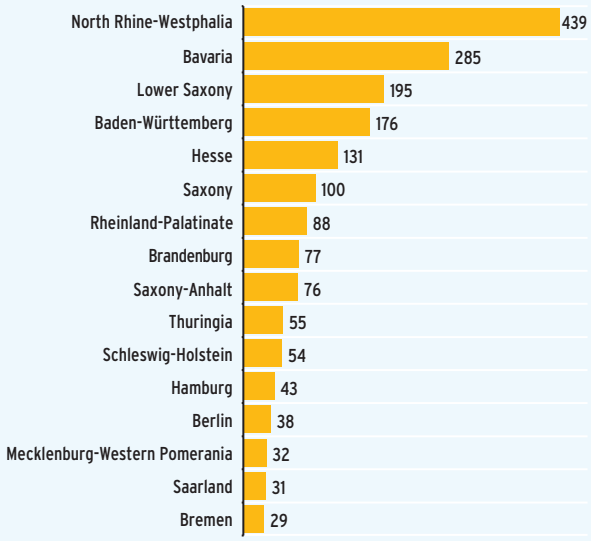
North Rhine-Westphalia is the Federal State with the highest number of installations, the largest total allocation and the largest individual plant. Brandenburg, on the other hand, is the Federal State with the largest average plants. The smallest average plants are situated in Bavaria and Thuringia. Although Bavaria is in second place in terms of the number of installations, it is only sixth in terms of allocations. North Rhine-Westphalia has the highest number of participating (439) installations while Bremen has only 29, Saarland 31, and Mecklenburg-Western Pomerania 32 (Fig. I 6-3).

Applying the allocation rules

By the Allocation Act 2007 maximum flexibility in applying for emission allowances was granted to the companies. In principle, companies could apply for their allowances either on the basis of their historic emissions caused during the base period or on account of declared and projected emissions. Furthermore, in the Allocation Act 2007, the legislator provided special rules to cover particular issues:

- early action, from 1994 onwards,
- process-related emissions that can only be cut down by reducing production,
- CHP electricity: a bonus for the particularly efficient electricity generation combining heat and power,

Fig. I 6-3: *Number of plants by Land*



Source: *Federal Environment Agency 2005 c*

- nuclear power: compensation for producing extra electricity in conventional power stations due to decommissioning nuclear power plants.

The allocation carried out in accordance with the special allocation rules largely corresponds to what was estimated in the National Allocation Plan early in 2004. The budgets for "process-related emissions" and "CHP special allocation" were claimed more often than planned. On the other hand, the early action budget fell short of 3 million emission allowances per year or 9 million for the commitment period (Tab. I 6-1).

Tab. I 6-1: *Allocations by allocation rule*

allocation rule	Calculated Emissions budget in the National Allocation Plan*)	Actual allocations*)
§ 12 ZuG Early Action	114	111
§ 13 ZuG Process-related emissions	69	71
§ 14 ZuG Special allocation for CHP	1.5	2
§ 15 ZuG Nuclear power plants	1.5	1.5

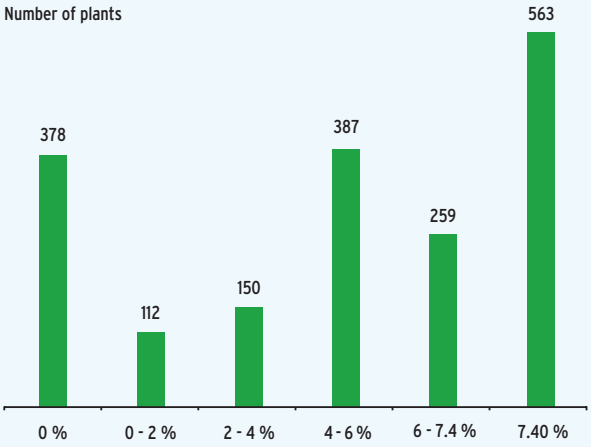
* in millions of emission credits per year

Source: *Federal Environment Agency 2005*

Who is affected by emission reduction obligations?

The Allocation Act 2007 (ZuG 2007) stipulates that the amount of emission allowances to be allocated for individual installations is to be proportionately reduced if the total allocation exceeds the value of 495 million credits per year (§ 4 Paragraph 4 ZuG 2007). This rule ensures that the amount of actually allocated allowances for the energy and industry sectors between 2005 and 2007 does not exceed the legally imposed emissions cap of 495 million tonnes of carbon dioxide per year. The reduction performance of individual installations differs according to the allocation rules selected and accepted. Around a quarter of all installations receive emission allowances with a total reduction of less than 2 %, while two-thirds have a reduction of over 4 % (Fig. I 6-4).

Fig. I 6-4: *Composition of reductions by number of plants*



Source: *Federal Environment Agency 2005 c*

Germany has managed to successfully implement emissions trading in due time. This will make an important contribution to fulfilling the country's climate protection obligations and those of the European Union.

I 7 Source sector households and measures

I 7.1 Contribution to the greenhouse effect and resource consumption

Household energy demand and the CO_2 emissions arising from the use of energy both depend on the chosen structure of fuels for heating purposes (to heat space and water) and on the amount of space and the building thermal insulation. Behaviour, in terms of lifestyle and appliance usage, also plays a major role in personal energy demand.

Final energy consumption and CO_2 emissions

During the last ten years, household fuel mix has shifted in favour of gas, with its relatively low specific CO_2 emission. In the period concerned, gas share grew from 27 % to almost 40 %, while in the years

after German reunification, the use of lignite declined from almost 14 % to below 1 % (Tab. I 7.1-1).

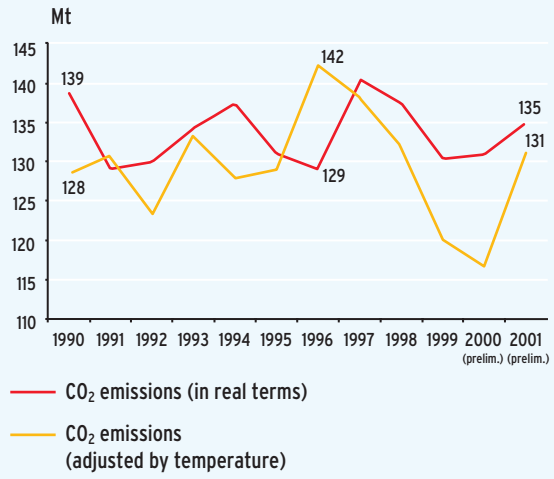
Tab. I 7.1-1: *Heating structure in German households*

Fuel	1990 in PJ	1990 in %	2002 in PJ	2002 in %
Black coal	9	0.4	6	0.2
Coke	16	0.7	3	0.1
Black coal briquettes	13	0.5	3	0.1
Lignite briquettes	325	13.7	18	0.7
Other solid fuels	65	2.7	190	6.9
Fuel oil	739	31	773	28.7
Other mineral oil products	1	0	2	0.1
Gases	633	26.6	1 061	39.3
Electricity	422	17.6	482	17.9
District Heating	160	6.8	161	6
Combined	**2 383**	**100**	**2 699**	**100**

Source: *Working Group on Energy Balances 2003 b*

In spite of this trend towards energy with comparatively low specific emissions, household CO_2 emissions did not fall. As Fig. I 7.1-1 shows, household CO_2 emissions, adjusted for temperature, fluctuated within a range from around 130 to 140 million tonnes CO_2, without there being a definitive trend. This negative finding is due to the fact that households have increased final energy consumption, which distinguishes this sector from all other consumer sectors. The rise in energy consumed between 1990 and 2002 was 13 %.

Fig. I 7.1-1: *CO_2 emissions from the households sector*



Source: *Federal Environment Agency 2005 d*

I 7.2 Reasons behind the insufficiency of emission reductions

One reason for the negative trend is the fact that energy systems in old buildings have been insufficiently modernised. This applies both to the insufficiency of the thermal insulation in the buildings themselves and the waning replacement of old heating systems with oil- and gas-fired units.

I 7.2.1 Heat demand as dependent on the age of the building

A building age is hugely significant to energy consumption, depending on whether it was built in the pre-war years, before the energy crisis, or the period between the different thermal protection regulations. Since 1975, there has been a 38 % reduction in energy consumption. After the change in the thermal protection regulation, a reduction of around 60 % might have been anticipated. The difference suggests the implementation gap. There is insufficient verification of planning standards and actual building standards. However, lifestyle behaviour (higher room temperatures, heating the entire home) may have more than compensated for efforts to save energy.

I 7.2.2 Small-scale furnace emissions as dependent on the age structure

The age structure of oil- and gas-fired plants

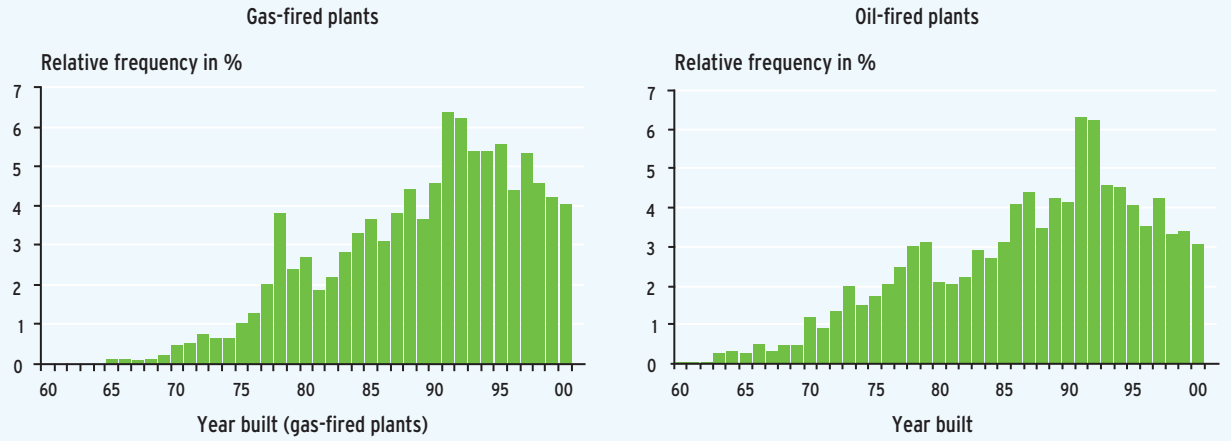
The age structure of oil- and gas-fired furnaces described in this section is based on chimney-sweep data taken from a representative sample of around 5 000 oil-fired furnaces and 11 000 gas-fired furnaces [1]. After a demand to modernise plant furnaces in the new *Länder*, the number of new systems installed annually showed a continual decline between 1992/1993 and 2000. System operators' willingness to renew their old furnace in good time has fallen sharply. However, it is anticipated that this trend will change by late 2008, as the energy saving ordinance stipulates that old central-heating boilers that are fired with liquid or gaseous fuels and were installed or mounted before 1 October 1978 should, under certain conditions, be decommissioned by, at the latest, 31 December 2008 (Fig. I 7.2.2-1).

Emissions by small-scale furnaces

Under the ordinance governing small- and medium-sized heating systems (1st BimSchV), all the small furnaces fueled by oil, gas, and solid fuel which are subject to mandatory measurements are to be monitored each year by the chimney-sweep trade. To be recorded are these plants' output and age, certain emissions and stack losses (energy lost via waste gas).

The 1st BImSchV specifies output-dependent, maximum stack losses of between 9 % and 11 % for oil- and gas-fired plants. New plants have had to observe the stipulated limits since 1 January 1998, while old facilities are subject to transitional regula-

Fig. I 7.2.2-1: *Age structure of gas- and oil-fired plants*



Source: *Federal Environment Agency 2005 e*

tions, due to expire in November 2004 at the latest, that relate to the stack losses measured, installation date and nominal heat output. Table I 7.2.2-1 shows the oil- and gas-fired furnaces that chimney-sweep measurements record as having a nominal heat output of 11 kW or above in 2003. Figure I 7.2.2-2 shows the values that plants with a nominal heat output of over 11 kW have achieved in recent years. The diagram shows that the proportion of plants with very low energy losses via waste gas has risen sharply since 1997.

As well as the plants included in the table, there are about 930 000 gas-fired sites and 68 000 oil-fired sites with nominal heat outputs of between 4 and 11 kW whose stack losses are not regularly measured. Moreover, around 780 000 gas-condensing boilers and about 18 500 oil-condensing boilers are not included in the table as their stack losses are not measured either.

The stock of furnaces run on solid fuels (mainly wood and coal) that came under the scope of the 1st

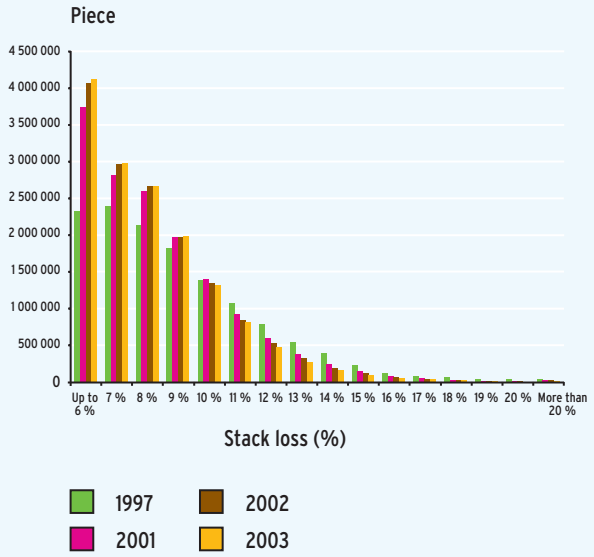
Tab. I 7.2.2-1: *Inventory of small-scale furnaces under the 1st BImSchV with nominal heat outputs of over 11 kW – divided by type of furnace system and level of stack losses recorded in 2003*

Recorded stack losses	Heating oil-vaporising burners excl. condensing boilers		Heating oil-atomising burners excl. condensing boilers		Gas burners without blowers		Gas burners with blowers		Oil-fired furnaces not reliant on ambient air	
to 6 %	1 988	(10.9 %)	1 284 991	(20.2 %)	2 267 797	(33.9 %)	287 833	(36.9 %)	281 299	(24.5 %)
7 %	1 734	(9.5 %)	1 232 846	(19.4 %)	1 355 763	(20.2 %)	165 078	(21.2 %)	218 247	(19.0 %)
8 %	1 938	(10.6 %)	1 229 360	(19.3 %)	1 082 463	(16.2 %)	132 312	(17.0 %)	229 839	(20.0 %)
9 %	1 960	(10.7 %)	998 571	(15.7 %)	718 370	(10.7 %)	86 919	(11.2 %)	174 853	(15.2 %)
10 %	2 030	(11.1 %)	694 701	(10.9 %)	454 014	(6.8 %)	50 433	(6.5 %)	116 636	(10.2 %)
11 %	1 960	(10.7 %)	425 570	(6.7 %)	289 110	(4.3 %)	25 611	(3.3 %)	66 961	(5.8 %)
12 %	1 719	(9.4 %)	228 765	(3.6 %)	191 752	(2.9 %)	12 248	(1.6 %)	31 667	(2.8 %)
13 %	1 356	(7.4 %)	121 578	(1.9 %)	131 602	(2.0 %)	6 909	(0.9 %)	14 289	(1.2 %)
14 %	1 010	(5.5 %)	67 742	(1.1 %)	82 629	(1.2 %)	4 073	(0.5 %)	6 271	(0.5 %)
15 %	580	(3.2 %)	36 917	(0.6 %)	50 887	(0.8 %)	2 599	(0.3 %)	3 863	(0.3 %)
16 %	416	(2.3 %)	16 499	(0.3 %)	31 960	(0.5 %)	1 650	(0.2 %)	1 476	(0.1 %)
17 %	306	(1.7 %)	10 468	(0.2 %)	21 706	(0.3 %)	1 103	(0.1 %)	862	(0.1 %)
18 %	213	(1.2 %)	6 820	(0.1 %)	10 946	(0.2 %)	626	(0.1 %)	440	(0.0 %)
19 %	128	(0.7 %)	4 235	(0.1 %)	3 622	(0.1 %)	379	(0.0 %)	324	(0.0 %)
20 %	114	(0.6 %)	2 509	(0.0 %)	1 926	(0.0 %)	256	(0.0 %)	178	(0.0 %)
above 20 %	785	(4.3 %)	7 400	(0.1 %)	4 474	(0.1 %)	1 046	(0.1 %)	616	(0.1 %)
Total plant inventory	**18 237**	**(100 %)**	**6 368 972**	**(100 %)**	**6 699 021**	**(100 %)**	**779 075**	**(100 %)**	**1 147 821**	**(100 %)**
Above the stack loss maximum limit[1)]	4 299	(23.6 %)	298 014	(4.7 %)	209 843	(3.1 %)	27 128	(3.5 %)	32 309	(2.8 %)
Rejected plants	2 339	(12.8 %)	270 369	(4.2 %)	67 336	(1.0 %)	13 538	(1.7 %)	14 486	(1.3 %)

[1)] According to Appendix III of the 1st BImSchV, the stack loss maximum limits are also deemed to have been observed when the value is 1–3 percentage points above the limit, depending on the plant type. Therefore a large number of plants that exceed the stack loss limit are not rejected. On the other hand, "Rejected plants" shows those plants that were rejected on the basis of other measurements (e.g., exceeding the soot number limit for oil-fired furnaces).

Source: *German Chimney Sweep Guild 2003*

Fig. I 7.2.2-2: *Stack losses from small-scale furnaces*



Source: *German Chimney Sweep Guild 2003*

BImSchV in 2000 is shown in Table I 7.2.2-2. Under the 1st BImSchV, furnaces for solid fuels are subject to mandatory monitoring when their nominal heat output is above 15 kW, and these facilities must observe a range of emission limits for dust and carbon monoxide, depending on the fuel and plant size.

Based on the chimney-sweep trade monitoring results, approx. 30 % of the furnaces for solid fuels that were examined were rejected in 2001 due to elevated emission levels. Normally these systems need to be re-installed and maintained or, where appropriate, replaced by new equipment.

I 7.3 Instruments and measures in the households sector

Up to now, efforts to reduce CO_2 emissions are showing no long-term effect. It is to be hoped that legal action, financial incentives to save energy in buildings such as adding insulation to modernise old premises, observing energy-saving standards in new buildings, monitoring measures to cut climate gas emissions, and labelling low-energy electric appliances will create a U-turn in the households sector.

I 7.3.1 Regulations and funding schemes

An important instrument within energy-saving and climate protection policy is the ordinance regulating energy-saving thermal insulation and energy-saving systems technology in buildings, known in short as the **Energy Saving Ordinance (EnEV)**, which governs both planned and existing buildings

Tab. I 7.2.2-2: *Inventory of installed furnaces for solid fuels in the area of application of the 1st BImSchV in Germany in 2000*

Fuel	Firing type	Quantity (1 000 units)
Solid fuels (coal, wood)	Heating boilers (central and one-floor systems)	678.9
	Slow-burning stoves	2 350.0
	Tiled stoves (for heating or as a base stove)	4 300.0
	Chimney stoves	2 480.0
	Open chimneys (with open or closed combustion chamber)	2 870.0
	Hot-water heaters	210.0
	Stoves (and heating stoves)	1 750.0
Total		**14 638.9**

Source: *Federal Environment Agency 2003 a*

and equipment and which came into effect on 1st February 2002. It integrates the previous requirements of the thermal protection regulation and the heating installation regulation, and sets new standards for energy-saving in new buildings. The energy demand permitted in new buildings is cut by 30 % compared with the existing requirement level, and thus achieves the low-energy standard. For new buildings, energy demand certificates based on the overall energy demand are introduced, which should increase energy transparency in buildings.

On 9 July 2004, the Bundesrat (upper house) approved an amendment to the EnEV and the General Administrative Regulation AVV § 13 Energy Demand Certificate. The amendment acknowledges changes in the underlying standards and seeks to provide more clarity and legal security when interpreting the EnEV. It covers thermal bridges and summertime insulation.

The Federal Government's **energy-saving funding schemes** are intended to act as financial incentives to invest in energy-saving measures. The Federal Government assumes a large part of the cost that is involved in providing advice. Furthermore, the Reconstruction Loan Corporation (KfW) is supporting energy-saving measures in buildings with low-interest loans in line with its "KfW CO_2 Reduction Programme". In 2003, the KfW buildings modernisation scheme was modified – the ERP Environmental and Energy Saving Programme provides loans for investing in energy-saving measures in business, particularly those taken by small- and medium-sized enterprises (SME).

I 7.3.2 Technical measures for saving energy

Old central-heating boilers are only at their most efficient when they are operating continuously. As

these boilers used to be considerably larger than necessary, one can usually assume a 15 % utilisation in old boilers and an efficiency factor of well below 70 %. The utilisation of old boilers gets even worse as the building heat demand decreases due to insulating measures. It is true that burner exchanges can reduce stack losses to the extent that the maximum stack losses specified in the 1st BImSchV is achieved, but cooling and surface losses remain high. Superior energy-saving of up to 40 % can only be achieved by installing a modern, low-temperature boiler or condensing boiler.

Small district heating plants (BHKW) and fuel cells are examples of the use of combined heat and power generation in the residential sector. However, micro gas turbines and Stirling engines are other options for certain CHP applications. The electrical efficiency level of BHKW for electricity and heat generation is 30 % to 40 %, while their overall efficiency level can be as high as 90 %. Manufacturers are even offering compact systems for single-family and two-family buildings.

The energy used in providing domestic hot water currently constitutes 10–15 % of the household's energy demand and shows a rising tendency. In passive energy buildings, the energy consumed is as much as 60 % of the total energy demand. One-third of the average water usage is needed in the form of hot water. The largest heat losses in centralised water heating systems occur while distributing it via the hot water and circulation pipes. These heat losses can comprise 20 % to 30 % of the energy demand. They fall along with the difference between the water temperature and the ambient temperature, and when effective insulation is added to the hot water and heating pipes. The heating installation regulations stipulate that domestic water systems should be fitted with automatic features for restricting the temperature to 60 °C when operating normally and for switching the circulation pumps on and off in as time passes. Hot water and heating pipes, therefore, need to be well-insulated and meet the provisions of the heating installation regulations at the very least.

I 7.3.3 Using renewable energies

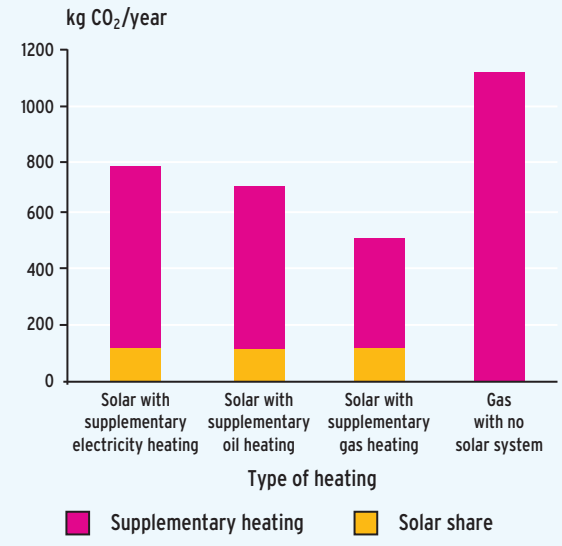
The use of renewable energies is also becoming increasingly popular in private households. The main applications here are generating heat through biomass and solar heating systems, and photovoltaic electricity generation.

The technology for biomass-based heating has improved significantly in recent years. So it is no longer difficult to produce heat and hot water using automatically fired wood pellet heaters. The encouragement provided to these technologies by the marketing incentives scheme has not only resulted in significant market growth, but also led to technological developments.

The same applies to heat generation using solar collectors. The fluctuations in the availability of solar energy can be at least partly offset by using increasingly well-aligned storage systems with short- and long-term heat stores. Only 35 % of annual solar radiation falls during the heating period, so the energy demand during the heating period has to be supplemented by other energy sources. Solar collectors will usually completely meet a domestic hot water demand during the summer (3000 kWh per annum). If solar power is to provide around 20 % of space heating, the capability must exist to store the heat using well-insulated reservoirs with a storage volume of 70–80 litres per square metre of solar collector surface area for several days. If 50 % is required, a storage tank with 120 to 150 litres per m^2 of collector surface area is needed.

As Figure I 7.3.3-1 illustrates, CO_2 emissions are curbed by well over 50 % when "solar with auxiliary gas" is used in comparison with the amount of CO_2 emitted when "gas with no solar system" is used.

Fig. I 7.3.3-1: *Annual carbon dioxide output from solar hot water supplies with different supplementary heating systems*



Source: *Federal Environment Agency 2003 b*

I 7.3.4 Energy efficiency and using energy-saving domestic appliances

Since 1998, German consumers buying electrical domestic appliances can find information about its en-

ergy efficiency on the EU energy label – since 1 January 1998 refrigerators, freezers and their combinations, and washing machines, tumble-dryers and their combinations (e.g., washer dryers), since 1st March 1999 dishwashers, since 1st July 1999 domestic lamps, and since 1st January 2003 air conditioning units. This information shows, for example, the energy consumption rating and which of seven energy consumption categories the appliance falls into. The "A" rating represents low energy consumption, and "G" is high. The obligation to provide labels applies to large domestic appliances, air conditioning units and lamps. It is based on European Union Directives, and embodied in German law by the regulations on labelling energy consumption (EnVKV). Because the categorisation is based on the situation as it was over 10 years ago, and many appliances are now in the top category, the figures only give consumers a rough guide. Category A has now been divided into A, A+ and A++ for coolers and freezers.

Other aids when purchasing electrical and electronic appliances are the Blue Angel and the GEEA label issued in Germany by the German Society for Energy Labelling.

Last but not least, it also helps if people are better aware of how to save energy when using domestic appliances such as refrigerators, freezers, stoves, and washing machines (the UBA brochure "Saving Energy in the Home", April 2004, provides detailed information). Compact fluorescent lamps use around 80 % less electricity than normal lightbulbs. They also last about eight times longer than conventional bulbs. The EU energy labelling system also applies to lamps and shows not only their energy consumption category but also their rated life.

It is particularly wasteful when appliances are consuming energy without fulfilling their purpose, i.e., when they are idling. The UBA has calculated that idling accounts for at least 11 % of the electricity consumed in private households. Standby is the best known of these wasteful situations, but not the only one by far. Systems such as audio and hi-fi, for example, often use up electricity when the switch is set to Off, but they are only apparently switched off. Wasting power through idling can often only be avoided by switching the system off fully, at the mains. Projected over a year, this causes a financial loss of 3.5 billion EUR in private households and offices in Germany (at 18 ct/kWh for private households, as of January 2004).

Heating appliances that are particularly efficient and low in pollutants bear the **Blue Angel** eco-label. Such systems include combined burner-boiler units equipped with forced gas burners, gas-fired calorific value systems, gas-fired water heaters, special gas boilers, and modern small district heating plants for simultaneously generating heat and power. Such systems are granted the eco-label if they meet certain efficiency levels and maximum contamination requirements. For example, with combined oil-burner boiler units, the Blue Angel only recognises those with thermal output of up to 70 kW. Low-emission atomising oil burners are given the label because they are, particularly on a larger-scale, a relatively environmentally-friendly option for generating heat. They are particularly efficient because the oil is atomised into the finest droplets, so that the combustion of the oil/air mixture is almost total and soot and contaminant emissions are very low. The UBA's 2003 brochure "The energy piggy-bank" provides further information.

[1] Kleemann M., Heckler R., Krüger B. (2003): Umweltschutz und Arbeitsplätze durch die Tätigkeiten des Schornsteinfegerhandwerks, Schriften des Forschungszentrums Jülich, Reihe Umwelt, Jülich

I 8 Source sector transport and measures

I 8.1 Contribution to the greenhouse effect and resource consumption

In Germany, the transport sector, along with the households sector, is the largest consumer of final energy and is taking a growing share of CO_2 emissions.

In 2003, transport accounted for around 28 % of final energy consumption, which was substantially more than the figure for industry or commerce and services (Tab. I 8.1-1). Transport was responsible for over 20 % of CO_2 emissions in 2003. CO_2 emissions from transport rose by 4.8 % between 1990 and 2003 (Tab. I 8.1-2).

Of the various transport modes, road traffic in particular is contributing to the rise in CO_2 emissions – it had a 19 % share of all energy-related emissions in 2003, a figure that has increased by 6.4 % since 1990. CO_2 emissions depend directly on the amount of fuel consumed, and this has risen sharply during the last decade (Chap. I 8.2.3). The rise in emissions

Tab. I 8.1-1: *Transport's share of final energy consumption in %*

	1990	1995	2000*)	2001*)	2002*)	2003*)
Transport	25.1	28.1	29.8	28.5	29.0	28.1

*) provisional figures
Deviations in totals due to rounding
Source: *Working Group on Energy Balances 2004*

Tab I 8.1-2: *Energy-related CO_2 emissions in Germany in 2003: transport compared with other source groups*

Source Group	Share in %	Change from 1990 in %
All transport	20.2	4.8
Road transport	19.0	6.4
Power and district heating plants	43.1	–12.4
Households	14.5	–5.3
Industrial furnaces	15.3	–34.3
Commerce, Trade, and Services	6.8	–34.0

Source: *Federal Environment Agency 2005*

between 1990 and 2000 is due to the fact that reductions in vehicular fuel consumption have been offset by an increase in miles driven (Chap. I 8.2). It has only been since 2000 that CO_2 emissions have declined slightly, mainly due to a fall in passenger traffic mileage. Emissions of the other climate gases (CH_4, No_x, and SO_2) on the road have fallen dramatically as a consequence of the repeated tightening of the permissible exhaust levels and of improved fuel quality (Tab. I 8.1-3).

I 8.2 Reasons for the increase in CO_2 emissions

The reason for the rise in emissions is the constant increase in the number of miles travelled, which requires greater fuel consumption to meet the need for the many types of journeys.

I 8.2.1 Vehicle mileage, transport performance, purpose of travel

Alongside driving speed and vehicle type, the distance travelled in the various transport modes is the most important factor determining emissions of pollutants and noise.

The mileage of all vehicles in Germany rose by 19.6 % between 1991 and 2003. The mileage of passenger transport increased by 15.7 % and freight transport mileage grew by 53.8 %. The sharp rise in vehicle mileage for heavy goods vehicles (HGV) is a particular problem for the environment, as they produce significantly more emissions and noise per kilometre travelled than cars. (Tab. I 8.2.1-1).

Transport performance is measured in passenger-kilometres (or tonne-kilometres for road haulage), and can be used to reveal the modal split in the use of different transport modes. Trends in motorised vehicle transport between 1991 and 2003 showed a rise in both passenger transport and freight transport. The rise in passenger transport between 1991 and 2003 was 21.5 %, with motorised passenger transport increasing by 22.3 %. It retains its overall dominance in passenger transport, with its share rising slightly between 1991 (81.6 %) and 2003 (82.1 %) (Fig. I 8.2.1-1). By far the sharpest rise among means of passenger transport was the rise in air transport. Transport performance in German air space rose by 91.6 % between 1991 and 2003. Over the same period, the transport performance of public road and rail transport increased by 6.1 %. These less environmentally harmful transport modes have maintained a share of around 14 % in total transport performance. If non-motorised means (pedestrians, cycling) are included in total transport performance, in 2002, passenger transport was dominated by motorised means (77.1 % share), much more than all the environmental forms of transport put together (pedestrians, cycling, rail, and road transport), which had a 19.1 % share. Among reasons for travel, leisure and holidays (44.2 %) and work and education (23 %) have the greatest shares in passenger transport, followed by business travel (12.8 %) and shopping (15 %).

Tab. I 8.1-3: *Road transport emissions in Gg*

	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
1990	150 261.54	62.73	9.46	1 284.78	6 684.18	1 463.85	90.20
2000	171 160.70	16.32	16.19	781.29	2 380.13	283.36	19.66
2002	166 002.00	12.82	14.45	664.63	1 910.61	213.69	2.81

Source: *Federal Environment Agency 2005*

Tab. I 8.2.1-1: *Total mileages by motor vehicle type in billions of km*

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Cars	500.3	514.2	526.5	528.6	535.5	539.9	542.5	552.0	563.9	565.3	576.4	584.7	579.7
Motorcycles	9.4	9.3	9.3	7.9	8.3	8.9	9.6	9.8	10.3	11.0	11.4	12.2	12.0
Mopeds	4.7	3.5	2.9	4.2	4.3	4.2	4.0	4.3	4.3	4.1	4.0	3.8	4.1
Buses	4.1	4.0	3.9	4.1	4.2	4.3	4.4	4.3	4.2	4.1	4.2	4.1	3.9
HGVs	59.5	61.7	63.1	67.3	70.7	73.5	77.3	80.4	84.2	86.4	88.5	90.7	91.5
Combined	**578.0**	**592.6**	**605.7**	**612.2**	**623.1**	**630.9**	**637.7**	**650.8**	**666.8**	**670.9**	**684.6**	**695.4**	**691.2**

Source: *Federal Environment Agency 2005 f*

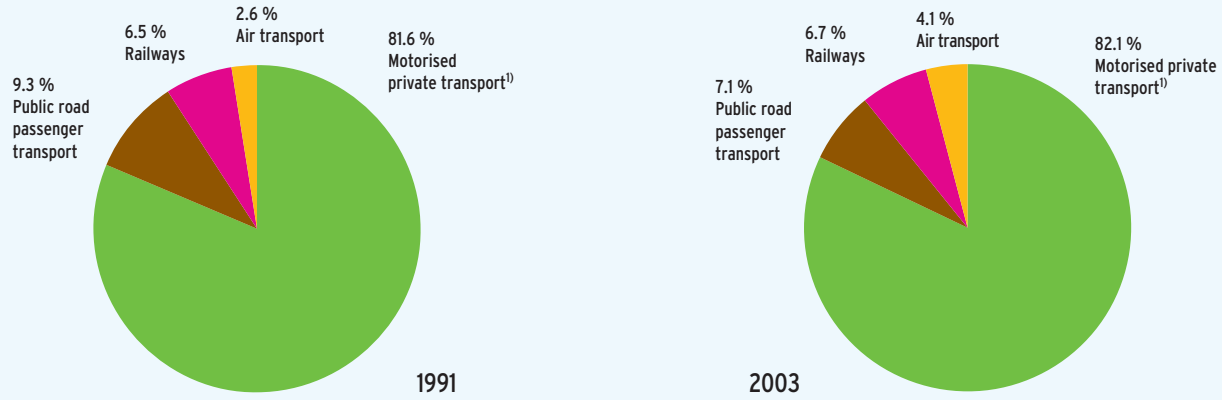
Freight transport performance (excluding pipelines) rose by 29.3 % between 1991 and 2003. The highest growth was in road transport (+47.7 %) and, although starting from a low level, air transport has doubled. The share of freight transport by road rose from 61.5 % in 1991 to 70.2 % in 2003 (Fig. I 8.2.1-2). This growth was primarily at the expense of the railways, which only accounted for 15.5 % of all freight transport performance (1991: 20.6 %). The total share of environmentally preferable freight transport modes (rail and inland waterways), which was roughly equal to that of road haulage in 1980, therefore fell to below 30 %.

I 8.2.2 Transport intensity for passenger and freight transport

Within the context of sustainable development, as a high degree of mobility is retained there ought also to be an increase in transport efficiency so that the impact transport has on humans and the environment is reduced. One measure of transport efficiency is transport intensity – transport performance related to gross domestic product. The figure recorded is how much transport performance in freight and passenger transport is "needed" per unit of gross domestic product (GDP). If transport performance (measured in tonne or person kilometres) can be maintained or reduced and the population's output (GDP) increased so that transport intensity declines, society will be handling its resources more efficiently and the environmental harm caused by the transport sector will be lessened.

From the mid-1990s, transport intensity in freight transport increased. Between 2000 and 2002, it was at least possible to prevent any further increase in transport intensity. With passenger transport, a downward trend in transport intensity has been apparent since the mid-1990s. Since 2000, this trend has been strengthened by environmental policy measures (the environmental tax reform).

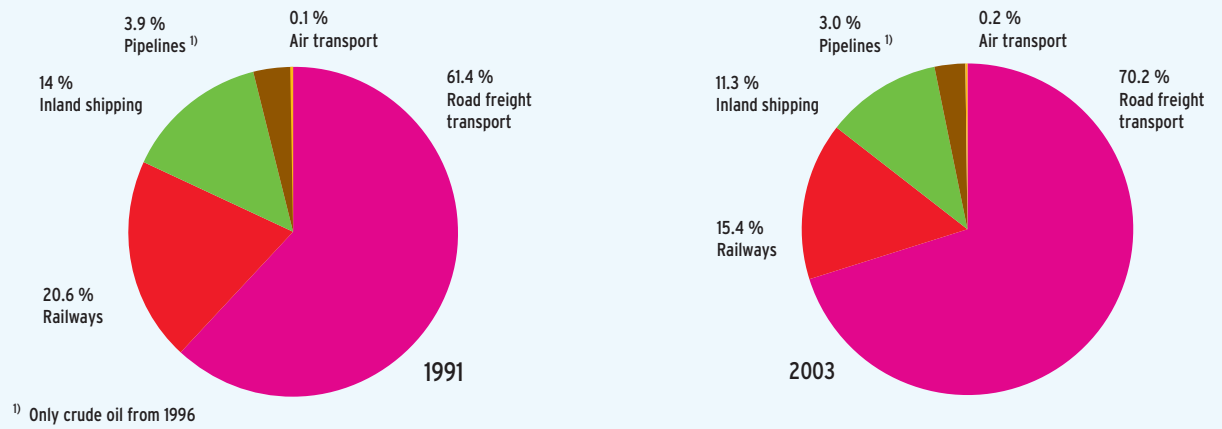
Fig. I 8.2.1-1: *Passenger transport performance in Germany*



1) Method changed post-1994, leading to higher transport performance

Source: *Federal Ministry of Transport, Building and Housing 2004*

Fig. I 8.2.1-2: *Freight transport performance in Germany*

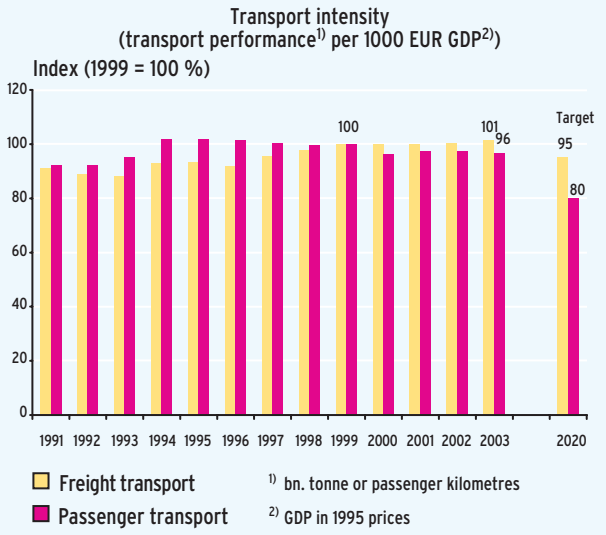


1) Only crude oil from 1996

Source: *Federal Ministry of Transport, Building and Housing 2004*

As part of the 2002 Sustainability Strategy, the German government set itself the objective of reducing transport intensity by around 5 % in freight transport and by 20 % in passenger transport by 2020 from 1999 levels. This objective can be achieved by designing sustainable transport systems, encouraging low-traffic settlement structures and regional economic channels (i.e., traffic avoidance) and increasing the efficiency of transport systems (Fig. I 8.2.2-1).

Fig. I 8.2.2-1: *Transport intensity for freight and passenger transport*



Source: *Federal Ministry of Transport, Building and Housing 2004, Federal Statistical Office 2004*

I 8.2.3 Fuel consumption

In 2003, about 4.4 billion litres of fuel were consumed in German road transport, an increase of 7.2 % from 1991. Whereas fuel consumption in passenger transport was only 0.1 % higher in 2003 than in 1991, the figure for freight transport was 32.8 % greater. Freight transport share of all fuel consumed by road transport thus grew from 22 % in 1991 to 27 % in 2002 (Tab. I 8.2.3-1).

Tab. I 8.2.3-1: *Fuel consumption in road transport in m. litres*

	1991	1995	2000	2002	2003
Passenger transport	47 821	49 729	48 893	48 985	47 892
Freight transport	13 285	15 409	17 134	17 518	17 641

Source: *Federal Environment Agency 2005 f*

Despite continuing technical progress in reducing the fuel consumption of cars and a sharp increase in the proportion of cars with diesel engines, the trend towards more powerful, heavier cars meant that average consumption of motor vehicle stocks in Germany fell by only 1.3 litres per 100 km between 1991 and 2003 (Tab. I 8.2.3-2).

Tab. I 8.2.3-2: *Average fuel consumption of cars/minivans in litres/100 km*

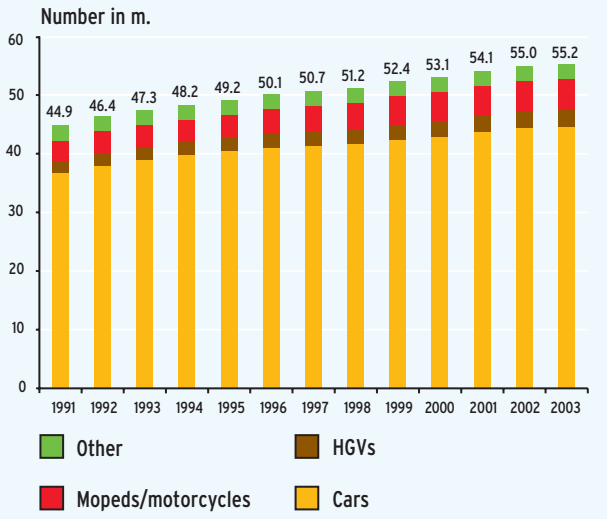
	1991	1995	2000	2001	2002	2003
Consumption	9.2	8.9	8.3	8.2	8.0	7.9

Source: *Federal Environment Agency 2005 f*

I 8.2.4 Motor vehicle stocks

Motor vehicle stocks in Germany continue to rise. In 2003, there were ca. 44.7 million cars, 2.8 million heavy goods vehicles (HGV) and 4.9 million mopeds and motorcycles in Germany. The number of cars rose by 21 % between 1991 and 2003. Car ownership in Germany rose from 460 to 541 per 1 000 residents in 2003, one of the highest rates in the world. During the same period, HGV stocks grew by 59 %. Due to the power of their engines, HGV contribute disproportionately to total motor vehicle emissions. Stocks of motorcycles and mopeds, which are subject to less stringent environmental controls, also grew considerably (+ 40 %) between 1991 and 2003 (Fig. I 8.2.4-1). In 2003, 17 % of cars had a diesel engine.

Fig. I 8.2.4-1: *Motor vehicle inventory trend*



Source: *Federal Ministry for Transport, Building and Housing 2004*

I 8.3 Instruments and measures in the transport sector

If transport is to contribute to climate protection and reducing CO_2 emissions, it has to be made possible for there to be increasing mobility with lower traffic-related CO_2 emissions. This can be supported with a bundle of different instruments and measures that also take into account other demands stemming from the vision of developing mobility

in a sustainable way, such as restricting pollutant and noise emissions and limiting the use of space and resources.

I 8.3.1 Changing regional planning to reduce traffic

The growth in traffic over the last ten years has largely been determined by settlement trends. Therefore measures to control residential development can also influence the generation of traffic.

Regional planning, town planning, environmental planning, and the promotion of regional trade and industry have to be aligned both with one another and environmental and climate policy objectives. Infrastructure expansion, the approval procedure for commercial zones and production sites, and the development of residential areas and urban structures all have to enable shorter journeys in order to reduce traffic and improve the availability of environmentally-friendly alternatives to motorised transport. The Federal Transport Network Plan is, in the long-term, to be refined until it becomes an environmentally-oriented long-distance transport strategy.

Expanding settlement areas while settlement density declines results in a growth in motorised transport. Journeys become longer; longer journeys, in turn, reduce the attractiveness of non-motorised transport (Chap. I 8.2.1). Because low-density settlement areas render it more difficult to run a cost-effective, efficient public transport system, this trend is encouraging car traffic.

In the transport statistics of the old *Länder*, the traffic-generating effect of these settlement structures is illustrated by the average distance travelled per journey which, depending on the purpose of travel, rose by up to 55 % between 1982 and 2002.

Targeted settlement policies, support for regional economic channels and regional marketing can also cut transport journeys for goods traffic. Regional aid has to take into account the impacts of business settlement on transport demand and CO_2 emissions. EU subsidies granted, not EU-wide, but only to particular regions, need to be reviewed.

The objective of any environmentally-oriented planning policy will be to keep routine journeys short by making use of compact settlement structures and mixed functions, making supplies, services and recreational opportunities available near to where people live, keeping home and workplace close together and intensifying usage. On top of this, longer journeys require good (i.e., nearby) public transport access to be planned by aligning regional development with public transport routes.

I 8.3.2 Promoting environmentally sound transport infrastructure

Promoting rail transport for goods and passengers

The trend in transport infrastructure development is one of increasing environmental pollution, evidence for which also comes from the following comparisons of pollutant emissions by the various transport modes.

In passenger transport, domestic air traffic creates three times and road traffic almost twice the amount of specific CO_2 emissions as rail passenger traffic. In urban traffic, petrol and diesel vehicles and create respectively 2.5 and 2.1 times the specific emissions as trams. This takes into account the CO_2 emissions from producing vehicle fuels and electricity generation.

Domestic air freight traffic generates 25 times and long-distance road haulage generates 5.6 times the specific CO_2 emissions of rail freight transport (TREMOD).

These example figures show that traffic-related CO_2 emissions can be significantly reduced by shifting road and air traffic to rail with its low specific energy consumption. For this reason, the German government announced in 2002 the transport policy objective of doubling rail freight transport demand by 2015.

However, improving rail's competitiveness is a major prerequisite for the environmental and transport policy objective of shifting more traffic to rail. Similar framework conditions need to be created for the competing transport modes of road, air, and water. Rail transport operators have to pay for using their infrastructure, while the same does not apply to a large part of the road network. The introduction of the heavy vehicle transport charge in Germany is, therefore, an important step towards equal treatment of road and rail. In the comparison between transport modes, rail, along with the waterways, has the lowest external costs, and rail competitiveness would be significantly increased if these costs were recovered. Tax law, too, differs from mode to mode, e.g., air traffic is particularly privileged, with no sales tax on international transport and no kerosene tax.

To ensure that freight retains long-term mobility, it is vital that intermodal interchanges are optimised. Information and communication technologies can

be deployed to convert freight traffic centres into multi-modal nodes for long-distance, regional and local traffic systems. Combined rail transport with quickly-bundled traffic can result in marketable services (post-express trains, trains for combined freight transport) between terminals. Given globalisation and the expansion of the EU, it is important for the competitiveness of the railways that rail systems match one another in technical terms. Shipping in coastal areas and the inland waterways can also take on some freight transport, providing that ports are given effective links to the European rail network. In promoting inland navigation, care needs to be taken that no further burden is placed on semi-natural rivers.

More efficient public transport (ÖPNV)

Public transport plays a key role in drawing up mobility options. Public transport provides all sectors of the population with car-free mobility, and, on average, is only responsible for around one-third of the CO_2 emissions per person kilometre compared with cars.

Public transport share of urban traffic volume (i.e., persons carried) varies widely depending on the underlying conditions. While public transport share averages 15 % over all German urban areas, the highest figures are found, e.g., in Frankfurt am Main (25 %), Munich (24 %), and Hamburg, Dresden and Freiburg (21 % each). In comparison, though, public transport has a 37 % share in Zurich. If public transport share of urban transport is to be increased, it is vital to have a well-developed route network, modern, efficient vehicles and a customer-oriented range of transport service options. Just as important, if not more so, are restrictions on car traffic in towns, principally well-designed parking controls with few, and carefully rationed, parking areas. Internalising car traffic external costs also helps to displace traffic in favour of public transport.

The German government, the *Länder*, and the municipalities provide 14 billion EUR per annum of funding to public transport. The funding system lacks transparency and is based on input (i.e., those who invest most, receive most) rather than on performance (e.g., customer numbers). To achieve larger traffic displacements, public transport funding needs to be restructured in a way that creates incentives to achieve the greatest possible transport performance, customer satisfaction, and cost efficiency.

According to the calculations of the UBA, each one percent of journeys displaced from urban car traffic to public transport reduces CO_2 emissions by around 260 kt compared with the trend (based on the year 2010). A displacement of 5 % of urban car traffic would mean a 24 % increase for public road passenger transport (buses, trams, light rail, and underground). Taking into account the fuel consumed by public transport, and depending on the public transport efficiency level, this would reduce CO_2 emissions by between 1.3 and 1.5 million tonnes in 2010.

More cycling and walking

The authorities often underestimate the potential of cycling, given that the bicycle is mainly a transport mode for short journeys. Nonetheless, cars account for around half of all journeys over distances of up to 6 km, a distance over which using a car generally provides no time benefit. It is precisely on short journeys that emissions from motor vehicles are particularly high, because the cold engine makes fuel consumption disproportionately high and the catalyst is not fully effective. This is why displacing car journeys to cycling has a particularly marked relief effect.

Currently in Germany, each resident covers around 300 km per year by bicycle, compared with the 1000 km that each resident cycles in the Netherlands and Denmark. If cycling was well-promoted so that German cycling statistics reached similar levels, the UBA estimates an annual saving of 3.5 to 12 million tonnes CO_2 per year.

I 8.3.3 Technical transport measures

The European Union's strategy for reducing CO_2 emissions

In 1995, the European Commission agreed on a strategy for cutting CO_2 emissions from cars with the aim of reducing the average carbon dioxide output from newly registered cars to 120 g/km by 2005, or 2010 at the latest. The strategy is based on three approaches: an agreement between the European Commission and car manufacturers to reduce fuel consumption in newly registered vehicles; tax measures; and the publication of fuel consumption data in an attempt to steer consumers' buying behaviour.

In contrast to the European Commission, European car manufacturers (ACEA) undertook, in 1998, to reduce CO_2 emissions in newly registered cars through technical means by 25 % from 187 g/km in 1995 to 140 g/km in 2008. The Japanese (JAMA) and Korean (KAMA) car industries have adopted this voluntary commitment (in their case the target year is

2009). In 1999, the directive was issued for labelling CO_2 emissions on cars on display in dealers' showrooms, and in June 2005 the Commission presented a proposal for restructuring car taxation, to link it to CO_2. With this, all three pillars of the Commission's strategy have been implemented.

For the ACEA, an interim goal was set in the voluntary commitment of achieving specific CO_2 emissions of 165–170 g/km (1995 initial level: 186 g/km) for the average of all the new vehicles sold in the 15 EU countries by 2003. The European automobile manufacturers achieved this aim ahead of schedule. The Japanese association, too, hit its interim target of 170–175 g/km in 2003, and it is generally anticipated that the Korean association will achieve its 2004 target range of 165–170 g/km. In 2003, the average specific CO_2 emissions in new cars were 163 CO_2 g/km (ACEA), 172 CO_2 g/km (JAMA), and 179 CO_2 g/km (KAMA). The figures for newly registered vehicles in Germany are in line with this trend, although the absolute figures are slightly above the European average.

The sharp falls are mainly attributable to the increase in the number of cars with direct injection diesel engines and turbochargers (TDI). Moreover, there has been a slight move amongst consumers towards buying smaller vehicles. The introduction of fuel direct injection (DI technology) into Otto engines is expected soon. This technology has the potential to reduce CO_2 emissions by up to 20 %. In practical terms, a reduction potential of around 5 % to 10 % is currently assumed.

Limits for transport-specific pollution emissions under EU law

Cars and light goods vehicles

The introduction of the three-way catalytic converter with a lambda sensor in Germany started in 1985 and received strong support, particularly via tax assistance and a ban on petrol-driven cars without a sensor-controlled catalytic converter when there is an ozone alert. According to the 91/441/EWG European directive which came into force for new models from 1992 and for all newly registered cars from 1993 (EURO I), all new cars with an Otto engine have to be fitted with this technology in order to meet emission requirements. At that time, 37 % of cars with Otto engines in Germany were already fitted with the technology. The directives 1994/12/EEC (EURO II, effective from 1996/1997) and 1998/69/EC (EURO III from 2000/2001 and EURO IV from 2005/2006) lowered the maximum limits and specified other requirements. Thus, e.g., from EURO III a modified model testing cycle is being used which includes the engine starting procedure, while emissions during periods of very low temperatures (−7 °C) have been given separate limits, emissions via evaporation are subject to significantly stricter limits, and from 2005 on-board diagnostics systems have to be built into the vehicle to provide warnings where defects in the pollution reduction system might be causing maximum limits to be exceeded. The overall impact of the EURO II to IV standards is to reduce the pollution emitted by cars with an Otto engine by 90 to 95 % over cars with no catalytic converter. In diesel-powered cars, for which up to now there has been no need for any exhaust gas after treatment comparable with the regulated three-way catalytic converter, the reduction is only 75 % to 90 %. The EURO IV standard permits diesel-driven cars to emit around three times as much as Otto cars, particularly in terms of nitrogen oxides. To achieve a reduction in the health risk posed by diesel soot and nitrogen oxides along the lines of Otto engines, a corresponding technology for exhaust gas after treatment (e.g., particle filters, DENOX) is required for diesel cars. As this is not currently necessary to meet the present pollution limits, Germany is lobbying for a further tightening of the limits for diesel engines (Tab. I 8.3.3-1 and Tab. I 8.3.3-2).

Tab. I 8.3.3-1: *Limits for pollutant emissions from cars*

Car Directive	Pollutant in g/km	EURO 1 from 1992/1993 (T) 91/441/EEC	EURO 1 from 1992/1993 (S) 91/441/EEC	EURO 2 from 1996/1997 (T/S) 94/12/EC	EURO 3 from 2000/01 (T/S) 98/69/EC	EURO 4 from 2005/06 (T/S) 98/69/EC
Petrol	CO	2.72	3.16	2.2	2.3	1
	$HC+NO_x$	0.97	1.13	0.5	–	–
	HC	–	–	–	0.2	0.1
	NO_x	–	–	–	0.15	0.08
Diesel	CO	2.72	3.16	1	0.64	0.5
	$HC+NO_x$	0.97	1.13	0.7	0.56	0.3
	NO_x	–	–	–	0.5	0.25
	Particles	0.14	0.18	0.08	0.05	0.025

T: Type S: Series

Source: *Federal Environment Agency 2004 a*

Tab. I 8.3.3-2: *Limits for pollutant emissions for light goods vehicles*

	< 1305 kg		1305–1760 kg		> 1760 kg	
EURO III g/km	**Otto 98/69/EC 3rd stage from 1.1.00/01**	**Diesel 98/69/EC 3rd stage from 1.1.00/01**	**Otto 98/69/EC 3rd stage from 1.1.00/01**	**Diesel 98/69/EC 3rd stage from 1.1.00/01**	**Otto 98/69/EC 3rd stage from 1.1.00/01**	**Diesel 98/69/EC 3rd stage from 1.1.00/01**
CO	2.3	0.64	4.17	0.8	5.22	0.95
HC	0.2		0.25		0.29	
NOx	0.15	0.5	0.18	0.65	0.21	0.78
HC + NO_x		0.56		0.72		0.86
Particles		0.05	0.07			0.1
EURO IV g/km	**Otto 98/69/EC 4th stage from 1.1.05/06 (T/S)**	**Diesel 98/69/EC 4th stage from 1.1.05/06 (T/S)**	**Otto 98/69/EC 4th stage from 1.1.05/06 (T/S)**	**Diesel 98/69/EC 4th stage from 1.1.05/06 (T/S)**	**Otto 98/69/EC 4th stage from 1.1.05/06 (T/S)**	**Diesel 98/69/EC 4th stage from 1.1.05/06 (T/S)**
CO	1	0.5	1.81	0.63	2.27	0.74
HC	0.1		0.13		0.16	
NOx	0.08	0.25	0.1	0.33	0.11	0.39
HC + NO_x		0.3		0.39		0.46
Particles		0.025		0.04		0.06

T/S: Type/Series

Source: *Federal Environment Agency 2004 a*

Mopeds and motorcycles

These vehicles have been regulated by two sets of limits which came into force in 1999 and 2002. These limits are to be upgraded in the future with the objective being to achieve the emission level of modern cars with Otto engines (EURO IV) (Tab. I 8.3.3-3).

HGV and buses

Standardised limits similar to those for cars have been defined for HGV and buses in Europe. Unlike with cars, there is no measurement of the emissions from the entire vehicle on the roller test bench – what is measured is the engine emission on an engine test bench in a specified sequence of operational states. Therefore the emissions are also not recorded and restricted in g/km but in g/kWh, i.e., based on the work the engine delivers in the test. Directive 1991/542/EEC defines the EURO I and II stages and guideline 1999/96/EC defines stages EURO III to V. The reduction rates anticipated as a consequence of these, in comparison to the regulations applicable previously, are similar to those in diesel-powered cars, and exhaust gas after treatment has not yet been needed in this case either. EURO IV, however, is not expected to bring any major reduction, particularly of particle emissions. EURO IV and V will probably be implemented using exhaust gas after treatment for nitrogen oxide emissions (Tab. I 8.3.3-4).

Mobile machinery and appliances

Legislation on exhaust fumes has also made steady progress in the mobile machinery and appliances sector, and it is being applied across ever-broader areas. The 1 and 2 limits only apply to construction machines with an output of max. 560 kW. Limits 3 and 4 were agreed in April 2004. As part of the legislation, the applicability of the directive was signifi-

Tab. I 8.3.3–3: *Limits for pollutant emissions from mopeds/motorcycles (in g/km) Stage*

Stage	Directive	Applies from	Category	Test cycle	CO	HC	NO_x
			Small motorcycle				
Euro 1	97/24/EC	17.06.1999	–	ECE R47	6	3[1)]	
Euro 2	97/24/EC	17.06.2002	–	ECE R47	1	1.2[1)]	
			Motorcycle				
Euro 1	97/24/EC	17.06.1999	2-stroke	ECE R40	8	4	0.1
			4-stroke	ECE R40	13	3	0.3
Euro 2	2002/51/EC	01.04.2003	< 150 ccm	ECE R40	5.5	1.2	0.3
			≥ 150 ccm	ECE R40	5.5	1	0.3
Euro 3	2002/51/EC	01.01.2006	< 150 ccm	ECE R40, cold	2	0.8	0.15
			≥ 150 ccm	ECE R40, cold + EUDC	2	0.3	0.15

ECE R 47: Economic Commission for Europe Regulation 47
EUDC: Extra-Urban Driving Cycle
ECE R 40: Economic Commission for Europe Regulation 40
[1)] Total limit

Source: *Federal Environment Agency 2004 a*

Tab. I 8.3.3-4: *Exhaust limits for heavy good vehicles (HGVs) and buses (limits for the type test)*

g/kWh	Dir. 88/77/ EEC since 1988/90	Dir. 91/542/ EEC 1st Stage from 1.7.92	Dir. 91/542/ EEC 2nd Stage from 1.10.95	Dir. 99/96/EC Stage A from 2000	Dir. 99/96/EC Stage B1 from 2005	Dir. 99/96/EC Stage B2 from 2008	Dir. 99/96/EC Stage C EEV**	Dir. 99/96/EC Stage A from 2000	Dir. 99/96/EC Stage B1 from 2005	Dir. 99/96/EC Stage B2 from 2008	Dir. 99/96/EC Stage C EEV**
		Type test values (From 1995 Series value = Type test value)									
		EURO I	EURO II	EURO III	EURO IV	EURO V	EEV	EURO III	EURO IV	EURO V	EEV
CO	11.2	4.5	4	2.1	1.5	1.5	1.5	5.45	4	4	3
HC	2.4	1.1	1.1	0.66	0.46	0.46	0.25	0.78	0.55	0.55	0.4
NO_x	14.4	8	7	5	3.5	2	2	5	3.5	2	2
Particles	–	0.36*	0.15	0.10; 0.13[a)]	0.02	0.02	0.02	0.16; 0.21[a)]	0.03	0.03	0.02
Methane[c)]	–	–	–	–	–	–	–	1.6	1.1	1,1	0.66
Smoke opacity				0.8	0.5	0.5	0.15	–	–	–	–
	(Limits in the 13-stage test)			(Limits for ESC and ELR test)				(Limits for ETC test)			

With the limit for particle emissions, a coefficient of 1.7 is used for engines with a maximum capacity of 85 kW.
** Enhanced Environmentally Friendly Vehicle
Readings for EURO Stages 1 and 2 are done in the 13-stage test
Readings for EURO III to V are done in the ESC and ELR procedure or the ETC test
[a)] For engines with a cubic capacity of below 0.75 dm^3 per cylinder and a nominal rotation speed of above 3000 U/min
"C" does not apply to gas-powered engines in Stage A and Stage 2000 and 2005 and 2008
EEV: Enhanced Environmentally Friendly Vehicle ESC: European Stationary Cycle
ELR: European Load Reponse Test ETC: European Transient Cycle

Source: *Federal Environment Agency 2004 a*

cantly extended. Also included now are diesel engines for use on the railways, inland shipping, and stationary-operated mobile diesel engines in power units (Tab. I 8.3.3-5).

Small petrol engines

Directive 97/68 also applies to small petrol engines (Tab. I 8.3.3-6). As purely Otto engines, they have very little in common with the diesel engines that come under this directive, so their limits were regulated in the separate directive 2002/88. As there is a worldwide market for such engines, the limits already applicable in the USA were specifically addressed (Tab. I 8.3.3-7).

Recreational craft

Through directive 94/25/EC of the European Parliament and Council, aimed at approximating the laws and administrative provisions of the Member States relating to recreational craft, a rule was laid down for the European zone. The directive, which came into force in 1998, covers the design and construction of recreational craft. It sought to create "harmonised regulations governing exhaust and noise emissions from recreational craft".

On 16 June 2003, directive 2003/44/EC came into force, altering directive 94/25/EC. Here, for the first time, maximum limits were set for exhaust and noise emissions from recreational craft within the member states. These apply to self-ignition and four-stroke extraneous ignition engines being deployed in transport from 1st January 2006 and to two-stroke external ignition engines from 1st January 2007.

The specific emissions from small engines are, relatively speaking, higher than from large engines. In the formula given, Term A stands for a basic level for high engine capacities and Term B / P_N^n for a

Tab. I 8.3.3-5: *Limits for mobile machinery and appliances in Stages 1 and 2*

Capacity (kW)	CO g/kWh)	HC (g/kWh)	NOx (g/kWh)	PT (g/kWh)	Date for type approval	Date for series approval
	Stage 1	Stage 1	Stage 1	Stage 1	after	after
37 < P < 75	6.5	1.3	9.2	0.85	30.06.1998	31.03.1999
75 < P <130	5	1.3	9.2	0.7	30.06.1998	31.12.1998
130 < P < 560	5	1.3	9.2	0.54	30.06.1998	31.12.1998
	Stage 2	Stage 2	Stage 2	Stage 2		
18 < P < 37	5.5	1.5	8	0.8	31.12.1999	31.12.2000
37 < P < 75	5	1.3	7	0.4	31.12.2002	31.12.2003
75 < P <130	5	1	6	0.3	31.12.2001	31.12.2002
130 < P < 560	3.5	1	6	0.2	31.12.2000	31.12.2001

Source: *Federal Environment Agency 2004 a*

Tab. I 8.3.3-6: *Petrol engine size categories*

Category	Cubic capacity category in cm^3	Application
Hand-held machines		
Category SH: 1	< 20	Trimmers/strimmers
Category SH: 2	≥ 20 to < 50	Power saws, trimmers/ strimmers, other
Category SH: 3	≥ 50	Power saws, trimmers/ strimmers, other
Non-hand-held machines		
Category SN: 1	< 66	Lawnmowers
Category SN: 2	≥ 66 to < 100	Lawnmowers
Category SN: 3	≥ 100 to < 225	Lawnmowers
Category SN: 4	≥ 225	Ride-on mowers

S: Smaller engines with an output of below 19 kW;
H: Engines for hand-held machines;
N: Engines for non-hand-held machines

Source: *Federal Environment Agency 2004 a*

Tab. I 8.3.3-7: *Emission limits[1] for Otto engines with an output of below 19kW*

Category	CO in g/kWh	HC in g/kWh	NO_x in g/kWh	HC+NO_x in g/kWh
Stage I				
SH: 1	805	295	5.36	–
SH: 2	805	241	5.36	–
SH: 3	603	161	5.36	–
SN: 1	519	–	–	50
SN: 2	519	–	–	40
SN: 3	519	–	–	16.1
SN: 4	519	–	–	13.4
Stage II				
SH: 1	805	–	10	50
SH: 2	805	–	10	50
SH: 3	603	–	10	72
SN: 1	610	–	10	50
SN: 2	610	–	10	40
SN: 3	610	–	10	16.1
SN: 4	610	–	10	12.1

[1] Emission values are ascertained in compliance with the cycles in ISO standard 8178-4

Introduction dates
EU directive 2002/88 defines different introduction dates for the limit stages. They depend on the type of machine.

	SH 1	SH 2	SH 3	SN 1	SN 2	SN 3	SN 4
Stage I	Aug 04	Aug 04	Aug 04	Aug 04	Aug 04	Aug 04	Aug 04
Stage II	Aug 10	Aug 10	Aug 11	Aug 04	Aug 04	Aug 08	Aug 06

S: Smaller engines with an output of below 19 kW; H: Engines for hand-held machines;
N: Engines for non-hand-held machines

Source: *Federal Environment Agency 2004 a*

supplement on low capacity engines. When calculating the maximum limits, the different engine designs are also taken into consideration, and a distinction is drawn between two-stroke, four-stroke Otto engines, and compression ignition engines (Tab. I 8.3.3-8).

Fuels

As well as the restrictions placed on pollution emissions in exhaust fumes, new requirements for different types of fuel are also being introduced, as defined in the directive 1998/70/EC. In particular, the sulphur content of Otto and diesel engine fuel is being reduced to 50 ppm from 2005 (low sulphur fuel). Low sulphur fuels are a vital support, or even a prerequisite, when deploying new types of exhaust gas after treatment system to reduce sulphur oxides and particles in cars and goods vehicles. Moreover, the European Union has decided to introduce another, improved fuel quality with a maximum of 10 ppm sulphur (sulphur-free) between 2005 and 2009 as it is needed for the function and stability of new types of exhaust gas after treatment systems while simultaneously exploiting the full potential for reducing consumption. This sulphur free fuel quality has been available for purchase everywhere in Germany since early 2003.

All the directives referred to can, under EU law, also be supported by tax measures in order to accelerate the early introduction of suitable vehicles, engines or fuels. This option had already been administered in 1997 with the alteration to the motor vehicle tax legislation, whereby cars with lower pollution emissions (including CO_2) were taxed at a particularly low rate and, furthermore, made exempt from tax up to a certain amount, while old cars with no catalytic converter, on the other hand, were taxed at a higher rate.

Low-emission cars and mini-vans in Germany

The proportion of low-emission cars grew sharply between 1992 (47 %) and 2003 (97 %) (Tab. I 8.3.3-9). This trend is also reflected in a reduction in the specific pollutant emissions by German road transport.

Tab. I 8.3.3-8: *Limits for recreational craft*

Type	Carbon monoxide CO = A + B / P_N^n g/kWh			Hydrocarbons HC = A + B / P_N^n g/kWh			Nitrogen oxides NOx g/kWh	Particles
	A	B	n	A	B	n		
Two-stroke Otto engines	150.0	600.0	1.0	30.0	100.0	0.75	10.0	Not applicable
Four-stroke Otto engines	150.0	600.0	1.0	6.0	50.0	0.75	15.0	Not applicable
Compression ignition engines	5.0	0	0	1.5	2.0	0.5	9.8	1

Source: *Federal Environment Agency 2004 a*

Tab. I 8.3.3-9: *Trends in low-emission cars and minivans*[1)]

		1992	1995	2000	2003
Low-emission cars and minivans	in millions	17.8	30.8	40.5	43.3
Share of the inventory of cars and minivans	in %	47.0	76.2	94.6	96.9

[1)] Vehicles as in directive 70/220/EEC and Appendices XXIII (US standard) and XXV (EC standard) of the Road Traffic Authorisation Ordinance to 2002: Version 1.7; from 2001 Version 1.1.

Source: *Federal Ministry of Transport, Building and Housing 2004*

Specific pollutant emissions by road traffic in Germany

Specific CO_2 emissions by newly registered cars

According to analyses carried out by the Federal Vehicles Agency, the average CO_2 emissions of newly registered cars in Germany (model test results under 1999/100/EC) are continuing to fall. In 2003, the average CO_2 figure in Germany was 175.9 g/km.

Specific pollutant emissions by the road transport fleet

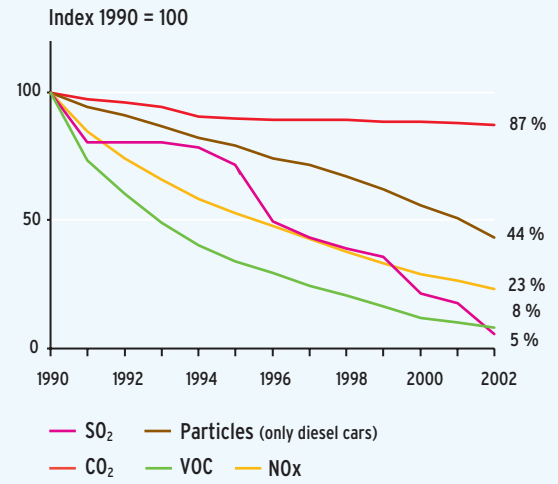
Cars:
The specific emissions per transport performance (person kilometre) have been reduced in all sectors in comparison with 1990 through gradually making emission regulations more stringent for newly registered cars, by retrofitting catalytic converters to old cars, and by improving fuel quality. SO_2 emissions have been cut by 95 % and VOC by 92 %, but CO_2 emissions have only fallen by 13 %.

In terms of the total emissions by motorised private transport, however, it is apparent that the technically-induced reductions per person kilometre in CO_2 and diesel soot particles are partly being offset by an overall increase in transport performance (Fig. I 8.3.3-1).

HGV:
Technical improvements to HGV engines and better fuel quality has enabled specific emissions per transport performance (tonne kilometre) to be reduced in all sectors in comparison with 1990. Major falls in SO_2 (98 %) stand in contrast to a far less marked reduction in CO_2 emissions (9 %) (Fig. I 8.3.3-2).

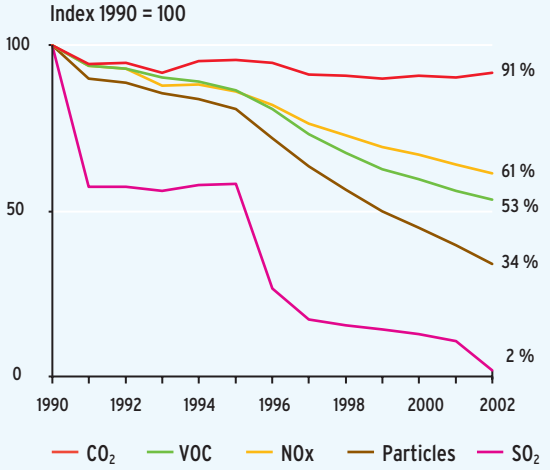
In terms of the total emissions from road freight transport, it is also apparent here that, with the exception of SO_2 emissions, the technically-induced reductions per tonne kilometre are being partly (particles), almost entirely (VOC), and considerably more than offset (diesel soot particles and CO_2) by the sharp rise in transport performance.

Fig. I 8.3.3-1: *Specific emissions from cars*



Source: *Federal Environment Agency 2004 a*

Fig. I 8.3.3-2: *Specific emissions from HGVs*



Source: *Federal Environment Agency 2004 a*

I 8.3.4 Finance policy measures

Removing subsidies and imposing taxes in air transport

Air transport represents an increasing problem for climate protection. The main reason for this is the marked increase in flight movements. NO_x emissions in the upper atmosphere and the emission of steam as vapour trails or cirrus cloud formation contribute to warming. Because of their altitude, the impact that air traffic emissions have on the climate is two to four times greater than if the same quantity was being emitted close to the ground [1].

The great environmental impact of emissions in the upper atmosphere and the strong growth in air travel require effective climate protection measures to be taken with air transport. From the perspective of climate policy, there can be no argument about the extent to which air traffic should be exempt

from taxation and receive other state favours. The commercial air transport industry pays no mineral oil tax on kerosene and no sales tax is imposed on international flights. On top of these, airlines and airports profit from the opportunity to sell goods free of sales tax on flights leaving the EU and in duty-free shops. This generates tax savings of many millions of euro each year.

Airports also receive direct subsidies, mainly for investing in infrastructure, and tax exemptions. An analysis of public infrastructure investment for the 17 German passenger airports and the air traffic monitoring system showed that their income did not cover the associated costs. The German government and the *Länder* largely support the airports out of public funds [2]. Links between airports and the road and rail network are also almost completely financed by the state, although they only favour environmentally-unfriendly air traffic. And finally, the aircraft industry, too, is subsidised for developing and building planes, and benefits from large tax write-offs of up to 20 % per year.

The most significant measures in connection with removing air transport tax allowances are the introduction of a tax on kerosene and the imposition of sales tax on the domestic portion of international flights. For both measures, the UBA and the Federal Statistical Office have had the Institute of Economic Structures Research carry out simulated calculations which can be used to forecast, for example, the impact on CO_2 emissions.

If commercial air transport current exemption from the mineral oil tax were to be abolished from 2005 and a 0.302 EUR per litre tax were raised on kerosene – in line with the energy tax directive 2003/96/EC that came into force on 31 October 2003 and gives member states the option of imposing a kerosene tax unilaterally – the cost of air passenger transport would rise by an average 3.3 % and that of air freight transport by approx. 11 %. This would reduce CO_2 emissions by an average of 1.5 million tonnes per annum by 2020 in Germany alone compared with the predicted trend.

Removing the exemption from sales tax enjoyed by international flights would also help to reduce CO_2 emissions and thus protect the climate. If 16 % VAT were imposed on the domestic portion of the route on international flights, air traffic transport performance would fall by around 6 % by 2020 compared with the figures currently predicted. Using the additional income from VAT could fund a reduction in VAT on long-distance rail transport from the current 16 % to 7 %, subject to this being permitted in law. Replacing private transport with rail and reducing air traffic would give a long-term reduction in CO_2 emissions by over 1.3 million tonnes per year by 2020 [3].

Apart from removing subsidies, which would, for example, create equality between the different transport modes, measures are also needed to reduce emissions directly. In this context, a route-based emission tax might be a suitable instrument for climate protection in air transport. Such a charge should encompass all CO_2 and NO_x emissions occurring during the entire flight including landing. This would create more incentive to reduce emissions and encourage the deployment of low-emission planes. An emission tax of 6 cents per kg CO_2 and 13.7 cents per kg NO_x could result in air transport harmful climate emissions falling by about 5 % compared with the status quo [4].

As an alternative, research is being done into the extent to which air transport can be integrated into an open emissions trading scheme. Currently, therefore, different ways of extending the EU emissions trading system for industrial facilities (which has existed since early 2005) to aircraft are being worked out and discussed at the European level. How much an emissions trading system broadened to include air transport would assist climate protection would depend upon how many emission rights were granted to aircraft. Also crucial is the question of whether the EU emissions trading system will also be extended to include aircraft emissions that occur outside the EU.

Introducing and extending an HGV toll

A "route-based charge for the use of German motorways by heavy goods vehicles" (HGV toll) has, since the beginning of 2005, imposed an average duty of 12.4 cents per kilometre driven on German motorways on HGV weighing over 12 tonnes. The level of the toll differs according to the number of axles and by emission category. The toll charges heavy goods traffic for the cost of using the motorway network and creates incentives for meeting demanding emission requirements at an early stage. At the same time, the German government receives an income of around 2.6 billion EUR (excluding administrative costs).

In a research project commissioned by the UBA, the Institute for Economic Research and Policy at the University of Karlsruhe (IWW) studied the impact that an HGV toll based on emissions and weight would have on traffic and the environment [5]. The studies results showed that the HGV toll will provide environmental relief, mainly due to the differentiation it makes between pollutant

types. This encourages leading companies to be willing to more speedily replace their old vehicles with newer HGV with lower air pollution emissions. The current HGV toll of an average 12.4 cents per kilometre is an important step towards a cost-charging system based on the emissions source. At the same time, however, it tends to encourage HGV to evade the toll by switching to more minor roads – particularly on short journeys of up to 150 km. The IWW calculates that the traffic volume on more minor roads will rise by an average of 4.5 %, with the highest figures being on parallel routes and shortcuts. In contrast, the toll only has a minor impact on CO_2 emissions.

Only by significantly increasing the HGV toll and rolling it out to the entire trunk road network will traffic avoidance and a reduction in harmful emissions from goods traffic become more apparent. It also seems that the current HGV toll will not succeed in displacing road freight transport to the railways as was hoped, at least not until the logistic quality of rail transport is considerably improved.

A higher toll for all federal trunk roads could considerably reduce the environmental damage from goods transport by slowing the forecasted growth in road freight transport and, if there were a better range of rail options for long-distance goods transport, displace more freight from the road to rail. A toll rate of 20 cents per kilometre raised on all federal trunk roads would increase the costs of road freight transport by 25 % by 2010 compared with today. If, at the same time, part of the toll income was used to vastly improve the options for rail freight transport, road freight transport and its associated environmental damage would fall by around 2.7 %. At the same time, the railways would maintain or even slightly improve their transport share. CO_2 emissions would be reduced by over 2.7 million tonnes per annum.

In a macroeconomic simulation, the GWS showed that this measure would not just be positive in environmental terms, but also have macroeconomic benefits. While higher costs in the transport industry would, indeed, slightly raise the price of goods in macroeconomic terms (by an average 0.2 %), the associated negative impact on the national economy would be more than offset by the fact that the state could use the additional toll income for more important public expenditure, e.g., to improve the transport infrastructure. This would have the overall long-term effect of slightly increasing employment and GDP compared with the base forecast. The positive economic effects are also attributable to the fact that a large proportion of the toll income would come from foreign transport companies.

The mineral oil tax

One of the outcomes of introducing the environmental tax reform was that the mineral oil tax on petrol and diesel was gradually increased by a total of 15.34 cents per litre between April 1999 and early 2003 (Chap. I 3). Public transport receives an eco-tax refund of 5.4 cents per litre for diesel or petrol plus 44 % electricity tax reductions for rail transport and trams.

The total eco-tax revenue for 2005 is estimated at 18.8 billion EUR [6]. The largest portion of this income is being used to cut employers' and employees' pension insurance contributions from 20.3 % in 1998 to 19.5 % as of 2003. Without the eco-tax, they would have been at least 21.2 % by 2004.

The eco-tax portion of the mineral oil tax is responsible for raising the price of petrol by about 15 % and diesel by around 18 %. For the average car driver, this means paying an extra 156 EUR per annum. The costs for a low-consumption vehicle fall (5-l-Auto: 92 EUR per year). The reduction in national insurance contributions means that these extra outgoings are usually more than offset. An employed person with a gross annual income of 40 000 EUR is spending around 340 EUR per year less on social security. On an income of 30 000 EUR, the saving is still 255 EUR. However the legislation has a negative impact on those parts of the population who are not paying compulsory social security contributions, such as the self-employed, pensioners, students, and the unemployed.

The mineral oil tax encourages demand for low-consumption vehicles and accelerates the replacement of high-consumption vehicles. It offers an incentive for low-fuel driving and using fuel-efficient tyres and oils. For the first time, fuel sales have shrunk for four years in a row (2000–2003). While an increase in grey imports (buying petrol outside Germany while using it in Germany) partly offsets the domestic decline, overall there remains a marked reduction in fuel consumption by motor vehicles registered in Germany amounting to 2 % for the period 1999 to 2003. In contrast, public transport has reported rising passenger numbers in recent years, and other environmentally-friendly transport modes such as rail, cycling, and walking have become more attractive.

A recent, representative survey commissioned by the UBA found that around half of the car drivers questioned have adopted fuel-efficient driving habits or are sometimes leaving their car and taking other forms of transport in response to the increase in the mineral oil tax occasioned by the environmental-tax reform [7].

CO_2-based road tax

The restructuring of existing taxes based on environmental concerns made it possible to increase the economic incentives for environmentally-friendly consumer behaviour. Thus the German government coalition agreement seeks to align road tax to CO_2 emissions with a view to promoting the development and sale of fuel-efficient vehicles.

The principle of structuring road tax to encourage fuel-efficient vehicles has proven itself in the past. It greatly accelerates the development and market penetration of environmentally-friendly vehicles. To encourage the marketability of fuel-efficient cars, the German government announced in the coalition agreement that it would continue to adjust road tax, in collaboration with the *Länder*, in a way that is both environmentally-friendly and volume-neutral, and integrate motor vehicle CO_2 emissions into the assessment basis.

The Institute of Economic Structures Research has run a simulation to study the impact of a road tax based on CO_2 emissions. It assumes that the road tax assessment basis is switched from cubic capacity to average CO_2 emissions per kilometre and, as is the case with the current road tax, applies higher tax rates to diesel cars than to Otto cars. To increase the incentive for buying low-consumption cars, it is also assumed that the tax to be paid for a car rises progressively along with the average CO_2 emissions per kilometre. Overall, road tax revenues should not exceed current levels.

According to this simulated calculation, the CO_2-based road tax increases purchases and use of vehicles with a low average consumption. From this it can be extrapolated that the increased demand for low-consumption cars would further reduce the specific consumption of newly registered diesel cars by up to 3.4 % compared with a situation with no CO_2-based road tax. The greater technical potential means that the average consumption by petrol-driven cars would be up to 5.5 % lower than without this measure. According to the simulation findings, CO_2 emissions from cars would be approx. 2.7 million tonnes CO_2 lower overall than the base forecast by 2020. Restructuring the road tax would have no macroeconomic impacts worthy of note.

[1] IPCC 1999: Aviation and the Global Atmosphere, Special IPCC Report, UNEP/WMO 1999.
[2] CE et al. 2002: Solutions for Environment, Economy and Technology et al.: Financial Support to the Aviation Sector, UFOPLAN-Vorhaben Nr. 299 96 106, Schlussbericht, Delft, February 2002.
[3] GWS 2004: Institute of Economic Structures Research: Schätzung der Wirkung umweltpolitischer Maßnahmen im Verkehrssektor unter Nutzung der Datenbasis der Gesamtrechnungen des Statistischen Bundesamtes, Studie im Auftrag des Statistischen Bundesamtes in Zusammenarbeit mit dem Umweltbundesamt, Schlussbericht, Osnabrück, August 2004.
[4] UBA 2001: UBA (Ed.): Maßnahmen zur verursacherbezogenen Schadstoffreduzierung des zivilen Flugverkehrs, UBA text 17/01, Berlin 2001
[5] IWW 2001 Rothengatter, Werner; Doll, Klaus: Anforderungen an eine umweltorientierte Schwerverkehrsabgabe für den Straßengüterverkehr; UBA text No. 57/01, Berlin 2001.
[6] BMF 2004: Bilanz der Ökologischen Steuerreform, Berlin, October 2004.
[7] ecologic 2004: Auswirkungen der Ökologischen Steuerreform auf private Haushalte, Berlin, November 2004

I 9 Climate, agriculture and forestry

I 9.1 Contribution to greenhouse gases

The application of mineral fertilisers and animal husbandry are the most significant sources of greenhouse emissions from agriculture.

The trace greenhouse gas methane (CH_4) occurs both from digesting (fermentation) in agriculture used ruminant animals (cattle and sheep) and with the storage of manure. Manure is also a source of the laughing gas nitrous oxide (N_20) and its precursor substances (NO_x and N_2) – this applies primarily to straw-based systems (solid manure).

Around 95 % of methane emissions are attributable to cattle farming; amongst cattle the milk cows are the most significant emitters. Cattle stock fell at the beginning of the 1990s as a result of German reunification; CH_4 emissions from animal husbandry likewise decreased by about 22 % (3.24 Tg per year in 1990, 2.59 Tg/year in 2002). At the same time the portion of agriculture emission in all German emissions increased from 30.4 % to 41.8 %. This development is due to larger emission reductions in other sectors.

Cattle, which make up 63 % of the share, are the greatest contributor to methane emissions through manure.

Emissions of dinitrogen oxide (N_2O) and nitrogen oxides (NOx) from manure also increased for the same reasons, however they have remained constant since 1994 (Tab. I 9.1-1).

Greenhouse gases from agriculturally used soils

Soils, too, are emission sources of greenhouse gases. A distinction is drawn between direct and indirect emissions. Direct emissions of greenhouse gases containing nitrous oxide (N_2O, NO_x) originate predominantly from fertilisation with mineral N fertilis-

Tab. I 9.1-1: *Greenhouse gas emissions from animal husbandry and commercial fertilisers in Tg*

Chemical	Source	1990	1996	2000	2002
CH_4	Fermentation	1.63	1.35	1.26	1.28
	Commercial fertilisers	1.61	1.35	1.3	1.31
N_2O	Commercial fertilisers	0.01	0.01	0.009	0.009

Source: *Federal Environment Agency 2005*

ers and manure as well as from biological N fixing and plant residue in the soil.

Indirect N_2O emissions are calculated from atmospheric deposition of reactive nitrogen compounds from agricultural sources, washed out by reactive nitrogen compounds, and the runoff of nitrogen deposition (Tab. I 9.1-2).

Tab. I 9.1-2: *Emissions of greenhouse gases containing nitrous oxide from agricultural soils in Gg*

Greenhouse gas	1990	1996	2000	2002
N_2O	141	120	125	120
NO	65	55	57	54

Source: *Federal Environment Agency 2005*

I 9.2 Measures in Agriculture

One important measure for protecting the climate is to reduce the excess of nitrogen in soils, preferably through the optimised use of manure and mineral fertilisers and by increasing the extent of organic farming. A clear trend for the decline of the nitrogen surplus as a result of the 1996 issued fertilisation regulation is so far not recognisable.

The livestock population, measured in livestock units, decreased by about 21 % between 1990 and 2000, mainly due to changes in the population's eating habits, food scandals, the BSE crisis, and agricultural restructuring in the new *Länder*.

The most important reduction measure is decreasing the nitrogen input into the whole cycle.

For this the following measures within the sector of animal husbandry are to be taken:

Milk cows

- optimise the energy/protein ratio,
- use rumen-stable protein to improve microbial utilisation of nitrogen,
- increase in output while simultaneously decreasing the number of milk cows,
- lower the age at first calving.

Pigs/Poultry

- phase-feeding and optimisation of the amino acid supply.

Manure management can also help reduce emissions. The following measures are thereby most important:

- creation of sufficient external storage capacities,
- minimise the temporary storage times of liquid manure in the housing systems,
- cover storage,
- reduce the surface of solid manure by construction and technical measures,
- low-emission spreading at the optimal time.

A further important reduction measure is the expansion of the use of manure for energy (including co-fermentation with other high-energy substrates).

Exhaust air purification (including acid washes for the recuperation of the nitrogen) is another useful reduction measure in large animal housing systems.

I 9.3 Land use change and forestry (LUCF)

§ 1.8 of the Framework Convention on Climate Change states that sinks are methods and processes, activities, and mechanisms that remove greenhouse gases, aerosols or greenhouse gas precursor substances from the atmosphere. The terrestrial biosphere, mainly forests, is a net sink or source of CO_2, depending on inventory trends. During photosynthesis, green plants take carbon dioxide from the air and bind it into an organic form. When these organic substances are broken down, the CO_2 is released again. For Germany, emissions of and regulations governing CO_2 from Land Use Change and Forestry (LUCF) are only relevant in the areas "changes to stocks of forests and other biomass" and "emissions of CO_2 and CO_2 concentrations in the soil".

Changes to stocks of forests and other biomass

The source or sink effect of forests can be determined by comparing new growth and timber harvests. In doing this, it is assumed, using the IPCC method, that the harvested timber decomposes and the bonded CO_2 is completely released in the same year as the timber harvest, which undervalues the forest's sink function. In Germany, the comparison between new growth and timber harvests currently results in an increase in the biomass stocks stored in forest, i.e., more carbon is being absorbed by the vegetation than is being re-

moved from forests through timber harvests. German forests are currently a net sink for CO_2 which is larger than previously assumed according to the findings of the 2nd National Forest Inventory (Tab. I 9.3-1).

Tab. I 9.3-1: *Land use change and forestry in Gg*

	1990	1995	2000	2002
Forest inventory change and other biomass change[1)]	–33 688.74	–33 399.91	–25 402.15	–25 402.15
CO_2 emissions and concentrations in the soil	41 203.97	39 052.83	39 499.17	39 308.64

[1)] Concentration from CO_2 (sink)

Source: *Federal Environment Agency 2004 b*

Emissions of CO_2 and CO_2 concentrations in the soil

Soils are important carbon stores. Globally, around five times as much carbon is stored in the soil as in vegetation [1]. Using the soil for agricultural purposes leads to elevated CO_2 emissions. The draining of organic soils, in particular, oxidises organic matter rapidly and releases large amounts of CO_2. Overall in Germany, emissions from agricultural soils exceed the CO_2 tied up in forests. Adding more organic matter to farmland, less ploughing, and so on, are measures that will reduce CO_2 emissions from the soil. The maintenance and retention of existing forests, added to afforestation, have proven to be measures that can increase the sink effect of German forests.

[1] Special Report on Land Use, Land Use Change and Foresty, IPCC, 2000, P.4, Tab. 1

II CONTAMINANTS AND POLLUTANTS

II 1 Human exposure to pollutants

The measurement of contaminants in human biological material is referred to as human biomonitoring. Blood, urine, and breast milk are most frequently studied. Contaminants or pollutants that have been absorbed by the body as a result of ingestion of foodstuffs and drinking water, breathing, or through contact with the skin, can be analysed in these fluids and tissues. Human biomonitoring is therefore better than any other method when it comes to determining the actual internal burden on the human body caused by contaminants and pollutants (also known as internal exposure). The absorption of contaminants may have occurred over a short or long period of time.

Though the majority of toxicological data relating to the effects of contaminants is obtained from tests on animals, human biomonitoring is also important in order to properly evaluate the effects on health from pollutants in the environment. It would otherwise not be possible to show what actually occurs in humans as a result of contaminants in foodstuffs or the environment. Thus, biomonitoring is able to indicate which pollutant reduction measures are necessary. Any human exposure to contaminants may have undesirable consequences. The uptake of contaminants should therefore be as low as possible and at an acceptable level with regard to the effects on health.

Human biomonitoring has proved to be a vital monitoring tool for assessing the success of environmental policy measures. It will also be used to check the effectiveness of the new European regulations relating to chemical substances policy, known as “REACH”. REACH is the acronym for “Registration, Evaluation and Authorisation of CHemicals.” These regulations are currently in development. The aim of REACH is to improve the state of knowledge relating to the properties of substances that are harmful to health or the environment, where those substances are produced and marketed in quantities of more than one tonne per year by a single manufacturer. Human biomonitoring is also vital with respect to chemicals that are produced in quantities of less than one tonne by several manufacturers.

There are certain contaminants that can be shown to be present in blood, urine, or breast milk samples for which the main pathway of exposure is not known. In such cases, further investigation is required in order to identify the pathway and the source of exposure and, if necessary, to allow appropriate measures to be developed and implemented to minimise exposure.

The following text primarily describes the results of two different human biomonitoring programmes that have been conducted in Germany since the mid-1980s. The German Environmental Survey (GerES) refers to a sample of the adult and/or child populations in Germany representative with regard to age, gender, and size of community. The 1985/1986 study looked at adults (only in the old *Länder*); the 1990/1992 study covered children, adolescents, and adults; in 1998, only adults were studied [1]. A very wide range of pollutants were studied using blood and urine samples. In order to obtain information about the possible causes of the human exposure to pollutants in the living environment, samples of drinking water, indoor air, and household dust (the contents of a vacuum cleaner bag) were also taken from the participants’ homes. The interpretation of the results of measurements made for the German Environmental Survey also takes into account information provided on questionnaires. This covers behaviour patterns related to the environment as well as conditions in the home and surroundings that are relevant to the human body burden. The aims of the German Environmental Survey include the collection, provision, updating, and evaluation of representative data, at a national level, to enable a health-related monitoring of and reporting on the state of the environment.

By compiling representative data for different age groups, it is possible to derive reference values. To derive of these reference values is the responsibility of the Human Biomonitoring Commission (HBM) [2] of the Federal Environment Agency. A reference value is defined as that concentration of a substance present in human biological material (e.g., blood or urine) that is not exceeded in 95 % of people tested. Reference values are derived on a purely statistical basis and give no direct indication of health effects. That is to say, if a reference value is exceeded, it does not necessarily follow that an increased risk to health exists; likewise, if the value is not reached, it does not prove that a risk to health is not present. These values are used to establish if certain groups of people or individuals have been exposed particularly heavily to a pollutant in comparison to the general population, and are also used in event-related and regionally

restricted studies, as well as for the evaluation of tests results on an individual basis by e.g., public health officials. In addition, the representative data also provide an indication of regional and temporal variations, and can therefore be used to monitor the success of environmental policy measures. In May 2003, the Federal Environment Agency began carrying out the first "Environmental Survey for Children" in cooperation with the "German Health Survey for Children and Adolescents" from the Robert Koch Institute.

The second programme is that of the Human Specimen Bank, which forms part of the German Environmental Specimen Bank (ESB). The ESB provides an archive of frozen environmental and human specimens, which are analysed prior to storage for various inorganic and organic substances that affect the environment. This not only provides a resource for studying changes over time, but also allows substances and their reaction products to be identified retrospectively where these were not known or could not be analysed at the time the specimen was collected.

The programme implemented by the Human Specimen Bank includes, among other things, the analysis of pollutants in whole blood, blood plasma, and 24-hour urine samples, taken from groups of students at universities in Munster (since 1984), Halle/Saale (since 1995), Greifswald (since 1995), and Ulm (since 1997). The students are all classed as having "no identifiable specific exposure to pollutants." Between 100 and 150 test subjects are selected annually from each university (approximately 90 % in the 20- to 29-year-old age group, with approximately the same number of men and women). Since the studies began, the student groups have been kept homogeneous in terms of size, age, living conditions, lifestyle, and state of health, both within the individual study groups and between groups; no significant variations in the boundary conditions have been observed.

II 1.1 Human biomonitoring for lead

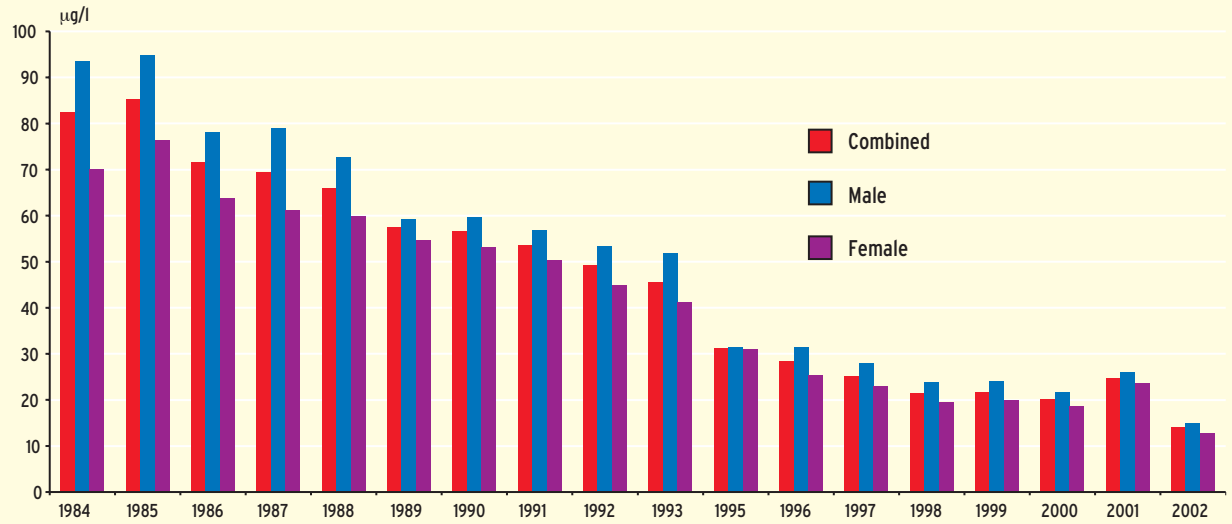
The level of lead in blood serves as a reasonable indicator of current levels of human exposure to lead, and the results from the Human Specimen Bank show a significant decrease among the student groups since the start of the continuous testing in 1984. Lead concentrations in whole blood fell from over 80 µg/l (1984) to less than one quarter of that value within 18 years (Fig. II 1-1). This can be seen as evidence of the positive effects of reductions in lead emissions from motor vehicles as a result of the lead-in-petrol law.

Evaluation

The gender-specific differences that can be seen in the lead levels in blood are likely to be due to variations in exposure situations and, because lead binds with the erythrocytes (red blood corpuscles) in blood, due to the lower proportion of erythrocytes in blood from females.

Analyses based on data obtained by the German Environmental Survey show that there is an association between the level of lead in blood and the amount of wine and beer a person consumes, and

Fig. II 1-1: *Lead in whole blood (average values) from students at the University of Munster, 1984 to 2004* [1)]



[1)] 1994 samples not collected

Source: *Federal Environment Agency 2004*

also that household drinking water plays a role. As of yet there is no plausible explanation for the association with wine and beer consumption (see also Chapter II 2.3, Heavy metals in foodstuffs), whereas the lead content of drinking water has been proven to relate to the influence of the installation materials used. By the 2003 Drinking Water Ordinance, among other values the limit value for lead was reduced from 40 to 25 µg/l on December 1, 2003. This limit value will be reduced again on December 1, 2013 to 10 µg/l, after which time the use of lead pipes for carrying drinking water will no longer be possible.

II 1.2 Human biomonitoring for platinum and noble metals

The determination of platinum was first included in the German Environmental Survey programme in 1998 (GerES III), in order to address the question of whether the environmental burden from platinum, observed following the introduction of catalytic converters for motor vehicles, has an effect on humans. The identification of gold was also included in order to provide an indicator for the use of platinum in dental alloys used for dental restoration. A random subsample of adult test subjects was used for the investigation. The results are shown in Table II 1-1 [3]. As the number of inlays, crowns and bridges made of noble metal alloys in a person's mouth increases (information provided by study participants themselves), then the clearest increase seen is in the platinum content of their urine, with a somewhat lower increase of gold content. For test subjects without dental alloys the geometric mean for the platinum content in urine was 34.2 ng/l; for test subjects who had more than 8 restored teeth this value rose to 71.8 ng/l.

Tab. II 1-1: *Noble metals in urine samples taken from 18- to 69-year-olds in Germany, 1998*

Noble metals	Population	LQ	N	P 50	P 95	GM
Gold	G	0.1	1 080	45.5	239	45.5
[ng/l]	AL	0.1	876	46.9	254	47.5
	NL	0.1	204	41.2	174	37.5
Iridium	G	0.1	1 080	0.3	1.1	0.24
[ng/l]	AL	0.1	876	0.3	1.1	0.23
	NL	0.1	204	0.1	1.1	0.28
Platinum	G	0.1	1 080	2.1	23.7	2.18
[ng/l]	AL	0.1	876	2.2	25.9	2.38
	NL	0.1	204	1.6	9.3	1.46

Explanatory notes: LQ: Limit of quantification; values < LQ are treated as LQ/2; N: Sample size; P 50, P 95: Percentile; GM: Geometric mean; G: Germany; OL: old *Länder*; NL: new *Länder*

Source: *Federal Environment Agency 2002*

Evaluation

The extent to which dental metals have significance with regard to health cannot currently be evaluated. It has not yet been possible to demonstrate a correlation between road traffic and the platinum content of urine.

II 1.3 Human biomonitoring for polycyclic hydrocarbons

Polycyclic hydrocarbons (PAH) are formed by incomplete combustion (domestic heating, motor vehicles, tobacco smoking, industry, etc.) and are widely distributed in the environment. Tests on animals have proven that certain PAHs have a carcinogenic effect.

Studies have looked at the PAH metabolites 1-hydroxy-pyrene and three different hydroxy-phenanthrenes in urine since as early as 1990/92. The results from the German Environmental Survey of 1998 are summarised in Table II 1-2 [1]. A random subsample was used for the investigation. In comparison to 1990/92 (GerES II) the 1998 Survey (GerES III) showed a clear reduction in the PAH burden, especially in the new *Länder*, where levels had begun to converge with the lower burdens seen in the old *Länder*. Smokers of approximately 10 cigarettes a day exhibit markedly higher concentrations of PAH metabolites than nonsmokers.

Tab. II 1-2: *PAH metabolites in urine samples taken from 18- to 69-year-olds in Germany, 1998*

Metabolites	Population	LQ	N	P 50	P 95	GM
1-hydroxypyrene	G	0.012	573	0.14	0.73	0.13
[µg/l]	AL	0.012	465	0.13	0.72	0.12
	NL	0.012	108	0.19	0.81	0.17
22/9-hydroxyphenanthrene	G	0.004	573	0.25	0.85	0.24
[µg/l]	AL	0.004	465	0.24	0.83	0.22
	NL	0.004	108	0.31	0.97	0.3
3-hydroxyphenanthrene	G	0.005	573	0.31	1.14	0.29
[µg/l]	AL	0.005	465	0.30	1.05	0.28
	NL	0.005	108	0.39	1.72	0.38

Explanatory notes: LQ: Limit of quantification; values < LQ are treated as LQ/2; N: Sample size; P 50, P 95: Percentile; GM: Geometric mean; G: Germany; OL: old *Länder*; NL: new *Länder*

Source: *Federal Environment Agency 2002*

Evaluation

The reduction in the PAH burden seen between 1990/1992 and 1998 is probably a result of the continuing changeover to modern heating systems. This assumption is indirectly substantiated by the fact

that people who live in properties without central heating (generally using coal-burning stoves) demonstrate higher levels of PAH metabolites. It should be emphasized that, alongside all advances in emission reductions, smoking of tobacco is the most dominant source of PAH exposure. Metabolites have also been detected in passive smokers. The influence from road traffic and the consumption of grilled and smoked food (both items on the questionnaire) that show up frequently in the literature could not be confirmed by this study. Because the environmental health database currently available is insufficient, it has not yet been possible to derive toxicology-based HBM values, which means that the health significance of the PAH metabolites measured cannot be evaluated.

II 1.4 Human biomonitoring for pentachlorophenol and hexachlorobenzene

Pentachlorophenol (PCP) and hexachlorobenzene (HCB) are biocides that were used widely in the past, including in Germany. Until they were banned in Germany in 1989 (Ordinance on the Prohibition of PCP), PCP was used predominantly as wood preservative and in protective treatments for textiles and leather; it was also used as a preservative in the production of pulp, paper, and cardboard. The use of HCB as a seed dressing for crop protection has been prohibited since 1977. Both of these chlorine compounds decompose very slowly and can therefore still be found in the environment, despite the length of time since they were last in use. HCB is known to accumulate in the food chain.

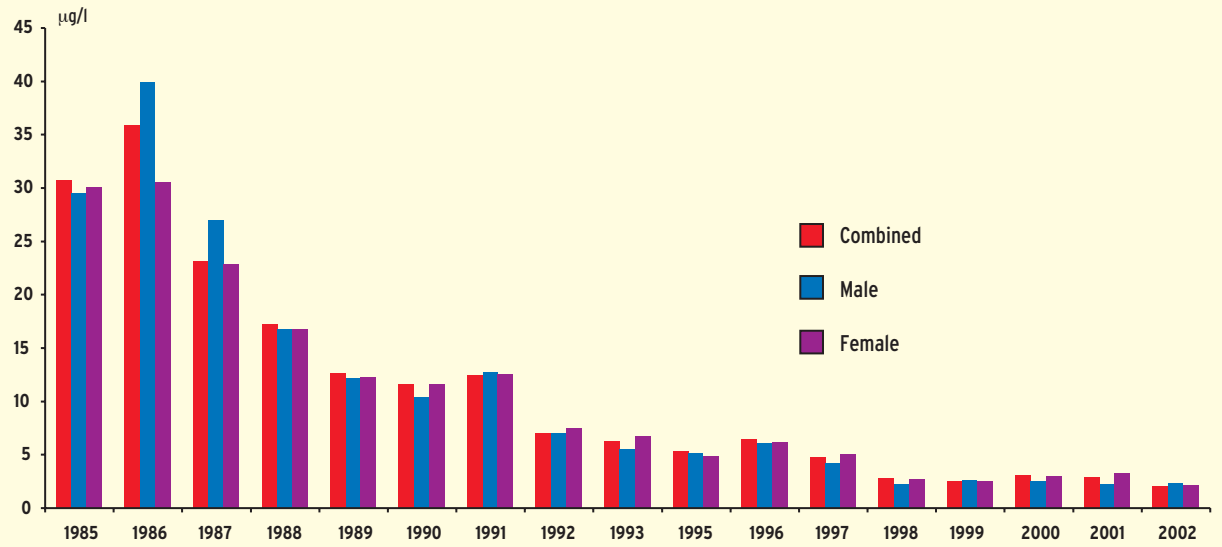
Testing for PCP and HCB was introduced to the Human Specimen Bank programme in 1985. The PCP concentrations in blood plasma collected from test subjects decreased significantly from 31 µg/l to 2 µg/l in 2002 (Fig. II 1-2). The same trend was seen in the concentrations measured in urine samples.

A significant reduction has also been recorded for HCB concentrations in blood plasma. Over a 17-year period, the average HCB content recorded fell from 3.1 µg/l to 0.18 µg/l in 2002 (Fig. II 1-3). A pronounced gender dependency was observed in relation to HCB, which was not the case with PCP; there is as yet no explanation for this.

Evaluation

The results from GerES II (1990/1992) and GerES III (1998) confirm a reduction in the PCP levels measured in urine samples (2.7 µg/l c.f. 1.0 µg/l) and household dust (0.33 mg/kg c.f. 0.25 mg/kg), which also attests to the effectiveness of the Ordinance on the Prohibition of PCP. Higher PCP levels in urine and household dust were identified for those people who indicated that wood preservatives had been used in their home in the past. PCP is released from treated wood surfaces for a long period after application, however the amount released does reduce over time [4]. Despite this, it is expected that a certain level of exposure to PCP will continue to occur due to the reuse of treated "old wood," and because of imports of treated wood, leather goods, and textiles from countries that lack or have different legal regulations relating to PCP.

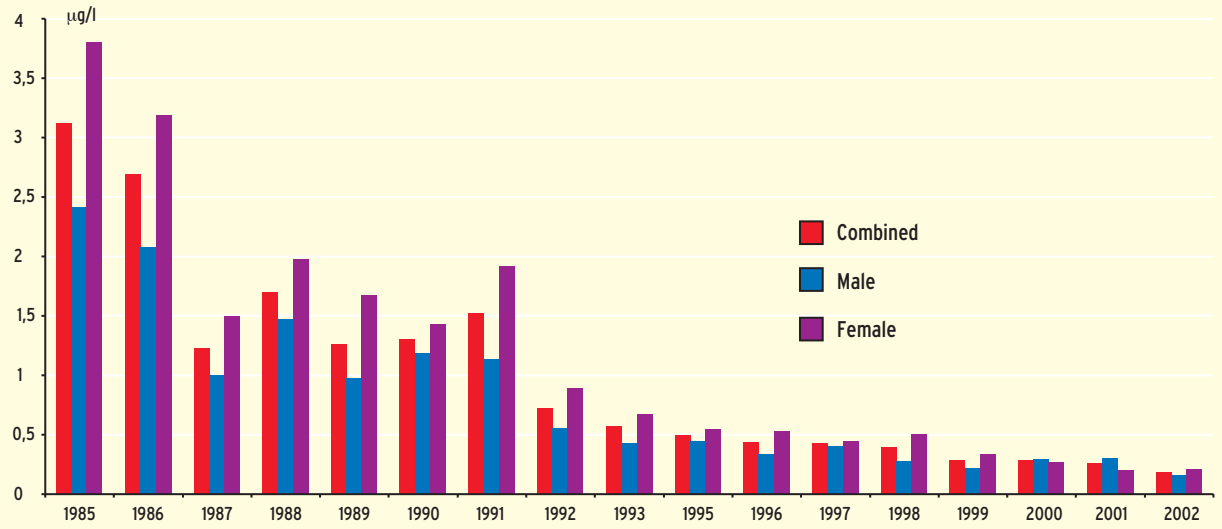
Fig. II 1-2: *Pentachlorophenol in blood plasma (average value) from students at the University of Munster, 1985 to 2002* [1)]



[1)] 1994 samples not collected

Source: *Federal Environment Agency 2004*

Fig. II 1-3: *Hexachlorobenzene in blood plasma (average values) from students at the University of Munster, 1985 to 2002* [1)]



[1)] 1994 samples not collected

Source: *Federal Environment Agency 2004*

II 1.5 Human biomonitoring for DEHP (plasticiser)

Di-(2-ethylhexyl) phthalate (DEHP) is widely used as a plasticiser for PVC and as a solvent. As a result it is found in a range of consumer related products, such as floor coverings, wall coverings, cables, children's toys and other commodity goods for children, as well as in medical equipment and packaging material for foodstuffs.

Certain phthalates have similar properties to hormones and belong to the category of endocrine disruptors. The primary area of discussion is the possible adverse effect of DEHP on human health. The testing programme for the pilot study of the "German Environmental Survey for Children" (GerES IV) therefore included the metabolites of DEHP. Urine samples taken from 3- to 14-year-old children in the period 2001/2002 were tested for these metabolites. A questionnaire was used to collect information relating to behaviour patterns likely to influence exposure, as well as conditions in the household, neighbourhood, and locality. The pilot study was intended primarily to test the methods to be used by GerES IV. The results must therefore only be taken as first indications that require further clarification through additional studies. The results are shown in Table II 1-3 [5]. DEHP was also measured in household dust (the contents of a vacuum cleaner bag). The DEHP concentrations were, in part, rather high. The geometric mean for household dust was 508 mg/kg.

Tab. II 1-3 *DEHP metabolites in urine samples from children, 2001/2002*

Metabolites	N	P50	P95	Max	GM	CI GM
MEHP [µg/l]	254	7.2	29.7	226	7.9	7.1– 8.8
MEHP [µg/g crea]	254	5.9	23.7	223	6.2	5.6– 6.9
5-OH-MEHP [µg/l]	254	52.1	188	2 590	52.1	47.2– 57.6
5-OH-MEHP [µg/g crea]	254	39.9	170	1 990	40.7	36.8– 45.1
5-Oxo-MEHP [µg/l]	254	41.4	139	1 420	39.9	36– 44.2
5-Oxo-MEHP [µg/g crea]	254	30.5	119	1 090	31.2	28.3–34.5

Explanatory notes: Limit of quantification: 0.1 µg/l

N: Sample size; P 50, P 95: Percentile; Max.: Maximum value; GM: Geometric mean; CI: Confidence interval; crea.: Creatinine (often used as a reference value for urine samples so that values for different test subjects are comparable, regardless of how concentrated the urine is as a result of how much or little they have drunk)

MEHP: Mono-(2-ethylhexyl) phthalate; 5-OH-MEHP: 2-ethyl-5-hydoxy-hexylphthalat; 5-Oxo-MEHP: 2-ethyl-5-oxo-hexylphthalat

Source: *Federal Environment Agency 2004 a*

Evaluation

There are indications that, as shown by the results of other studies, the concentration of so-called secondary metabolites (5-OH-MEHP und 5-oxo-MEHP) in urine is lower in samples taken from older children than in those from younger children. This difference between the age groups may be due to a change in the metabolism of contaminants during puberty. It was also shown that boys exhibited higher concentrations than girls. It was not possible to establish a link between the concentration of DEHP in household dust and the human body burden. It can be presumed that the main intake route is through foodstuffs. Further investigations are being carried out in this respect.

II 1.6 Human biomonitoring for organophosphates and pyrethroids

Organophosphates and pyrethroids are used in the control of agricultural and horticultural insect pests, as well as for protection of materials in commercial and domestic sectors. Use of these substances for agricultural and horticultural purposes – including use in domestic gardens and allotments – is subject to permit requirements. It can be assumed that, when used correctly, there is no danger to human health and the environment. Non-agricultural uses are also subject to an approval procedure, however this is only in the development stage. In general, the main pathway with respect to human population exposure to these biocides is through foodstuffs, however the exposure due to other mechanisms, while still insufficiently explained, should not be underestimated.

The pilot study for the "German Environmental Survey for Children" analysed urine samples, taken from 2- to 17-year-old children and adolescents in the period 2001/2002, for organophosphate and pyrethroid metabolites. The questionnaire included questions, among other things, on the use of biocides in the household. The results are shown in Tables II 1-4 and II 1-5 [6]. The pilot study was intended primarily to test the methods used by the "Environmental Survey for Children". The results must therefore only be taken as first indications that require further clarification.

Evaluation

The evaluation of the data for the organophosphate metabolites showed that the levels in urine decreased with increasing age. Higher concentrations of metabolites in urine were associated with the frequency of consumption of fresh fruit and fruit juice,

Tab. II 1-4: *Dialkylphosphates (metabolites of organophosphates) in urine of children and adolescents, 2001/2002*

Metabolites	N	P 50	P 95	Max	GM	CI GM
DMP [µg/l]	363	14	118	660	13.5	11.9–15.3
DMTP [µg/l]	363	8.3	124	505	8.2	7.0–9.7
DMDTP [µg/l]	363	<1	10.8	71.5	<1	
DEP [µg/l]	363	3.8	20	41.7	3.3	2.9–3.8
DETP [µg/l]	363	<1	11	53.4	1,1	1.0–1.3
DEDTP [µg/l]	363	<1	<1	1.61	<1	

Explanatory notes: Limit of quantification: 1 µg/l, excluding DMP: 5 µg/l

N: Number of test subjects; P 50, P 95: Percentile; Max.: Maximum value; GM: Geometric mean; CI: Confidence interval; DMP: Dimethylphosphate; DMTP: Dimethylthiophosphate; DMDTP: Dimethyldithiophosphate; DEP: Diethylphosphate; DETP: Diethylthiophosphate; DEDTP: Diethyldithiophosphate

Source: *Federal Environment Agency 2004 b*

Tab. II 1-5: *Metabolites of pyrethroids in urine from children and adolescents, 2001/2002*

Metabolites	N	P50	P95	MAX	GM	CI GM
3-PBA [µg/l]	396	0.29	2.35	19.2	0.31	0.28– 0.34
cis-DCCA [µg/l]	396	0.11	0.74	13.0	0.12	0.11– 0.13
trans-DCCA [µg/l]	395	0.19	1.73	75.9	0.2	0.18– 0.22
DBCA [µg/l]	396	< 0.1	0.52	20.9	< 0.1	
F-PBA [µg/l]	395	< 0.1	< 0.1	0.12	< 0.1	

Explanatory notes: Limit of quantification: 0.1 µg/l

N: Number of test subjects; P 50, P 95: Percentile; Max.: Maximum value; GM: Geometric mean; CI: Confidence interval

3-PBA: 3-phenoxybenzoic acid; cis-DCCA: cis-3-(2.2-dichlorovinyl)-2-2-dimethyl-cyclopropane-1-carbolic acid; trans-DCCA: trans-3-(2.2-dichlorovinyl)-2-2-dimethyl-cyclopropane-1-carbolic acid;

DBCA: 3-(2.2-dichlorovinyl)-2.2-dimethyl-cyclopropane-1-carbolic acid; F-PBA: 4-flouro-3-phenoxybenzoic acid

Source: *Federal Environment Agency 2004 b*

warmer times of year, rural living, and occupancy of rooms with wood panelling. According to conservative estimates the ADI (Acceptable Daily Intake) could be exceeded for certain children. This finding must still be confirmed by the results from the main phase of the "German Environmental Survey for Children" (GerES IV) that is currently in progress.

For pyrethroids, a significant correlation was found between the metabolites in urine and the pyrethroid content of household dust. This suggests that the human body burden associated with pyrethroids is caused by the use of these biocides in the home. According to provisional estimates, all test subjects had levels of pyrethroids well below the ADI values. This must also be confirmed by GerES IV.

II 1.7 Human biomonitoring for polybrominated flame retardants

Polybrominated diphenyl ether (PBDE) have been used since the 1970s as a flame retardant for polymers used in electronics and in synthetic textiles. Since that time, diphenyl ethers with varying degrees of bromination (congeners) have also become widespread in the environment. These are fat-soluble compounds that accumulate in the food chain, and thus find their way into human beings. The results of the evaluation of the three PBDEs with technical applications up to now carried out in the framework of the EC Existing Substances Regulation with respect to possible endocrine (hormone-like), immunotoxic, ecotoxic, and reprotoxic effects resulted in the prohibition of the marketing and use of penta- and octa-BDE within the EU (Directive 2003/11/EC, of 6 February 2003); the use of deca-BDE requires further clarification.

The results of a Swedish study show increasing levels of PBDE in breast milk samples taken between 1972 and 1997. The PDBE levels doubled every five years. Therefore, the European Scientific Committee on Toxicity, Ecotoxicity, and Environment (CSTEE) expressed its concerns regarding the exposure of suckling infants to penta-BDE, and pointed out that the increasing levels in breast milk were possibly caused by a still unidentified application of this group of materials.

Breast milk serves not just as a foodstuff for infants, but can also be used as a good biological indicator for the characterisation of the internal exposure experienced by the general population.

The Federal Institute for Risk Assessment (German: Bundesinstitut für Risikobewertung – BfR), acting on behalf of the UBA, carried out a study to investigate the question of whether the intake of food of animal origin has a significant influence on exposure to the congeners 28 (tri-BDE), 47 and 66 (both tetra-BDE), 99 (penta-BDE), 253 and 254 (both hexa-BDE), 183 (hepta-BDE), and 209 (deca-BDE). The study ran from 2001 to 2003, and involved 41 mothers who ate a mixed diet containing meat and 32 mothers with a vegetarian diet (including one vegan); milk samples were taken two and/or twelve weeks after the mothers gave birth [7]. A total of 108 milk specimens were analysed, showing an average PBDE content of 2.11 ng/g of milk fat. In the mixed diet group the average PBDE content of the breast milk was 2.47 ng/g milk fat, whereas for the vegetarian group the value was 1.65 ng/g milk fat (Table II 1-6). No difference was found between the two study groups in terms of the pattern of congeners. The largest proportion had BDE 47, followed by BDE 153, BDE 99, and BDE 100. No significant decrease of the PBDE content of the breast milk was seen after 10 weeks of breast-feeding.

Tab. II 1-6: *Average concentrations of PBDE congeners in breast milk samples, 2001 to 2004*

BDE congener	Milk samples from	
	"Omnivorous" N = 41 [ng/g milk fat]	"Vegetarian" N = 32 [ng/g milk fat]
BDE 28	0.04	0.04
BDE 47	0.95	0.53
BDE 66	0.01	0.01
BDE 99	0.29	0.15
BDE 100	0.23	0.16
BDE 153	0.66	0.52
BDE 154	0.03	0.02
BDE 183	0.09	0.07
BDE 209	0.17	0.16

Explanatory notes: "Omnivorous" mothers eat both animal and plant based foodstuffs. "Vegetarian" mothers avoid the consumption of any meat or fish. Individual choices vary with regard to the consumption of products produced by animals, such as eggs, milk, milk products, and honey. Vegans decline to consume any foodstuff that have any form of animal origin. They not only avoid the consumption of meat and fish, but also eggs and milk.

Source: *Federal Institute for Risk Assessment 2005*

Evaluation

The average PBDE level of 2.1 ng/g milk fat measured in the study corresponds well to the results from other European countries. It should be emphasized that the results from Germany lie in the lower range of values. In contrast, the current values from Canada and the USA are considerably higher, with levels of 22 ng/g milk fat and 74 ng/g milk fat respectively.

II 1.8 Human biomonitoring for nicotine and cotinine

The German Environmental Survey of 1998 (GerES III) determined levels of nicotine and its metabolite cotinine for all participants. The geometric mean values for smokers were 365 µg nicotine/l and 854 µg cotinine/l. Among ex-smokers and those who had never smoked the geometric mean values for nicotine and cotinine were below the analytical determination limits of 2 µg/l and 4 µg/l.

Nonetheless, approximately 20 % of nonsmokers in Germany are exposed to tobacco smoke in the home, at work, and in other situations [8]. Quantifiable nicotine and cotinine levels in urine were more frequent in cases where nonsmokers were exposed to tobacco smoke, compared to nonsmokers who did not experience these types of exposure. The frequency was four to six times higher in cases where family members smoked in the home, and twice as high where other people smoked in the workplace (Table II 1-7).

Tab. II 1-7: *Nicotine and cotinine in urine samples taken from 18- to 69-year-old people in Germany, 1998*

Substance	Population	LQ	N	P 50	P 95	GM
Nicotine	D	2	4 739	<2	2 110	10.5
[µg/l]	R	2	1 609	619	3 420	365
	NR	2	3 129	<2	20	1.7
Cotinine	D	4	4 739	<4	2 790	21.4
[µg/l]	R	4	1 609	1 490	3 710	854
	NR	4	3 129	<4	25	3.2

Explanatory notes: LQ: Limit of quantification; values < LQ are treated as LQ/2; N: Sample size; P 50, P 95: Percentile; GM: Geometric mean

G: Germany; S: Smoker; NS: Nonsmoker

Source: *Federal Environment Agency 2002*

Evaluation

Nicotine and cotinine in urine are valid biomarkers for use in the identification of exposure to tobacco smoke. The results of multiple regression analyses show that the consumption of foodstuffs containing nicotine (e.g., potatoes, tea, and cabbage) has no demonstrable effect on the nicotine or cotinine levels in urine.

Tobacco smoke is detrimental to health because it contains numerous carcinogenic compounds. Because of this, the MAC Commission has classified "passive smoking in the workplace" as carcinogenic to humans (causes cancer in people). Nonsmokers are entitled to specific protection from exposure to tobacco smoke. A change to workplace regulations in October 2002 has led to improvements in the protection for nonsmokers in the workplace (§ 3a ArbstättV: *Workplace Ordinance*).

[1] Becker, K., Schulz, C., Kaus, S., Seiwert, M., Seifert, B.: German Environmental Survey 1998 (GerES III): environmental pollutants in the urine of the German population. Int. J. Hyg. Environ. Health 206 (2003) 15–24,

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II 2 Exposure of foodstuffs to contaminants

In the context of the Foodstuffs and Commodities Act, foodstuffs are defined as substances that are ingested by humans in an unchanged, prepared, or processed form, and that do not have a medicinal nature. This definition of foodstuffs comprises food (including diet products), semi-luxury food (such as tea, coffee, and alcoholic beverages), and drinking water, the quality of which is monitored in accordance with the Drinking Water Ordinance.

In addition to the legislated foodstuff monitoring requirements, the German federal government and individual *Länder* also carry out an annual foodstuffs monitoring programme on the basis of the Foodstuffs and Commodities Act (LMBG). The aim is to obtain meaningful, representative data on the occurrence of undesirable substances (contaminants, residues) in the foodstuffs available in Germany, thus enabling early identification of any potential long-term health risks associated with these substances. Collection and examination of foodstuff

specimens is the responsibility of the official foodstuff inspection departments of the individual *Länder*. The responsibility for the organisation of the monitoring activities, collation of data, data archiving, evaluation of the monitoring results, and preparation of reports lies with the Federal Office of Consumer Protection and Food Safety (BVL).

Approximately 4 700 monitoring samples are collected annually, representing approximately 20 different foodstuffs. The specimens are examined for the following substances: residues of plant protective agents, heavy metals, nitrates, certain mycotoxins, and certain undesirable, persistent chlorinated hydrocarbons; the latter may be transferred to vegetable- and meat-based foodstuffs either from the environment or in the course of collecting, preparing, or processing the product. Statements based on these data in relation to trends are only possible to a limited extent, since the range of undesirable substances affecting health included in the study may vary from year to year. The identification of the dioxins present in foodstuffs is carried out in the framework of specialised dioxin measurement programmes in the individual *Länder*.

The maximum permissible content (also referred to as maximum residue level or maximum residue limit) of the following substances in certain foodstuffs is subject to mandatory legal limits specified in European law: residues of plant protective agents; contamination by lead, cadmium, mercury, and dioxins; nitrates; inorganic tin; PAH; and mycotoxins.

These quantities are established from a toxicological perspective using the "ALARA" principle ("as low as reasonably achievable"), and such that they are justifiable in terms of health considerations. The EC regulations are supplemented by national regulations for maximum permissible quantities for polychlorinated biphenyls (PCBs) in foodstuffs of animal origin.

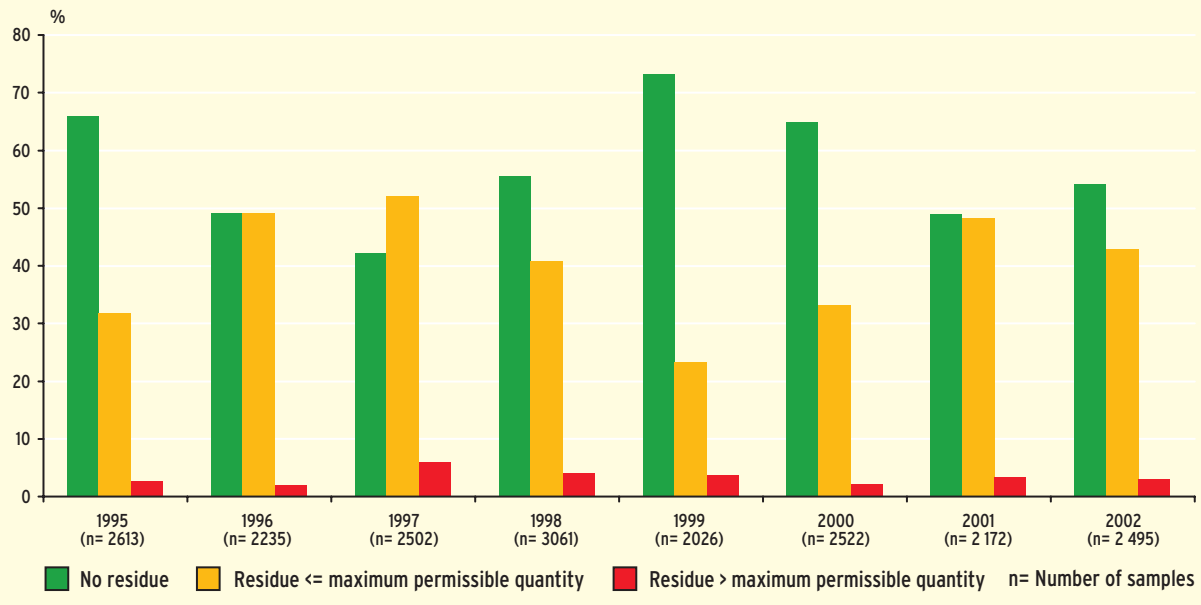
II 2.1 Plant protective agents and other persistent organic compounds in foodstuffs

Plant protective agents

Plant protective agents are used to protect cultivated plants against pests and disease while they are growing; they also ensure high yields, and prevent perishing of harvested crops during storage and transport from the producer to the consumer. They have specific uses in horticulture and agriculture and, in Germany, may only be applied in situations where approval has been granted. A plant protective agent must fulfil strict criteria in order to gain approval status. When applied correctly, approved plant protective agents will only leave small quantities of residue and there is no reason to expect that they will have any negative effect on health or the environment.

Foodstuffs monitoring uses foodstuffs selected from a specified basket of goods and looks for residues of plant protective agents whose presence cannot be excluded as a result of earlier findings or the pattern of application of the particular agent. The results are shown in Figure II 2.1-1.

Fig. II 2.1-1: *Agricultural pesticide residues in plant based foodstuffs from 1995 to 2002*



Source: *Federal Office of Consumer Protection and Food Safety 2004*

Evaluation

The majority of foodstuffs tested were not contaminated, or showed only low levels of plant protective agent residue. The permissible maximum quantities specified by the Regulation on Maximum Residue Limits were only exceeded in a small proportion of samples. The only exception to this was in 1997, when 5.9 % of samples tested had levels above the maximum permissible quantities.

Persistent chlorinated hydrocarbons, bromocyclen, and musk compounds

Persistent chlorinated hydrocarbons (also known as CHCs or organochlorine compounds) refers to a class of materials that includes numerous different substances, the best known examples of which are DDT (dichlorodiphenyl trichloroethane), PCBs (polychlorinated biphenyls), HCB (hexachlorobenzene), and HCH (hexachlorocyclohexane). They belong to a group of substances whose use in Germany is prohibited or restricted.

As a result of intensive application in the past, these CHCs are now widespread in the environment. These may find their way into foodstuff as environmental contaminants. Imported animal foodstuffs from countries in which the use of these substances is still permitted are another possible source of contamination.

Musk compounds are used, among other things, as scents in cosmetics and washing and cleaning products; bromocyclen is a medication used for animals. In 1990, both of these happened to be found in trout. They have now been included in the foodstuffs monitoring programme, although their effects on health are not known at this time.

Due to their good fat-solubility, organochlorine compounds accumulate in the food chain mainly in the fatty tissues of animals. The same is true for musk compounds and bromocylen. Mainly foodstuffs of animal origin are therefore contaminated with these substances.

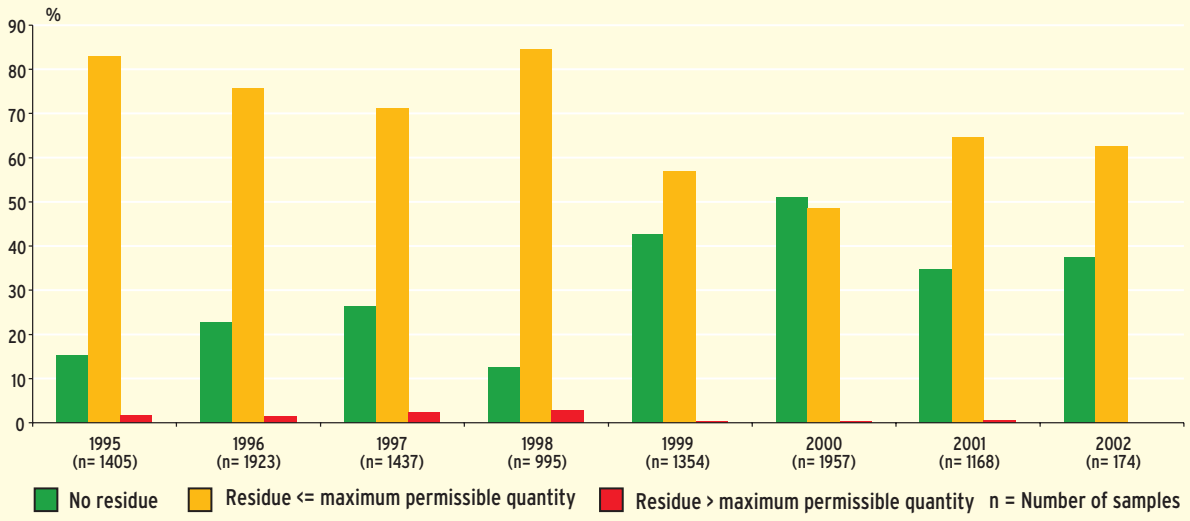
The results of the foodstuffs monitoring programme are shown in Figure II 2.1-2.

Evaluation

Happily, the occurrence of these contaminants in foodstuffs is decreasing and, apart from a few exceptions, the burden is low. This comes as a result of many years of prohibition in Germany of the use of certain persistent organic substances and, as in the case of musk compounds, from restrictions on permitted uses.

Further reductions can be expected as a result of mandatory prohibition orders under international law specified in the Stockholm Convention, which came into force on 17 May 2004. These orders cover so-called POPs (persistent organic pollutants) and are intended to provide worldwide protection for humans and the environment against these harmful substances. In the long term this will also lead to the minimisation of long range transport by air and water to Germany. Currently the convention covers the following 12 substances/groups of substances:

Fig. II 2.1-2: *Persistent chlorohydrocarbon, bromocyclen, and musk compounds in foodstuffs of animal origin from 1995 to 2002*



Source: *Federal Office of Consumer Protection and Food Safety 2004*

Aldrin, dieldrin, endrin, chlordane, heptachlor, hexachlorobenzene, mirex, toxaphene, polychlorinated biphenyls (PCBs), DDT, dioxins (PCDDs), and furans (PCDFs). Other substances that exhibit so-called "POP characteristics" may be restricted according to the terms of the Convention.

Dioxins and furans

The group of substances comprising polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), the individual substances being referred to as "congeners," are not specifically manufactured, rather they are formed as unwanted by-products of numerous industrial chemical and combustion processes. These may be transferred to the environment via exhaust, sewage, and waste material. Due to their fat-solubility, these compounds find their way into the food chain and can be shown to occur in animal fat.

Figure II 2.1-3 gives an overview of the average dioxin and furan levels in foodstuffs in Germany from 2000 to 2003, compared to the maximum permissible quantities specified by the Regulation 2375/2001/EC amended by Regulation 684/2004/EC. None of the maximum permissible levels were observed to have been exceeded.

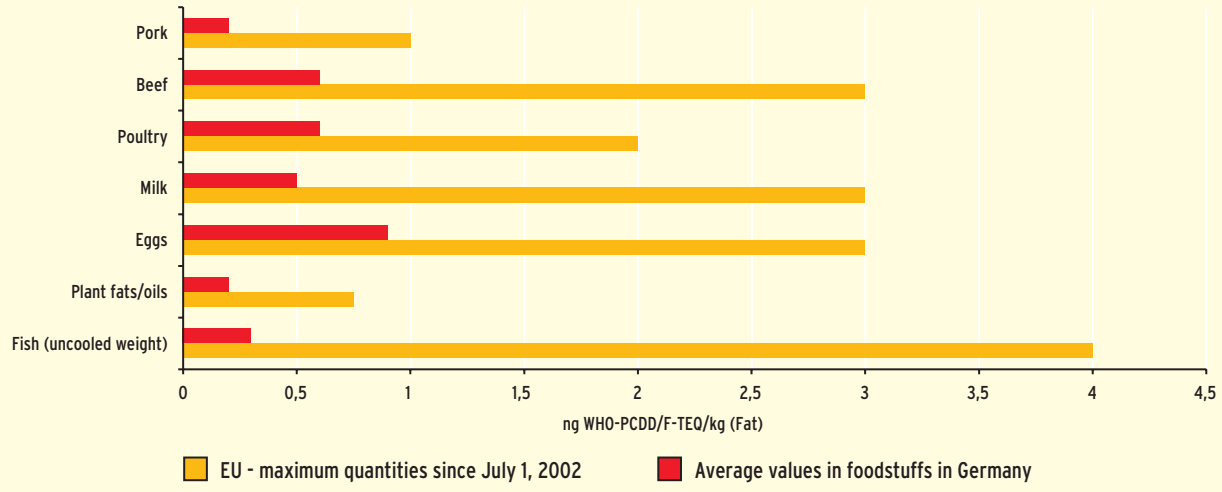
Evaluation

The dioxin congener with the greatest toxic effect is 2,3,7,8-TCDD (tetrachloro dibenzo p-dioxin), also referred to by the name "Seveso poison." The toxicity equivalents specified by the World Health Organization (WHO) determine the toxicity of other dioxin congeners in relation to the toxicity of 2,3,7,8-TCCD. In 1998, an expert group convened by the WHO determined that the tolerable daily intake of PCDD/PCDF, including dioxin-like PCBs, lies in the range from 1 to 4 pg WHO-TEQ/kg bodyweight. At the same time, the expert group recommended that all possible efforts be made to reduce the intake of these substances to a level below 1 pg WHO-TEQ/kg bodyweight. In May 2001, the European Commission Scientific Committee on Food (SCF) specified a tolerable daily intake of 2 pg WHO-TEQ/kg bodyweight.

Ninety-five percent of the human body burden from dioxins/furans comes from consumption of food, particularly foodstuffs of animal origin. The main intake sources in Germany are milk and milk products (approximately 40 %) and meat and meat products (20 %). Fish and eggs contribute a further 17 % and 8 % of the dioxin intake, respectively. The dioxin intake from sources such as fish is lower in Germany because the population consumes less fish than it does meat.

Based on the dioxin levels measured in foodstuffs during the period from 2000 to 2003, the daily intake for adults in Germany has been calculated as 0.72 pg WHO-TEQ/kg bodyweight. Compared to the period from 1987 to 1990 this represents a reduction of around 30–40 %. If dioxin-like PCBs are also taken into consideration, then the average daily intake is 2 pg WHO-TEQ/kg bodyweight. Children show a higher level of dioxin exposure because they consume more food in proportion to their bodyweight. Infants who are breastfed have a dioxin intake over 50 times higher than that experienced by adults from the food they eat. A reduction in the exposure levels for unborn children (via the placenta)

Fig. II 2.1-3: *Average dioxin and furan concentrations in foodstuffs in Germany from 2000 to 2003*



Source: *Federal Institute for Risk Assessment 2003*

and infants can only be achieved by reducing the mother's exposure.

It is therefore important that efforts continue to be made in the areas of chemical and plant safety, as well as in the monitoring of animal and human foodstuffs, in order to protect both humans and the environment from the effects of dioxins.

II 2.2 Nitrate in vegetable foods

Nitrate is a plant nutrient that occurs naturally in vegetable foods, however it may also be present as a residue due to the use of fertilisers. The concentrations in both cases can vary significantly. Some types of vegetables act as excellent "nitrate accumulators," while others accumulate significantly less nitrate given the same nitrate levels in the soil.

Some samples of lettuce, which is well-known as being one of the nitrate-rich vegetables, showed nitrate concentrations above the maximum permissible quantity (Table II 2.2-1).

Evaluation

Regulations have been introduced in order to limit the nitrate levels found in the so-called "nitrate accumulators". Maximum permissible nitrate quantities apply to spinach and lettuce within the European Union. When determining the maximum permissible quantities, certain factors are considered that have an influence on the nitrate content of vegetables. This includes the climatic conditions and, above all, the production technique, such as whether the food is grown under glass or in the open. Crops cultivated under glass during the winter months, when there are low light levels, are seen to have high nitrate levels.

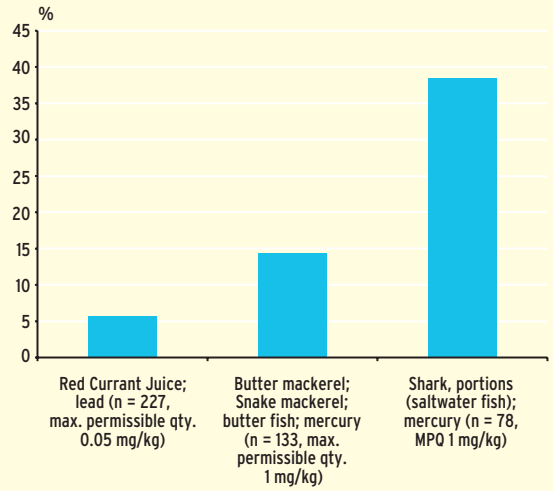
II 2.3 Heavy metals in foodstuffs

Heavy metals may be transferred to foodstuffs from the environment. The occurrence of lead, cadmium, and mercury in foodstuffs is restricted by maximum permissible quantities specified in Regulation 466/2001/EC. Measurements carried out in 2001 and 2002 to establish lead, cadmium, and mercury levels showed that only a low proportion of samples exceeded the permissible values for these heavy metals (Table II 2.3-1, Table II 2.3-2, and Table II 2.3-3).

Evaluation

Apart from the exceptions shown in Figure II 2.3-1, no particularly unusual situations were identified.

Fig. II 2.3-1: *Exceeded maximum permissible quantities (MPQ) for heavy metals in foodstuffs in more than 5 % of samples, 2001 and 2002*



Source: *Federal Office of Consumer Protection and Food Safety 2004*

Tab. II 2.2-1: *Nitrate in foodstuffs, 2001 and 2002*

Foodstuff	Number of Samples	Nitrate level (mg/kg) Median	90th percentile	Maximum
Lettuce	100	2 166	3 875	4 973
Leeks	238	307	745	3 585
Tomatoes	275	10	64	268
Apples	100	10	10	20
Spinach	99	951	1 953	3 745
Green beans	135	288	602	1 640
Carrots	82	118	352	714
Carrot juice	221	101	219	377
Prepared infant food (without animal products)	65	46	132	210
Prepared infant food (with beef)	62	34	89	122
Prepared infant food (with poultry)	61	28	95	123
Prepared infant food (with veal)	51	39	111	144

Source: *Federal Office of Consumer Protection and Food Safety 2004*

Tab. II 2.3-1: *Lead in foodstuffs, 2001 and 2002*

Foodstuffs and foodstuff groups	Number of samples	Samples with lead content > maximum permissible quantity/guide value	
		Quantity	%
Veal liver (incl. frozen)	198	1	0.5
Veal kidney (incl. frozen)	226	5	2.2
Beef kidney (incl. frozen)	290	3	1
Cuts of beef (incl. frozen)	289	3	1
Cuts of ostrich (incl. frozen)	75	1	1.3
Infant and toddler food containing corn	238	3	1.3
Norway haddock fillet (salt-water fish)	237	1	0.4
Potatoes	108	1	0.9
Green beans	160	1	0.6
Carrots	90	2	2.2
Grapes, red	226	10	4.4
Currant juice, red	227	13	5.7

Explanatory notes: The analyses carried out in 2001 were based on derived guide values provided by the former German Federal Institute for Consumer Health Protection and Veterinary Medicine; in 2002 the maximum legally permissible quantities were used. Only those foodstuffs with levels that exceeded the maximum permissible quantities/guide values are shown.

Source*: Federal Office of Consumer Protection and Food Safety 2004*

Tab. II 2.3-2: *Cadmium in foodstuffs, 2001 and 2002*

Foodstuffs and foodstuff groups	Number of samples	Samples with cadmium content > maximum permissible quantity/guideline value	
		Quantity	%
Veal kidney (incl. frozen)	226	5	2.2
Beef kidney (incl. frozen)	290	11	3.8
Pork kidney (incl. frozen)	298	7	2.3
Cuts of ostrich (incl. frozen)	75	1	1.3
Shark, portions (salt-water fish)	78	2	2.6
Spinach	104	4	3.8
Carrots	90	2	2.2
Lettuce	101	2	2.0
Leeks	256	4	1.6
Red wine	236	1	0.4
Chocolate	286	8	2.8

Explanatory notes: The analyses carried out in 2001 were based on derived guide values provided by the former German Federal Institute for Consumer Health Protection and Veterinary Medicine; in 2002 the maximum legally permissible quantities were used. Only those foodstuffs with levels that exceeded the maximum permissible quantities/guide values are shown.

Source: *Federal Office of Consumer Protection and Food Safety 2004*

Tab. II 2.3-3: *Mercury in foodstuffs, 2001 and 2002*

Foodstuffs and foodstuff groups	Number of samples	Samples with mercury content > guideline value/maximum permissible quantityt	
		Quantity	%
Veal liver (incl. frozen)	198	2	1.0
Pork kidney (incl. frozen)	293	5	1.7
Butter mackerel, snake mackerel, butterfish (salt-water fish)	133	19	14.3
Plaice (salt-water fish)	286	1	0.3
Shark, portions (salt-water fish)	78	30	38.5

Explanatory notes: The analyses carried out in 2001 were based on derived guideline values provided by the former German Federal Institute for Consumer Health Protection and Veterinary Medicine; in 2002 the maximum legally permissible quantities were used. Only those foodstuffs with levels that exceeded the maximum permissible quantities/guide values are shown.

Source: *Federal Office of Consumer Protection and Food Safety 2004*

The tables show that the maximum permissible quantity of mercury was exceeded for a high proportion of certain types of fish. This can be explained by the fact that micro-organisms found in aquatic environments convert mercury into a fat-soluble form, methylmercury. Particularly high con-

centrations of methylmercury are found in mature, fat-rich predatory fish that sit at the top of the food chain.

II 2.4 Organically produced foodstuffs

One measure aimed at reducing the environmental impact of by-products due to agricultural activity is the promotion of organic farming. In order to improve the general conditions for organic farming, at the end of 2001 the Federal Government introduced a program to encourage organic farming that includes, among other measures, increased support for the marketing of organically produced products. In order to improve the labelling of organically produced products, in 2001 a consistent national eco-label, the Bio-Siegel seal, was introduced across Germany. The market share for organically produced foodstuffs in Germany in 2002 amounted to 2.3 % (= 3 billion EUR) [1].

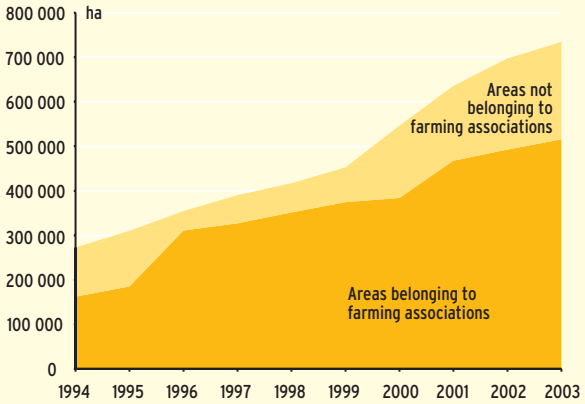
In Germany, the conversion and retention of organic agriculture are supported as a part of the Rural Development Plan, in accordance with Regulation (EC) No. 1257/1999 on the development of rural areas (as amended by Regulation 1783/2003). The federal government assists the German *Länder* with the promotion of organic farming through the joint task of "improving agricultural structures and coastal protection" (GAK). The financing for the support programme is shared between the European Union, the Federal Government, and the Lands of the Federal Republic.

Environmentally-friendly farms after the EU Eco-regulation

The legal foundations for organic farming are specified in EU Regulation 1092/91/EEC dated 24 June 1991 on organic production and labellingof agricultural products and food. This regulation is supplemented by the Council Regulation 1804/99/EC of 19 July 1999, to include animal production.

At the end of 2003, there were 16 476 farms managed in Germany, cultivating a total effective agricultural area of 734 027 ha in accordance with the EU regulations on organic farming (Table II 2.4-1 and Fig. II 2.4-1). Compared to the preceding year,

Fig. II 2.4-1: *Overall land coverage of the organic farms in Germany*



Source: *Ecology and Agriculture Foundation; Federal Ministry of Food, Agriculture and Consumer Protection 2004*

Tab. II 2.4-1: *Development of organic farms in Germany (as of 1 Jan. 2003)*

Organic Farming Associations	1989	1991	1993	1995	1997	1999	2001	2003
Demeter	17 146	23 914	30 875	38 486	46 251	48 065	51 465	
Bioland	20 000	36 343	60 313	84 750	102 542	116 739	153 916	
Naturland[1)]	2 720	10 830	20 270	32 027	35 766	57 440	72 177	
Biokreis	1 282	2 151	2 414	2 393	3 022	3 397	11 500	
ANOG	825	2 009	3 032	4 355	3 879	3 387	1 739	
EcoVin	420	285	669	966	871	877	901	
Gäa			9 667	20 830	26 535	35 254	41 200	
Ökosiegel				918	1 444	1 296	1 076	
Biopark[2)]					106 546	107 754	133 123	
Total area belonging to farming association memberst	42 393	75 532	127 240	184 725	326 856	374 209	467 097	515 254
Areas in accordance with EU Regulation 1257/1999[3)]				124 762	62 837	78 070	167 901	218 773
Overall area, organically farmed				309 487	389 693	452 279	634 998	734 027
Organic farming as a percentage of total agricultural land				1.8	2.3	2.6	3.7	4,3

[1)] excluding certified forest areas
[2)] 51 100 ha agrarian land, 81 717 ha grassland, 306 ha permanent crops
[3)] own calculation

Source: *Ecology and Agriculture Foundation; Federal Ministry of Food, Agriculture and Consumer Protection 2004*

this represented an increase in the number of organic farms of 5.3 %, and the cultivated area increased by 5.4 %.

Organic farming in Germany is, in terms of land use, above the EU average, however it still only occupies a middle position behind countries such as Italy, Austria, Switzerland, Liechtenstein, Sweden, Denmark, or Finland (Fig. II 2.4-2).

Environmentally-friendly farms in accordance with farming associations

The farming associations were originally a part of the "Arbeitsgemeinschaft für Ökologischen Landbau" (AGÖL) but since 2002 most of them belong to the Association of Organic Food Producers and Traders (BÖLW). The aims of the BÖLW are to promote the development of organic farming and to provide a united voice to represent the members' common interests. The focus of its activities is the formation of a political framework.

The following organic farming associations presently operate in Germany:

- Demeter: Research network for Biodynamic(r) Agriculture (founded 1924),
- ANOG: *AG für naturnahen Obst-, Gemüse- und Feldfruchtanbau e.V.* (founded 1962). Merged with Naturland in 2002,
- Bioland: *Bioland-Verband für organisch-biologischen Landbau e.V.*: Bioland organic farming association (founded 1971),
- Biokreis: *Biokreis Ostbayern e.V.*: association for organic agriculture and a healthy diet, East Bavaria (founded 1979),
- Naturland: *Naturland-Verband für naturgemäßen Landbau e.V.* (founded 1982),
- ECOVIN: *Bundesverband ökologischer Weinbau e.V.* (founded 1985),
- Ökosiegel: *Ökosiegel e.V.* (founded 1988),
- Gäa: *Vereinigung Ökologischer Landbau e.V.* (founded 1989),
- Biopark: *Biopark e.V.* (founded 1991).

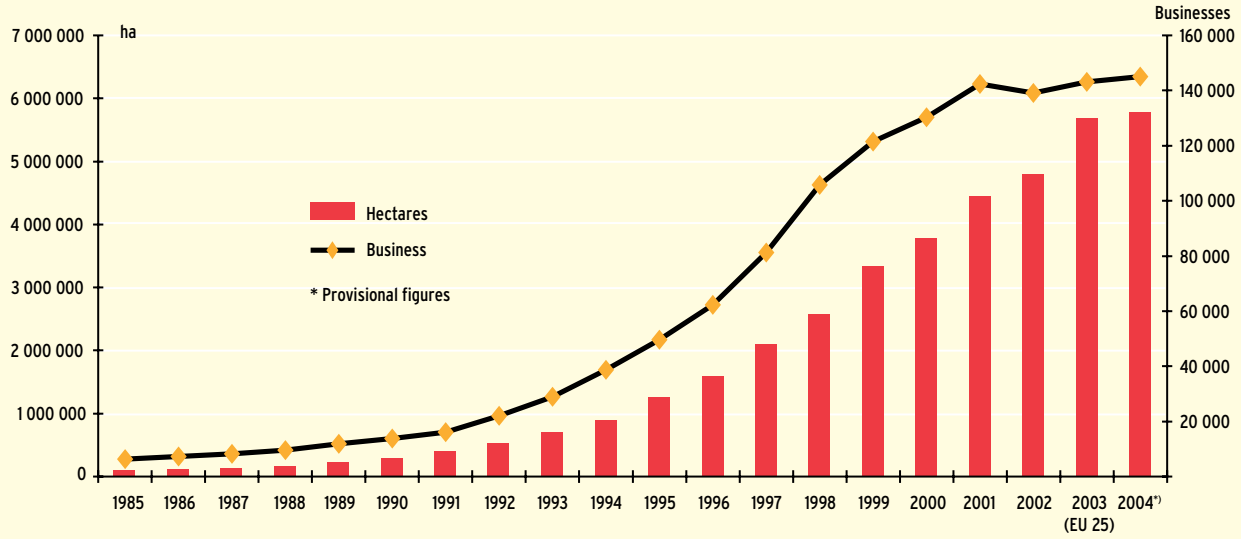
According to information from BÖLW, the number of federation-associated organic producers rose by 179 farms in 2003, or just over 2 % of the total membership of 9 566. The cultivated land used by these business rose by 23 348 ha, or 4.7 % of a total 515 254 ha.

[1] Ulrich Hamm: *Zentrale Markt- und Preisberichtstelle (ZMP),* Neubrandenburg 2003 www.soel.de/oekolandbau/deutschland

II 3 Drinking water

The term "drinking water" is used synonymously with the term "water for human consumption" here, as per the amended drinking water regulations (valid from January 1, 2003). Drinking water is defined as being water that is suitable for human use and consumption, which must comply with particular quality standards, as defined by law and in technical regulations. Among the basic requirements are that drinking water be free of pathogenic agents, does not contain concentrations of chemicals that may be harmful to health, is low in bacteria, and is appetising (clear, colourless, cold, odourless, no unpleasant taste).

Fig. II 2.4-2: *Development of organic farms in the European Union (as of 12/31/2004)*



Source: *Welsh Institute of Rural Sciences; Ecology and Agriculture Foundation; Research Institute for Biological Farming 2005*

Tab. II 3-1: *Quality of drinking water from large waterworks in Germany (supply area with more than 1 000 m^3 or more than 5 000 inhabitants)*

Parameter	Limit value (as per-drinking water regulation 1990)	Number of measurements			Category A limit value Complies			Category B limit value Does not comply		
		1999	2000	2001	1999	2000	2001	1999	2000	2001
Odour	2 bei 12 °C 3 bei 25 °C	77 571	77 420	69 225	77 554	77 412	69 223	17	8	2
Turbidity	1.5 turbidity units/formazin	78 459	81 990	79 461	78 361	81 887	79 356	95	103	105
Temperature	25 °C	65 633	63 367	67 786	65 631	63 366	67 783	2	1	3
Conductivity	2000 µS cm^{-1}	75 923	79 006	76 944	75 923	79 005	76 944	0	1	0
pH value	not below 6.5 not over 9.5	57 270	65 391	54 622	57 217	65 254	54 588	38	137	34
free chlorine	0.3 mg/l	47 906	50 773	39 167	47 895	50 734	39 143	11	39	24
Nitrate	50 mg/l	18 772	20 411	18 341	18 556	20 193	18 199	213	218	142
Nitrite	0.1 mg/l	13 327	14 179	12 785	13 703	14 161	12 776	30	18	9
Ammonium	0.5 mg/l	12 174	14 048	11 558	12 153	14 028	11 546	21	20	12
Coliform bacteria	0 in 100 ml	188 376	191 389	202 396	194 854	190 289	201 124	1 278	1 100	1 272
E. coli	0 in 100 ml	188 293	191 525	202 434	195 800	191 178	202 226	468	347	208
Colony count 20°C	100[1])(20[2]) per ml	165 960	181 880	175 511	173 260	134 072	174 650	621	669	861
Colony count 36°C	100[1])(20[2]) per ml	165 960	181 964	175 529	173 417	134 325	174 925	489	500	604

[1]) Guide value; [2]) with disinfection of the drinking water

Source: *Federal Ministry of Health and Social Security 2002*

The monitoring of drinking water in Germany is regulated through the new drinking water regulations (Drinking Water Ordinance 2001), which implement the European directive on the quality of water for human use set forth in the November 3, 1998 (98/83/EC) national law.

The following text describes the data routinely obtained by the centralised public utilities relating to the quality of drinking water delivered by waterworks in Germany.

In 2001, over 68 million inhabitants, approximately 84 % of the population, were supplied with 4 212 million cubic meters of drinking water from the central drinking water supplies. Of the raw water treated to be supplied as drinking water, 74 % originated from ground water, 17 % from surface water, and 9 % from other sources (e.g., bank filtrate). It is not possible to present a complete summary of the data held due to the lack of homogeneous data relating to the quality of the drinking water supplied throughout Germany as a whole. The data summarised in Table II 3-1 are extracted from the sectoral report on drinking water quality submitted to the EU. This report is prepared for the European Commission every three years by the Federal Government. The report contains information on a range of drinking water quality parameters specified by the EU, and relates to those water supply facilities that supply drinking water to more than 5 000 residents, or that feed more than 1 000 m^3 of drinking water per day into the public supply network. The figures relate to reports submitted by each of the 16 *Länder* during the period 1999 to 2001, in accordance with the prescribed parameters, and are grouped into two catergories; Category A (limit value complied with) and Category B (limit value not complied with).

In comparison to the total number of measurements, the number of times the limit values are exceeded is very small at less than 1 % (with the exception of nitrate, for which 1.1 % of the samples exceeded the limit value in 1999 and 2000). The data reflects the fact that in Germany the overall quality of the drinking water can be classified as good to very good. The number of times the limit values were exceeded does not in itself show to what extent the drinking water in Category B is negatively affected. Moreover, it is not possible to make any inference from the values in Category B about the quantity of water supplied, or the number of consumers affected. This is because samples taken from the water supply facilities in accordance with the drinking water regulations are not collected at regular intervals, and only the measurement totals and respective classifications in the two categories are reported.

II 4 Bathing waters

While bathing is necessary for good health, it can also be associated with certain health risks. Because of the occurrence of certain pathogenic agents, the possibility of sickness must be considered when bathing in open waters; this is often characterised by fever, diarrhoea, and vomiting. These types of incident are predominantly caused by discharges from sewage treatment plants, combined waste and rainwater drainage systems, and agricultural sources.

The discharge of excessive quantities of nutrients, particularly phosphorus and nitrogen compounds, causes a further problem by encouraging the mass reproduction of cyanobacteria (also known as blue-green algae) and the associated formation of algal toxins and allergens. Algal toxins and allergens can cause acute health problems (e.g., conjunctivitis, rashes) and chronic reactions (liver damage). In addition to this, affected waters will have a high level of turbidity, which is not only a problem from an aesthetic point of view, but could also interfere in the rescue of someone who is drowning.

Monitoring of natural bathing waters

The monitoring of outdoor bathing water quality in Germany is regulated by the individual *Länder* by means of state orders that implement the limit values and guidelines specified by European directive (76/116/EEC) on the quality of bathing water dated December 8, 1975 (116/83/EC). Copies of this directive can be obtained from the member states. In order to avoid or reduce the health problems associated with bathing, natural outdoor bathing waters should contain as few pathogenic micro-organisms as possible. The level of certain indicator organisms must not be exceeded and the visibility must extend to a depth of 1 m.

The evaluation of health risks is carried out using limit values for so-called indicator organisms. The following text only considers Escherichia coli *(E. coli)* and coliform bacteria. The *E. coli* bacterium serves as an indicator of faecal pollution. This bacterium occurs in the intestines of humans and animals and, although generally harmless, can be used to indicate that sewage contaminated with faeces has been transferred into a body of water. The EU directive requires that bathing waters contain no more that 2 000 E. coli bacteria per 100 ml of water. The term coliform bacteria refers to bacteria that live outside of the intestine. These must not be present in bathing waters in concentrations any higher than 10 000 bacteria per 100 ml. In addition to these values, which are referred to as limit values, the EU bathing waters directive also defines lower, that is stricter, values that should be complied with whenever possible. These are known as guide values (100 E. coli/100 ml and 500 coliform bacteria/100 ml).

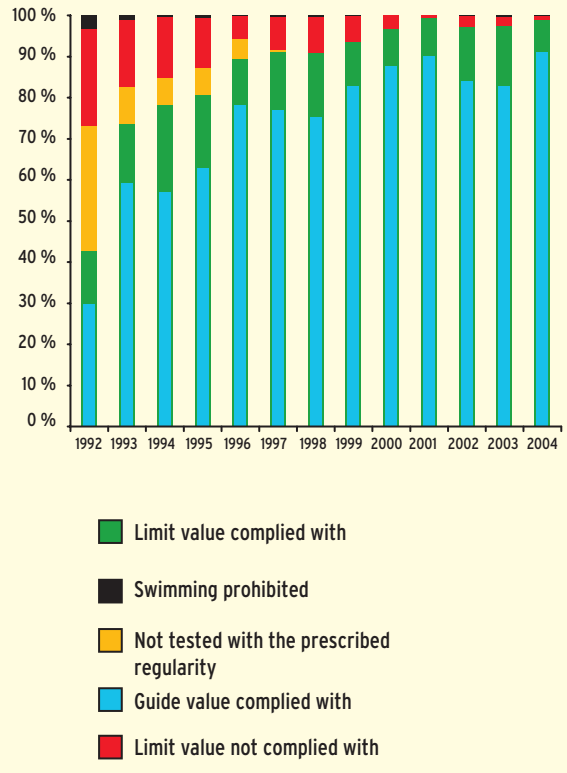
Quality of bathing waters in Germany from 1992 to 2004

In 2004 a total of 1 951 bathing areas in Germany were designated as so-called "EU bathing areas," of which 390 are on the coast. The hygiene data from these bathing areas are reported to the EU, which in turn produces a quality rating for each location (Fig. II 4-1 and Fig. II 4-2).

Evaluation

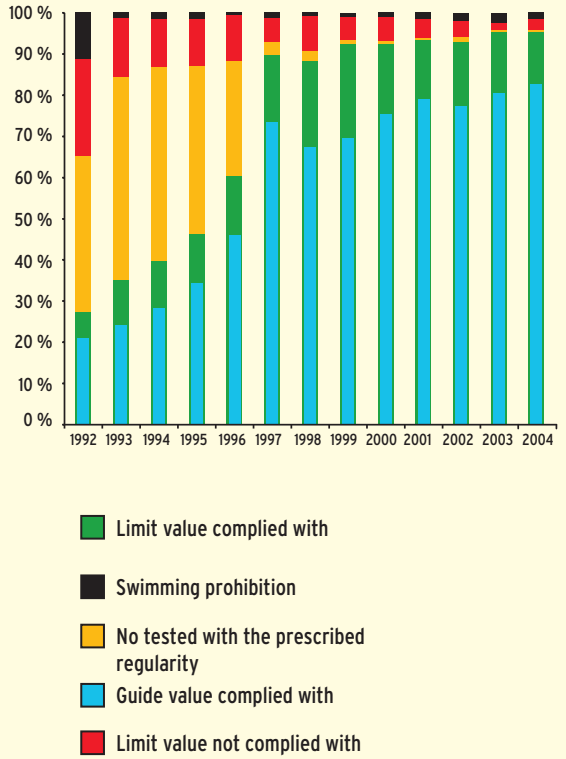
The number of incidences of guide and limit values, and correspondingly the level of pollution in bathing waters, being exceeded has been continually decreasing since 1992. This does not, however, preclude the possibility that there remains a risk to health from bathing waters. When the limit values specified in the EU bathing water directive were set in 1975 it was assumed that there would be no appreciable risk to health provided that the limit values were complied with. The main reason for this was that, in those countries where levels similar to those chosen already existed, no pronounced clusters of bathing-related illness had been observed.

Fig. II 4-1: *Bathing water quality on the German coasts, 1992 to 2004*



Source: *European Commission 2005*

Fig. II 4-2: *Bathing water quality for inland waters in Germany, 1992 to 2004*



Source: *European Commission 2005*

Epidemiological studies into the infection risks from bathing that have been carried out since that time have confirmed the suspicion that the current limit values are set too high. An increased incidence of illness has also been observed following bathing in those bodies of water that do comply with the EU limit values. Serious illnesses do not occur however. The illnesses seen included mild diarrhoea that cleared up in a few days without any treatment. As a result, an amendment to the EC directive with regard to stricter limit values is currently under discussion at the EU level.

III NOISE

Every type of sound that can cause a disturbance, a nuisance, or harm is referred to as noise. Noise cannot be measured using physical measuring techniques because noise is the result of cognitive analysis of various sounds. It is only possible to measure the physical properties of sounds, such as sound pressure, sound spectrum, etc. Noise pollution is characterised using sound pressure levels given in decibels (dB(A)).

III 1 Disturbances from noise from different sources

There is hardly a single resident in Germany who is not affected by noise. This is the finding of a representative survey of the population comprising approximately 2000 adults ("Environmental Awareness in Germany 2004" Umweltbewusstsein in Deutschland 2004) (Tab. III 1-1).

Tab. III 1-1: *Noise disturbances affecting the population, according to noise source, 2004*

Noise source	Severity of disturbance (% of population affected)				
	Extreme	High	Medium	Low	Not affected
Road transport	4	6	20	30	40
Neighbours	2	4	11	26	57
Air traffic	1	3	8	20	68
Trade and industry	0	2	5	12	81
Rail traffic	1	2	5	12	80

Source: *Federal Environment Agency 2004*

Traffic noise

As in previous years, the predominant source of noise in residential environments is road traffic, which over half the population still finds to be a nuisance, and 10 % (8 million people) consider to be a "serious nuisance".

After road traffic, air traffic is the most significant cause of noise pollution in Germany. Across Germany as a whole, almost one-third of people considered air traffic noise to be a nuisance.

About one-fifth of the population found rail traffic noise to be a problem.

Noise from trade and industry

About one-fifth of the population are troubled by noise from industry and businesses.

Neighbourhood noise

The survey also shows that noise generated by neighbours is also among the most significant causes of noise disturbance. Over 40 % of respondents felt themselves affected.

Noise exposure from road and rail traffic

The exposure to traffic noise of the populatin is usually estimated using model-based simulations (Tab. III 1-2). In comparison to previous years, the input variables for the simulation models have not changed considerably. Although technical measures implemented on vehicles have achieved lower noise emissions, other factors, such as the increase in road traffic mileage, have served to negate any improvement.

Tab. III 1-2: *Noise disturbance to the population (old Länder) from traffic noise*

Equivalent level	Population in (%) affected by:			
	Road transport 1999		Rail traffic 1997	
[dB(A)]	Daytime	Nighttime	Daytime	Nighttime
> 45 – 50	16.4	17.6	12.4	15.5
> 50 – 55	15.8	14.3	14.9	10.8
> 55 – 60	18	9.3	10.4	6.2
> 60 – 65	15.3	4.2	6.2	2.7
> 65 – 70	9	2.9	2.3	0.9
> 70 – 75	5.1	0.2	0.7	0.4
> 75	1.5	0	0.1	0.1

Source: *Federal Environment Agency 2000*

In 1999, as in previous years, road traffic represented the predominant source of noise. During the daytime, 15.6 % of the population are affected by sound levels over 65 dB(A), and nearly half by levels over 55 dB(A). The noise exposure is also high overnight in many locations, with about 17 % of the population exposed to sound levels above 55 dB(A) and 31 % by levels over 50 dB(A).

The percentage of the population affected by noise from rail traffic is lower than with road traffic. In 1997, 3.1 % of the population were affected during the day by sound levels over 65 dB(A), and about 20 % by levels over 55 dB(A). Overnight, about 10 % of the population were exposed to sound levels above 55 dB(A) and 21 % by levels over 50 dB(A).

Assessment

Noise is not something that is simply a nuisance or something that interferes with communication, but

can also represent a risk to health due to chronic disturbance of sleep, relaxation, and intellectual work.

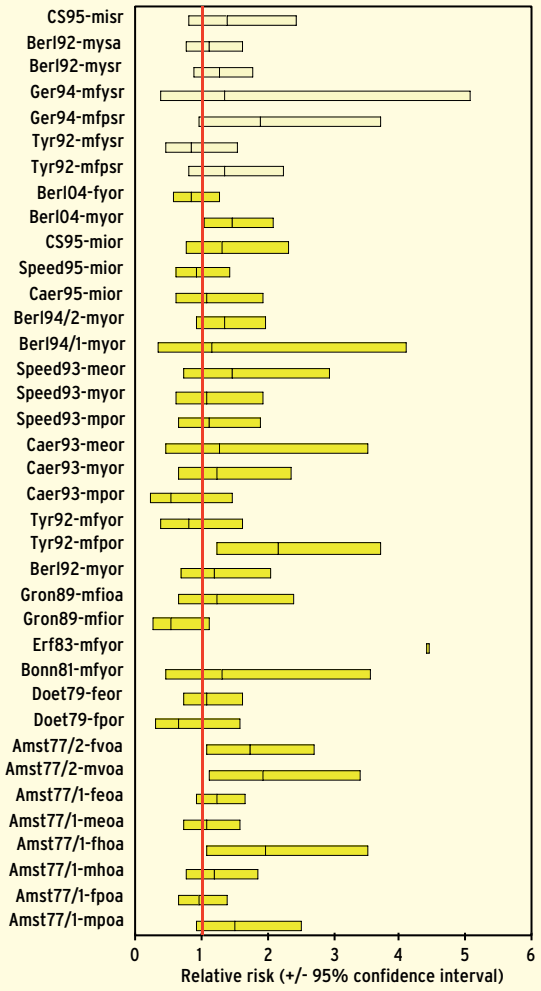
Noise caused by road and rail traffic can give rise to vegetative and endocrinal reactions (extra-aural effects). With sound levels over 45 dB(A), disturbance to sleep can be expected at night when sleeping with an open window, and daytime levels over 65 dB(A) give cause for concern due to an increased risk of illnesses such as cardiovascular disease.

Epidemiological studies have shown a relationship between traffic noise and ischaemic heart disease (e.g., angina pectoris, cardiac infarction) [1], [2]. The results of an evaluation of these types of study are given in Figure III 1-1 in the form of an analysis of various international studies. The individual studies are identified using a code that summarises the location of the survey, the publication year, and the population group studied (see key on the diagram). For example, "Berl92-myor" indicates that the study was compiled in Berlin and published in 1992. The study group comprised men (m), the illness considered was cardiac infarction (y), the source of noise was road traffic noise (r), and measurements were obtained using objective techniques (o).

The relative risks (RR) and statistical spread are shown for the individual traffic noise studies (95 % confidence interval). Bars that lie towards the right and have an RR of greater than 1 show that ischaemic heart disease is more common in areas with higher levels of traffic noise than in those with lower levels. If the entire statistical spread is in the range greater than 1, then the difference is statistically significant.

Taken in conjunction with the Federal Environment Agency's simulation models this gives rise to the concern that approximately 12 million inhabitants of Germany are at increased risk of ischaemic heart disease as a result of traffic noise. Currently it is considered that an appreciable increase in the risk occurs with sound exposure levels outside dwellings greater than 65 dB(A) during the day and 55 dB(A) at night. Keeping noise below these levels therefore represents an environmental quality objective that should be achieved. In contrast to the results from previous investigations, the new study results from 2004 [3] do not allow a threshold value for increased risk to be identified. This means that even with moderate exposure levels there is a slightly increased risk of cardiovascular problems.

Fig. III 1-1: *Statistical relationship between traffic noise and ischaemic heart diseases*



Key: f Females, m Males; Noise measurement: o Objective (sound level), dark yellow bars; s Subjective (nuisance), light yellow bars; Type of noise: a Aircraft noise; r Road noise; Type of heart problem: e ECG ischaemic indications, h Heart trouble, i Ischaemic heart disease, p Angina pectoris, v General cardiovascular problems, y Cardiac infarction

Source: *Federal Environment Agency 1998*

[1] Babisch, W.: *Epidemiological studies on cardiovascular effects of traffic noise*. In: Prasher, D. and Luxon, L. (eds.): Advances in noise research, Volume 1: Biological effects of noise. Whurr Publishers Ltd., London 1998, 312–327

[2] Babisch. W.: (2000) *Traffic noise and cardiovascular disease*: *epidemiological review and synthesis*. Noise Health 2 (2000), 9–32

[3] Federal Environment Agency (UBA) (Ed.): *Chronischer Lärm als Risikofaktor für den Myokardinfarkt*. Research report 297 61 003, UBA-FB 000538. Berlin 2004

III 2 Means and measures for the reduction of disturbance due to noise

A significant reduction in the disturbance caused by environmental noise from road, rail, and air traffic can only be achieved by using an agreed set of individual means and measures – including vehicle and aircraft technology, tax law, and traffic planning.

Alongside various means for traffic avoidance (including the "Stadt der kurzen Wege" – literally "city of short distances" – concept) and the shift of traffic to more environmentally friendly means of transport, the use of state of the art measures for limiting noise emissions also plays a particularly important role in this type of concept. This type of "at source" measure has an all-encompassing effect, and as such is preferable to localised solutions, such as noise barriers and sound insulating windows. Means for reducing noise emissions are targeted at producing quieter cars and aircraft, driving styles, inbound and outbound flight procedures, and road systems. In this respect it is essential that noise emission limit values be consistently matched to the state of the art, and that the advancement of the state of the art be promoted and supported through tax incentives.

Noise emission limit values for motor vehicles

EU directives, which have been adopted in the Road Traffic Licensing Ordinance (StVZO), specify measuring techniques and noise emission threshold values for driving noise (maximum pass-by level under acceleration at a distance of 7.5 m). The emission threshold values for cars, heavy goods vehicles, and buses were reduced in two stages during the 1980s. The last reduction has been applicable to new vehicles since October 1996. In addition to this, an EU-wide noise regulation has been established covering all new tyres sold, and this forms an important basis for reducing tyre and road noise.

Driving noise type approval for cars, vans, and heavy goods vehicles

Motor vehicles must comply with the limit values for noise specified by the StVZO in all cases where they are licensed for use on public roads. An officially mandated measuring technique is used to determine the driving noise from motor vehicles ("type-approval test procedure"), and the type test value is entered on the vehicle registration documents by the Federal Road Vehicle Authority (KBA). The United Nations Economic Commission for Europe (UN-ECE) is currently preparing a revised version of the type-approval test procedure in order to ensure that the driving and operating conditions specified in the type-approval test procedure are better matched to the relevant conditions in real traffic.

Noise emission threshold values for railways

Within the framework of Directive 2001/16/EC of 19 March 2001 on the interoperability of the trans-European conventional rail system, the European Commission has introduced binding, Europe-wide requirements, including noise emission limits for newly approved rail-bound vehicles, be specified in the "technical specifications for interoperability (TSIs)". A further contribution to the reduction of rail traffic noise in all areas can be expected from measures applied to rail-bound vehicles already in operation, above all from the equipping/converting of the particularly noisy goods wagons to use quieter composite brake shoe inserts. It is also possible that, as a supporting measure on the side of the railway infrastructure companies, a sliding scale of noise-emission-dependant prices for different routes may be considered.

Noise emission limit values for aircraft

In 2001, the International Civil Aviation Organisation (ICAO) reduced the noise limit values for new commercial aircraft by 10 decibels (cumulative value at three measuring points). Advancement of the state of the art will require a further reduction of the limit value. The new directive 2002/30/EC on the "rules and procedures for noise-related operating restrictions at Community airports" of 26 March 2002 (OJ EC No. L85, P. 40) created, for the first time, a Community-wide framework for the introduction of noise-related operating restrictions.

Exposure limit values

Road and rail noise

The traffic noise directive of 12 June 1990 (16th BimSchV) specifies exposure limit values for the protection of neighbourhoods from harmful environmental impact caused by traffic noise (noise provisions), which apply to noise protection in relation to newly built or substantially altered public roads and track systems for railways and trams.

There are no statutory regulations of this type that apply to the existing transportation network, however the 1997 "guidelines for protection against traffic noise on federal trunk roads included in the construction obligations of the state" do apply, and include noise remediation thresholds which govern remediation of federal trunk roads. Noise reduction measures on existing state railway track systems are part of a remediation programme introduced in 1999. Approximately 51 million EUR have been made available annually from the federal budget and used for noise reduction in accordance with remediation thresholds that correspond to those applicable to the federal trunk road network.

Aircraft noise

Noise protection in areas surrounding large airports is governed by limit values for the designation of

noise protection areas as specified by the German federal law on prevention of aircraft noise of 30 March 1971 (BGBl. I S. 282). This includes structural sound protection measures as well as prohibitions on construction and building restrictions. On 25 May 2005 the German Federal Government passed the draft version of a law amending the aircraft noise law, which has the objective of substantially improving the protection provided to the population against noise from all airports.

Noise mapping and noise reduction planning

As a result of the requirements of Directive 2002/49/EC, which is adopted into German law, in the future strategic noise maps must be prepared for all main roads, major railway routes, large airports, and other sources of noise in metropolitan areas. These maps will form the basis for the subsequent development of noise reduction plans, with the aim of combating environmental noise by means of traffic planning, regional planning, technical measures implemented at source, sound protection measures, and economic incentives.

Reduction of neighbourhood noise

A so-called "building-passport for acoustics" is currently under development. This will contain all data relevant to the acoustics of a building or apartment. The quality of a building with respect to its acoustic properties is very difficult for a purchaser or tenant to identify since these are "hidden quality characteristics". The building-passport for acoustics will list all sound protection measures according to their classification. The specification of sound protection according to quality levels makes the sound protection used in a building transparent for the potential user. This type of passport will be created during construction and updated when modifications are made; it will be passed on to the occupant as a supplement to the rental or purchase contract.

III 3 Historical trends in noise emissions from different sources

Noise emissions from passenger vehicles and heavy goods vehicles

Trends in pass-by noise levels

The reduction of noise limit values for motor vehicles over the last 25 years has not resulted in a corresponding reduction in noise emissions from actual traffic (Fig. III 3-1 and Fig. III 3-2).

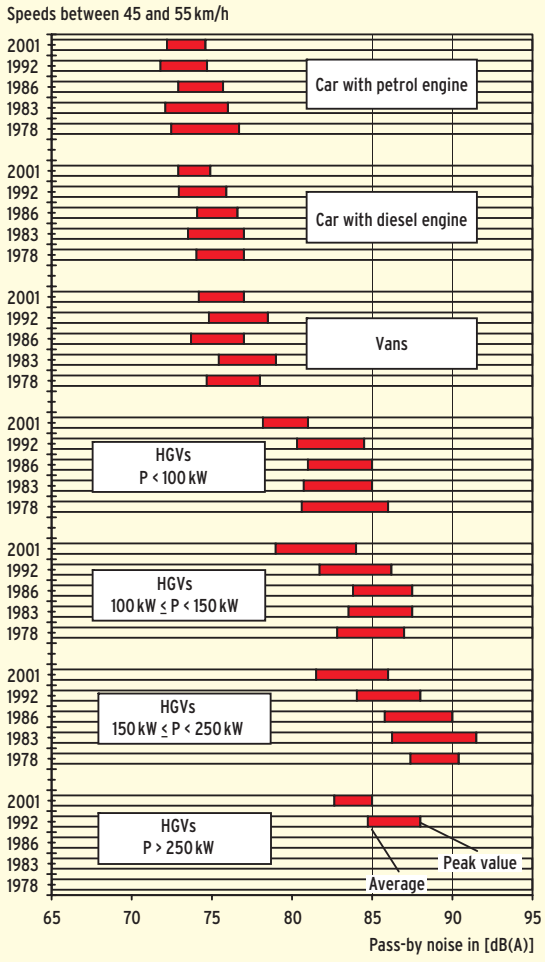
- The average noise emissions from passenger vehicles in built-up areas have remained unchanged, and for steady out-of-town driving they have actually increased slightly.

- A 5 dB(A) reduction in the pass-by sound level from goods vehicles was reported in built-up areas. The greatest reduction in noise emissions in built-up areas was achieved for heavy goods vehicles. Unfortunately, this positive development was not seen for steady out-of-town driving, where pass-by noise levels remained largely unchanged.

At higher speeds, the tyre/road noise dominates the overall noise emissions of motor vehicles. Noise-optimised tyres and road surfaces can therefore make an effective contribution to the reduction of noise emissions from road traffic.

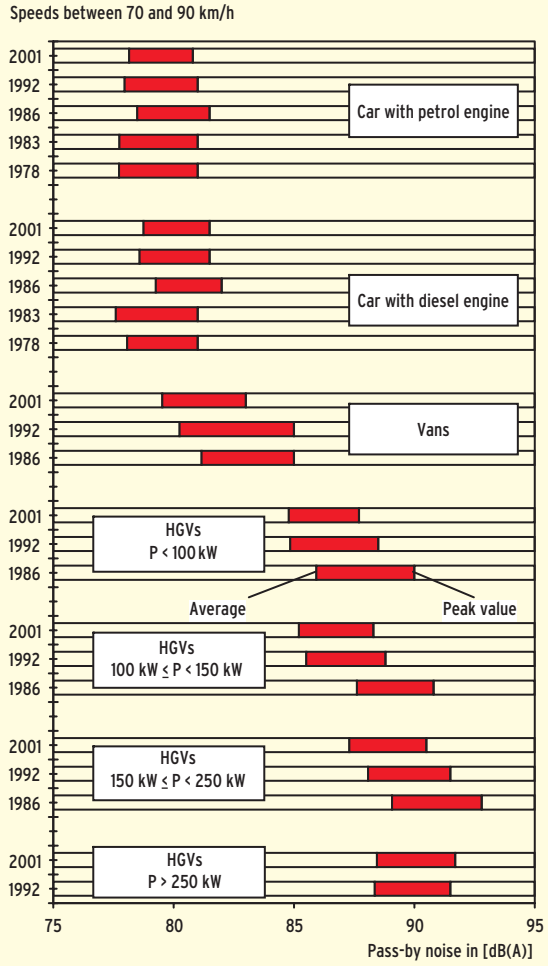
On the same road surface, the tyre/road noise (rolling noise) varies by about 3–4 dB(A) between different types of passenger vehicle tyres that correspond to the state of the art. Moreover, it has been

Fig. III 3-1: *Trends in pass-by noise for different vehicle classes for steady driving in built-up areas*



Source: *Federal Environment Agency 2005*

Fig. III 3-2: *Trends in pass-by noise for different vehicle classes for steady driving in out-of-town areas*



Source: *Federal Environment Agency 2005*

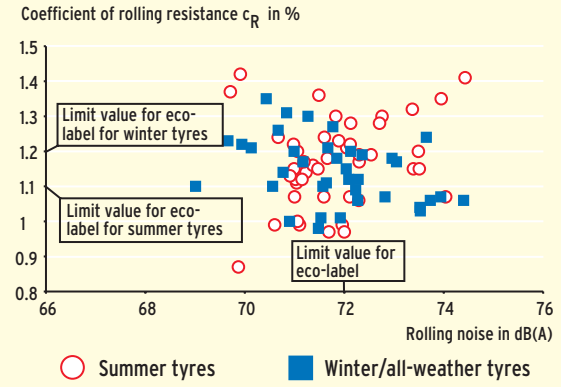
shown that there is no conflict between low noise properties and the rolling resistance value, which is an important factor for fuel consumption (Fig. III 3-3), nor is there any conflict with other safety-relevant properties of the tyre. This means that every individual car driver is able to make a contribution to the reduction of road traffic noise by buying low-noise, fuel-efficient tyres.

Noise emissions from wind power stations

The German Federal Government's Environmental and Energy Saving Program (ERP) supports, among other things, the installation of wind power stations (Chapter VII 1.3). In 2001, around 1.5 billion EUR in the form of reduced-interest, long-term development loans was made available by the Deutsche Ausgleichsbank to provide financing for these projects.

In promoting wind power stations, there are requirements for noise prevention that must be considered alongside the eco-political merit of the development; meeting these requirements should be ensured by use of state of the art installations and operating practices.

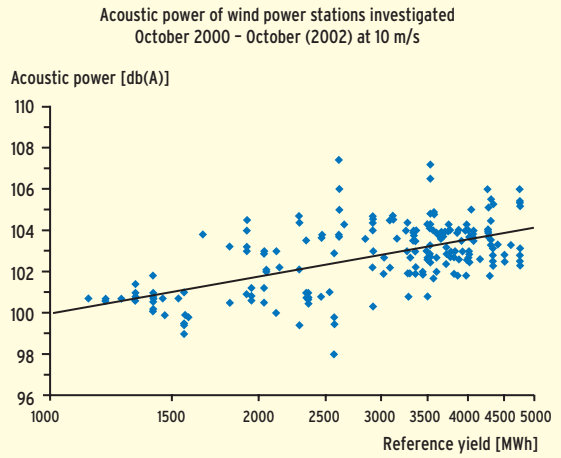
Fig. III 3-3: *Relationship between rolling noise and coefficient of rolling resistance (measured on 82 tyre types)*



Source: *TÜV Automotive GmbH 2003*

The UBA has investigated the generation of noise by this type of installation. In total, the agency has evaluated 587 sets of data from 1 923 individual installations. The results are shown in Figure III 3-4. The illustration shows the relationship between the acoustic power of the installation and the reference yield according to the renewable energy law. The reference yield is a measure for the amount of energy that this type of turbine installed at a reference location would provide within five years of operation.

Fig. III 3-4: *Acoustic power of wind power stations investigated, with respect to reference yield*



Source: *Federal Environment Agency 2004 a*

IV RADIATION

The public is exposed to ionising and non-ionising radiation.

IV 1 Public exposure to ionising radiation

The public is continually exposed to natural radiation, consisting of cosmic radiation, terrestrial radiation, and radiation from naturally radioactive substances which are inhaled or ingested. Changes to our environment, due to technological developments which result in an accumulation of naturally radioactive substances, lead to an anthropogenic increase in exposure to radiation. Radon in buildings and naturally radioactive substances from mining and processing activities can add to this increase. The anthropogenic contribution to public radiation exposure comes from the operation of nuclear plant, the use of ionising radiation and radioactive substances in medicine, research, other technologies, and the home, as well as fallout from atmospheric nuclear weapons testing and the 1986 Chernobyl reactor accident.

IV 1.1 Public exposure to radiation from natural and artificial sources

The average effective dose of natural and anthropogenic radiation for a German resident is 2.1 mSv per annum, while the dose from medical use of radioactive materials and ionising radiation is estimated to be about 1.9 mSv per annum. Contributions from other sources are very small.

Total exposure per annum, therefore, is 4.0 mSv.

Effective doses in Germany in 2003 were made up as follows:

- Exposure to natural radiation consists of several components. External exposure via cosmic and terrestrial radiation average 0.3 mSv/a and 0.4 mSv/a respectively. With internal exposure, via inhalation and ingestion of radioactive substances, a distinction is drawn between inhalation (on average 0.2 mSv/a when constantly outdoors) and ingestion. Potassium-40 and radionuclides in the decay series of uranium-238 and thorium-232 are ingested via food and drinking water, with an average effective dose of 0.3 mSv. This unavoidable exposure to natural radiation of 1.2 mSv/a in total rises due to anthropogenically-based exposure indoors (inhalation of radon decay products) by 0.9 mSv/a to 2.1 mSv per annum.
- The effective dose of anthropogenic radiation was ca. 1.9 mSv per resident per annum. The majority of this is caused by the use of radioactive materials and ionising radiation in medicine, primarily diagnostic radiology.
- The contribution made by occupational exposure to radiation changed little between 2000 and 2003. The number of people whose work exposes them to radiation was approximately 314 000 in 2003. The average annual dose of those monitored with annual personal doses other than zero (ca. 48 000 people) is 0.92 mSv.
- In 1999, the component from nuclear power plants and other atomic facilities in the average effective dose to Germans remained below 1 % of anthropogenic radiation exposure. Annual emissions of radioactive materials from atomic facilities were below – in most cases well below – the maximum permitted levels.
- The average exposure of the public to radiation arising from the Chernobyl accident has fallen from 0.11 mSv in 1986 to under 0.015 mSv in 2003, although foodstuffs from forest areas still contain greatly increased levels of Caesium-137. In some regions, there are exposure levels that lie one magnitude above those stated.
- The component in the effective dose due to atmospheric nuclear weapons testing in past decades continues to fall, and was below 0.01 mSv in 2003. There has been no atmospheric nuclear weapons testing since 1981 (Fig. IV 1.1-1 and Tab. “Average effective public dose 2003”).

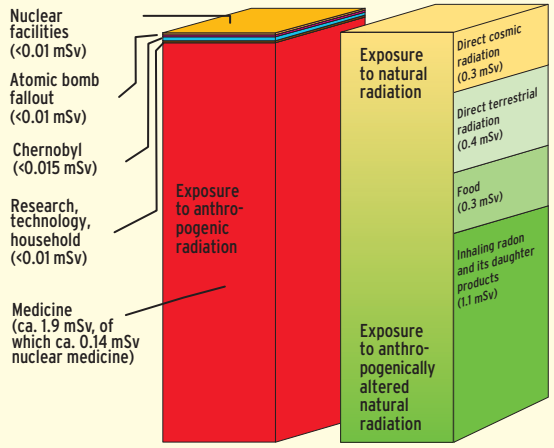
IV 1.2 Radiation exposure from radon in buildings

Radon concentrations in residences

In the early 1980s, radon concentrations over a period of three months were measured in 5 970 residences in West Germany. In addition, between 1991 and 1994, the Federal Office for Radiation Protection (BfS) monitored radon levels over one year in a random sample of 1 515 houses in 50 towns and communities in the new *Länder*. A large number of readings were also taken during the course of research projects to analyse:

- the effect on health of exposure to radon in buildings,
- the links between the geology of the construction site, the construction method, and the radon concentration in buildings

Fig. IV 1.1-1: *Average effective public dose in Germany 2003*



Source: *Federal Ministry for the Environment, Nature Conversation and Nuclear Safety 2004*

- and some other issues, particularly in the public interest (e.g., exposure to radon through mining and mining residues)

In all, the radon concentration in over 50 000 houses (ca. 0.4 % of the stock of residential buildings) was measured.

The European Commission had issued a "Recommendation for the protection of the public against indoor exposure to radon" [1] (Tab. IV 1.2-1).

Radon concentrations in German homes are determined primarily by the concentrations in the soil

Tab. IV 1.2-1: *Indoor radon concentration levels as recommended by the European Commission*

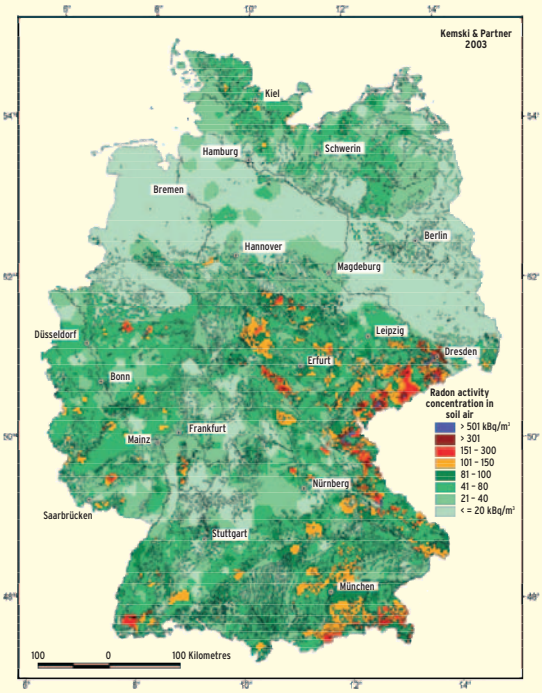
	Bq/m³ [1]	Measures
Design level for future constructions	200	The design level should be used in establishing regulations, standards or codes of construction practises for circumstances under which the design level might otherwise be exceeded.
Reference average for existing buildings	400	The urgency of the remedial action take account of the extent to which this reference level is exceeded

[1] Annual average radon gas concentration, normal use of space

Source: *European Commission 1990*

air of the ground on which they are built. The elevated levels of radon apparent in buildings in certain *Länder* are, therefore, not distributed evenly across the *Land* in question, but are concentrated into particular geological regions. The highest geogenic radon concentrations are found in houses with granite below them. Figure IV 1.2-1, which is an overview map for planning purposes, summarises radon concentrations in the soil air at 1 m depth. There is insufficient base data to be able to draw detailed conclusions about small areas or to make predictions about exposure in individual houses [2].

Fig. IV 1.2-1: *Regional distribution of radon concentration in soil air*



Source: *Federal Office for Radiation Protection 2005*

Table IV 1.2-2 provides an overview of the *Land*-based distribution of radon concentration in residential buildings with one or two apartments. It shows the proportion of buildings with radon concentrations of above 100, 200, and 1 000 Bq/m³ in living rooms. This data was estimated according to the current state of knowledge based on the regional distribution of radon concentrations in the soil air and on the findings from measuring the radon concentration in buildings over a number of months and up to one year.

The geogenic radon concentrations measured in German homes are comparable with those found in other countries. Geological conditions alone can give rise to yearly averages of peak values of some thousands of Bq/m³. Measurements in buildings

Tab. IV 1.2-2: *Radon concentrations in homes, by Länder*

No.	Land	Number of buildings 31/12/1999[1)]	Number of buildings with one or two residences that have radon concentrations in habitable rooms >100 Bq/m³	>200 Bq/m³	>400 Bq/m³	>1000 Bq/m³
1	Schleswig-Holstein	596 171	45 800	11 000	2 500	200
2	Hamburg	142 095	5 000	800	200	Implausible
3	Lower Saxony	1 652 184	88 000	26 000	4 900	600
4	Bremen	94 567	3 800	1 400	100	Implausible
5	North Rhine-Westphalia	2 629 009	250 000	77 000	23 000	3 000
6	Hesse	1 037 495	76 000	20 000	5 200	800
7	Rheinland-Palatinate	920 781	94 000	30 000	9 100	1 500
8	Baden-Württemberg	1 756 105	160 000	51 000	15 000	2 500
9	Bavaria	2 297 391	310 000	120 000	41 000	6 400
10	Saarland	258 111	16 000	4 000	900	100
11	Berlin	151 675	5 400	800	200	Implausible
12	Mecklenburg-Pomerania	446 810	19 000	5 900	700	Fairly implausible
13	Brandenburg	263 810	19 000	4 900	1 200	Fairly implausible
14	Saxony	528 401	92 000	41 000	16 000	3 500
15	Saxony-Anhalt	429 977	41 000	14 000	4 300	600
16	Thuringia	402 063	69 000	28 000	9 700	1 400

[1)] Database: Länder statistical offices, update of the building and property inventory as of 31.12.1999

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2003*

within mining areas have shown that mining activity and its legacy (tunnels driven close to buildings and housing development on slag heaps) can significantly increase radon concentrations in homes.

The mean radon concentration indoors in Germany is about 50 Bq/m³.

It is currently assumed that radon concentrations of below 20 kBq/m³ are present in the soil air beneath about 38 % of Germany. When building in such areas, properly protecting the building against encroaching soil dampness simultaneously provides adequate protection against soil radon.

In areas with radon concentrations of between 20 and 100 kBq/m³ (58 % of Germany), such damp coursing measures should be supplemented by a continuous, armoured base plate at least 15 cm thick.

The radon concentration exceeds 100 kBq/m³ across about 4 % of Germany. An armoured, rated foundation plate conforming with DIN 1045 should be installed in such areas rather than a base plate. At these sites, it is also a good idea to, depending on the material, take further action to protect from soil radon penetration, such as deploying radon-proof foils and drainage systems. The German Radon Manual contains further advice on this [3].

More information is also available on the BfS website at http://www.bfs.de/ bfs/druck/infoblatt/ massnahmen_radon.html.

Radon as an important risk factor in lung cancer

Lung cancer is currently by far the most frequent cause of death by cancer in men in Germany. With women, it ranks third and is rising quickly. Bronchial carcinomas are amongst the most malignant tumours, with a very poor prognosis. Almost 90 % of all new diagnoses result in death within a year. As no better therapy procedures are in sight, preventive measures constitute the only method of reducing the number of those affected. As is well-known, smoking is by far the most significant risk factor. However, the public are largely unaware that elevated levels of radon in dwellings are the second-most important cause of lung cancer.

The danger to health does not issue from the radon gas itself, but from its radioactive decay products with a short life (polonium, bismuth, lead) which mainly attach themselves to dust particles. Inhaling them leads to the bronchial epithelium being selectively irradiated by densely ionising alpha-radiation with high biological effectiveness. This can damage cells and promote cancer.

Since the 1980s, over 20 large-scale epidemiological studies of lung cancer and radon in homes have been carried out in Europe, North America, and China [4], [5], [6]. Their findings have now been published and consistently indicate an elevated risk of lung cancer from radon in homes. The link between radon concentration and risk can best be explained using a linear, dose-effect model with no threshold value, i.e., any radon concentration, no

matter how small, increases the risk of lung cancer. The totality of the studies' evidence points to a rise of around 10 % in the risk of lung cancer for every 100 Bq/m^3 increase in the radon concentration. This equates to a doubling of the lung cancer risk at 1 000 Bq/m^3.

Two of the largest-scale studies were the two case-control studies commissioned by the BfS [7], [8] carried out in East and West Germany between 1990 and 1996 and headed by Prof. Dr. Dr. H.E. Wichmann of the GSF Centre for Environmental and Health Research at the Institute for Epidemiology in Neuherberg. The joint analysis of both of these German studies, now concluded, took in 2 963 lung cancer patients and a random sample of 4 232 members of the public [9]. The radon concentration levels were measured in over 9 000 homes that the test subjects were either living in at the time of the study or had lived in previously. The average radon concentration for each test subject was then calculated for the last 5 to 35 years. The mean value in the East German study area (Thuringia and Saxony) was 75 Bq/m^3, while in the West German study area (the Eifel, Eastern Bavaria, parts of North Rhine-Westphalia, and Saarland) it was 50 Bq/m^3. All the risk analyses took into account age, gender, lifelong smoking habits, and other risk factors. This study also showed a 10 % rise in the risk for every 100 Bq/m^3 increase in the radon concentration. The findings from the indoor studies are a good match with the risk assessments from studies of miners when extrapolated in the low dose area.

There is also now a combined European study which indicates statistical significance for the biological effectiveness of radon from the 100–200 Bq/m^3 range [10].

The synergistic effect of radon and smoking

The risk of lung cancer in an average smoker is 15 times higher than in a nonsmoker, while a heavy smoker runs a risk up to 40 to 50 times higher. In comparison, a doubling of the risk posed by radon in a concentration of 1 000 Bq/m^3 compared with 0 Bq/m^3 is relatively low. However, a particular disadvantage lies in the fact that the effects of radon and smoking are largely synergistic. This means that, if both these risk factors coexist, the effects are not cumulative, but multiplied. Thus, an average smoker with a radon concentration of 1 000 Bq/m^3 in their home has a risk of lung cancer that is 15 times 2, or 30 times higher. This is why most radon-induced lung cancer cases occur in smokers.

How radon relates to health policy

The relative risk of acquiring lung cancer from radon, put at an extra 10 % per 100 Bq/m^3 increase in the radon concentration, appears at first glance to be minor. Yet because much of the general public is affected by it, radon constitutes a serious health issue. Earlier estimates from West Germany indicated that around 7 % of all lung cancer cases are attributable to radon [11]. If this was roughly extrapolated across Germany, almost 3 000 of the 40 000 newly diagnosed cases of lung cancer each year would be induced by radiation. Radon is, therefore, the second-most important cause of lung cancer after smoking. In terms of reducing the number of cases of lung cancer, therefore, reducing the radon concentration in homes is another important step, alongside the containment of smoking. The Federal Ministry for the Environment is currently drawing up legislation to protect against radon indoors, their aim being to reduce radon exposure in buildings to values of below 100 Bq/m^3. Where exposure is 100 Bq/m^3 or above, modernisation measures are to be gradually, depending on radon concentration levels, taken in existing buildings and construction conditions are to be put in place for planned buildings.

[1] European Commission: Commission Recommendation of 21 February 1990 on the protection of the public against indoor exposure to radon (90/143 Euratom), Official Journal of the European Communities No. L 80/26 of 27/03/90

[2] Kemski, J., Siehl, A., Stegemann, R., Valdivia-Manchego, M.: Geogene Faktoren der Strahlenexposition unter besonderer Berücksichtigung des Radonpotentials. Schriftenreihe Reaktorsicherheit und Strahlenschutz, BMU-1999-534, 133 P., Bonn, 1999

[3] Federal Office for Radiation Protection/Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Ed.), German Radon Manual, Bremerhaven 2001

[4] Lubin, J.E.: Studies of radon and lung cancer in North America and China. Rad Prot Dosimetr 2003; 315–319

[5] Darby, S.C., Hill, D.C.: On behalf of the European Collaborative Group on residential radon and lung cancer: Health effects of residential radon: a European perspective at the end of 2002. Rad Prot Dosimetry 104 (2003) 321–329

[6] Schaffrath-Rosario, A., Heid, I.M., Kreienbrock, L., Heinrich, J., Wellmann, J., Kreuzer, M., Steinwachs, A., Langer, B., Wichmann, H.E.: Bewertung des Lungenkrebsrisikos durch Radon in Wohnungen in Deutschland mit Hilfe statistisch-epidemiologischer Methoden. Abschlußbericht des Forschungsvorhabens, Funding Reference StSch 4237, Federal Office for Radiation Protection 2004

[7] Kreuzer, M., Heinrich, J., Wölke, G., Schaffrath-Rosario, A., Gerken M, Wellmann J, Keller G, Kreienbrock L, Wichmann HE. Residential radon and risk of lung cancer in Eastern Germany. Epidemiology 14 (2003): 559–568

[8] Kreienbrock, L., Kreuzer, M., Gerken, M., Dingerkus, G., Wellmann, J., Keller, G., Wichmann, H.E.: Casecontrol study on lung cancer and residential radon in West Germany. Am J Epidemiol 153 (2001) 42–52

[9] Steindorf, K., Lubin, J.H., Wichmann, H.E., Becher, H.: Lung cancer deaths attributable to indoor radon exposure in West Germany. Int J Epidemiology 24 (1995) 485–492
[10] Darby, S., Hill, D. et al, BMJ 330 (2005) 223–227
[11] Wichmann, H.E., Schaffrath-Rosario, A., Heid, I.M., Kreuzer, M., Heinrich, J., Kreienbrock, L.: Increased lung cancer risk due to residential radon in a pooled and extended analysis of studies in Germany. Health Phys 2004, in press

IV 1.3 Frequency and dose of diagnostic radiological examinations in Germany – current analysis for the period 1996 to 2001

Since the 1990s, the BfS has been gathering data regarding exposure to medical radiation in Germany and has been analysing it -most recently in 1994 and 1997. The amendment to the Ordinance on Protection against Injuries caused by medical radiation (RöV) in 2002 made the BfS officially responsible for regularly ascertaining the population's exposure to medical radiation. The frequency of examinations and the collective, effective radiation dose are both to be assessed. The effective dose covers the varying sensitivity of the organs and tissues with respect to the stochastic radiation effect (an induced cancer or genetic defect). The unit used to measure the effective dose is the Sievert (Sv). The collective dose is the effective dose accumulated across the entire population, and is calculated as a product of the size of the population and the average dose per person.

The most current analysis to have been done of the data regarding the frequency of radiological examinations in Germany relates to the period 1996 to 2001, and involved a new strategy for ascertaining the exposure to medical radiation. The following objectives were sought to be achieved:

- Develop a procedure that could be used to provide standard time series analyses and thus indicate trends. The newly-developed strategy should also serve as a basis for evaluating medical radiation exposure in the future.
- Adjust the procedure to international standards that have arisen mainly from two 2000 surveys carried out in Switzerland and the United Kingdom. These concern, for example, the definition of the term "examination". It now covers all the x-rays required to answer a clinical query about an organ using x-ray techniques. Thus, for example, when an angiograph is taken of the heart, all the steps together are regarded as a single examination unlike the previous interpretation in which each step (add the radiocontrast agent, 1st series, 2nd series, etc.) was counted as a separate examination. On the other hand, the present analysis method treats all dental x-rays (projections) as separate examinations where they relate to different teeth or groups of teeth.
- Incorporate current surveys on CT examination practice during the reporting period, and findings from new research projects funded by the BMU (nationwide survey of the frequency of x-ray examinations in the in-patient sector, surveys on determining dosage in the conventional sector), and recent literature.

Like previous analyses of the frequency of diagnostic radiological examinations, the current evaluation is also based on data from the relevant cost unit, such as the national associations of statutory health insurance physicians and dentists and the Association of Private Health Insurance. A regular, structured system of data transfer has now been developed. In the case of in-patient services provided by the general nursing care fund, however, individual care items are not settled with the cost unit. Therefore, the data from in-patient care has to be used to provide estimates of the frequency with which radiological examinations are carried out. With previous BfS surveys, relatively unreliable data from an earlier random survey of hospitals, plus an analysis of trends in outpatient care and the private medical sector in the early 1990s was used to make this estimate. The present analysis, however, incorporates the early results from a research project that is currently underway. Radiological examinations that are paid for by accident insurance companies or that are carried out by the Federal Armed Forces cannot yet be quantified. Past experience suggests that such examinations constitute ca. 5 % of the total frequency and ca. 2–3 % of the collective dose. Provisionally, therefore, 5 % and 2.5 % respectively have been added to the figures currently presented on frequency and effective dose.

Findings from the current analysis for the period 1996–2001

Frequency of diagnostic radiological examinations

During the period concerned, the figures fluctuated between 1.78 and 1.85 examinations per member of the population per year, with no indication of any trend. The relative frequency of the different examination procedures also varied little with diagnostic dental x-rays constantly making up around one-third of all the radiological examinations. The most striking feature of the trends analysis is the constant 7 % per annum increase in CT examinations over the entire period of the study. However, this dose-intensive procedure's share of all the x-ray examinations still remains relatively low. In 2001, it has risen to about 6 %. In contrast to the CT trend, there has been a decrease in the frequency of conventional

examinations carried out in the stomach area, including the gastrointestinal tract, the bile system, and the urinary tract (Fig. IV 1.3-1).

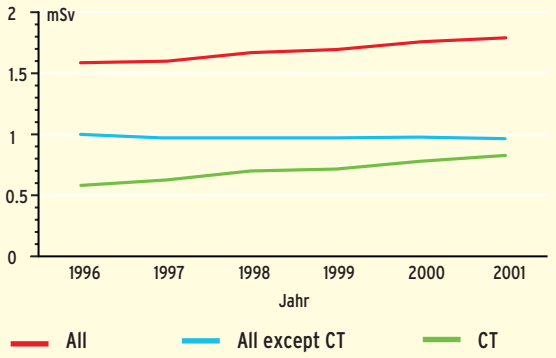
Collective effective dose

In contrast to the overall frequency, there has been a continuous rise in the – purely numerical – effective dose per resident from ca. 1.6 mSv in 1996 to ca. 1.8 mSv in 2001, which equates to around 2 % per annum. Within the uncertainty range indicated of ± 0.5 mSv, the earlier figure of 2 mSv that the BfS estimated for 1997 tallies with these figures. The dose increase identified by this latest analysis is largely linked to the significant rise in the frequency of CT examinations. CT examinations' share of the overall effective dose was only around one-third in 1996, while by 2001 it had reached almost one-half. In comparison, the effective dose per resident from the other examination procedures remained nearly constant (Fig. IV 1.3-2).

Germany in international comparisons

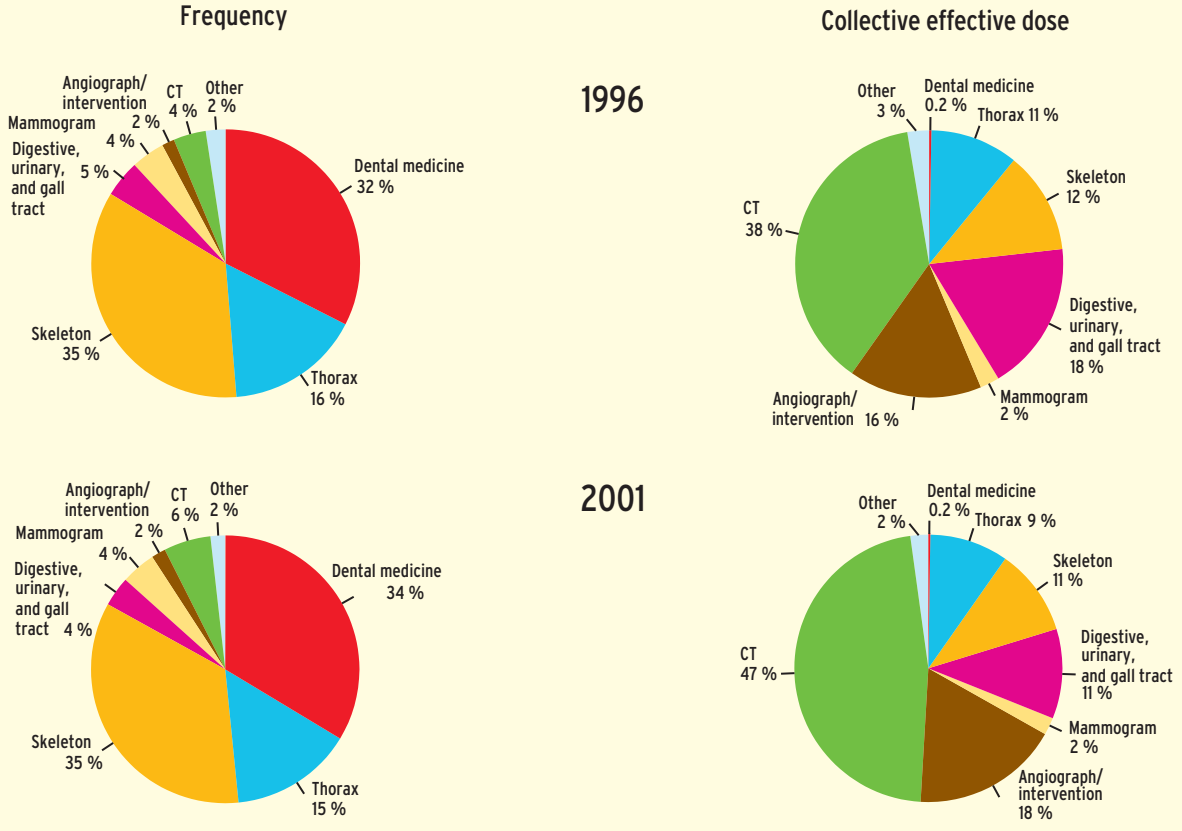
Compared with other countries, Germany is ranked fairly high both in terms of frequency and the effective dose per resident. However, the Federal Republic is certainly not the "X-ray world champion". This assessment is based on a comparison of the figures given for different countries in the UNSCEAR Report 2000 [1]. However, caution should be taken with this comparative analysis, since the variation in the different countries' health systems produces widely-differing analysis systems which are sometimes not sufficiently known. Furthermore, the data on frequency and dose for different coun-

Fig. IV 1.3-2: *Average effective dose per resident from radiological and CT examinations*



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004*

Fig. IV 1.3-1: *Radiological examinations' percentage share in the frequency and collective effective dose in Germany for 1996 and 2001*



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004*

tries provided by the UNSCEAR Report 2000 is somewhat inconsistent. Current data from the literature available [2], [3] indicates that only the annual effective doses per resident from CT examinations in the USA (around 1.6 mSv) and Japan (2.3 mSv) are similar to or greater than the overall dose of 1.8 mSv for all the radiological examinations carried out in Germany (including CT, angiographs, and interventional radiology).

Problems with analysing radiation and health

The global increase observed in the frequency and dose of radiological examinations reflects the increased value placed on this method of producing images in diagnostics and the planning and monitoring of therapy. Germany provides a very high level of medical care.

When analysing exposure to medical radiation, the fact that the dose is distributed very unevenly across the population also needs to be taken into account. The only people affected are patients, i.e., that portion of the population that can draw a direct diagnostic or therapeutic benefit from their exposure. Moreover, these patients are typically older people who are far less sensitive to stochastic injury from radiation than younger people. Furthermore, the life expectation of seriously ill patients is often far shorter than that of the population as a whole. It is these patients, however, that are often subjected to multiple frequent examination because of their illness. So if exposure to medical radiation is to be analysed in a way that properly assesses its effect on health, the gender and age distribution of the patients and the indications need to be ascertained for the treatments provided. For data protection reasons, however, gathering such details is extremely difficult and fraught with inaccuracy as it requires access to patients' personal files. The Federal Office for Radiation Protection has commissioned a research project in the in-patient sector to gather data relating to age and gender.

Medical and dental surgeries will provide quality assurance in this connection, based on the regulations in the radiation protection ordinance and x-ray legislation.

[1] UNSCEAR 2000 Report: Sources and Effects of Ionizing Radiation. Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. Volume I: Sources, United Nations, New York 2000

[2] Linton, O.W., Mettler, F.A. Jr.: National Council on Radiation Protection and Measurements. National Conference on dose reduction in CT, with an emphasis on pediatric patients. Am J Roentgenol 181 (2003) 321–329

[3] Nishizawa, K., Matsumoto, M., Iwai, K., Maruyama, T.: Survey of CT practice in Japan and collective effective dose estimation. Nippon Acta Radiologica 64 (2004) 151–158

IV 2 Public exposure to non-ionising radiation

Continuing technological developments mean that the public are increasingly exposed to non-ionising radiation, mainly to low-frequency energy supply fields and high-frequency fields from wireless communication networks. The rollout of mobile networks in Germany, particularly the introduction of UMTS technology, has triggered a public debate about possible health risks from new communication technologies.

The non-ionising radiation (NIR) sector comprises low-frequency electric and magnetic (in the 0 to 10 kHz frequency range) and high-frequency electromagnetic fields (100 kHz to 300 GHz) plus optical radiation, which includes ultraviolet (UV) radiation with wavelengths of between 100 and 400 nanometres (nm).

Unlike ionising radiation, low- and high-frequency radiation lacks the energy to form harmful radicals in biological systems through ionising processes and to trigger mutations in the genome. The effect of low-frequency electrical and magnetic fields and high-frequency electromagnetic fields is expressed in forces exerted on electrical charges. In the case of high-frequency fields, this can lead to a rise in temperatures. Recommended limits are being issued that are based on scientifically demonstrated health impacts and which take international findings into consideration. The limits that currently apply to fixed low- and high-frequency equipment are specified in the 26th Regulation regarding the implementation of the Federal Immission Control Regulation (the ordinance on electromagnetic fields – 26th BImSchV). However, evaluations based on the current state of scientific knowledge have revealed uncertainties where there is evidence regarding possible biological effects where the intensities of low- and high-frequency fields are beneath the applicable limits. Therefore, both national and international organisations, such as the SSK, are calling for further research to study possible biological effects and to estimate their relevance to health.

A Bavarian study indicates that the public's exposure to low-frequency magnetic fields as emitted by fixed low-frequency equipment and household appliances is, on average, far lower than the limits specified by law. Compliance with the limits for fixed high-frequency equipment is verified by Germany's telecoms regulator, RegTP, in accordance with the provisions of telecommunications legislation, in an official announcement proceeding for issuing the site license. Various RegTP measuring

projects have given readings that fall well below the limits in populated areas.

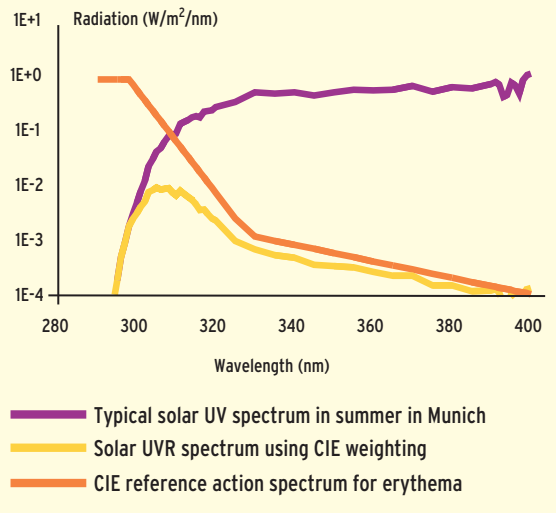
IV 2.1 Ultraviolet solar radiation

Even in our northern latitudes, the intensity of the summer sun is sufficiently high to affect human health. Since solar radiation does not penetrate deeply into human tissue, the skin, eyes, and the immune system are the most strongly affected. The important acute effects of UV radiation are erythema (sunburn) and keratitis, while chronic effects include cataracts, premature ageing of the skin, and skin cancer. Although the risk of a cataract can be increased even by natural environmental radiation, and is the largest cause of blindness worldwide, ultraviolet solar radiation presents the greatest health risk to skin in Germany, due to the more intense uncontrolled exposure, and this is therefore the aspect which is generally used to assess the health risks from UV solar radiation.

The aforementioned effects are heavily dependent on wavelength, but those on skin – tanning (melanogenesis), sunburn (erythema), premature ageing (elastosis), and cancer (carcinogenesis) – are very similar, which means that exposure cannot produce the desired effect without causing the undesirable effects as well. Sunburn is easily the most noticeable acute effect, albeit only after the fact, and it is, therefore, an appropriate indicator for the effects of UV radiation. The UV sunburn dose uses the (weighted) reference action spectrum for erythema recommended by the CIE, integrated over the wavelength of 290 to 400 nm (Fig. IV 2.1-1).

Figure IV 2.1-2 shows the annual sequences of erythema-inducing exposure level measurements taken from all four of the stations in the BfS/UBA's measurement network, at 11 o'clock UTC [1] in each case. These values equate to the exposure rates at local solar noon for each day of the year at the four stations. The extent to which ground-level UV radiation depends on the sun's altitude is particularly well-illustrated by comparing irradiation during summer and winter. While the figures can go above 200 mW/m^3 in Munich during the summer, they do not go beyond ca. 20 mW/m^3 in the winter. However, the effect of latitude is also quite clearly identifiable from the readings. The maximum erythema-inducing irradiation level reached 160 mW/m^3 on Zingst, but almost 240 mW/m^3 at the Schauinsland station, i.e., the value was 1.3 times higher in southern than in northern Germany.

Fig. IV 2.1-1: *Evaluation of UV spectra*



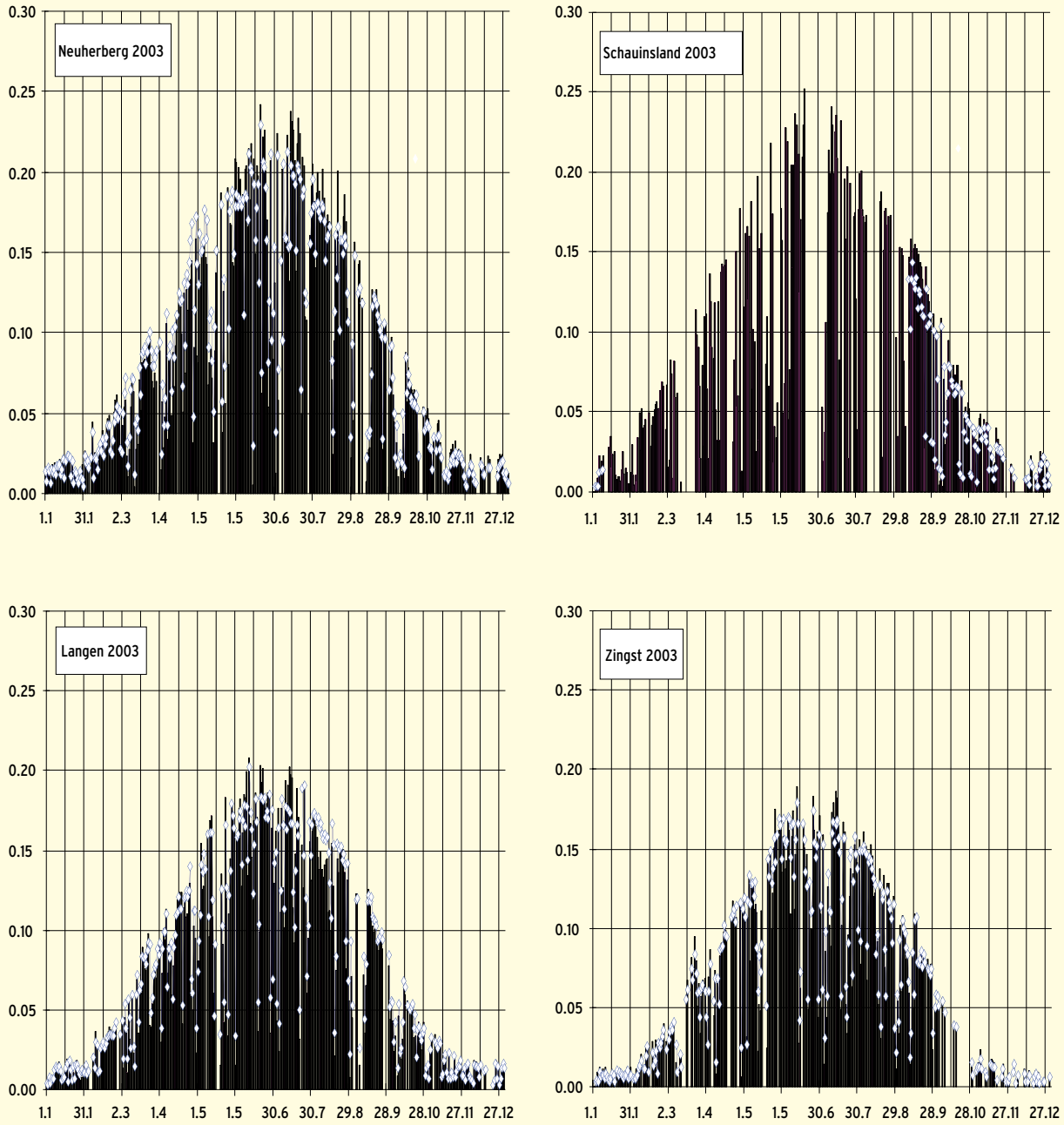
Source: *Federal Office for Radiation Protection 2004*

As expected, in 2003, the highest erythema-weighted irradiation levels occurred in summer in southern Germany. The erythema-inducing irradiation level on Schauinsland exceeded the value E = 190 mW/m^3 between Day 132 (12 May 2003) and Day 231 (19 August 2003). This equates to a UV index [2] of 7–8 and is classed by the Radiation Protection Commission (SSK) as the limit for very high UV exposure. At this level, the SSK seriously recommends that measures be taken to protect oneself against UV radiation. In Neuherberg, the same value was exceeded during a somewhat briefer time period, from Day 150 (30 May 2003) to Day 231 (19 August 2002). In northern Germany, in Zingst, not one day had such a high reading — the readings there rose to 170 mW/m^3. This still corresponds to a UV index of 6, which the SSK classifies as high UV exposure, and for which they recommend protective measures.

With lower ozone levels, readings can be higher, especially at higher altitude, such as the *Mittelgebirge* and the Alps in southern Germany. Regional variations in cloud cover are far more common than completely cloudless days, and cloud cover can reduce UV radiation by up to 80 %. In contrast, air quality has relatively little effect on UV radiation.

Personal exposure, as opposed to physical terrestrial UV radiation, depends on what protection measures the individual takes against the sun and the kind of outdoor activity. Sunbathing naturally involves the greatest exposure to UV radiation, while moving around in the sun reduces exposure. The skin itself can also influence the effectiveness of UV radiation. Actinic calluses (thickening of the skin) and pigmentation (suntan) can protect skin to a certain extent against high levels of UV radiation. Skin type and the age of the skin can also influence sensitivity to UV radiation.

Fig. IV 2.1-2: *Measured (black bars) and modelled (star-shaped dots), erythema-weighted irradiation levels (290–400 nm) at 11.00 UTC for Munich (Neuherberg), Schauinsland (Feldberg), Langen (Frankfurt/M.) and Zingst (Baltic coast) over the course of the year*



Source: *Federal Office for Radiation Protection 2004 a*

In order to raise public awareness of the risks from UV exposure and encourage better use of UV protection, the Federal Office for Radiation Protection and others have, for some time, been publishing UV levels and predictions.

The incidence of skin cancer is increasing significantly, predominantly due to changes in leisure and social behaviour. The personal risk of developing skin cancer depends upon an individual's habits with respect to UV radiation exposure. There is a direct link between exposure to UV solar radiation and the development of nonmelanoma skin cancer (basal cell and squamos cell carcinoma). The incidence of basal cell carcinoma is increasing in Germany, with about 60 new cases in women and about 90 in men per 100 000 inhabitants being registered annually, and with a mortality rate of less than 1 %. Malignant melanoma are significantly less common, but are the main cause of skin cancer mortality, and represent a serious problem for the health care of Caucasian population groups. The

risk of skin cancer is partly determined by an individual's genetic make-up and other personal factors, but is also dependent on exposure to solar radiation. The risk of skin cancer is greatest in people with fair complexion, blue eyes, and freckles, but frequent acute exposure to UV radiation during childhood and adolescence increases the risk, especially of potentially fatal malignant melanoma. The incidences of melanoma are also on the increase. Currently, about 8 to 10 new cases per 100 000 are being registered annually in women and men. Some 20 % of cases are fatal, and a relapse or metastasis occurs in 20–30 % of cases.

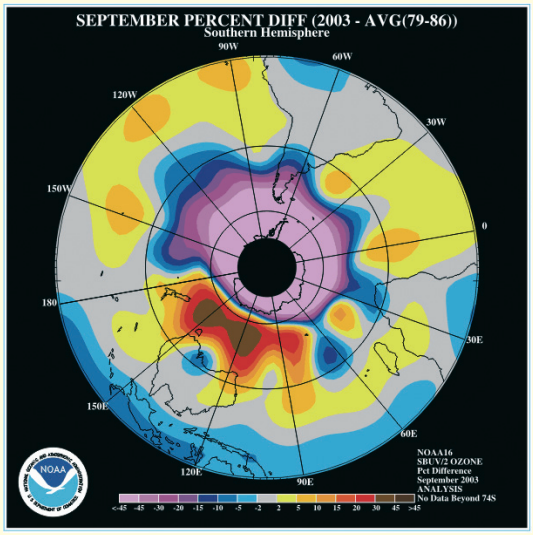
[1] UTC: Coordinated Universal Time, roughly corresponds to Greenwich Mean Time. UTC plus 1 hour applies in Germany.
[2] The highest daily value for the UV radiation which causes sunburn (25 mW/m^3 equates to a UV index of 1).

IV 2.2 Depletion of the stratospheric ozone layer

The stratospheric ozone layer, at 15 to 35 km above ground level, contains 90 % of atmospheric ozone. Ideally, an equilibrium exists between the creation and destruction of ozone. Ozone is only formed by photolysis of oxygen molecules by short-wave UVC radiation, and is destroyed by various processes such as photolysis by long-wave UV radiation and catalytically occurring decomposition reactions with certain compounds containing chlorine, bromine, nitrogen, and hydrogen. The release of persistent compounds of chlorine and bromine, particularly of CFC and halons, the concentration of chemicals that destroy ozone has increased, which has led to a decline in stratospheric ozone content (Tab. IV 2.2-1).

Ozone depletion does not occur evenly in time and space. It is most marked in the polar regions and there during the months of September to December at the South Pole – the Antarctic ozone hole (Fig. IV 2.2-1 and Fig. IV 2.2-2). Over the last 30 years, the ozone layer over Central Europe has fallen by some 7 %, without falling further in recent years (Fig. IV 2.2-3). The equatorial zone has scarcely been affected.

Fig. IV 2.2-1: *Distribution of total ozone under the conditions of the ozone hole in September 2003*



Deviation of the values measured for total ozone content in the stratosphere above the southern hemisphere in September 2003 from the long-term September average 1979–1986 in %. Areas where the September 2003 values are almost in line with the long-term average are shown in grey. The South Pole region shows a deviation of more than – 45 %.

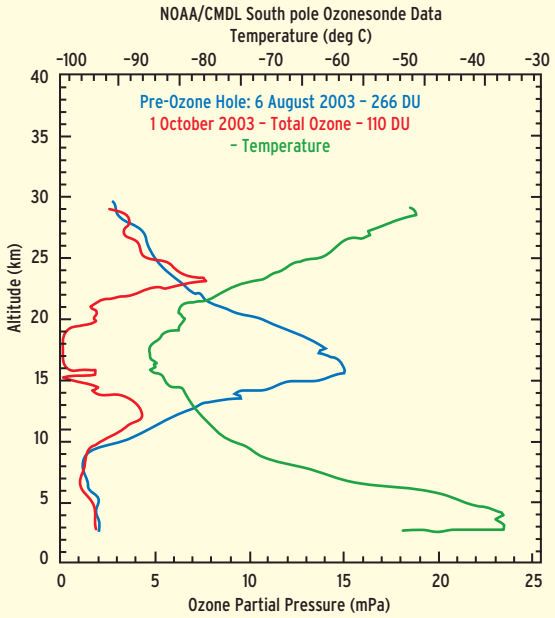
Source: *US National Oceanic and Atmospheric Administration 2003*

Tab. IV 2.2-1: *Significant data about selected Ozone Depleting Substances*

Gases	Background concentration (2000)	Change	Atmospheric retention	Ozone Depletion Potential (from model calculations)	Global Warming Potential [1]
	ppbv	% per annum	years		
CFC-11	0.262	–0.5	45	1	4 680
CFC-12	0.53	0.4	100	0.9	10 720
CFC-113	0.082	–0.1	85	0.9	2 700
CFC-114	–	–0.4	300	1.0	8 780
CCl4	0.1	–1.0	26	1.1	437
CH3–CCl3	0.045	–2.0	5.0	0.12	45
CH3 Cl	0.54	–	1.3	0.02	5
HCFC-22	0.142	3.8	12.0	0.05	1 780
HCFC-141b	0.013	15	9.3	0.1	222
HCFC-142b	0.08	12	18.5	0.05	709
CH3 Br	0.009–0.008	–	0.7	0.4	5
H-1211	0.004	3.0	16	5	978
H-1301	0.003	2.5	65	12	2 780

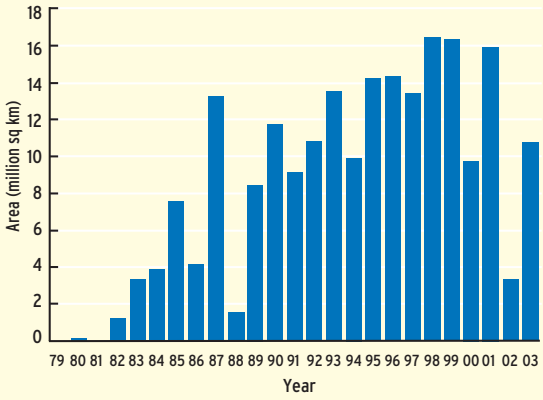
[1] for unit mass over a century
Source: *World Meteorological Organization 2002*

Fig. IV 2.2-2: *Vertical distribution of ozone under the conditions of the ozone hole (October 1st, 2003)*



Source: *US National Oceanic and Atmospheric Administration 2003 a*

Fig. IV 2.2-4: *Chronological growth in the size of the ozone hole (area < 220 DU)*



Average expansion of the ozone hole over the Antarctic (entire ozone = < 220 DU) between 1/10 and 30/11, determined by spectrometric (SBUV) measurements using Nimbus-7 and NOAA satellites in polar orbit

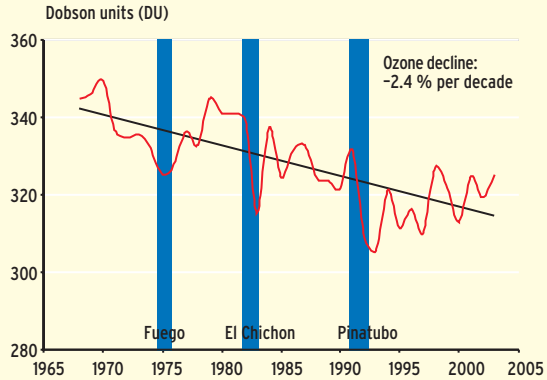
Source: *US National Oceanic and Atmospheric Administration 2003 b*

The Antarctic ozone hole forms because geographic symmetry causes turbulence in the Antarctic winter during which temperatures fall to below −80 °C. Under these conditions, polar stratospheric clouds form to which compounds of chlorine and bromine attach themselves. Then, when spring comes, light very efficiently destroys the stratospheric ozone. Figure IV 2.2-4 illustrates how the ozone hole has developed.

As a result of the Montreal Protocol on ozone depleting substances (ODS) and its update, global production and use of CFC and halons has fallen sharply. In the EU, with few exceptions, it has been banned since 1995. The conditions have, therefore, been put in place for the concentration of ozone depleting substances to be reduced and for the ozone layer to gradually recover (Fig. IV 2.2-5).

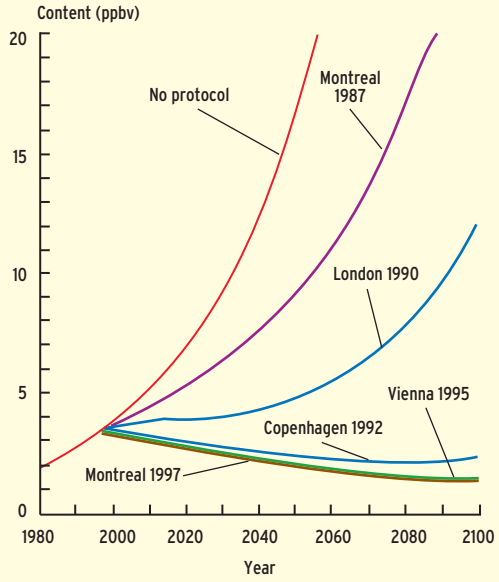
However, the ozone layer's recovery and the filling of the ozone hole over the coming decades will be delayed by the fact that the greenhouse effect that warms the troposphere has the opposite, cooling, effect on the stratosphere. In the past, a cooling of 0.6 °C per decade has been ascertained, with ozone

Fig. IV 2.2-3: *Ozone layer thickness at Hohenpeißenberg with episodes when the aerosol content in the lower stratosphere was elevated after volcanic eruptions*



Source: *German Weather Service 2004*

Fig. IV 2.2-5: *Influence of the international agreements on the concentration of ozone depleting substances chlorine and bromide in the stratosphere*



Source: *World Meteorological Organization 1998*

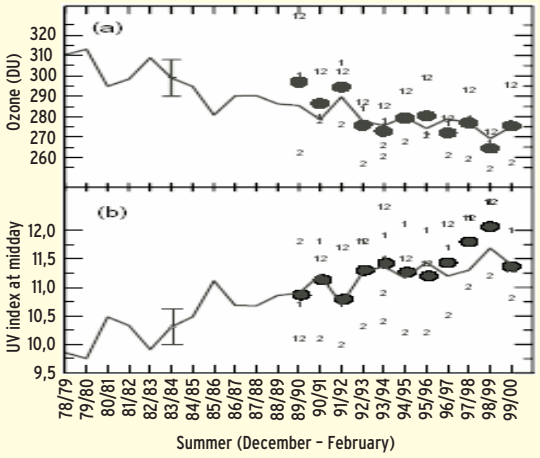
depletion itself playing a role. This cooling, which is expected to go on, encourages the formation of clouds, which help to deplete ozone.

UVB radiation at ground level

The ozone layer absorbs a large proportion of incoming ultraviolet (UVB) solar radiation. Ozone depletion reduces the amount absorbed, exposing humans, as well as terrestrial and aquatic ecosystems, to harmful UV radiation.

The way that the thickness of the ozone layer and the intensity of UV radiation move in opposite directions is best illustrated when the skies are clear. By way of example, Figure IV 2.2-6 shows the progress of total ozone and the UV index during the six summer months in Lauder, New Zealand. However, this trend has ceased during recent years.

Fig. IV 2.2-6: *Trends in average total ozone content and the UV index at midday in Lauder (New Zealand)*



The trend line in (a) shows measured ozone levels during summers since 1978/79. The symbols mark the ozone levels during summers since 1989/1990. The median of the values for each month is also marked by the month number. The trend line in (b) shows anticipated UV levels under cloudless skies. The symbols show the peak values of the UV index. Month numbers show the mean values of the measurements in each month. The margins of error (standard deviations) are given in the charts as a reference. The readings shown are based on spectral measurements of UV radiation.

Source: *World Meteorological Organization 2002 a*

But since other factors such as cloudiness, aerosol content, and albedo (reflectivity) also affect UV radiation, the link is less obvious in continuous time series. The length of the time series with spectrally triggered UV measurements which, for example, are important in relation to the effects, is insufficient to show significant trends.

This complication becomes apparent when one compares the UVB trend as calculated based on the thickness of the UVB layer and that measured at ground level.

Using radiation transfer models, the level of UV radiation reaching the earth's surface can be calculated from the total atmospheric ozone. By measuring monthly average ozone columns, the meteorological observatory at Hohenpeißenberg has been using such models for 35 years to calculate the increase in specific wavelengths of UV radiation on cloudless days, depending on the position of the sun. These are shown in Table IV 2.2-2.

Tab. IV 2.2-2: *Calculated annual changes in UV radiation intensity 1986–2003 for different months and wavelengths (mW/m²/nm at 40 °C)*

wavelength	Annual change (%)		
	April	June	August
300 nm	1.8	1.2	0.7
305 nm	0.8	0.5	0.3
310 nm	0.4	0.2	0.2
wavelength	**Total change 1968–2003 (%)**		
	April	**June**	**August**
300 nm	64	40	24
305 nm	29	18	12
310 nm	14	8	6

Source: *German Weather Service 2004*

The variability of the ozone layer's thickness during the course of the year results in different trends for different months. The stagnation of the ozone layer's thickness seen in recent years at Hohenpeißenberg is reducing the trend of increasing UV.

Solar UVB radiation has been measured at four representative locations in Germany by the Federal Office for Radiation Protection (BfS) and the Federal Environment Agency (UBA) since 1994. Other federal and *Länder* institutes at new locations have recently begun measuring with comparable equipment and accuracy, and these are now working closely with the BfS/UBA measuring network (Fig. IV 2.2-7).

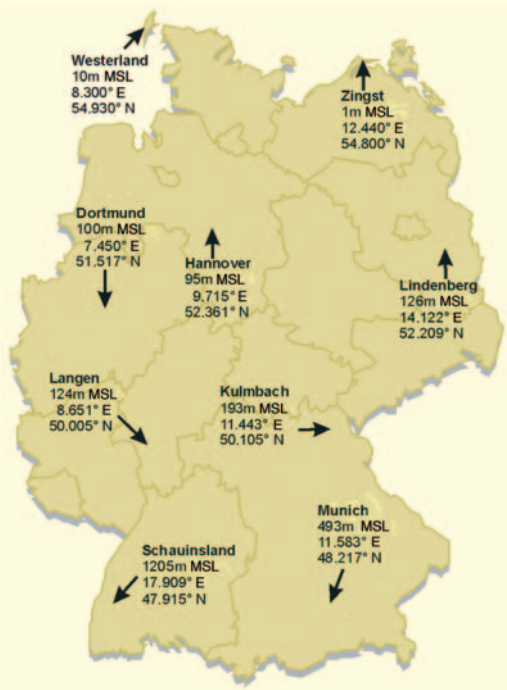
No significant UV trend was identifiable between 1995 and 2004 at the four locations (Fig. IV 2.2-8).

The strongest UV radiation intensity occurred during the ozone hole conditions at the South Pole, with some time delay compared with the UV minimum. The ozone hole still remains at that point, but the sun's position is higher than during the UV minimum.

IV 2.3 The use of certain substances in Germany that deplete the ozone layer and affect the climate

In 2003, 38 742 tonnes (t) of substances that deplete the ozone layer and affect the climate were used.

Fig. IV 2.2-7: *Joint BfS and UBA UV measuring network*



Source: *Federal Office for Radiation Protection, Federal Environment Agency 2005*

Substances that deplete the ozone layer are used primarily as feedstock to manufacture other chemicals (76.7 %). By definition, they are completely destroyed or converted during the production process.

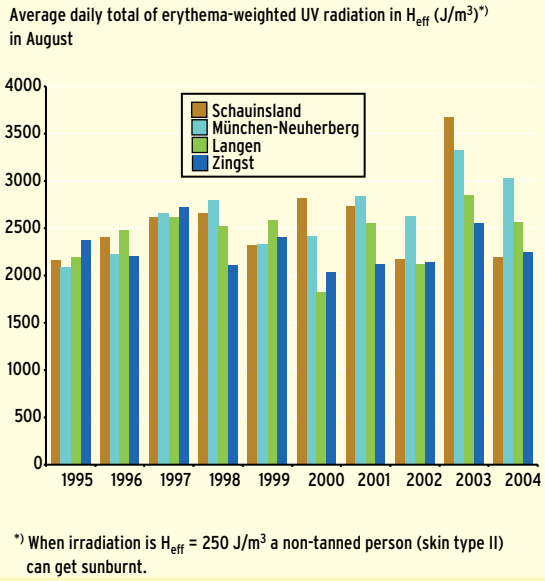
After subtracting the feedstock (29 719 t) from the overall amount, 9 023 t of substances that potentially relate to emissions remain. This is a slight fall of 3.4 % over 2002. The main area of use (97.7 %) is as coolants for refrigerators, freezers, and air conditioning systems, as a propellant for aerosols, and in plastics and foam. As they are mainly found in closed systems, the ozone layer and the climate are only harmed if they are released, which is why these substances are classified as potentially related to emissions.

To represent the potential risk, the metric tonnes are converted to ODP values (ozone depletion potential) or to GWP values (global warming potential). Based on these calculations, 305 ODP-weighted tonnes were used in 2003, compared with 622 ODP-weighted tonnes in 2002. If these substances had been released in 2003, their ozone depleting effect would have been almost halved compared with the previous year. Climatic effect is expressed in GWP-weighted tonnes. In 2003, using this method, 15 761 thousand GWP-weighted tonnes were used, compared with 21 599 thousand GWP-weighted tonnes in 2000.

The falls in both ODP-weighted tonnage and GWP-weighted tonnage since 2000 are attributable to the greater use of other substances and blends that have far less or no ozone depleting potential and mostly do less damage to the climate. Thus, for example, the use of the ozone depleting substance R-12 (dichlorodifluoromethane) in aerosols fell by 91 %, while the use of the alternative R-134 A (1,1,1,2-tetrafluoroethane) rose by 58 % compared with the previous year.

(Fig. IV 2.3-1 and Fig. IV 2.3-2 and Tab. “The use of certain substances that deplete the ozone layer in metric tonnes” and Tab. “The use of certain substances that deplete the ozone layer in ODP-weighted tonnes”)

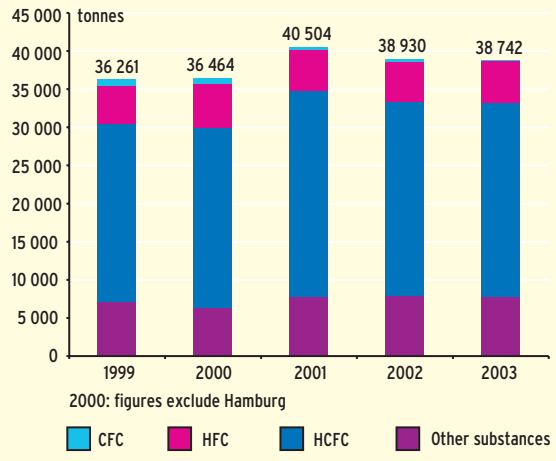
Fig. IV 2.2-8: *Trends in UV exposure in the BfS/UBA solar UV measurement network*



*) When irradiation is H_{eff} = 250 J/m² a non-tanned person (skin type II) can get sunburnt.

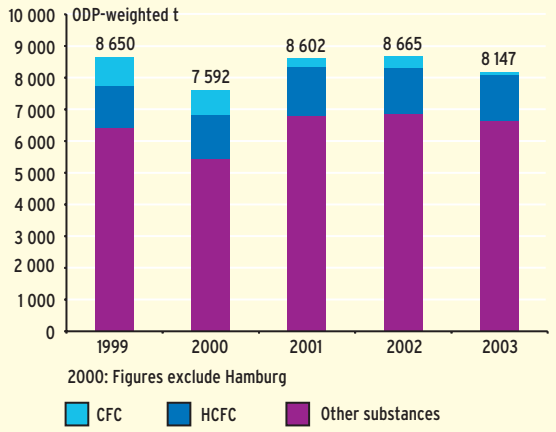
Source: *Federal Office for Radiation Protection 2005*

Fig. IV 2.3-1: *The use of specific substances in Germany that deplete the ozone layer and affect the climate in metric tonnes*



Source: *Federal Statistical Office 2005*

Fig. IV 2.3-2: *The use of specific substances in Germany that deplete the ozone layer and affect the climate in ODP-weighted tonnes*



Source: *Federal Statistical Office 2005*

More information on the survey of substances that deplete the ozone layer and the climate 1999–2003 is available from the Federal Statistical Office's website at http://www.destatis.de/basis/d/umw/umwtab7.htm.

IV 2.4 Implementing the Montreal Protocol

Measures to reduce the global production and sale of ODS

The Montreal Protocol (16/9/87) made legally binding commitments to phase out the use of ozone depleting substances. The schedule agreed to at Montreal has been tightened up and extended at follow-up conferences in London (June 1990), Copenhagen (November 1992), Vienna (December 1995), Montreal (September 1997), and Beijing (1999).

The participating industrialised nations committed themselves to cease production and use of fully halogenated CFC, carbon tetrachloride, and 1,1,1-trichloroethane by January 1996. Article 5 (developing) countries committed themselves to a gradual phasing out by 2010. The Montreal Protocol does not cover the production and use of ozone depleting substances as feedstock, since these are completely destroyed or transformed during production.

However, fully halogenated CFC are still permitted for "essential use" after January 1996. Halon use was already phased out by 1994 (Article 5 countries until 2010). The Copenhagen Conference set a schedule for partially halogenated CFC (HCFC) and extended the protocol to cover partially halogenated halons (HCBC) and methyl bromide, capping consumption and setting a schedule for phasing out their use. At the 1997 Montreal Conference, the regulations for methyl bromide were tightened up. At Beijing in 1999, a further ozone depletor, bromochloromethane, was included in the Montreal Protocol, and control measures and measures for dealing with HCFC from non-signatories were also drawn up. 129 countries agreed to provide financial aid for Article 5 countries in their efforts to phase out the production and consumption of ozone depleting substances.

The Montreal Protocol set these schedules for reducing the production and consumption of HCFC and HCBC:

1. Methyl bromide (Basis 1991)	
Freeze from	1995
25 %	1999
50 %	2001
70 %	2003
100 %	2005 (with exceptions)
100 %	2015
2. HCBC	
100 %	1996
3. HCFC (Basis 1989)	
Freeze from	1996
35 %	2004
65 %	2010
90 %	2015
99.5 %	2020
100 %	2030

Signatory states must also ensure that:

- the use of HCFC is restricted to areas where no more environmentally sound alternative substance or process is available,
- only in exceptional cases (human health) should the use of HCFC be permitted outside the areas where previously regulated substances were used,
- HCFC should be selected to cause as little harm to the ozone layer as possible

Production of HCFC rose steadily in the 1990s until 1996, as they are used as substitutes for CFC. The gradual production ban for industrialised countries as of 1 January 1996 in the Montreal Protocol halted this trend. By 2000, global production of fully halogenated CFC had been reduced by 92 % from 1986 levels (Tab. IV 2.4-1).

The Montreal Protocol succeeded in stemming the global production and use of ozone depleting substances, and the amounts, now being produced and used, are low compared with those of 20 years ago. Nonetheless, large quantities are still entering the atmosphere. One reason for this is the amount "stored" in products: ozone depleting substances

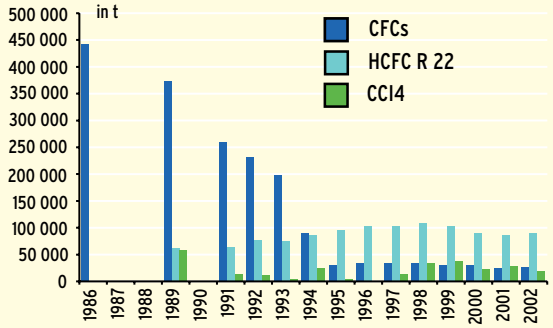
Tab. IV 2.4-1: *Global production of CFC, HCFC, halons and methyl bromide 1986–2000 in t (ODP-weighted)*

	1986	1990	1995	2000
CFC	1 046 906	693 662	225 276	85 800
HCFC	–	–	27 239	31 287
Halons	142 513	120 321	38 875	1 270
Methyl bromide	–	–	35 064	26 150

– No data available

Source: *United Nations Environmental Programme 2002*

Fig. IV 2.4-1: *Production of selected ozone depleting substances in the European Union*



CCl4: From 1999 on, data includes production quantities for export to Article 5 countries for "basic domestic needs"

Source: *European Commission 2005*

have been and are still being deployed in open applications (e.g., propulsion gas) and in closed loops (e.g., as coolants, fire extinguishing agents). The type of application determines the level and time of the emissions. While emission and use occur in the same year in open applications, large quantities are stored (inventory) in closed applications. The substances in this inventory, which grows each year, are emitted wholly or partially across the entire useful life and upon disposal. The fact that ozone depleting substances are, in many sectors, used for many years has led to the development of a large inventory. Ozone depleting substances can particularly be found in insulating materials, fire extinguishing equipment, refrigerators and freezers, and air conditioning systems. The United Nations Environmental Programme estimates this inventory to be 2.4 Mio t (ODP-weighted).

Therefore, to supplement the restrictions on the production and use of these substances – including in less developed countries – consideration is now also being given to action on this inventory. Measures are being debated and, to some degree, implemented to recover, recycle, and destroy ozone depleting substances.

European Union measures to reduce the production and sale of ODS

Regulation (EC) No. 2037/2000 of the European Parliament and Council on substances that deplete the ozone layer was passed on 20 June 2000 and came into force on 1 October 2000, and was recently amended by Regulation (EC) No. 1804/2003 of 22 September 2003. Regulation (EC) No. 2037/2000 replaced the previous Regulation (EC) No. 3093/94. The new regulation contains more deadlines for ceasing production of ODS, and bans certain usages. While production of most ODS was prohibited before the regulation came into force, it provides for an end to methyl bromide production, and the phasing-out schedule for HCFC production has been redrafted. The EU schedule is now as follows:

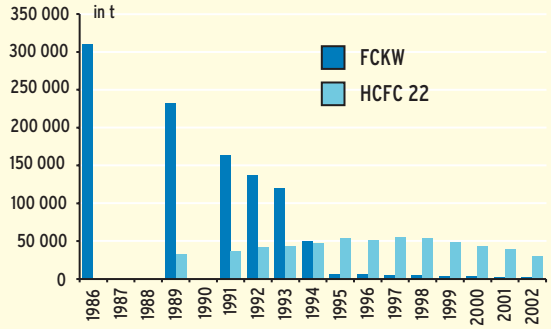
1. CFC R 11, R 12, R 113, R 114, R 115	
100 %	1995
2. Other fully halogenated CFC	
100 %	1995
3. Halons	
100 %	1994
4. Carbon Tetrachloride	
100 %	1995
5. 1.1.1-Trichlorethane	
100 %	1996
6. HCBC	
100 %	1996
7. Methyl bromide (Basis 1991)	
Freeze from	1995
25 %	1999
60 %	2001
75 %	2003
100 %	2005
8. HCBC (Basis 1997)	
Freeze from	2000
65 %	2008
80 %	2014
85 %	2020
100 %	2026

Further regulations state that

- Placing on the market and use of the substances listed in 1 to 6 above is prohibited. Exceptions are granted where the material is destroyed by the manufacturer or user, and for meeting licensed requirements or in special uses as a primary or process material. The use of halons will continue to be permitted in a very few exceptional cases, specifically listed in Appendix VII of the regulation. Temporary exceptions for medical implants and military uses may be applied for,

- The quantities of methyl bromide and HCFC placed on the market by manufacturers and retailers is to be successively reduced and
- Products and installations containing the substances listed in 1 to 6 above may not be marketed if manufactured after the regulation came into force.

Fig. IV 2.4-2: *Sale of CFC and HCFC 22 in the European Union*



Source: *European Commission 2005*

Tab. IV 2.4-2: *Use of methyl bromide in the European Union in t (ODP-weighted)*

	1991	1995	1996	1997	1998	1999
Methyl bromide	11 530	10 557	10 907	10 644	7 056	7 532

Source: *Oberthür 2001*

The bans on HCFC use contained in regulation 3093/94 have been widened further, bringing the following main restrictions:

- As of 2004, HCFC use as a coolant in all new refrigeration or air conditioning equipment, including combined air conditioning systems with an integrated heat pump, is prohibited.
- As of 2010, the use of virgin HCFC is banned for maintaining or servicing of existing refrigeration or air conditioning equipment, and the use of HCFC as refrigerant is prohibited as of 2015.
- Foam production using HCFC has been prohibited as of 2004, and previous exemptions have ceased to apply.
- Products and installations containing HCFC may no longer be marketed. Products and installations manufactured before the ban on their use came into force are exempt.

As well as the restrictions on production and use, regulation 2037/2000 specifies that substances in refrigeration and air conditioning systems, equipment containing solvents, fire protection appliances, and fire extinguishers have to be recovered. Substances from other products should be recovered where practical, and recovered substances should be recycled or destroyed.

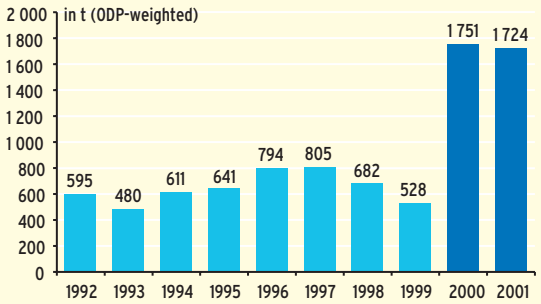
German measures to reduce the production, sale, and use of substances that deplete the ozone layer and affect the climate

The reduction targets are set out in German law in an ordinance banning CFC and halons of 6 May 1991 which, with few exceptions, prohibits the production, marketing, and use of CFC and halons in Germany. The ordinance banning CFC and halons does not cover the production and use of ozone depleting substances as feedstock. As feedstock, by definition, is completely destroyed or converted during the production process and is thus not emitted, its production is not subject to the Montreal Protocol on the protection of the ozone layer, which the ordinance implements at national level.

As of 1995, CFC use as a refrigerant in existing refrigeration or air conditioning equipment was permitted only until viable substitutes became available and were announced by the Federal Environment Agency (UBA), as has already been the case with R-12 (December 1995) and R-502 (May 1999). As of 2001, regulation 2037/2000 has prohibited the use of coolants containing CFC in Germany, whether or not the UBA has announced substitutes. As of 2000, the ban on CFC and halons in Germany has prohibited the use of HCFC-22 (R-22) as a coolant in new appliances. The same applies to the marketing of R-22 and to products that contain R-22. R-22 may still be used in old appliances.

CFC use in medical aerosols has been reduced, thanks to the development of alternative propellants. There are still a few exceptions for essential

Fig. IV 2.4-3: *Production of HCFC in Germany*



2000, 2001: including production for feedstock

Source: *United Nations Environmental Programme 2002 a*

use, but no new licenses for CFC aerosols may be granted as of 2000.

Exceptional permission for halon use in fire extinguishers exists in the interests of public health and safety. Both the number of exceptional permits and the number of criteria for awarding them have been reduced since the end of 1998, when the original permits expired. Current exceptional permits will expire by the end of 2008.

In addition to legal regulation, industry has made a number of voluntary commitments to reduce ODS use and emissions in some areas, for example the aerosol and insulation industries. These voluntary commitments are actually no longer relevant, but they were often the basis for ending the use of ODS before the legal regulations came into force (Fig. IV 2.4-3).

V AIR QUALITY MANAGEMENT

Air quality in Germany

Article 44 of the Federal Immission Control Act prescribes regular assessments for monitoring of air quality. Area-wide air quality monitoring is the responsibility of the *Länder*, which have established air monitoring networks to meet legal objectives. In addition to this, the Federal Environment Agency (UBA) collects immissions data at measurement stations in rural regions in order to monitor the background air pollution. This data also forms the basis for the fulfilment of international reporting duties according to conventions signed by the Federal State.

The assessment of the air quality in Germany is carried out on the basis of data collected from the 16 ambient air monitoring networks operated by the *Länder* and that of the UBA.

Emission of air pollutants

Emissions data is provided on an annual basis and follows the principle of territoriality. This means, for example, that emissions caused by international traffic outside German borders are not considered. In addition, emissions are calculated according to the "principle of origin", i.e., the emissions are reported according to the location at which they are produced. For example, emissions from heating plants are allocated to the relevant power station or district heating station, although the heat is actually used in the domestic sector, which is therefore the indirect source of the emissions. Emissions relating to traffic that result from the exploitation, transportation, and processing of crude oil and the distribution of fuel components are not considered.

The mechanisms by which harmful substances are emitted can be divided into two main groups: combustion processes in industrial plants or motor vehicles, and a broad range of other processes.

In general, energy conversion processes are the predominant source of emissions with regard to the individual components/substance groups considered; for example, these contribute approximately 98 % of carbon dioxide emissions. There are, however, examples of emissions that originate predominantly from non-energetic processes; for example, these cause 98 % of ammonia and methane emissions.

In order to provide a comparison for evaluation, emissions are categorised according to the emission source that caused them, and grouped according to the general structure proposed by the IPCC [1] (Table V-1).

V 1 Airborne pollutants

Large-scale trends in concentrations of airborne pollutants

Air pollution in the old *Länder*, due to the traditional pollutants sulphur dioxide and airborne particulates, was considerably higher between the 1950s and 1970s than today. The reduction in the concentration of pollutants has been forced by regulations that caused the change over from solid fuels like coal and lignite to oil and gas, the increased use of low-sulphur heating oil, and, later, the desulphurisation of flue gases in large combustion plants (LCP).

Air pollution control measures, regulated by law from 1983 onwards, have led to a further major pollutant reduction of average annual levels – to below 25 $\mu g/m^3$ in the case of SO_2 concentrations. In the new *Länder*, decreases in SO_2 and particulate emissions associated with economic restructuring, redevelopment of smokestack industrial areas, and the construction of advanced, state-of-the-art industrial plants are also reflected in the immission concentrations measured. For example, the annual mean SO_2 pollution levels in the industrial and urban conurbations of West Saxony, southern Saxony-Anhalt, and eastern Thuringia fell by about 150–175 $\mu g/m^3$ to 8–15 $\mu g/m^3$ between 1990/1991 and 2003. As a result of the reductions achieved, the winter smog alarms that were previously caused by sulphur dioxide emissions have been effectively eliminated. This applies to both old and new *Länder*, even in topographically unfavourable locations such as valleys and geological basins. Consequently, all *Länder* have now repealed their winter smog regulations.

Developments relating to motor vehicle traffic have played a key role in the situation change with regard to immissions of nitrogen oxides in both the old and new *Länder*. The reduction of NO_x emissions stated has only started to be reflected to a limited extent in trends in immission levels. Traffic-related emissions of NO_x in large cities in the new *Länder* have increased, and as a result, there is a tendency towards higher NO_x immission values with levels approaching those seen in comparable regions in the old *Länder*.

Because of the fact that air pollution is not being kept within national borders, this is an issue that

Tab. V-1: *Source groups for emission of air pollutants*

Source Group (CRF)	CRF category	Sources of emissions
Energy industries	1.A.1	Public electricity and heat suppliers, district heating stations, industrial furnaces, industrial power plants for mineral oil processing, extraction and manufacture of solid fuels, and other energy industries
Manufacturing industries and construction	1.A.2	Industrial furnaces and industrial power plants in the stone and earth extraction sectors, all other mining and processing industries, construction industry
Transport	1.A.3	Road transport and other transport (not agricultural and forestry transport)
Road transport	1.A.3b	Private cars, busses, light and heavy goods vehicles, motorcycles
Other transport	Remainder of 1.A.3	Rail transport, coastal and inland navigation, national civil air traffic, mobile sources related to the construction industry (not road transport), fishing (part of 1.A.4c not open sea), natural gas compressing stations
Other sectors Other: Military	1.A.4. 1.A.5.	Furnaces in the trade, commercial, and service sectors, agricultural and forestry traffic, military
Residential	1.A.4b	Furnaces and mobile sources related to private households (not road transport)
Fugitive emissions from fuels	1.B	Fugitive emissions from the extraction of coal, crude oil, and natural gas, the energy conversion sector, gas distribution networks, distribution of petrol
Industrial processes	2	Industrial production processes that cause non-energy related emissions (e.g., product emissions)
Solvent and other product use	3	Use of solvents by trade, industry, and private households use of nitrous oxide for anaesthesia
Agriculture	4	Fermentation during digestion storage and application of commercial and inorganic fertilisers, emissions from agricultural soils
Land use change and forestry	5	Changes to forest resources and other biomass resources, CO_2 emissions, carbon-fixation in soil
Waste	6	Waste landfill and waste water treatment
Other	7	Handling of bulk goods

Categories established under the terms of the Federal Environmental Agency and according to the report format stipulated by the CRF (Common Reporting Format) of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

Source: *Federal Environment Agency 2004*

has been tackled by the European Union for a long time, resulting in increasingly strict regulations for air quality management, as new knowledge and concepts are taken into consideration. The framework for these regulations is the Council "Framework" Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management, the objectives and principles of which are set out in concrete terms in so-called daughter directives. The framework directive and the first two daughter directives were adopted in German law through the 22nd Federal Immission Control Ordinance (22nd BImSchV). The third daughter directive was subsequently adopted through the 33rd Federal Immission Control Ordinance

(33rd BImSchV), whilst the fourth daughter directive is currently passing through the legislative process. The limit values specified in the daughter directives are based on the work of the World Health Organisation (WHO) and, in general, are considerably lower than the limits specified in previous regulations. Where particle emissions are considered, new limit values for fine dust (PM_{10}) have replaced the previous limit values for total suspended particulate matter. Another new feature compared to the previous EC directives is that the first daughter directive makes it compulsory to make up-to-date information on ambient air quality and air pollution situation routinely available to the public.

In addition to the air quality directives, the European Commission has also issued Directive 2001/81/EC on national emission ceilings (NEC) for certain atmospheric pollutants, restricting maximum national emission levels for the first time. This directive covers sulphur dioxide, nitrogen oxides, ammonia, and volatile organic compounds (VOCs), and was adopted into German law through the 33rd BImschV.

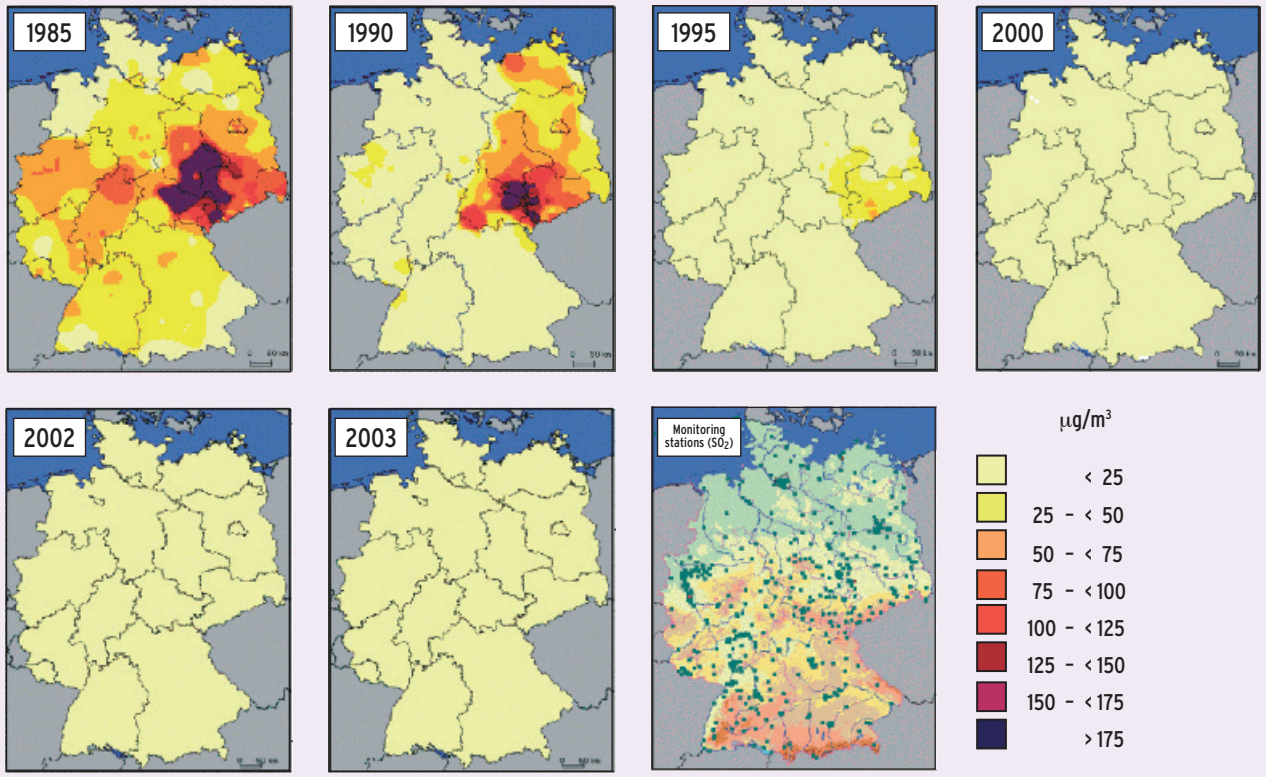
V 1.1 Sulphur dioxide (SO_2)

Trends in SO_2 immission concentrations

The nationwide representation and evaluation of SO_2 immission levels is based on the measurement results from approximately 500 ambient air monitoring stations belonging to the networks of the *Länder*, and approximately 30 stations operated by the UBA.

The annual mean SO_2 concentrations clearly show a downward trend in SO_2 pollution in the period 1985

Fig. V 1.1-1: *Annual mean SO_2 levels*



Data: Monitoring networks operated by the German *Länder* and the Federal Environment Agency
A small-scale interpretation is not feasible because of the interpolation method used

Source: *German Länder, Federal Environment Agency 2004*

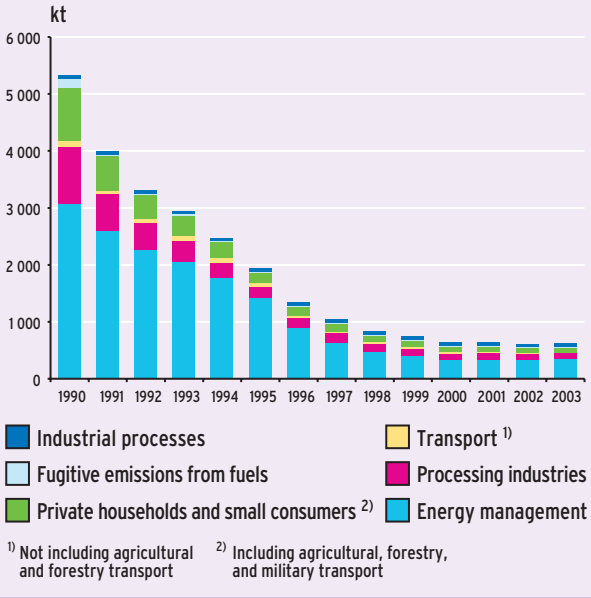
to 2003 (Fig. V 1.1-1). Taking as a basis the large-scale concentration levels between 1985 and 1987 of approximately 25–50 µg/m³, and levels of 50–75 µg/m³ in certain regions (Ruhr area, Rhein-Main area, North Hesse), reductions in levels to below 25 µg/m³ were achieved almost everywhere in the old *Länder* at the end of the 1980s and in the early 1990s.

In the years leading up to 1990, SO_2 pollution in the new *Länder* regions reached extremely high levels, particularly in the industrial regions of Saxony, Saxony-Anhalt, and Thuringia. The annual mean value was found, in places, to be above 150 µg/m³ across large areas. An appreciable reduction in levels started in 1990, and this trend has continued every year since. In the period up to 1994, the large-scale annual mean levels in Mecklenburg-Western Pomerania and Brandenburg showed low levels of SO_2 pollution, similar to the levels in the old *Länder*. During this time, the values remained between 25 and 50 µg/m³ only in Saxony, Saxony-Anhalt, and Thuringia, with a few places recording levels above 50 µg/m³. Today, differences in the levels of SO_2 pollution between the new and old *Länder* are no longer identifiable. The annual mean limit value of 20 µg/m³ defined for the protection of ecosystems is achieved everywhere in Germany.

Trends in SO_2 emissions

The reduction in emissions from 1990 to 2003 has been shown to be more than 4.7 Mt (–88 %) (Fig. V 1.1-2). The main reason for this in the new *Länder*

Fig. V 1.1-2: *SO_2 emissions in Germany by source group*



Source: *Federal Environment Agency 2005*

regions is the enforcement of the 13th Federal Immission Control Ordinance concerning large combustion plants (LCP; in German: 13th BImSchV – 'Großfeuerungsanlagenverordnung'), which lays down technical regulations for the limitation of emissions, the introduction of low emission fuels, and major reductions in energy demand through decommissioning of operations and economic restructuring. In 2003, the main producers of SO_2 emissions were still non-vehicular sources in the energy conversion sector (combustion plants in power stations and district heating plants –55.2 %) and the manufacturing sector (industrial furnaces –17.8 %) Nonetheless, it was still possible to reduce emissions in these areas by 3.6 Mt in the period from 1990.

Polluters

By far the largest proportion of SO_2 is produced by the oxidation of the sulphur contained in the fuels used in combustion processes. Emissions from processing industries remain almost constant, however they are relatively minor. The main emission sources in this sector are: industrial production processes in the chemical industry, metal production, stone and earth processing, and refining of crude oil and natural gas.

Fulfilling of international conventions by Germany

Under the terms of the UN ECE Geneva Convention on Long-range Transboundary Air Pollution Control (CLTRAP, 1979) , the Federal Republic of Germany was obliged by the UN ECE Helsinki Protocol (First Sulphur Protocol, 1985) to reduce its annual sulphur emissions by at least 30 % by 1993, as compared to 1980 levels. In 1993, the SO_2 emissions were 2 945 kt, compared to approximately 7.5 Mt in 1980. This represents a reduction of 61 %. The second UN ECE protocol on the reduction of sulphur emissions obliged Germany to reduce SO_2 emissions to 1,300 kt by 2000, and to 990 kt by 2005. The target set for 2005 had already been achieved by 1998.

The latest UN ECE protocol aims to minimise the damage caused by acidification, eutrophication, and ground level ozone (known as "Göteborg multi-component protocol", s. NEC Directive of the EC, adopted in German law through the 33rd Ordinance – 33. BImschV) and obliges the Federal Republic of Germany to reduce SO_2 emissions to 550 kt by 2010. In order to achieve this target, the emissions recorded in 2003 will need to be reduced by a further 10 %. It should be noted that between 2000 and 2003 emissions remained roughly constant, so further measures will be required in order to achieve this target.

V 1.2 Nitrogen Oxides (NO_x)

Trends in NO_x immission concentrations

The majority of emissions of nitrogen oxides (NO, NO_2) are emitted as nitrogen monoxide (NO). NO does not occur on a wide scale however, since this gas oxidises relatively quickly with atmospheric oxygen and ozone to form NO_2. In the summer months, nitrogen dioxide degrades due to the action of UV(B) radiation. As a result, in rural regions away from metropolitan areas, the concentrations rarely exceed a value of 30 $\mu g/m^3$, and generally lie below 10 $\mu g/m^3$ except in areas with heavy traffic. Depending on the location of the monitoring station, annual mean values of between 30 and 60 $\mu g/m^3$ may be measured in a few metropolitan areas. The first EC daughter directive on ambient air quality (1999/30/EC) specifies an annual limit value of 40 $\mu g/m^3$ for the protection of human health, which must not be exceeded after 2010. This limit value is currently not complied with in all parts of Germany.

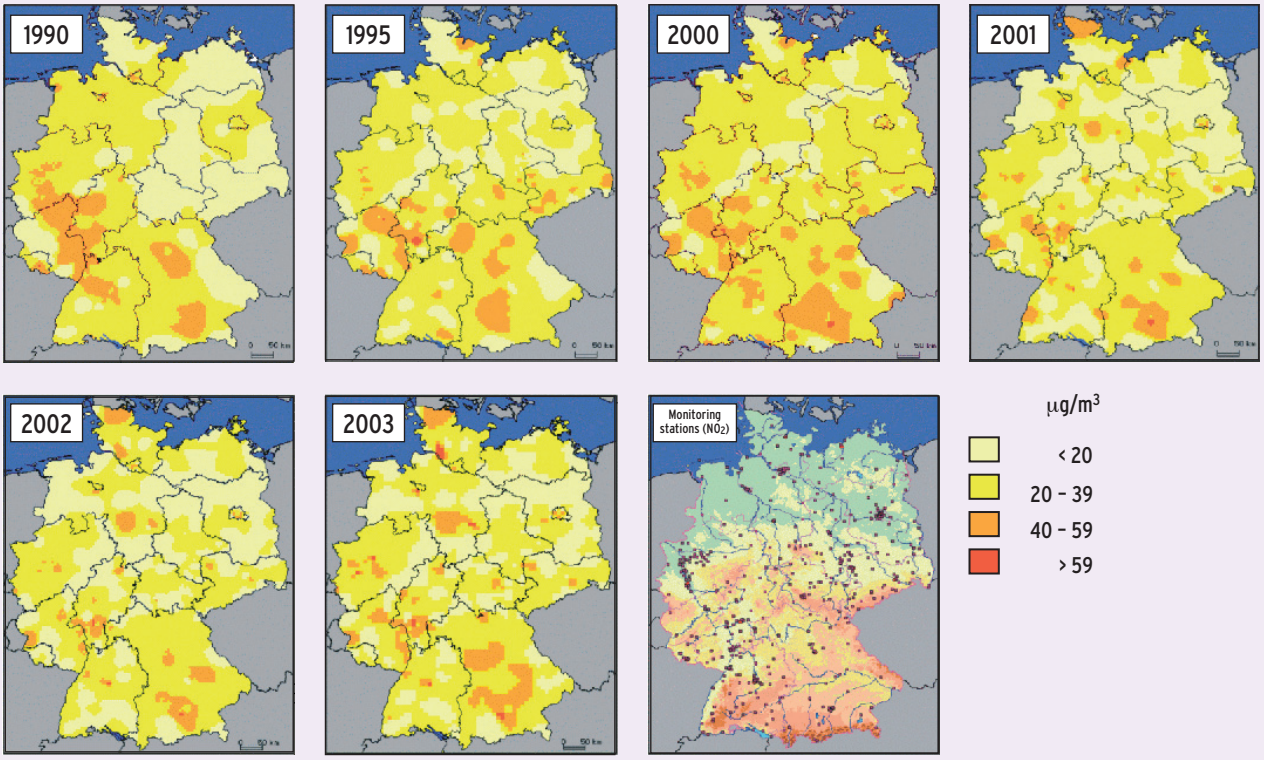
In the former German Democratic Republic NO_2 levels were only recorded in exceptional cases, with the result that very few measurements from the years before 1988 are available. As such, the area-wide figures only go back as far as this year. Across Germany as a whole, NO_2 measurements are taken at about 450 stations (Fig. V 1.2-1).

Trends in NO_x emissions

Emissions data for nitrogen oxides (NO_x) are counted in terms of NO_2. The reduction in emissions from 1990 to 2003 has been shown to be 1 418 kt (–50 %) (Fig. V 1.2-2). This reduction comes from all categories of emissions sources – the most significant reduction in terms of volume being the transportation sector, which contributed over 700 kt (–49 %). Despite this reduction, the transportation sector still produces by far the largest proportion of emissions, contributing almost 50 % of NO_x emissions. Emissions reductions in other sectors come as a result of the introduction of low-emission fuels/burners and more efficient use of energy, as well as from the benefits of economic restructuring, mainly in the new *Länder*.

Nitrogen oxides are produced almost exclusively by industrial and vehicular combustion processes as the result of oxidisation of the nitrogen content of the fuel and the combustion air. The majority of these 'nitrous' gases are emitted as nitrogen monoxide (NO) and subsequently oxidised in the atmosphere to form NO_2. The proportion attributed to non-combusting processing operations is only in the parts per thousand range, and can be chiefly attributed to the chemical industry (e.g., manufacturers of nitric acid)

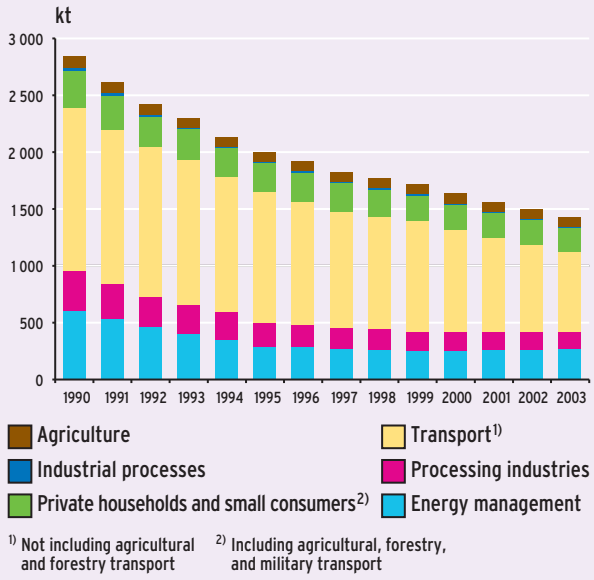
Fig. V 1.2-1: *Annual mean NO_2 levels*



Data: Monitoring networks operated by the German *Länder* and the Federal Environment Agency
A small-scale interpretation is not feasible because of the interpolation method used

Source: *German Länder, Federal Environment Agency 2004*

Fig. V 1.2-2: *NO_x emissions in Germany by source group*



Source: *Federal Environment Agency 2005*

and the stone and earth processing sectors (except clinker & clay brickstone furnaces, etc.).

The decisive factors in determining the extent of NO_x formation are the thermodynamic combustion conditions such as pressure, temperature, residence time, and excess air. These vary considerably between furnace plants depending on the technology used. The amount of NO_x released can be substantially reduced using aftertreatment systems (catalytic converters in vehicles, $DeNO_X$ systems at large-scale combustion plants, etc.). The highest emissions per unit of energy used come from the transport sector, followed by power stations and industrial furnaces. The lowest specific emissions are produced by small household heating facilities, especially those with low-NO_x burners.

Within the scope of the UN ECE Göteborg protocol on the reduction of NO_x emissions, the Federal Republic of Germany was obliged to reduce emissions to the 1987 level of 3 177 kt by 1994. However, this value is inconsistent with the time series data after 1990 because, for example, it does not include any emissions from the agricultural sector. Emissions were successfully reduced by over 30 % to 2 130 kt in this period, exceeding the obligatory requirements of the protocol and also meeting the additional voluntary commitment that was entered into by Germany and 11 other ECE countries (reduction of NO_x emissions before 1998 by 30 % compared to 1986 levels).

Germany has made a commitment under the multi-component protocol to minimise emissions, as it has

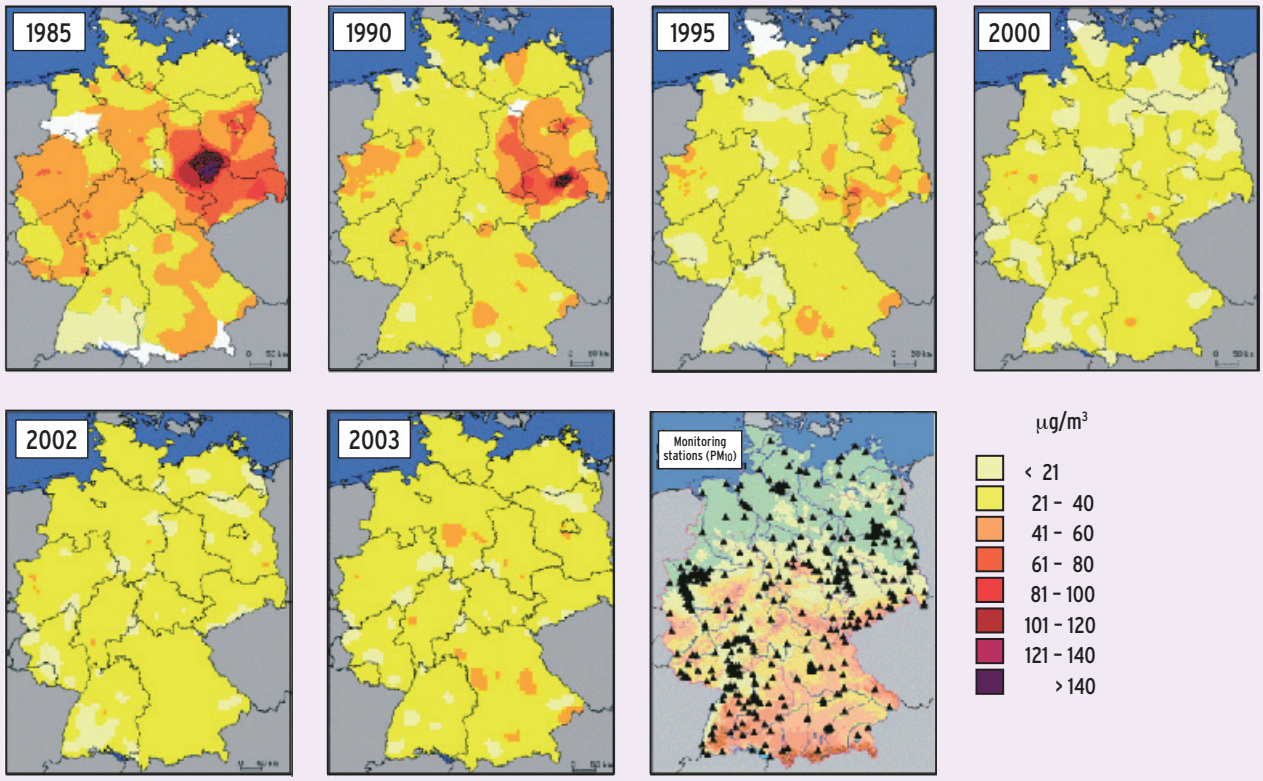
with SO_2. By 2010, it will no longer be permissible to exceed a National Emission Ceiling of 1 081 kt NO_x for Germany as whole. In order to achieve this target, the emissions recorded in 2003 will need to be reduced by a further 24 %.

V 1.3 Airborne particulates (particulate matter, PM)

Trends in ambient air concentrations of airborne particulate matter ('dust')

Discussions relating to public health policy no longer tend to consider overall concentrations of airborne particulates, rather, they give increasing attention to the PM_{10} and $PM_{2.5}$ components of suspended dust (PM = particulate matter). This takes into account the limit values for PM_{10} specified in the first EC daughter directive (1999/30/EC) across the whole of Europe. The terms PM_{10} and $PM_{2.5}$ refer to the mass concentrations of all airborne particles with diameters less than 10 µm and 2.5 µm, respectively. Of all the dispersed particulate matter in the atmosphere, these PM fractions come mainly from combustion processes of stationary (industrial and household) and mobile (traffic related) sources; significant industrial processes include cement clinker manufacture and the handling (including transportation) of dustproducing goods. Airborne PM can also be formed from gases (SO_2, ammonia, hydrocarbons), and natural sources exist as well. Scientific investigations on the particle distribution of total suspended particles (TSP) in the atmosphere have shown that on average 83 % of the TSP falls into the PM_{10} category. Several *Länder* monitoring networks began individually with measurements for the PM_{10} fraction in the mid-1990s. Since 2000, PM_{10} has been measured throughout Germany. In order to produce a complete picture of PM_{10} pollution across Germany in the years for which only incomplete measurements are available, the PM_{10} concentrations have been calculated from the data relating to TSP concentrations. The results from this calculation process do not necessarily correspond to actual PM_{10} levels in every individual case; it does however provide a reasonably good guide to current and previous pollution levels. The first year in which both measured PM_{10} values and those calculated from TSP concentrations were used as the base data for the nationwide figures was 1998. The proportion of measured PM_{10} data increased in subsequent years, and since 2001 the pollution maps have been produced based exclusively on measured PM_{10} data (Fig. V 1.3-1).

Fig. V 1.3-1: *Annual mean PM_{10} levels*



Data: Monitoring networks operated by the German *Länder* and the Federal Environment Agency

For 1985 to 1998, suspended dust data (TSP) was converted to PM_{10} values (factor 0.83). From 1999 onwards over half of all PM_{10} data was based on measurements. The remainder was converted as previously.

A small-scale interpretation is not feasible because of the interpolation method used

Source: *German Länder, Federal Environment Agency 2004*

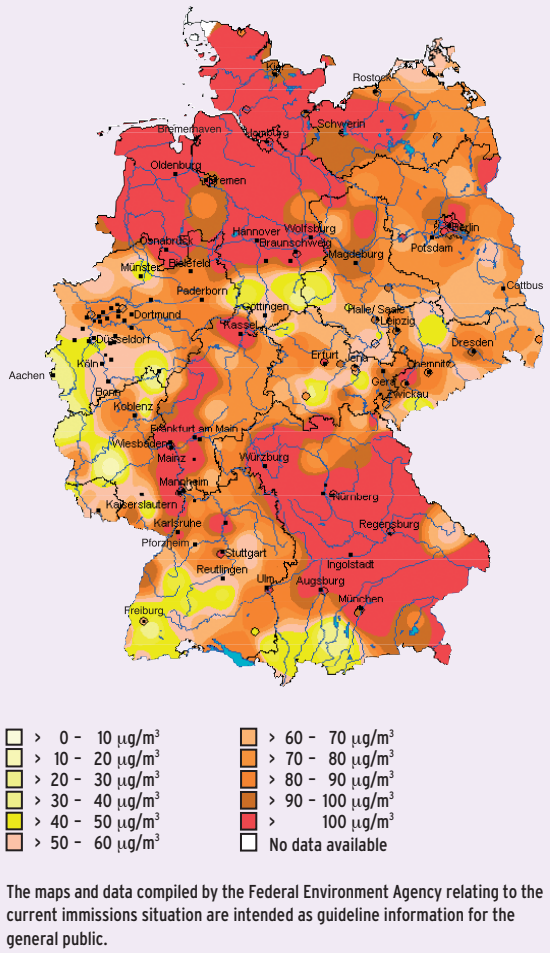
Since about 1989, and particularly since 1993/1994, it has been possible to identify a downward trend in the airborne PM pollution in the new *Länder* regions, whereby pollution is calculated using annual average PM_{10} concentrations. Marked differences in the levels of PM_{10} pollution between the old and new *Länder* were not present, as was the case for SO_2. The trends show that PM_{10} concentrations in the old *Länder* since the late 1980s and early 1990s have tended towards low values of around 50 µg/m³. At the end of the 1980s, PM_{10} concentrations in Thuringia, Saxony, Saxony-Anhalt could still be shown to be over 100 µg/m³ (annual mean), whereas in 1998 the levels in the same areas were between 25 and 50 µg/m³ in only a few locations. Across Germany as whole, the current wide-scale annual mean PM_{10} levels are between 25 und 35 µg/m³. In 2003, the annual mean levels that approached 50 µg/m³ were seen predominantly at measuring stations affected by traffic.

The Ordinance on Immissions Values for Airborne Pollutants (22nd BImSchV) specifies a limit value for annual mean PM_{10} of 40 µg/m³, which must be complied with by 2005. This limit value is currently not complied with in all parts of Germany. As a result of the drastic reductions in TSP and fine PM emissions in Germany in the last decade, it is to be expected that concentrations of airborne PM will only be reduced gradually in future. This is because the contribution of long-distance transport and natural emissions will be increasingly significant. Further measures for the reduction of PM_{10} emissions will therefore be required.

In order to comply with the 22nd Ordinance (22nd BImSchV), from 2005 onwards daily mean PM_{10} concentrations may exceed the short-term limit value of 50 µg/m³ only on 35 days in one calendar year. Particularly in dry winters, but also in hot summers, there are still days when high PM_{10} concentrations occur across the whole of Germany. On such days, the value of 50 µg/m³ may be exceeded almost everywhere in Germany. Figure V 1.3-2 shows an example of this type of pollution situation. On the day illustrated, PM_{10} levels of 120 µg/m³ or greater were measured at 65 stations. The highest values (around 180 µg/m³) were measured at roads carrying heavy traffic. Values under 50 µg/m³ were almost exclusively detected at sites at altitudes of 1 000 m a.s.l.

The height of the PM_{10} pollution level during such periods is mainly dependent on the meteorological conditions. The deciding factors are the speed at which fine PM is distributed in the air, and how quickly it dissipates. Similar to the situation in the past with winter smog, high-pressure, low-wind weather patterns in winter create conditions in which pollutants are not transported away, but rather collect in the lower layers of the atmosphere (up to about 1 000 m) in a bell-shaped formation. A significant improvement in the level of air pollution occurs when the weather conditions change and stronger winds can dilute the polluted air mass. This results in a considerable decrease in PM_{10} values.

Fig. V 1.3-2: *Daily average values of particle concentrations from 27.02.2003*



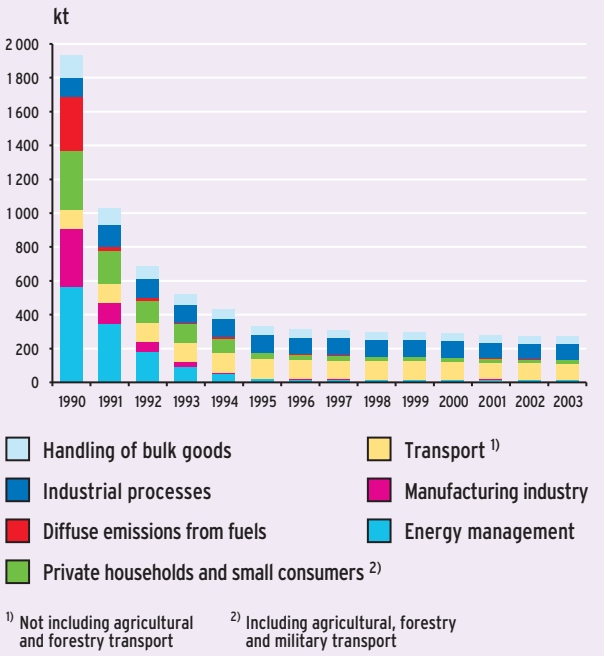
The maps and data compiled by the Federal Environment Agency relating to the current immissions situation are intended as guideline information for the general public.

Source: *German Länder, Federal Environment Agency 2004*

Trends in suspended particulate matter [SPM] emissions

From 1990 to 2002, an overall reduction in SPM emissions from over 1.6 Mt to only 0.3 Mt has been seen (Fig. V 1.3-3). This reduction was possible to a large extent due to the change in emissions in the new *Länder*. As part of this change, numerous aging combustion plants and other industrial facilities have been decommissioned, and the efficiency of existing dust extraction facilities in power stations and district heating stations has been considerably improved in a short time. The conversion from solid

Fig. V 1.3-3: *Dust emissions in Germany by source group*



Source: *Federal Environment Agency 2005*

fuels to low-emission liquid and gaseous fuels, especially in smaller furnaces, has also had an effect.

The data does not currently include emissions from the transportation sector that are not produced as a result of combustion processes. The current state of knowledge suggests that emissions caused as a result of abrasive processes are certainly not insignificant (sources include: tyres, which contribute approximately 70 kt per year; road surfaces, which contain a substantial proportion of fine PM; and brake linings, which produce fine PM almost exclusively). As such, the low overall levels already achieved will be considerably affected in terms of the proportional results when this data is included.

Pollutants

Within the sectors already considered, all combustion processes and other sources of emissions are considered to be emissions-relevant. The other sources of emissions are predominantly attributable to the iron and steel industries, stone and earth processing sectors, and the handling of solid bulk goods.

If the handling of bulk goods is not considered, then the main producers after the transportation sector – with 43 % – are industrial processes – with 40 %. Since the mid 1990s, combustion processes have only contributed about half of overall emissions.

V 1.4 Ground level ozone and photochemical smog ('summer smog')

The lower levels of the atmosphere, up to 10 km altitude (e.g., troposphere), contain a base level of naturally occurring ozone. Additional ozone forms under intensive sunlight, i.e. solar irradiation, as a result of complex photochemical reactions between oxygen and pollutants in the air – particularly volatile organic compounds (VOC) and nitrogen oxides (NO_x), but carbon monoxide (CO) and methane (CH_4), too. These airborne pollutants as ozone precursor substances mainly originate as a result of human activity. Ozone is not produced and not emitted directly, and is, therefore, referred to as a secondary pollutant.

Photochemical smog (also known as 'summer smog') is a mixture of pollutants in the atmosphere that is created from a number of precursor substances under the influence of sunlight. Ozone is the primary substance in summer smog, as it dominates photochemical smog in terms of pollutant concentration and its effects..

The values for ozone in ambient air, specified in Directive 2002/3/EC of the European Parliament and of the Council have been adopted in German law as part of the Ordinance on the reduction of summer smog, acidification, and inputs of nutrients (33rd BImSchV). The 33rd BImSchV includes target values, long-term goals, and threshold values for ground level ozone.

Target values for the protection of human health and vegetation:

120 µg/m³ over 8 hours may only be exceeded on 25 days in one calendar year, averaged over 3 years.

Long-term objective for the protection of health:
120 µg/m³ should be the highest 8-hour mean value in any calendar year, and never exceeded.

Target value for the protection of vegetation:
18 000 µg/m³ per hour, averaged over 5 years (AOT40, calculated as 1-hour values from May to July).

Long-term goal for the protection of vegetation:
6 000 µg/m³ per hour (AOT40, calculated as 1-hour values from May to July).

Alert threshold value for the protection of health:
240 µg/m³ 1-hour average value measured over 3 successive 1-hour periods.

Information threshold value for the protection of health:
180 µg/m³ 1-hour average value.

Because the emissions do not come directly from man-made equipment, pollutant emission levels do not exist for ozone in the same way like for sulphur dioxide, particulate matter, and nitrogen dioxide e.g., in the "*TI Air*" Technical Instructions on Air Quality Control.

In 2003, in Germany, 340 monitoring stations operated by the government and the individual *Länder* were used to monitor concentrations of ground level ozone (Fig. V 1.4-1 and Fig. V 1.4-2).

Annual average values

Annual average values for ozone concentrations (Fig. V 1.4-3) play a minor role in the evaluation of the of summer smog levels. They can however still be useful in assessing the immission situation. The annual mean values are of more importance when it comes to discussions on long-term ozone pollution trends, insofar as ozone measurement values already go as far back as the turn of the last century. The following average values are included in the records:

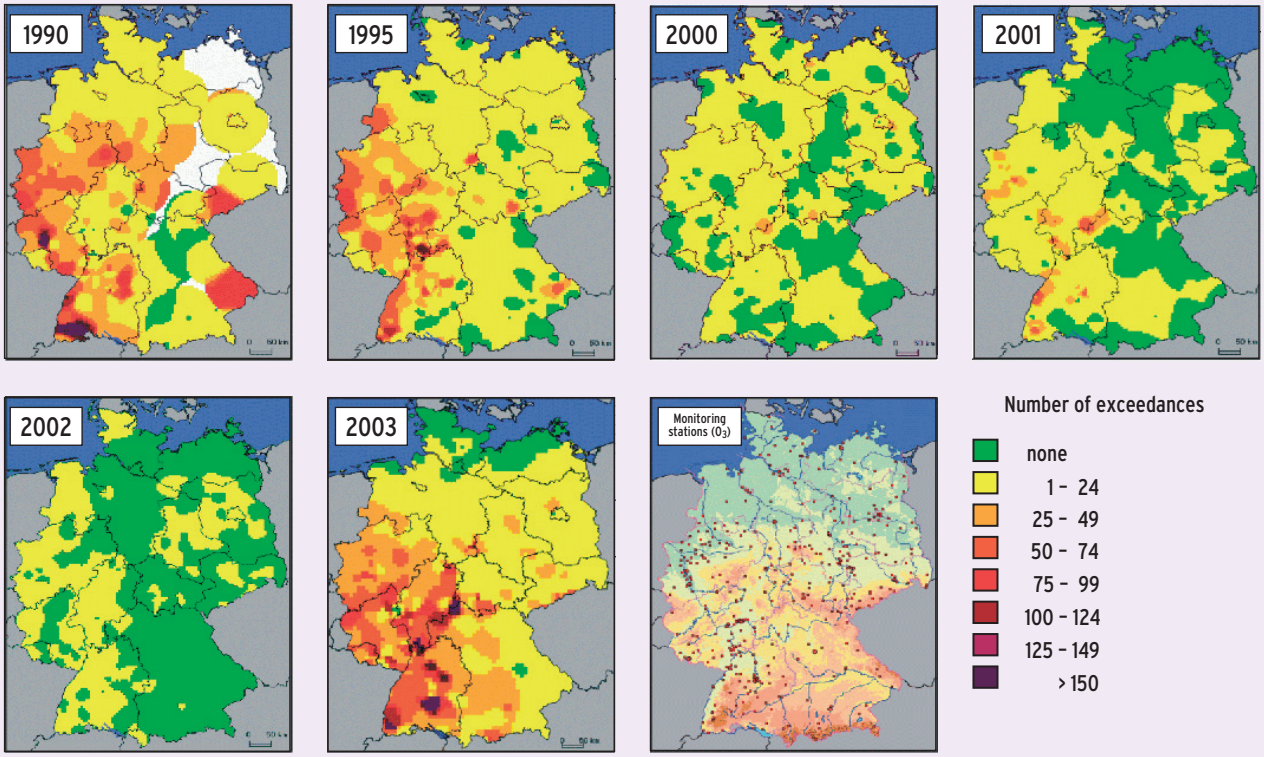
At Montsouris (near Paris), approximately 20 µg/m^3 (ca. 1875–1900), according to the Encyclopaedia of Technical Chemistry (ca. 1915–1920), for valley locations approximately 40 µg/m^3, and for higher altitude locations approximately 95 µg/m^3.

This historical data is only comparable with the ozone concentrations measured today to a certain extent, due to modified measuring techniques, the locations of the monitoring stations, and the conditions under which samples were taken. The annual average ozone concentrations from 1984 to 2003 show an upward trend (Fig. V 1.4-4). It is highly probable that this can be attributed to the growing contribution from background levels in the northern hemisphere, as well as to the reduction of NO_x emissions in Germany (the main source of NO_x pollution is nitrogen monoxide (NO) generated by road traffic). A further reduction in NO emissions (from use of catalytic converters in automotive exhaust equipment) can lead to an increase in ozone levels close to heavily used roads, since ozone is normally absorbed by the so-called titration reaction with NO to form NO_2.

Exceedance of threshold values

The frequency with which threshold values are exceeded is a parameter that is regularly discussed in the ozone data debate. The data relating to absolute exceedance (e.g., hours during which values are exceeded) is dependent on both the number of moni-

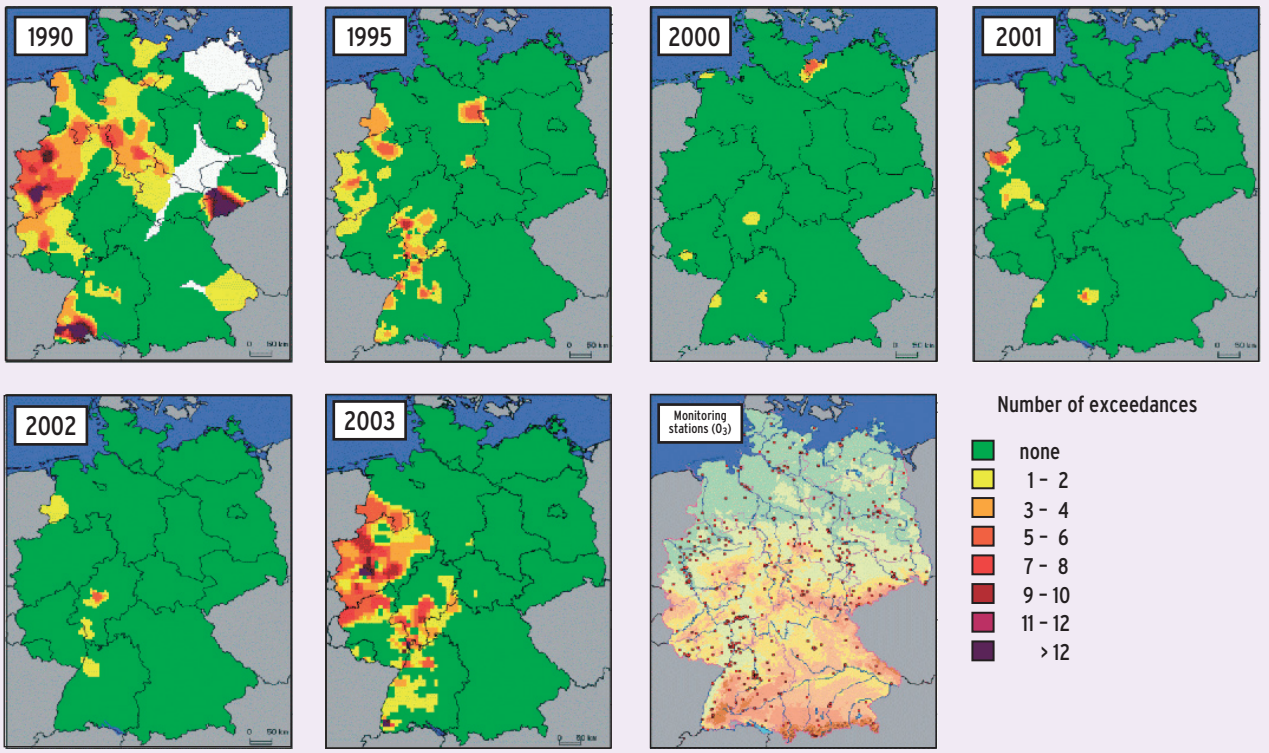
Fig. V 1.4-1: *Exceedance of ozone levels of 180 µg/m^3*



Data: Monitoring networks operated by the German *Länder* and the Federal Environment Agency
A small-scale interpretation is not feasible because of the interpolation method used

Source: *German Länder, Federal Environment Agency 2004*

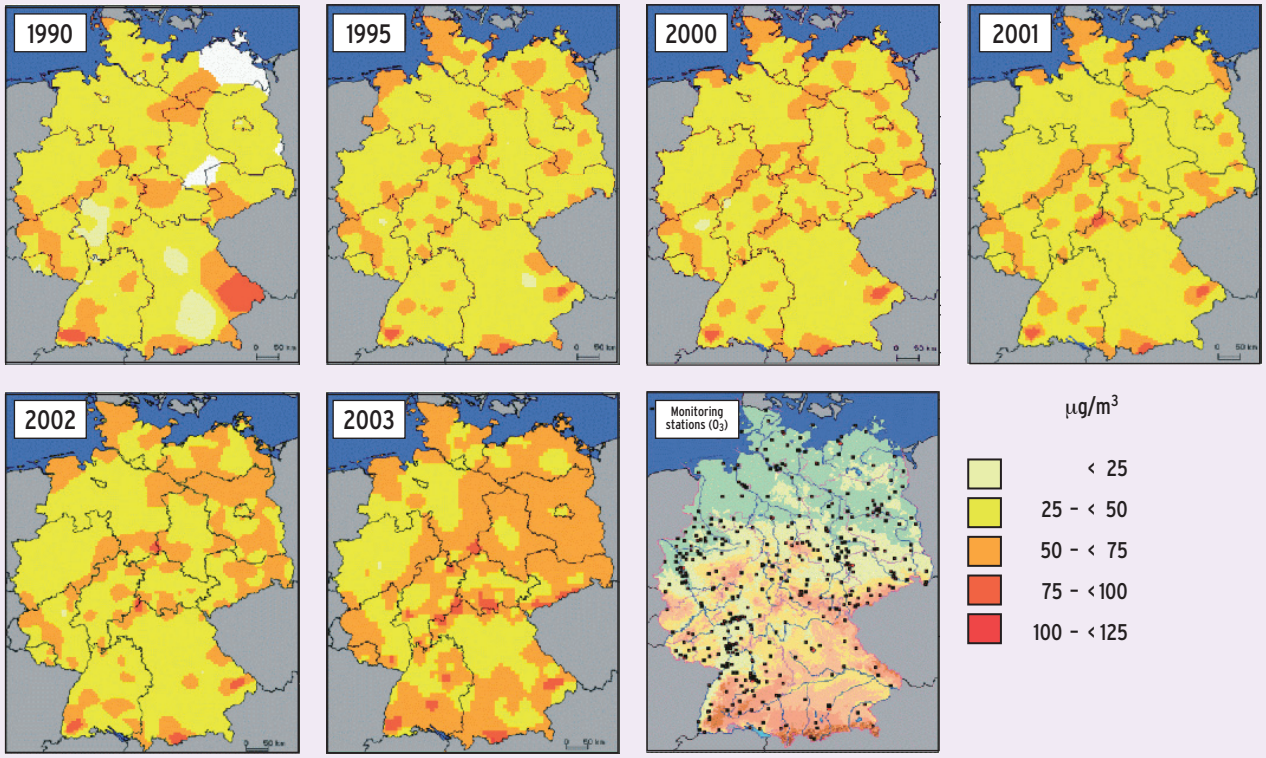
Fig. V 1.4-2: *Exceedance of ozone levels of 240 µg/m³*



Data: Monitoring networks operated by the German *Länder* and the Federal Environment Agency
A small-scale interpretation is not feasible because of the interpolation method used

Source: *German Länder, Federal Environment Agency 2004*

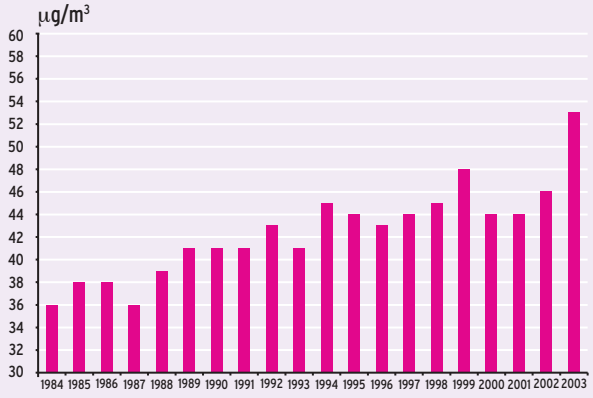
Fig. V 1.4-3: *Annual mean ozone levels*



Data: Monitoring networks operated by the German *Länder* and the Federal Environment Agency
A small-scale interpretation is not feasible because of the interpolation method used

Source: *German Länder, Federal Environment Agency 2004*

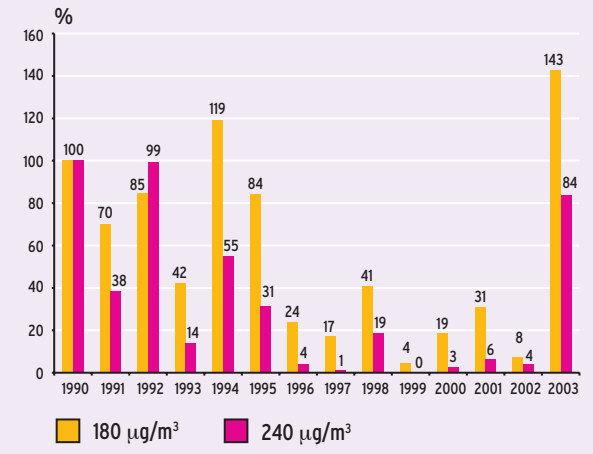
Fig. V 1.4-4: *Annual average values for ozone concentration averaged across all measuring stations*



Source: *Federal Environment Agency 2004*

toring stations installed and the number of periods of increased ozone concentration. It is also dependent on the type and location of the monitoring stations (i.e., proximity to traffic, large town site, rural site, mountainous site). For example, in recent years a number of monitoring stations have been installed at rural sites, and the ozone measurements from these have a significant influence on the overall nature and structure of the nationwide ozone database (Fig. V 1.4-5).

Fig. V 1.4-5: *Exceedance hours (relative to 1990 and to the number of measuring stations in operation each case)*



Source: *Federal Environment Agency 2004*

If average values for the number of hours during which ozone levels of 180 and 240 µg/m³ were exceeded are normalised for the measuring stations in operation in 1990, then it can be seen that the incidence of values over 180 and 240 µg/m³ fluctuated from year-to-year between 1990 and 2003. It is very difficult to identify any particular trend in this representation of the data due the similarly fluctuating meteorological conditions each year. In the summer of 2003, the conditions for the formation and accumulation of ozone (and ozone precursor substances) were very favourable over a sustained period (two weeks), with the result that a high base level of ozone was able to accumulate, with peaks in excess of the threshold values. This type of unusual weather situation was only observed for the first time in 2003, so the "ozone summer" of 2003 is regarded with particular significance in this context. Compared to 1990 levels, emissions of ozone precursor substances (nitrogen oxides and volatile organic substances) have been reduced by between 42 % and 50 % to date in Germany. If the same quantity of ozone precursor substances had been released to the atmosphere in 2003 as were in 1997, even higher levels of ozone pollution would have occurred, with 10 % more incidences of exceedance.

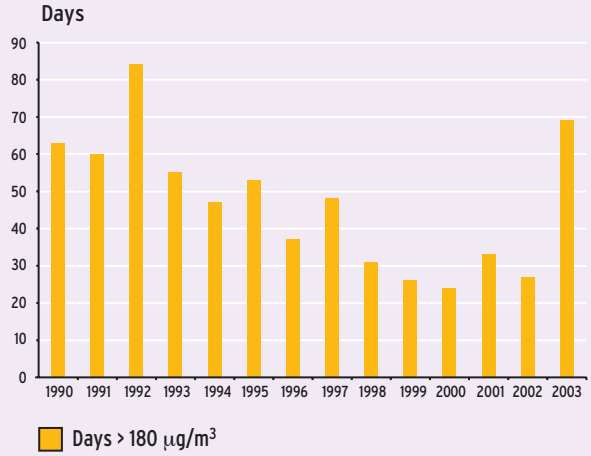
Summer smog (photochemical smog)

The following are prerequisite conditions for the occurrence of summer smog: presence of both precursor substances, NO_x and NMVOC; intense solar radiation; a continuous and a stable period of dry, sunny weather over several days, leading to accumulation of ozone within the troposphere.

The altitude and frequency of periods of summer smog is largely dependent on the characteristics of a particular summer. Periods of summer smog are defined as occurring when ozone levels exceed the information threshold value of 180 µg/m³ for at least two days over a wide area. Figure V 1.4-6 and Figure V 1.4-7 show the number of hours in which levels exceeded 180 µg/m³ and 240 µg/m³,respectively, with values averaged across all relevant monitoring stations.

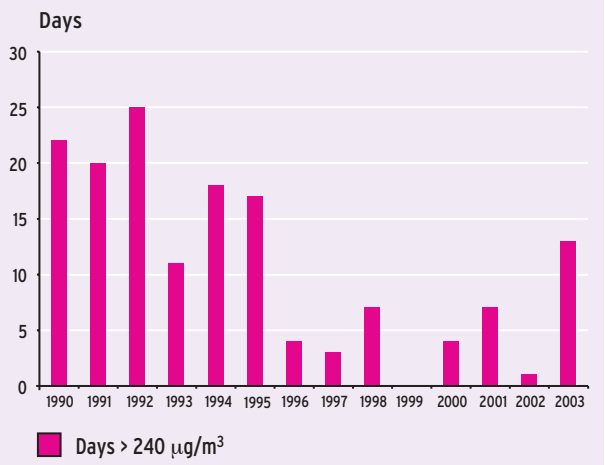
During the longest lasting incident of high ozone levels since 1990 (from 1st to 14th August 2003), the

Fig. V 1.4-6: *Number of days when the 180 µg/m³ level was exceeded*



Source: *Federal Environment Agency 2004*

Fig. V 1.4-7: *Number of days when the 240 µg/m³ level was exceeded*



Source: *Federal Environment Agency 2004*

meteorological conditions were favourable to the formation and accumulation of ozone (and ozone precursors) for a very long period. By way of illustration, the maps shown in Figure V 1.4-8 give the daily maximum ozone concentrations at the peak of the occurrence between 5th and 13th August 2003.

Trends in traffic-specific emissions of ozone precursor substances

The 33rd Ordinance (BImSchV) defines controls on the emissions of ozone precursor substances, which must be reduced to the national maximum emissions limits by 2010 (NO_x to 1 051 kt and VOC to 995 kt).

Motor vehicle traffic is a major source of ozone precursor substance emissions. In addition to this, emissions of volatile organic compounds are largely attributable to nitrogen oxides from the power generation sector and from the use of paints and solvents. There are also some emissions from natural sources.

In view of the considerable reductions in emissions of ozone precursors since 1990 (Fig. V 1.4-9) and the emissions reduction targets for 2010 across Germany and Europe, it is of particular interest to know how ozone concentrations have changed in response to the reductions, and when it can be expected that the ozone emissions levels specified in the 33rd BImSchV will be complied with. Investigations have shown that peak ozone concentrations in Germany between 1990 and 2002 have decreased significantly. This decrease is mainly attributable to the considerable reductions in precursors, and not to the effects of meteorological conditions. Peak ozone levels will decrease further in coming years, albeit not to the same degree as in the period 1990 to 2002. In contrast to the pleasing trends and prognosis with regard to peak ozone levels, the average ozone concentrations in Germany are not set to decrease significantly in the next decade. This means that the new target values for the protection of vegetation are unlikely to be met in this period.

The following measures should be introduced in order to achieve further reductions in pollutant emissions:

- Enforcement of three-way catalytic converter regulations for existing cars with petrol engines
- Continued tightening of permissible automotive exhaust limit values
- Diesel particle filters
- Further development of environmentally-friendly alternative propulsion technologies
- Training for motorists in driving techniques that use less fuel and reduce emissions
- Measures to increase occupancy and load levels (freight exchanges, car sharing, etc.)
- Measures to reduce traffic levels and transfer road traffic to less environmentally damaging forms of transport (changing the 'modal split').

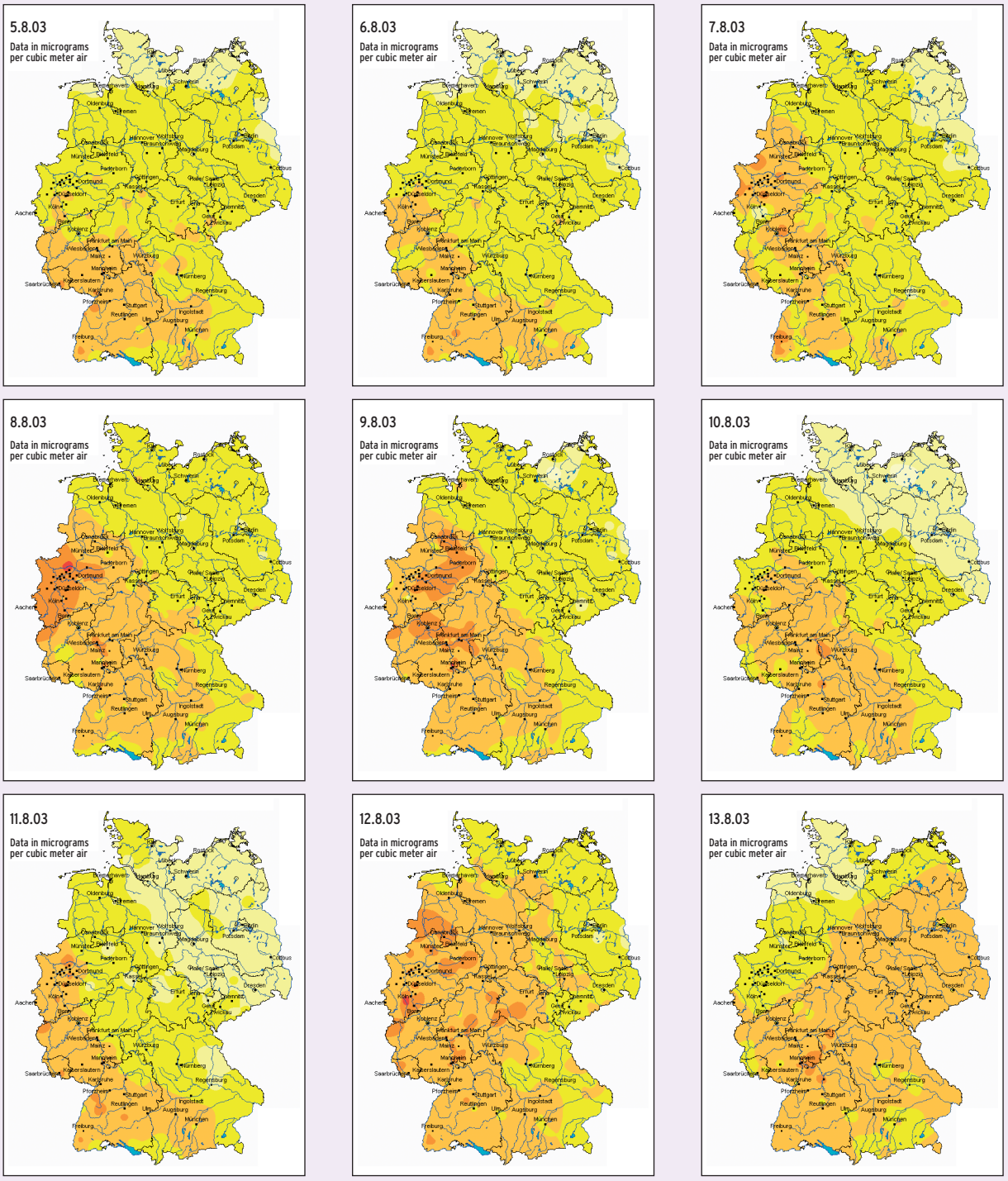
V 1.5 Pollution in urban agglomerations

The Ruhr area was, for a long time, one of the worst affected parts of the old Federal Territory in terms of air pollution. The trends in SO_2 pollution seen here represent one of the main components in the evaluation of air pollution. In the mid-1960s in Gelsenkirchen, the annual mean sulphur dioxide levels were measured at between 180 and 270 µg/m³. Since then, SO_2 concentrations have continuously decreased, with levels in the mid-1980s falling below 100 µg/m³. Further reductions were seen up to 2002, with levels falling to 8 µg/m³ as a result of emission reduction measures undertaken at power stations and industrial plants.

The situation in Leipzig is representative of the trends seen for urban agglomerations in the new *Länder*. The annual mean SO_2 concentrations measured in the 1980s were about 200 µg/m³, but between 1984 and 1987, when the winters were very severe, concentrations in some places exceeded 300 µg/m³. In the years following 1988 that experienced mild winters, mean values of up to 200 µg/m³ were achieved. Marked reductions related to emissions have been seen since 1990. At the same monitoring stations in 2002, annual mean SO_2 immission concentrations of 4 µg/m³ were achieved (Fig. V 1.5-1).

Following these reductions in SO_2 pollution, achieved primarily through the successful introduction of

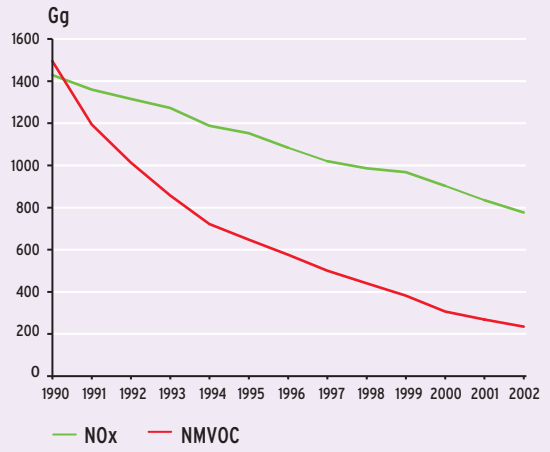
Fig. V 1.4-8: *Maximum hourly average values for ozone concentrations from 5th to 13th August 2003*



Source: *German Länder, Federal Environment Agency 2004*

emission reduction measures in the electricity generation sector and at industrial plants, air pollution has started to become an issue of increasing concern, mainly due to emissions from the transportation sector. Diesel soot and benzene are the most important factors to consider here, because they have properties that present a risk to health. The trend in frequent years has, in many cases, been towards a reduction in benzene pollution. During the 1990s, annual mean benzene levels above 5 µg/m³ were still being recorded at roughly 20 % to 30 % of monitoring stations, however, since 2000, these lev-

Fig. V 1.4-9: *Transport related emissions*



Source: *Federal Environment Agency 2004*

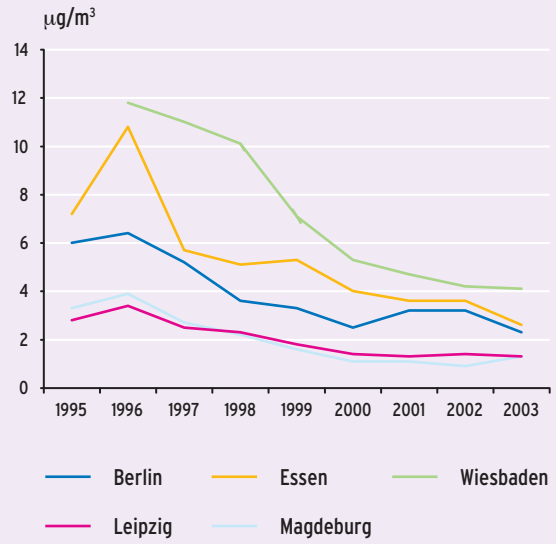
els have only been seen at less than 10 % of measuring stations. A decline in the maximum average values measured anywhere in Germany can also be seen. Between 1995 and 1998, the places in Germany that were most seriously affected by benzene pollution had annual mean values as high as 15 µg/m³, whereas current maximum annual mean levels are approximately 8.5 to 9 µg/m³. Currently, the annual benzene levels at around 90 % to 95 % of all measuring locations lie between 0.5 and 5 µg/m³, with levels in rural areas only reaching 0.5 µg/m³. The highest levels of benzene pollution occur in areas close to heavily used roads, particularly in street canyon environments. The annual average benzene levels for the period 1995 to 2002 for five agglomeration areas/ towns are summarised in Figure V 1.5-2. Benzene pollution levels fluctuate between 1 µg/m³ and almost 12 µg/m³.

The EC Directive 2000/69/EC on benzene and carbon monoxide limit values, which is implemented in German law through the 22nd Federal Immission Control Ordinance specifies a threshold value for annual mean benzene pollution levels of 5 µg/m³, which must be complied with by 2010. This value is currently exceeded in some areas.

In addition to benzene, airborne particle pollution plays a significant role in urban agglomerations and cities.

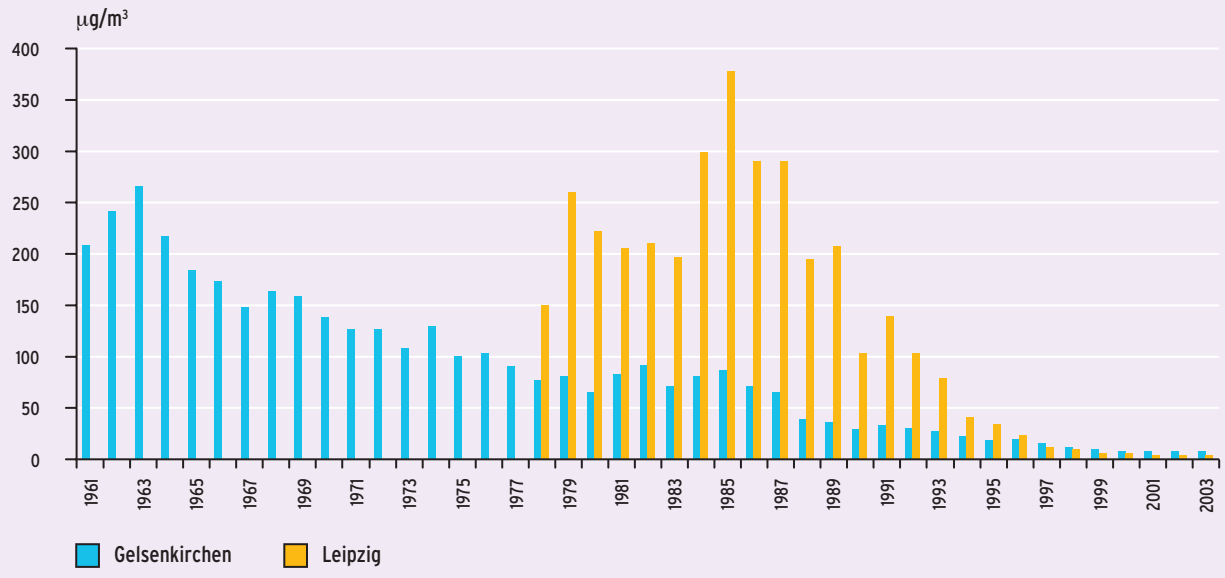
Since mid-1997, the UBA has been carrying out measurements for the PM_{10} and $PM_{2.5}$ components of dispersed particulate matter and soot ("environ-

Fig. V 1.5-2: *Benzene concentrations at selected measuring stations in urban agglomerations/cities*



Source: *Federal Environment Agency 2004*

Fig. V 1.5-1: *Comparison of annual mean SO_2 levels, Gelsenkirchen – Leipzig*



Source: *Federal Environment Agency 2004 a*

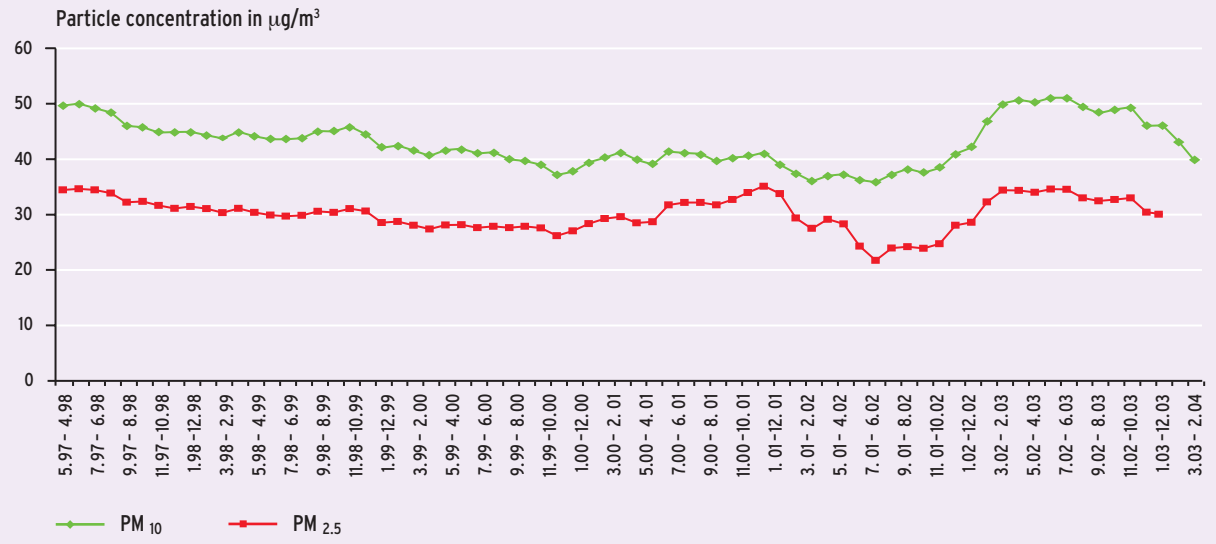
mental carbon", EC) concentrations at a monitoring station in Berlin, which is located in a heavily built-up part of the city in the immediate vicinity of the urban motorway.

This monitoring station is located at one of the most heavily polluted sites in Germany, due to the high levels of emissions from traffic, including (diesel) soot, tyre particles, and dust raised up by vehicles, as well as emissions from the city, including particulate matter produced by domestic heating & furnace systems, small businesses, and industrial plants.

The suspended particles concentrations show a gradual decrease between May 1997 and December 2002, as illustrated by the example in Figure V 1.5-3, which shows the moving-average annual mean PM_{10} and $PM_{2.5}$ levels at the Berlin urban motorway. The increase in 2003 can be attributed to the periods of increased PM_{10} pollution seen across the whole of Germany. The curve can be seen to decrease again at the start of 2004 to the concentration levels recorded prior to the 2003 increase.

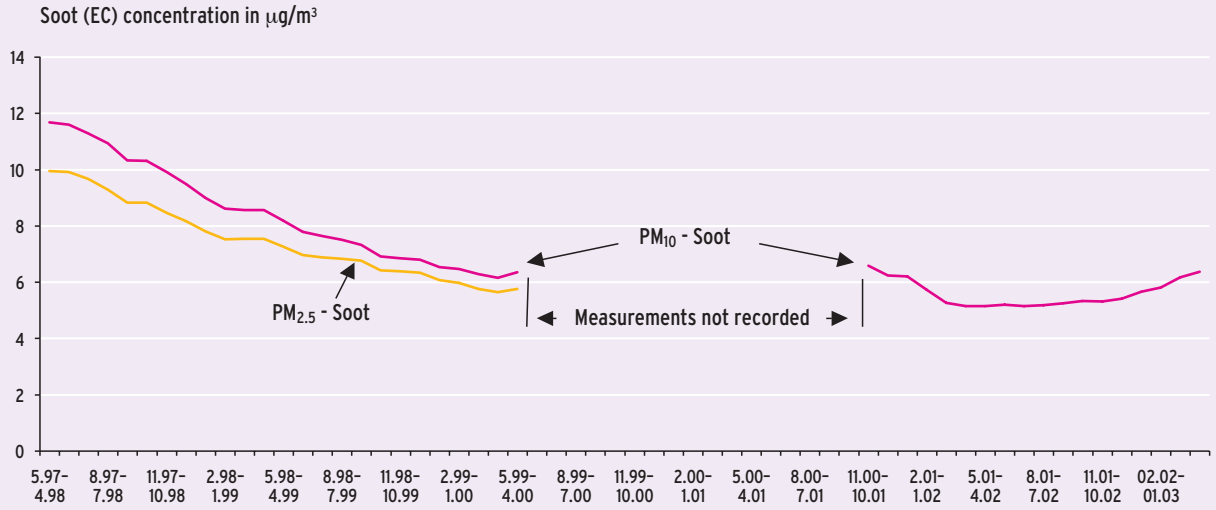
With the exception of the periods of high PM_{10} concentrations during 2003, it can be seen from Figure V 1.5-4, that, during the measurement period, reductions in mean EC (diesel soot) concentrations were achieved at these monitoring locations (around 6 µg/m³ for PM_{10} and 4 µg/m³ for $PM_{2.5}$) while traffic volume density remained constant. This reduction in soot concentrations also corresponds to the reduction in concentrations of PM_{10}

Fig. V 1.5-3: *Moving-average annual mean PM_{10} and $PM_{2.5}$ levels at the urban motorway measuring station, Berlin*



Source: *Federal Environment Agency 2004*

Fig. V 1.5-4: *Moving-average annual mean soot (EC) concentrations at a traffic monitoring station, Berlin*



Source: *Federal Environment Agency 2004*

and $PM_{2.5}$ in the same period. Both figures show that the difference in concentrations between PM_{10} soot and $PM_{2.5}$ soot has been significantly reduced during the measurement period.

It can be deduced from the pattern of the curves that modern diesel vehicles produce less soot, measured in grams of soot emitted per kilometre, than they did in the past. The reduction in the differences between PM_{10} soot and $PM_{2.5}$ soot levels suggests the further conclusion that modern HDV (high-duty vehicle) engines do not produce such a high proportion of coarse soot particles (larger than 2.5 µm) as previously.

V 2 Expenditure by manufacturing industries, the State, and privatised public sector companies on environmental protection measures related to air quality management

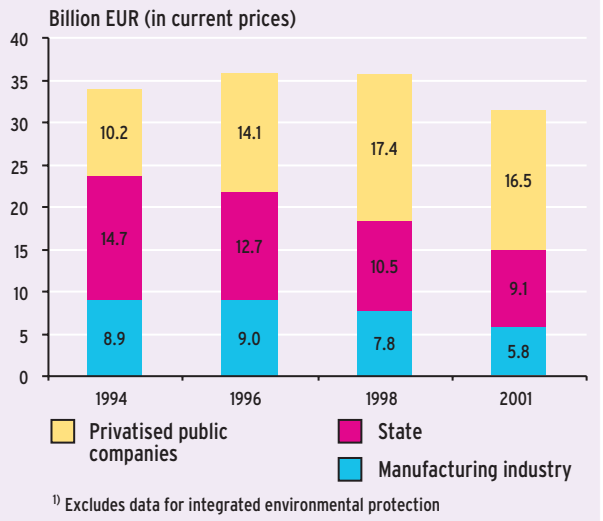
"Expenditure on environmental protection" describes investments in environmentally friendly facilities and ongoing expenditure for the operation of these (Fig. V 2-1). Due to statistical limitations on the acquisition of data, the items of expenditure described below should be considered as lower limits for the overall financial expenditure on environmental protection. The absence of data relating to parts of the service sector and integrated environmental protection investments by manufacturing industries should be noted in particular.

Investments in environmental protection take into account the value of long-lasting, reproducible resources that are procured by domestic business entities with the aim of protecting the environment. This includes both equipment (e.g., machines and mechanical installations, vehicles) and structures (e.g., buildings, sewage facilities, waste disposal).

Ongoing expenditure on environmental protection by manufacturing industries includes personnel costs (including maintenance and repair), spare parts, and the cost of raw materials, operating materials, and auxiliary supplies. State expenditure includes personnel costs (gross wages/salaries, effective social security contributions) and functional expenditure (commercial requirements, fuel, rent, etc.).

As time progresses, the ongoing expenditure gains in significance in comparison to initial investments in environmental protection (Table V 2-1). The reason for this is the significant number of environmental protection facilities that have already been installed, primarily in the last two decades.

Fig. V 2-1: *Trends in expenditure on environmental protection*[1)]



1) Excludes data for integrated environmental protection

Source: *Federal Statistical Office 2004*

In 2002, the combined expenditure on environmental protection by commercial enterprises, the state, and privatised public companies totalled around €31.4 billion (current prices). This amount corresponds to approximately 1.5 % of gross domestic product. The expenditure was distributed as follows: manufacturing industries, €5.8 billion; public funds (state), €9.1 billion; privatised public companies, €16.5 billion.

Around €2.3 billion, or 7 %, of the overall expenditure on environmental protection was spent on air quality management. Investments in 2001 constituted approximately one-third of this expenditure (Fig. V 2-2).

V 3 Overview of pollutant-specific emissions

The calculation of emissions is carried out mainly on the basis of the energy balance that is published each year. Statistical data, and any additional detailed data from individual associations that is necessary, are used in addition to the emissions calculation.

This data makes it possible to calculate the energy used by individual categories of emission sources according to the type of fuel burnt. It is possible to draw conclusions about emissions in relation the sectors that cause them by linking them with emissions factors for the energy consumed and other processes that produce emissions – this can be carried out according to the required boundary conditions. The IPCC structure [1], for example, is used for greenhouse gases.

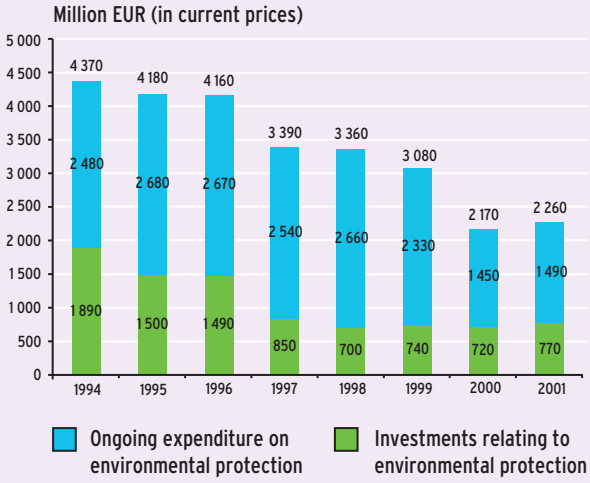
Tab. V 2-1: *Expenditure on environmental protection in millions of EUR (in current prices)*

Category	1994	1996	1998	2000*)	2001*)
Total expenditure on environmental protection	33 870	35 770	35 640	31 400	31 380
Of which:					
Manufacturing industries[1) 2)]	8 910	9 000	7 780	5 760	5 840
State	14 730	12 700	10 460	9 550	9 070
Privatised public companies[4)]	10 230	14 070	17 400	16 080	16 470
Investments relating to environmental protection	15 180	12 780	12 050	9 360	8 670
Of which:					
Manufacturing industries[1)]	3 030	2 550	1 630	1 560	1 580
State	6 840	4 970	3 740	3 010	2 630
Privatised public companies[4)]	5 310	5 260	6 680	4 790	4 470
Ongoing expenditure on environmental protection	18 690	22 990	23 600	22 040	22 710
Of which:					
Manufacturing industries[1) 2) 3)]	5 880	6 460	6 140	4 200	4 270
State	7 890	7 720	6 730	6 540	6 440
Privatised public companies[4)]	4 920	8 810	10 730	11 300	12 000

1) Excludes construction industry and expenditure for integrated environmental protection measures
2) From 2000, excludes ongoing expenditure for energy and water supply
3) Excludes fees and charges for supply of services by third parties
4) Enterprises run outside the scope of public funding, particularly owner-operated municipal enterprises for waste disposal and prevention of water pollution
*) Provisional figures

Source: *Federal Statistical Office 2004*

Fig. V 2-2: *Expenditure on environmental protection for air quality management*



Source: *Federal Statistical Office 2004*

This takes into consideration direct greenhouse gases (CO_2, CH_4, and N_2O) and indirect greenhouse gases (NO_x, NMVOC, and CO), as well as SO_2 and overall dust concentrations.

Trends in emissions since 1990 demonstrate considerable success in the reduction of these pollutants (Tab. V 3-1).

The main reasons for this positive trend are given below; all of these are relevant to the components considered here, to a greater or lesser extent:

- Because of the German Reunification in 1990, the initial levels for emissions were very high due to the emissions contributed by the states in former German Democratic Republic.
- Aging and inefficient industrial facilities in Eastern Germany were decommissioned in subsequent years. These were replaced to by new facilities that, as far as possible, met the most up-to-date requirements.
- In addition to this, and especially in Eastern Germany, facilities were converted to use energy sources associated with lower emissions, such as natural gas and petroleum, instead of the locally available lignite.
- The transportation sector saw the introduction of vehicles equipped with technology aimed at reducing pollution.
- Following the expiration of time-limited intermediate regulations in the years after 1990, the immission control regulations that had applied in the former West Germany also gained full legal applicability in Eastern Germany. In many instances, the applicable law was also changed to conform to further developments in the state-of-the-art.
- Legal regulations and the demands of the market economy also led to more economical use of energy and raw materials.
- International legislation, particularly that of the European Community, has also had an effect in reducing emissions (e.g. the NEC Directive).

[1] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

Tab. V 3-1: *Emissions of selected airborne pollutants by source group*

	1990	1995	2000	2001	2002	2003
Carbon dioxide (CO_2) in Mt[1]						
Energy management	414	355	344	349	357	363
Processing industries	196	150	136	133	132	129
Transport[2]	162	177	182	178	176	170
Private households and small consumers[3]	216	194	173	190	176	180
Industrial processes	26	26	25	24	23	24
All	**1 015**	**902**	**860**	**874**	**864**	**865**
Nitrogen oxide (NOx, calculated as NO2) in kt						
Energy management	603	288	254	258	262	266
Processing industries	355	210	165	156	152	154
Transport[2]	1 429	1 152	896	828	771	700
Private households and small consumers[3]	328	252	220	224	216	214
Industrial processes	31	14	12	10	10	12
Agriculture	101	84	88	85	82	82
All	**2 846**	**2 000**	**1 634**	**1 560**	**1 493**	**1 428**
Sulphur dioxide (SO_2) in kt						
Energy management	3 078	1 418	325	329	337	340
Processing industries	994	188	119	119	109	113
Transport[2]	106	76	21	18	4	2
Private households and small consumers[3]	923	171	96	105	88	87
Fugitive emissions from fuels	169	27	20	20	20	20
Industrial processes	57	57	54	53	53	55
All	**5 326**	**1 937**	**636**	**643**	**611**	**616**
Carbon monoxide (CO) in kt						
Energy management	179	122	112	115	119	119
Processing industries	828	676	687	640	605	638
Transport[2]	6 765	3 937	2 434	2 145	1 960	1 756
Private households and small consumers[3]	2 711	1 210	1 062	1 065	1 020	1 049
Fugitive emissions from fuels	47	11	9	7	7	8
Industrial processes	682	624	608	589	588	584
All	**11 212**	**6 581**	**4 913**	**4 561**	**4 300**	**4 155**
Nitrous oxide (N_2O) in kt						
Energy management	14	12	12	12	12	12
Processing industries	6	4	3	3	3	3
Transport[2]	10	18	17	16	15	14
Private households and small consumers[3]	4	2	2	2	2	2
Industrial processes	76	81	18	24	25	33
Solvent and other product usage	6	6	6	6	6	6
Agriculture	156	131	136	132	129	128
Waste	7	7	7	7	7	7
All	**279**	**261**	**201**	**202**	**199**	**205**
Ammonia (NH_3) in kt						
Energy management	4	3	3	3	3	3
Processing industries	3	2	1	1	1	1
Transport[2]	5	9	9	9	8	7
Private households and small consumers[3]	4	4	4	4	3	3
Fugitive emissions from fuels	1	0	0	0	0	0
Industrial processes	15	10	10	9	10	10
Solvent and other product usage	1	2	2	2	2	2
Agriculture	704	582	578	588	578	573
All	**736**	**611**	**607**	**616**	**606**	**601**
Dust in kt						
Energy management	565	18	11	11	12	12
Processing industries	343	5	3	3	3	3
Transport[2]	113	116	106	102	98	95
Private households and small consumers[3]	347	32	22	22	21	21
Fugitive emissions from fuels	317	7	4	4	4	4
Industrial processes	114	103	99	93	91	92
Handling of bulk goods	136	49	44	44	44	44
All	**1 934**	**329**	**289**	**279**	**273**	**271**
NMVOC in kt						
Energy management	8	9	8	8	8	9
Processing industries	12	8	7	6	6	6
Transport[2]	1 495	647	304	267	233	199
Private households and small consumers[3]	182	91	88	88	87	89
Fugitive emissions from fuels	283	110	66	62	57	55
Industrial processes	90	96	118	115	123	124
Solvent and other product usage	1 160	1 050	875	812	750	750
Agriculture	304	237	231	233	229	228
All	**3 534**	**2 248**	**1 697**	**1 592**	**1 494**	**1 460**
Methane (CH_4) in kt						
Energy management	8	6	5	5	6	6
Processing industries	12	6	6	6	5	6
Transport[2]	64	30	17	15	13	11
Private households and small consumers[3]	133	38	32	32	31	32
Fugitive emissions from fuels	1 561	1 197	835	722	697	678
Industrial processes	16	16	18	18	17	19
Agriculture	2 891	2 458	2 342	2 361	2 298	2 269
Waste	1 605	1 245	693	617	574	560
All	**6 290**	**4 996**	**3 948**	**3 777**	**3 642**	**3 582**

[1] Not including land use change and forestry
[2] Not including agricultural and forestry transport
[3] Including agricultural, forestry, and military transport

Source: *Federal Environment Agency 2005*

VI WATER QUALITY

VI 1 Surface waters

Surface water bodies are polluted by point source (e.g., sewage discharges), diffuse inputs (e.g., runoff from agricultural land), and usage-related hydromorphological changes (e.g., altering banks and river beds for shipping), which can affect their suitability for certain uses and their aquatic communities. National and international monitoring programmes, therefore, regularly test surface water bodies. The *Länder* and the river commissions collect data on biological parameters and also specific indicators such as levels of nutrients, heavy metals, organic micropollutants, and the characteristics of hydromorphological quality. Since 1975, the Working Group of the Federal States on Water Issues (LAWA) has produced a five-yearly map of biological water quality in Germany which appraises the state of flowing water according to biological and ecological features, and a supplemental publication "Germany's flowing water – water quality maps" showing its physico-chemical quality and, in 2001, the first map showing morphological water structure. Data on the quality of surface waters (bodies of flowing water and lakes) is gathered by the *Länder* and passed on to the Federal Environment Agency (UBA) so that it can be presented in the form of statistics and charts, and documented and analysed at national level. This system is based on an administrative agreement between the German government and the *Länder* on the exchange of environmental data and its annexes.

Tab. VI 1.1-1: *Structural quality classification*

Class	Degree of impairment	Brief Description
1	Unchanged	The morphological water structure matches the potential natural state.
2	slightly changed	The morphological water structure is only slightly influenced by one-off, localised interventions.
3	moderately changed	The morphological water structure is only moderately influenced by multiple, localised interventions.
4	distinctly changed	The morphological water structure is distinctly influenced by different interventions, e.g., on the river bed, banks, backwater, and/or activities in water meadows.
5	obviously changed	The morphological water structure is negatively influenced by a combination of interventions, e.g., the route, embankments, horizontal construction projects, congestion management, flood protection facilities, and/or through activities in water meadows.
6	strongly changed	The morphological water structure is very negatively influenced by a combination of interventions, e.g., the route, embankments, horizontal construction projects, congestion management, flood protection facilities, and/or through activities in water meadows.
7	completely changed	The morphological water structure is completely negatively influenced by a combination of interventions, e.g., the route, embankments, horizontal construction projects, congestion management, flood protection facilities, and/or through activities in water meadows.

Source: *Working Group of the Federal States on Water Issues 2002*

The European Parliament and Council's Directive 2000/60/EC of 23.10.2000 (Water Framework Directive – WFD) establishes a framework for Community action in the field of water policy; it resulted in a standardised legislation for managing water and newly defined objectives for the state of surface waters in the EU. Whereas previous targets had related primarily to substances, now the ecological quality of water bodies was made the centre of attention, and morphological conditions in particular have become extremely significant. Future monitoring programmes will be tailored to this new content by the end of 2006 at the latest, i.e., water biology monitoring will be far more intensive than before.

VI 1.1 Morphological water structure and flood protection

Morphological water structure

For the first time, the morphological water structure map drawn up by the Working Group of the Federal States on Water Issues (LAWA) in collaboration with the UBA gives an overview of human's hydromorphological interventions into watercourses [1]. The analysis is based on the classification of morphological water structure quality developed by the LAWA (Tab. VI 1.1-1). This reference publication is a seven-stage record of change in the structures of water bodies as a deviation from their potentially natural status. The main principle, and Class I, is the potentially natural status, i.e., the status that would arise if current usage and building projects were to be undone. Under these conditions, the

aquatic communities typical of the unspoiled area would all be present (the reference status). The other stages, from slightly changed (Class II) to completely changed (Class VII) denote the extent of anthropogenic structural changes. Under these conditions, aquatic life, other than those in the reference status, are present. The methods used to draw up the morphological water structure map were the general method (Tab. VI 1.1-2) and the local

Tab. VI 1.1-2: *General method – recording morphological water structure*

Overall value	Partial value	Interim analysis	Recording parameters
Morphological water structure	Water bed dynamic (river bed and banks)	Structure formation potential	Routing Riparian degradation Horizontal construction projects Runoff management Growth on banks
	Water meadows dynamic	Retention	Flood protection structures Potential when banks break
		Development potential	Use of water meadows Bank belts

Source: *Working Group of the Federal States on Water Issues 2002*

method (Tab. VI 1.1-3) for small- to medium-sized flowing water. The assessment in the general method was mainly based on aerial photographs and thematic maps, while the data in the local method was largely gathered on the ground.

Rivers and their meadows are amongst the landscapes that are used most intensively but, at the same time, have particular ecological significance. They are lifelines for mankind and for the balance of nature. Figure VI 1.1-1 shows a high proportion of distinctly to completely changed sections of watercourse. Only 21 % of German rivers and streams – mainly in less populated regions – are still in a semi-natural state, i.e., man has changed them little or to a moderate degree. The research and analysis was carried out on a total of 33 000 kilometres of flowing water. Figure VI 1.1-2 shows the results in seven stages, from category I (unchanged) to category VII (completely changed).

The fact that only a limited number of stretches of watercourses remain in a semi-natural state is the consequence of hydraulic engineering measures carried out on most of the waters that are now hydromorphologically changed. For example, water-

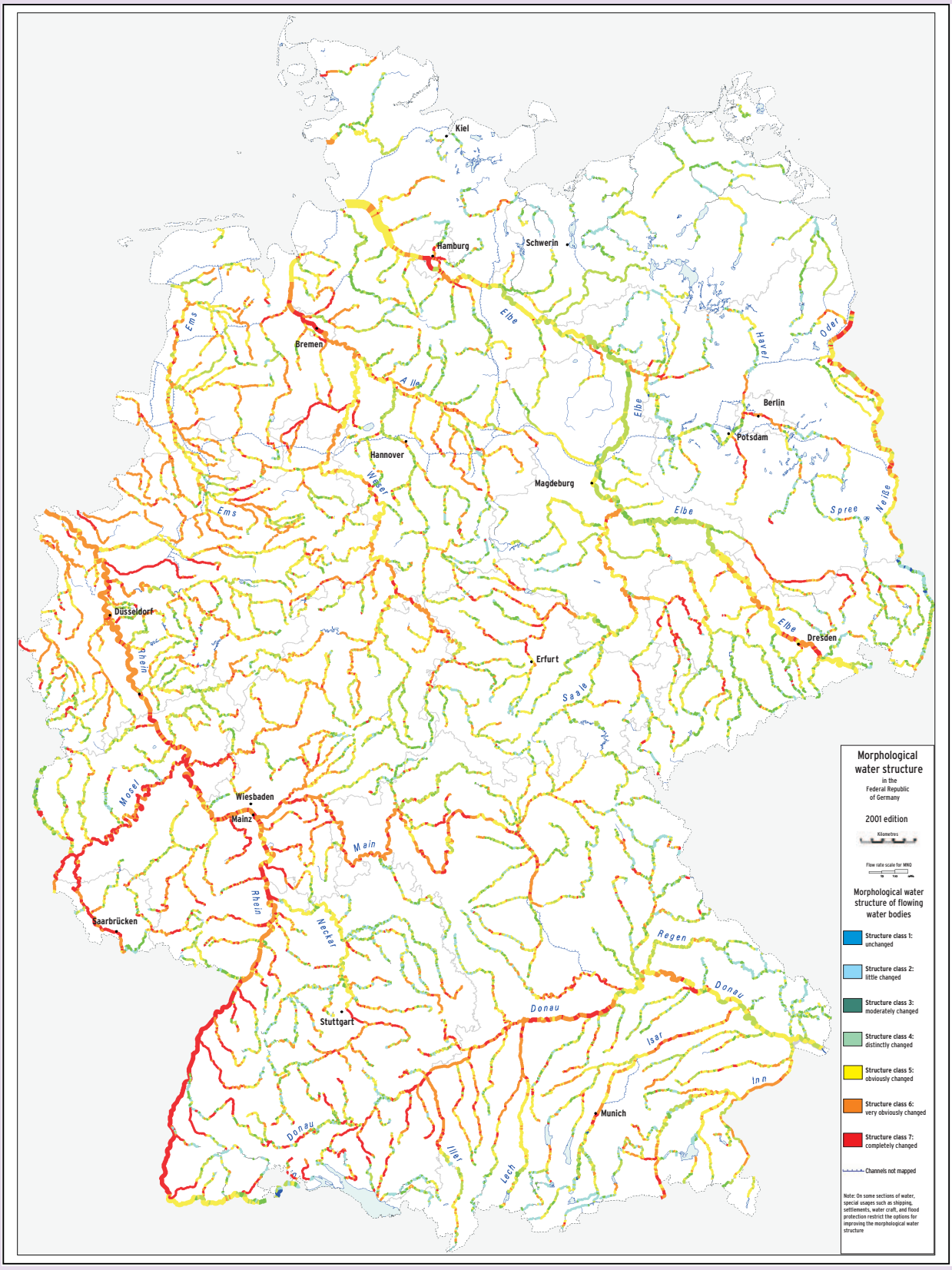
Tab. VI 1.1-3: *Local method – recording morphological water structure*

	Area	Main Parameter	Functional Unit	<Individual Parameters
Overall analysis	River bed	Course	Bending	Meandering Longitudinal beds Special flow structures
			Flexibility	Meander erosion Profile depth Bank fixation
		Longitudinal profile	Natural longitudinal profile elements	Transverse beds Diversity of currents Variance in depth
			Anthropogenic migration barriers	Horizontal construction projects Piping Apertures Backwater
		River bed structure	Type and distribution of substrate	Substrate type Substrate diversity Special river bed structures
			River bed fixationau	River bed fixation
	Banks	Cross-profile	Profile depth	Profile depth
			Breitenentwicklung	Width erosion Width variance
			Profile form	Profile form
		Bank structure	Natural characteristics typical to the area	Special bank structures
			Characteristics of natural cover typical to the area	Growth on banks
			Bank fixation	Bank fixation
	Land	Environs of water body	Riparian zone	Riparian zone
			Foreland	Use of space Other structures nearby

Source: *Working Group of the Federal States on Water Issues 2002*

courses have been shortened, banks remodelled, dams erected, water channelled out, and flood protection structures, e.g., dykes, built. Extensive drainage works have also been carried out. In many bodies of water, the river bed was deepened to improve water runoff and thus reduce the frequency of flooding.

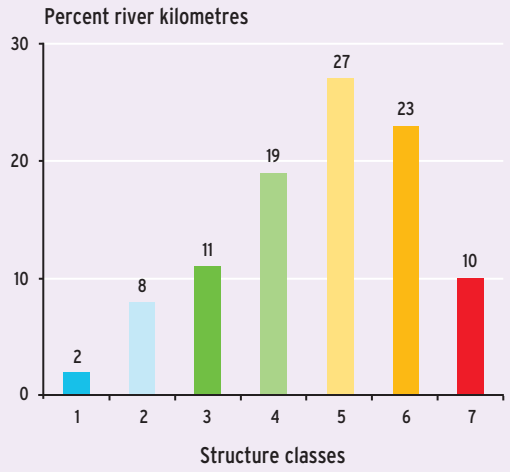
Fig. VI 1.1-1: *Morphological water structure map*



Source: *Working Group of the Federal States on Water Issues, Federal Environment Agency Presentation 2001*

In the majority of rivers and streams, the consequences of development and maintenance have led to considerable change in structures, something which is particularly apparent in larger rivers. Defences and locks have been added to most of these in order to assist shipping and hydropower, and their flood plains have usually been dyked. This is why most of them are assigned to the classes of ob-

Fig. VI 1.1-2: *Distribution of the stretches of water studied (ca. 33 000 kms) in structure categories 2001*



Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues, 2002*

viously changed (V) to completely changed (VII). Of the larger rivers, the mid-Elbe and the Danube below the Isar estuary constitute exceptions. The Danube, which still flows freely there, is classified as distinctly changed (IV), while the middle reaches of the Elbe fall into the distinctly (IV) to moderately (III) changed class.

Most of the smaller rivers and streams in the low mountains, hills, and lowlands have also been remodelled in the past to assist hydropower and agriculture, and protect residential areas and traffic routes (e.g., reclamation), and they are maintained regularly. This prevents morphodynamic processes (independent development) from taking place. These waters mostly feature in the distinctly changed (IV) to completely changed (VII) classes.

Unchanged (I) to moderately changed (III) streams and stretches of river still exist in the Alps and Alpine foothills, the granite and gneiss landscapes of the Bavarian Forest, the upper reaches of low mountain ranges, the heathland areas of the lowlands of northern Germany, and the areas of Mecklenburg Pomerania that were shaped by the ice age. In these landscapes, natural conditions such as the soil, climate, and relief are sometimes such that river works and reclamation of the land alongside the water has rarely occurred.

[1] Working Group of the Federal States on Water Issues (LAWA): Gewässergüteatlas der Bundesrepublik Deutschland – Gewässerstruktur in der Bundesrepublik Deutschland 2001

Selected flood incidents

Floods are essentially natural, seasonal events which belong to the water cycle. They depend, on the one hand, on the strength, intensity, and distribution of precipitation, on the other hand, on the size and structure of the river's catchment area and the soil's character.

The effects of flooding on the balance of nature have recently become far more serious due to human intervention in the natural hydrological regime. This anthropogenic contribution to flooding has developed over a long period, in the regulation of river flows (dykes, straightening, weirs, and dams), the sealing over of land for increased residential or infrastructure development, the drainage of residential area, in the intensification of agriculture (draining water meadows, soil compacting and improvement, land sealing or clogging), and in the use and development of areas at risk of flooding. The flow of rivers, once adapted to their surroundings and to seasonal variation, has been fundamentally altered. In particular, development in the form of barriers automatically destroys alluvial flora which are well adapted to, and depend upon, periodic flooding. Since the straightening of the Rhine by Johann Tulla in the middle of the 19th century, for example, the number of meadow sites between Basle and Karlsruhe has fallen by 87 %. The area of flooded land along the entire upper Rhine has fallen by 60 %, a loss of 130 km^2. Straightening has shortened the upper Rhine by ca. 82 km, the lower Rhine by ca. 23 km, so that the river now flows faster. For example, a flood wave now flows down the stretch between Basle and Karlsruhe in 23 hours, as opposed to 64. In the Danube region, the intensification of flooding since 1845 has been quantitatively shown to be the result of human intervention. At the Kehlheim flood gauge, flood peak have been over 10 % higher on various occasions, and flood durations are ca. 20 hours shorter. On Federal Republic territory on the Elbe, embankments have been constructed since the 12th century; of the earlier available flood plains measuring 6 172 km^2, an area of 838 km^2 now remains to retain flooding. This 86 % reduction in flood plains goes hand-in-hand with less retention in meadows. At the same time, the shortening of the Elbe's length by 55 km on Czech Republic territory and 60 km in Germany due to the removal of its bends has caused the flow rate to increase. Since tributaries and smaller rivers in the catchment areas of major rivers are also regulated, flood waves in a river and its tributaries are increasingly combining unfavourably. The loss of natural flood plains, the severe increase in flow rates caused by the concentration of the runoff from many rivers in a single wa-

tercourse, and the straightening of rivers have produced flood waves which now flow significantly faster, higher, and with greater volumes. Flood protection downstream has suffered correspondingly. At the same time, economic activity and development has tended to concentrate along river banks, increasing the extent of the risks from flooding. Technical flood protection measures alone will not provide sufficient prevention from disastrous flooding in the future. On the contrary, such measures frequently serve only to shift the problem elsewhere, where its effects may be even more severe. In recent years, the problem of flooding and its associated damage have increasingly become the subject of public attention, not just in Germany but throughout the world. In particular, the flooding of Dresden's historic old town by the Elbe in August 2002, the spectacular collapse of the dykes on the Oder in 1997, and the Danube in 1999 have shown that serious damage and risk can occur in areas behind dykes; these were supposedly protected.

The Elbe flooding in August 2002

Meteorological conditions during the summer of 2002 were characterised by repeated high cold fronts in the Mediterranean area and the return of humid, warm air masses northwards from the Mediterranean area. These areas of low pressure caused extreme precipitation in Central Europe, including in the Elbe's catchment area. The monthly rainfall that might be expected based on long-term averaging fell during the first ten days of the month across a large part of the catchment area. In places, total rainfall was 1.5 to 2 times the August average. These torrential rains caused the soil to become saturated so that it was unable to soak up any more rain and the water flowed straight across the surface. The rains of 11th and 12th August 2002 can now be regarded as the final straw that caused the Elbe to flood. During those days, too, the rainfall reached levels that were well above the monthly average. For example, between 01 August 2002 and 10 August 2002, 71 mm of rain fell across the 7 300 km^2 Mulde catchment area, while another 177 mm then fell between 11 August 2002 and 13 August 2002. Comparing this with the 1961–1990 average of 73 mm for the entire month of August, this shows how extreme the rains were.

These underlying meteorological conditions caused the Elbe floodwaters to rise around its middle reaches. The contribution of runoff from its tributaries was another vital factor in its water level. It is clear that the Mulde, with a flow rate of 1 500 m^3/h at the gauge in Bad Düben, caused the largest inflow. As a result of these volumes of water, the Elbe and its tributaries not only burst their banks, but also broke through more than 100 dykes and caused widespread flooding. The largest area to be flooded as a consequence of dykes breaking was 139.9 km^2 of land at Dautschen in Saxony, along a stretch of ca. 30 km. Calculations revealed that a volume of around 300 million m^3 of water was drained off by this unintentional flooding, which caused the water level at the flood's peak in Wittenberg to fall by around 30 cm.

From 18 August 2002, the entire runoff from the Havel into the Elbe was held back by closing the weirs at Quitzöbel in order to provide relief for the dykes further downstream. This enabled the water level to be reduced by another approximately 10 cm. As evening came on 20 August 2002, the lowlands around the Havel estuary flooded, which resulted in another 75.6 million m^3 being retained so that the flood peak fell by a further 41 cm.

As landfill sites, abandoned industrial sites, and sewage systems flood, more chemicals often enter the water. Many pollutants, e.g., heavy metals, are attached to suspended particulate matter so that they become highly mobile as the floodwaters rise. Thus measurements taken at the Magdeburg sampling point on 18 August 2002 and 17 August 2002 showed that suspended particulate matter had become increasingly polluted by the heavy metals arsenic and lead. Old hazardous sites in the Mulde's catchment area were thought to be the source of this inflow of heavy metals. Levels of arsenic and lead pollution had dropped by 50 % by 29 August 2002, but they were still up from their normal levels.

Further studies were carried out for organic pollutants, and the suspended particulate matter in the Elbe was deemed to have suffered no greater pollution through this pollutant group. However, it may be assumed that dilution effects had occurred. The Magdeburg measuring point also found evidence that the waters of the Elbe had been polluted by faeces, though there was no evidence of soiling through mineral oils, as had been observed when the Oder flooded in 1997.

To get a historical perspective of this flood incident, it is useful to look at the history of the Elbe's high watermark. This shows that the August 2002 water level of 9.4 metres at the Dresden gauge was the highest since flood records began in 1275. During recent centuries, periods of more frequent winter flooding and summer flooding have alternated, but during the last 200 years it can be seen that the decisive flooding occurs in the spring. During the last 40 years, the greatest runoffs have occurred once more during the summer months, while maximum

runoffs in the winter have declined. Peak runoffs can be used to estimate the probability when floods of a particular intensity might return. In this way, it may be assumed that the 2002 flooding of the Elbe constituted a 200-year return-period. For Wittenberg, however, the theoretical runoffs, i.e., reconstructed without taking into account the retention effects caused by dykes breaking, indicate a 300- to 400-year return-period [1].

The May 1999 floods in Bavaria

During May 1999, southern Bavaria experienced the most severe flooding for a century. Under certain meteorological conditions, precipitation at the edge of the Alps and in low mountain regions can regularly lead to a risk of flooding in Bavaria.

On 11 May 1999, the front of a low pressure system over Poland ran across southern Germany. Moderate rain to the south caused the snow mantle at altitudes up to 2 000 m to melt, adding to the snow melt, and saturating the ground.

The heavy, persistent rain between the 20 and 22 May could not, therefore, be absorbed. The runoff from Alpine catchment areas into the upper reaches of the Iller, Lech, Ammer, and Isar was extremely high, with a statistical return-period of 300 years. Since the levels in the affected reservoirs had been lowered in anticipation of the torrential rains, some of the inflow was retained there, for example, 60 % of the peak runoff in the Lech and 98 % in the Isar, which reduced the extent of the damage.

On 23rd May, the flood peaks in the Lech and the Iller reached the Danube, creating an elongated flood peak below the Iller confluence. On the 24th May, the flood gauge at Ingolstadt recorded a flow of 2 200 m^3/s, 10 % higher than any flood since 1821. The pressure of this water could not be released onto natural flood plains, which led to backing up in all the rivers. Bavaria's technical flood protection systems are based on a 100-year return-period, so measurements, the flood peaks were often significantly higher than the protection level.

In Kehlheim, the Danube reached a record level of 8m, half as much more than its normal levels. As water overflowed the crest of the dam, severe erosion began from above. The enormous forces broke through 150m of a dyke in Neustadt on 24th May, covering a 20 km^2 area in 2.5m of water, and causing extensive damage to houses and factories.

Oil tanks were broken open by the water pressure or began to float, causing 2 to 2.3 million litres of heating oil to escape from broken tanks and pipes. Some 800 000 litres were recovered immediately, but some has concentrated in the banks of slower-moving drainage ditches. The oil contaminated 36.6 ha of soil to depths of up to 90 cm with mineral oil and hydrocarbon materials. By the end of August, over 450 t of this earth had been removed or decontaminated. In addition, there was some contamination of groundwater, although the thresholds for remedial action which apply in Bavaria were not exceeded [2].

In some parts of Bavaria, microbiological drinking water quality no longer satisfied the limits set out in the Drinking Water Regulation (TrinkwV), but appropriate action (generally chlorination) was taken, and drinking water supplies were no time at risk. Thirty-seven waste water treatment plants were damaged, and a temporary ban was placed on bathing in lakes, due to increased nutrient loads (30 t phosphorus). In Bavaria as a whole, 421 ha of land were contaminated with heating oil (one exception: plant protective agents), 74 ha severely [2].

At present, flood risk maps [3] take no account of the fact that a significant proportion of flooding is not from surface waters, but from groundwater (50 % of the May 1999 flood water in southern Bavaria, for example), although this is especially important in urban areas.

Flood damage to the environment and prevention strategies

Provisional figures show that the Elbe floods caused damage valued at ca. 9.2 billion EUR. 2.1 billion EUR of this was damage to private households, and 1.7 billion EUR to business. State-run infrastructure in the flooded area sustained 3.4 billion EUR of damage.

Saxony, which was the *Land* hit hardest by the Elbe floods, corrected its flood damage estimates in September 2003 to 8.6 billion EUR, so damage in Germany as a whole is now put at 11.6 billion EUR.

The total cost of the 1999 flood damage in Bavaria was 335.8 million EUR, of which, 54 % were borne by private individuals and companies, and over 30 % were spent on water supplies and hydraulic engineering [4].

Both the Danube's May floods and the summer flooding of the Elbe once again illustrated the limits of technical protection. In order to minimise the risks to which the community is exposed, preventive flood protection must be taken into account at all levels of decision-making. The anthropogenic com-

ponent in flooding can be minimised by, for example, maintaining and restoring the ground's natural ability to retain water (restoring natural flood plains, renaturation of rivers and meadows, encouraging appropriate local farming and forestry practices), or by influencing land use decisions in flood risk areas. These recent events demonstrate, without a doubt, the importance of keeping flood risk areas as free from building development as possible. In the long-term, only coordinated action in water management, dyke building, local planning, and public information can be effective. International cooperation, especially in drawing up regional flood action plans, is also essential. All these issues are the objective of the Act to Improve Preventive Flood Protection, which the German government presented 03 March 2004 and the Upper house (the Bundestag) agreed on 01 August 2004. After extensive consultation, the arbitration commission's compromise proposal was approved by the Upper house on 17 March 2005 and the lower house (the Bundesrat) on 18 March 05. The Act, which came into effect on 10 May 2005, changes and extends several federal laws to tighten up and make more stringent the regulations on preventive flood protection. Its key points include defining more flood risk areas by 2010 and 2012, a nationwide ban on planning new construction zones in flood risk areas (exemptions are only permitted if nine strict conditions are met), drawing up flood control plans by 2009 and specifying areas at risk of flooding (e.g., behind embankments).

[1] International Commission for the Protection of the Elbe: Dokumentation des Hochwassers vom August 2002 im Einzugsgebiet der Elbe

[2] Bavarian State Ministry for Regional Development and Environmental Affairs: Bericht zum Pfingsthochwasser 1999: Analyse des Hochwassers, Umweltauswirkungen und Konsequenzen für den Hochwasserschutz, 12 October 1999

[3] International Commission for the Protection of the Rhine (IKSR): Grundlagen und Strategie zum Aktionsplan Hochwasser. 1999

[4] Anhörung Hochwasser Pfingsten 1999 und die Folgen. Bericht der Bayerischen Staatsministerien für Wirtschaft, Verkehr und Technologie, für Ernährung, Landwirtschaft und Forsten und der Finanzen zur finanziellen Abwicklung der Hilfeprogramme, November 1999

VI 1.2 Biological water quality

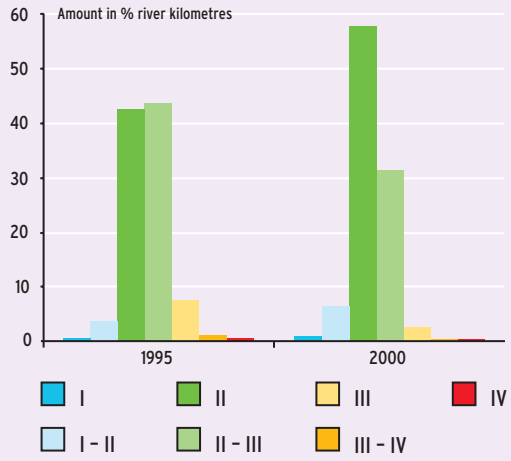
The Working Group of the Federal States on Water Issues (LAWA) has published the map of biological water quality, showing the findings of the saprobial water quality classification, every 5 years since 1975 [1]. The proportion of stretches of water mapped that fall into quality Class II and better has risen from 47 % in 1995 to 65 % in 2000. The total length of the rivers mapped is around 30 000 km (Fig. VI 1.2-1 and Fig. VI 1.2-1).

Tab. VI 1.2-1: *Biological water quality classification (share of river kilometres within the ca. 30 000 kms waterways network)*

Quality Class	Degree of pollution	1995	2000
I	unpolluted to very lightly polluted	0.7 %	0.8 %
I-II	lightly polluted	3.8 %	6.5 %
II	moderately polluted	42.7 %	57.8 %
II-III	critically polluted	43.6 %	31.4 %
III	heavily contaminated	7.4 %	2.8 %
III-IV	very heavily contaminated	1.1 %	0.3 %
IV	excessively contaminated	0.7 %	0.4 %

Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2002 a*

Fig. VI 1.2-1: *Biological water quality classification 1995 and 2000 (river kilometres as % of waterways network of ca. 30 000 kms)*

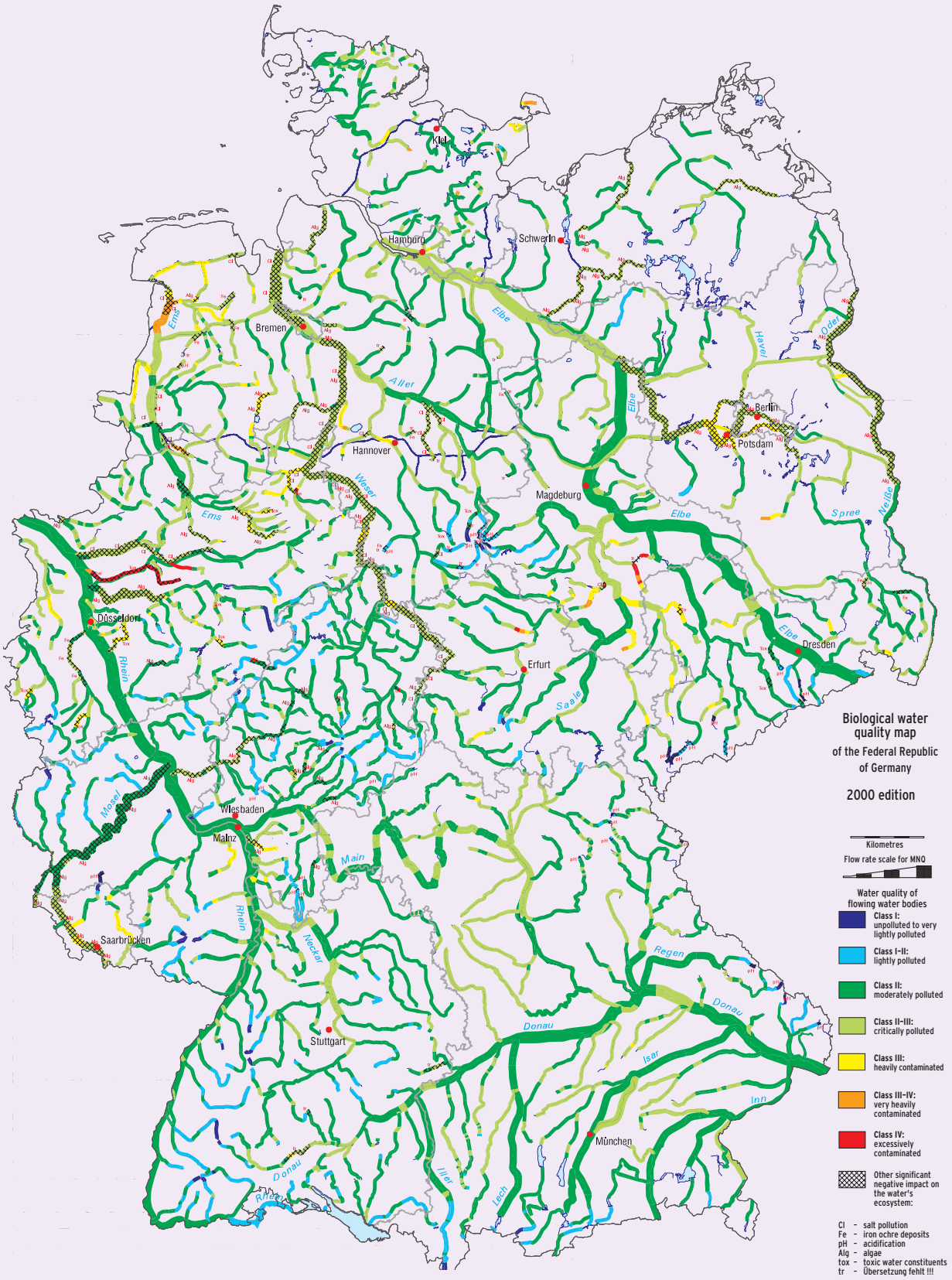


Source: *Federal Environment Agency, data of the Working Group of the Federal States on Water Issues, 2002 a*

As the comparison of the biological quality maps for 1975, 1990, and 1995 shows, improved and more intensive waste water treatment has resulted in a significant improvement in biological water quality (Fig. VI 1.2-2).

The demands made on quality classification by the EC's Water Framework Directive, which came into force in December 2000, go well beyond previous practice. The ecological condition of water bodies is now characterised by describing the state of flora and fauna in rivers, lakes, transitional waters, and the sea. The reference scale for the analysis consists of conditions defined for specific water types. The ecological quality category is determined using the level of deviation from these reference conditions. The previous analytical practice thus has to take into account the fact that water bodies naturally differ widely in their characteristic aquatic communities and in their sensitivity to anthropogenic influences. For example, the aquatic communities present in high mountains differ from those found in

Fig. VI 1.2-2: *Biological water quality map 2000*



Source: *Working Group of the Federal States on Water Issues, Federal Environment Agency Presentation 2000*

lowlands. Rivers, lakes, transitional waters (estuaries), and coastal waters were, therefore, divided into water types. The ecological analysis also has to be given a broader base. Therefore, efforts were made to develop new biological study methods to meet the requirements involved in monitoring water ecol-

ogy within the Water Framework Directive. Analysis methods are now available for all the biological elements indicated by the Directive (macrozoobenthos, macrophytes/phytobenthos, fish fauna, phytoplankton, macroalgae/angiosperms). These methods are now being tested for practicality. As the organism groups prescribed for the analysis have differing needs in terms of habitat and indication characteristics, it can be assumed that in the future it will be possible to record the sometimes extremely complex effects of individual pollutants to a much greater degree (Fig. VI 1.2-3).

[1] Working Group of the Federal States on Water Issues (LAWA): Gewässergüteatlas der Bundesrepublik Deutschland – Biologische Gewässergütekarte 2000, Hannover, 2002

Tab. VI 1.3-1: *Chemical water quality classification*

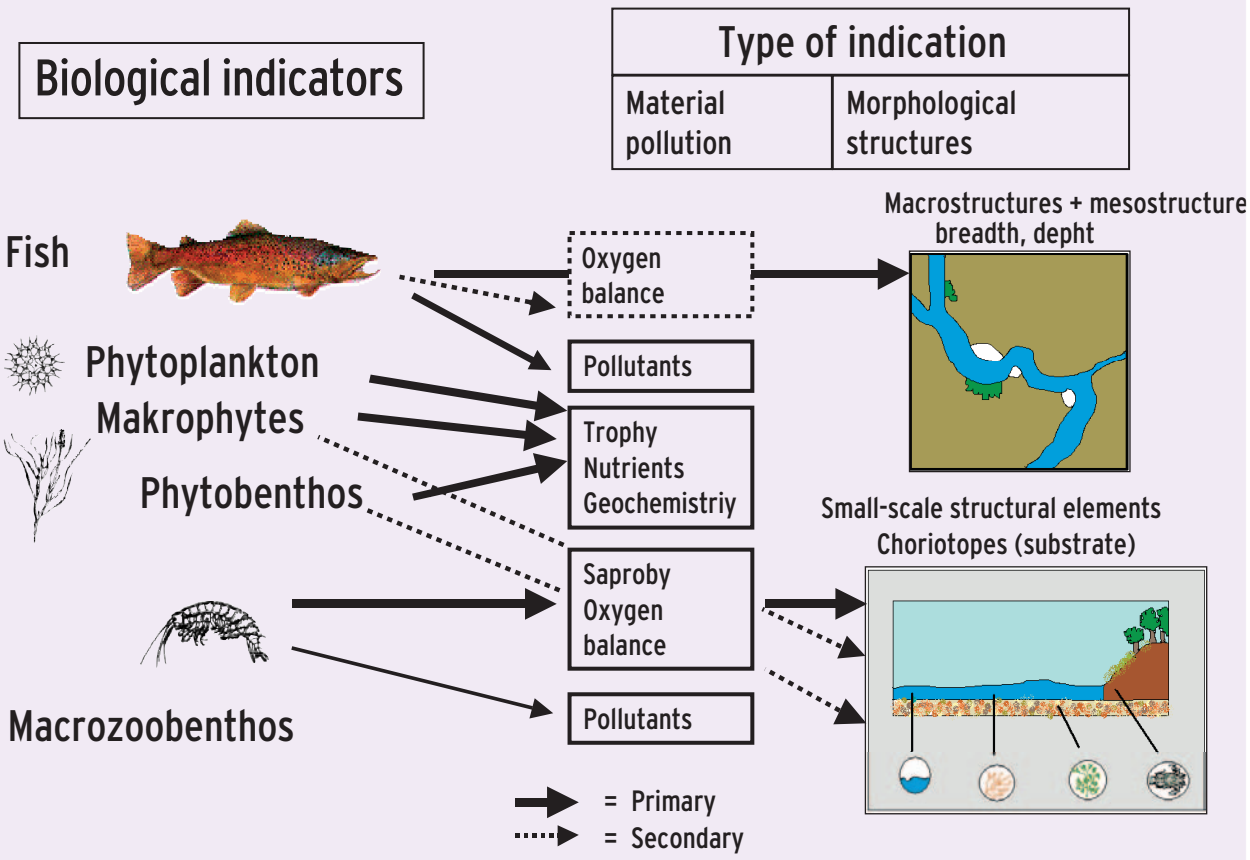
Quality Class	Description of quality classes
I	No anthropogenic pollution: geogenic background value (for natural substances) or "zero" (for xenobiotics)
I-II	Lightly polluted: up to half target value
II	Moderately polluted: target complied with
II-III	Critically polluted: up to twice target value
III	Heavily polluted: up to four times target value
III-IV	Very heavily polluted: up to eight times target value
IV	Excessively polluted. more than eight times target value

Source: *Working Group of the Federal States on Water Issues 1998*

VI 1.3 Chemical water quality

The chemical quality of water is degraded by direct (e.g., sewage discharges) and diffuse (e.g., agricultural runoff) inputs. LAWA published a classification system for physico-chemical water quality in 1998 with which these environmental burdens are assessed (Tab. VI 1.3-1). The system uses quality targets for organic environmental chemicals and heavy metals to define Class II. These targets are scientifically based guidelines for good water quality, but are not legally binding. On the contrary, the environmental quality standards under the Water Framework Directive, which are largely based on the values of the targets for protecting aquatic communities, are legally binding. In the water quality classification system, the strictest guidelines for aquatic communities, drinking water supply, sus-

Fig. VI 1.2-3: *Indication characteristics of various groups of organism*



Source: *Revised 2001 by Braukmann et al.*

pended matter and sediment, and fishing were defined for Class II. The levels of other indicators (e.g., nutrients) in Class II are based on assessment methods used by the *Länder* (Tab. VI 1.3-2).

Discharges/losses to surface water, priority polluters, and measures

Inputs of biodegradable materials can disrupt the oxygen balance in water bodies. Nutrients can encourage blooms of algae, and pollutants like pesticides or heavy metals can be toxic to aquatic organisms. This has a negative impact on water use, such as bathing or drinking water abstraction. The Water Framework Directive (WFD) that came into force in 2000 across the European Union aims to achieve good ecological and chemical water quality. It requires that discharges of nutrients and pollutants into water are gradually reduced and eventually eliminated. Its objective is to achieve a concentration of high-priority, hazardous substances in the oceanic environment that, for substances that occur naturally, is close to their background values and that is close to zero for anthropogenic, synthetic substances. The EU Member States undertook to collect data on anthropogenic pollution and significant cases of water pollution from diffuse and point sources. Models are used to estimate the proportions from natural, point, and diffuse sources, and the results are compared with the substance loads measured in the rivers themselves.

The main sources of nutrient and pollutant loads in water are agriculture, municipal sewage treatment plants, power stations, transport, and industry. However, the water pollution load caused by waste water inputs from local authorities and industry has declined considerably in recent years. One of the reasons behind this fall is the cessation of production by chemical industry companies that have moved to the new *Länder*, which have caused a reduction in the nutrient and pollutant inputs into surface water. Changes to the Act on Managing Water Resources also required measures to be taken by both local authorities and industry, and led to an overall reduction in emissions from point sources. In both the Old and new *Länder*, improved waste water purification methods, widespread use of "state of the art" technology, and waste water avoidance have led to an above-average fall in emissions of heavy metals. Improvements in the industrial sector have been evident mainly since the early 1990s – i.e., since the waste water administration regulations came into force in the industrial sectors.

The above-average fall in discharges of nutrients and pollutants into the surface water from point sources means that pollution losses from diffuse sources, i.e., primarily from agriculture, predominate within the overall sum of discharges. This is still causing the targets (water quality Class II), set by the LAWA to protect surface inland water, to be exceeded and the WFD objective to achieve good ecological and chemical water quality by 2015 to remain unfulfilled. Some of the water pollution load from agriculture gets into surface waters via erosion and surface runoff of soil particles (mainly phosphate and pesticides). In terms of groundwater pollution, the main factors are the leaching of nitrate through using nitrogen fertilisers and displaced pesticides. Water is also polluted by:

- washing pesticide machines out in yards connected to sewage systems,
- directly discharging fertilisers, liquid and semi-liquid manures, and pesticide residues,
- animal pathogenic germs and veterinary medical products from surface runoff from areas fertilised using liquid and semi-liquid manures, and
- ammonia degasification from livestock farming and liquid manure production.

The most important measure to reduce water pollution from agricultural sources is observing correct

Tab. VI 1.3-2: *Physico-chemical water quality classification for selected key indicators*

Class	Tot. P [1] mg/l	NO_3-N [1] mg/l	NH_4-N [1] mg/l	Tot. N [1] mg/l	AOX [1] µg/l	Pb [2] mg/kg A,S	Cd [2] mg/kg A	Cr [2] mg/kg S	Cu [2] mg/kg S	Ni [2] mg/kg S	Hg [2] mg/kg A	Zn [2] mg/kg S
I	≤ 0.05	≤ 1.0	≤ 0.04	≤ 1.0	"0"	≤ 25	≤ 0.3	≤ 80	≤ 20	≤ 30	≤ 0.2	≤ 100
I-II	≤ 0.08	≤ 1.5	≤ 0.10	≤ 1.5	≤ 10	≤ 50	≤ 0.6	≤ 90	≤ 40	≤ 40	≤ 0.4	≤ 150
II	≤ 0.15	≤ 2.5	≤ 0.30	≤ 3.0	≤ 25	≤ 100	≤ 1.2	≤ 100	≤ 60	≤ 50	≤ 0.8	≤ 200
II-III	≤ 0.30	≤ 5.0	≤ 0.60	≤ 6.0	≤ 50	≤ 200	≤ 2.4	≤ 200	≤ 120	≤ 100	≤ 1.6	≤ 400
III	≤ 0.60	≤ 10	≤ 1.20	≤ 12	≤ 100	≤ 400	≤ 4.8	≤ 400	≤ 240	≤ 200	≤ 3.2	≤ 800
III-IV	≤ 1.20	≤ 20	≤ 2.40	≤ 24	≤ 200	≤ 800	≤ 9.6	≤ 800	≤ 480	≤ 400	≤ 6.4	≤ 1600
IV	> 1.20	> 20	> 2.40	> 24	> 200	> 800	> 9.6	> 800	> 480	> 400	> 6.4	> 1600

A = asset "aquatic biocoenoses"; S = asset "suspended matter and sediment"

[1] reference level: usually 90 percentile

[2] reference level: usually 50 percentile

Source: *Working Group of the Federal States on Water Issues 1998*

practice as defined by agricultural law. The Fertiliser Ordinance and the basic principles of correct practice in plant and soil conservation are particularly significant here.

VI 1.3.1 Nutrients

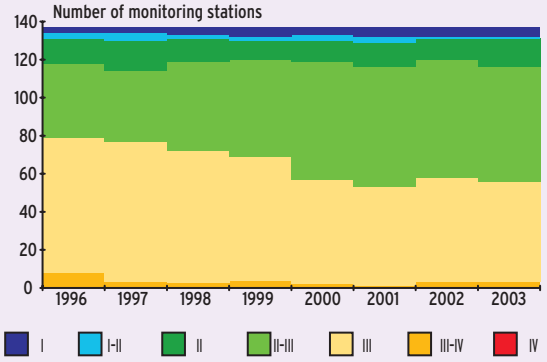
Nutrients in flowing waters

There has been a clear downward trend in pollution through ammonia and total phosphorus, due to the construction and upgrading of waste water treatment plants and, in the case of phosphorus, also to the use of phosphate free washing products. However, levels of nitrate pollution have remained high. The distribution of water quality classes for total nitrogen (or, alternatively, nitrate) at 137 identical monitoring stations between 1996 and 2003 shows a slight decline in those with elevated pollution levels (Class III) (Fig. VI 1.3.1-1). Class II and better was achieved at 15 % of stations in 2003 (Fig. VI 1.3.1-5). In 2003, this objective was achieved for ammonia at 56 % of 149 stations (Fig. VI 1.3.1-2), for total phosphorus at 29 % of 148 stations (Fig. VI 1.3.1-3) and for nitrate at 15 % of 151 (Fig. VI 1.3.1-4) stations. Class II results were mainly achieved for total phosphorus in southern Germany (Fig. VI 1.3.1-6), where high runoff dilutes phosphorus inputs, the Rhine up to Mainz, flows into Lake Constance, the mining areas in Lusatia, where ferrous mine water precipitates and sediments the phosphorus, and some areas with low pollution levels (reference monitoring stations). Very low to moderate concentrations of total nitrogen and nitrate are, again, only found in the foothills of the Alps where there is much runoff, in the Rhine as far as Mannheim, in the Havel and at the reference monitoring stations.

Nutrients in lakes

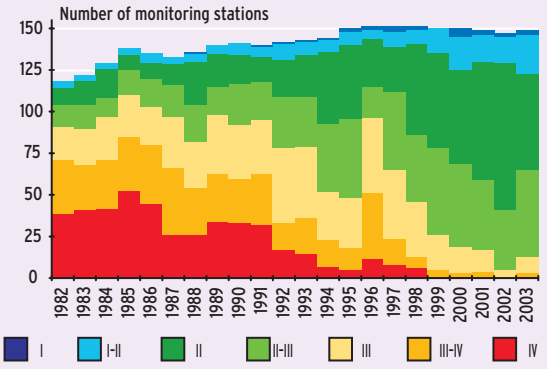
Excessive nutrient input and the resulting eutrophication pose a major problem for lakes. Since the water in still water systems is only changed slowly and nutrients are stored in the sediments and can, under certain circumstances, be released again, alga

Fig. VI 1.3.1-1: *Quality classification for total nitrogen at 137 LAWA monitoring stations*



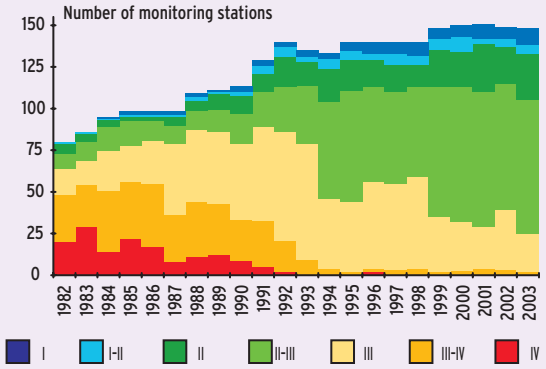
Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

Fig. VI 1.3.1-2: *Quality classification for ammonium-nitrogen (LAWA monitoring network)*



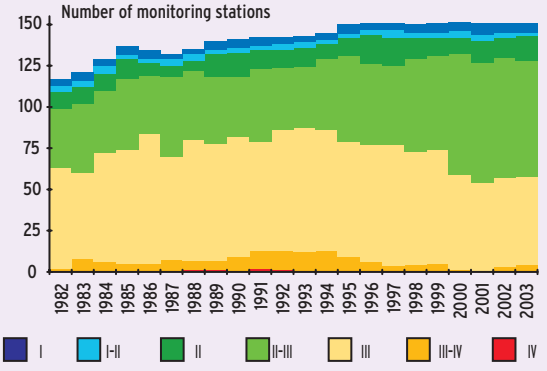
Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

Fig. VI 1.3.1-3: *Quality classification for total phosphorus (LAWA monitoring network)*



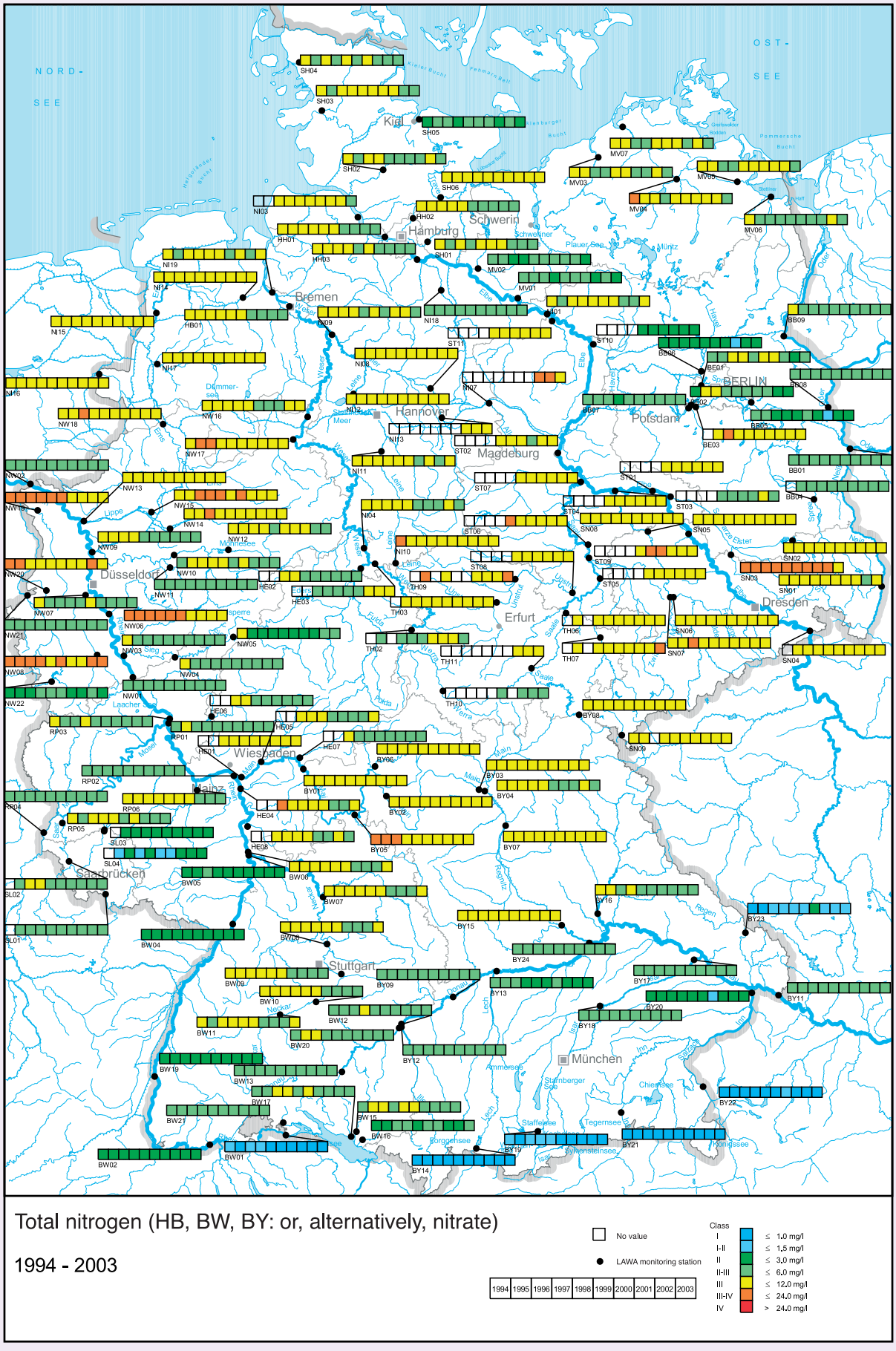
Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

Fig. VI 1.3.1-4: *Quality classification for nitrate-nitrogen (LAWA monitoring network)*



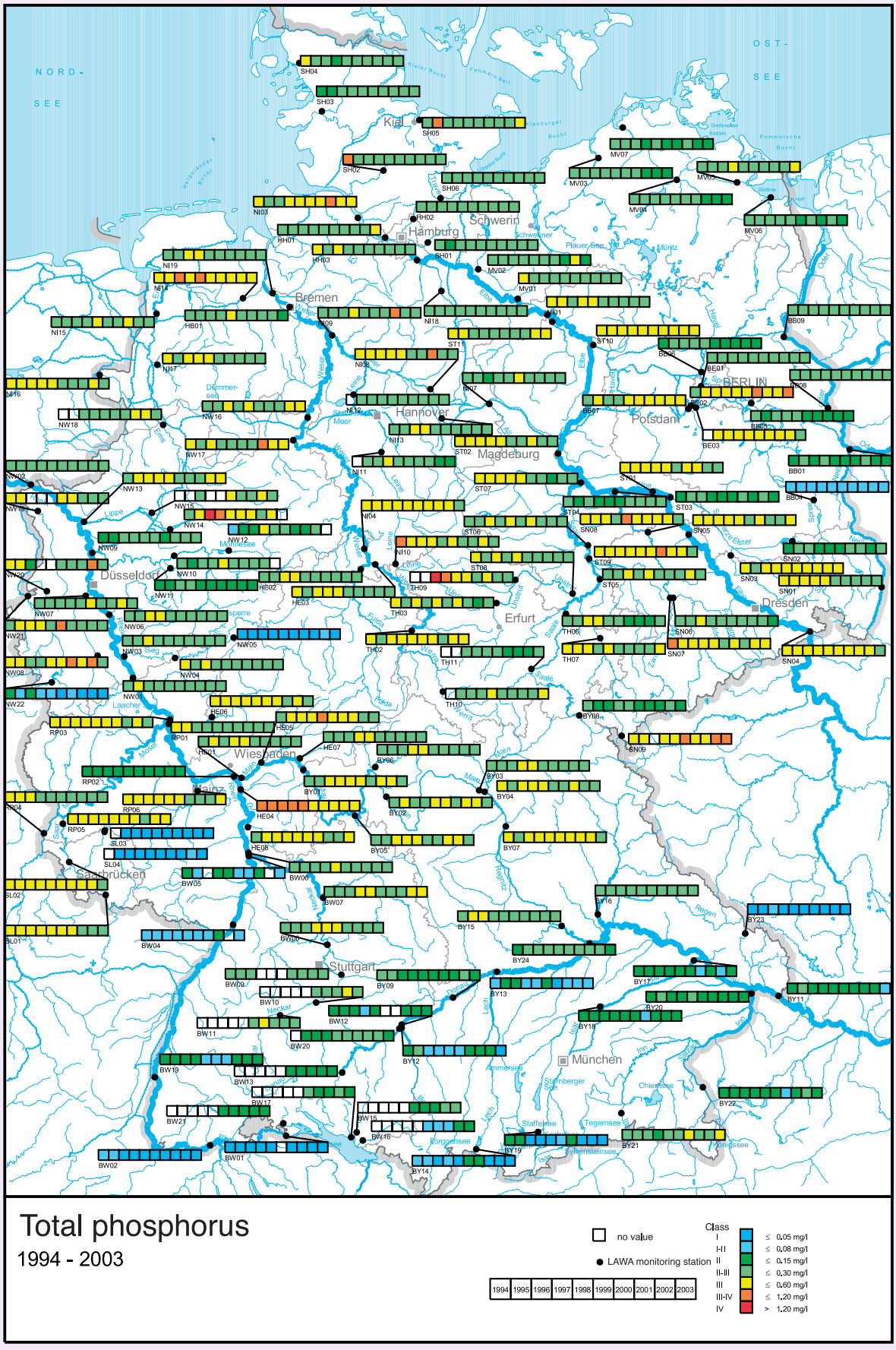
Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

Fig. VI 1.3.1-5: *Water quality map for total nitrogen*



Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

Fig. VI 1.3.1-6: *Water quality map for total phosphorus*



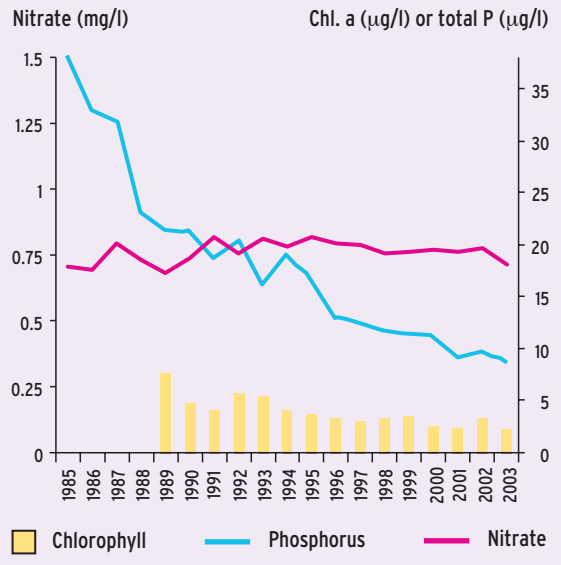
Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

growth in lakes reacts very slowly to a reduction in nutrient inputs.

The transformation of nutrients into vegetable biomass depends not only on the available levels of nutrients – in most cases, phosphorus determines the extent of growth – but also on the form and wind exposition of the lake's basin, and on its hydrology. Deep lakes with stable thermal strata in the summer, a small catchment and slow rates of exchange are naturally less productive, i.e., their "potentially natural" or "reference" state is oligotrophic (low in nutrients), while shallow, continually circulating lakes tend to produce more growth from their nutrients, i.e., their reference state is eutrophic (high in nutrients). In 1999, LAWA developed a seven-level classification system for the eutrophication in German lakes, based on the difference between a lake's actual state and its reference state. The classification runs from Class 1 (no anthropogenic pollution) to Class VII (excessively polluted).

Lakes can be returned to their reference state, for example with improved waste water treatment technology, as in Lake Constance and the lower Alpine lakes of Bavaria (Fig. VI 1.3.1-7).

Fig. VI 1.3.1-7: *Trends in water quality in the Lake Constance*

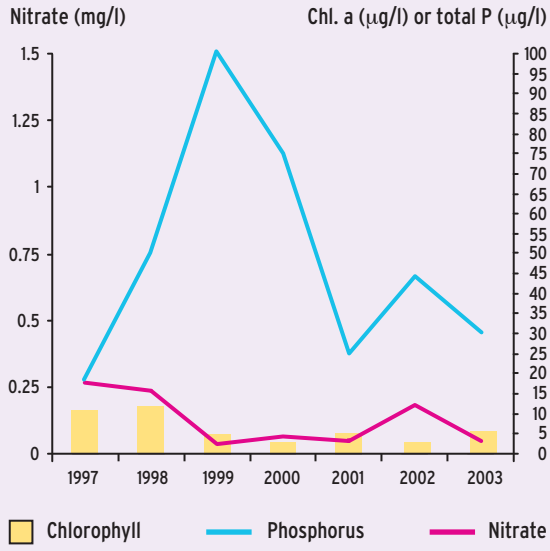


Source: *Federal Environment Agency 2004*

Improved sewage treatment and the introduction of phosphate free detergents has also significantly reduced the impact of sewage on eutrophication in the New *Länder* in recent years (Fig. VI 1.3.1-8).

In the future, measures to combat eutrophication must concentrate on reducing diffuse agricultural

Fig. VI 1.3.1-8: *Trends in water quality in the Müritz (outer Müritz)*



Source: *Federal Environment Agency 2004 a*

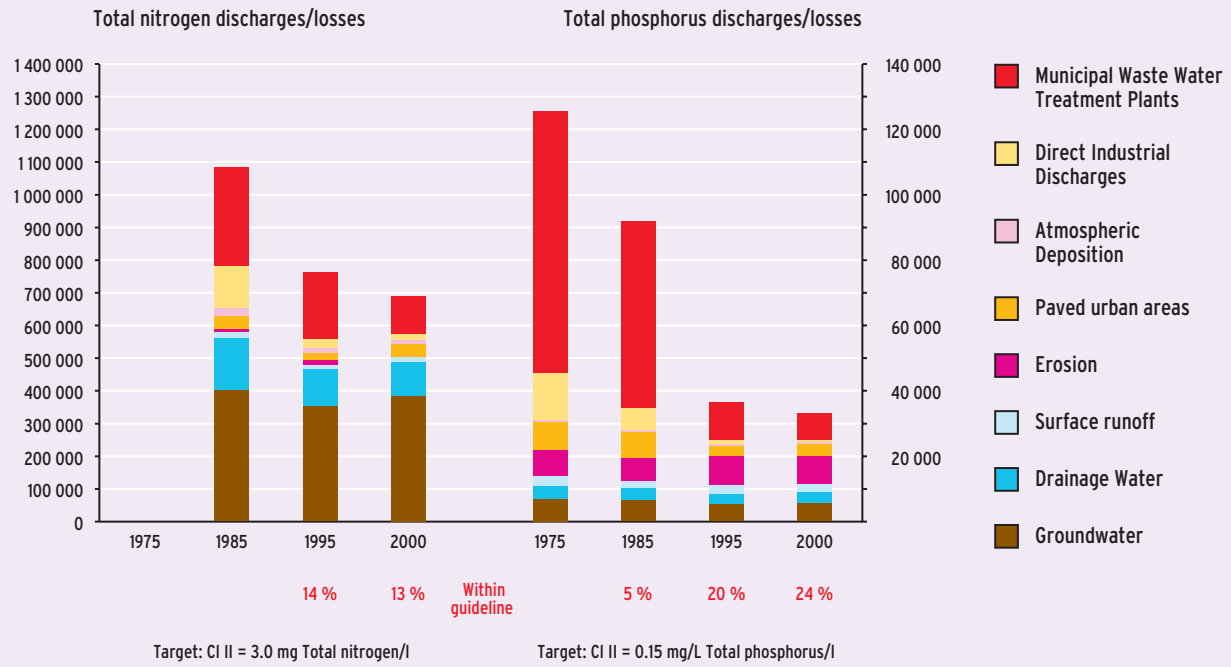
inputs. Even then, some types of lake will require additional site-specific remedial measures to reduce eutrophication, such as reaerating the hypolimnion, treating sediment or calcite precipitation. Of course, these measures are only meaningful once nutrient inputs from the catchment area have been reduced dramatically.

Another, often less noticed, but ever-increasing problem is the destruction of banks that fulfil an important ecological function. Thus there is not only a need to fight eutrophication, but also to develop strategies for using banks in an environmentally-friendly way.

Nutrient inputs to surface water

Total nitrogen inputs into Germany's surface water between 1998 and 2000 amounted to 688 kt/a, or a fall of 400 kt/a compared with the 1983–1987 period (Fig. VI 1.3.1-9). This meant that the internationally agreed objective of cutting nitrogen emissions into the North Sea and the Baltic by half between 1985 and 2000 was not met. The reduction actually achieved, of 37 %, was mainly the result of a sharp decline (70 %) in nitrogen inputs from point sources. Nitrogen inputs from diffuse sources, on the other hand, were only cut by 15 %. Overall, the dominant path for inputs in Germany during 1998–2000 was via groundwater, with 56 %. Point sources' share of nitrogen inputs was 19 %. Inputs to surface waters through erosion, runoff, and atmospheric deposition each only contributed a small amount (less than 2 %) to overall inputs.

Fig. VI 1.3.1-9: *Nitrogen and Phosphorus discharges/losses from point and diffuse sources to German surface waters in t/a*

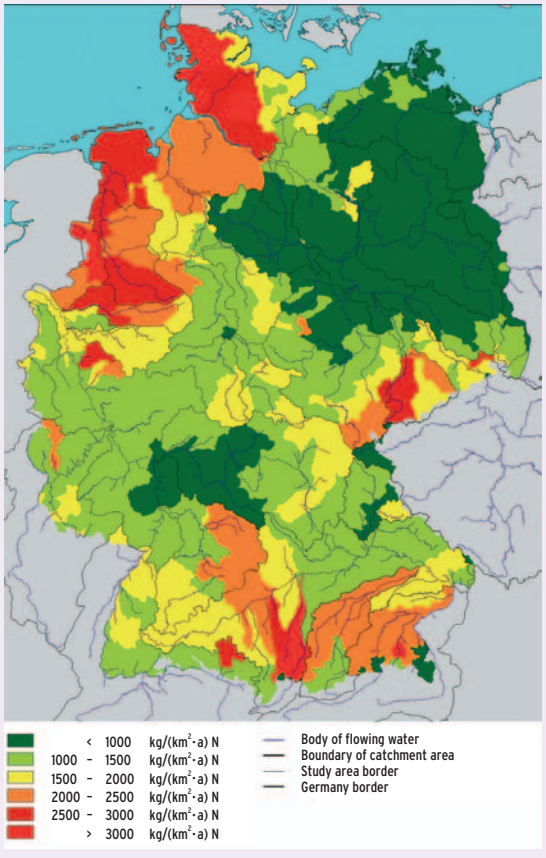


Source: *Federal Environment Agency 2003*

Total phosphorus inputs into Germany's surface waters were ca. 33 kt/a in the period 1998–2000. Compared with the 1983–1987 period, phosphorus inputs fell by ca. 59 kt/a, or 64 %, thus meeting the objective of halving phosphorus inputs in the North Sea and Baltic in all river areas. The fall in phosphorus inputs is also predominantly attributable to cutting inputs from point sources, which fell by 86 %. There was only a 13 % fall in phosphorus inputs from diffuse sources. This was due to the above-average (59 %) reduction in inputs from sealed areas. In spite of the huge fall in inputs from point sources, this remained the dominant input path during 1998–2000, with 27 %. Phosphorus inputs via erosion, at 26 %, predominate among the diffuse sources.

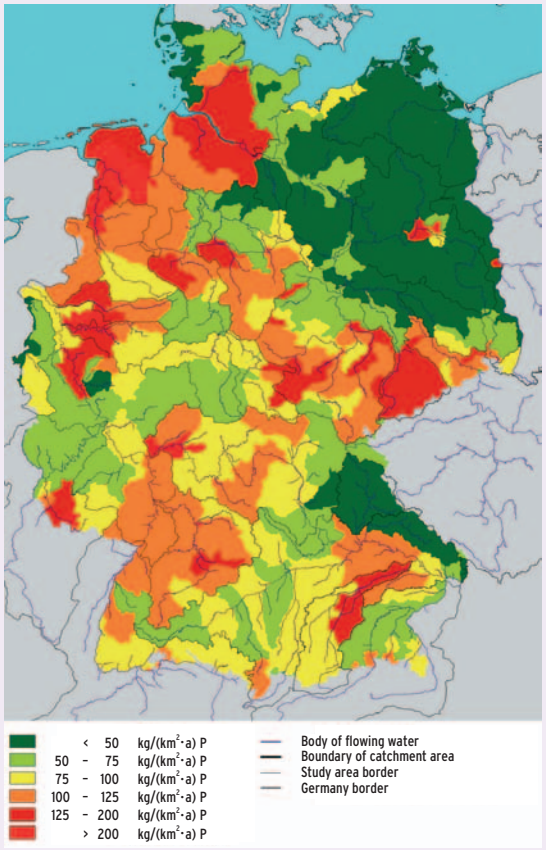
The balance of nutrient inputs is increasingly shifting towards diffuse sources. Between 1985 and 2000, nutrient inputs of nitrogen from agricultural sources fell by only around 15 %, while those of phosphorus actually rose slightly (7 %). Diffuse nutrient sources are highest where excessive livestock numbers are kept in locations where high levels of leaching and runoff are likely. For phosphorus this is the case in the moors of the extreme Northwest, while the entire Northwest (sandy soil) and some Alpine regions (runoff) are danger areas for nitrogen (Figs. VI 1.3.1-10 and VI 1.3.1-11). While nutrient inputs into surface waters fell sharply up to 2000,

Fig. VI 1.3.1-10: *Spatial distribution of fugitive nitrogen discharge/losses into surface waters 2000*



Source: *Behrendt et al., UBA text 82/03*

Fig. VI 1.3.1-11: *Spatial distribution of fugitive phosphorus discharge/losses into surface waters 2000*



Source: *Behrendt et al., UBA text 82/03*

they are still very high, with the result that LAWA's targets for nutrient concentrations (water quality Class II) are generally exceeded.

Fertiliser sales in the agricultural sector

Compared with the second half of the 1980s, turnover of nitrogen in commercial fertilisers fell sharply in the first half of the 1990s, after which it rose again up to late 1990s before it fell back again. When interpreting the figures, it should be remembered that sales do not equate to usage in the agricultural sector, since resources are purchased when prices are favourable to keep in stock. (Tab. VI 1.3.1-1). The goal of the Use of Fertilisers Ordinance, which came into force in 1996, is to permanently reduce nitrogen inputs to water bodies and other ecosystems by using fertilisers with more care and avoiding loss of nutrients. The slight decline in sales of nitrogen fertilisers since 2000 is, without a doubt, a result of the ordinance. In fiscal year 2002/2003, the use of nitrogen fertilisers per unit of land (excluding fallow) was unchanged from the previous year. If one takes into consideration the rising share of organically farmed land (2002: 696 978 ha = 4.1 % of total land), which has to be removed from the calculation of mineral nitrogen fertiliser use because no mineral nitrogen fertilisers may be used on such land, it is evident that the intensity of nitrogen fertiliser use in conventional farming has tended to rise. Turnover of commercial fertilisers in the medium-term is also influenced by economic conditions and agricultural or environmental policy, for example the amount of fallow land and the structure of extensive farming programmes.

Tab. VI 1.3.1-1: *Domestic sales of mineral fertilisers in Germany (1 000 t nutrient)*

	1990/91	1995/96	2000/01	2002/03[1)]
Nitrogen (N)	1 885.3	1 769.2	1 847.6	1 787.8
Phosphate (P_2O_5)	672.2	401.7	351.3	327.4
Potash (K_2O)	1 031.7	652.2	544.0	479.7
Lime (CaO)	2 407.6	1 886.5	2 171.1	2 117.2

[1)] provisional figures

Source: *Federal Ministry of Food, Agriculture and Consumer Protection 2003*

Surplus nutrients on agricultural land (overall balance)

The main reason for the accumulation of nitrate in ground- and surface waters which has been evident for decades is the intensification of agricultural soil use and livestock farming, and the consequent nitrogen surpluses. Many agricultural trends and their consequences for nutrient inputs to water bodies are reflected in the nationwide nutrient balance. The surplus in the land balances is an indicator for potential inputs into surface and groundwater. The surplus in the farm gate balance (total agricultural balance – Tab. VI 1.3.1-2) is by far the most important determinant of any overall burden from agricultural use of nutrients. The total agricultural, or farm gate, balance shows that, in the case of nitro-

Tab. VI 1.3.1-2: *Nutrient balances for agricultural land 2002 (total balance)*

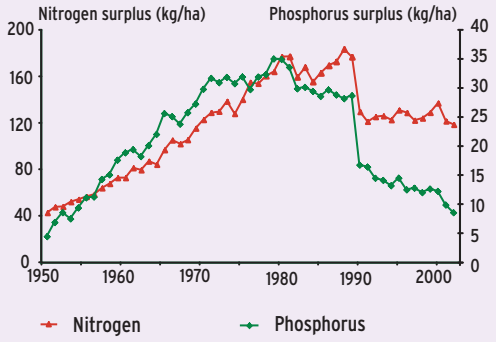
in kg / ha N or P		Nitrogen	Phosphorus
Added	Inorganic fertilisers	106	8.2
	Animal foodstuff from imports	21	2.4
	Animal foodstuff from domestic processing	12	3.5
	Leguminosae	13	–
	P inorganic feed	–	3.7
	Atmospheric deposition (net)	10	–
	Total added	165	20.0
Removed	Vegetable market products	40	7.8
	Animal market products	20	3.8
	Total added	60	11.6
Balance	Surplus Total Balance	105	8.4

Source: *M. Bach and H.-G. Frede, University of Giessen 2004*

gen, gaseous losses to the atmosphere would add ca. 30 kg N/(ha·a) to the surplus.

The nitrogen surplus in the farm gate balance has fallen by 27 % since its peak in 1987, the phosphorus surplus by almost 80 % since 1980 (Fig. VI 1.3.1-12). There has been a noticeable decline since German reunification, attributable to the dramatic fall in livestock numbers in the New *Länder*. Nitrogen pollution is currently stagnating at a high level.

Fig. VI 1.3.1-12: *Trends in the surplus from farmland (farm gate balance)*

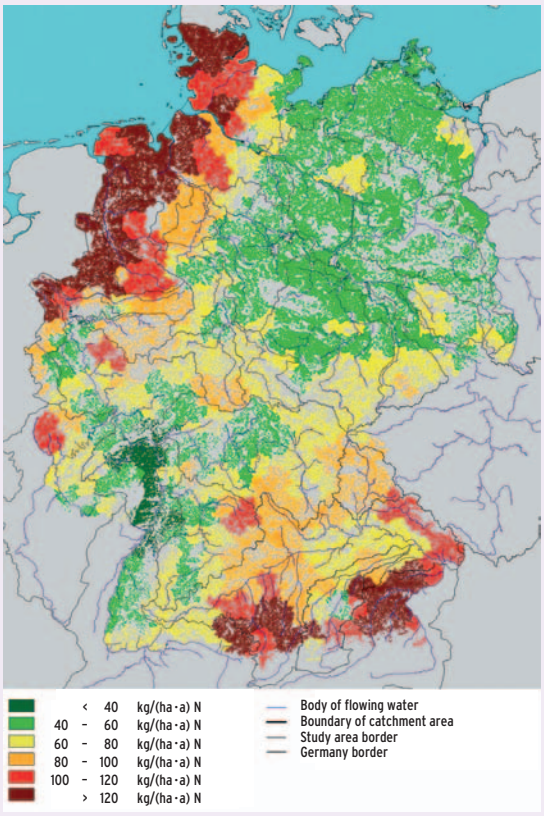


Source: *M. Bach und H.-G. Frede, University of Giessen 2004*

The realisation that less use of chemicals produces economic savings, that the phosphate content in two-thirds of all agricultural land is sufficient, high or very high, the increased environmental awareness among farmers brought about by public debate, as well as the 1992 EU reform of the common agricultural policy (CAP), have all contributed to these reductions. Nonetheless, phosphate levels in soil, and consequently phosphate discharges, are still rising, due to the continuing surplus.

The 1996 Use of Fertilisers Ordinance appears to have had little effect on agricultural surpluses. The fall in nitrogen surpluses from agriculture since 1990 is only mildly reflected in improved flowing water quality (Figs. VI 1.3.1-13 and VI 1.3.1-14). The reason for this appears to be nitrogen's long average residence periods in groundwater. The first estimates of these come from correlating surpluses from agriculture with riverine concentrations of nitrogen. Average residence periods in groundwater are 5–15 years in the Danube, 10–20 years in the Rhine, and as much as 30 years in the Elbe. A flow model for groundwater in the lowlands of the Elbe region has produced similar results: the median time of flow was 25 years, within a range of 1.5 to ca. 500 years. Most lowland aquifers still have a large capacity to break down nitrates, with their low levels of oxygen and high levels of iron and pyrite.

Fig. VI 1.3.1-13: *Spatial distribution of nitrogen surpluses on farmland 1999*



Source: *M. Bach, University of Giessen, UBA text 82/03*

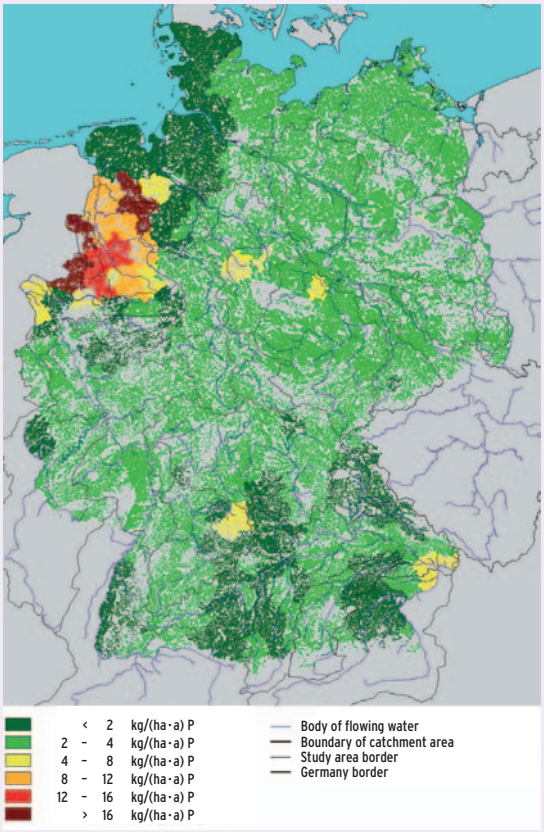
Despite successes with waste water treatment, much remains to be done to achieve good quality as defined in the EC Water Framework Directive and policy goals such as halving nitrogen loads in line with the requirements of conventions on protecting the oceans. According to more recent findings, to do this measures are required that would lead to a further decline in the nitrogen surplus to ca. 50 kg N/ha (land surplus) and an increase in the landscape's denitrification capacity (e.g., through drainage, rewatering wetlands and improvements to the morphological water structure).

Measures in the agricultural sector

Through the Federal Water Act, the ordinances on fertilisers, soil conservation, and life-cycle management, the EC Nitrates Directive on protecting waters from being polluted by nitrates from agricultural sources, and the integrated avoidance and reduction of environmental pollution (IVU) directive, substantial legislation has been put in place to achieve an environmentally-friendly agricultural sector.

The most important measure to reduce water pollution from agricultural sources is observing correct practice as defined by agricultural law. The Fertilis-

Fig. VI 1.3.1-14: *Spatial distribution of phosphorus surpluses on farmland 1999*



Source: *M. Bach, University of Giessen, UBA text 82/03*

er Ordinance and the basic principles of correct practice in plant and soil conservation are particularly significant here. The new instruments in the EU Common Agriculture Policy that were recently agreed will also play a vital role:

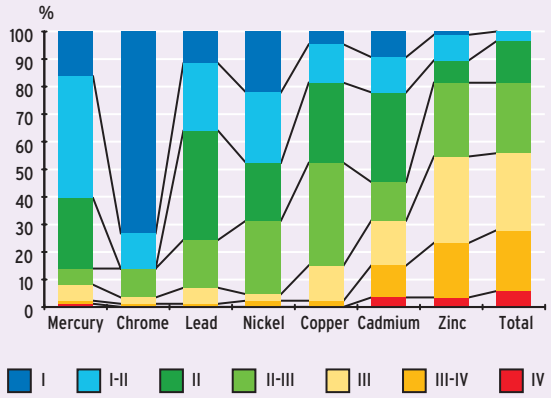
- direct payments decoupled from production and tied to acreage,
- cross compliance, i.e., tying direct payments to standards of environmental, animal protection and food safety; the 91/676/EEC Nitrates Directive and the Groundwater Directive,
- compulsory modulation, i.e., cutting direct payments by up to 5 % from 2007 to 2012, in order to use these funds to support the funding programmes for developing agricultural areas (including the Agri-Environmental Programmes).

VI 1.3.2 Heavy metals

Heavy metals in flowing waters

One of the ways in which heavy metal pollution is measured is using measurements in suspended particulate matter. Most measurements are taken in large- and medium-sized water bodies, where higher levels of contamination are expected. In 2003, the target of Class II water quality was achieved at 19 % of the 86 LAWA stations where heavy metals were tested in the case of zinc, 48 % for copper, 55 % for cadmium, 69 % for nickel, 76 % for lead, 86 % for mercury and 86 % for chrome. This meant that water quality Class II was achieved for all 7 heavy metals at 19 % of the 86 LAWA stations (Fig. VI 1.3.2-1). There has nonetheless been a pronounced downward trend in the levels of these 7 heavy metals – with a few exceptions – during 1988–2003. In the course of working on the EC Water Framework Directive, EU-wide environmental quality standards are currently being drawn up to classify chemical water quality for lead, cadmium, nickel, and mercury. National environmental quality standards have been specified for classifying the ecological quality for chrome (640 mg/kg), copper (160 mg/kg), and zinc (800 mg/kg). Where these standards are exceeded, surface water will not have good quality and measures will have to be taken to restrict inputs.

Fig. VI 1.3.2-1: *Quality classification for heavy metals in suspended matter 2003 (Number of monitoring stations = 86, strictest asset in each case)*

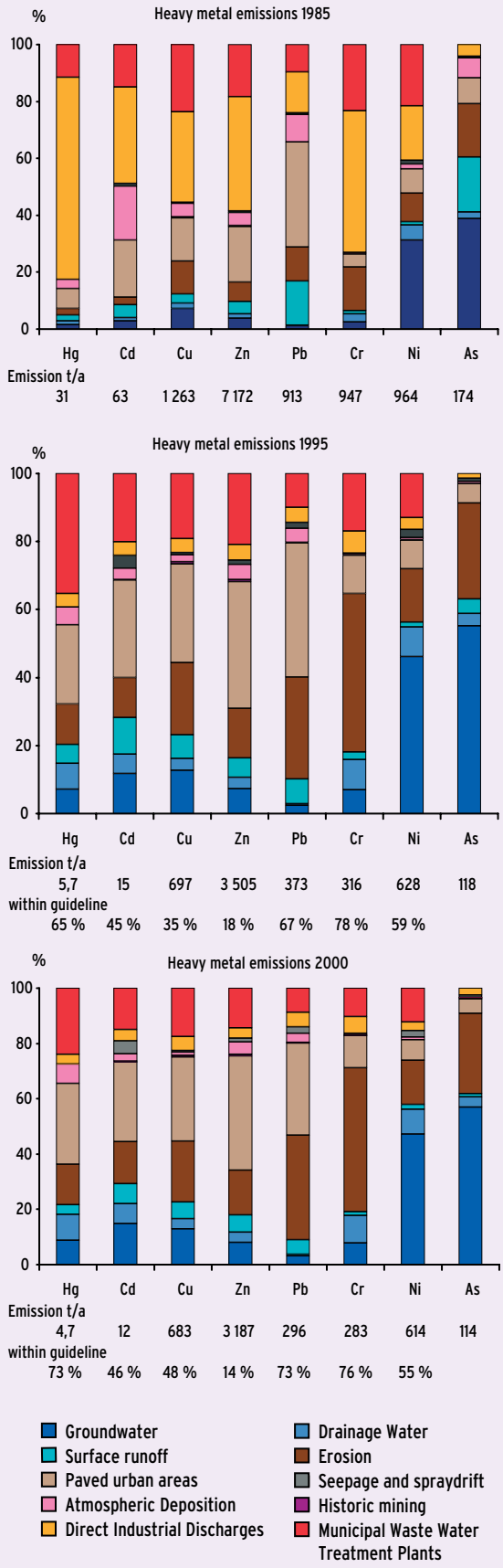


Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

Heavy metal inputs to surface water

Inputs of heavy metals into surface waters have a negative impact on aquatic biocoenoses that requires systematic measures to reduce these inputs into inland waters and the sea. Between 1985 and 2000 in Germany, there was a sharp decline in heavy metal inputs to surface waters (Fig. VI 1.3.2-2). Apart from arsenic and nickel, whose geogenic share cannot be influenced and is fairly high, the reductions required by the international conventions on protecting the oceans have been either achieved or exceeded by 50 % (Cr, Cu, Ni, Zn, and the metalloid As) or 70 % (Cd, Hg, Pb) for these

Fig. VI 1.3.2-2: *Heavy Metal discharges/losses from point and diffuse sources to the German surface waters in t/a*



Source: *S. Fuchs, U. Scherer, UBA-Texte 54/02*

heavy metals. The reductions are 36 % for nickel and 85 % for mercury, and are primarily due to the dramatic fall (74 % for nickel, 95 % for mercury) in direct industrial discharges. Measures taken by the industrial sector in response to tighter regulations have played a major role in this environmental relief, as has the decline in industrial activity in the New *Länder* since 1990. By 2000, direct industrial discharges were only of minor significance. The significance of discharges from municipal sewage treatment plants continued to be high, but water pollution in 2000 was dominated by diffuse sources.

The reduction in inputs from diffuse sources, which has fluctuated between 5 % for copper and 72 % for cadmium since the mid-1980s, is directly linked to the reduction in atmospheric emissions. Along with the reduction in direct atmospheric inputs to the water's surface which actually only form a small part of the total input, atmospheric deposition directly impacts on inputs through surface runoff, particularly from sealed urban areas. For other significant diffuse input paths, such as erosion and groundwater, there has been no real change in inputs to water since the mid-1980s.

Priority pollution sources

Diffuse sources currently have a share of around 72 % for mercury, 76 % for cadmium and copper, 84 % for lead and chrome, 80 % for zinc, 82 % for nickel, and 94 % for arsenic. The main input paths were identified to be sewage systems and the population not connected to the sewage system, erosion, and groundwater inflows. Combined sewage systems and storm-water flows from dual sewage systems cause 10–40 % of all heavy metal inputs to surface waters, with high proportions of zinc, lead, and copper being particularly evident. As a large proportion of the stormwater flows are routed to waste water treatment plants in combined sewage systems, these systems cause less water pollution through heavy metals than the dual sewage system. The metals chrome and lead enter waters through erosion, while geogenic inputs (groundwater route) predominate with arsenic (57 %) and nickel (45 %). There are significant differences in pollution levels between the various river basins through land use and climatic factors.

The highest pollution levels from specific areas in 2000 were identified in the Rhine catchment area. This is because of the high population density (ca. half of Germany's population live in the Rhine basin, which only contains 30 % of its land) and the associated high level of urbanisation and industrialisation. Most inputs of cadmium, copper, mercury, lead, and zinc in the Rhine basin came from urban

sources such as municipal waste water treatment plants, sewage systems and industry. Because of the decline of industry in the New *Länder*, increased levels of pollution are no longer being recorded in the Elbe and Oder river basins in eastern Germany.

So, at the moment, it is the diffuse sources of heavy metals that are of most interest, since it has become clear that, despite reductions of up to 95 % from point sources and a sharp fall in riverine concentrations, the LAWA targets (water quality Class II) are often not being met. Zinc, cadmium, copper, and nickel are posing particular problems.

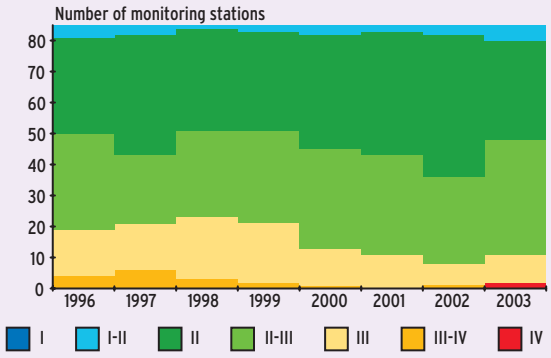
Measures

Reducing diffuse losses of heavy metals entails first and foremost improvements to the treatment of municipal storm water. Storm water passes through storm drains in dual sewage systems, or through overflows when the treatment plants in a combined sewage system reach full capacity, and waste enters surface waters with scarcely any treatment, if at all. Combined sewage systems are designed so that their overflows cut in 50 times a year, on average, discharging a large proportion of the storm water, mixed with domestic sewage and virtually untreated, directly into water bodies. Only the first surge is retained, although this is admittedly usually the most heavily polluted. Any agricultural measure to reduce erosion (e.g., mulching, ploughing against the slope on hills) also help reduce heavy metal inputs. Drainage flows are especially important for cadmium, as it accumulates with phosphate fertilisers in many soils. This situation could be improved in the long-term by using low-cadmium phosphate fertilisers and shutting off drainage when land is set aside.

VI 1.3.3 Organic environmental chemicals in flowing waters

Of organic environmental chemicals (Tab. VI 1.3.3-1), the complexing agent EDTA frequently exceeds targets at LAWA stations (> 25 % of those surveyed). Some isolated stations also report excessive dichloromethane, trichloromethane, 1,4-dichlorobenzene, 1,3,5-trichlorobenzene, hexachlorobenzene, nitrobenzene, 3,4-dichloraniline, DTPA, and NTA. The concentrations of 21 other chemicals give no cause for concern. Unfortunately, the water quality targets, especially for dichloromethane, 1,4-dichlorobenzene, 3-chloroaniline and 4-chloroaniline, are far too low, relative to the detection limits of the analytical methods used, making it impossible to test for target compliance at some monitoring stations. From 1993 to 2003, there has been a downward trend in levels of chlorinated hydrocarbons such as trichloromethane, trichloro ethane and tetrachloro ethane. The continuing reduction in production-related inputs has shifted the focus for some chemical inputs to releases during use, which must be reduced further. Between 1996 and 2003, data from the total parameter AOX (Absorbable Organic Halides) was analysed for 85 identical stations in the LAWA monitoring network on behalf of the UBA's environmental barometer (Fig. VI 1.3.3-1). One of the items included in the AOX was chlorinated compounds (Tab. VI 1.3.3-1 and Tab. VI 1.3.3-2). In 2003, water quality Class II or better was achieved at 44 % of the stations and here, too, there was a decline in pollution at highly polluted stations. For the chemicals mentioned, work is currently being undertaken to draw up EU-wide environmental quality standards (under the Water Framework Directive) for classifying chemical water quality, and national environmental quality standards for classifying ecological water quality. Where these standards are exceeded, surface water will not have the desired quality, and measures will have to be taken to restrict inputs.

Fig. VI 1.3.3-1: *Quality classification for AOX at 85 LAWA monitoring stations*



Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

VI 1.3.4 Pesticides in flowing waters

The *Länder* conduct special studies of pesticide pollution. Some of these programmes focus on intensively farmed areas (e.g., Nidda in Hesse) or on water bodies which are important for drinking water supplies (e.g., Stever in North Rhine-Westphalia, reservoir inflows in Thuringia). The programmes concentrate on chemicals whose production and use give grounds to expect their presence in water bodies. Therefore, not all the 38 potentially polluting agents are measured at all the 151 LAWA stations, so the data base varies considerably. A drinking water quality of 0.1 µg/l has been defined for each of

Tab. VI 1.3.3-1: *Compliance and non-compliance with quality targets (GL) for organic environmental chemicals during the period 2001–2003, reference level 90th percentile*

Chemical	GL in mg/l (A)	GL in mg/l (T)	Non-compliance with quality targets: 0 %	to 10 %	> 10 % – 25 %	> 25 %	LQ > GL[1]
Dichloromethane	10	1	A	T			T
Trichloromethane (Chloroform)	0.8	1		A, T			
Tetrachloromethane	7	3	A, T				
1,2-dichloroethane	2	1	A, T				
1,1,1-trichloroethane[*)]*	100	1	A, T				
Trichloroethene	20	1	A, T				
Tetrachloroethene	40	1	A, T				
Hexachlorobutadiene	0.5	1	A, T				
1,4-dichlorobenzene	*10*	1	A, T	F[2]			F
1,2,3-trichlorobenzene	8	1	A, T				
1,3,5-trichlorobenzene	20	0.1	A	T			
1,2,4-trichlorobenzene	4	1	A, T				
Hexachlorobenzene	0.01	0.1		A, T	F[3]		
Nitrobenzene	*0.1*	10	T	A			
1-chloro-2-nitrobenzene	*10*	1	A, T				
1-chloro-4-nitrobenzene[*)]*	30	1	A, T				
1,2-dichloro-3-nitrobenzene[*)]*	20	1	A, T				
1.4-dichloro-2-nitrobenzene[*)]*	20	1	A, T				
1,2-dichloro-4-nitrobenzene[*)]*	20	1	A, T				
2-nitro-toluol	50	10	A, T				
3-nitro-toluol	50	10	A, T				
4-nitro-toluol	70	10	A, T				
4-chloro-2-nitro-toluol[*)]*	20	1	A, T				
2-chloro-4-nitro-toluol		1	T				
2-chloroaniline	*3*	1	A, T				
3-chloroaniline	*1*	0.1	A, T				T
4-chloroaniline	*0.05*	0.1	A, T				A
3,4-dichloraniline	*0.5*	0.1	A	T			
DTPA		10		T			
EDTA		10				T	
NTA		10		T			

T = asset "drinking water supplies",
A = asset "aquatic biocoenoses",
F = asset "fishing"

Bold: Directive No. 2455/2001/EC on specifying the list of priority substances in the water policy sector and to change Directive 2000/60/EC
Italics: Environmental quality standards in the *Länder's* ordinance on implementing Annexes II and V of EC Directive 2000/60/EC (excluding priority substances), reference level: Average

1) Limit of qualification (LQ) lies above the target (water sample) at a minimum of 50 % of the stations surveyed; at these stations, it may is possible that the target is both exceeded and not reached.
2) Quality target for asset "fishing": 0.02 µg/l
3) Quality target for asset "fishing": 0.001 µg/l or 40 µg/kg in sediment
*) Environmental quality standard = 10 µg/l

Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

Tab. VI 1.3.3-2: *Compliance and non-compliance with quality targets (GL) for pesticides during the period 2001–2003, reference level 90th percentile*

Chemical	GL in mg/l (A)	GL in mg/l (T)	Non-compliance with quality targets: 0 %	to 10 %	> 10 % – 25 %	> 25 %	QL > GL[1]
2.4-D	2	0.1		A, T			
alpha-endosulfan	0.005	0.1	A, T				
beta-endosulfan	0.005	0.1		A, T			A
Ametryn	*0.5*	0.1	A	T			
Atrazine	–	0.1		T			
Azinphos-methyl	*0.01*	0.1	A[2],T				A
Azinphos-ethyl	–	0.1	T				
Bentazone	70	0.1	A	T			
Bromacil	*0.6*	0.1	A	T			
Chloridazon	10	0.1	A	T			
Chlortoluron	*0.4*	0.1		A, T			
Dichlorprop	10	0.1	A		T		
Dichlorvos	*0.0006*	0.1	T			A[2]	A
Dimethoat	0.2	0.1	A, T				
Diuron	0.05	0.1			T	A	
Etrimphos	*0.004*	0.1	T		A[2]		A
Fenitrothion	*0.009*	0.1	A[2],T				A
Fenthion	*0.004*	0.1	T		A[2]		A
Hexazinone	*0.07*	0.1	T	A			
Isoproturon	0.3	0.1		A		T	
Lindane	0.3	0.1	A, T				
Linuron	0.3	0.1	A, T				
Malathion	*0.02*	0.1	A, T				
MCPA	2	0.1	A		T		
Mecoprop	50	0.1	A		T		
Metazachlor	*0.4*	0.1		A, T			
Methabenzthiazuron	2	0.1	A	T			
Metolachlor	*0.2*	0.1	A	T			
Parathion-methyl	*0.02*	0.1	A, T				
Parathion-ethyl	*0.005*	0.1		A[2],T			A
Prometryn	*0.5*	0.1	A, T				
Propazine	–	0.1	T				
Simazin	0,1	0.1		A, T			
Terbuthylazine	*0.5*	0.1	A	T			
Triazophos	*0.03*	0.1	A, T				A
Tributyltin-cation[3]	0.0001	0.1	T[2]			A[3]	A
Trifluralin	0.03	0.1	A,T				A
Triphenyltin-cation[4]	*0.0005*	0.1	T[2]		A [2, 4]		A

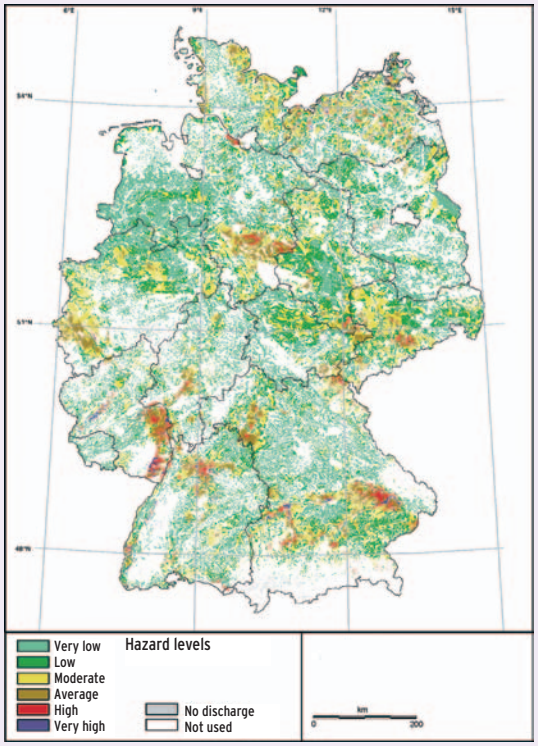
T = asset "drinking water supplies"
A = asset "aquatic biocoenoses"
Bold: Directive No. 2455/2001/EC on specifying the list of priority substances in the water policy sector and to change Directive 2000/60/EC
Italics: Environmental quality standards in the *Länder's* ordinance on implementing Annexes II and V of EC Directive 2000/60/EC (excl. priority substances), reference level: average; Azinphos-ethyl = 0.01 µg/l

1) Quantification limit (QL) lies above the quality targets (water sample) at at least 50 % of the stations; at these stations, it may be that the guideline is both exceeded and not reached.
2) Not statistically firm, as number of stations < 15
3) Quality targets for asset "aquatic biocoenoses": 2 µg/kg in suspended matter
4) Quality targets for asset "aquatic biocoenoses": 10 µg/kg in suspended matter

Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

the 38 pesticides, and different target values have been defined for the asset aquatic communities. Between 2001 and 2003, LAWA water quality targets for dichlorvos, diuron, isoproturon, and tributyl tin (TBT) were frequently exceeded (> 25 % of the stations surveyed). Isolated cases of non-compliance occurred for 21 of the 38 pesticides. Levels of only 13 pesticides complied with the targets for both protected assets. Since the concentrations of pesticides are frequently near the detection limit, trends in contamination could only be distinguished for a few pesticides. There has been a fall in contamination by atrazine, simazine, and lindane, while levels of diuron and isoproturon have remained more or less constant. For some of the pesticides listed in Tab. VI 1.3.3-2, work is currently being undertaken to draw up EU-wide environmental quality standards (under the Water Framework Directive) for classifying chemical water quality, and national environmental quality standards for classifying ecological water quality. Where these standards are exceeded, surface water will not have good quality, and measures will have to be taken to restrict inputs.

Fig. VI 1.3.4-1: *Spatial distribution of potential pesticide inputs with surface runoff*



Source: *Bach et al. 2000*

Pesticide inputs to surface water

Inputs of pesticide to surface waters amount to around 30 t/a, with a high level of uncertainty, which is around 0.1 % of all pesticides used. Surface runoff and farmyard seepage are the most significant input paths. Agricultural surface runoff (Fig. VI 1.3.4-1) is particularly significant in vineyards, strip cropping on plains, loess, and marshland with a high proportion of root crops (sugar beets, maize, potatoes), as well as in arable farming in climatically unfavourable low mountains. A high potential for leaching was determined for regions with light soils, such as between the Aller and the Elbe, Emsland, the Schleswig-Holstein Geest, Munsterland and the central Franconian basin, small areas in Upper Franconia, Vogtland, the northern Thuringian Forest and the Ore Mountains. Drainage seems to be important where leachable soil were drained in river plains (e.g., Munsterland, the upper Rhine valley, and Lausitz). Spraydrift is only an important factor in marshland orchards, with their dense open drainage networks. Riverine loads are of the same order of magnitude as these estimated discharges.

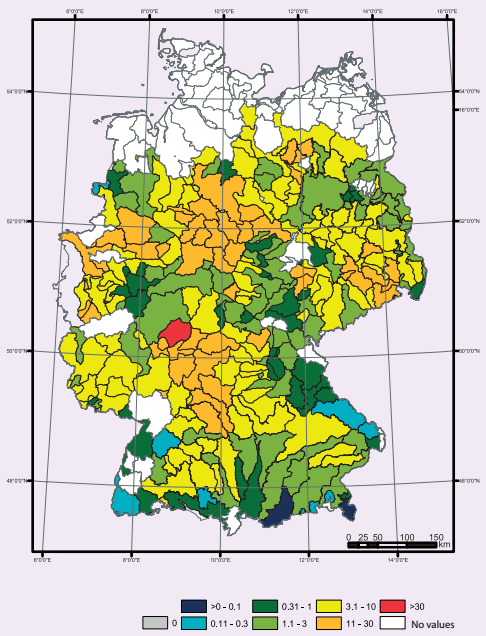
Farmyard seepage accounts for a very large share of all inputs (up to 90 % in southern and western Germany), where there is a disproportionately large number of pesticide usage equipment due to a small-farms structure. This has also been confirmed in the course of several monitoring schemes in the *Länder* concerned, where farms are connected to sewage treatment plants. The sources of the pesticide contamination in municipal sewage treatment plants may be connected farms, non-permitted use in sealed areas, and indirect inputs of waste water from formulation facilities.

Simulating models have been used to determine the potential hazards of surface runoff, drainage, and spraydrift. These employ data on pesticide use, cultivation and soil ratios, sorption, chemical degradation in the soil and weather conditions to calculate substance inputs. These simulations cannot, of course, predict input situations with precision. Neither do they take into account degradation in the water itself, so the concentrations they indicate for water bodies are fairly vague and should only be used to suggest which regions surveys should focus on. Figure VI 1.3.4-2 shows an estimate of concentrations of isoproturon, which is the herbicide most often used in arable farming. It shows the level of pollution in streams adjoining fields that were treated with isoproturon in 2000 after heavy rainfall. Levels in the medium-sized and large rivers covered by the *Länder* monitoring scheme were far lower due to dilution through uncontaminated runoff.

Pesticide sales in the agricultural sector

Pesticide sales in Germany dropped prior to 1993, but since 1994 they have rose once more, particularly due to increased sales of herbicides.

Fig. VI 1.3.4-2: *Estimated isoproturon concentrations in small water bodies in 2000 in µg/l*



Note: Loads of isoproturon from surface runoff, drainage, and spraydrift were calculated, with over 99 % of surface runoff coming from heavy rainfall events. The 90 percentile of the concentrations that result from event loads being diluted in daily runoff is given for the catchment areas. Thus the map shows both the concentration ranges anticipated in small water bodies and key areas of grain cultivation where the agent was used. Similar results are available for 58 other agents.

Source: *Röpke, B., Bach, M. 2004*

Domestic turnover of pesticides does not directly determine consumption per hectare of usable agricultural area, since the amounts spread can vary considerably, depending on farming techniques, crop cycles, and local conditions, and the chemicals are often stored for many years before use. The quantities of pesticide actually spread are not currently recorded. However, many modern farms keep a log of which products are spread when on each field, and how much is spread. The amendment to the Federal Nature Conservation Act of 25 March 2002 requires farmers, in line with good practice in the sector, to precisely document the use of pesticides as required by the agriculture laws. This has not yet been converted into agricultural law.

Assessing the environmental impact of crop protection is less a question of quantities than of the actual effects. Lower doses and improved degradability reduce the risk of pesticides entering groundwater. On the other hand, low doses of modern crop protection agents can present the same potential risks as high doses of older products.

Crop protection agents are of special concern for the environment when their effects spread beyond their intended purpose, for example, bound residues in soil, traces in groundwater or pollution of neighbouring biotopes, as a result of drifting or transport via evaporation and precipitation. The number of water bodies containing traces of crop protection agents has been stable in recent years, and cases in groundwater have fallen from 5 % to 0.1 %. Although it was banned in 1991, atrazine and its metabolites are still frequently to be found in groundwater, demonstrating the familiar delay inherent in ecological processes and justifying its strict prohibition in Germany. Modern crop protection agents are found far less than old in groundwater.

European and German plant protection legislation requires that the only pesticides on the market are those that have been approved in terms of their environmental impact. Since 1987, well over 200 active agents and over 1 200 agents have been checked and approved, and these are used to manufacture, currently, 1 156 plant protection products.

Agricultural measures

The most important measures to reduce water pollution from agricultural sources are the tightening up of requirements in line with good plant practice in the sector, and the use and extension of the damage threshold principle in plant protection:

- only low-spraydrift machines/nozzles to be used. The ability to fund such equipment has recently been granted through the Common Sheme for Improving the Agricultural Structure and Coastal Protection (GAK),
- cleaning to be done in the fields rather than the farmyard, and the obligation introduced to record pesticide use (both of these form part of the re-worked but, as yet, unpublished principles in support of good practice in the plant protection sector),
- efficient monitoring of improper and thus banned usage and disposal, responsibility lying with the *Länder*,
- approved customer status to be withdrawn where rules are broken
- the guidelines for integrated plant protection to be used, and continually revised (particularly the compulsory application of the damage threshold principle).

Other physico-chemical water quality maps (on CD-ROM):

Fig. Ammonia (water quality map 1994–2003)
Fig. Lead in suspended matter (water quality map 1999–2003)

Fig. Cadmium in suspended matter (water quality map 1998–2002)
Fig. Chrome in suspended matter (water quality map 1999–2003)
Fig. Copper in suspended matter (water quality map 1999–2003)
Fig. Nickel in suspended matter (water quality map 1999–2003)
Fig. Nitrate (water quality map 1994–2003)
Fig. Mercury in suspended matter (water quality map 1998–2003)
Fig. Zinc in suspended matter (water quality map 1999–2003)

VI 2 Groundwater quality

Groundwater forms part of the hydrologic cycle – it feeds rivers and streams and its quality has a major influence on surface waters. There is also a close link between near-surface groundwaters and wetland habitats that depend on groundwater.

In Germany, groundwater is the most important source of drinking water supplies, so good groundwater quality is a basic prerequisite for secure water supplies.

The aim of groundwater protection is to protect this resource as far as possible from contamination and to clean up contaminated groundwaters.

The main pollution factors are pesticides and nitrate from the agricultural sector.

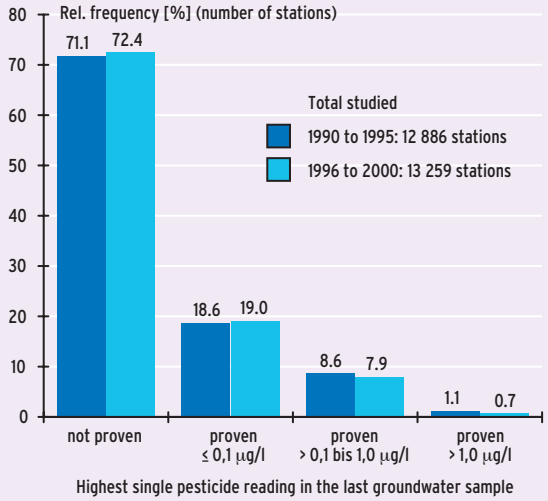
VI 2.1 Pesticides in groundwater

In 2003, the LAWA/UBA jointly issued an updated report on pesticides and groundwater quality.

The analysis of pesticides in groundwater is based on the findings from 13 259 monitoring stations in near-surface groundwater during the period 1996 to 2000 and 12 886 stations for 1990 to 1995 (Fig. VI 2.1-1).

9 592 monitoring stations (72.4 %) found no pesticide agents or metabolites, but 2 521 (19 %) reported positive on at least one pesticide agent or metabolite, although the concentration was below 0.1 µg/1. 1 049 stations (7.9 %) reported a concentration of between 0.1 und 1.0 µg/l . As many as 97 stations (0.7 %) found a concentration of over 1.0 µg/l for a single pesticide or a metabolite. A comparison of pesticide pollution for the periods 1990–1995 and 1996–2000 shows that the overall situation has changed little in recent years. The relative frequency of monitoring stations with a high pesticide content has fallen slightly, but since the findings are not based on a fixed, representative monitoring network, any changes in the figures are too minor to be able to conclude that there has been a significant reduction in pesticide contamination of groundwater.

Fig. VI 2.1-1: *Frequency distributions of pesticide findings in groundwater (at monitoring stations filtered near the surface)*



Source: *Working Group of the Federal States on Water Issues 2004*

The analysis of active agents combines the *Länder* findings for each individual pesticide. Altogether findings are available for 257 individual pesticides for the period 1996 to 2000 (Tab. VI 2.1-1).

The list of "Frequently occurring pesticide agents and metabolites in near-surface groundwater in Germany" continues to be headed by desethylatrazine. This is followed by the agents atrazine and bromacil, despite the fact that pesticides containing atrazine and bromacil have been banned since 1990 and the use of both is completely forbidden by the ordinance on pesticide use. At the same time, the number of monitoring stations that found over 0.1 µg/l atrazine has fallen from 519 to 272, and bromacil cases have dropped from 217 to 177. The increased number of stations reporting over 0.1 µg/l bentazone gives cause for concern. Worthy of note, too, is the new appearance of two individual pesticides – the agent ethidimuron and the metabolite 2,6-dichlorobenzamide – found with a high relative frequency in concentrations of above 0.1 µg/l. Of the twenty individual pesticides occurring most frequently, eight are currently a component of plant protection agents approved in Germany. Clarification regarding the active agents bentazone, diuron,

Tab. VI 2.1-1: *Frequently occurring pesticide agents and metabolites in near-surface groundwater (ranking order by number of stations with findings > 0.1 µg/l)*

Ranking Order 1996–2000	Ranking Order 1990–1995	Agent / Metabolite	Number of participating federal *Länder*	Number of Monitoring Stations: total studied	Not Recorded	Recorded ≤ 0.1 µg/l	Recorded > 0.1 to ≤ 1.0 µg/l	Recorded > 1.0 µg/l
1	1	*Desethylatrazine*	15	12 167	9 882	1 715	557	13
2	2	Atrazine	16	12 353	10 472	1 609	262	10
3	3	Bromacil	13	8 176	7 855	144	151	26
4	9	**Bentazone**	15	8 578	8 313	195	61	9
5	6	**Diuron**	16	10 078	9 845	166	50	17
6	4	Simazin	16	12 084	11 563	454	62	5
7	5	Hexazinone	13	7 702	7 526	119	51	6
8	8	*Deisopropylatrazine*	15	10 479	10 207	216	51	5
9	– [2]	*2,6-dichlorobenzamide*	5	2 362	2 215	98	46	3
10	10	**Mecoprop (MCPP)**[3]	15	7 851	7 690	119	37	5
11	– [2]	Ethidimuron	6	689	658	4	10	17
12	7	Propazine	13	8 173	7 980	168	21	4
13	– [2]	1,2-dichloropropane[1]	4	984	948	12	16	8
14	12	**Isoproturon**	16	10 838	10 675	145	18	0
15	17	**Dichlorprop (2,4-DP)**[3]	15	7 101	6 998	92	10	1
16	15	**Terbuthylazine**	13	8 122	8 035	78	9	0
17	13	**Metolachlor**	15	7 961	7 875	78	7	1
18	18	*Desethylterbuthylazine*	12	7 505	7 465	32	7	1
19	16	Chlortoluron	14	6 116	6 039	71	5	1
20	– [2]	**Metazachlor**	13	11 098	11 009	83	6	0

Bold: an agent that is a currently licensed ingredient in a pesticide;
Italics: metabolites of pesticide agents; (the other substances are not an ingredient in licensed pesticides)

[1] 1,2-dichloropropane was used in a chemical mixture with the agent 1,3-dichloropropene (completely banned), though some *Länder* also permit it as an individual pesticide

[2] This individual substance was recorded during the period 1990 to 1995 at six or fewer monitoring stations in a concentration > 0.1 µg/l and thus is not one of the 20 most frequently occurring pesticides or metabolites

[3] Mecoprop-P and dichlorprop-P are permitted as agents in plant protection products

Source: *Federal Environment Agency, data from the Working Group of the Federal States on Water Issues 2004*

mecoprop, isoproturon, terbuthylazine, und metolachlor has been requested from the BBA or BVL.

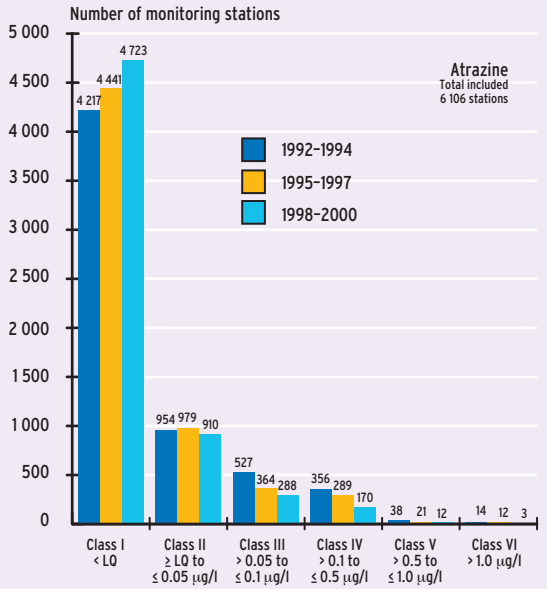
Of interest is not only a description of the current pollution levels, but the trend in pesticide pollution over time.

Figure VI 2.1-2 shows the trend in atrazine findings, and indicates that the number of monitoring stations reporting intermediate to very high levels of atrazine content is falling. In particular, the number of stations with extreme pollution levels of > 1 µg/l atrazine has dropped from 14 to three between 1992 and 2000. A similar trend may be observed with desethylatrazine.

The LAWA pesticides report (2004) describes other findings with relation to desethylatrazine, diuron, and bentazon.

The situation is different for diuron and bromacil. The total number of stations polluted by diuron (Limit of qualification = LQ) has remained more or

Fig. VI 2.1-2: *Frequency distributions of atrazine in near-surface groundwater*



Source: *Working Group of the Federal States on Water Issues 2004*

less constant during the periods studied, in spite of the ban on its use on railway tracks, one may even assume a certain increase in groundwater contamination through bentazone.

VI 2.2 Nitrate content in groundwater

Groundwater pollution through nitrate have a worryingly negative effect on environmental quality. Elevated nitrate content impacts negatively on groundwater ecology, and can also harm drinking water supplies and thus endanger health.

The *Länder* have set up their own internal monitoring networks to supervise groundwater quality. The "Nitrate" parameter is checked regularly at almost all of the stations in these networks.

To provide regular reports on the quality of Germany's groundwater to the European Environment Agency, the *Länder* selected certain representative monitoring stations and combined them to form an EEA groundwater monitoring network. The nitrate content at about 730 stations in the EEA monitoring network was analysed to provide a nationwide overview for 2002 (Fig. VI 2.2-1).

Nitrate concentration levels depend on a whole series of different factors, but pollution depends particularly on land use in the monitoring station's catchment area. The hydrogeological conditions in the region, such as the depth to groundwater, flow speed, and the hydrochemical conditions underground, also play a crucial role.

Figure VI 2.2-1 shows that 69.6 % of the monitoring stations fall within the concentration range of less than 25 mg/l, but the nitrate directive's limit of 50 mg/l, which is the same as that in the drinking water regulation, is clearly exceeded at 14.4 % of the stations. According to the Water Framework Directive, the groundwater at those points is poor, and measures should be taken to improve its quality.

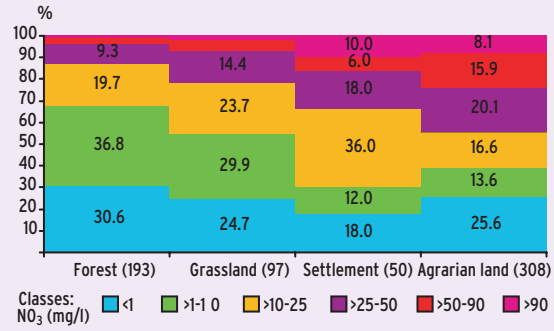
Fig. VI 2.2-1: *Distribution of nitrate content in groundwater (2002)*



Source: *Federal Environment Agency 2004 b*

In attempting to discover the main reasons for the pollution of groundwater through nitrate, Figure VI 2.2-2 confirms the supposition that usage is of major significance. When the monitoring stations are sorted according to the usage in their immediate environs, it becomes apparent that the highest levels of nitrate pollution are found beneath arable land. 44.1 % of the stations in this group show nitrate pollution levels of over 25 mg/l, while the corresponding figures for forest and grassland usage are 12.9 % and 21.7 % of stations respectively. The differences between the different groups becomes even more evident when one takes into account land use further afield, in the stations' catchment area.

Fig. VI 2.2-2: *Distribution of nitrate content (2002) for the monitoring stations in the EEA groundwater monitoring network, divided by land use from CORINE LANDCOVER (point-related allocation of monitoring stations)*



Source: *Federal Environment Agency 2004 b*

For many German regions, the nitrate parameter illustrates very clearly the extent to which diffuse nitrogen inputs contribute to groundwater pollution. How trends in nitrate pollution develop from here will indicate whether the schemes aimed at reducing nitrate pollution that have been running for years are sufficient to create good groundwater quality.

In order to protect public health, the EC's drinking water directive for nitrate specifies a limit of 50 mg/l, and where this concentration is exceeded the directive defines this as an area of polluted groundwater. The frequency of nitrate monitoring can only be reduced when levels fall below 25 mg/l.

The Water Framework Directive (WFD) is aligned with the provisions of the EC's nitrate directive. According to the WFD, groundwater is classified as be-

ing in a "poor condition" if it contains over 50 mg/l nitrate, and measures should then be taken to reduce this pollution.

Elevated nitrate concentrations in ground and surface waters can only be cut by reducing inputs. As agricultural use is currently the major source of recorded pollution, measures to halt nitrate surpluses in line with the provisions of the nitrate directive, by properly implementing the fertilizer ordinance, should be extremely useful.

VI 3 Seas

Marine ecosystems are sinks for substances that are transported via the atmosphere and rivers, including numerous hazardous substances such as the nutrients nitrogen and phosphate. Hazardous substances only degrade very slowly as they are transported, and some of them are now present in sizeable quantities in the marine environment, especially if they accumulate in organisms, the food web, or sediments. Hazardous substances include substances or substance groups that are persistent, bioaccumulate, and toxic (PBTs) or that pose a comparable potential risk (e.g., heavy metals, endocrine-disrupting substances). Nutrients can cause eutrophication, which can have adverse effects such as exceptional and toxic algae blooms, mass development of large algae, and oxygen depletion caused by microbial decomposition processes that consume oxygen.

Monitoring of inputs into and pollution of the North Sea and the Baltic, and measures to reduce them, are regulated at both international and national level.

The Contracting Parties to the Commission for the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Commission) and the North-East Atlantic (the OSPAR Commission) agreed on strategies for hazardous substances. Their aim is to prevent pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances" by the year 2020 (a one-generation objective).

OSPAR has drawn up two lists of substances, for the North-East Atlantic including the North Sea, to specify which substances this objective relates to.

Working from a long list of substances that give cause for concern, the Helsinki Commission (HELCOM) selected 42 hazardous substances for priority measures to protect the Baltic. These include pesticides and biocides (e.g., lindane and pentachlorophenol), metals and metal compounds (e.g., mercury and lead) and industrially manufactured substances (such as short-chain chloroparaffins and nonylphenols).

OSPAR's strategy to combat eutrophication aims to secure a healthy marine environment, in which eutrophication no longer occurs, by 2010 at the latest. HELCOM has set a similar goal – to reduce eutrophication to reinstate the Baltic's ecological balance and ensure a functioning marine ecosystem.

A measure aimed at achieving these objectives has been and continues to be the decisions taken under both conventions to reduce inputs of certain hazardous substances and nutrients by 50 % (70 % for four contaminants) during the period 1985 (1987 for HELCOM) to 1995. This obligation continues to exist for the reduction goals not achieved during that time.

In Germany, the responsibility for monitoring concentrations of hazardous substances and mineral nutrients in the seas lies with the Federal/*Länder* Monitoring Programme for the North Sea and the Baltic (BLMP), and is implemented through federal institutions and the coastal *Länder*, depending on the area of responsibility. The BLMP aims to meet the obligations arising from the conventions to protect the marine environment in the Baltic area and the North-East Atlantic, and from the European Union's directives. The UBA's environmental specimen bank participates in the BLMP by studying hazardous substances in marine organisms. The UBA is responsible for quality assurance and supports data management in the Database of the Marine Environment (MUDAB).

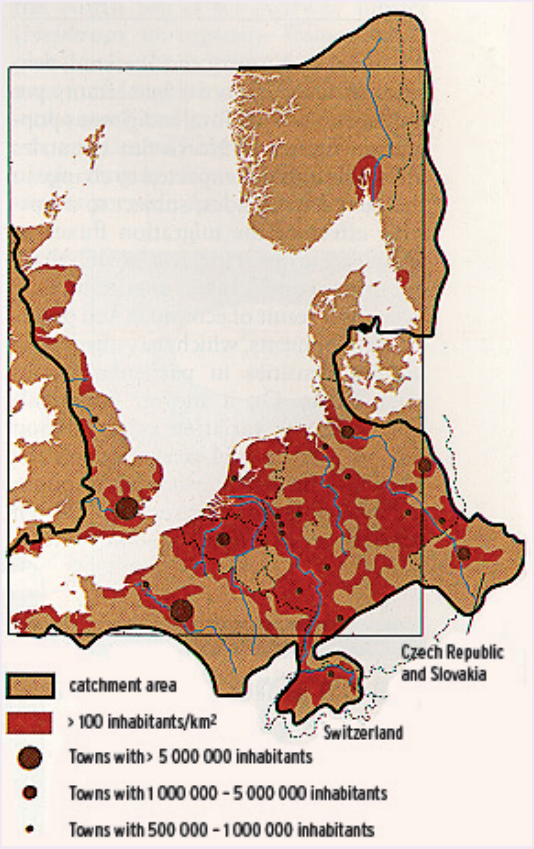
In the future, in the course of implementing the Water Framework Directive (directive 2000/60/EC, WFD), 33 hazardous substances based on a list of priority substances (Annex X of the WFD in line with Directive No. 2455/2002/EC) will be regularly measured in the coastal waters of the North Sea and the Baltic. The environmental quality standards for concentrations of these 33 priority substances in the water have been revised, but not yet agreed. Where one or more quality standards are exceeded, good chemical quality and, therefore, good surface water quality, are deemed to have not been achieved. The levels of the nutrients nitrogen and phosphate, and oxygen count as supporting quality elements for the WFD and are monitored and analysed along with the biological quality elements.

VI 3.1 North Sea

VI 3.1.1 The Catchment area of the North Sea

The catchment area of the North Sea covers approximately 842 000 km² (Fig. VI 3.1.1-1), and is populated by 184 million people. Some 300 km³ water per year flow into the North Sea from rivers, although there is considerable fluctuation from year to year, and this affects the transport of pollutants. Snowmelt from Sweden and Norway makes up a third of river water flow. The major North Sea tributaries, the Rhine, Elbe, Weser, Maas, Schelde, Seine, Thames and Humber, also contribute a considerable part of the total influx. The catchment areas of these rivers are densely populated, highly industrialised, and intensively farmed, and the rivers are therefore among the primary sources of pollutants and nutrients in the North Sea (Tab. VI 3.1.1-1).

Fig. VI 3.1.1-1: *North Sea catchment area*



Source: *OSPAR Commission 2000*

Tab. VI 3.1.1-1: *Average annual runoff from different subregions in the Nort Sea*

Region	Flow rate in km³/a	Catchment area in km²
Coast of Norway	58–70	45 500
Coast of Skageraks and Kattegats	58–70	102 200
Coast of Denmark and Germany (including the Danish and German Wadden Seas)	32	219 900
Coast of the Netherlands and Belgium (including the Dutch Wadden Sea and the Rhine, Maas, and Schelde)	91–97	221 400
Coast of England and France along the English Channel (including the Se	9–37	137 000
East coast of England (including the Tyne, Tees, Humber, and Themes)	32	74 500
Coast of Scotlland	16	41 000
Total North Sea	**296–354**	**841 500**
Total Wadden Sea	**60**	**230 000**

Source: *OSPAR-Commission 2000*

VI 3.1.2 Discharges/losses to surface waters

Discharges/losses to surface waters in the North Sea catchment area by the OSPAR Contracting Parties

In order to balance the terrestrial discharges/losses into the North Sea discharges from anthropogenic point and diffuse sources are quantified for the entire North Sea catchment area.

At the International Conferences on the Protection of the North Sea 1987 (London) and 1990 (The Hague), ministers from all the North Sea states agreed on measures to reduce inputs of nutrients and certain hazardous substances by 50 % between 1985 and 1995. For those substances that failed to achieve the input reduction goal by 1995 (Esbjerg), the objective was put back to 2000. A final balance was drawn at the International Conference on the Protection of the North Sea in 2002 (Bergen), and the findings for Germany (status in late 2003 for nutrients and late 2002 for heavy metals and lindane) are described below.

Discharges/losses to surface waters in the German North Sea catchment area

Nutrients

Discharges/losses to surface waters in the German North Sea catchment area were 875 030 t/a nitrogen and 77 170 t/a phosphorus in 1985, and 530 770 t/a nitrogen and 27 140 t/a phosphorus in 2000. Therefore nitrogen and phosphorus discharges/losses to surface waters in the German North Sea catchment area fell by 39 % and 65 % respectively compared with the 1985 reference year. The inventory of nutrient emissions in the surface

waters of the German North Sea catchment area shows that the reduction target (50 % reduction for both) was met for phosphorus but not for nitrogen.

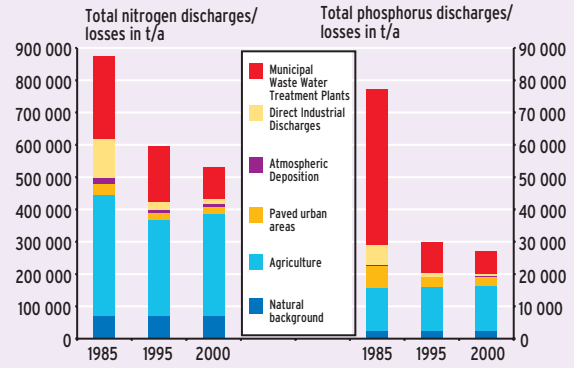
The 39 % reduction in nitrogen discharges/losses was achieved mainly through a sharp fall in nitrogen discharges/losses from point sources (70 %). In contrast, nitrogen discharges/losses from diffuse sources only fell by ca. 16 %. In 2000, ca. 60 % of all nitrogen discharges/losses came from agriculture, with discharges/losses via the groundwater route (54 %) and via drainage (15 %) being particularly significant. Nitrogen inputs via erosion, surface runoff from mainly agricultural areas, and atmospheric deposition each contributed ca. 2 %, or very little, to the total inputs to surface waters. The share of nitrogen discharges/losses from point sources was ca. 21 % in 2000. (Fig. VI 3.1.2-1 and Tab. VI 3.1.2-1).

The 65 % reduction in phosphorus discharges/losses is also mainly attributable to a fall in discharges/losses from point sources of around 86 %. Phosphorus discharges/losses from diffuse sources fell by 15 %, mainly due to a reduction in inputs from runoff from sealed areas and atmospheric deposition. Although discharges/losses via the groundwater route dropped by ca. 15 %, phosphorus discharges/losses from agriculture rose by ca. 6 % between 1995 and 2000, mainly due to increased inputs through erosion, making erosion the dominant diffuse input path (24 %) in the year 2000. Given the huge fall in phosphorus discharges/losses from point sources, diffuse sources constitute the dominant route (71 %) in 2000, with ca. 51 % coming from agriculture alone (Fig. VI 3.1.2-1 and Table VI 3.1.2-1). To simplify the data presentation, the investigated periods – from 1983 to 1987, from 1993 to 1997, and from 1998 to 2000 – are given as 1985, 1995, and 2000.

Heavy metals and lindane

Discharges/losses of heavy metals and lindane to surface waters in the North Sea catchment area fell sharply between 1985 and 2000. Apart from arsenic and nickel, whose geogenic share cannot be influenced and is fairly high, the reductions for heavy metals and lindane required by the International Conference on Protecting the North Sea have been either achieved or exceeded by 50 % (Cr, Cu, Ni, Zn, the metalloid As, and lindane) or 70 % (Cd, Hg, Pb). The reductions for nickel (41 %) and mercury (87 %) are primarily due to the dramatic fall in direct industrial discharges (74 % for nickel, 95 % for mercury). Measures taken by the industrial sector in response to tighter regulations have played a major role in this environmental relief, as has the decline in industrial activity in the new *Länder* (Elbe catchment area) since 1990. By 2000, direct industrial discharges were only of minor significance. The significance of discharges from municipal sewage treatment plants continued to be high, but water pollution in 2000 was dominated by diffuse sources. The most significant input routes were urban areas (particularly sewage systems and residents that are not connected to the sewage system), erosion and groundwater inflows (Fig. VI 3.1.2-2).

Fig. VI 3.1.2-1: *Nitrogen and phosphorus discharges/losses*



Source: *Federal Environment Agency 2003*

A large part of heavy metal inputs to surface waters comes from urban areas, including inputs from combined and separated sewage systems. These combined sewer overflows and storm-water flows from separated sewage systems cause 10–40 % of all heavy metal discharges/losses, with high proportions of zinc, lead, and copper being particularly evident. Since a large proportion of the storm-water flows are routed to waste water treatment plants in combined sewers, these systems cause less water pollution through heavy metals than separated systems. The metals chrome and lead, in particular, enter waters through erosion, while geogenic inputs (groundwater route) predominate with arsenic (45 %) and nickel (54 %). There are significant differences in pollution levels between the various river basins due to varying land use and climatic factors.

The fall in lindane discharges/losses to surface waters in the German North Sea catchment area between 1985 and 2000 is mainly linked to the fact that the use of lindane has been tightly restricted in Germany since the mid-1980s, and it has been banned as a pesticide since 1997. As lindane present in the environment is degraded very slowly, it can still be found in the atmosphere, in the soil and in water, and it was still entering surface waters in 2000, with a major share coming from inputs from sealed surfaces.

Tab. VI 3.1.2-1: *Emissions of phosphorus and nitrogen from the German North Sea gathering grounds*

		Nitrogen emissions in t/a						
		1985		1995		2000		Reduction 1985–2000
	Diffuse intake routes:							
1	Groundwater	307 810	35.2 %	264 960	44.4 %	285 540	53.8 %	-7 %
2	Drainage Water	118 970	13.6 %	85 700	14.4 %	79 930	15.1 %	-33 %
3	Erosion	9 120	1.0 %	10 650	1.8 %	10 490	2.0 %	15 %
4	Surface Runoff	10 150	1.2 %	6 800	1.1 %	9 350	1.8 %	-8 %
5	Paved Urban Areas	34 430	3.9 %	21 410	3.6 %	21 270	4.0 %	-38 %
6	Atmospheric Deposition	15 850	1.8 %	8 680	1.5 %	11 150	2.1 %	-30 %
1-6	**Total diffuse sources**	**496 330**	**57 %**	**398 200**	**67 %**	**417 730**	**79 %**	**-16 %**
	of which due to:							
7	Natural Background Load	70 920	8.1 %	70 920	11.9 %	70 920	13.4 %	0 %
8	Agriculture (1-4 minus 7)	375 130	43 %	297 190	50 %	314 390	59 %	-16 %
	Point sources:							
9	Direct Industrial Discharges	122 230	14 %	25 070	4 %	14 340	3 %	-88 %
10	Municipal Waste Water Treatment Plants	256 470	29 %	173 110	29 %	98 700	19 %	-62 %
9-10	**Total point sources**	**378 700**	**43 %**	**198 180**	**33 %**	**113 040**	**21 %**	**-70 %**
1-6 + 9-10	**Total inputs**	**875 030**	**100 %**	**596 380**	**100 %**	**530 770**	**100 %**	**-39 %**

		Phosphorus emissions in t/a						
		1985		1995		2000		Reduction 1985–2000
	Diffuse intake routes:							
1	Groundwater	5 587	7.2 %	4 702	15.8 %	4 757	17.5 %	-15 %
2	Drainage Water	3 325	4.3 %	3 083	10.3 %	3 087	11.4 %	-7 %
3	Erosion	5 235	6.8 %	6 634	22.2 %	6 597	24.3 %	26 %
4	Surface Runoff	1 438	1.9 %	1 690	5.7 %	1 896	7.0 %	32 %
5	Paved Urban Areas	7 004	9.1 %	2 903	9.7 %	2 816	10.4 %	-60 %
6	Atmospheric Deposition	263	0.3 %	185	0.6 %	185	0.7 %	-30 %
1-6	**Total diffuse sources**	**22 852**	**30 %**	**19 197**	**64 %**	**19 338**	**71 %**	**-15 %**
	of which due to:							
7	Natural Background Load	2 477	3.2 %	2 477	8.3 %	2 477	9.1 %	0 %
8	Agriculture (1-4 minus 7)	13 108	17 %	13 632	46 %	13 860	51 %	6 %
	Point sources:							
9	Direct Industrial Discharges	6 163	8,0 %	1 104	3.7 %	810	3.0 %	-87 %
10	Municipal Waste Water Treatment Plants	48 153	62.4 %	9 516	31.9 %	6 994	25.8 %	-85 %
9-10	**Total point sources**	**54 316**	**70 %**	**10 620**	**36 %**	**7 804**	**29 %**	**-86 %**
1-6 + 9-10	**Total inputs**	**77 168**	**100 %**	**29 817**	**100 %**	**27 142**	**100 %**	**-65 %**

Source: *Federal Environment Agency 2003*

VI 3.1.3 Riverine and direct discharges

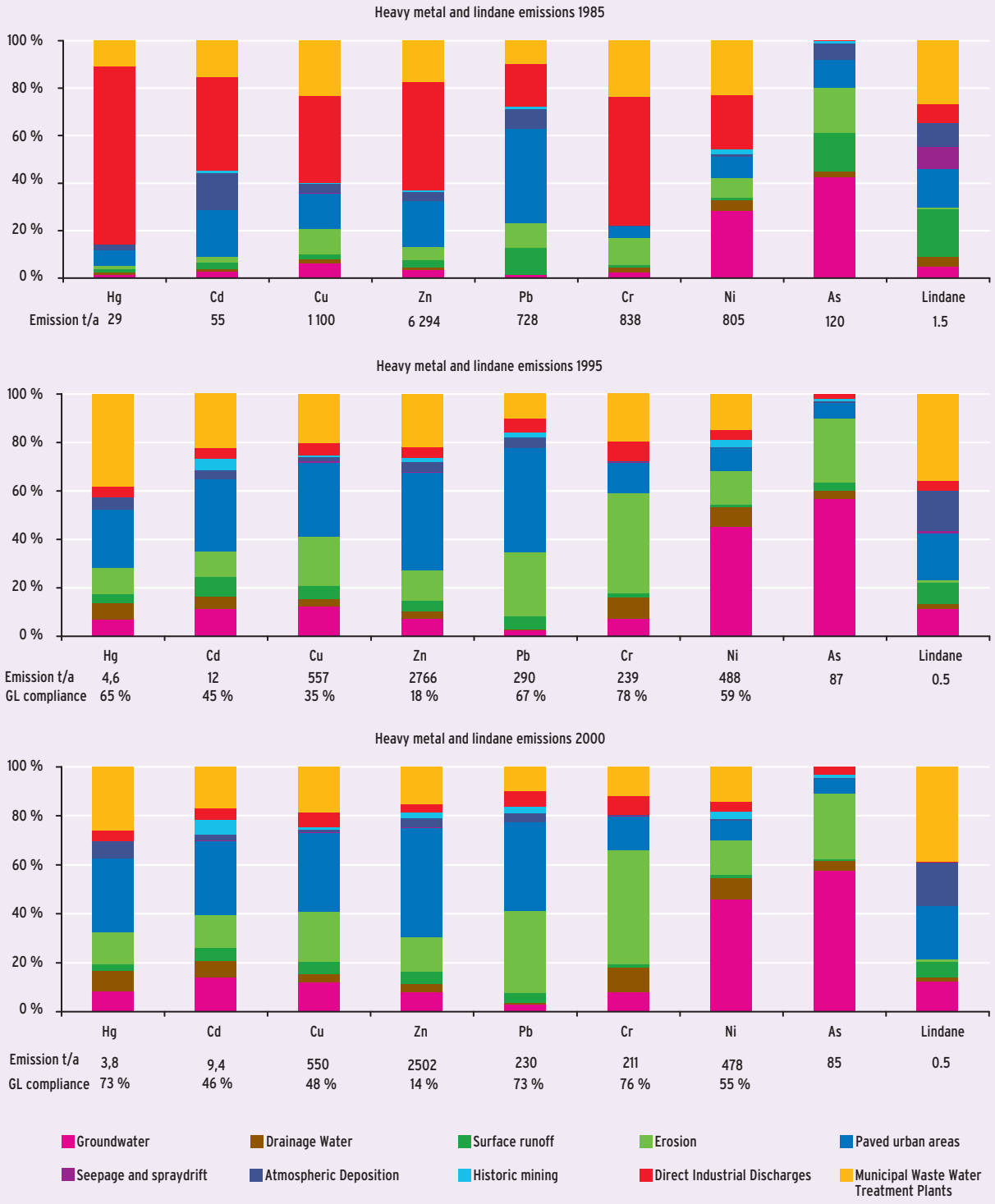
Riverine and direct discharges to the North Sea by the OSPAR Contracting Parties

Since 1990, data has been collected and evaluated (on behalf of the OSPAR Commission) on inputs of nutrients and pollutants to the North Sea both from rivers and direct discharges. Direct discharges to the North Sea include inputs of substances from municipal and industrial sources that enter coastal waters or river estuaries below the river-based monitoring stations (the tidal or freshwater limit) and are thus not recorded in those stations' data. As such, riverine discharges (inputs measured at the tidal or freshwater limit) can be many times higher than direct discharges.

In Germany, the data on the Elbe, Weser, Ems and Eider is gathered for the OSPAR Commission by Schleswig-Holstein, Lower Saxony, and Bremen, as well as by the ARGE Elbe (working group for the restoration of the Elbe) and the ARGE Weser (working group for the restoration of the Weser).

During 1990–2002, the highest inputs of nutrients and heavy metals were discharged by Germany, Great Britain, and the Netherlands. Dutch discharges

Fig. VI 3.1.2-2: *Emissions from point and diffuse sources in the German North Sea catchment area*



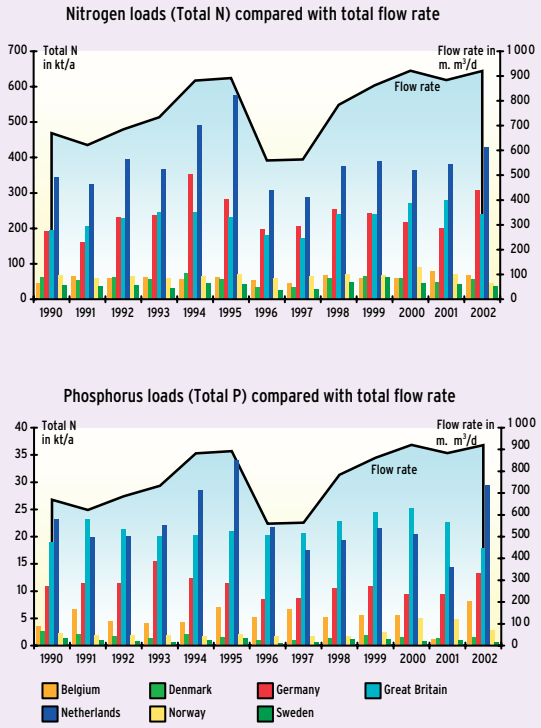
Source: *Federal Environment Agency 2002*

of nutrients and pollutants do not all come from within the Netherlands itself, but also contain shares from the Rhine's catchment areas in Switzerland, France, and Germany. German discharges from the Elbe also contain nutrients and pollutants from the Elbe's catchment area in the Czech Republic.

IIn 1990, a total of ca. 1 015 000 t nitrogen and ca. 75 000 t phosphorus were discharged into the North Sea via the rivers of its littoral states. In 2002, the amounts were ca. 1 180 000 t and ca. 74 000 t respectively. When comparing riverine and direct discharges of nutrients to the North Sea between 1990 and 2002, the river flow rates, which vary from year to year, must be taken into account. In wet years – 1994/1995 and 2000–2002 – the annual riverine outflow was almost double that in the dry years 1990 and 1996/1997, which contributed to the

higher nitrogen discharges in 1994/1995 and 2000–2002 (Fig. VI 3.1.3-1).

Fig. VI 3.1.3-1: *Nutrient inputs into the North Sea from littoral states (Region II)*



Source: *Federal Environment Agency 2004 c*

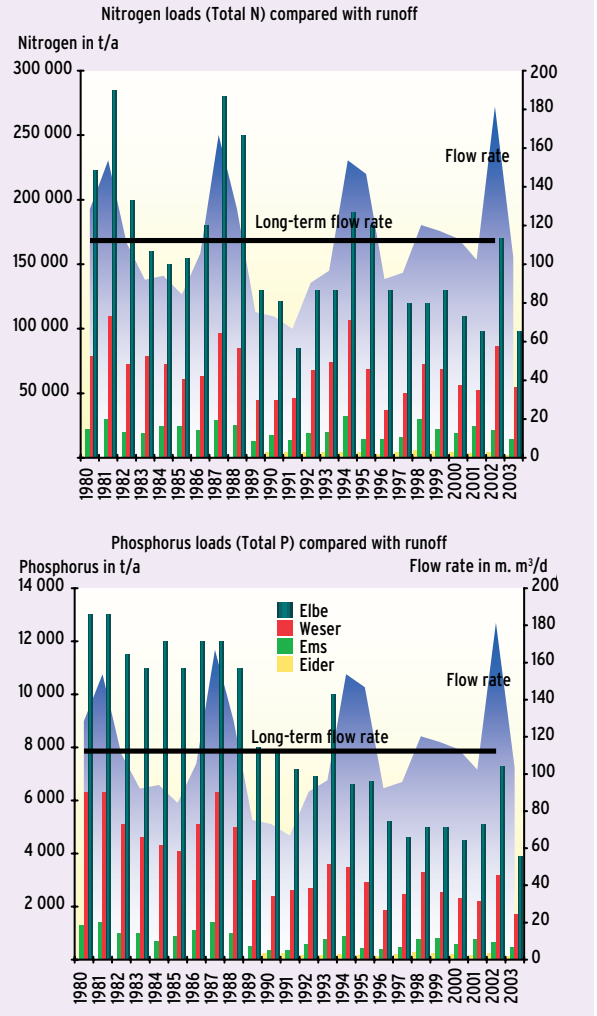
Despite the influence of flow rates, the findings from 1990 to 2002 clearly show that the riverine mercury and cadmium inputs, in particular, from almost all the North Sea littoral states have fallen sharply. One can conclude from these falls in pollution loads that the measures taken to reduce discharges of municipal and industrial waste water are having an effect and helping to improve the water quality of inflows to the North Sea (Fig. VI 3.1.3-2).

Riverine and direct discharges to the North Sea by Germany

Comparing the riverine nutrient and pollutant discharges from German rivers to the North Sea between 1980 and 2003, it becomes clear that the Elbe plays a major role, mainly because of its catchment area.

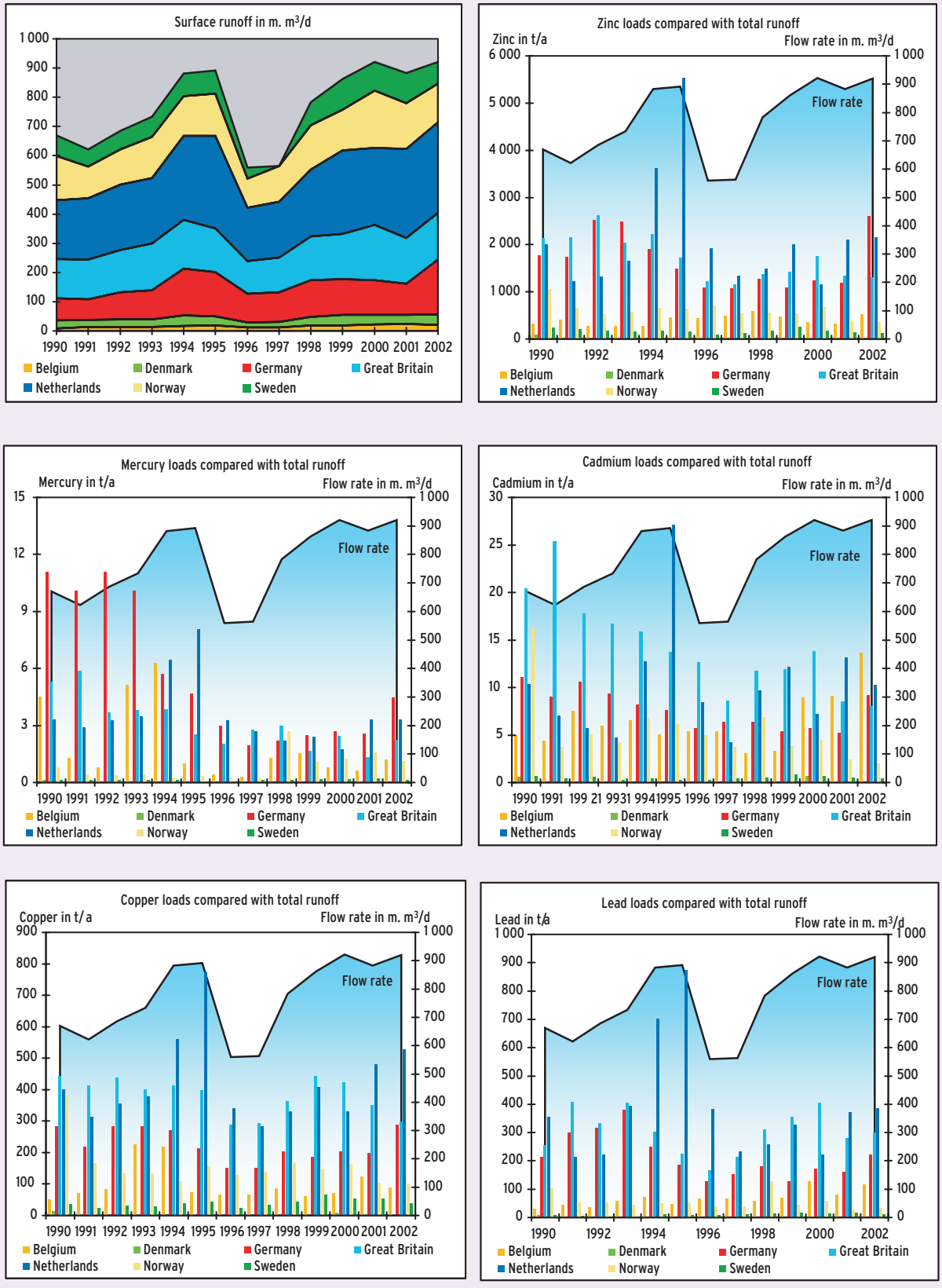
Although monitoring has been carried out in the Elbe, Weser, and Ems basins since 1980, it is difficult to determine any trend, as the measuring methodology has not always been the same throughout the entire period, and monitoring stations have changed in the Elbe and Weser basins. Any comparison of nutrient and pollutant inputs from German inflows to the North Sea also has to take into account the flow rates which vary from year to year. In wet years – 1994/1995 – and in 2002, when the Elbe flooded, the annual riverine outflow was almost double that in the dry years 1990/1991. In particular, the behaviour of phosphorus, nitrogen, and heavy metals seems to depend very much on the flow rate (Fig. VI 3.1.3-3 and Fig. VI 3.1.3-4). Since phosphorus compounds bind relatively strongly to the soil, higher rainwater runoff causes a fall in phosphorus concentrations (dilution effect). Nitrogen compounds, on the other hand, bind more loosely to the soil, so that higher rainwater runoff causes both more leaching and runoff from agricultural areas and, therefore, greater riverine inputs of nitrogen. Whereas nitrogen loads, adjusted for river flow rates, hardly fell at all between 1980 and 2003, it is clear that since 1990 phosphorus loads have levelled off at lower values than in the years before. This confirms the success of measures to reduce phosphorus discharges from municipal and industrial waste water discharges and from

Fig. VI 3.1.3-3: *Nutrient inputs from German North Sea rivers (Elbe, Weser, Ems, Eider)*



Source: *Federal Environment Agency 2004 c*

Fig. VI 3.1.3-2: *Heavy metal inputs into the North Sea from littoral states (Region II)*

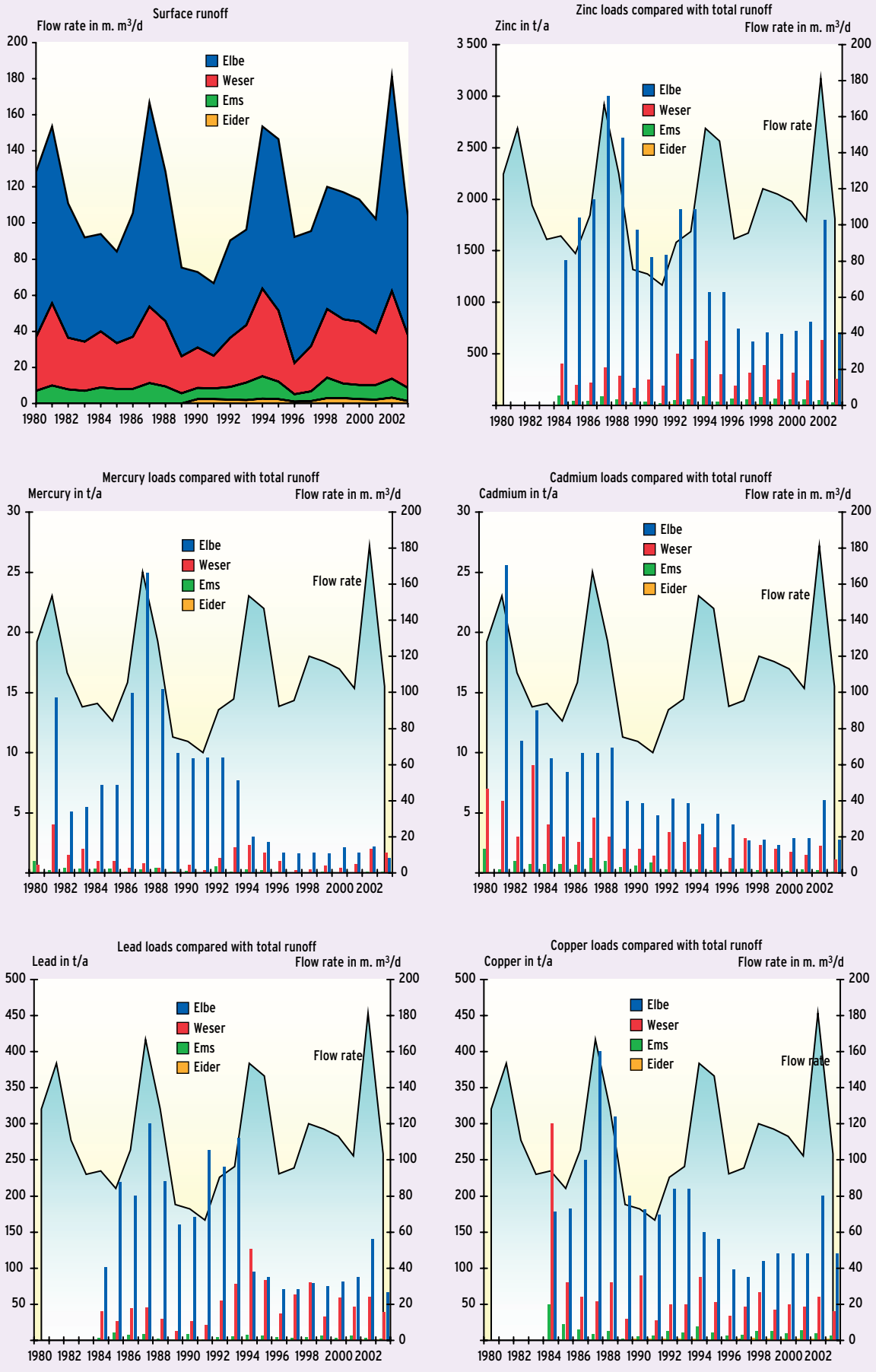


Source: *Federal Environment Agency 2004 c*

diffuse sources in order to improve the water quality of German inflows to the North Sea and thus the North Sea itself.

Despite the influence of flow rates, the findings from 1980 to 2003 clearly show that mercury and cadmium inputs from the Elbe, in particular, but al-

Fig. VI 3.1.3-4: *Heavy metal inputs into the North Sea from German rivers (Region II)*



Source: *Federal Environment Agency 2004 c*

so from the Weser and the Ems, have fallen sharply. The fall – adjusted for river flow rates – in pollution inputs since 1989 in the Elbe catchment area is primarily attributable to the decommissioning of chemical industry plants in the new *Länder* since reunification. Moreover, the tightening of the Act on Managing Water Resources led to measures being taken by local authorities and industrial organisations, which led to an overall reduction in discharges/losses to surface waters in river catchment areas. In the old *Länder*, this has resulted in better waste water treatment technology and a over proportional fall in heavy metal inputs. Improvements in the industrial sector have also been evident since the early 1990s – i.e., since the waste water administration regulations came into force in the industrial sectors. Extreme values linked to river flow rates probably reflect the mobilisation of old pollution accumulated in river sediments.

VI 3.1.4 Inputs of airborne pollutants to the North Sea

To begin with, atmospheric inputs to the seas regulated by the OSPAR Commission were determined using data from the Comprehensive Atmospheric Monitoring Programme (CAMP) for airborne pollutants. Nowadays, however, specially modified EMEP (Co-operative Programme for Monitoring and Evaluation of Long-range Transmissions of Air pollutants in Europe)model calculations for estimating airborne pollution inputs to areas such as the North Sea are used. The data is combined for nitrogen and heavy metal inputs from model calculations and for selected persistent organic pollutants (POP) from measurement data in the following tables.

Inputs of the heavy metals lead and cadmium have fallen constantly since 1990 (over 60 %). In the early 1990s, there was also a drop of up to 60 % in mercury, but since 1996 inputs have settled back at their old level (Tab. VI 3.1.4-1).

Nitrogen inputs have shown no significant change over the last decade (Tab. VI 3.1.4-2).

POPs mainly enter the seas via the atmosphere. Due to their toxicity and tendency to bioaccumulation, they are increasingly controlled within new monitoring programmes. Measurement results are also used to validate the models used to calculate POP inputs.

There is no unambiguous trend in POP inputs – the only fall apparent since 1997 is in γ-HCH, by 60 %. The results for BaP rose by 36 % up to 1998 since measurements started but have fallen back by 65 % since 1998. Nothing can be concluded about

Tab. VI 3.1.4-1: *Input of air pollutants into the North Sea in t/a (525 000 km²)*

	Lead	Cadmium	Mercury
1990	946	34	5
1991	1 353	29	6
1992	963	23	6
1993	1 141	33	3
1994	848	22	3
1995	670	22	4
1996	574	16	7
1997	332	6	8
1998	255	5	7
1999	340	12	7

Source: *OSPAR Commission; EMEP 2001*

Tab. VI 3.1.4-2: *Total nitrogen inputs into the North Sea in kt/a, based on EMEP estimates*

	NO_x	NHy	N-total
1990	278	148	425
1991	294	160	454
1992	290	166	456
1993	268	159	427
1994	294	177	471
1995	245	148	393
1996	362	226	588
1997	351	195	54
1998	314	202	516
1999*)	–	–	–
2000	381	218	599

*) Not yet available

Source: *EMEP 2000*

Aldrine and HCB as the levels were measured at the detection limits. The marked fluctuation in POP measurement results is probably due to both significant meteorological fluctuations and the fact that the analytical laboratory was changed in 1998 (Tab. VI 3.1.4-3).

Tab. VI 3.1.4-3: *Annual depositions of selected POPs for the Westerland Station in µg/m²*

	α-HCH	γ-HCH	HCB	Aldrine	Heptachlore	BaP
1996	0.297	3.511	0.036	0.006	0.006	1.389
1997	0.289	5.425	0.049	0.008	0.008	1.177
1998	0.423	4.467	0.095	0.073	0.131	3.870
1999	0.280	3.509	0.010	0.008	0.003	0.809
2000	0.357	3.033	0.126	0.000	0.000	1.425
2001	0.335	1.712	0.100	0.009	0.003	0.840

Source: *Federal Environment Agency 2002 a*

VI 3.1.5 Pollution in North Sea marine waters

In the Federal/*Länder* Monitoring Programme for the North Sea, a number of hazardous substances are regularly monitored for the OSPAR Joint Assessment and Monitoring Programme (JAMP) – cadmium (Cd), lead (Pb), mercury (Hg), hexachloroben-

zene (HCB), α-, β-, γ-, δ-hexachlorobenzene (HCH), polycyclic aromatic hydrocarbons (PAK) and polychlorinated biphenyl (PCB). In the future, in the course of implementing the Water Framework Directive, 33 hazardous substances in the water are to be regularly examined (total sample including dissolved substances and those bound to suspended matter). The marine environment database already contains data on some of these substances (Fig. VI 3.1.5-1). Since there is not yet a standardised way of presenting the data under the Water Framework Directive, here the annual mean of all measured values obtained in coastal waters (inside the 12 nm zone excluding Helgoland) is shown, and compared with the provisional environmental quality standards proposed by the European Commission (annual average of the environmental quality standard (AA-EQS) and the maximum accepted concentrations (MAC-EQS)).

Heavy metals in sea water

Water in the Ems, Weser, and Elbe estuaries is significantly more polluted with cadmium (Cd), lead (Pb), mercury (Hg), copper (Cu), and zinc (Zn) than the waters of the German Bight.

A large proportion of the heavy metals is attach to suspended matter. Some elements, such as Cd, Pb, Zn, and Cu, are accumulated by phytoplankton and are thereby removed from the water column when the plankton sinks to the sea bed.

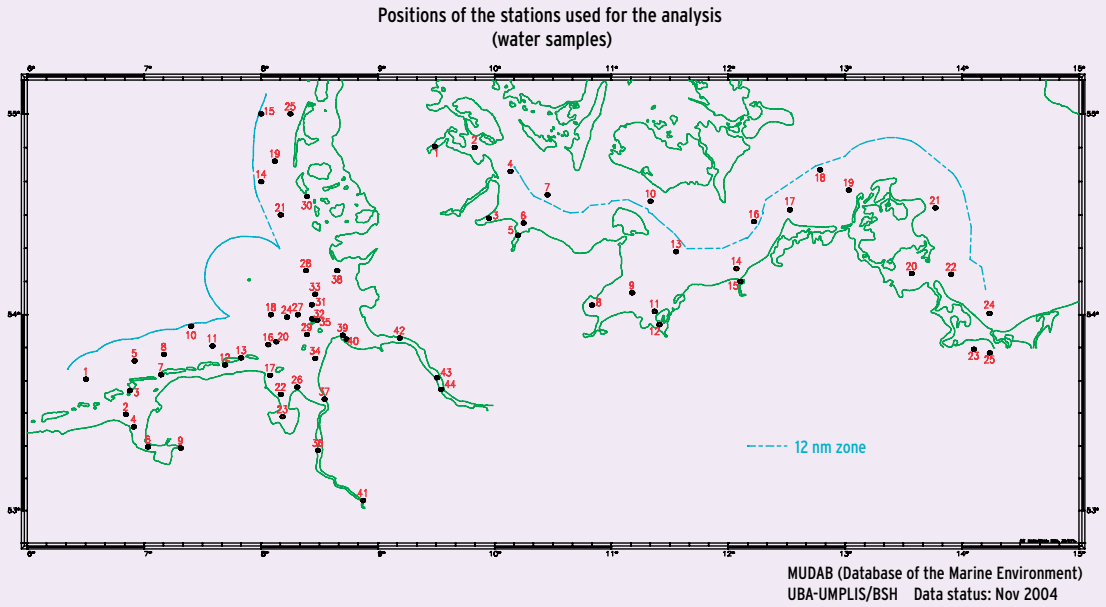
Time series of heavy metals from amongst the 33 priority substances covered by the Water Framework Directive show a slight decrease in the average concentrations of mercury, cadmium, lead, and nickel in waters within the 12 nautical miles zone, with lead, nickel, and cadmium concentrations being above or in the range of the proposed environmental quality standards (AA-EQS) and mercury below them (Fig. VI 3.1.5-4).

Organic pollutants in sea water

There do not yet exist sufficient measurements in coastal waters for all 33 priority substances covered by the Water Framework Directive, as the monitoring programme is only compulsory from 2006. The following substances have been measured in the coastal waters of the North Sea in concentrations that are below the WFD's proposed environmental quality standards: atrazine, anthrazene, hexachlorbutadiene, naphthalene, indenopyrene, fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(b)fluoranthene, benzo(a)pyrene, pentachlorobenzene. Other substances have only been measured in the detection limits range and so lie below the proposed environmental quality standards: chloroform, pentachlorophenol, trichlorobenzene, dichloroethane 1,2 and benzene. However, for four substances average concentrations have been found that are within the range of the proposed environmental quality standards: hexachlorobenzene, lindane, beta-HCH, and alpha-HCH, but whose average concentrations have fallen below the AA-EQS in recent years (Fig. VI 3.1.5-5).

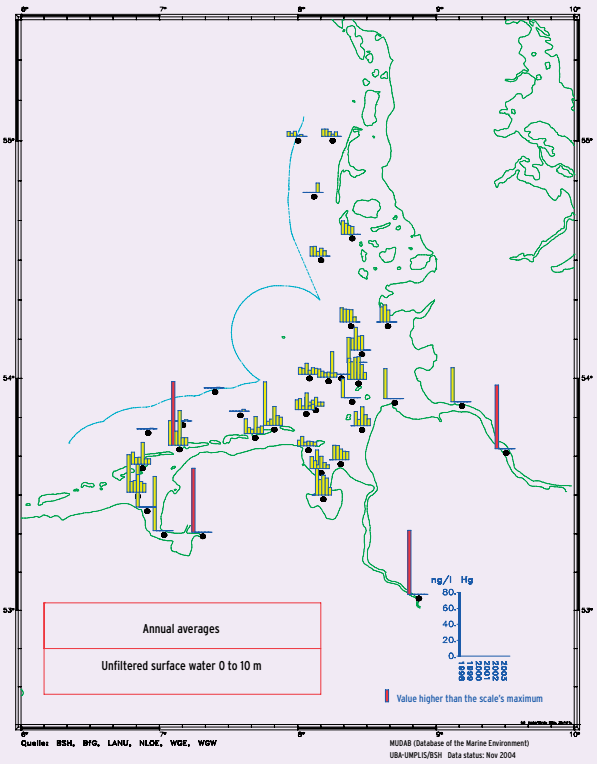
Despite reduced use, lindane (γ-HCH) continues to be present in many areas. α-HCH and β-HCH are

Fig. VI 3.1.5-1: *Station map for water samples in the North Sea and Baltic Sea*



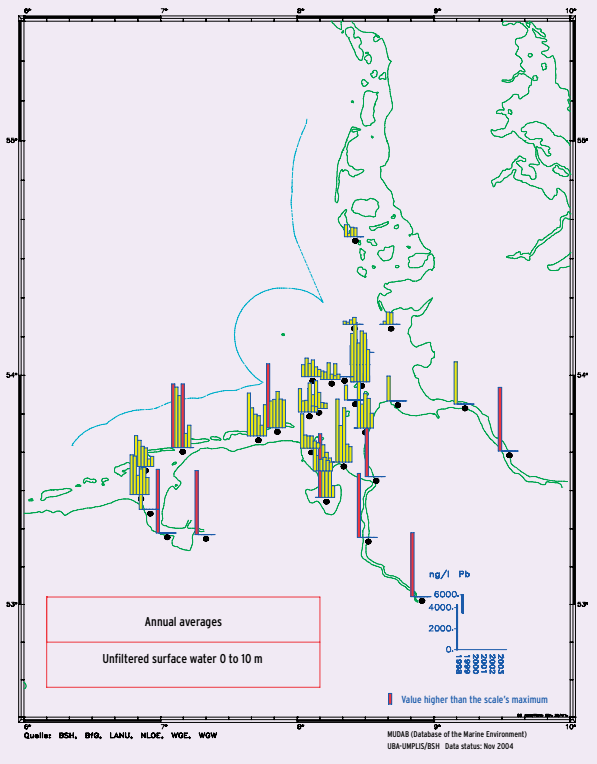
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.5-2: *Mercury concentrations in North Sea waters (1998–2003)*



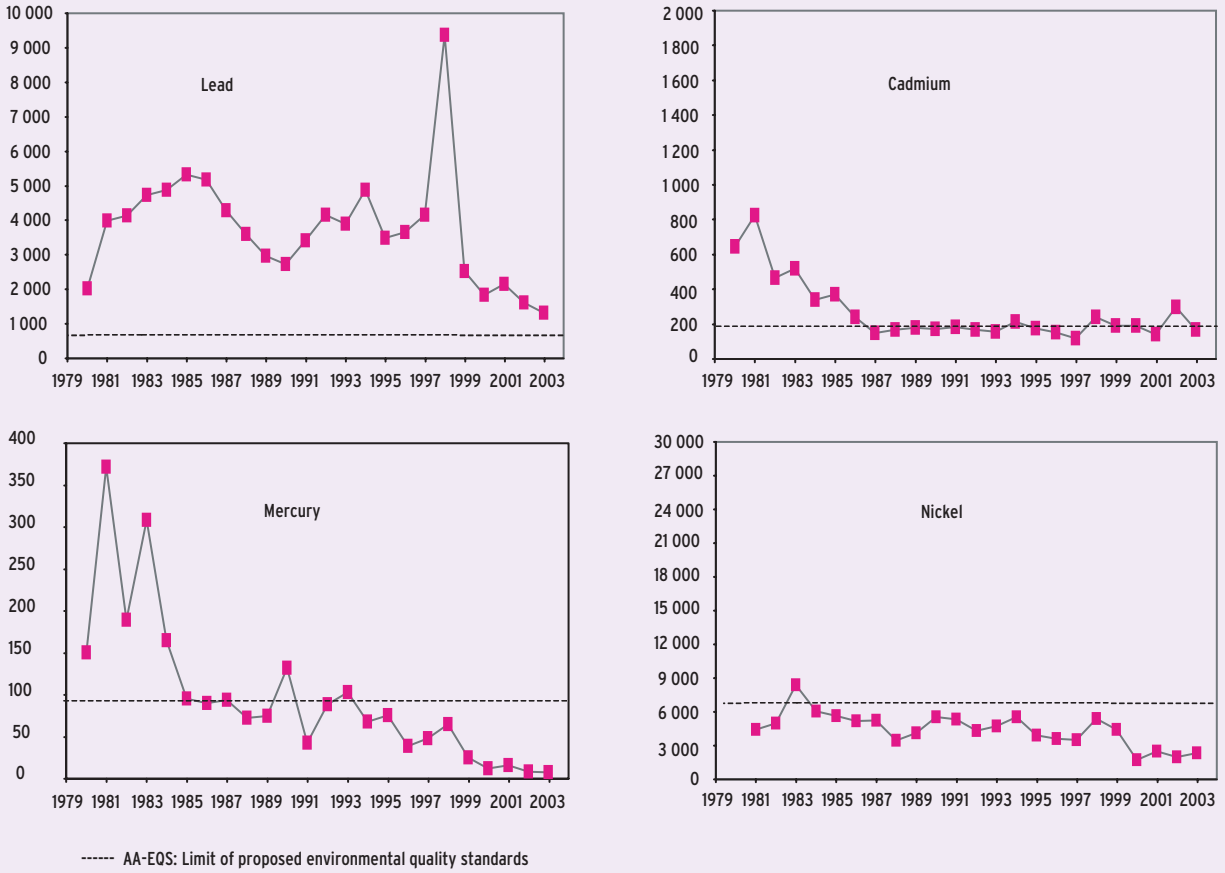
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.5-3: *Lead concentration in North Sea waters (1998–2003)*



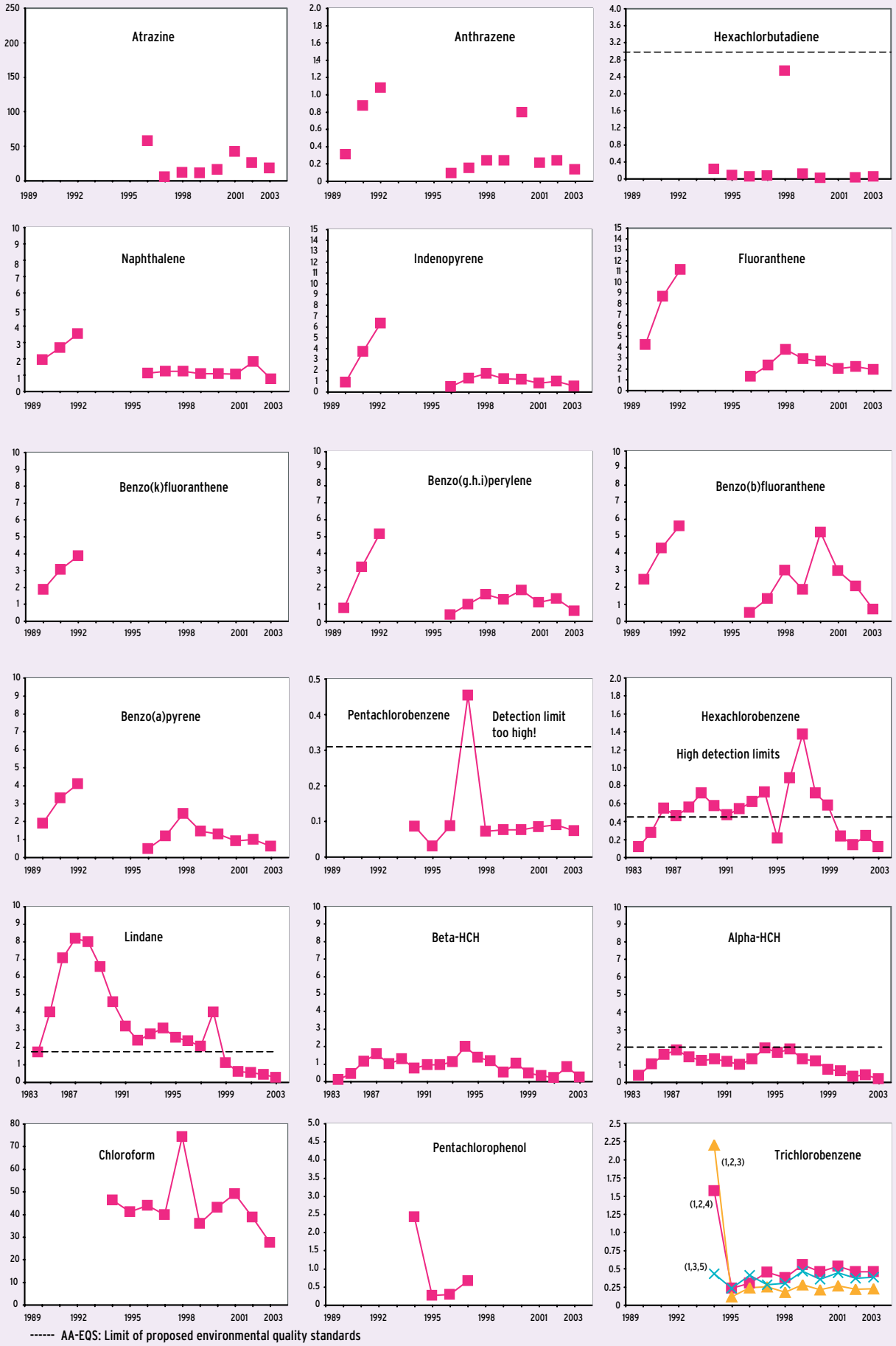
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.5-4: *Annual averages ng/l of heavy metals in unfiltered water (0–10m) of the North Sea (12 nm zone excl. Helgoland)*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.5-5: *Time series of average annual values (ng/l) of organic pollutants in unfiltered water (0–10 m) from the North Sea (12 nm zone excluding Helgoland)*



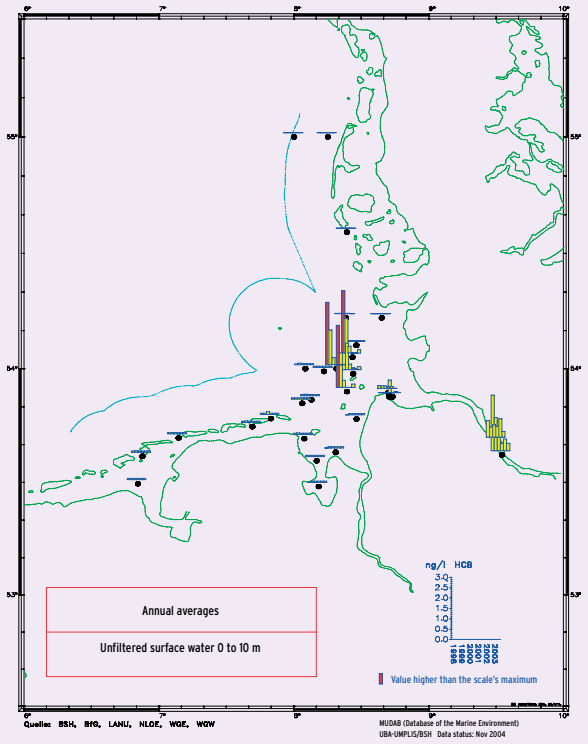
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

found in far lower concentrations. After concentrations peaked in the 1980s (during the dolphin catastrophe in 1987/88, lindane was one of the most frequently found pesticides in analyses), there is a general downward trend. One of the main areas of pollution by all HCH compounds are coastal waters adjacent to the Elbe/Weser estuary, but the reason for this is unknown.

Hexachlorobenzene (HCB) concentrations are usually below the detection limits of 1.0 ng/l, though the proposed environmental quality standard requires a lower detection limit of 0.4 ng/l. The coastal waters adjacent to the Elbe/Weser estuary are, again, a focal point of pollution (Fig. VI 3.1.5-6).

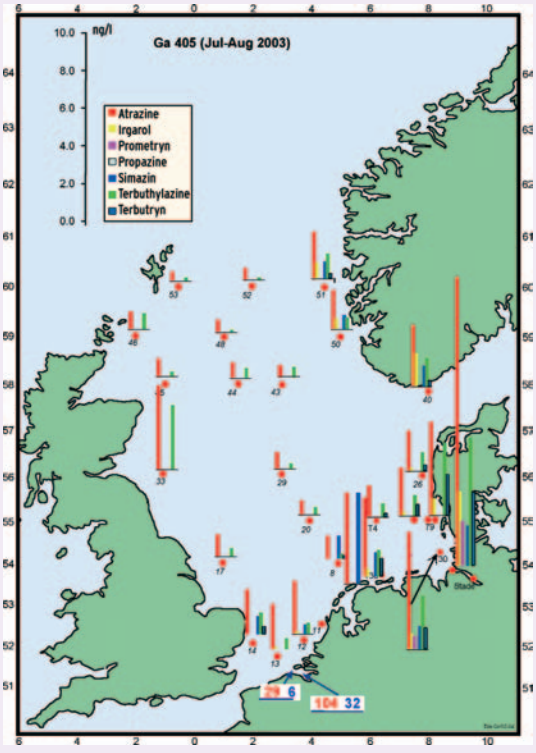
The spatial distribution of the most important triazine and phenylurea pesticides shows, for all compounds, a gradient that declines from the coast to the open sea. The Schelde and the Rhine are, like the Elbe, significant sources. The elevated concentrations of triazine and phenylurea on the Norwegian coast are largely due to the waters flowing out of the Baltic (Fig. VI 3.1.5-7).

Fig. VI 3.1.5-6: *Hexachlorobenzene concentration in North Sea waters (1998–2003)*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.5-7: *Distribution of triazines in North Sea waters*



Source: *Theobald, N. and Gerwinski, W., Federal Environment Agency, Federal Maritime and Hydrographic Agency 2004*

VI 3.1.6 Pollution in North Sea sediments

Heavy metals in sediment

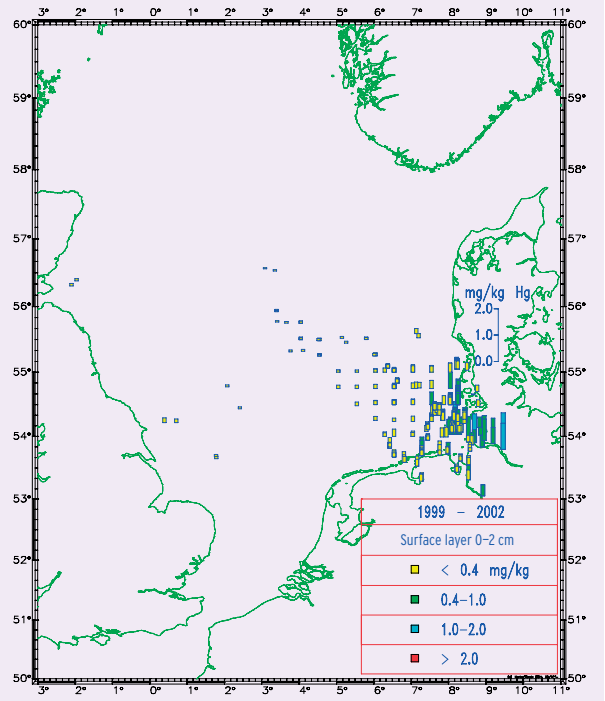
The distribution of heavy metals (Cd, Hg, Pb) in the sediments of the southeastern North Sea (including the German Bight) has a clear pattern. The German Bight remains an area of high mercury pollution (Fig. VI 3.1.6-1). High lead content in sediments (Fig. VI 3.1.6-2) is found throughout the entire North Sea, while Cd and Hg content in the open sea is only slightly and sporadically higher than natural background levels (Hg: 0.2 mg/kg, Cd: 0.3 mg/kg, Pb: 25 mg/kg in the 20 m sediment fraction).

The sometimes considerable mercury pollution in German Bight of the past, principally due to discharges from the Elbe, has improved slightly, as mercury loads in the Elbe fell sharply when industries closed down and environmental measures improved after German reunification. The widespread pollution of the North Sea sediment with lead is probably due to a relatively high atmospheric input from before the introduction of lead-free petrol.

VI 3.1.7 Pollution of organisms in the North Sea

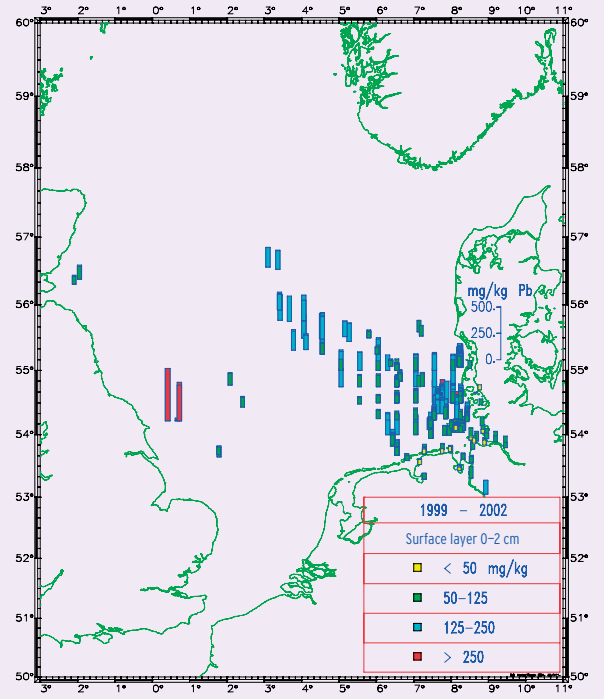
Pollutants in mussels, fish and seabird eggs are monitored as part of the Federal/*Länder* Monitoring Programme for the North Sea and the Baltic (BLMP) (Fig. VI 3.1.7-1). Germany's Environmental Specimen

Fig. VI 3.1.6-1: *Mercury concentration in the fine grain fraction (< 20 µm) of the North Sea's sediments*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

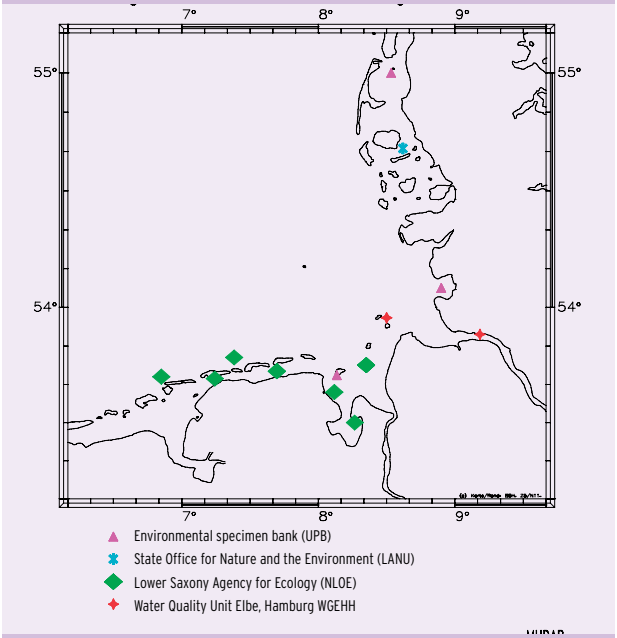
Fig. VI 3.1.6-2: *Lead concentration in the fine grain fraction (< 20 µm) of the North Sea's sediments*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Bank has been studying concentrations of pollutants in marine organisms on the North Sea coast since 1985 in sections of the Wadden Sea National Park –

Fig. VI 3.1.7-1: *North Sea station network for hazardous substances in organisms*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

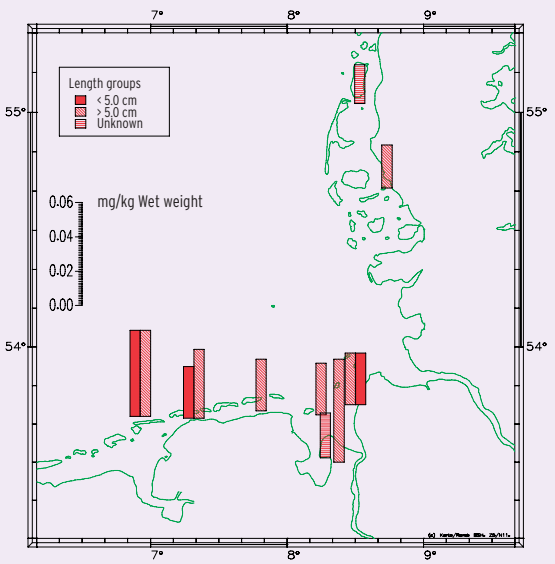
Sylt-Römö-Watt, the Meldorf Bight in Schleswig-Holstein and Jade Bay in Lower Saxony. The Environmental Specimen Bank's policy is to collect bladder wrack (Fucus vesiculosus), mussels (Mytilus edulis), muscle and liver tissue from the eelpout (Zoarces viviparus), and herring gull (Larus argentatus) eggs, to characterise them in biometric terms, and to pool, grind and store them above liquid nitrogen. Concentrations of trace metals (Cd, Pb, As, Cu, Se, Hg, and partially methyl mercury), polycyclic aromatic hydrocarbons (PAH) and chlorinated hydrocarbons (e.g. PCB, DDT, HCH) are regularly recorded.

Heavy metals in organisms

Spatial analysis of mussel monitoring results in 2001 of the German North Sea coast, showed similar levels of pollution through heavy metals for mussels in the coastal areas of Lower Saxony and Schleswig-Holstein showed similar levels of pollution through heavy metals (Fig. VI 3.1.7-2, Fig. VI 3.1.7-3). Heavy metal pollution in flounder varies more widely, though the fish's movements make it impossible to provide precise geographic classifications of pollution sources (Fig. VI 3.1.7-4 and Fig. VI 3.1.7-5).

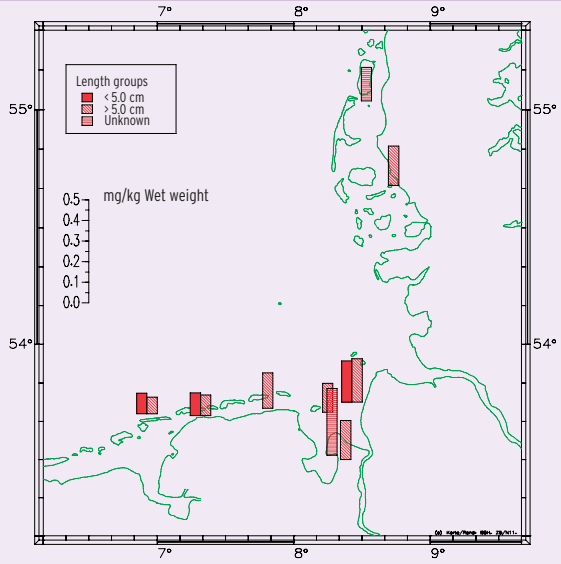
The temporal analysis shows that mussels taken from Jade Bay (near Eckwarderhörne) during 1985 to 1993 are far more polluted with Pb, Cd, and Hg than mussels from Sylt-Römö-Watt (at List/Königshafen). In subsequent years (1994 to 2003) these differences became less prominent as the pollution in mussels from Jade Bay decreased while that in mus-

Fig. VI 3.1.7-2: *Mercury concentration in mussels, North Sea 2001*



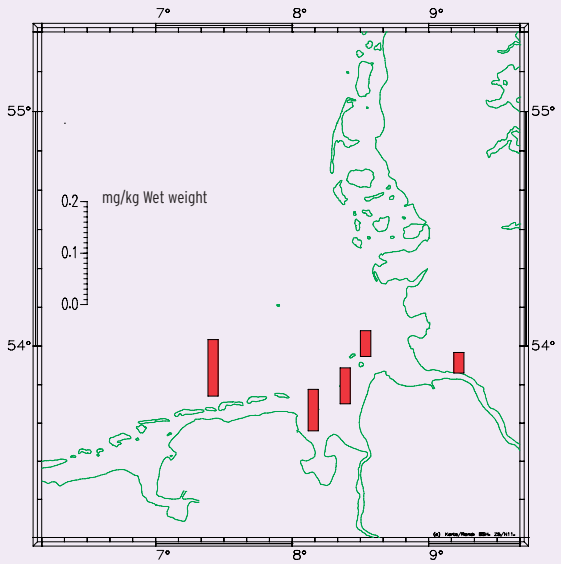
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.7-3: *Lead concentration in mussels, North Sea 2001*



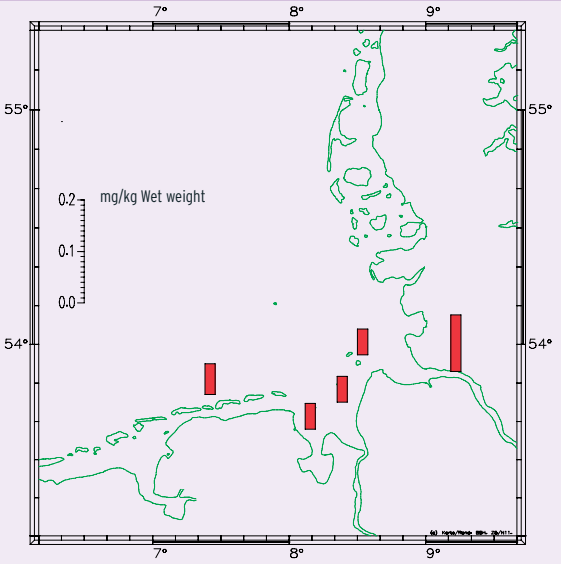
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.7-4: *Mercury concentration in flounder muscle tissue, North Sea 2001*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.7-5: *Lead concentration in flounder livers, North Sea 2001*

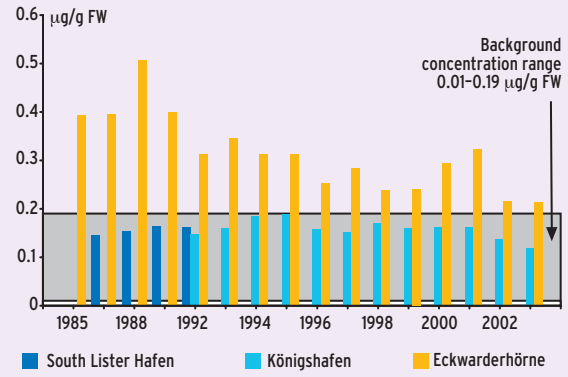


Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

sels from Sylt-Römö-Watt remained roughly the same or increased slightly (Fig. VI 3.1.7-6, Fig. VI 3.1.7-7).

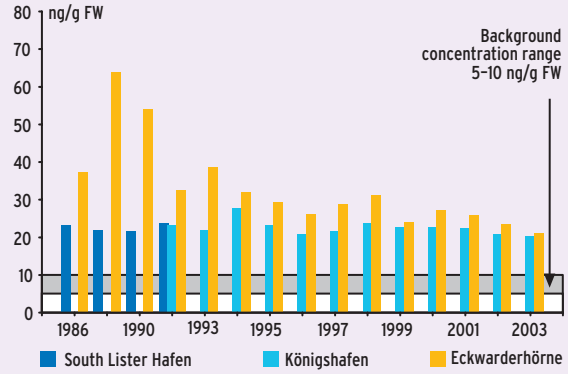
The assessment is based on the concentration ranges for the natural background for metals in mussels that OSPAR [1] provides for the entire North-East Atlantic (including the North Sea). These are 0.07–0.11 µg/g for Cd, 0.01–0.19 µg/g for Pb and 5–10 ng/g for Hg, in each case based on the fresh weight (FW). In the case of cadmium, the concentrations found in mussels are tending to decrease, but the concentrations in mussels from Eckwarderhörne are still above the background range. In the case of lead, only the concentrations in mussels from Eckwarderhörne are above the background range. Mercury content in mussels from the two North Sea sampling stations has, indeed, decreased since the late 1980s, but is still well above background concentrations. For flatfish such as flounder, OSPAR only specifies a background level for Hg in fish flesh, from 0.03–0.07 mg/kg fresh weight (FW), and the concentrations found in flounder are also higher than this.

Fig. VI 3.1.7-6: *Lead in mussels*



Source: *Federal Environment Agency 2004 d*

Fig. VI 3.1.7-7: *Mercury in mussels*

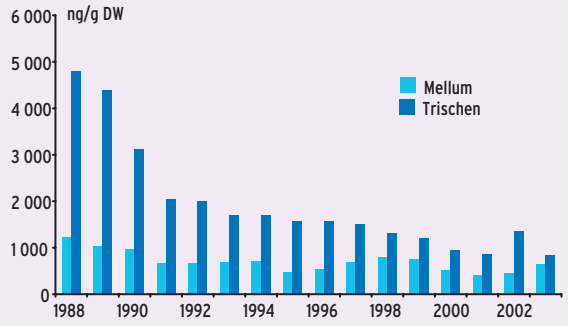


Source: *Federal Environment Agency 2004 d*

When assessing pollutant concentrations in relation to human health issues, the maximum levels for food for human consumption laid down by the Commission of the European Community apply. These are: 0.5 µg/g FW for Hg in mussels and fish flesh; for Pb, 1.5 µg/g FW in mussels and 0.2 µg/g FW in fish flesh; and for Cd 1.0 µg/g FW in mussels and 0.05 µg/g FW in fish flesh. The concentrations of Pb, Cd, and Hg measured in mussels and Hg in flounder in the area of the German North Sea coast are well below these limits. No direct comparison can be made for Cd and Pb in flounder livers, since pollutants accumulate heavily in liver and are more concentrated there than in fish flesh.

The mercury pollution in seabird eggs is generally a good indicator of local contamination, as the mercury is passed on from the female, who feeds in the vicinity of the breeding ground during the formation of the egg. Mercury content in herring gull eggs from the island of Trischen (Schleswig-Holstein Wadden Sea) is 2 to 3 times higher than that in eggs from the island of Mellum (Lower Saxony Wadden Sea), indicating high inputs from the river Elbe compared with those from the rivers Jade and Weser. Time series for the period 1988–95 show a significant decrease in Hg contamination. While this trend has continued (except for 2002) in eggs sampled from Trischen, a intermediate increase in mercury content was found in the eggs from Mellum in the late 1990s and in 2003 (Fig. VI 3.1.7-8).

Fig. VI 3.1.7-8: *Mercury in herring gull eggs*



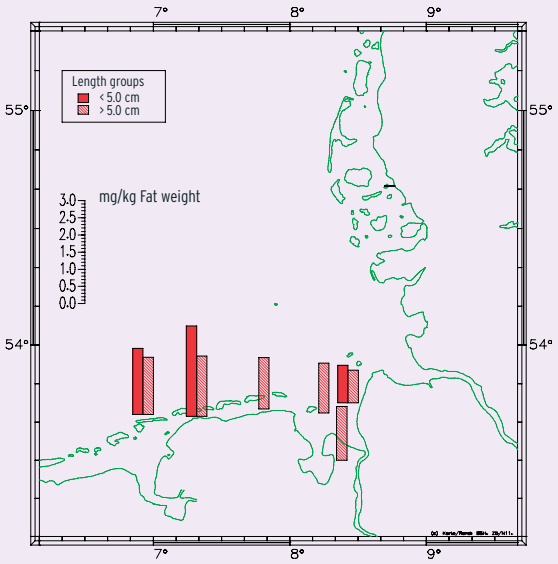
Source: *Federal Environment Agency 2004 d*

Organic pollutants in organisms

Unlike most inorganic compounds, organochlorine compounds accumulate in an organism's fatty tissue. The Federal/*Länder* Monitoring Programme for the North Sea and the Baltic has provided data on the spatial distribution of lindane and PCB 138 in mussels, and lindane, PCB 138 and HCB in flounder (Figs. VI 3.1.7-9, VI 3.1.7-10, VI 3.1.7-11, and VI 3.1.7-12). While the distribution of PCB 138 in flounder is relatively similar throughout the German North Sea coast, a relatively new pollution hot spot has been observed in mussels in the Weser estuary, where higher concentrations have been recorded in small (young) mussels, in particular. Lindane content in both flounder and mussels appears higher off the coast of Lower Saxony, which may be due to agricultural inputs. Although the use of lindane as a pesticide has been banned since 2002 in the EU, it only degrades very slowly as a PBT substance and will still be found in fish in coming years. HCB content in flounder fluctuates widely from region to region.

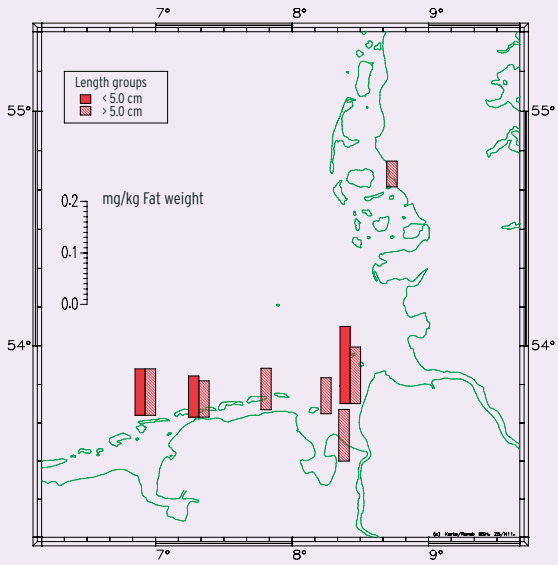
The Environmental Specimen Bank's samples of mussels, eelpout, and herring gull eggs can be used to examine the distribution of organic pollutants over time and space. The main contaminants of marine organisms in both the North Sea and Baltic coastal regions are polychlorinated biphenyls (PCBs). Analysis of mussel, eelpout, and herring gull egg samples revealed that some PCB congeners, especially the hexa- and heptachlorinated biphenyls (B 138 and B 153), accumulate in the food chain, while others like tetra- and pentachlorinated biphenyls (B

Fig. VI 3.1.7-9: *Lindane concentration in mussels, North Sea 2001*



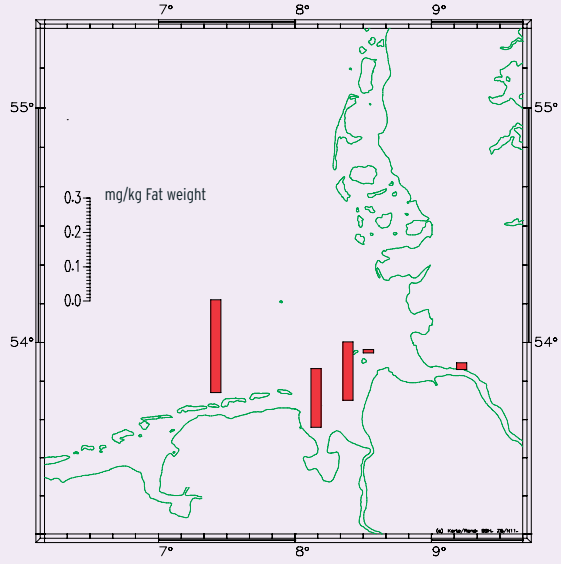
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.7-10: *PCB 138 concentration in mussels, North Sea 2001*



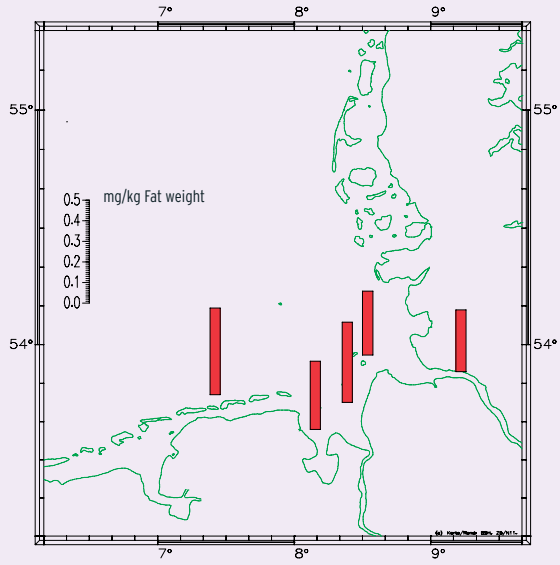
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.7-11: *Lindane concentration in flounder livers, North Sea 2001*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.7-12: *PCB 138 concentration in flounder livers, North Sea 2001*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

52 and B 101) show an increasingly lower share among the PCB congeners found in the samples.

For the sum of seven PCB congeners (PCB 28, 52, 101, 118, 138, 153, and 180), OSPAR has determined 1 to 10 ng/g fresh weight for fish and 5 to 50 ng/g dry weight for mussels as ecotoxicological assessment criteria for identifying areas with potential ecotoxicity problems. The Σ PCB_7 found in the muscle tissue of eelpout in 2003 was 12.8 ng/g fresh weight, and therefore above the limit of the ecotoxicological assessment criterion. In 2003, eelpout muscle tissue from the Meldorf Bight had PCB content of 7.5 ng/g fresh weight, thus towards the top end of the range. PCB levels fluctuate widely over the 1994 to 2003 period. Particularly noticeable was a significant rise in PCB pollution in both sampling regions between 1999 and 2000, for which no explanation has yet been found (Fig. VI 3.1.7-13).

Although the flooding of the Elbe in 2002 caused demonstrably large amounts of chlorinated hydrocarbons to be discharged into the North Sea, one year after the event only relative small increases in

eelpout contamination through these substances was being detected.

In the case of DDT and its metabolites DDE and DDD, slight increases in levels of the parent compounds o,p'-DDT and p,p'-DDT were found in the muscle tissue of eelpout from Meldorf Bight and Jade Bay in 2003 compared with 2002 (Fig. VI 3.1.7-14).

For the HCH isomers studied here (α-, β-, and γ-HCH), there was only a small increase in the β-HCH levels in muscle tissue from eelpout taken from Meldorf Bay one year after the flood. Otherwise, the marked decline in α-HCH and in γ-HCH (lindane) in eelpout in both sampling regions on the German North Sea coast is continuing (Fig. VI 3.1.7-15).

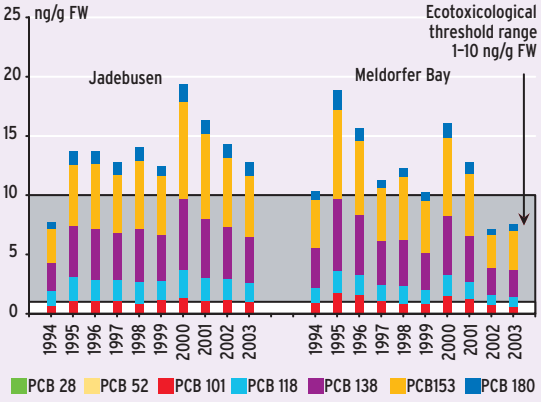
The extensive damage to marine organisms caused by organic tin compounds became known in the early 1980s, manifested most clearly in an impaired or lost reproductive function in snails and oysters.

During 1985–99, contamination of marine organisms with triphenyl tin compounds decreased significantly, while concentrations of TBT (tributyl tin) in tissue remained at a constant high level. This continuing high level of TBT pollution is presumably due to the ongoing use of TBT-based antifouling paints in commercial shipping. The results also indicate that the ban on TBT use for pleasure boats in marinas has had a positive effect. However, any significant decrease in the pollution of marine ecosystems beyond local effects is unlikely to be achieved with this measure alone, as pleasure boats accounted for only 10 % of market share in antifouling paint sale.

The extremely high levels of TPT (triphenyl tin) in the mid-1980s, which have been decreasing steadily since then, were due to the use of TPT compounds in antifouling paints, which ceased in 1985.

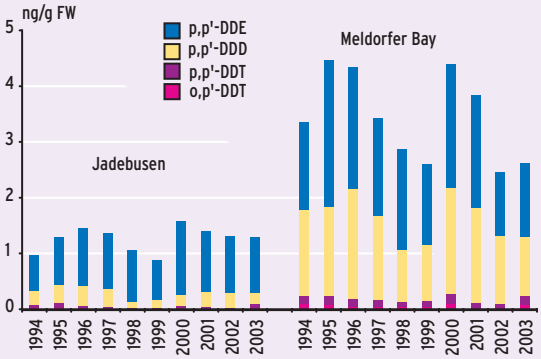
To identify potential problem areas for TPT, OSPAR uses a ecotoxicological assessment criterium of 1 to 10 ng/g dry weight for the common mussel [2]. Mussels sampled at List/Königshafen between 1986 and 1999 contained 5 to 11 times the TBT concentration level that indicates a potential problem

Fig. VI 3.1.7-13: *PCB in eelpout muscle tissue*



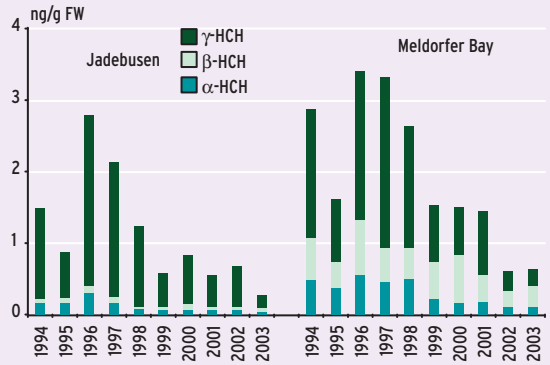
Source. *Federal Environment Agency 2004 d*

Fig. VI 3.1.7-14: *DDT and metabolites in eelpout muscle tissue*



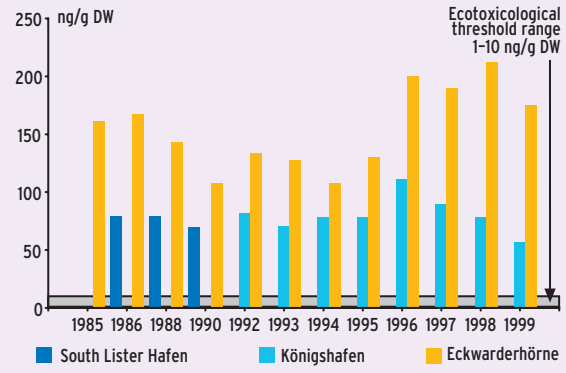
Source. *Federal Environment Agency 2004 d*

Fig. VI 3.1.7-15: *HCH in eelpout muscle tissue*



Source. *Federal Environment Agency 2004 d*

Fig. VI 3.1.7-16: *Tributyl tin in mussels*



Source. *Federal Environment Agency 2004 d*

area, while samples at Eckwarderhörne contained 10 to 20 times the level. Comparisons of organic tin concentrations in mussels, eelpout, and herring gull eggs have provided no indication of biomagnification along the food chain in the corresponding ecosystems.

[1] OSPAR (1997): Agreed Background/Reference Concentrations for Contaminants in Sea Water, Biota and Sediment.
[2] OSPAR (1997): Agreed ecotoxicological assessment criteria for trace metals, PCBs, PAHs, TBT and some organochlorine pesticides

VI 3.1.8 Eutrophication in the North Sea

A common agreed definition of eutrophication used within the European Community and OSPAR reads: "Eutrophication means the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients." Finally, lack of oxygen due to the bacterial decomposition of dead algae can occur under certain climatic and hydrographic circumstances.

Both riverine and atmospheric inputs of nutrients rose sharply during the last century, which has caused an increase in nutrient concentrations in our coastal waters. Increased direct and indirect effects have been observed since the 1980s, including massive blooming of single-cell phytoplankton species in the Wadden Sea and oxygen deficiencies in the German Bight.

In the 20 years from the mid 1970s, biomass production of phytoplankton in the Dutch Wadden Sea doubled and even tripled, and similar trends were seen in the North Friesian Wadden Sea. The successful and considerable fall in phosphate inputs did not lead to a decline in algae biomass. Unlike with freshwater, nitrogen limits are imposed at times in many estuary and coastal waters, but further efforts need to be taken to reduce nitrogen and phosphate inputs.

The parameters of relevance for eutrophication are monitored within the BLMP. A distinction needs to be drawn between ship based measurements (hydrographic, physico-chemical, and biological parameters), fixed monitoring buoys (hydrographic and physico-chemical parameters) and airborne surveillance by airplanes (macroalgae, seagrass, mussel banks, etc.).

Eutrophication levels in the German Bight and the Wadden Sea

Eutrophication plays a vital role in marine protection. It is essential that a detailed assessment of the eutrophication status is drawn up before any measures are taken to combat it. Under the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic, there were long negotiations on this topic between the Contracting Parties before a harmonised assessment, the "Common Procedure for the Identification of the Eutrophication Status of the Maritime Area" was developed and agreed. At the same time, this is a core element of OSPAR's strategy to combat eutrophication, which aims to ensure a healthy marine environment, in which eutrophication no longer occurs, by 2010 at the latest.

The assessment method consists of an integrated set of assessment criteria which, as a whole, enable an assessment of the eutrophication status of marine areas to be assessed in a holistic, standardised way. Using this process, the OSPAR Convention Area, i.e., the North Sea including the Wadden Sea, has been divided into three categories in terms of eutrophication: problem area (PA); potential problem area (PPA); and non-problem area (NPA).

The assessment criteria selected for the common assessment comprise both physico-chemical and biological parameters, and are listed in Table VI 3.1.8-1.

A summary report on the state of eutrophication in the OSPAR Commission region, based on national reports, was published in 2003. One important finding was that large areas of the southern North Sea as far as the south coast of Norway and Sweden, plus some coastal areas of Great Britain, were classified as eutrophication problem areas (Fig. VI 3.1.8-1). Measures now need to be taken to reduce levels in these areas and to make them non-problem areas – in line with the respective OSPAR strategy – by 2010 [1].

Figure VI 3.1.8-2 clearly shows the eutrophication status in the German North Sea region. The area close to the coast is particularly eutrophied, mainly due to inputs of nutrients from German rivers, but also to substances that have come from the English coast and the Rhine river, and to atmospheric inputs of nitrogen. As dilution increases towards the open seas, eutrophication problems lessen, so that the outer part of the German Bight has been classified as a non-problem area.

In 2003, the countries abutting on the Wadden Sea used the OSPAR Common Procedure to assess the

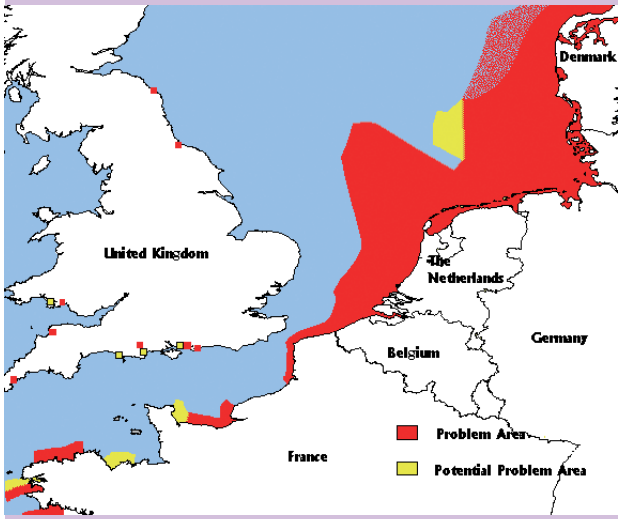
VI 3.1.8-1: *Criteria for assessing physico-chemical and biological parameters*

Category		Assessment Parameter
I		**Level of Nutrient Accumulation**
	1	**Riverine and direct inputs** Increased inputs and/or rising trends (compared with previous years)
	2	**Winter DIN and/or DIP concentrations** Increased content levels (defined as concentration > 50 % above background concentration when adjusted for salt content and/or in the specific region)
	3	**Increased winter N/P ratio (Redfield N/P = 16)** Increased compared with the natural Redfield ratio (> 50 % deviation: > 25)
II		**Direct effects of nutrient accumulation (in the growth period)**
	1	**Maximum and mean chlorophyll a concentration** Increased content levels (defined as concentration > 50 % above regional (e.g., open seas) or historic background concentrations)
	2	**Specific regional/local phytoplankton indicator species** Increased densities (and increased bloom duration)
	3	**Macrophytes including macroalgae (specific to region)** Shifts from long-lasting to short-lived (interfering) species (e.g., Ulva)
III		**Indirect effects of nutrient accumulation (in the growth period)**
	1	**Level of oxygen depletion** Reduced content levels (< 2mg/l: acutely toxic, 2–6 mg/l: oxygen depletion)
	2	**Changes/dying off of zoobenthos and fish** Dying off (caused by oxygen depletion and/or poisonous algae) Long-term changes in zoobenthos (biomass and/or species mix)
	3	**Organic carbon/organic substance** increased content levels (in relation to oxygen deficiency, relevant in areas of sedimentation)
IV		**Other possible of nutrient accumulation (in the growth period)**
	1	**Algae toxins (DSP/PSP occurring in mussels)** Presence (phytoplankton indicator species)

DSP = Diarrhetic Shellfish Poisoning
PSP = Paralytic Shellfish Poisoning

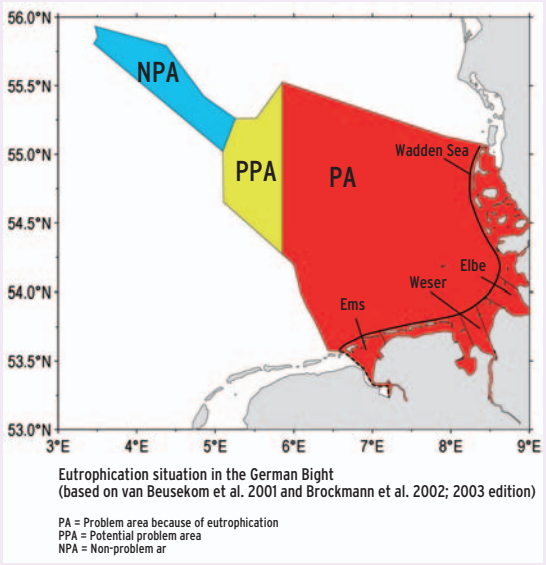
Source: *Federal Environment Agency 2005*

Fig. VI 3.1.8-1: *Eutrophication situation in the southern North Sea and the English Channel*



Source: *OSPAR Commission 2003*

Fig. VI 3.1.8-2: *Eutrophication situation in the German Bight*



Source: *Federal Environment Agency 2003 a*

eutrophication status of the Wadden Sea and, as a result classified this region as similarly eutrophied. The current, 2003, quality status report on the Wadden Sea [2] identifies various improvements relative to earlier analyses, but the overriding quality objective for the Wadden Sea, that no more eutrophication occurs, is yet to be achieved.

Despite the sometimes considerable falls in nutrient inputs to the German Bight (phosphate, in particular), the all-clear cannot yet be sounded in terms of their ecological impact. The effort to reduce levels needs to go on, and in the case of nitrogen needs to be strengthened.

Trends in nutrient concentrations and the phytoplankton in the German Bight

Salinity and nutrient concentrations in the coastal waters of the German Bight continue to be influ-

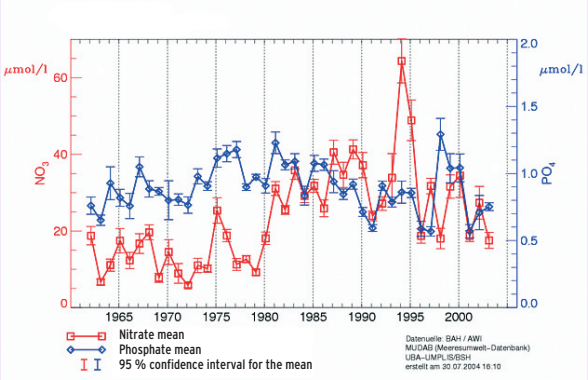
enced not only by inputs from the rivers Elbe, Weser, Ems, and Eider, but also from coastal waters arriving from the west. Atmospheric deposition of nitrogen also plays a part.

Distributions of nutrients are determined by current patterns and by biological factors such as uptake, depletion, and degradation (remineralisation), and biogeochemical processes such as sedimentation and denitrification. When there is sufficient light, during summer time, algae build up biomass from inorganic nutrients. Higher water temperatures during the summer also accelerate the degradation of organic substances. All biological processes are speeded up at this time of year so that concentrations of nutrients are generally lower during the summer. During the winter, the uptake of nutrients by algae and their subsequent release is significantly lower, so nutrient concentrations in the water during winter are higher than in spring and summer. It is preferable to measure nutrient concentrations during winter as that is when there is the least biological activity. This provides an idea of how many nutrients are available to spring blooms, even if the nutrients in the water body studied have long since been carried out by the current.

Nutrient concentrations in the German Bight fall off significantly as one moves from the coast towards the open seas. The Federal/*Länder* Monitoring Programme's findings between 1999 and 2003 [3] show that phosphate levels fell from 1.1 to 1.3 µmol near to the coast (1.1–1.5 µmol in the mudflats) to roughly 0.5 µmol in the open German Bight, while nitrate concentrations of 300–700 µmol in the estuaries and 80–100 µmol in the Wadden Sea fell to 5–10 µmol in the open German Bight.

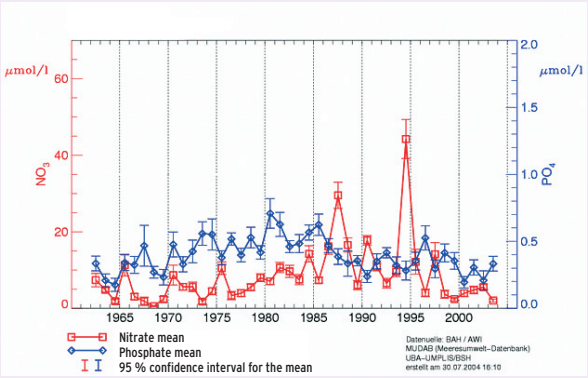
The Marine Station Helgoland (Biologische Anstalt Helgoland, BAH, now part of the Alfred-Wegener Institute) has been conducting long-term monitoring on nutrients and plankton in the German Bight at the Helgoland Reede station since 1962. Results show that phosphate eutrophication in the German Bight began in the 1960s (Figs. VI 3.1.8-3 and VI 3.1.8-4) and was due, among other things, to an increased use of phosphate detergents. By the mid-1970s, the yearly average winter concentrations of phosphate around Helgoland had risen sharply, and they remained at this level for about a decade before falling again. This can be taken as a consequence of phosphate reduction measures, such as the introduction of phosphate free detergents and the installation of phosphate elimination plants in industrial and municipal waste water treatment plants. Summer values for phosphate show a similar pattern but at a lower level, as nutrients are absorbed into cells during the algae's growth period,

Fig. VI 3.1.8-3: *Nutrient concentrations during winter months, Helgoland-Reede*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.1.8-4: *Nutrient concentrations during summer months, Helgoland-Reede*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

so lower concentrations are present in the water column.

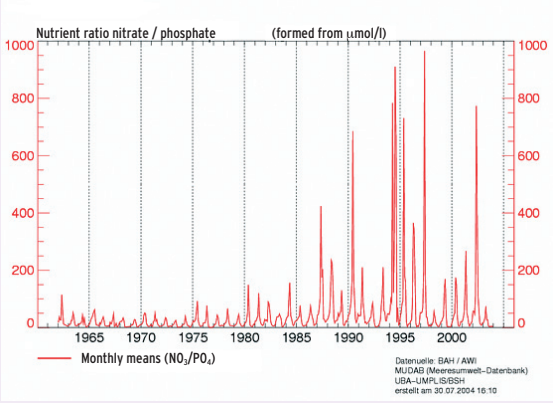
Nitrate eutrophication developed differently. Winter nitrate concentrations did not rise significantly until the 1980s, when the yearly average doubled within 10 years, falling again from 1989 to 1991 (Fig. VI 3.1.8-3). In the following two years it rose again, showing the highest concentration observed in the entire study in 1994. After that, the average monthly nitrate levels in winter fell sharply until 1996, and since then have hovered between 20 and 35 µmol/l. Summer nitrate concentrations since 1962 have experienced a similar pattern but on a lower level. Unlike the case with phosphate, it is clear that the measures to reduce nitrogen inputs to water, especially from agriculture, are inadequate, or at least that their effects are delayed by many years.

The OSPAR Quality Status Report [4] concluded that, although there is no clear trend in concentrations of nutrients in the North Sea as a whole, this is not the case in local areas. It noted a significant down-

ward trend in inputs of nutrients and their concentrations (especially in phosphates) in Danish waters and the German Bight (including the Wadden Sea).

The asymmetric development of nitrogen and phosphate eutrophication has shifted the ratio of nitrogen to phosphate. Under certain circumstances, this can be more important to phytoplankton than the absolute concentrations of nutrients. The nitrogen surplus has risen sharply since 1980, and is significantly higher than the Redfield ratio of 16:1, which is normal for oceanic phytoplankton cells. Since 1988, the surplus has been seen to extend into the summer. Previously, the N:P ratio had always fallen to below 16 (i.e., a phosphate surplus) during the summer, due to the faster remineralisation of phosphorus. Today, the nitrogen surplus is not only considerable in the winter (N:P > 100), it is also noticeable in the summer (Fig. VI 3.1.8-5).

Fig. VI 3.1.8-5: *Nutrient ratio Helgoland-Reede*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

The summer nitrogen surplus along the continental coastline of the North Sea is considerable. Calculations for the Quality Status Report for the North Sea [5] indicated a surplus in the region of 300 000 t. This impacts on the phytoplankton taxonomic spectrum, as certain species of algae (e.g., *Phaeocystis globosa*) are able to use organic phosphorus in conditions of surplus nitrogen and insufficient phosphate and thus gain an advantage over other species. The composition of phytoplankton varies considerably. Around Helgoland it is assisted by the variety of bodies of water that exist there. Since 1962, phytoplankton biomass (measured as organic carbon) at the Helgoland Reede station has tripled during the vegetation period (March to September), although stocks of diatoms have not increased. Instead, numbers of flagellates (phytoplankton excluding diatoms) have grown dramatically since the 1970s. Alongside the bloom of dinoflagellates, small nanoflagellates are thriving particularly well.

Spring blooms are determined by cold-loving diatoms. After warm winters such as 2000, *Coscinodiscus wailesii* is the dominant species in early spring. This alga can dominate the biomass throughout the German Bight as it has a high carbon content and is difficult to consumed by zooplankton. After the diatoms, in spring, flagellates play an increasingly important role in the ongoing development of algae blooms. The non-native, potentially toxic flagellate Chattonella sp. can achieve very high cell numbers. One member of this genus (*Chattonella cf. verruculosa*) caused fish to die in the northern North Sea in the late 1990s, and there was also evidence of this species around Sylt and Helgoland in May 2000, though fish stocks were not seen to be affected [3].

In the Schleswig-Holstein Wadden Sea, only isolated cases of unusual algae bloom were observed between 1999 and 2003. For instance, there was a short summer blooming of a *Chrysochromulina* species with very high cell numbers (up to 4 million cells per litre) [3].

Trends in nutrient concentrations and the phytoplankton off the coast of Lower Saxony

Measurements by the Lower Saxony Agency for Ecology (NLÖ) show the annual cycle of nitrate and phosphate concentrations at the long-term measuring station on Norderney. They fall to their lowest levels during the main growth period, achieving their annual maxima in the winter. The maxima for ortho-phosphate off Norderney are seen at the end of the summer. The only explanation available at present is remineralisation of organic material from the mud-flats. High summer levels of ortho-phosphate have also been observed in other mud-flat areas (Schleswig-Holstein, Netherlands). In these areas, it is known that a long phosphate minimum dominated the summer months in past decades, and the high summer levels are interpreted as a clear indication of eutrophication.

The NLÖ found a decrease in concentrations of phosphate and dissolved inorganic nitrogen from 1985 to 2003 in the East Friesian Wadden Sea at the permanent station off the island of Norderney. The reduction in nitrogen began after 1990, and silicate concentrations remained unchanged.

The decrease in winter phosphate levels off Norderney, and in the Dutch Wadden Sea (Marsdiep), and the German Bight (Helgoland Reede) is due to extensive action to reduce phosphate inputs. No change was expected in silicate concentrations, as winter levels are determined by weathering, which is more or less independent of human influence.

The drop in dissolved inorganic nitrogen has not been observed in the decisive regional inputs from the Ems, nor in other areas, such as Helgoland Reede. In view of this, the NLÖ has concluded that the observed decrease in winter nitrogen concentrations cannot reasonably be attributed to reduction measures.

In the Norderney study area, dense spring blooms of *Phaeocystis globosa* have been observed almost every year. These algae can amount to over 99 % of the phytoplankton algae in the waters. The density of the spring bloom increased steadily from 1982 to 1993, although the expected spring bloom around Norderney failed to appear in April/May in 1996 and 1997. A pronounced spring maximum was again seen in 2004.

From 1993 to 2003 higher cell densities of the potentially toxic *Dinophysis species* reoccurred in the Lower Saxony Wadden Sea. They form the poison DSP, which can cause diarrhoea and vomiting in human beings. Uptake occurs when people eat mussels, which can accumulate this toxin from ingesting Dinophysis. In Germany, the sale of mussels is prohibited when DSP limits are exceeded in the soft bodies of mussels, which occurred various times during the study period.

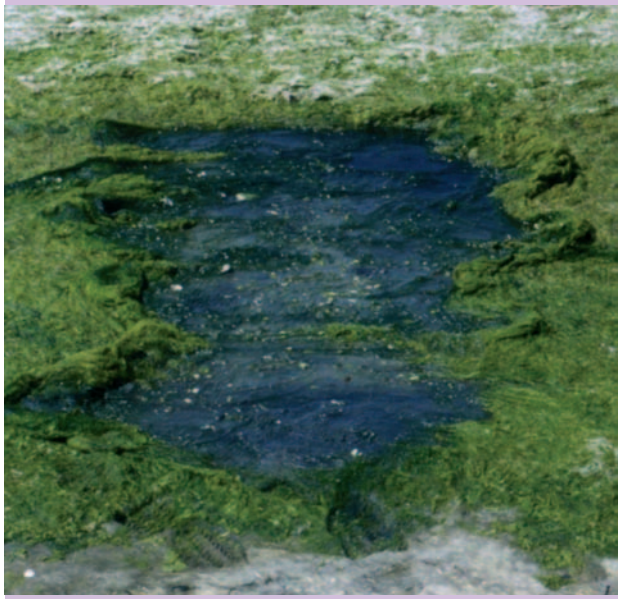
The spread of green algae in the Wadden Sea

Visible green macro-algae (Fig. VI 3.1.8-6) were quantitatively insignificant in the Wadden Sea until they first appeared over large areas around twenty years ago. Ten years later the first mass occurrence was observed, with high levels of coverage across the mud-flats. This phenomenon was repeated in the following three summers, and the green algae occurrence remained relatively high in subsequent years. The carpet of green algae covering the mud should be seen as a sign of increasing eutrophication. They damage surface fauna in the mud-flats and the sea grass in tidal areas, and the superposed inhabitants of the mud die off through lack of oxygen, or through sulphide poisoning which can be linked to the lack of oxygen. The appearance of green algae carpets has produced a noticeable change in the summer landscape. One reason is thought to be elevated inputs of nutrients and nutrient deposits in the sediments.

The Schleswig-Holstein Wadden Sea

The spread of green algae in the Schleswig-Holstein Wadden Sea, after peaking from 1990 to 1992 with up to 20 % land cover, is currently falling back again. Since 1994, this massive algae bloom has clearly begun to subside. Compared with the mass occurrences in the early 1990s, the levels in 2003 were low, though still higher than spreads before the 1980s. In 2003, there were hardly any cases of compact, widespread green algae mats. Altogether, growth in 2003 fell to around 1.7 % of the mud-flats, and the phytobiomass was also relatively low in the summer of 2003.

Fig. VI 3.1.8-6: *Green algae in tidal areas*



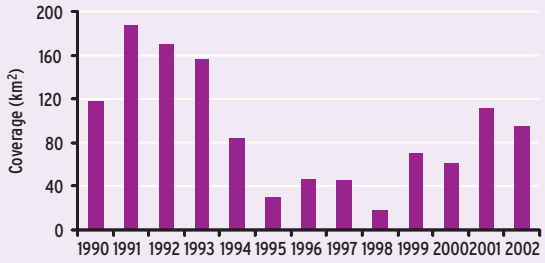
Source: *Federal Environment Agency 2004 e*

These trends imply that the mass growth of green algae on the Schleswig-Holstein Wadden Sea is an extended episode in the course of eutrophication, which has not yet come to an end. The incidence of green algae does not correlate with changes in nutrient levels in the German Bight. One possible explanation is that increased nitrogen inputs into coastal waters, combined with suitable weathering, have led to an accumulation of algal spores in the mud-flat sediments, making mass growth in the summer possible, even under less favourable conditions. This Wadden Sea “spore bank” appears to be declining only gradually [6].

The Lower Saxony Wadden Sea

In the late 1980s in the Lower Saxony Wadden Sea, there was a mass occurrence of macro-algae on the drying mud-flats. The spread of green algae reached its maximum to date in 1991 when it covered 187 km^2 (Fig. VI 3.1.8-7), which equates to approximately 15 % of all the Lower Saxony mud-flats. Between 1991 and 1995, coverage declined constantly to 30 km^2 and remained below 50 km^2 until 1998, which equates to coverage of below 5 %. Since 1999 another increase has been seen, of around 100 km^2 (about 8 % coverage) during the current decade [7].

Fig. VI 3.1.8-7: *Annual maximum macroalgae coverage of the eulitoral mudflats in the Lower Saxon Wadden Sea*



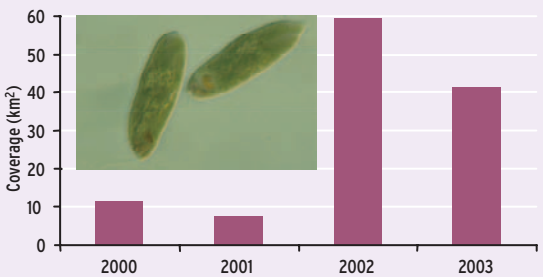
Source: *Lower Saxony State Office for Ecology 2004*

Green sand – a new phenomenon in the Lower Saxon Wadden Sea?

The Lower Saxony Wadden Sea has been monitored from the air since 1988, but 1999 was the first time that mud-flats clearly coloured green had been observed. The green colouring was visible from late spring (May) to autumn (November) and had a significant effect on the appearance of the beach and mud-flats landscapes during the summer months. Tests showed that the colouring was caused by single-cell flagellates such *as Euglena viridis var. maritima*.

In the Lower Saxony Wadden Sea, these "green sands" have progressed from an initial coverage of 11 km² in 2000 to almost 60 km² (ca. 4 % of the drying mud-flats) in 2002 (Fig. VI 3.1.8-8). In 2003, air monitoring indicated a slight decrease in coverage to 41 km² (ca. 3 % of the mud-flats). The largest occurrence each year has been in the Weser/Jade and Scharhörn/Neuwerk area, while it has decreased going west. The protozoa have frequently occurred in sandy areas and/or along tidal gullies [8].

Fig. VI 3.1.8-8: *Maximum coverage (km²) of the Lower Saxon beach and mudflats area with green sand (Euglena viridis var. maritima)*



Source: *Lower Saxony State Office for Ecology 2004*

In fresh water, Euglena viridis is an indicator species for waters that have been severely organically polluted, though whether Euglena viridis var. maritima in the Wadden Sea performs a similar function as an indicator species has yet to be clarified.

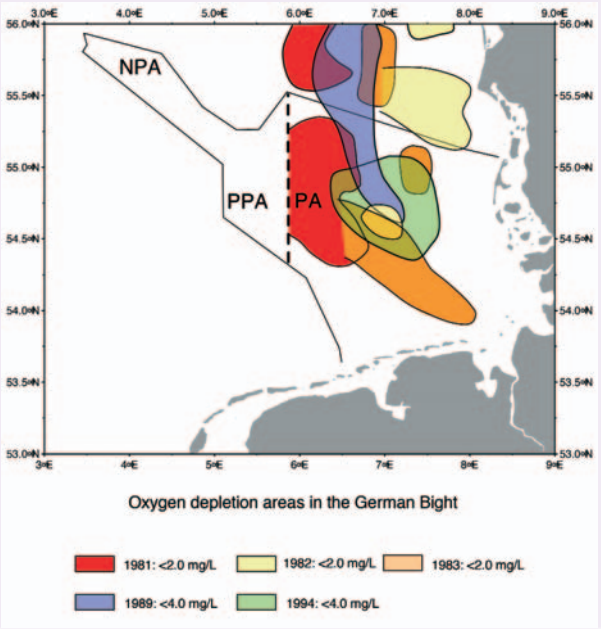
Oxygen deficiency in the German Bight

Occurrences of oxygen deficiency in the sea may have natural or anthropogenic causes. It is regarded as a secondary effect of eutrophication. Oxygen is consumed by microbial degradation processes in organic substances. This oxygen depletion can lead to the complete disappearance of oxygen from the water body and the appearance of the cell poison hydrogen sulphide, which is interpreted as a warning indicator of anthropogenic eutrophication.

Since the early 1980s, oxygen deficiency has repeatedly been observed during the summer in the shallow waters of the German Bight (Fig. VI 3.1.8-9). This widespread phenomenon occurred following unusual phytoplankton blooms in the spring. When these underwent microbial degradation as the year progressed, elevated organic loads resulted which, under certain hydrographic and meteorological conditions (stratified water bodies) near the seabed, could cause oxygen to be continually depleted. Depending on the extent of the oxygen deficiency, the sediment's inhabitants are harmed to a greater or lesser degree. Adapted, robust and opportunistic species withstand this situation better than more sensitive species such as starfish and sea-urchins. Fish take flight in order to survive, and so have greater survival rates than sedentary creatures.

[1] OSPAR (2003): OSPAR Integrated Report 2003 on the Eutrophication Status of the OSPAR Maritime Area Based upon the First Application of the Comprehensive Procedure. 59pp.
[2] K. ESSINK, C. DETTMANN, H. FARKE, K. LAURSEN, G. LÜERßEN, H. MARENCIC, W. WIERSINGA (2005): Wadden Sea Quality Status Report 2004. Wadden Sea Ecosystem No. 19. Trilateral Monitoring and Assessment Group, Common Wadden Sea Secretariat, Wilhelmshaven, Germany
[3] Marine Environment Monitoring Programme (2005): Zustandsbericht 1999–2002 für Nord- und Ostsee
[4] OSPAR Commission 2000. Quality Status Report 2000. OSPAR Commission, London. 108 + vii pp.
[5] NSTF 1993. North Sea quality status report 1993. North Sea Task Force, Oslo and Paris Commissions, London. Olson & Olson. 132pp.
[6] REISE, K. C. 2004: Vorkommen von Grünalgen und Seegras im Nationalpark Schleswig-Holsteinisches Wattenmeer 2003: Forschungsbericht im Auftrag des Landesamtes für den Nationalpark Schleswig-Holsteinisches Wattenmeer
[7] Lower Saxony State Office for Ecology (2004), Coastal Research Centre personal communication
[8] JAKLIN, S., BRENNHOLT, S. & J. PIONTEK (2004): Der grüne Sand: Zur Verbreitung und Ökophysiologie von Euglenia Viridis var. Maritima im niedersächsischen Wattenmeer. Final report of the research project from the Lower Saxon Wadden Sea Foundation No. 28/02.

Fig. VI 3.1.8-9: *Oxygen depletion areas in the German Bight*



Source: *Federal Environment Agency 2004 f*

VI 3.2 Baltic Sea

VI 3.2.1 Catchment area of the Baltic Sea

The catchment area of the Baltic Sea covers approximately 1 720 000 km², 95 % of which is in the nine littoral states Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, and Sweden. The remaining 5 % belong to Belarus, the Ukraine, the Czech and Slovak Republics, and Norway (Tab. VI 3.2.1-1 and Fig. VI 3.2.1-1).

Fig. VI 3.2.1-1: *Water catchment area and Baltic Sea divisions*



Source: *Helsinki Commission 2004*

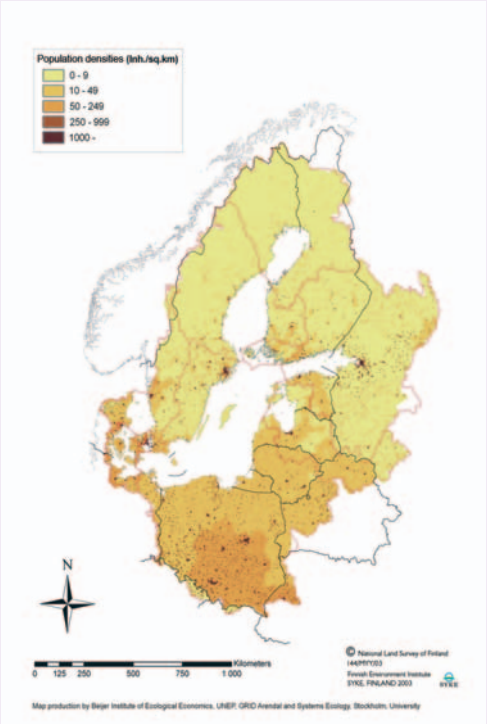
Tab. VI 3.2.1-1: *The Baltic Sea littoral states' share of the Baltic Sea's catchment area, in relation to the Baltic Sea's subregions and the entire Baltic Sea (in km²)*

Subregion/ country	Bothnian Bay	Bothnian Sea	Archipelago Sea	Gulf of Finland	Gulf of Riga	Baltic Proper	Western Baltic	Sund	Kattegat	All
Helsinki Commission signatories										
Finland	146 000	39 300	9 000	107 000	–	–	–	–	–	301 300
Russia	–	–	–	276 100	23 700	15 000	–	–	–	314 800
Estonia	–	–	–	26 400	1 7600	1 100	–	–	–	45 100
Latvia	–	–	–	3 600	49 600	11 400	–	–	–	64 600
Lithuania	–	–	–	–	11 140	54 160	–	–	–	65 300
Poland	–	–	–	–	–	311 900	–	–	–	311 900
Germany	–	–	–	–	–	18 200	10 400	–	–	28 600
Denmark	–	–	–	–	–	1 200	12 340	1 740	15 830	31 110
Sweden	113 620	176 610	–	–	–	83 225	–	2 885	63 700	440 040
All	259 620	215 910	9 000	413 100	102 040	496 185	22 740	4 625	79 530	1 602 750
Helsinki Commission non-signatories										
Belarus					25 800	58 050				83 850
Ukraine						11 170				11 170
Czech Republic						7 190				7 190
Slovakia						1 950				1 950
Norway	1 055	4 855							7 450	13 360
Entire Baltic Sea catchment area										
All	**260 675**	**220 765**	**9 000**	**413 100**	**127 840**	**574 545**	**22 740**	**4 625**	**86 980**	**1 720 270**

Source: *Helsinki Commission 2004*

The greatest portion of the Baltic catchment area is in Sweden, followed by those in Poland, Russia, and Finland. Although the 29 000 km² in Germany make up the smallest Baltic catchment area of any country, they are very densely populated. The Baltic Proper (BAP) catchment area has 74 inhabitants per km², the Western Baltic (WEB) catchment area has 159. The catchment areas of Bothnian Bay (BOB) or Bothnian Sea (BOS) are, by comparison, very sparsely populated (Fig. VI 3.2.1-2).

Fig. VI 3.2.1-2: *Population densities in the Baltic Sea catchment area*



Source: *Helsinki Commission 2004*

Some 60 % of the German Baltic catchment area is in Mecklenburg-Western Pomerania, 18 % is in Schleswig-Holstein, and 22 % in Brandenburg and Saxony.

The largest pollution load flows into the Baltic Sea via its rivers, which comes from point and diffuse sources spread over the entire Baltic catchment area. The long-term mean riverine flow into the Baltic Sea is 479 km³ per annum (15 190 m³/s), of which approximately half is contributed by the seven largest rivers: the Neva, Vistula, Neman, Daugava, Oder, Göta älv, and Kemijoki (Table VI 3.2.1-2).

Freshwater outflow from the German Baltic catchment area is limited to a large number of small rivers and basins, which contributes little to the total influx. The Oder, which runs along the Polish-German border for some 200–300 km, reaches the Baltic Sea in Poland.

60–70 % of land in the German, Danish, and Polish catchment area is arable land. In Estonia, Latvia and Lithuania this figure is only 30–50%, while only 10 % of the Swedish, Finnish, and Russian catchment area is farmed. Between 66 % and 90 % of the Russian, Swedish, and Estonian catchment area is forest, marsh, or water bodies, ca. 30–50 % in Poland, Latvia, and Lithuania, and only 20–25 % in Denmark and Germany (Tab. VI 3.2.1-3 and Fig. VI 3.2.1-3).

VI 3.2.2 Discharges/losses to surface waters

Discharges/losses to surface waters in the Baltic Sea catchment area by HELCOM Contracting Parties

The main sources of nutrient pollution and the associated eutrophication in the Baltic Sea are nitrogen and phosphorus inputs from runoff from dry land and from the atmosphere. Discharges of waste water from municipalities and industry, especially from the territories of Eastern European countries, and intensive agricultural use, particularly in the Western European countries but also in the Baltic states and Poland, play a crucial role in this contamination.

In 2000 for the first time, the Helsinki Commission as part of the "Fourth Baltic Sea Pollution Load Compilation – PLC-4", drew up a balance of nutrient discharges/losses from point and diffuse sources into the surface waters throughout the whole Baltic Sea catchment area belonging to the HELCOM signatories. Discharges/losses from point sources were grouped according to whether they originated from direct discharges, municipal sewage treatment plants, and fish farming plants. The differentiation according to PLC-4 guidelines into six categories of diffuse sources – atmospheric deposition, erosion, surface runoff, groundwater, drainage and urban spaces, plus the natural background load – was not followed by most of the signatories because of methodological difficulties, so the discharges/losses from diffuse sources were only shown as a total. This type of discharges/losses inventory throughout the Baltic Sea catchment area is required so that conclusions can be drawn about whether the reduction targets for nutrient and pollutant inputs of 50 % that were set at the Ministers Conference of all the Baltic Sea littoral states in Rønneby in 1988 have been met, i.e., whether measures taken to reduce pollutant inputs at source have been successful and which measures have to be taken in the future to achieve the nitrogen target.

According to the PLC-4 report, nutrient discharges/losses to surface waters in the Baltic catchment area belonging to the HELCOM signatories amounted to 822 000 t/a nitrogen (Fig. VI 3.2.2-1)

Tab. VI 3.2.1-2: *River catchment area of the seven largest Baltic Sea rivers*

River / Country	Neva	Weichsel	Neman	Daugava	Oder	Göta älv	Kemijoki	All
Long-term average runoff of the seven largest Baltic Sea rivers								
in m^3/s	2 488	1 081	664	637	574	572	553	6 569
Period	1859–1988	1951–1990	1811–1995	1881–1914; 1924–2000	1951–1990	1961–1990	1961–1990	–
Lengths of the seven largest Baltic Sea rivers								
in km	74[1)]	1 047	937	1 020	854	90[2)]	600	–
Helsinki Commission signatories' catchment area								
Finland	56 200						49 470	105 670
Russia	215 600		3 170	27 000			1 660	244 130
Estonia				2360				2360
Latvia			90	23 700				23 840
Lithuania			46 700	170				48 560
Poland		168 700	2 510		106 060			277 270
Germany					5 590			5 590
Denmark								
Sweden						42 780		42 780
Helsinki Commission non-signatories' catchment area								
Belarus		12 600	45 450	2 5800				83 850
Ukraine		11 170						11 170
Czech Republic					7 190			7 190
Slovakia		1 950						1 950
Norway						7 450		450
Entire Baltic Sea catchment area								
All	**271 800**	**194 420[3)]**	**97 920**	**84 170**	**118 840**	**50 230**	**51 130**	**868 510**

[1)] Length of the Neva to the Ladoga Sea
[2)] Length of the Göta to Lake Vänern
[3)] excl. delta

Source: *Helsinki Commission 2004*

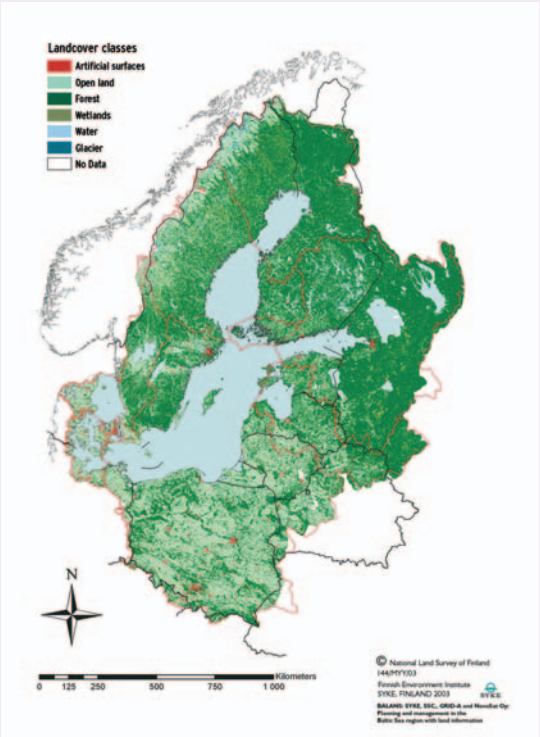
Tab. VI 3.2.1-3: *Land use in the Baltic Sea catchment area in %*

Signatories / Land Use	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden
Urban land	14	3	2	4	2	5	6	2	3
Forest (incl. rocks)	16	44	51	15	44	31	29	55	70
Agricultural land	66	30	7	72	39	54	60	12	6
Water (lakes)	1	5	10	4	1	4	3	17	8
Marsh, wetlands	1	17	27	–	5	2	–	13	12
Other	2	1	3	5	9	4	2	1	1

Source: *Helsinki Commission 2004*

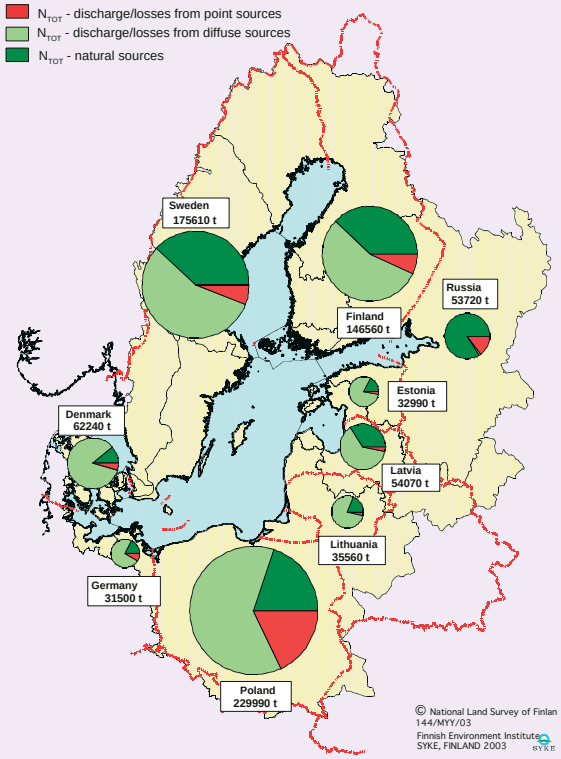
and 41 200 t/a phosphorus in 2000 (Fig. VI 3.2.2-2). Most of the nitrogen (59 %) and phosphorus discharges/losses (54 %) came from diffuse sources, mainly from agricultural areas, so if nutrient discharges/losses to surface waters in the Baltic catchment area are to be reduced, effective measures need to be taken in the agricultural sector. The natural background load has a share of 32 % for nitrogen, while the remaining 10 % of nitrogen discharges/losses are caused by point sources in the Baltic catchment area. For phosphorus, the natural background load has a share of 27 %, and 20 % comes from point sources. Regarding the shares from diffuse sources from the littoral states, it can be seen that these are highest in Denmark (87 %), Estonia (74 %), and Lithuania (73 %) for nitrogen and in Denmark (65 %), Poland (63 %), and Germany (60 %) for phosphorus. While point sources in general constitute the smallest share of discharges/losses to surface waters, they nonetheless amount to between 14 % and 18 % for nitrogen in Poland and Russia, and between 19 % and 29 % for phosphorus in Denmark, Latvia, and Poland. In Russia, around half of the phosphorus discharges come from industry and municipalities. This indicates that in the Baltic states, Poland and Russia, in particular, measures in the point sources area would be an effective way of reducing nutrient discharges/losses to surface waters in the Baltic catchment area.

Fig. VI 3.2.1-3: *Distribution of land use in the Baltic Sea catchment area*



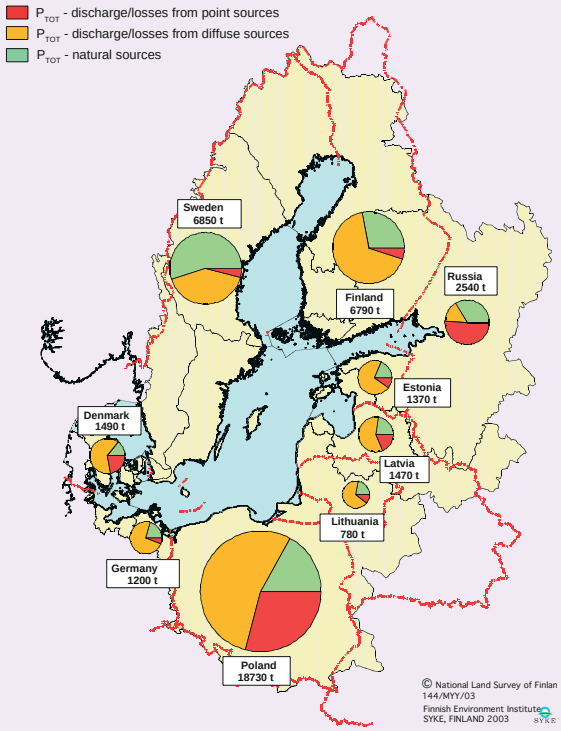
Source: *Helsinki Commission 2004*

Fig. VI 3.2.2-1: *Nitrogen discharge/losses from point and diffuse sources to surface waters in the Baltic Sea's catchment area of the HELCOM signatories in 2000 (in t)*



Source: *Helsinki Commission 2004*

Fig. VI 3.2.2-2: *Phosphorus discharge/losses from point and diffuse sources to surface waters in the Baltic Sea's catchment area of the HELCOM signatories in 2000 (in t)*



Source: *Helsinki Commission 2004*

Discharges/losses to surface waters in the German Baltic Sea catchment area

Nutrients

The main sources of nutrient inputs to the Baltic are agriculture, municipal sewage treatment plants, power stations, transport, and industry. Approximately 95 % of atmospheric emissions of NO_x are due to transport and power stations (including industrial furnaces). Agricultural NH_3 emissions are another important component. In contrast, industrial sewage is a relatively unimportant source, as there are only small industrial sites in the German catchment area of the Baltic Sea, and industrial activity in the new *Länder* has fallen dramatically since 1989.

Nutrient discharges/losses from point and diffuse sources to the Baltic catchment area have been calculated for the periods from 1983 to 1987, 1993 to 1997, and 1998 to 2000, for simplicity's sake referred to hereafter as 1985, 1995, and 2000.
Discharges/losses are shown separately for municipal sewage treatment plants, direct industrial discharges (point sources), and for atmospheric deposition, erosion, runoff, groundwater, drainage and ur-

ban areas (diffuse sources). Discharges/losses to surface waters in the Baltic catchment area in Germany were 60 300 t/a nitrogen and 4 070 t/a phosphorus in 1985, and 34 120 t/a nitrogen and 1 370 t/a phosphorus in 2000. Therefore in 2000, nitrogen and phosphorus discharges/losses to surface waters in the German Baltic Sea catchment area have fallen by 43 % and 66 % respectively compared with the 1985 reference year. The inventory of nutrient emissions in the surface waters of the German Baltic Sea catchment area shows that the reduction target (50 % reduction for both) was met for phosphorus but not for nitrogen.

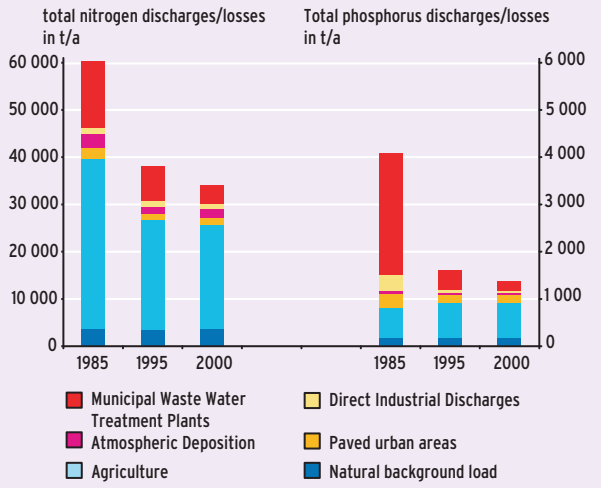
The 43 % reduction in nitrogen discharges/losses was achieved mainly through a sharp fall in nitrogen discharges/losses from point sources (67 %). In contrast, there was a ca. 35 % fall in nitrogen discharges/losses from diffuse sources, with inputs from agriculture (65 %) playing a crucial role in 2000 in this area. Of agricultural inputs in 2000, drainage and groundwater, with 37 % each, are the dominant diffuse input paths. Nitrogen discharges from point sources now only have a 15 % share of all nitrogen discharges/losses. Nitrogen inputs via erosion, surface runoff from mainly agricultural areas, and atmospheric deposition altogether contributed around 10 %, or very little, to the total inputs.

The ca. 61 % reduction in phosphorus discharges/losses is also due primarily to reductions in point source discharges (92 %). Diffuse losses fell by only 5 %; this was caused above all by reductions in runoff from urban areas (45 %) and atmospheric deposition (40 %), accompanied by a considerable rise in the contribution from runoff from mainly agricultural areas (+75 %). Due to the enormous reduction in point source discharges of phosphorus in the German river catchment areas, they ceased to be the dominant input path in 2000, as they had been in 1985 – in 2000 diffuse phosphorus losses constituted 82 % of all phosphorus discharges/losses, with agriculture having a ca. 55 % share. Phosphorus discharges/losses via groundwater or erosion (22 % and 34 %) caused by agricultural inputs are the main input sources (Fig. VI 3.2.2-3).

Heavy metals and lindane

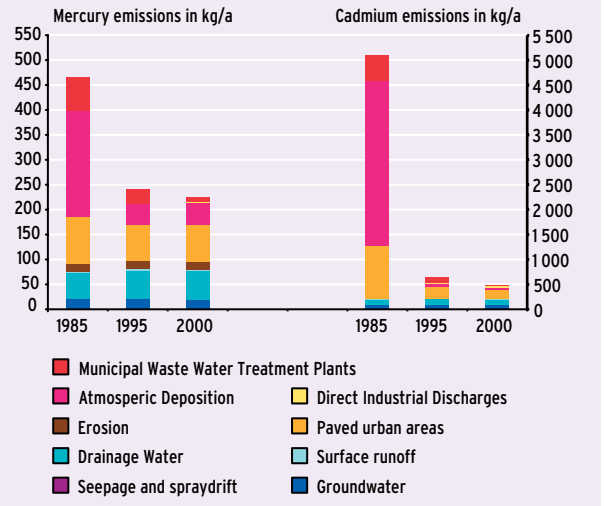
Discharges/losses of heavy metals and lindane to surface waters in the Baltic Sea catchment area fell sharply between 1985 and 2000. The halving of heavy metal inputs to the Baltic required by the Helsinki Commission was either achieved or exceeded in the case of cadmium (90%), mercury (52 %), lead (70 %), chrome (69 %), and the metalloid arsenic (68 %). The exceptions are zinc (19 %), copper (29 %), and nickel (41 %). There was a 78 % reduction in lindane. The reductions are primarily due to the dramatic fall in direct industrial discharges, of 60 % for lead and up to 95 % for mercury (Fig. VI 3.2.2–4). Measures taken by the industrial sector in response to tighter regulations have played a major role in this environmental relief, as has the decline in industrial activity in the Oder's catchment area in Germany. By 2000, direct industrial discharges were only of minor significance. The significance of discharges from municipal sewage treatment plants continued to be high, but water pollution in 2000 was dominated by diffuse sources. The most significant input paths were sewage systems and unconnected residents, erosion, and groundwater inflows.

Fig. VI 3.2.2-3: *Nitrogen and phosphorus discharges/losses from the German Baltic Sea catchment area*



Source: *Federal Environment Agency 2003*

Fig. VI 3.2.2–4: *Mercury and cadmium discharges/losses from point and diffuse sources in the German Baltic Sea catchment area*



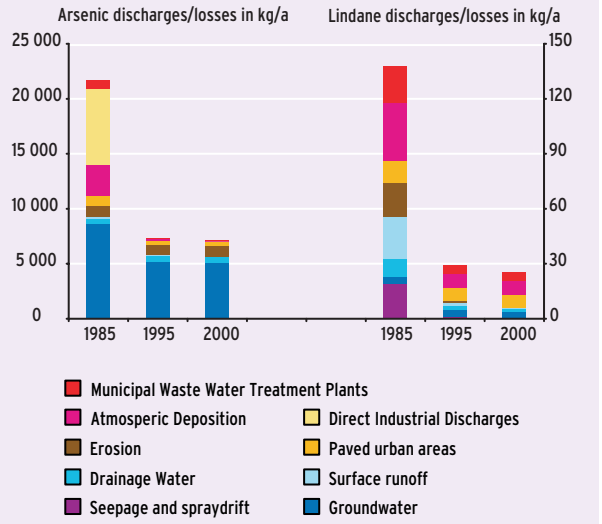
Source: *Federal Environment Agency 2003*

Urban areas are a major source of heavy metal inputs to surface waters, including the combined and separated sewage systems. The combined sewer overflow and storm-water flows from separated sewage systems cause 10–40 % of all heavy metal discharges/losses, with high proportions of zinc, lead, and copper being particularly evident. Since a large proportion of the storm-water flows are routed to waste water treatment plants in combined sewers, these systems cause less water pollution through heavy metals than the separated system. The metals chrome and lead, in particular, enter waters through erosion, while geogenic inputs (groundwater route) predominate with arsenic (45 %) and nickel (54 %). There are significant differences in pollution levels between the various river basins due to varying land use and climatic factors.

The fall in lindane discharges/losses to surface waters in the German Baltic Sea catchment area between 1985 and 2000 is mainly linked to the fact that the use of lindane has been tightly restricted in Germany since the mid-1980s, and it has been banned as a pesticide since 1997. As lindane present in the environment is only degraded very slowly, it can still be found in the atmosphere, in the soil and in water, and it was still entering surface waters in 2000.

In 1985, municipal sewage treatment plants were identified as the most important input path, but since 1985 discharges have fallen by 52 % due to the sharp decline in the use of lindane and smaller concentrations in storm-water flows from urban areas (Fig. VI 3.2.2-5). Another significant input path in 1985 – the reference year – was runoff from non-urban areas (20 %). In the catchment area of the Oder and the Baltic Sea coast, the largest share of contamination came from lindane runoff due to the greater amounts used in the former GDR. In 2000, discharges/losses from urban areas and direct atmospheric deposition onto the water surface were the most significant diffuse input paths, with 28 % in each case. As a result of the decline in overall discharges/losses, the share of input from groundwater rose to 15 % in 2000. As a result of the reduced sorption of lindane, only ca. 1 % of all lindane inputs were caused by erosion.

Fig. VI 3.2.2-5: *Arsenic and lindane discharges/ losses from point and diffuse sources in the German Baltic Sea catchment area*



Source: *Federal Environment Agency 2003*

The "Fourth Baltic Sea Pollution Load Compilation – PLC-4" produced estimates of inputs of organic substances, nutrients, and heavy metals via the rivers that discharge into the Baltic Sea, the coastal catchment areas that are not monitored, and direct discharges of waste water. Compared with the surveys done in 1987, 1990, and 1995, the new survey for 2000 delivered more reliable and comprehensive data which provide an overview of inputs of pollutants into the Baltic Sea.

In 2000, total inflows from rivers, unmonitored coastal catchment areas and direct point source discharges amounted to 584 200 million m^3 per annum, which equates to runoff of 11 l/(s km^2). Of this, ca. 91 % comes from inflows into the Baltic Sea, ca. 8 % from unmonitored coastal catchment areas and less than 1% from direct discharges from municipal sewage treatment plants and industry. Riverine inputs are measured as immissions at the last riverine monitoring station, and inputs from unmonitored coastal catchment area and direct inputs from point sources to coastal waters are added to these.

Discharges into the Baltic Sea in 2000 consisted of 1 130 kt BOD_7 (biochemical oxygen demand by micro organisms in decomposing organic material within seven days), 745 kt nitrogen (N_{TOTAL}) and 34.6 kt phosphorus (P_{TOTAL}). That equates to an input of 680 kg/km^2 BOD_7, 440 kg/km^2 nitrogen, and 21 kg P/km^2 phosphorus. Ca. 82% of the BOD_7 and 77 % of the nitrogen and phosphorus loads were input from the Baltic Sea Rivers. The pollution share from unmonitored catchment areas is 10–17 % and the share from municipal sewage treatment plants

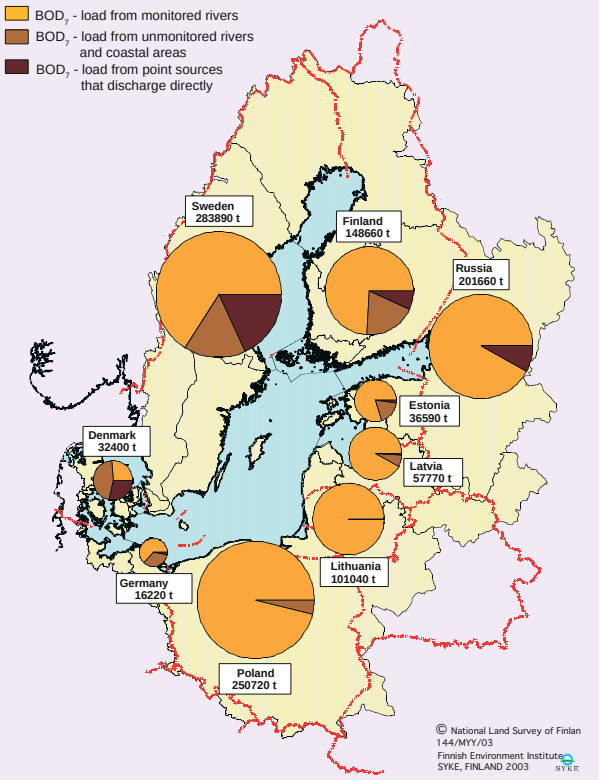
VI 3.2.3 Riverine and direct discharges

Riverine and direct discharges to the Baltic Sea by HELCOM Contracting Parties

Since 1980, the Helsinki Commission [1] has carried out complicated Periodic Assessments of the State of the Environment of the Baltic Sea and Baltic Sea Pollution Load Compilations every five years.

and industrial operations that discharge directly into the Baltic Sea is under 10 %. The individual signatories' shares of the pollution input of BOD_7, N_{TOTAL}, and P_{TOTAL} are shown in Figures VI 3.2.3-1, VI 3.2.3-2, and VI 3.2.3-3.

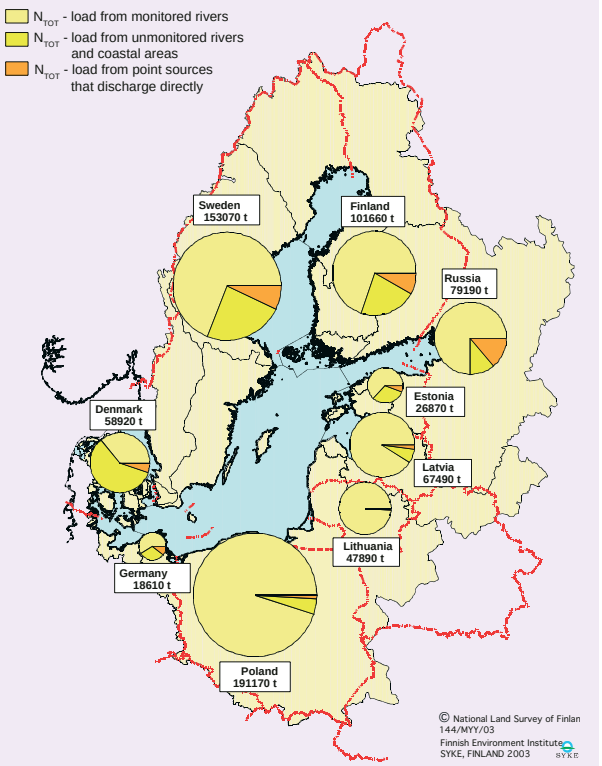
Fig. VI 3.2.3-1: *1 BOD_7 inputs from rivers that discharge into the Baltic Sea, unmonitored coastal catchment areas and point sources that discharge directly into the Baltic from the HELCOM signatory states in 2000 (in t)*



Source: *Helsinki Commission 2004*

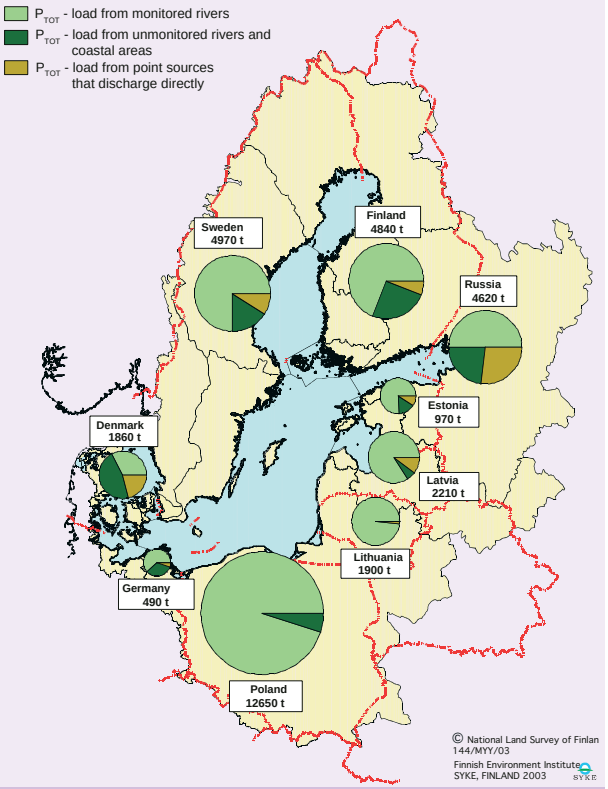
The majority of nutrients and organic matter is discharged into Baltic Proper, the largest subregion with the most polluters. However, the Gulf of Riga and Gulf of Finland must also be considered heavily polluted, in terms of both their relative sizes and the number of discharges. Oxygen deficiencies often cause occurrences of eutrophication on the seabed here. Bothnian Bay should also be noted, owing to the inputs of organic substances in industrial sewage. This is where most of the pulp processing factories are located. The highest per square kilometre inputs of nitrogen and phosphorus occur in the Western Baltic and the Kattegat, regions where marine over-fertilisation during the summer can cause increased levels of algae growth, shifts in the species mix and, when climatic and hydrographic conditions are suitable (layered water masses), oxygen deficiencies on the seabed due to the bacterial degradation of dead algae. This deficiency can cause organisms that live in the soil to die off in large quantities.

Fig.VI 3.2.3-2: *Nitrogen inputs (Total N) from rivers that discharge to the Baltic Sea, unmonitored coastal catchment area and point sources that discharge directly into the Baltic from the HELCOM signatory states in 2000 (in t)*



Source: *Helsinki Commission 2004*

Fig. VI 3.2.3-3: *Phosphorus inputs (Total P) from rivers that discharge to the Baltic Sea, unmonitored coastal catchment area and point sources that discharge directly into the Baltic from the HELCOM signatory states in 2000 (in t)*



Source: *Helsinki Commission 2004*

Alongside nutrients, heavy metals and a wide variety of ecotoxicologically significant organic substances flow into the Baltic Sea from the rivers and play a major part in its contamination. The survey in 2000 provided an overview of the heavy metals input into the Baltic Sea. The actual inputs of heavy metals into the Baltic Sea in 2000 probably exceed the levels shown in Table VI 3.2.3-1, as not all the HELCOM signatories provided full data on all the categories required. This is due to insufficient analytical techniques and unsuitable measuring methods, particularly those for measuring small concentrations of heavy metals. Only four HELCOM signatories submitted heavy metal inputs from point sources discharging directly into the Baltic (Denmark, Germany, Poland, and Sweden) and from unmonitored coastal catchment areas (Denmark, Germany, Finland, and Sweden). Although the data on riverine inputs is also incomplete and there is no information at all on inputs of heavy metals from the Russian Kaliningrad catchment area, it is evident that the largest quantities of cadmium, lead, and copper are discharged to the Finnish bays. In contrast, mercury reaches mainly the Baltic Proper via the large Baltic rivers.

Lead and copper inputs from the Russian Neva River, for example, account for 60 % and 40 % of the total, while ca. 90 % of all riverine mercury inputs are carried by the Weichsel and Oder rivers in Poland.

Riverine and direct discharges to the Baltic Sea by Germany

German riverine inputs are calculated on the basis of 31 rivers with a catchment area of 23 010 km^2 in Mecklenburg-West Pomerania and Schleswig-Holstein, of which 16 170 km^2 are monitored catchment areas, i.e., measurements are taken in the riv-ers below the last riverine monitoring station. The inputs from the 6 800 km^2 of unmonitored German Baltic Sea catchment area are determined by projecting to 100 % of the catchment surface area while taking into account the direct discharges from municipal sewage treatment plants and industry (Tab. VI 3.2.3-2). Inputs from the Oder catchment area in Brandenburg and Saxony (5 600 km^2) are not included, since the Oder reaches the Baltic Sea in Poland. Overall, the pollution loads to the Baltic Sea from Germany account for something in the region of 2 % of total discharges by all littoral states.

Some measurements for nutrients and pollutants in German Baltic Sea Rivers reach back to 1975, and these figures have been used in evaluating inputs. In 1988, 20 447 t nitrogen and 1 108 t phosphorus were discharged into the Baltic Sea via German rivers. In comparison, in 2002 730 t phosphorus were discharged, but the 31 600 t nitrogen load in 2002 is around 10 000 up on 1988. When comparing riverine inputs over the 1988 to 2002 period, the decisive influence of flow rates should not be ignored. In 1994 and 2002, heavy rainfall caused flow rates that were almost double those of 1990, 1996, and 1997. Discharges of both phosphorus and nitrogen correlate strikingly with river flow. Higher flow rates are accompanied by a drop in the concentrations of phosphorus (dilution), while nitrogen reacts in the opposite way. Greater leaching and runoff from agricultural land produces higher nitrogen input, which leads to a significant rise in concentrations and loads of nitrogen (Fig. VI 3.2.3-4).

Thus no direct comparison between the nutrient loads in 1988 and 2002 is possible. However, the comparison of nutrient loads from 1988 and 2000, which had similar runoff conditions, indicates that discharges/losses from the German catchment area had fallen for phosphorus but not for nitrogen. So the large fall in phosphorus discharges is currently reflected in the water quality of Germany's Baltic

Tab. VI 3.2.3-1: *Inputs of heavy metals into the Baltic Sea via rivers, unmonitored coastal catchment area and point sources discharging directly into the Baltic Sea in t/a*

	Inputs into the Baltic Sea from rivers			Inputs into the Baltic Sea from directly discharging point sources Data from DK, GE, PL, SW only			Total inputs into the Baltic Sea
	Rivers	Unmonitored coastal areas[2)]	Total[2)]	Sewage treatment plants[1)]	Industry[1)]	Total[1)]	
Cadmium	49	2,7	**51**	0,7	0,9	**1,6**	**53**
Mercury	45	1,1	**46**	0,5	0,1	**1**	**46**
Copper	924	125	**1 049**	15	5	**19**	**1 068**
Lead	434	38	**472**	3,3	2,5	**6**	**477**
Zinc	2 446	493	**2 939**	70	49	**119**	**3 059**

1) Point source inputs from Denmark, Germany, Poland, and Sweden only

2) Inputs from unmonitored coastal areas of Denmark, Germany, Finland, and Sweden only

Source: *Helsinki Commission 2004*

Tab. VI 3.2.3-2: *German chemical inputs into the Baltic Sea from rivers and unmonitored coastal catchment area from 1995 to 2002*

	1995	2000	2002
Runoff			
Q in m m^3/a	4 551	3 548	5 877
Nutrients			
P_{total} in t/a	613	462	729
PO_4-P in t/a	276	229	351
N_{total} in t/a	23 988	16 607	31 619
NH_4-N in t/a	1 515	692	893
NO_2-N in t/a	245	132	256
NO_3-N in t/a	18 621	12 555	24 308
Heavy metals			
Hg in kg/a	140	39	26
Cd in kg/a	204	114	229
Zn in kg/a	21 945	13 811	37 398
Cu in kg/a	13 659	4 020	12 705
Pb in kg/a	2 350	1 814	4 856
Ni in kg/a	2 988	4 583	7 366
Cr in kg/a	1 504	762	2 643
As in kg/a	2 108	890	7 625

Source: *Federal Environment Agency 2004 g*

Sea inflows. No downward trend is yet discernible for nitrogen, neither in riverine loads nor in concentrations.

In contrast, a downward trend can only be seen in mercury and copper inputs to the Baltic Sea from the German Baltic Sea catchment area between 1995 and 2002. Inputs of other heavy metals during the same period have remained stable or risen slightly. However, in the rainy year of 2002, all the heavy metal loads were far higher than 2001 due to the increased runoff.

VI 3.2.4 Inputs of airborne pollutants to the Baltic Sea

Over the last decade, inputs of the trace materials lead (72 %), cadmium (65 %), and mercury (50 %) have declined (Tab. VI 3.2.4-1).

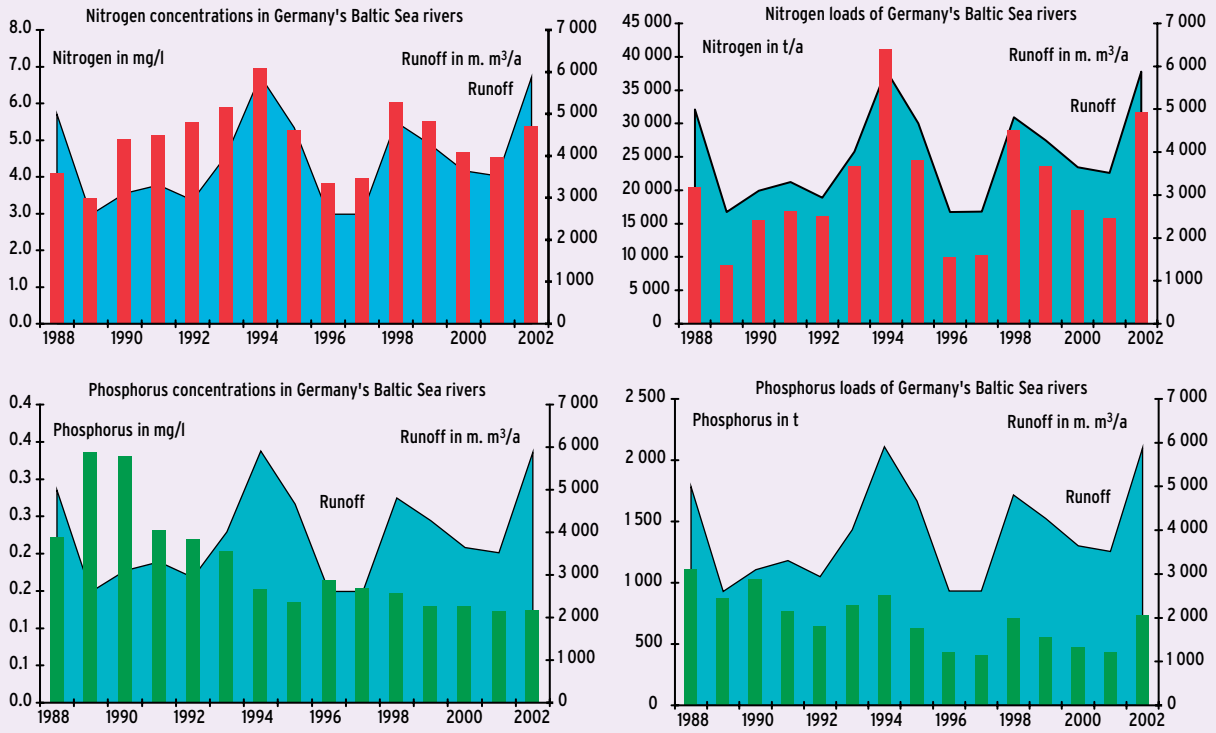
Heavy metal and nitrogen inputs are calculated based on model calculations run by the EMEP for HELCOM.

Nitrogen inputs had fallen since 1990, but have risen slightly again. This is comparable to the trend of air emissions of the other HELCOM countries (Table VI 3.2.4-2).

Heavy metal inputs have fallen by over 80 % for lead and 65 % for cadmium since 1990, while mercury inputs to the Baltic Sea have fallen by half. However, since 1996 heavy metals inputs have remained constant or declined only slightly.

POPs mainly enter the seas via the atmosphere. Due to their toxicity and tendency to bioaccumulation, they are increasingly controlled by new monitoring programmes. Measurement data are also used to validate the models used to calculate POP inputs.

Fig. VI 3.2.3-4: *Nutrient concentrations and loads in Germany's Baltic Sea rivers*



Source: *Federal Environment Agency 2004 g*

Tab. VI 3.2.4-1: *Inputs of air pollutants into the Baltic Sea in t/a*

	Lead	Cadmium	Mercury
1991	628	26	6
1992	–	26	–
1993	703	29	–
1994	677	29	6
1995	577	25	6
1996	187	9	3
1997	185	10	3
1998	194	4	3
1999	170	7	3
2000	178	9	3

Source: *EMEP 2004*

Tab. VI 3.2.4-2: *Total nitrogen inputs into the Baltic Sea in kt/a*

	NO_x	NH_y	N-total
1990	175	102	276
1991	158	142	300
1992	146	134	280
1993	140	133	273
1994	137	131	268
1995	128	120	248
1996	134	95	229
1997	129	86	215
1998	115	110	225
1999*)	–	–	–
2000	180	113	293

*) Not yet available

Source: *EMEP 2004*

POP inputs at the Zingst station have been falling since 1994, with the decrease being 78 % for α-HCH and 75 % for γ-HCH. Nothing can be concluded about HCB and Aldrine as the levels were measured at the detection limits. From when monitoring began, BaP levels rose by ca. 40 % up until 1998 but have been declining since then (47 %). The marked fluctuations in POP measurement results is probably due to both significant meteorological fluctuations and the fact that the analytical laboratory was changed in 1998 (Tab. VI 3.2.4-3).

VI 3.2.5 Pollution in Baltic Sea marine waters

The Federal/*Länder* Monitoring Programme for the Baltic regularly monitors a number of hazardous substances, as defined by HELCOM's Baltic Monitoring Programme, in the open seas. In the future, in line with the Water Framework Directive, 33 hazardous substances in coastal waters are to be regularly measured (total sample including dissolved substances and those bound to suspended matter). The marine environment database (MUDAB) already contains data on some of these substances (Fig. VI 3.1.5-1). Since there is not yet a standardised way of presenting the data under the Water Framework Directive, here the annual mean of all measured values obtained in coastal waters (inside the 12 nm zone) is shown, and compared with the provisional environmental quality standards proposed by the European Commission (annual average of the environmental quality standard (AA-EQS) and the maximum accepted concentrations (MAC-EQS)).

Tab. VI 3.2.4-3: *Annual depositions of selected POPs for the Zingst Station in µg/m³*

	α-HCH	γ-HCH	HCB	Aldrine	Heptachlore	BaP
1993	0.65	4.33	0.235	1.566	0.118	–
1994	–	5.18	0.076	1.346	0.287	–
1995	0.78	3.00	0.111	0.060	0.117	1.76
1996	0.44	7.88	0.079	0.008	0.008	2.86
1997	0.57	8.85	0.067	0.009	0.021	2.52
1998	0.48	5.81	0.066	0.063	0.114	4.49
1999	0.26	2.66	0.006	0.006	0.002	1.64
2000	0.29	2.24	0.000	0.000	0.000	1.03
2001	0.29	1.75	0.096	0.006	0.002	1.00

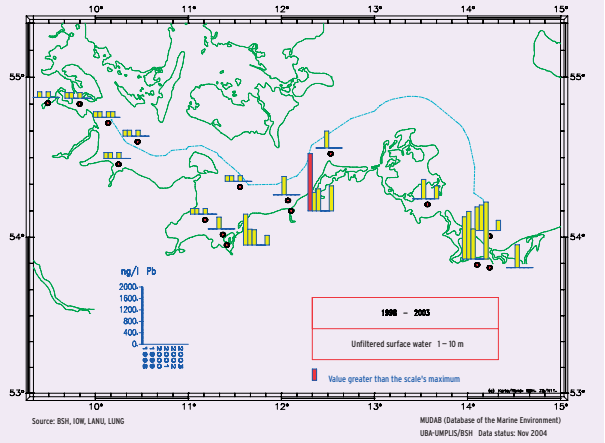
Source: *Federal Environment Agency 2004 h*

Heavy metals

There is far less regional variation in heavy metal concentrations in western Baltic Sea waters than in North Sea waters. Average concentrations of cadmium and copper are slightly higher in coastal waters than in the central Baltic. Similarly to the North Sea, mercury, lead, and zinc concentrations are often higher in coastal waters, and especially around Wismar, the Warnow estuary, and the Odra Lagoon. The overall concentrations of heavy metals in the Baltic Sea waters are nevertheless lower than in the North Sea waters. Owing to the high levels of suspended matter in North Sea coastal waters, no direct comparison can be made between the two sets of coastal measurements. High variability in salinity and suspended matter content make it difficult to establish temporal trends in heavy metal concentrations (Fig. VI 3.2.5-1 and Fig. VI 3.2.5-2).

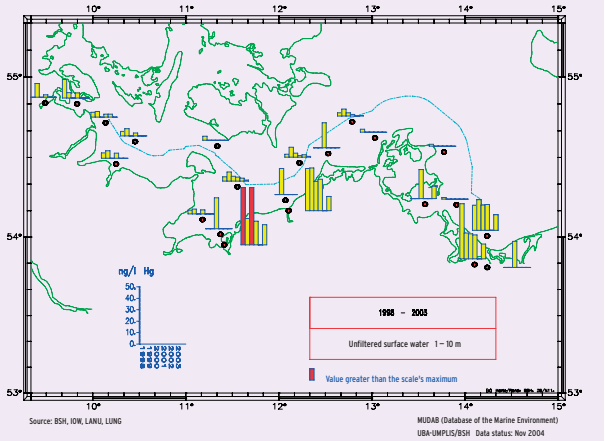
In terms of temporal trends in the heavy metals included in the 33 priority substances in the Water Framework Directive, for mercury, cadmium, lead, and nickel no clear trend is discernible in average concentrations in waters is visible within the 12 nautical miles zone. Average cadmium and nickel concentrations are below the proposed environmental quality standards (AA-EQS), while lead concentrations are above. Mercury concentrations are below the maximum permitted environmental quality standard (Fig. VI 3.2.5-3).

Fig. VI 3.2.5-1: *Lead concentration in Baltic Sea waters*



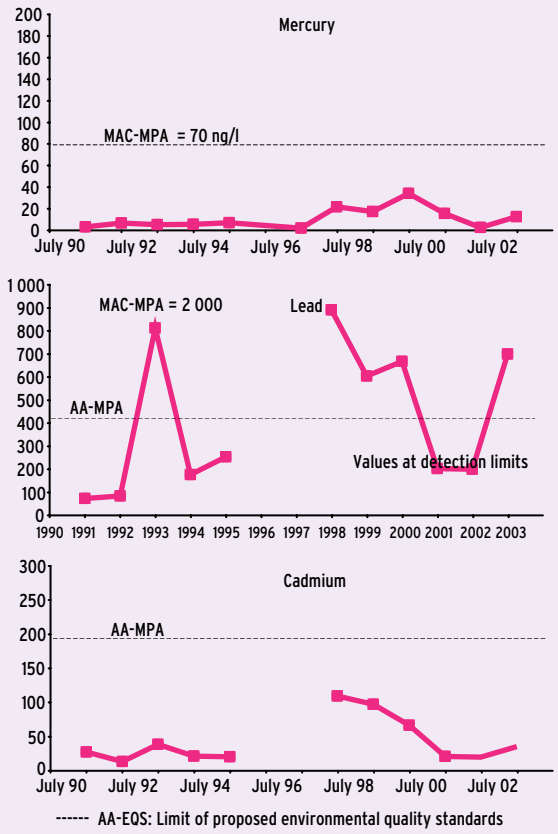
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.5-2: *Mercury concentration in Baltic Sea waters*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.5-3: *Time series of annual averages (ng/l) of heavy metals in unfiltered water (0–10 m) from the Baltic Sea (12 nm zone)*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Organic pollutants

Sufficient data for organic pollutants in water are not available for all of the 33 priority substances specified by the Water Framework Directive. The following substances have been measured in the coastal waters of the Baltic Sea in concentrations that are below the WFD's proposed environmental quality standards: anthrazene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, alpha-HCH, beta-HCH, and indeno(1,2,4-cd)pyrene. For other substances of the Water Framework Directive, there is currently too little data to be able to draw conclusions (Fig. VI 3.2.5-4).

Due to their high solubility in water, HCH isomers are slowly removed from the water column by being bound to suspended matter and subsequent sedimentation. Despite the low rate of water exchange with the North Sea, levels are also falling in the Baltic. Concentrations of α-HCH have strongly decreased, to one-fifth of the levels in 1975, due to the ban of technical HCH in the mid-1970s. There has also been a significant decrease in levels of lindane, starting in 1983 (Figs. VI 3.2.5-5 and VI 3.2.5-6).

The spatial distribution of lindane, hexachlorobenzene, fluoranthene, anthrazene, and naphthalene in the German section of the Baltic Sea indicates no areas of particularly heavy pollution (Fig. VI 3.2.5-7).

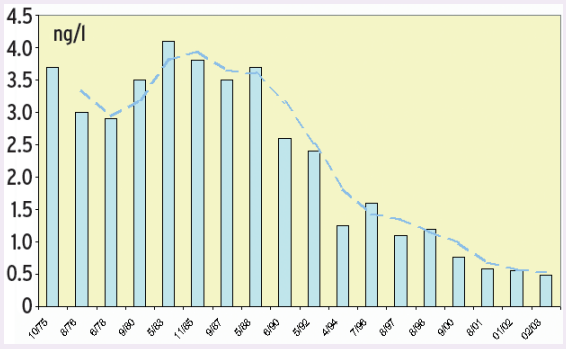
The findings from a screening project show the distribution of diuron and isoproturon in the western Baltic Sea (Fig. VI 3.2.5-8 and Fig. VI 3.2.5-9). While the distribution is relatively even in the open sea, there are clear differences in concentrations in coastal areas. The high concentrations of diuron at the western stations are probably due to the increase in shipping traffic and are accompanied by high concentrations of irgarol – both compounds are found in antifouling paints. The distribution of isoproturon and that of 2,4-D, terbutylazine und atrazine shows that the Odra is a significant input path for these herbicides.

Fig. VI 3.2.5-4: *Time series of annual averages (ng/l) of organic pollutants in unfiltered water (0–10 m) from the Baltic Sea (12 nm zone)*



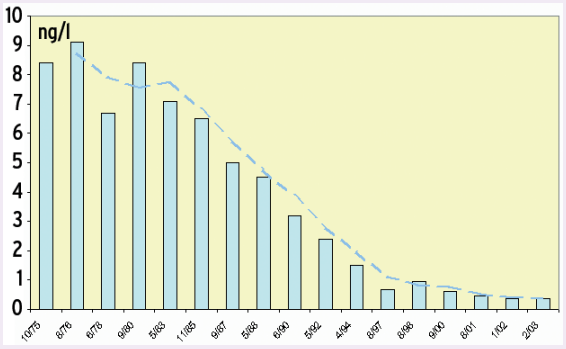
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.5-5: *γ-HCH in water, Arkona Sea*



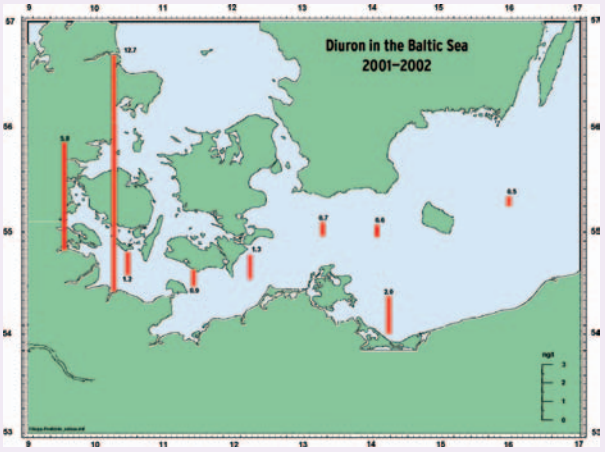
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.5-6: *α-HCH in water, Arkona Sea*



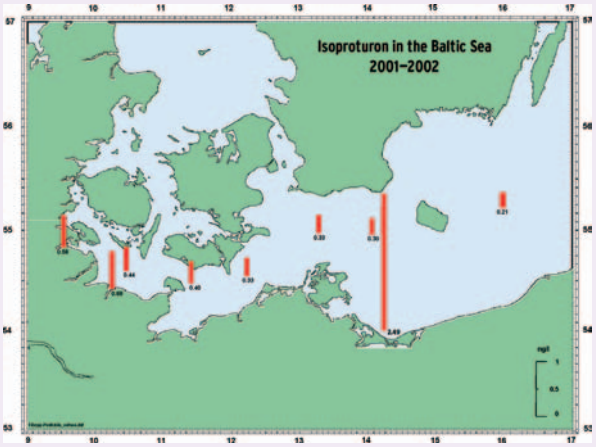
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.5-8: *Distribution of diuron in surface waters (5 m) of the western Baltic Sea*



Source: *Theobald, N. and Gerwinski, W., Federal Maritime and Hydrographic Agency 2004*

Fig. VI 3.2.5-9: *Distribution of isoproturon (ng/l) in surface waters (5 m) of the western Baltic Sea*



Source: *Theobald, N. and Gerwinski, W., Federal Maritime and Hydrographic Agency 2004*

VI 3.2.6 Pollutants in sediment

Heavy metals

Cadmium, mercury, and lead content in coastal sediments is far higher than in the Baltic Proper (Fig. VI 3.2.6-1 and Fig. VI 3.2.6-2). While cadmium and mercury content in the Baltic Proper is close to background concentrations (Hg: 0.05 mg/kg, Cd: 0.25 mg/kg, Pb: 15 mg/kg in the 20 µm sediment fraction) as defined by the UBA research project [2], the lead content is higher than background levels. Pollution is concentrated (according to the available data) in the Kiel and Lübeck Bight areas and the Odra Lagoon. By far the highest cadmium levels, of up to 7.8 µg/kg dry substance, were found in the lagoon's sediment – the average level there was around triple that in the Greifswalder Bodden.

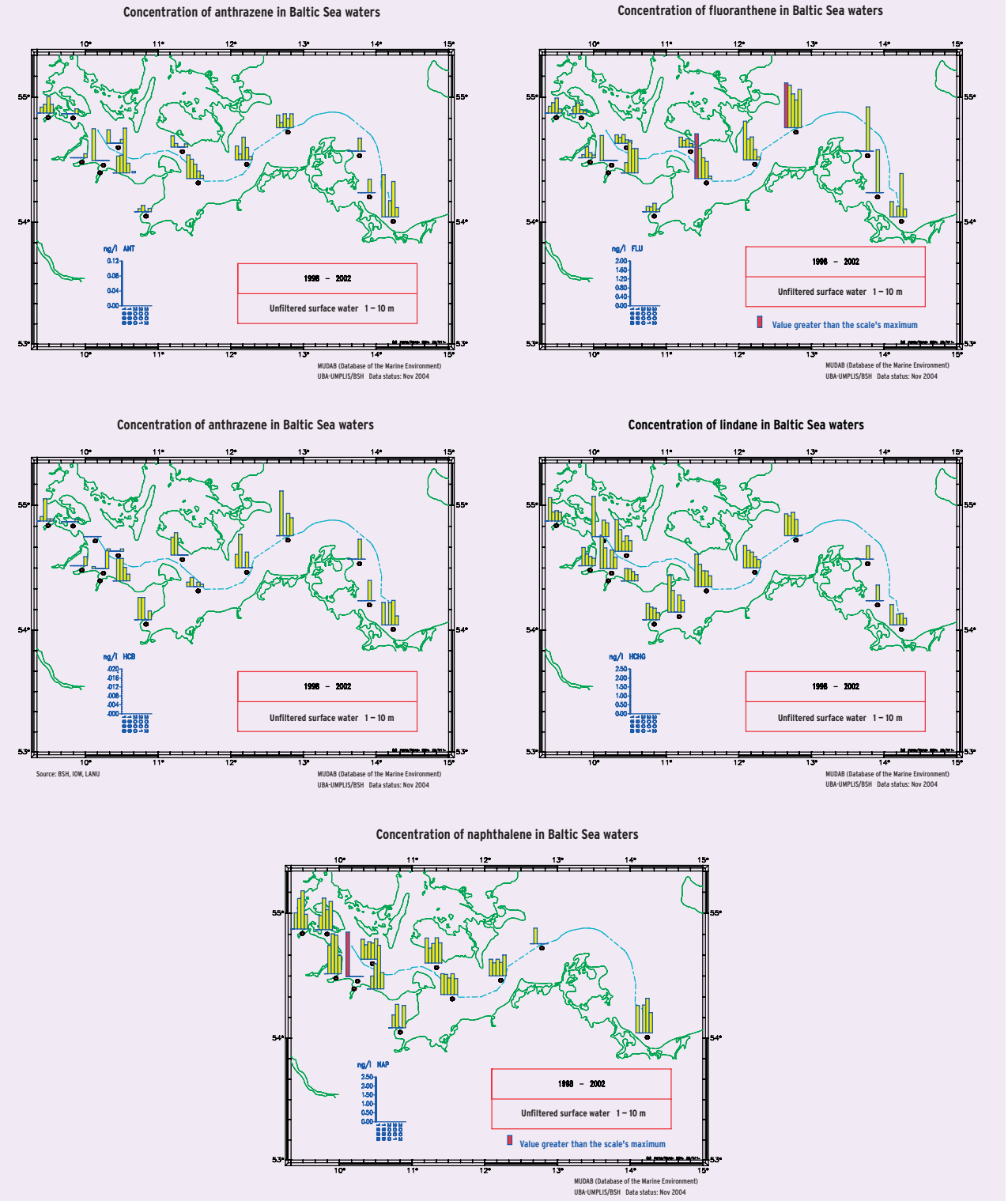
Organic pollutants

Data exists for concentrations of organic pollutants in sediments of coastal waters of Mecklenburg Pomerania. Highest pollution levels by polycyclic hydrocarbons (PAH) occur in the area of the ports of Rostock and Stralsund, and in the area affected by the Odra. PAH content in the sediments of the Mecklenburger Bucht are on average more than twice the level found in the sediments of the Darß-Zingst and Rügenscher Bodden.

The highest PAH content was found in the Lower Warnow. On average, concentrations in the sediment from the Lower Warnow were 10 to 50 times higher than those of sediments in other regions. Very low PCB concentrations were recorded in sediments from the Darß-Zingster und Rügenscher Bodden.

DDT and its metabolites still occur in a total concentration that is 10 times above the total HCH concentration. For both substance categories, the highest levels were found in the Lower Warnow. Levels in the Kleines Haff were also relatively high, while the lowest contamination was again found in sediment of the Darß-Zingst and Rügenscher Bodden. The pattern of distribution was almost identical for HCB,

Fig. VI 3.2.5-7: *Concentrations of organic pollutants in Baltic Sea waters*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

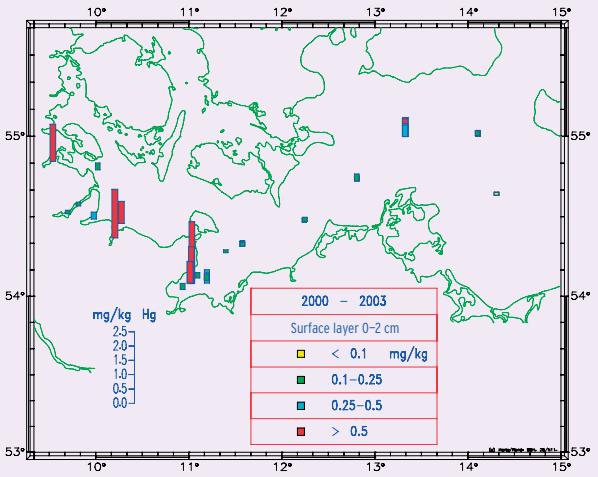
except for the fact that the highest concentration was recorded in the Haff sediments.

The highest TBT loads on the coast of Mecklenburg Pomerania were measured in the Lower Warnow, the body of water with the highest density of shipping. High levels of TBT are usually found in harbour mud and in the vicinity of ports (Tab. VI 3.2.6-1).

VI 3.2.7 Pollution in organisms

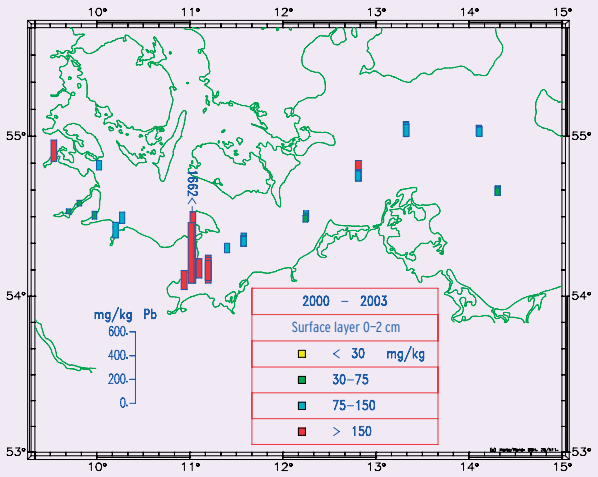
Pollutants in mussels, fish, and seabird eggs are monitored as part of the Federal/*Länder* Monitoring Programme for the North Sea and the Baltic (BLMP) (Fig. VI 3.2.7-1). Germany's Environmental Specimen Bank's monitoring programme was expanded in the early 1990s to include sampling areas along the

Fig. VI 3.2.6-1: *Mercury concentrations in the fine-grain fraction (< 20 µm) of Baltic Sea sediments*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004 a*

Fig. VI 3.2.6-2: *Lead concentration in the fine-grain fraction (< 20 µm) of Baltic Sea sediments*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004 a*

Tab. VI 3.2.6-1: *Average levels of organic pollutants in silt sediments from coastal waters off Mecklenburg-West Pomerania in the period 2000–2002, all figures in µg/kg TM*

Water Body	n	PAH6	PAH16	PCB21	DDTs	HCHs	HCB	TBT
Mecklenburger Bay	7	730	1 304	22	49.1	0.32	0.25	24
Wismar Bay incl. Salzhaff	20	537	899	37.5	34.3	0.19	0.7	226
Lower Warnow	16	1 934	4 023	224	229	1.89	0.98	954
Darß-Zingst Bodden	20	395	678	5.3	31.1	0.16	0.15	18
Rügenscher Bodden	14	304	532	4.2	3.4	0.14	0.1	14
Strelasund	9	1 107	1 853	11.9	12.7	0.3	0.4	72
Greifswalder Bodden	14	417	771	12.2	41.3	0.3	0.18	72
Peenestrom	14	687	1 272	31.5	80.2	0.75	0.44	61
Kleines Haff	10	1 167	2 253	17.3	154	1.14	1.66	64

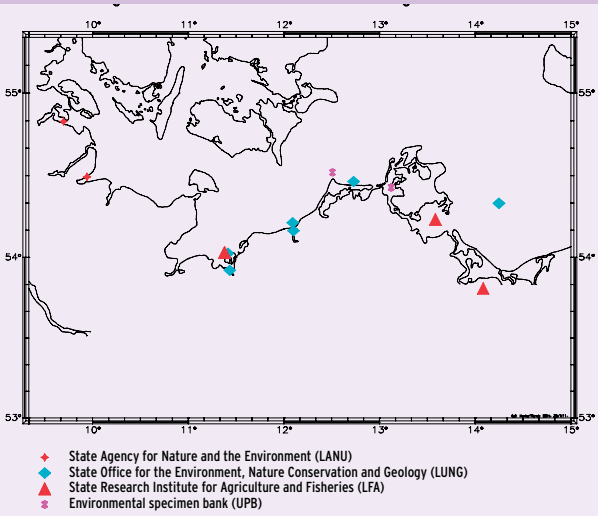
Source: *Mecklenburg-West Pomerania State Office for the Environment, Nature Conservation and Geology 2004*

German Baltic Sea coast. The common mussel (Mytilus edulis) has been sampled in the western Pomeranian Bodden (Darßer Ort) since 1992, the eelpout (Zoarces viviparus) since 1994, and herring gull (Larus argentatus) eggs from the island of Heuwiese have been analysed since 1991. There was no sampling in 1997.

Heavy metals

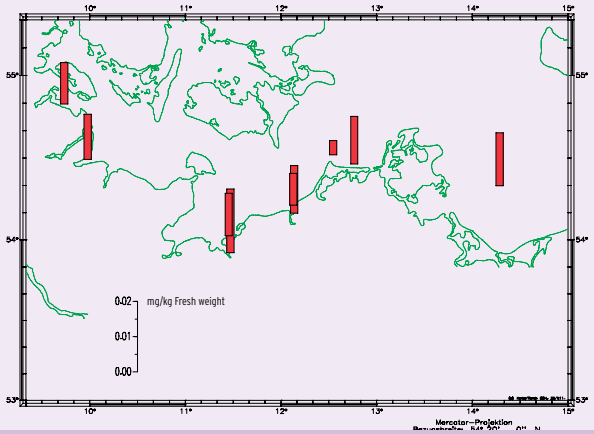
The lead, mercury, and cadmium contamination of organisms in the Baltic Sea coastal areas studied here can be considered low to moderate (Figs. VI 3.2.7-2, VI 3.2.7-3, and VI 3.2.7-4). No areas of particularly heavy pollution are evident. With concentrations of 3.1 ng/g fresh weight (FW) in mussels in the sampling year, 2003, mercury levels were about 7 times lower than in the North Sea. Lead and cadmium concentrations in mussels from Darßer Ort (0.1 µg/g FW and 0.07 µg/g FW, respectively) is almost identical to that found in Königshafen in the North

Fig. VI 3.2.7-1: *Baltic Sea network of stations monitoring hazardous substances in organisms*



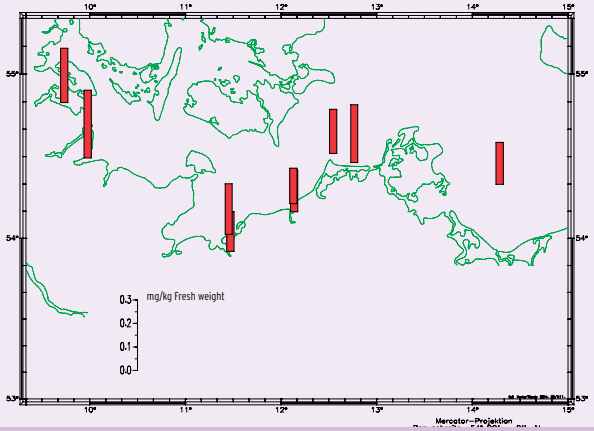
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.7-2: *Mercury concentration in mussels, Baltic Sea 2001*



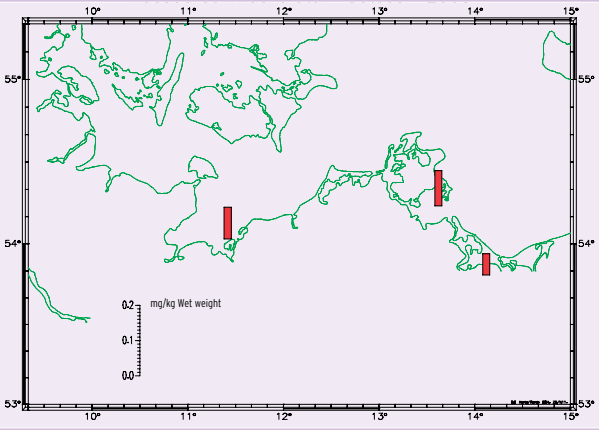
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.7-3: *Lead concentration in mussels, Baltic Sea 2001*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

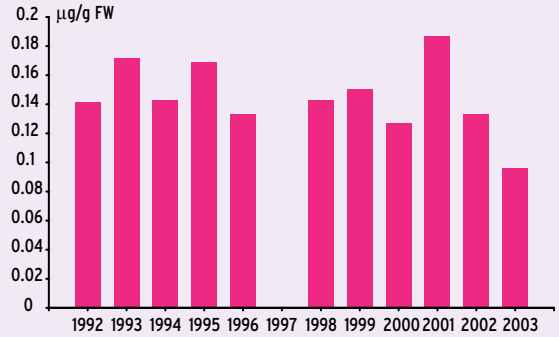
Fig. VI 3.2.7-4: *Mercury concentration in perch muscle tissue Baltic Sea 2003*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

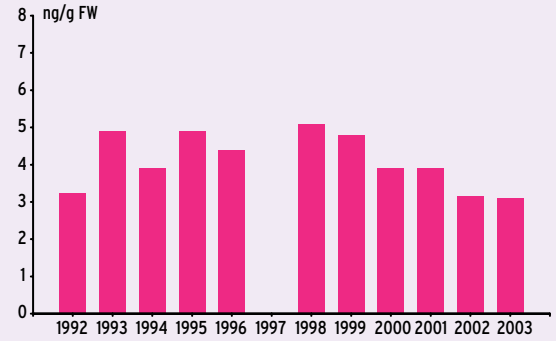
Sea (Fig. VI 3.2.7-5 and Fig. VI 3.2.7-6). For the three heavy metals studied here, recent years have seen a decrease in concentrations in mussels.

Fig. VI 3.2.7-5: *Lead in mussels (Darßer Ort)*



Source: *Federal Environment Agency 2004 d*

Fig. VI 3.2.7-6: *Mercury in mussels (Darßer Ort)*



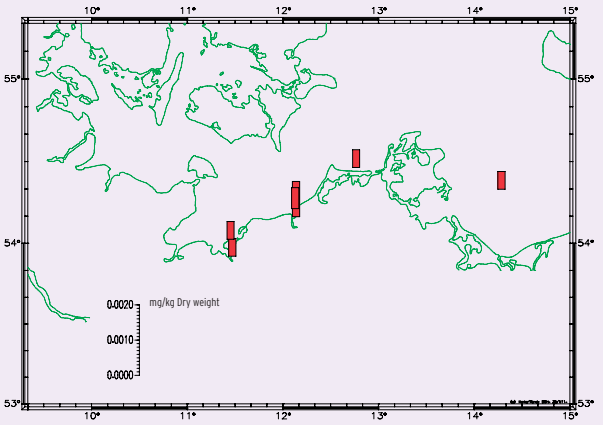
Source: *Federal Environment Agency 2004 d*

Organic pollutants

Contamination with organic pollutants in the German Baltic Sea region is caused mainly by diffuse inputs from agriculture and point source inputs from former disposal sites rather than inputs via major rivers, as is the case in the German North Sea region. The spatial distribution of the pollutants studied shows a similarly low contamination level for lindane, while the Warnow estuary is a hot spot for contamination with PCB 138 (Fig. VI 3.2.7-7 und Fig. VI 3.2.7-8). Mussels and eelpout from the sampling area around Darßer Ort are, on the one hand, far less contaminated by PCBs but, on the other hand, more contaminated by the insecticide DDT (dichlorodiphenyl trichloroethane) and its metabolites than organisms in the North Sea. It should be noticed that, beside the metabolites DDD and DDE, relative large proportions of the mother substance DDT have also been found here (Fig. VI 3.2.7-9).

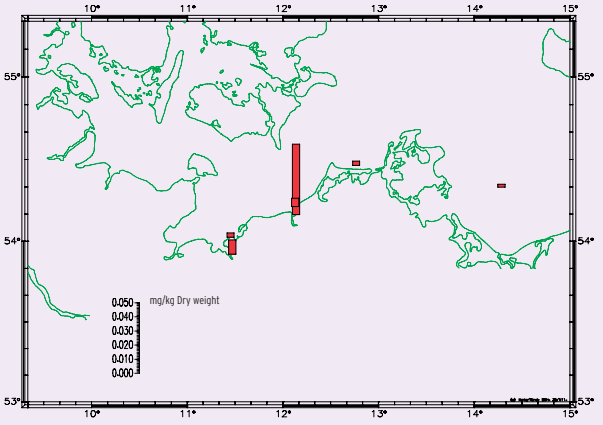
There are also differences in the contamination of the Baltic Sea and North Sea organisms with HCH isomers. While α- and β-HCH are negligible in organisms from the Wadden Sea, samples from the Baltic coast exhibit far higher concentrations of α- and β-HCH although total HCH contaminations is

Fig. VI 3.2.7-7: *Lindane concentration in mussels Baltic Sea 2001*



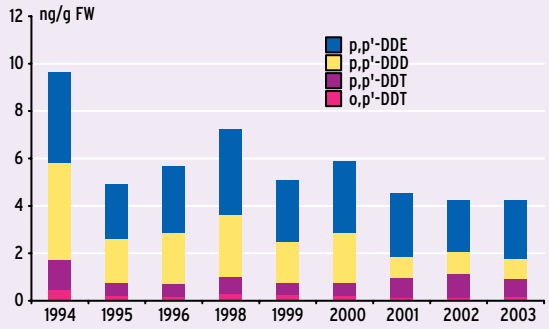
Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

Fig. VI 3.2.7-8: *PCB 138 concentration in mussels Baltic Sea 2001*



Source: *MUDAB (Federal Environment Agency, Federal Maritime and Hydrographic Agency) 2004*

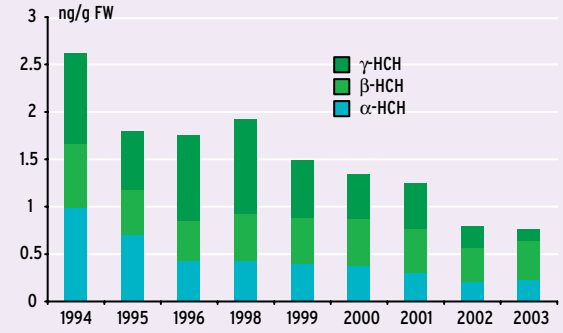
Fig. VI 3.2.7-9: *DDT and metabolites in eelpout muscle tissue (Darßer Ort)*



Source: *Federal Environment Agency 2004 d*

significantly lower. The combined levels of alpha and beta isomers were almost twice as high as those of lindane in mussels and eelpout muscle tissue from the West Pomeranian Bodden. This indicates that the contamination originates from ongoing production or from disposal sites (Fig. VI 3.2.7-10). During the study period 1994 to 2003, HCH concentrations in eelpout muscle tissue decrease significantly, with the strongest decrease being seen in γ-HCH (ca. 90 %) and α-HCH (ca. 80 %), while β-HCH content levels only dropped by 40 %.

Fig. VI 3.2.7-10: *HCH in eelpout muscle tissue (Darßer Ort)*

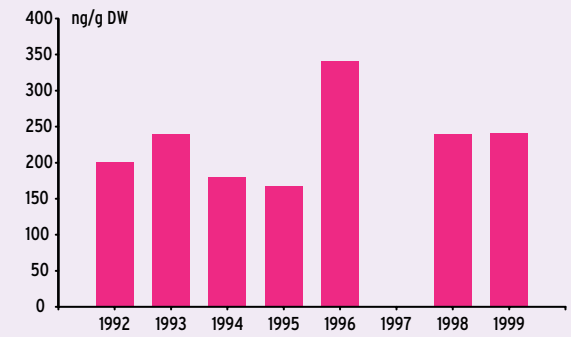


Source: *Federal Environment Agency 2004 d*

These results reflect clearly the former importance of the agricultural chemicals DDT and lindane in the former GDR and Poland.

Tributyl tin concentrations in mussels taken from Darßer Ort during the study period 1986 to 1999 were higher than those seen in mussels from the North Sea coast (Fig. VI 3.2.7-11).

Fig. VI 3.2.7-11: *Tributyl tin in mussels*



Source: *Federal Environment Agency 2004 d*

VI 3.2.8 Eutrophication in the Baltic Sea

Nutrients

In the coastal waters off Mecklenburg Pomerania, the spatial distribution of nutrients is often marked by horizontal gradients. In inner coastal waters, in particular, which are fed by river waters with high nutrient content, concentrations are many times

higher than in the wider, outer coastal waters. These differences become more exaggerated, the greater the inflow of river water, which is linked to nutrient input, to the coastal waters [1].

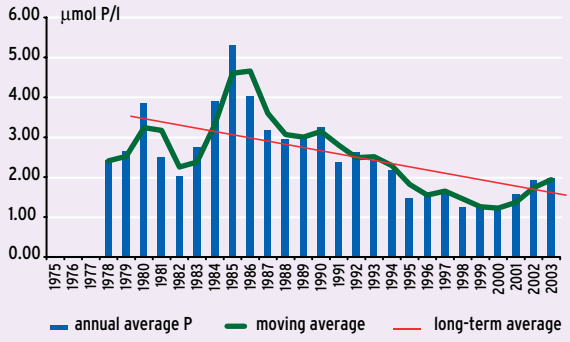
Over the course of a year, there are marked fluctuations in nutrient concentrations. In the more polluted inner coastal waters, direct inflows from rivers and agricultural land, as well as sediment resuspension, give rise to various seasonal maxima in nutrients. In outer coastal waters, the highest levels are recorded during the winter months, i.e., when phytoplankton is at its lowest. Through spring and summer, and up to autumn, almost all the nutrients available are usually consumed by the phytoplankton.

Relatively high winter concentrations of phosphate were measured in the inner coastal waters off Schleswig-Holstein between 2000 and 2002, particularly in 2001, while the same occurred with nitrate in 2002. In each case, the levels exceeded, almost without exception, those recorded between 1990–99 [2].

In the inner coastal waters off Mecklenburg Pomerania and the Greifswalder Bodden, once maximum levels of total phosphorus concentrations had been reached in the mid-1980s there was, first, a downward trend and then a levelling off at a low level up until 2000. The lowest annual averages for total phosphorus since coastal monitoring began were recorded between 1998 and 2000. Since 2001, content levels have risen slightly (Fig. VI 3.2.8-1). In the outer coastal waters off Mecklenburg Pomerania, too, a significant downward trend in total phosphorus concentrations was recorded between the early 1990s and 1996. They rose again from 1997 to 2003, and then there was another sharp drop. (Fig. VI 3.2.8-2). The phenomenon of increased concentrations witnessed in both the inner and outer coastal waters off Mecklenburg Pomerania in recent times is probably partly caused by large amounts of phosphate being remobilised from sediment at times of oxygen deficiency. There has also, for some time, been a clear linkage between phosphate inputs and runoff, which is a new phenomenon, only occurring since nutrient inputs from point sources had fallen sharply [2]. The relationship between runoff and nitrate concentrations, in contrast, has been known for some time. The main reasons for the generally positive trend in total phosphate since 1990 are found primarily in the sizeable reduction in contamination in this coastal region's catchment areas.

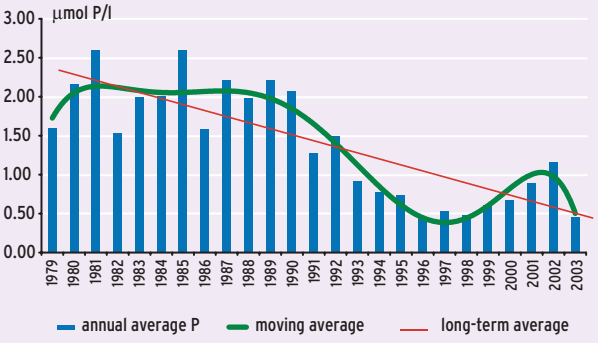
Trends in inorganic dissolved nitrogen in the inner coastal waters of Mecklenburg Pomerania have been monitored since 1975, and no significant downward trend has been identified (Fig. VI 3.2.8-3). Neither has there been a clear trend in inorganic dissolved nitrogen in the outer coastal waters off Mecklenburg Pomerania (Fig. VI 3.2.8-4).

Fig. VI 3.2.8-1: *Trends in total phosphorus in the inner coastal waters off Mecklenburg-West Pomerania, Greifswalder Bodden*



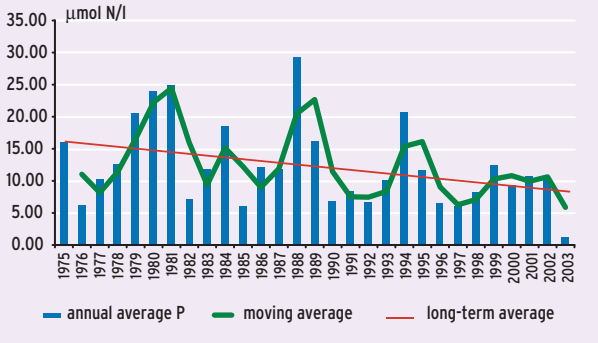
Source: *Mecklenburg-West Pomerania State Office for the Environment, Nature Conservation and Geology 2004*

Fig. VI 3.2.8-2: *Trends in total phosphorus in the outer coastal waters off Mecklenburg-West Pomerania, Mecklenburger Bay (northern Warnemünde)*



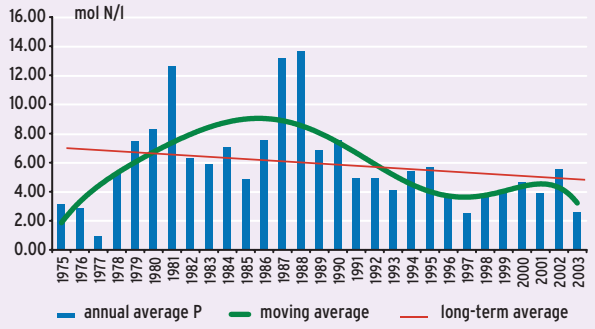
Source: *Mecklenburg-West Pomerania State Office for the Environment, Nature Conservation and Geology 2004*

Fig. VI 3.2.8-3: *Trends in inorganic dissolved nitrogen in the inner coastal waters off Mecklenburg-West Pomerania, Greifswalder Bodden*



Source: *Mecklenburg-West Pomerania State Office for the Environment, Nature Conservation and Geology 2004*

Fig. VI 3.2.8-4: *Trends in inorganic dissolved nitrogen in the outer coastal waters off Mecklenburg-West Pomerania, Mecklenburger Bay (northern Warnemünde)*



Source: *Mecklenburg-West Pomerania State Office for the Environment, Nature Conservation and Geology 2004*

Phytoplankton and water transparency

One well-known consequence of eutrophication is increased algae growth, associated with the negative ecological impacts described above. Since 1979, studies of trends in the Baltic Sea show a significant increase in dinoflagellates and a decrease in diatoms.

In the Kiel Bight between 1999–2002, spring and autumn blooms were more or less clearly seen every year. No unusual phytoplankton trends were observed in the algae spectrum during the study period [2].

In the inner coastal waters off Mecklenburg Pomerania, the records on chlorophyll-a, water transparency, and phytoplankton reflect the close link between the trophic level in the water body, the intensity of primary production, chlorophyll content, and water transparency. High trophic levels are caused by high primary production with high chlorophyll-a content, low water transparency, and occasional high pH values.

These relationships are found, as expected, in waters such as the Darß-Zingst Bodden system, the small Jasmunder Bodden, and the Oder estuary. These water systems have unfavourable hydrographic conditions, i.e., they exchange water slowly with the wider Baltic Sea, and receive large volumes of water from upstream.

Inner coastal waters with lower nutrient potentials and more favourable hydrographic conditions, such as Wismarer Bucht, Westrügenscher and Nordrügenscher Bodden, Strelasund and Greifswalder Bodden, have significantly lower levels of chlorophyll-a and are less turbid.

Eutrophication in the outer coastal waters off Mecklenburg Pomerania exhibit a characteristic east-west gradient. Chlorophyll-a levels and turbidity measured in the marine areas within the "Oder triangle" sphere of influence, east of Rügen and the Pommersche Bucht, were significantly higher than those north of Rügen and in the Mecklenburger Bucht.

Between 2000 and 2002, locally unusual, extreme phenomena in relation to phytoplankton trends were observed in the coastal waters off Mecklenburg Pomerania, particularly during the winter and spring. These included an extremely early, intensive, and sustained appearance of cryptoflagellates in eastern areas. The change in the phytoplankton's appearance was absent or considerably delayed. During the course of the year, biovolumes and chlorophyll concentrations both reached levels well in excess of their long-term maxima on many occasions [1], [2]. During the summer, particularly in eastern areas, there were local, occasional incidences of intensive blue algae growth (Fig. VI 3.2.8-5).

Fig. VI 3.2.8-5: *Blooming of the Aphanizomenon flos-aquae blue algae in the Greifswalder Bodden*



Source: *Mecklenburg Pomerania State Office for the Environment, Nature Conservation and Geology 2004*

Oxygen content and oxygen saturation

During summer and autumn every year, oxygen deficiency occurs in the coastal waters off Schleswig-Holstein and Mecklenburg Pomerania, just as they do off the Danish coast. The weather and current conditions lead to enduring spells of extremely stable thermohaline stagnation. The microbial degradation of organic materials (e.g., phytoplankton) causes oxygen levels to gradually drop at the seabed. In the summer and autumn of 2002, there was an extreme example of this phenomenon. Bright sunshine and low winds caused the water body to become extremely stagnant until September. Driven by increased nutrient inputs as a consequence of high rainfall during the winter and spring, September saw vast areas of the western

Baltic Sea, off the coast of Denmark and Schleswig-Holstein, suffering from extreme oxygen deficiency near the seabed, to the extent that hydrogen sulphide appeared. The western coast of Mecklenburg Pomerania was also hit. The inner waters off Schleswig-Holstein were practically devoid of oxygen near the seabed below a depth of 15 metres. Hydrogen sulphide was still present there in October 2002, and even in November the oxygen content in the depths of the Flensburg Fjord was 0.2–1.5 mg/l, an extremely low level for that time of the year [2].

In the highly productive inner coastal waters, above all during the spring and summer months, the intensive biological processes can cause considerable fluctuation in oxygen levels. Between 2000–2002 in the heavily eutrophied waters, there were frequent incidences of over-saturation levels of up to 200 % in the surface layers, caused by primary production of phytoplankton [1]. Microbial decomposition can lead to substantial oxygen deficits near the seabed, particularly in the Wismarer Bucht and the Lower Warnow.

The biological processes in outer coastal waters are less intensive, and the oxygen regime is therefore subject to less fluctuation. Nevertheless, there too, primary production of phytoplankton during spring and summer can lead to cases of oxygen saturation. Between Boltenhagen and Cape Arkona, between 2000 and 2002, these reached a maximum of 130 % [1]. Levels of up to 100 % were recorded east of Rügen and in the highly eutrophied Pommersche Bucht in 2002 in particular. Almost every year in the Lübecker and Mecklenburger Bucht, the hydrographic special features, including extremely stable thermohaline stagnation which prevents oxygen getting to deeper water levels, leads to oxygen deficits from depths of about 20 metres. Critical oxygen levels were also recorded in the sediment water of the Lübecker and Mecklenburger Bucht between 2000 and 2002. During the hot summer of 2000 there was a particularly sustained and marked oxygen deficiency which began when levels fell in May [2].

During the same period, the Wismarer Bucht saw oxygen deficits of between 5 mg/l (relatively moderate) and 2–3 mg/l. Similar ratios had also been observed in the past.

Increased oxygen depletion, where oxygen content levels fall to below 4 mg/l, is deemed to be critical for fish, and causes them to take flight. The inhabitants of the sediment are unable to endure levels of below 2 mg/l. When the oxygen is completely consumed, sulfur bacteria produce the cell toxin hydrogen sulphide, which can kill off the macrozoobenthos across large areas.

During these three years, critical oxygen content levels of 4 or even 2 mg/l were observed from July to November, so one can assume that the resident macrobenthos was harmed throughout wide areas.

Macrozoobenthos

A succession model for the Baltic benthos has shown that, comparing modern data with the results of surveys conducted 30 years ago, almost all the Baltic sea beds studied have deteriorated by at least one class. The changes in the structure of the coastal zoobenthos off Mecklenburg Pomerania are essentially due to eutrophication, even if certain phenomena (such as increased levels of nutrients) do not correlate directly with them. Specific meteorological and hydrographic particularities have already produced more or less pronounced changes in benthic biocoenoses in the past.

The macrozoobenthos at the German Baltic Sea coast is dominated by marine bristle worms, mussels, and snails. Mussels determine the biomass of the inhabitants of the benthos. The distribution of inhabitants of the sea bed in the Baltic particularly depends on three factors: the nature of the substrate, and oxygen and salt content at the sea bed. Pollution and eutrophication impact negatively on this biocoenosis. In 2002, the exceptional oxygen deficiency situation mentioned above led to a widespread dying off of the sediment's inhabitants in the Mecklenburger Bucht. At depths of over 20 m, only a few very robust species survived. Since 1999, it has been observed that the living conditions for sediment biocoenoses in the western Baltic Sea have deteriorated, a fact also illustrated by a fall in the numbers of species being found in sediment samples. Between 2000–2002, on the other hand, certain species were found close to the coast which feature as "threatened with extinction" on the Baltic Sea's red list. *Marenzelleria viridis*, a polychaete worm introduced from North American waters in the mid-1980s, has come to dominate the inner coastal waters off Mecklenburg Pomerania and the Pommersche Bucht with densities of individuals that are often extremely high [1], [2].

Trophic classification and organic pollution

Currently, the *Land* of Mecklenburg Pomerania is still using its own internal method to assess the water quality of its coastal waters. Classification is based on the trophic state and organic pollution, and provides a simple analysis of chemical and biological monitoring data. The quality of coastal waters is determined by nutrient inputs from land and from polluted sediment.

In the past, the classification's results reflected the constantly high trophic level of the inner coastal waters, due partly to high inputs from the catchment area, partly to the levels of nutrients in the sediments in the water. During the last 10 years, the reduction in pollution through nutrients from rivers, agriculture and municipal sewage treatment plants has resulted in a significant improvement in water quality. Nonetheless, they continue to have high potential for eutrophication. "Favoured" types of water, with a small catchment area and good water exchange with the Baltic Sea, such as Wismarer Bucht, Salzhaff, Westrügensche and Nordrügensche Bodden, Strelasund and Greifswalder Bodden naturally exhibit better water quality. Waters with large catchment areas and little exchange with the Baltic Sea inevitably have poorer quality. These include the Lower Warnow, the Darß-Zingst Bodden, Peenestrom, Achterwasser, and the small Stettiner Haff. The general improvement that had been recorded for inner coastal waters since 1995 stabilised during 2000–2002. The outer coastal waters off Mecklenburg Pomerania continue to exhibit a far better trophic level than the inner coastal waters. This is partly due to the Bodden, which acts as a filter and buffer for terrestrial inputs, and partly to the intensive water exchange with the wider Baltic Sea and its highly favourable hydrographic conditions. Oxygen deficiencies in the sediment water of the western Mecklenburger Bucht and higher concentrations of nutrients led to a decline in water quality between 1999–2002. In the Baltic Sea area Pommersche Bucht, the influence of nutrient inputs via the Oder estuary becomes noticeable, and water quality deteriorates steadily as it goes south. High concentrations of nutrients and phytoplankton, associated with low levels of water transparency, meant that it fell into the poor water quality categories during these years. Incidences of oxygen deficiency, particularly during the hot summer of 2002, caused the outer coastal waters off Mecklenburg Pomerania to experience a slight deterioration in trophic levels compared with previous years [2].

[1] Mecklenburg Pomerania State Office for the Environment, Nature Conservation and Geology (Ed.): Gewässergütebericht Mecklenburg-Vorpommern (2000/2001/2002), Ergebnisse der Gewässerüberwachung der Fließ- Stand- und Küstengewässer und des Grundwassers in Mecklenburg-Vorpommern.

[2] Marine Environment Monitoring Programme (Messprogramm Meeresumwelt 2005): Zustandsbericht 1999–2002 für Nord- und Ostsee

VI 4 Waste water treatment

VI 4.1 Public connection to waste water treatment plants

In 2001, 95 % of the population was connected to the sewage system (Tab. VI 4.1-1 and Tab. VI 4.1-2).

Tab. VI 4.1-1: % *of the population connected to the public sewage system*

Connection to sewage system	1991	1995	1998	2001
G	90	92	93	95
OL	94	95	96	–
NL	75	77	80	–

Population as at 31.12 in each case
– Not shown in the statistics
Source: *Federal Statistical Office 2003*

Tab. VI 4.1-2: *% of the population connected to the public sewage system, by Land, 2001*

	% connected to the public sewage system
Baden-Württemberg	99
Bavaria	94
Berlin	99
Brandenburg	77
Bremen	100
Hamburg	100
Hesse	99
Mecklenburg-Western Pomerania	82
Lower Saxony	93
North Rhine-Westphalia	97
Rheinland-Palatinate	99
Saarland	99
Saxony	85
Saxony-Anhalt	84
Schleswig-Holstein	94
Thuringia	91

Population as at 31.12 in each case
Source: *Federal Statistical Office 2003*

In the same year, 93 % were connected to public waste water treatment plants (Tab. VI 4.1-3). There are differences between connection levels in the different *Länder* (Tab. VI 4.1-4). The new *Länder*, in particular, had low connection levels (Fig. VI 4.1-1).

The total number of biological treatment plantscontinues to rise. In 2001, these represented 96 % of all plants. Due to its insignificance, mechanical waste water treatment has not been shown in the statistical surveys since 1998.

Waste water from residents who are not connected is usually treated in onsite small sewage treatment plants.

Sewage disposal (sewage systems and sewage treatment plants) and drinking water supply are two of

Tab. VI 4.1-3: *Sewage treatment plants and connected population*

			1991	1995	1998	2001
sewage treatment plants	in 1 000	G	9 935	10 273	10 312	10 188
		OL	8 669	8 376	8 032	–
		NL	1 266	1 897	2 280	–
among						
biological sewage treatment plants with and	in 1 000	G	8 141	8 970	9 526	9 786
without systematic nutrient elimination		OL	7 301	7 393	7 469	–
		NL	840	1 577	2 057	–
connected population	in 1 000	G	68 488	72 219	74 204	76 512
		OL	59 089	61 919	63 241	–
		NL	9 399	10 301	10 965	–
among						
biological sewage treatment plants with and	in 1 000	G	63 118	68 819	73 334	76 359
without systematic nutrient elimination		OL	57 721	61 163	62 982	–
connected population		NL	5 397	7 656	10 352	–
level of public connection						
– at biological sewage treatment plants with	in %	G	79	84	90	93
and without systematic nutrient elimination		OL	72	75	77	–
		NL	7	9	13	–
– at mechanical sewage treatment plants	in %	G	6	4	1	0
		OL	2	1	–	–
		NL	5	3	–	–

Source: *Federal Statistical Office 2003*

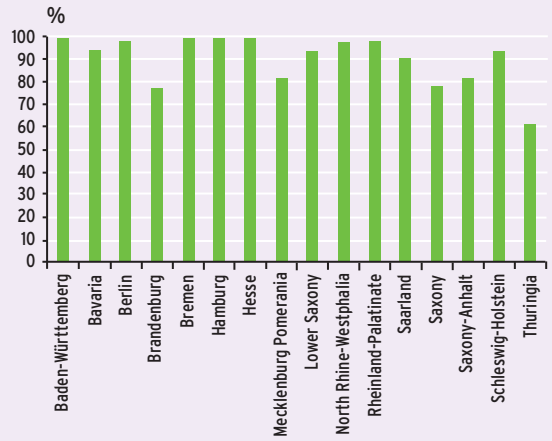
Tab. VI 4.1-4: *Public connection to sewage treatment plants by Land, 2001*

	Level of connection to sewage treatment plants in %
Baden-Württemberg	99
Bavaria	94
Berlin	98
Brandenburg	77
Bremen	100
Hamburg	100
Hesse	99
Mecklenburg-Western Pomerania	81
Lower Saxony	93
North Rhine-Westphalia	97
Rheinland-Palatinate	98
Saarland	90
Saxony	78
Saxony-Anhalt	81
Schleswig-Holstein	93
Thuringia	61

Population as at 31.12 in each case

Source: *Federal Statistical Office 2003*

Fig. VI 4.1-1: *Public connection to sewage treatment plants by Land, 2001*



Source: *Federal Statistical Office 2003*

the focal points of the water management measures taken by the government and *Länder*. Around 65.5 billion DM was invested in sewage disposal between 1991 and 2000 [1].

In 2001, the cost of implementing water management measures for sewage disposal amounted to 2.6 billion EUR (excluding Lower Saxony, North Rhine-Westphalia, and Mecklenburg-West Pomerania) [2].

VI 4.2 Volume of waste water treated in public sewage treatment plants

The objective of waste water treatment is to reduce water pollution loads through waste water discharges.

In 2001, a total of around 10.5 billion m^3 waste water was treated in public plants and then discharged into surface waters. Of this, around 5.3 billion m^3 was foul water, i.e., water that has been changed through use, and around 5.2 billion m^3 was extraneous and rain water (Table VI 4.2-1).

Tab. VI 4.2-1: *Quantity of waste water treated in public sewage treatment plants in million m^3*

	1991	2001
Total waste water to be treated per annum	8 512	10 473
of which is		
Foul water	5 158	5 254
Extraneous and rain water	3 354	5 219
Among biological sewage treatment plants with		
systematic nutrient elimination	4 617	9 916
of which is		
Foul water	2 922	5 051
Extraneous and rain water	1 695	4 865
Among biological sewage treatment plants without		
systematic nutrient elimination	3 295	542
of which is		
Foul water	1 814	196
Extraneous and rain water	1 481	345
Among in mechanical sewage treatment plants	582	16
of which is		
Foul water	404	7
Extraneous and rain water	178	9

Foul water: water that is altered by being used

Extraneous water: unwanted runoff into a drainage system

Source: *Federal Statistical Office 2003*

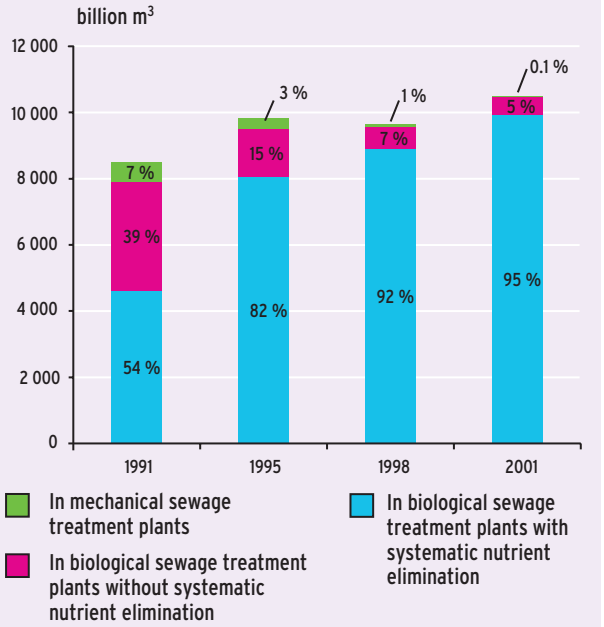
94.7 % of all the treated waste water was treated in biological sewage treatment plants where nutrients are systematically eliminated. Another 5.2 % was treated in biological plants with no additional process. The number of plants with only primary treatment has become insignificant, accounting for 0.1 % of the waste water treated in Germany (Fig. VI 4.2-1).

Final destination of sewage sludge from public sewage treatment plants

In 2001, a total of 2.4 million t of sewage sludge (as dry matter) accrued after the waste water treatment. By far the largest proportion (ca. 58 %) was recycled, primarily in the agricultural sector and landscaping.

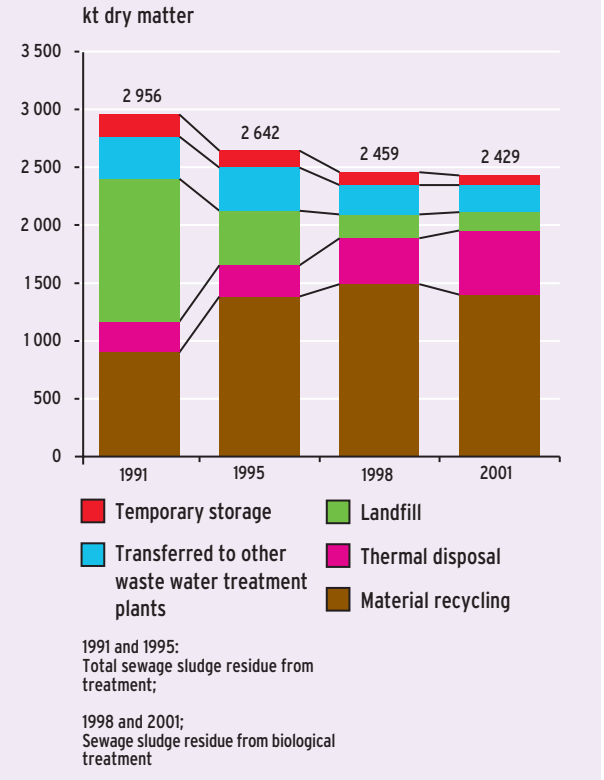
Alongside recycling, there continues to be a significant proportion of thermally disposed sewage sludge, 23 % of the total accumulated. Around 7 % of the sewage sludge was still being disposed of in landfill sites in 2001 (Fig. VI 4.2-2 and Table VI 4.2-2).

Fig. VI 4.2-1: *Waste water volumes treated in public sewage treatment plants*



Source: *Federal Statistical Office 2003*

Fig. VI 4.2-2: *Sewage sludge residue from biological waste water treatment in public sewage treatment plants*



Source: *Federal Statistical Office 2003*

Tab. VI 4.2-2: *Sewage sludge residue from biological waste water treatment in public sewage treatment plants in t dry matter*[1)]

	1991	2001
Total amount disposed of including	2 955 613	2 429 403
Material recycling	901 176	1 399 456
Thermal disposal	266 086	554 924
Landfill	1 236 392	159 673
Transferred to other waste water treatment plants[2)]	364 492	234 227
Temporary storage	187 467	81 123

[1)] 1991 and 1995: Total sewage sludge residue from treatment; 1998 and 2001: Sewage sludge residue from biological treatment

[2)] 1991 and 1995 incl. other residue

Source: *Federal Statistical Office 2003*

For further information, please refer to "Soils/inputs of heavy metals via sewage sludge on land used for agricultural or gardening purposes" and "Key environmental indicators from the waste management industry/thermal treatment plants for municipal waste".

VI 4.3 Performance of public sewage treatment plants

The quality of the waste water that is treated and discharged into water bodies is extremely important in terms of preventing water pollution. To this end, the German Association for Water, Waste Water and Waste (ATV – DVWK) regularly compares the performance of municipal sewage treatment plants. The new *Länder* were included in this for the first time in 1992. The performance comparison is based on control measurements made by plant staff. In 2002, a total of around 1.5 million measurements were made at 5 934 treatment plants, with a total capacity of 135.6 million PE (population equivalent), 90 % of the total German capacity.

Nationwide, about 94 % of capacity in PE, and ca. 80 % of treatment plants surveyed reported oxygen demand Classes 1 to 2, with the national average of 1.4 still within Class 1 (very little residual pollution), indicating that organic matter is more or less eliminated in treatment plants. Performance in plants in the new *Länder* has improved noticeably, although there is still a considerable gap between Old and new *Länder*, especially in Thuringia and Saxony.

The average level of nutrient pollution for 5 927 plants was 1.7. Although around 2/3 of the plants involved in the comparison, or 88 % of the total capacity, meet nutrient elimination requirements, different regions still have different treatment needs (Tab. VI 4.3-1).

Tab. VI 4.3-1: *Trends in oxygen demand and nutrient pollution in treated water for 1992 to 2002*

		1992	1994	1996	1998	2000	2002
Oxygen depletors							
BOD_5	mg/l	9	8	7	6	5	5
COD	mg/l	50	44	42	37	34	32
NH_4-N	mg/l	11	8	7	5	3	2
Oxygen demand class		**2.7**	**2.0**	**2.0**	**1.7**	**1.5**	**1.4**
Eutrophiers							
Nitrogen	mg/l	22	19	18	14	11	9
Phosphorus	mg/l	1.7	1.2	1.0	1.0	0.8	0.8
Nutrient pollution class		**2.9**	**2.5**	**2.4**	**2.1**	**1.8**	**1.7**

Classification of residual pollution in treated water (oxygen demand and nutrient pollution)

Class	Residual pollution	Key indicators in mg/l for Oxygen demand classes			Nutrient pollution classes	
		BOD_5	COD	NH_4-N	N_{total}	P_{total}
1	Very low	0–5	0–30	0–1	0–8	0–0.5
2	Low	6–10	31–50	2–3	9–13	0.6–1.0
3	Moderate	11–20	51–90	4–10	14–18	1.1–2.0
4	High	21–30	91–120	11–20	19–35	2.1–5.0
5	Very high	>30	>120	>20	>35	>5.0

Source: *Waste Water Technical Association 2002*

VI 4.4 Waste water treatment in mining and manufacturing industry

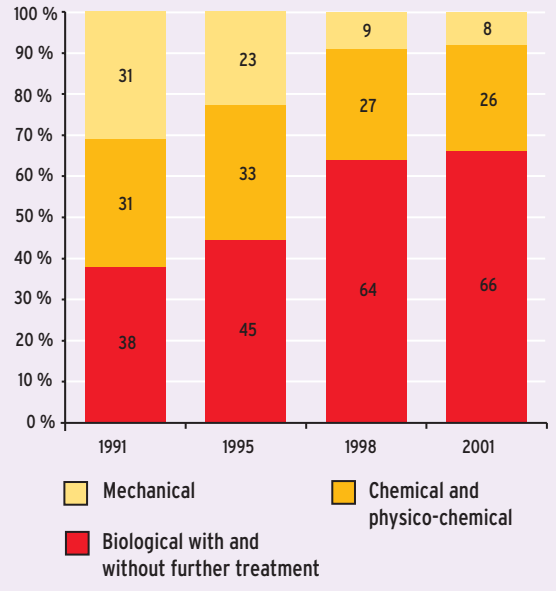
A total of ca. 1.06 billion m^3 waste water was treated in 3 320 treatment plants owned by mining and manufacturing companies in 2001, a fall of around 52 % from 1991 (Table VI 4.4-1). The share of mechanically treated waste water in 2001 fell to 8 %, while biological treatment grew to take a 66 % share, demonstrating a trend towards better treatment efficiency (Fig. VI 4.4-1).

Tab. VI 4.4-1: *Waste water treatment in company-owned treatment plants of the mining and manufacturing industry*

		1991		2001	
Facility	Quantity	5 646		3 320	
Treated Sewage	billion m^3	2.2	(100 %)	1.06	(100 %)
mechanical	billion m^3	0.7	(31 %)	0.09	(8 %)
chemical and physico-chemical	billion m^3	0.7	(31 %)	0.27	(26 %)
biological without and with tertiary treatment	billion m^3	0.9	(38 %)	0.70	(66 %)

Source: *Federal Statistical Office 2003 a*

Fig. VI 4.4-1: *Waste water treatment in company-owned treatment plants of the mining and manufacturing industry*



Source: *Federal Statistical Office 2003 a*

Final destination of sewage sludge from privately owned treatment plants

In 2001, a total of 1.2 Mt of sewage sludge (as dry matter) accrued after waste water treatment in company-owned chemical, physico-chemical, and biological treatment plants.

13 % of the sewage sludge from chemical and physico-chemical treatment plants were disposed of as special waste, while around a third went to landfill sites.

Most of the sewage sludge from biological waste water treatment was incinerated, though almost a third was able to be recycled. Only 11 % went to landfill (Table VI 4.4-2).

Tab. VI 4.4-2: *Sewage sludge residue from company-owned sewage treatment plants of the mining and manufacturing industry 2001 in t dry matter*

Total amount disposed of	**1 205 384**
of which is	
From chemical and physico-chemical waste water treatment	550 255
of which	
Disposed of as waste requiring special supervision	71 051
Landfill	181 401
Other destination	297 803
From biological waste water treatment	655 129
of which	
Landfill	72 956
Material recycling	203 171
Thermal disposal	357 521

Source: *Federal Statistical Office 2003*

Waste water treatment in privately owned treatment plants in selected sectors

The five selected sectors shown in Figure VI 4.4-2 treated some 1.0 billion m^3 waste water in their own treatment plants.

By far the largest amounts of waste water were treated by the chemical industry, with a remarkably high proportion of biological treatment. This ca. 7 % increase in waste water volumes (relative to the total volume treated) over the 1998 survey could be due to modification of both production and waste water treatment processes. The share of chemical and physico-chemical treatment fell significantly in the same period.

Direct and indirect discharge of untreated sewage by selected sectors

In the year of the survey, 2001, ca. 5.5 billion m^3 untreated waste water was discharged. Figure VI 4.4-3 shows the sectors that produce the greatest share (ca. 5 billion m^3).

Of the sectors selected, the chemical industry was once again the largest discharger of waste water, with about 2.9 billion m^3, mainly due to the large amount of cooling water, which was nonetheless ca. 146 million m^3 less than in 1998.

Compared with cooling water, the quantities of production waste water were relatively small in all sectors (Tab. VI 4.4-3).

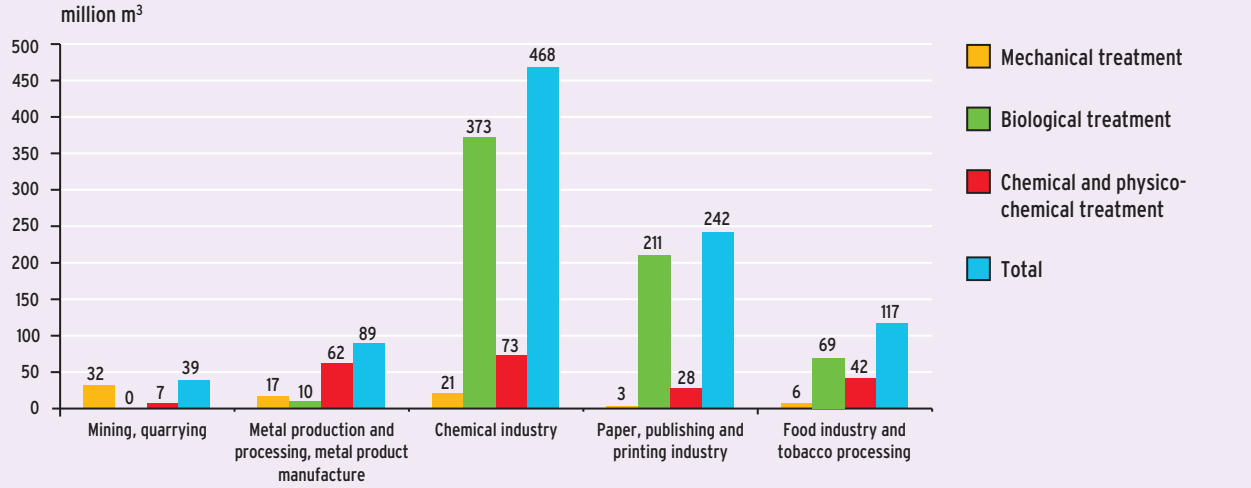
VI 4.5 Waste water treatment by public thermal power stations

Almost all of the waste water arising from use in public thermal power stations (ca. 25 billion m^3 in 2001) was discharged directly into surface water bodies. This was predominantly cooling water. Discharges of cooling water fell by 14 % between 1991 and 2001 (Fig. VI 4.5-1). Waste water treatment (ca. 52 million m^3) from power stations is relatively insignificant in this category. In 2001, 111 910 t of sewage sludge from thermal power plants' waste water treatment were disposed of, of which the greatest share originated from chemical and physico-chemical treatment.

Discharged cooling water, especially from circulatory cooling, is not unproblematic for water quality, as chemicals are added to the water for technical reasons (e.g., anti-corrosion, water softening, sterilisation).

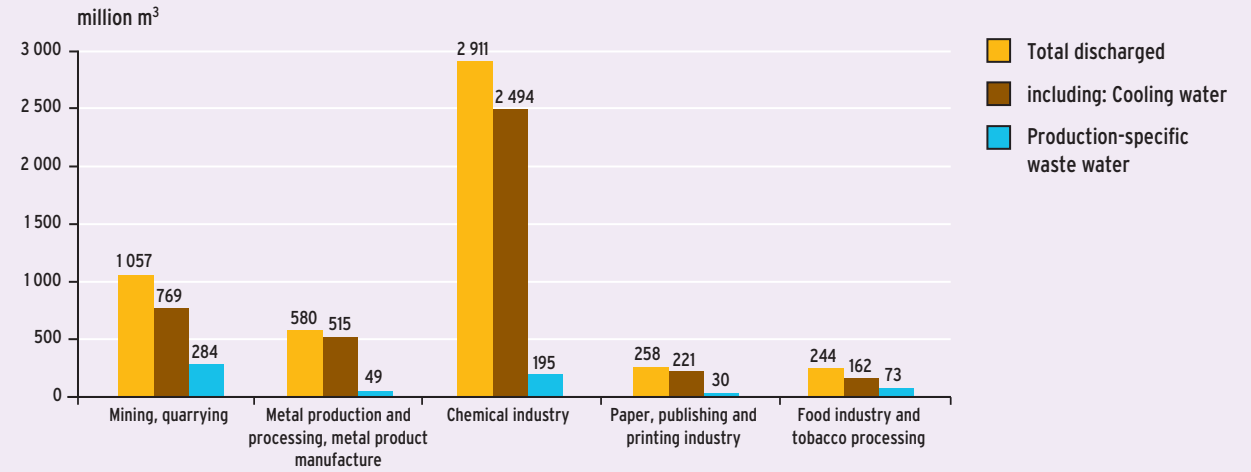
In order to keep water pollution within acceptable limits, Annex 31 of the Waste Water Ordinance (on water conditioning, coolant systems, steam production) sets out a number of requirements. For example, only easily degradable complex formers may be

Fig. VI 4.4-2: *Waste water treatment in privately owned treatment plants in selected sectors 2001*



Source: *Federal Statistical Office 2003 a*

Fig. VI 4.4-3: *Direct and indirect discharge of untreated sewage by selected sectors 2001*



Source: *Federal Statistical Office 2003*

Tab. VI 4.4-3: *Waste water discharges from mining and manufacturing industry 2001*

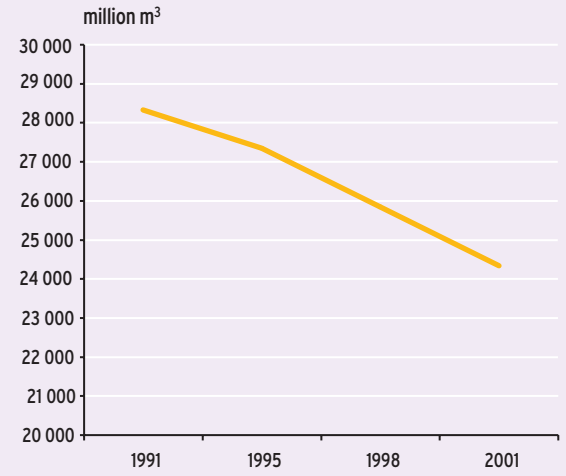
Commercial Sector	Direct and Indirect Discharges						Direct Discharges	Indirect Discharges
	Total	Untreated Waste Water			Treated Waste Water	Unused Water		
		Combined	including					
			Cooling water	Production-specific waste water				
	1 000 m³							
Mining, quarrying, processing trade	7 576 146	5 460 287	4 462 094	702 262	1 062 020	1 053 840	6 793 961	782 186
Mining, quarrying	2 030 754	1 056 968	768 657	284 165	38 655	935 131	2 024 267	6 487
Mining of coal and lignite, extraction of peat, extraction of crude petroleum and natural gas	1 684 571	763 674	754 222	5 728	26 980	893 917	1 679 221	5 350
Mining of metal ores, quarrying, other mining	346 183	293 294	14 436	278 435	11 675	41 214	345 046	1 137
Processing trade	5 545 393	4 403 319	3 693 437	418 094	1 023 366	118 709	4 769 694	775 699
Manufacture of food products and beverages and manuf. of tobacco products	368 408	244 440	162 356	72 922	116 523	7 445	224 272	144 137
Manufacture of textiles and apparel	41 619	22 384	3 258	17 029	18 719	516	6 491	35 128
Tanning and dressing of leather	2 667	199	57	80	} 2 974	} 104	563	2 104
Wood and wood product manufacturing (excluding furniture)	9 662	9 052	6 034	2 426			7 659	2 003
Paper, publishing and printing industry	500 007	257 686	221 324	30 374	241 902	420	442 558	57 450
Processing and manufacture of coke, refined petroleum prod. and nuclear fuel	130 888	084 938	80 114	2 733	40 872	5 078	117 708	13 180
Chemical Industry	3 395 757	2 910 685	2 493 657	194 608	467 563	17 509	3 032 110	363 648
Manufacture of rubber and plastic products	87 760	83 520	74 411	5 329	3 639	601	67 969	19 791
Processing of glass, ceramic, and other products from earth and stone	114 499	46 424	19 204	23 767	9 751	58 325	103 403	11 097
Manufacture of basic metals and fabricated metal products, except machinery and equipment	687 073	579 647	515 099	49 392	88 515	18 912	630 979	56 094
Manufacture of machinery and equipment	41 043	36 614	21 719	8 850	2 368	2 062	25 723	15 320
Manufacture of office machinery and computers, DP equipment and installations, electronics etc.	90 180	74 549	62 775	4 198	13 746	1 885	63 737	26 443
Manufacture of motor vehicles	70 985	48 926	30 669	5 511	16 274	5 785	43 797	27 189
Manufacture of furniture, jewelry, musical instruments, etc., Recycling	4 843	4 255	2 762	870	520	68	2 727	2 116

Source: *Federal Statistical Office 2003*

used (apart from phosphonates and carboxylates), and the discharge of chrome, mercury, or organometallic compounds is banned.

Discharging cooling water can raise the temperature of water bodies. Temperature rises of 3°C in waters populated by cyprinidae [3], 1.5°C for salmonidae [4], give no cause for concern, although the temperature immediately below the point of discharge must never exceed 28°C. Where species spawn in cold waters, temperatures must not rise above 10°C during the spawning season. Particularly problematic in this respect are discharges which were licensed a long time ago. Thermal load schemes exist for water bodies seriously affected by thermal pollution, such as the Moselle and Saar rivers.

Fig. VI 4.5-1: *Cooling water discharged by public thermal power stations*



Source: *Federal Statistical Office 2003*

The category "other waste water" is irrelevant to waste water volumes, as it refers mainly to water used to feed boilers and waste water from employees (Tab. VI 4.5-1).

Tab. VI 4.5-1: *Waste water discharged by public thermal power stations in thousand m³ 2001*

	1991	2001
Direct and indirect discharges	28 461 040	24 478 991
Untreated waste water	28 396 836	24 363 557
among Cooling water	28 320 300	24 328 859
Production-specific waste water	62 799	23 112
Treated Waste Water	58 492	52 349
Unused water	5 712	63086
Direct discharges	28 385 390	24 386 768
Indirect discharges	75 650	92 223

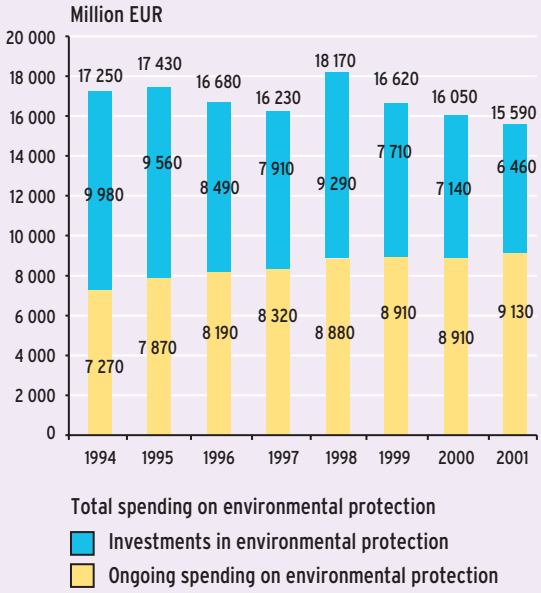
Source: *Federal Statistical Office 2003*

VI 4.6 Spending on environmental protection in water management by manufacturing industry, the state, and privatised public companies

The Federal Statistical Office records what the public authorities and private industry spends on environmental protection. Further information, e.g., the combined spending by all sectors, is available in Chapter V 2 "Spending by manufacturing industry, the state, and privatised public companies on environmental protection in air quality management".

In 2001, almost 50 % of all spending on environmental protection (15.6 billion EUR) went towards water pollution prevention. Investments represented around 41 % of all spending (Fig. VI 4.6-1).

Fig. VI 4.6-1: *Environmental protection spending on water pollution prevention*



Source: *Federal Statistical Office 2004*

[1] Jahresbericht der Wasserwirtschaft. Gemeinsamer Bericht der mit der Wasserwirtschaft befassten Bundesministerien – Haushaltsjahr 2000. In: Wasser & Boden, 53/7+8 (2001), P. 7
[2] Jahresbericht der Wasserwirtschaft. Gemeinsamer Bericht der mit der Wasserwirtschaft befassten Bundesministerien – Haushaltsjahr 2001. In: Wasser & Boden, 54/7+8 (2002), P. 5
[3] Fish of the carp/minnow family
[4] Fish of the trout/salmon family

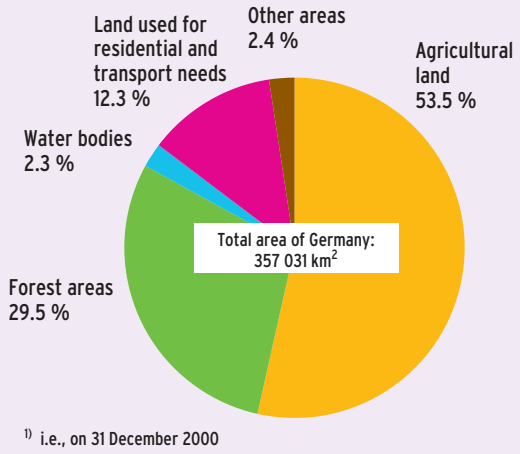
VII SOIL CONSERVATION

VII 1 Land use/residential structure

VII 1.1 Land use structure

The total area of Germany in 2001 (i.e., on 31 December 2000) was 35,703,099 ha, excluding jointly held German-Luxembourgian territory (Fig. VII 1.1-1).

Fig. VII 1.1-1: *Land use 2001*[1)]



[1)] i.e., on 31 December 2000

Source: *Federal Statistical Office 2003*

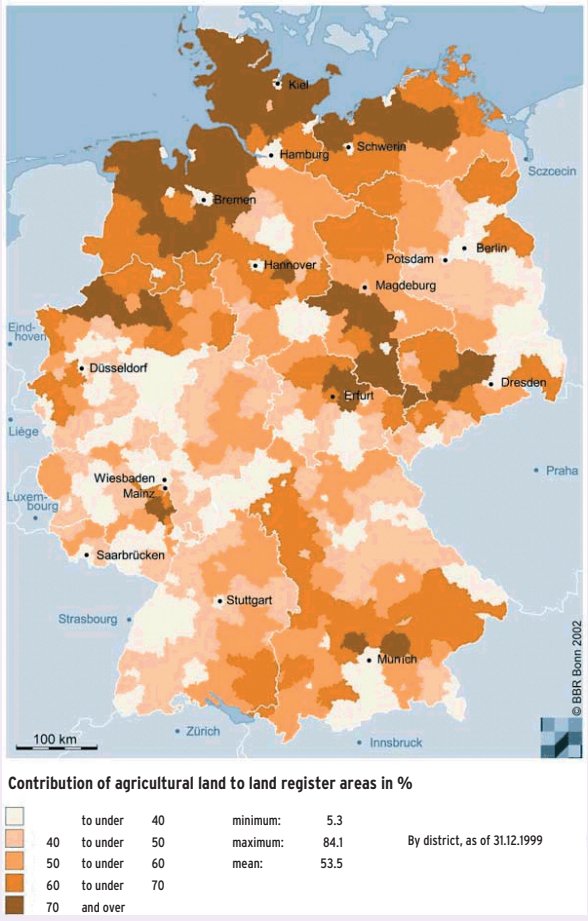
The proportion of agricultural land (including moors and heaths) in Germany in 2001 was 53.5 % (19 102 791 ha), 0.6 % lower than in 1997 (i.e., on 31 December 1996) with 54.1 %; this remains the main land use (see Fig. VII 1.1-2).

There has been a steady reduction in agricultural land use, particularly around large urban population centres, primarily due to continuous growth in land used for residential and transport needs.

Although many animal and plant species depend directly on agricultural management – often forms of extensive pastoral management – intensive forms of agricultural land use can place great burdens on the balance of nature: disrupt valuable habitats, eutrophy waters, and burden soils and groundwater in other ways. Structural changes (the use of large-scale agricultural machinery) to agricultural land also frequently leads to ecologically valuable landscape features being cleared, as hedges, embankments and copses are removed, rivers and streams are straightened, or networks of paths are constructed for agricultural use.

Forest areas covered 29.5 % (10 531 415 ha) of Germany's land in 2001, 0.1 % more than in 1997. In the centres of large population centres and on in-

Fig. VII 1.1-2: *Agricultural areas 2000*



Source: *Federal Statistical Office 2000*

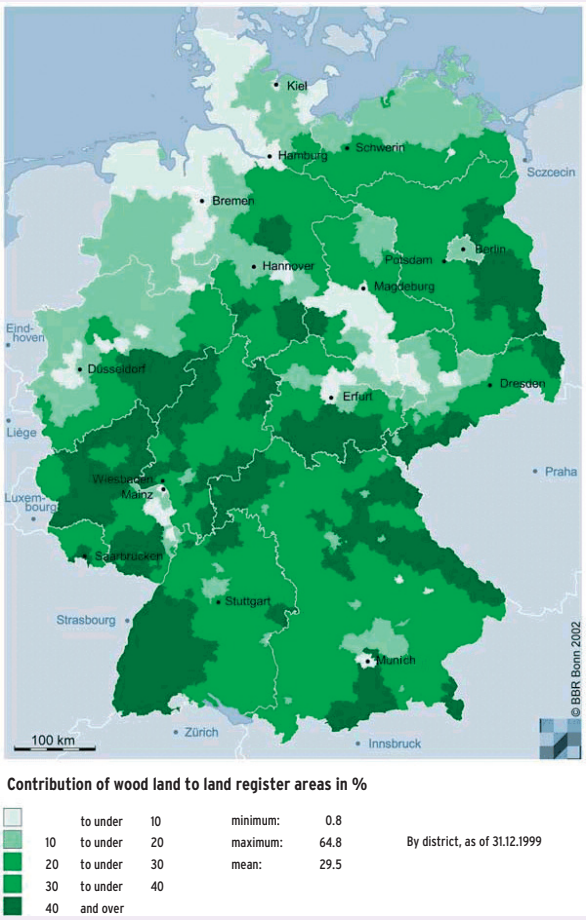
tensively farmed land, forest covers less than 20 % of the total area. Above-average shares of forest land (over 60 %) are found in sparsely settled low and high mountain regions poorly suited to agriculture, for example the Harz, the Thuringian Forest, the Sauerland, the Eiffel, the Black Forest, the Bavarian Forest, and the Alps (Fig. VII 1.1-3).

Besides water bodies, moors, and heaths, forests hold a special ecological value (including renewing groundwater, filtering air, preventing erosion). They are also a principal leisure resource for the population.

Water bodies in Germany cover only 808 462 ha (2.3 %) and make up the smallest share.

The principal reason for the 1.8 % or 14 448 ha increase in water bodies is the mining of raw materials such as gravel, sand, and lignite. The worked areas, upon closing, are then flooded, which gives rise to the formation of new lakes in post-mining landscapes.

Fig. VII 1.1-3: *Forest areas in 2000*



Source: *Federal Statistical Office 2000*

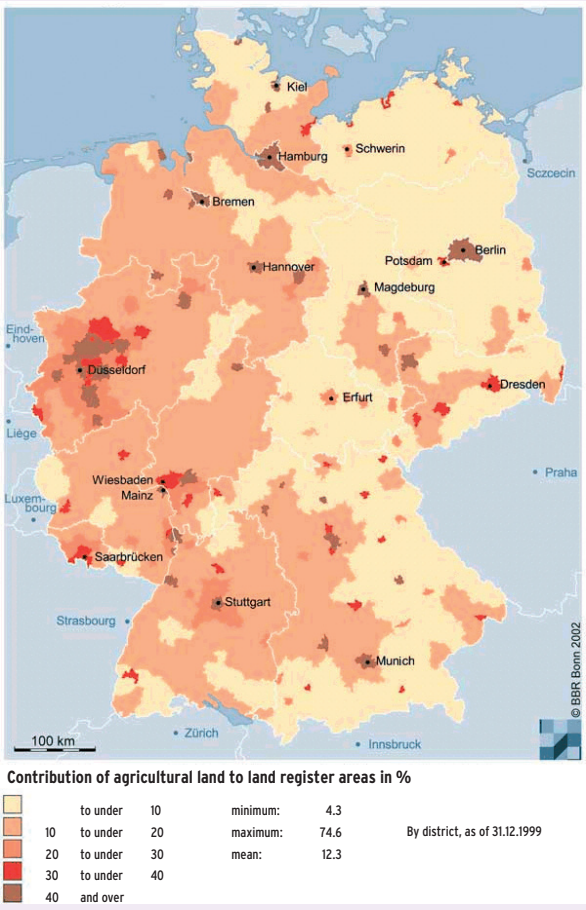
The share of land used for residential and transport needs (SuV) in 2001 (i.e., on 31 December 2000) rose by 0.5 % (4 393 895 ha, 12.3 %) compared to 1997, and is the third largest land use type in Germany. Regional distribution varies widely across the country, exceeding 50 % in the core urban regions of population centres.

Despite a weak economy, the share of land used for residential and transport needs rose by 115 194 ha between 31 December 2000 and 31 December 2003.

In 2003, buildings and their associated plots made up 6.6 %, transport 4.9 %, and recreational land 0.8 % of land used for residential and transport needs in Germany. Only roughly half of this land is actually sealed [1]; amounting to approximately 2.3 million ha or 6.3 % of the country.

The city states (Berlin, Hamburg, and Bremen) aside, North Rhine-Westphalia (with 20 %) and the Saarland (with approx. 19 %) reveal particularly high shares of residential land (Fig. VII 1.1-4). Environmental impacts caused by increasing land consumption for residential and transport needs go beyond the direct loss of agricultural land mentioned earlier; they also include, for example, increased material and energy consumption for new buildings, a continued rise in fuel consumption and emission of pollutants due to increased traffic levels, noise pollution, and the isolation and shrinking of natural habitats for wild flora and fauna.

Fig. VII 1.1-4: *Land used for residential and transport needs in 2000*



Source: *Federal Statistical Office 2000*

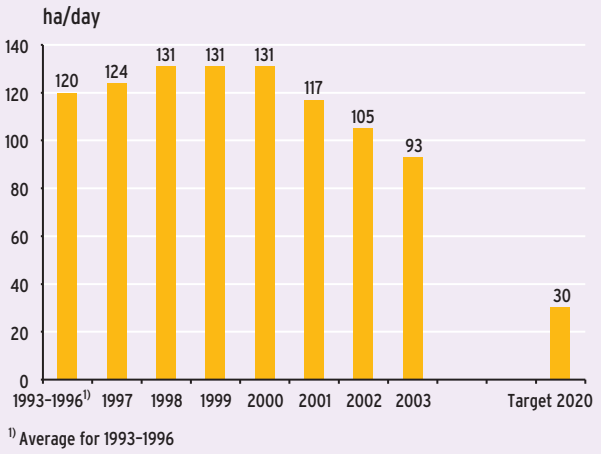
[1] Information on the extent of Residential and Traffic Area (SuV) sealing is not derivable from official land statistics. According to research carried out in 1996 based on national results from the land survey and on studies on sealing carried out in Bavaria and North Rhine-Westphalia, approximately 41 % to 59 % of Germany's SuVs are sealed.

VII 1.2 Daily rise in land used for residential and transport needs

In 2003, the sharp growth in land used for residential and transport needs [1] continued in Germany (93 ha per day) to the considerable detriment of agricultural land (Fig. VII 1.2-1).

According to the partial survey carried out in 2003, additional nation-wide consumption has dropped to the current 93 ha a day for the third consecutive

Fig. VII 1.2-1: *Average daily redesignation of open landscape in land used for residential and transport needs*



Source: *Federal Office for Building and Regional Planning 2003*

time. It had already fallen from 129 ha (1997–2000) to 117 ha by 2001 [1].

The highest increases in land used for residential and transport needs are, as in previous years, in the old *Länder* of Baden-Württemberg, Bavaria, and Lower Saxony. Saxony-Anhalt, Mecklenburg-West Pomerania, and Brandenburg show similar figures. It should be noted that the increases were partly overestimated in the new *Länder* due to statistical amendments regarding recreational space and farmland.

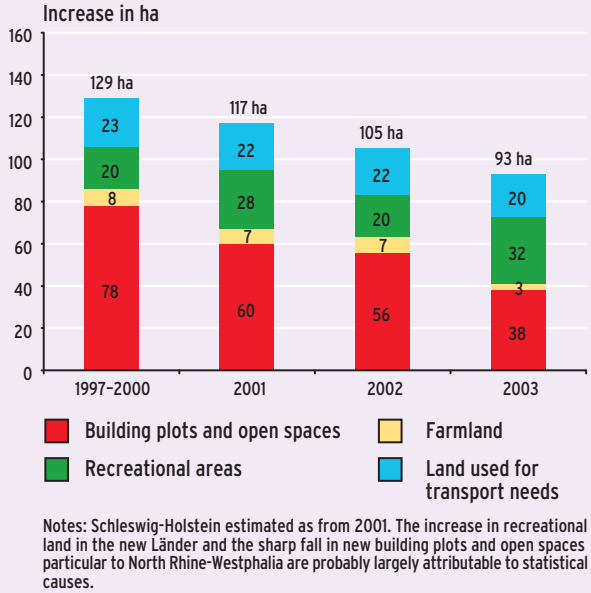
The nation-wide increase of 93 % a day is split between the old *Länder* with around 62 ha a day and the new *Länder* with around 32 ha a day.

The old *Länder* have experienced the slowest growth in land used for residential and transport needs in 50 years. However, this encompasses a sharp decline in designations of new building plots and open spaces, especially in North Rhine-Westphalia, attributable to statistical recoding. The actual decrease, measured against the mean over many years, is therefore overestimated.

In the new *Länder*, 2003 growth was only 2 ha lower than that for 2002. There was a regressive increase in building plots and open spaces. Two-thirds of the increase is attributable to recreational land. However, it must be assumed that this is largely due to statistical amendments rather than to actual changes in utilisation [2], [3].

In comparison, the increase in building plots and open spaces contributing to over half of the increase in SuVs is clearly regressive (Fig. VII 1.2-2). The increase of only approximately 20 % in land for transport needs is disproportionately low. However, this is associated with adverse environmental impacts, in particular the continued isolation of open spaces and noise pollution [4] (Chapter III and Chapter VIII).

Fig. VII 1.2-2: *Daily shift in land used for residential and transport needs*



Notes: Schleswig-Holstein estimated as from 2001. The increase in recreational land in the new Länder and the sharp fall in new building plots and open spaces particular to North Rhine-Westphalia are probably largely attributable to statistical causes.

Source: *Federal Statistical Office 2004*

The strongest growth in building plots and open spaces is in the south of Germany and around metropolitan areas. Yet development revealed significant regional variation in 2003. Comparatively high growth rates were recorded in Rhineland-Palatinate and Brandenburg (1.1 % each), Bavaria, Hamburg, and Lower Saxony (1.0 % each), Baden-Württemberg, and Bremen (0.9 % each). In contrast, low growth rates were reported for Hessen (0.5 %), Saxony (0.3 %), North Rhine-Westphalia (only 0.2 % due to statistical recoding), and Berlin and Thuringia (0.1 % each) [2].

For this reason, the increase in land used for residential and transport needs (SuV) is to be reduced to 30 ha a day by 2020 [5]. We are still a long way from achieving this national sustainability strategy goal.

The regression over recent years is essentially influenced by economic factors. Renewed growth is expected in the case of an economic upswing, especially within the construction industry. Considerable efforts will be required to prevent another rise in land consumption in the case of economic revival. Continued resolute development of planning, legal, and economic instruments and their practical utilisation is, therefore, required. The utilisation of the

potential of brownfield sites in many areas is also being carefully targeted. Increased public awareness of the problems must also be developed.

In view of the considerable regional variation in demographic development trends, economical land consumption also contributes to a sustainable economic and financial policy in terms of avoiding expensive future developments of ill-adapted false investments (Chapter VII 1.5).

[1] Federal Statistical Office 2003, 2004
[2] www.bbr.bund.de/raumordnung/siedlung/Flaechenerhebung_2004.htm
[3] Federal Environment Agency (UBA) Texts 90/03: Reduzierung der Flächeninanspruchnahme durch Siedlung und Verkehr – materials handbook, footnote page 67
[4] Bergmann, Eckhard; Dosch, Fabian: Von Siedlungsexpansion zum Flächenkreislauf, Trendwende zum haushälterischen Umgang In: Planerin, Fachzeitschrift für Stadt-, Regional- und Landesplanung, Book 1_04, March 2004
[5] The Press and Information Office of the Federal Government (Ed.): Fortschrittsbericht 2004: Perspektiven für Deutschland: Unsere Strategie für eine nachhaltige Entwicklung. Berlin 2004

VII 1.3 Regional planning in the Exclusive Economic Zone

Traditional exploitation of the seas (including shipping, fishing, ocean dumping and tipping, mining, military exercises among others) was regulated in previous decades by sectoral technical planning laws and ordinances. However, the advent of new forms of exploitation such as offshore windfarms and aquacultures have created a situation where exploitation demands clash with protection demands such as nature conservation sites at sea under the European ecological network "Natura 2000". This gives rise to conflicts. These can be coordinated and, guided by sustainability criteria, solved through comprehensive, balanced, and forward-looking regional planning. The scope of validity of the Federal Regional Planning Act which already covers territorial coastal waters (12 sea miles zone) has been extended to the Exclusive Economic Zone (EEZ, 200 sea miles zone). The Federal Ministry of Transport, Building and Housing (BMVBW) was authorised to set regional planning goals and basic principles in the German EEZ (Regional Planning Act – 24 July 2004, German Civil Code (BGB, Bundesgesetzbuch)l I page 1359) in a joint venture with the technically affected federal ministries including the Environmental Ministry. The EEZ itself does not belong to the territory of the Federal Republic of Germany. Under the 1982 United Nations Convention on the Law of the Sea (SRÜ, Seerechtsübereinkommen – BGBl 1994 II page 1799), restricted forms of exploitation are permitted. These include:

- the sovereign right to the conservation of living marine resources (Article 56 and 61),
- the sovereign right to the utilisation of living marine resources (Article 56 and 62),
- the exclusive right to continental shelf research and the exploitation of its non-living and living resources (Article 56 and 77),
- the sovereign right to economic research and exploitation of the EEZ with regard to other activities such as the production of energy from water, currents, and winds (Article 56),
- territorial jurisdiction with regard to protection and preservation of the marine environment (Article 56).

Regional planning on the seas aims to set up offshore regional planning using instruments developed for onshore use. The specific features of the marine landscape must be taken into account and require that existing regional planning instruments be adapted. EEZ regional planning strategies, including the designation of areas suitable for wind farms are to be developed in agreement with neighbouring countries and German coastal regions. The coastal regions of Lower Saxony, Schleswig-Holstein and Mecklenburg-West Pomerania have extended the scope of their regional planning schemes to coastal waters (12 sea miles zone).

In terms of the Exclusive Economic Zone (EEZ) scope of validity, amendments were made to the Federal Nature Conservation Act (BnatSchG) and Marine Facilities Ordinance (SeeAnlV, Seeanlagenverordnung) in 2002 and to the Regional Planning Act in June 2004, adapting them to existing and future planning purposes.

Marine Facilities Ordinance approval

The Federal Maritime and Hydrographic Agency (BSH) approved the erection, operation, and utilisation of facilities (constructions and artificial islands) in the North and Baltic Seas used for the production of energy from water, currents, and winds or other economic purposes in the Exclusive Economic Zone (EEZ) of the Federal Republic of Germany, in accordance with the Marine Facilities Ordinance. Since 1997, numerous large-scale projects have been planned for this area, including many large offshore wind farms, since offshore wind power gained the support of the legislative authorities under paragraph 7 of the Act on Granting Priority to Renewable Energy Sources (EEG). The facilities must be located in the designated areas. At that time (January 2005) 33 applications (27 North Sea/6 Baltic Sea)

were submitted to BSH, partially representing several hundred individual wind power stations. The Federal Environment Agency (UBA) is involved in the procedure as public body.

By 2030 25 000 wind power stations with an approximate total of 20 000 to 25 000 MW of installed capacity are to be erected in the North and Baltic Seas in the German Exclusive Economic Zone. Together with the existing onshore wind farms, these facilities could generate around a quarter of Germany's power requirements from wind power (Chapter I 4.4).

Integrated Coastal Zone Management (IKZM)

The "Recommendation of the European Parliament and of the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe" (2002/413/EC) encourages Member States to develop a national strategy for the implementation of IKZM basic principles. The European Commission will report on this by February 2006.

The Recommendation is supported by the Agenda 21 declaration at the 1992 "UN Conference on Environment and Development" (UNCED) in Rio de Janeiro, which states that use and development of marine and coastal areas should follow new approaches "that are integrated in content and are precautionary and anticipatory in ambit". The EU is providing co-financial support under the INTERREG III B support programme. The Federal Ministry of Education and Research (BMBF) set up the research programme "Research for a sustainable coastal management" in August 2002. Two cooperative projects for the Oder estuary region and the west coast of Schleswig-Holstein have already been allocated funds. Together with the Federal Office for Building and Regional Planning (BBR), the Federal Ministry of Transport, Building and Housing allocated funds to the research project "Towards a national strategy for an integrated coastal zone management – regional planning perspectives" in March 2003 which is expected to develop proposals for a national IKZM strategy from a regional planning perspective.

UBA is developing implementation strategies for an integrated coastal zone management with particular emphasis on Germany's environmental issues, in cooperation with the Federal Ministry for the Environment (BMU). The foundation for this is EU Recommendation 2002/413/EC. The national strategy for the implementation of an integrated coastal zone management is to be drawn up by autumn 2005. The Federal Government is currently working on a national strategy for the integrated management of marine and coastal areas. Within the Federal Government, BMU is coordinating the development of the strategy in close cooperation with the coastal *Länder* with involvement from the public and all parties concerned. A national IKZM internet platform has been set up at

www.ikzm-strategie.de in order to promote information exchange.

VII 1.4 Regional planning progress

Regional planning carried out by the *Länder* provides considerable influential guidance in terms of environmental issues at the *Länder* and regional level in Germany by way of the established binding central ideas under the Regional Planning Act (24 July 2004, BGBl I 3.1359). National planning should therefore take into account all issues in order to achieve sustainable regional development.

These include:

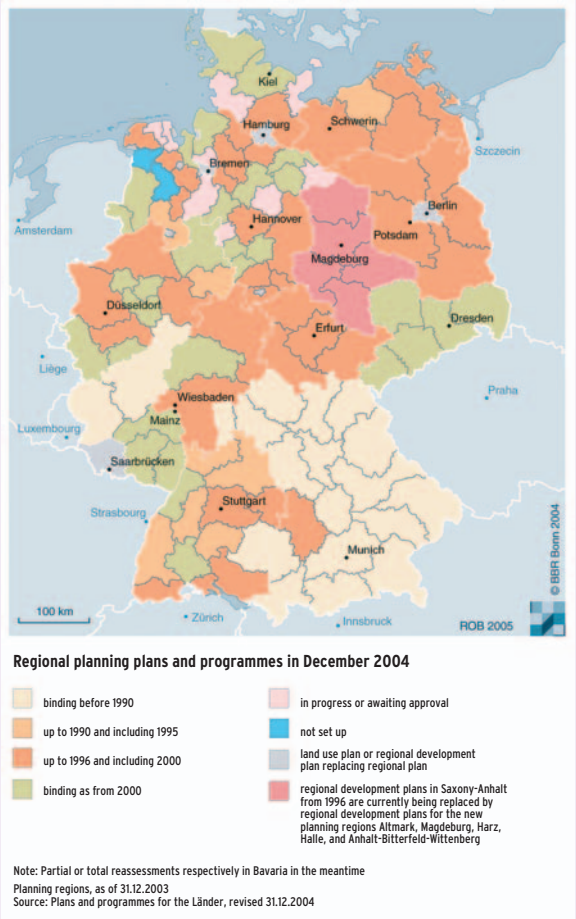
- guaranteeing the free expression of identity in the community and in responsibility for future generations,
- protecting and developing the natural prerequisites for life,
- strengthening regional characteristic diversity,
- creating local prerequisites for economic development and
- establishing equal living conditions in all participating regions.

Progress and quality in regional and national planning have now reached a high level in Germany. At the end of 2004 binding regional plans were in place in almost all regions (Fig. VII 1.4-1).

In recent years, the Federal Environment Agency has been compiling opinions on many regional and national plans concerning the particular demands in view of flood protection, utilisation of renewable forms of energy and other issues. Commendable examples given for 2004 are:

- 35th amendment of the regional development plan (GEP) for the Düsseldorf administrative region, relevant section *vorbeugender Hochwasserschutz* (Preventative flood protection), 2004,
- Schwarzwald-Baar-Heuberg regional plan: continuation of the *Regionales Gewerbegebiet*, (Regional industrial park) *Rohstoff-Sicherung* (Safeguarding raw materials) and *Windenergie* (Wind power) chapters, 2004,
- GEP for the Cologne administrative region – relevant section *Vorbeugender Hochwasserschutz* (Preventative flood protection) – Part 1: *Regionen*

Fig. VII 1.4-1: *Regional planning progress*



Source: *Federal Office for Building and Regional Planning 2005*

Köln, Bonn/Rhein-Sieg und Wassereinzugsgebiet der Erft (Regions Cologne, Bonn/Rhine-Sieg, and Erft catchment area), 2004,

- 1998 alterations to the 1995 Braunschweig area municipal association Regional Planning Programme (RROP): *Vorrangstandorte für Windenergienutzung* (Priority locations for wind power utilisation), 2004,
- draft for alteration to the Saxony-Anhalt *Eignungsgebiete zur Nutzung von Windenergie* (Suitable areas for utilisation of wind power) GEP, 2004,
- re-establishing the Mecklenburg-West Pomerania regional development plan, map chart detailing expected designated sites for wind power installations in Mecklenburg-West Pomerania coastal waters under the GEP and LED (Regional Development Programme), 2004,
- Lower Saxony regional development plan: draft for an alteration to the coastal waters' 12 sea miles zone, *Empfehlungen zur Festlegung von Vorrang- oder Eignungsgebieten für die Windenergienutzung* (Recommendations for establishment of priority or suitable areas for utilisation of wind power), 2004,
- partial alteration to the Verden district Regional Planning Programme (priority location for wind power), 2004.

Since July 2004, the Regional Planning Act has required all new or fundamentally altered Regional Development Plans to undergo an environmental audit (SUP, Strategische Umweltprüfung in accordance with EU Directive 2001/42/EC). The expected main environmental impacts of the plans will be ascertained, described, and evaluated in an environmental report. This will involve the public and neighbouring states. Significant environmental impacts will be monitored. The Federal Ministry of Transport, Building and Housing (BMVBW) was authorised to set regional planning goals and basic principles in the German EEZ, in a joint venture with the technically affected federal ministries including the Environmental Ministry, with regard to economic and scientific utilisation, guaranteeing the security and importance of maritime navigation and protecting the marine environment.

In terms of environmental protection, the improvement of the information base and its availability in the participatory procedure can improve the decision-making process and raise the level of acceptance.

VII 1.5 Demographic shift and residential structure

Many aspects contribute to Germany's demographic shift. The population is set to rise sharply in coming decades. According to the Federal Statistical Office's 10th coordinated population projection, the population is set to decrease, given certain conditions, from its present level of over 82 million to as low as 67 million by 2050 (Tab. VII 1.5-1 and Fig. VII 1.5-1). The number of old persons will also increase sharply within this timeframe. Between 2001 and 2050, the group of persons aged 60 and over will have risen from a quarter to a third of the total population, the group of persons aged 80 and over will almost triple. At the same time, there will be a sharp decline in the group of persons aged 20 and under.

These assumptions are based on:

- a constantly low birth rate,
- a death rate higher than the birth rate,
- a continued increase in life expectancy.

Germany already has one of the lowest birth rates in the world: 1.38 (Tab. VII 1.5-2). Among the 15 European Union Member States, only Italy (1.24), Spain (1.23), Greece (1.29), and Austria (1.34) had lower birth rates in 2000. Comparable or still lower birth

Tab. VII 1.5-1: *Area and population*

	Area km²	Population[1] in 1000 total	male	female	Inhabitants per km²
Year/month/day			**31.12.2003**		
Baden-Württemberg	35 751.65	10 693	5 247	5 445	299
Bavaria	70 549.19	12 423	6 079	6 344	176
Berlin	891.75	3 388	1 651	1 737	3 800
Brandenburg	29 477.16	2 575	1 273	1 302	87
Bremen	404.23	663	321	342	1 640
Hamburg	755.16	1 734	843	891	2 296
Hesse	21 114.72	6 089	2 982	3 108	288
Mecklenburg-Western Pomerania	23 174.17	1 732	858	874	75
Lower-Saxony	47 618.24	7 993	3 915	4 078	168
North Rhine-Westphalia	34 083.52	18 080	8 803	9 277	530
Rheinland-Palatinate	19 847.39	4 059	1 989	2 070	204
Saarland	2 568.65	1 061	516	546	413
Saxony	18 413.91	4 321	2 103	2 219	235
Saxony-Anhalt	20 445.26	2 523	1 231	1 292	123
Schleswig-Holstein	15 763.18	2 823	1 380	1 443	179
Thuringia	16 172.14	2 373	1 166	1 207	147
Germany	**357 030.32**	**82 532**	**40 356**	**42 176**	**231**

[1] Results of Population extrapolation

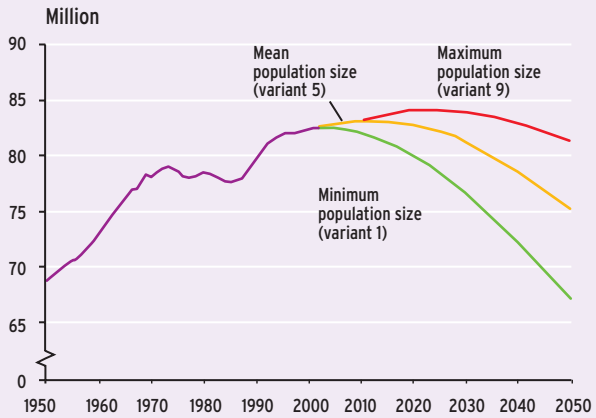
Source: *Statistical Offices of the Federal Government and the Länder 2004*

rates were recorded in a further eight states in economic and social turmoil: the Czech Republic (1.18), Estonia (1.28), Hungary, (1.38), Latvia (1.17), Lithuania (1.38), Romania (1.32), the Russian Federation (1.25), and the Ukraine (1.25). In the mid-1970s in the USA a minimum birth rate was reached which subsequently rose steadily and has been fluctuating since 1989 between 2.0 and 2.1. Measures orientated towards a basic reconsideration of the social and individual value of children is a lengthy process and it is decades before they will have any effect on population development.

Migration patterns play a central role in demographic shifts. Since reunification, population growth has rested for the most part on a fairly constant high net immigration from abroad. Without it, a sharp fall in population would have been recorded in Germany in recent years. Effectively, population increases are principally recorded in regions with thriving economies [1].

This demographic shift is characterised by regional diversity. An ever-increasing group of shrinking districts is confronted with an ever-decreasing group with constantly high growth rates. As Figure

Fig. VII 1.5-1: *Trends in population size in Germany*



Variant 9: Large increase in immigration, Large increase in life expectancy
Variant 5: Moderate increase in immigration, moderate increase in life expectancy
Variant 1: Low increase in immigration, low increase in life expectancy

Source: *Federal Statistical Office 2003 a*

Tab. VII 1.5-2: *Birth figures for selected countries*

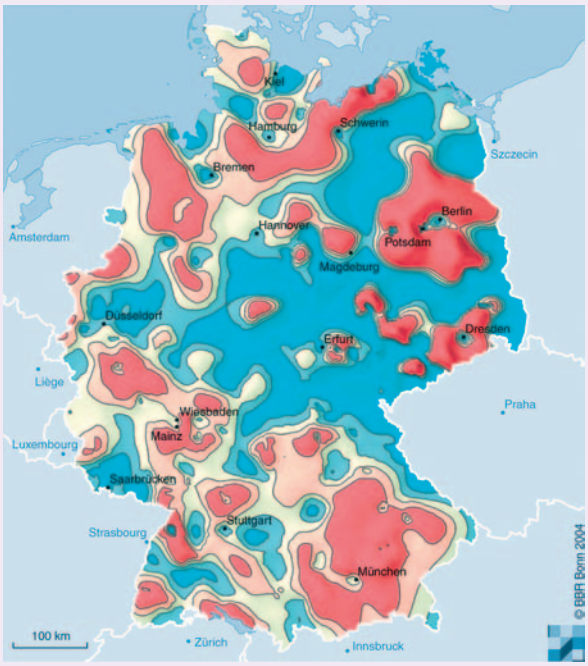
	1990	1995	2000
European Union (15 states)	1.57	1.42	1.48
Belgium	1.62	1.55	1.66
Denmark	1.67	1.80	1.77
Germany	1.45	1.25	1.38
Finland	1.78	1.81	1.73
France	1.78	1.70	1.88
Greece	1.39	1.32	1.29
Ireland	2.11	1.84	1.89
Italy	1.33	1.18	1.24
Luxembourg	1.61	1.69	1.8
Netherlands	1.62	1.53	1.72
Austria	1.45	1.40	1.34
Portugal	1.57	1.40	1.52
Sweden	2.13	1.73	1.54
Spain	1.36	1.18	1.23
United Kingdom	1.83	1.71	1.64
Iceland	2.30	2.08	2.10
Japan	1.54	1.42	1.41
Norway	1.93	1.87	1.85
Switzerland	1.59	1.48	1.50
USA	2.08	2.02	2.06

[1] Information not available

Source: *Eurostat 2003*

VII 1.5-2 illustrates, a forecast carried out by the Federal Office for Building and Regional Planning (BBR) shows that population increases occur principally in regions in the vicinity of urban areas with higher population densities ("islands of growth"), above all in the old *Länder*. The new *Länder*, mostly sparsely populated rural regions, are losing increasing numbers of young qualified persons as they migrate to economically strong regions. This means that the average age in sparsely populated regions is well over the national average. The population is therefore decreasing both in the East as well as in the West, yet with varying degrees of intensity.

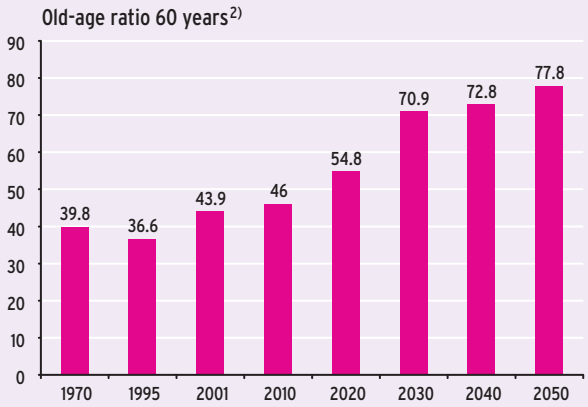
Fig. VII 1.5-2: *Change in population size 1999–2020 in %*



Source: *Federal Office for Building and Regional Planning 2004*

A significant indicator of an ageing society is the so-called old-age ratio. This measures the relation between the population cohort of working age and that of retirement age. In Germany the old-age ratio is currently 44 persons of retirement age to every 100 persons of working age, a figure set to rise to 78 to every 100 by 2050 (Fig. VII 1.5-3). The number of persons of working age is set to drop to 53.6 million by 2020 according to a BBR forecast (Fig. VII 1.5-4) [2].

Fig. VII 1.5-3: *Old-age ratio with retirement age of 60*[1)]



[1)] Estimated values as from 2002 of 10th coordinated population projection, variant 5 "mean" population: Mean increase in migration W2 (annual balance of at least 200,000) and mean increase in life expectancy L2 (average life expectancy for 2050 at 81 or 87 years of age).

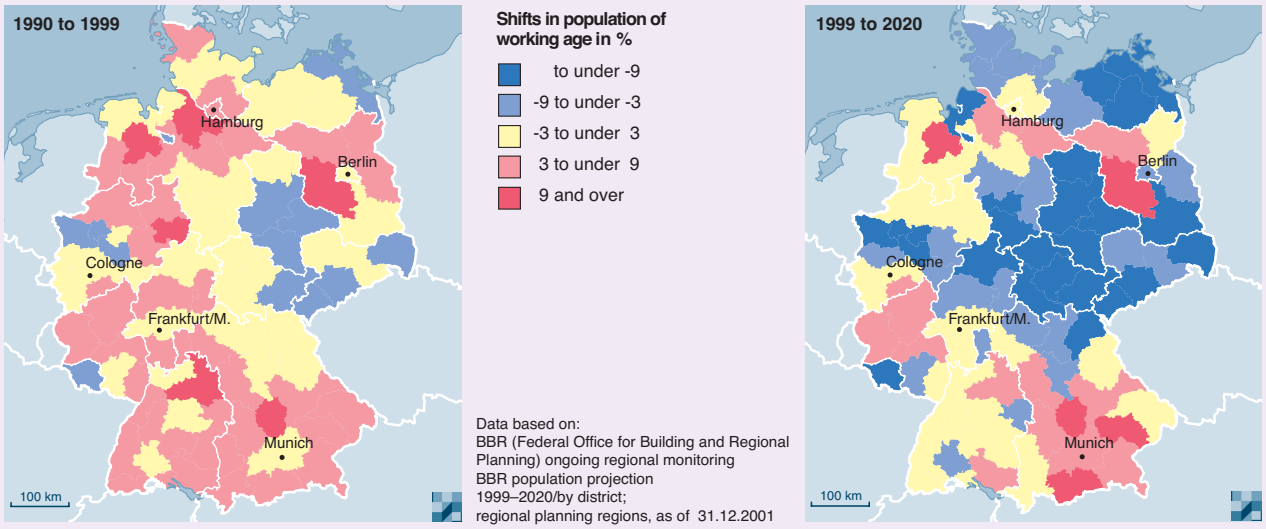
[2)] 60-year-olds and above per 100 persons between 20 and 59 years of age.

Source: *Federal Statistical Office 2003 a*

Despite a decreasing population, the number of households is also set to rise in the future. Modified ways of life and family structures and particularly an ageing population are leading to a sharp increase in smaller households. Although characterised by regional variation, this is a nation-wide tendency. According to a BBR forecast, there will be a 2.9 % increase in the number of households by 2020, corresponding to approx. 1.1 million new households. In 2020 almost three quarters of all households will consist of only one or two persons. Between 1970 and 2000 the average household size in the old *Länder* had already fallen from 2.74 to 2.17 persons and a further decrease is expected in the future: 2.1 persons per household by 2020 and 1.95 by 2050. Available per capita living space has tripled – pertaining to the former federal territory – from 15 m^2/house in 1950 to 41.1 m^2/house in 2003. 2 % of all households have second or holiday homes. If incomes continue to increase, so will per-household living space demands. Increasing living space consumption will be supplemented by increasing qualitative housing demands, whereby replacement demand could play an ever-increasing role alongside primary demand. These trends suggest that despite the fall in population, living space demand will increase generally. At the same time, both small- and large-scale differentiations in demand are expected [3] (Fig. VII 1.5-5).

The shifts in settlement structure are primarily attributable to progressive suburbanisation. Emigration from the cities to the surrounding countryside means that metropolitan areas have spread to penetrate well into rural infrastructures. In most conur-

Fig. VII 1.5-4: *Shifts in population of working age 1990–2020 in %*

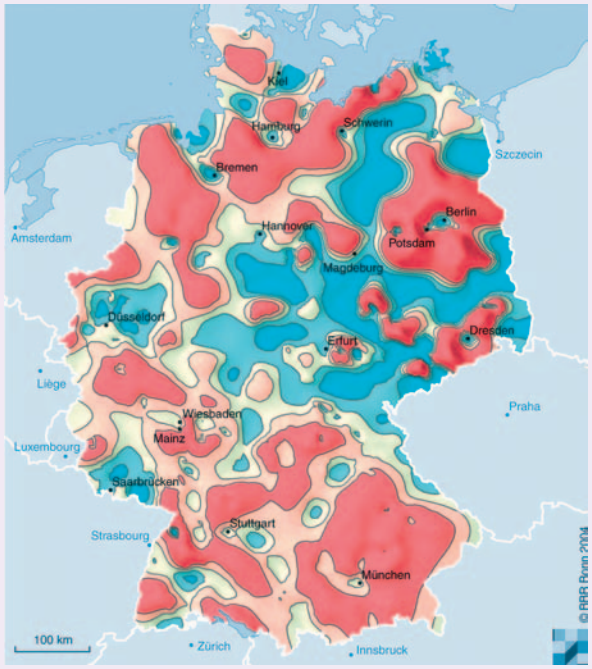


Source: *Federal Office for Building and Regional Planning 2004*

bations, more people now live in the surrounding countryside than in the core urban regions.

Figure VII 1.5-6 illustrates this phenomenon. The most significant increases in population and the consequent highest rises in land for residential and transport needs in both the old and the new *Länder* were recorded in the 1990s in rural districts situated a long distance from core urban regions. It is precisely in these regions that residential development competes with the conservation of large contiguous expanses (Chapter VIII).

Fig. VII 1.5-5: *Shifts in number of households 1999–2020 in %*



Source: *Federal Office for Building and Regional Planning 2004*

In the new *Länder* there was no suburbanisation before reunification. This began to change in the early 1990s. Although residential suburbanisation in some areas of the new *Länder* is currently declining, migratory processes from the cities and towns to the surrounding countryside continue, which also limits development opportunities in the core urban regions of the New *Laender*. Population losses as a result of East-West migration are eclipsed by drops in population levels and worker numbers, an effect of migration from cities and towns to the surrounding countryside. One visible sign of this development is a severe vacant housing phenomenon. Regions of West Germany are also increasingly affected by population decreases, particularly derelict industrialised regions [4].

The shifts in Germany's basic socio-demographic framework present our cities and regions with new challenges. In view of the different patterns of demand and scales of requirement, greater emphasis will in the future be placed on adapting present residential, open space, transport, and provision systems to the new conditions. The aims should be the maintenance, strengthening, and continued development of the functional capacity and potential of cities and regions, in line with the "sustainability" model. A central task in the coming years will therefore be "urban restructuring" in East and West.

VII 1.5-6: *Population shifts in German metropolitan areas*



Source: *Federal Office for Building and Regional Planning 2003*

[1] Federal Statistical Office, 10th coordinated population projection, Wiesbaden, Germany 2003
[2] Old-age ratio: Börsch-Supan, Axel: Kann die Finanz- und Sozialpolitik die Auswirkungen der Bevölkerungsalterung auf den Arbeitsmarkt lindern? Paper for the 2001 financial sciences committee's annual conference in Cottbus, Germany. Cottbus 2001. Zahl der Erwerbsfähigen: Federal Office for Building and Regional Planning Information zur Raumordnung 3/4 2004, page 159
[3] Federal Office for Building and Regional Planning (Ed.): Raumordnungsprognose 2020, Informationen zur Raumentwicklung, Book 3/4, 2004
[4] www.bbr.bund.de/raumordnung/stadtregionen/umland.htm

VII 2 Chemical soil contamination

VII 2.1 Background levels of inorganic pollutants in Germany's soils

The background content of a soil is determined by the geogenic basic content of a pollutant in the soil and the ubiquitous loading resulting from diffuse deposition into soil. The geogenic (natural) basic content of inorganic pollutants, particularly metal ores, are characterised by the balance of parent rock in the soil formation and in some cases by mineralisation and redistribution during the formation of the soil (accumulation or depletion). Major influences on the ubiquitous dispersion of hazardous substances are a variety of input pathways. Ubiquitous/diffuse background soil levels are distinguished from those which result from large point chemical content (emissions or contamination).

Under the direction of the Federal Environment Agency, a working group on soil protection – Federal/Länder Working Group on Soil Conservation (LABO) – in cooperation with the Federal Institute for Geosciences and Natural Resources (BGR) and regional environmental agencies has evaluated the available federal and *Länder* data on the parent material of soil formation, soil horizons, main types of utilisation and residential areas. It has also deduced federal as well as *Länder*-specific background levels for upper and lower soils and underground. These levels are representative for generally distributed background levels of a chemical or chemical group in soils.

Table VII 2.1-1 contains the nation-wide background levels for inorganic chemicals in soils (90th percentile) for Germany's predominant soil parent stones. These background levels provide a broad basis for formulating conclusions on background levels in soils in rural areas. The LABO (2003) [1] report also contains information on the 50th percentile and *Länder*-specific background values for inorganic as well as organic chemicals in soils reported via monitoring programmes in the individual *Länder* (www.labo-deutschland.de).

The representatively derived background levels of inorganic pollutants in soils are detailed on map charts based on widely available information on land use and soil parent stone. Figures VII 2.1-1 and VII 2.1-2 illustrate, for example, the background levels for lead in upper and lower soils. Small-scale differentiations such as small-scale socialised lithological bodies, soil units, and depth differentiation are not represented due to limitations of scale. In lower soils, the average lead contents are calculated across the entire depth of each lower soil.

In order to guarantee an overview true to scale, the 90th percentile of the lead contents in upper soils is grouped into six classes. This classification was adopted for the direct comparison with lower soils.

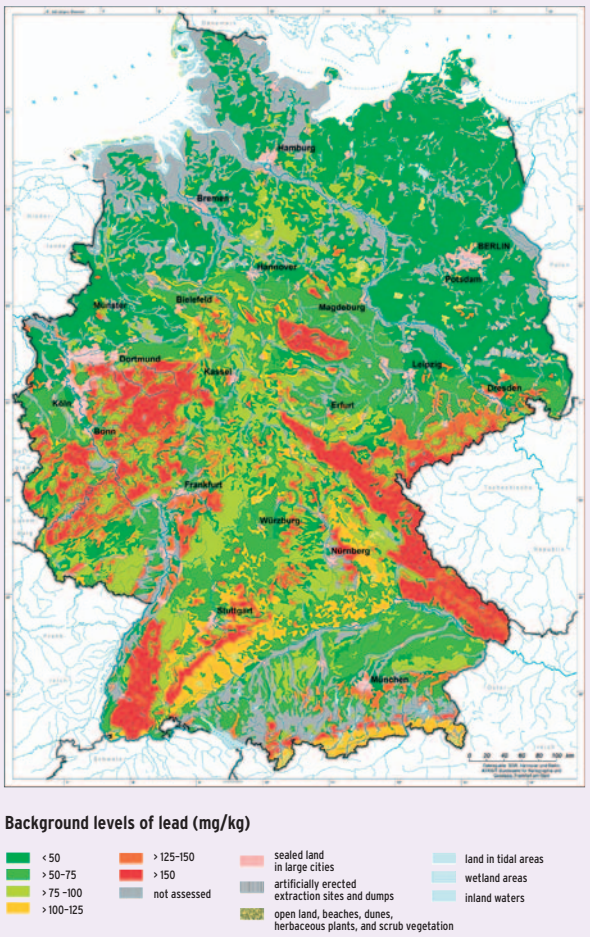
Tab. VII 2.1-1: *Nation-wide background levels for inorganic chemicals in soils (90th procentiles)*

	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
River and gravel deposits							
Arable upper soil	0.69	33	31	0.22	29	47	75
Forest upper soil	0.48	28	28	0.22	23	130	69
Lower soil	(0.14)	38	21	–	40	22	64
Sand							
Arable upper soil – NW	0.3	20	13	0.06	7.6	23	41
Arable upper soil – NE	0.42	13	11	0.13	9.3	38	39
Grassland upper soil – NW	0.36	16	14	–	(7.5)	29	35
Grassland upper soil – NE	0.35	17	15	(0.2)	12	48	44
Forest upper soil – NW	0.74	17	13	0.26	10	86	32
Forest upper soil – NE	0.32	7	8.5	0.17	6.9	41	25
Lower soil	(0.24)	15	7	0.05	9.4	12	24
Alternating marl deposits/boulder clay with shallow sandy surface layers							
Arable upper soil	(0.26)	13	13	0.16	10	44	41
Forest upper soil	(0.28)	9.1	7.2	–	5.9	33	32
Peats							
Grassland org. upper soil – NE	0.4	27	26	–	10	48	50
Lower soil/underground	0.49	10	18	0.14	22	22	33
Alternating marl deposits/boulder clay							
Arable upper soil – NE	0.25	16	13	0.13	18	29	45
Grassland upper soil – NE	–	23	16	–	17	26	49
Forest upper soil – S	0.49	26	17	–	–	54	68
Lower soil – N	(0.31)	22	15	0.11	22	31	47
Lower soil – S	0.31	40	29	019	48	28	79
Loess							
Arable upper soil	0.7	43	24	0.19	33	60	75
Grassland upper soil	0.7	32	25	0.22	34	61	100
Forest upper soil	0.55	37	19	0.25	24	99	65
Unterboden	(0.23)	46	21	0.11	38	26	63
Sand loess							
Arable upper soil	0.45	25	20	0.17	15	41	49
Forest upper soil	–	29	18	–	10	151	41
Lower soil	(0.18)	25	11	0.06	14	17	32
Periglazial surface layers over calcareous gravel							
Arable upper soil	0.59	56	45	0.23	59	60	102
Grassland upper soil	1.19	60	34	0.16	54	63	130
Forest upper soil	1.6	48	32	0.26	43	115	172
Lower soil – rich in loess clay	0.55	45	25	0.19	44	52	84
weak in loess clay	0.67	65	39	0.19	70	68	137
Periglazial surface layers over argillaceous gravel							
Arable upper soil	0.94	57	45	0.17	70	85	158
Grassland upper soil	0.67	57	33	0.2	68	99	141
Forest upper soil	0.6	54	31	0.32	56	205	129
Lower soil – rich in loess clay	0.31	52	25	0.14	58	48	107
weak in loess clay	0.34	59	40	0.15	66	53	124
Periglazial surface layers over sandstone							
Arable upper soil	0.37	40	23	0.17	26	48	82
Grassland upper soil	0.33	33	13	0.13	22	33	63
Forest upper soil	0.34	27	12	0.23	20	94	60
Lower soil – rich in loess clay	(0.34)	35	19	0.14	28	42	70
weak in loess clay	(0.33)	27	10	0.12	22	25	51
Periglazial surface layers over intermediary and basic igneous and metamorphic rock							
Arable upper soil	0.77	355	69	0.15	248	59	158
Grassland upper soil	0.92	228	64	–	222	79	179
Forest upper soil	1.04	278	71	0.38	221	129	171
Basic igneous and metamorphic rock							
Lower soil – rich in loess clay	0.53	145	63	0.1	208	42	139
weak in loess clay	0.59	240	79	0.13	332	40	173
Periglazial surface layers over acidic igneous and metamorphic rock							
Arable upper soil	0.94	40	40	0.25	34	143	151
Grassland upper soil	1.15	51	52	0.23	34	131	146
Forest upper soil	0.91	40	31	0.27	33	189	104
Granite and rhyolites							
Lower soil – rich in loess clay	–	–	28	–	–	–	79
weak in loess clay	0.39	28	30	0.14	28	59	93
Gneiss							
Lower soil – rich in loess clay	0.25	65	45	0.59	52	41	121
Mica-schist							
Lower soil – rich in loess clay	–	67	45	–	67	56	190

Comments on table:
1. The background levels apply to the 90th percentile.
2. The background levels for upper soils apply to the following use-specific upper soil horizons: Arable land – Ap-horizon (approx. 0–30cm); Grassland – Ah-horizon (approx. 0–10cm); Forest – Ah-horizon (approx. 0–10cm).
3. Share of loess clay periglazial surface layer: rich in loess > 25–100 %; weak in loess 0–25 %
4. The background levels apply to aqua regia extractable nitrogen contents.
5. (...) if the 50th percentiles are within the analytic limit of quantification, the 90th percentiles are not statistically guaranteed and therefore appear in brackets.

Source: *Federal/Länder Working Group on Soil Conservation 2003*

Fig. VII 2.1-1: *Nation-wide background levels of lead in upper soils (90th percentile)*



Source: *Federal Institute for Geosciences and Natural Resources 2004*

Fig. VII 2.1-2: *Nation-wide background levels of lead in lower soils (90th percentile)*



Source: *Federal Institute for Geosciences and Natural Resources 2004*

The comparison between the map charts shows the anthropogenic influence on the background levels of lead.

[1] Federal/Laender Working Group on Soil Conservation (LABO), Hintergrundwerte für anorganische und organische Stoffe in Böden. Appendix 3, revised and amended edition, 2003

VII 2.2 Soil contamination caused by dioxins

Polychlorinated dibenzodioxins and dibenzofurans (PCDD/Fs) have never been selectively produced. Rather, they come into being via the production of chlorinated organic compounds such as polychlorinated biphenyls (PCBs) and pentachlorophenol. These chemicals are inadvertently formed as part of the pulping process and during all thermal processes such as metal extraction and recycling, domestic fuel burning, and waste incineration. Due to their high chemical, physical, and biological stability, they belong to the Persistent Organic Pollutant (POP) group.

Since the early 1990s, levels of polychlorinated dibenzodioxins and furans (PCDD/F) from over 2 500 soil samples from various measurement programmes have been recorded in the Federal/Laender Working Group on Dioxins DIOXINE database [1]. The average background soil contamination was ascertained by selecting from the total data inventory those measurement results of soil samples with no marked contamination. Analysis of the soil samples was carried out according to horizon, region type following the former Federal Regional Studies and Planning Research Institute's classification system (BFLR) and use type. The homologous profile (each of the sums of the tetra to octachlorodioxins) were ascertained from the median values of the profiles for the three use types (forest, grassland, and arable land).

The toxicity equivalents (TEQs) were calculated using the measured concentrations of the PCDD/F congeners (Tab. VII 2.2-1). The PCDD/F congeners with a lesser or equal concentration to that of the limit of detection were not taken into account (set at absolute zero).

Tab. VII 2.2-1: *International toxic equivalence factors in accordance with NATO-CCMS1) (I-TEF, 1988) and the World Health Organization (WHO-TEF, 1998)*

polychlorinated dibenzodioxins (PCDDs)	I-TEF	WHO-TEF	Polychlorinated dibenzofuranes (PCDFs)	I-TEF	WHO-TEF
2,3,7,8-TCDD	1	1	2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PeCDD	**0.5**	**1**	1,2,3,7,8-PeCDF	0.05	0.05
1,2,3,4,7,8-HxCDD	0.1	0.1	2,3,4,7,8-PeCDF	0.5	0.5
1,2,3,6,7,8-HxCDD	0.1	0.1	1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1	1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01	1,2,3,7,8,9-HxCDF	0.1	0.1
OCDD	**0.001**	**0.0001**	2,3,4,6,7,8-HxCDF	0.1	0.1
			1,2,3,4,6,7,8-HpCDF	0.01	0.01
			1,2,3,4,7,8,9-HpCDF	0.01	0.01
			OCDF	**0.001**	**0.0001**

[1] North Atlantic Treaty Organization, Committee on Challenges of modern Society
Toxicity equivalent factors (TEFs) indicate the relative effect in relation to 2,3,7,8, TCDD. The concentration of a congener is multiplied by this factor. The values are added to a toxicity equivalent concentration (TEQ). This is a measure for the toxic effect concentration. The factors are published in papers and updated by technical committees. The last update was carried out by WHO in 1998. The various factors from NATO-CCMS and WHO appear in bold in the tables.

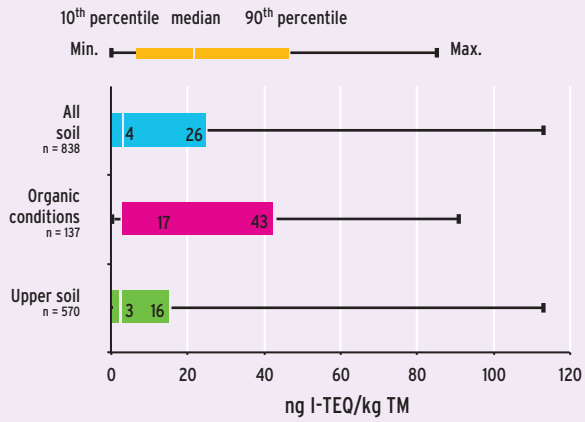
Source: *North Atlantic Treaty Organization 1998*

Evaluation

Analysis of the soil samples from the dioxin database of soils with no marked contamination obtained the following results: the median of all assessed horizons amounts to 4 ng I-TEQ/kg TM, the 90th percentile was 26, the maximum level 112. Most measurement results are for upper soils (A horizons), with a median of 3 ng/kg I-TEQ/kg TM and the 90th percentile of 16 ng/kg I-TEQ/kg TM (Fig. VII 2.2-1). Forest organic conditions reveal the highest levels with a median of 17 ng I-TEQ/kg TM and a 90th percentile of 43. Analysis of mineral upper soil according to region type (BBR type: metropolitan, urban, rural) did not reveal any significant difference. The median levels were between 1 und 3 ng/kg I-TEQ/kg TM and the 90th percentile between 8 and 16 ng/kg I-TEQ/kg TM (Fig. VII 2.2-2). The measured PCDD/F concentrations from agricultural arable soils are predominantly below the target values for the unrestricted agricultural use of 5 ng I-TEQ/kg TM, as recommended by the Federal/*Länder* DIOXINE working group (Fig. VII 2.2-3).

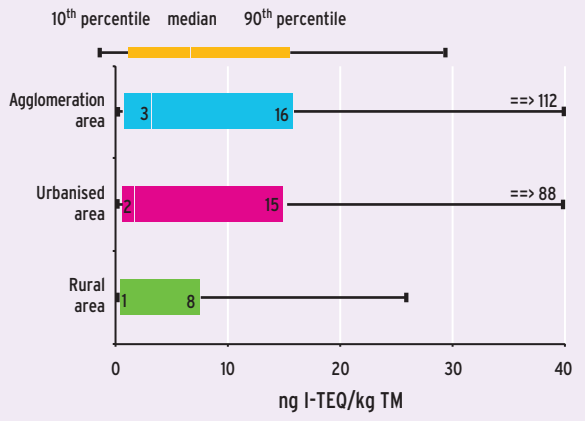
The homologous profiles reveal an increase in concentration from tetrachlorodibenzo-p-dioxins (TeCDDs) to octachlorodioxins (OCDDs) homologenes. OCDDs dominate with a share of almost 30 % for arable land and grasslands. In forest soil the 19.7 %, share of tetrachlorodibenzofurans (TCDFs) and pentachlorodibenzofurans (PeCDFs) is well over the OCDD concentration share of 14.5 % (Fig. VII 2.2-4).

Fig. VII 2.2-1: *PCDD/PCDF content (ng I-TEq/kg TM) in uncontaminated soils disregarding the detection limits (modified box-whisker plot, figures in the chart = median, 90th percentile)*



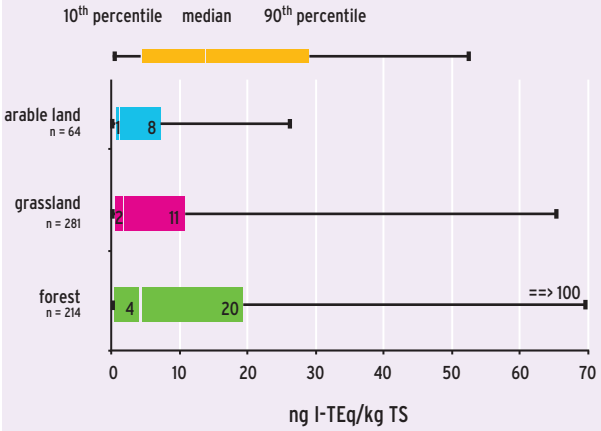
Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2002*

Fig. VII 2.2-2: *PCDD/PCDF content (ng I-TEq/kg TM) in mineral, uncontaminated upper soils in various types of area disregarding the detection limits (modified box-whisker plot, figures in the chart = median, 90th percentile)*



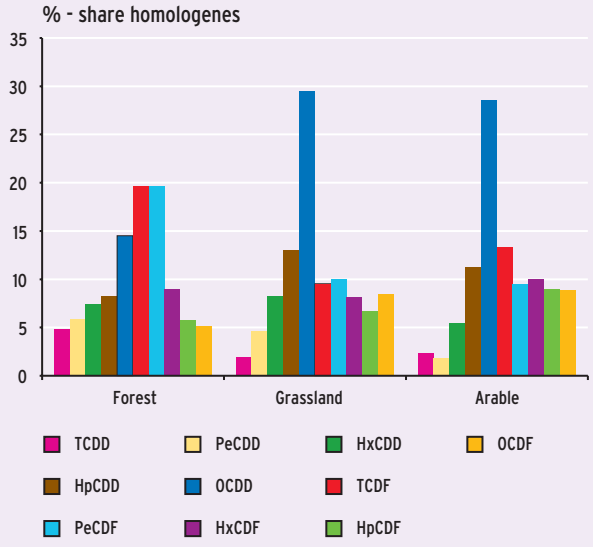
Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2002*

Fig. VII 2.2-3: *PCDD/PCDFcontents (ng-Teq/kg TM) in uncontaminated upper soils in relation to various use types without any particular contamination (modified box-whisker-plot, numbers in figure = mean, 90th percentile)*



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2002*

Fig. VII 2.2-4: *Homologous profiles of PCDD/F concentrations in forests and on grassland and arable land*



Source: *Federal Environment Agency 2002*

Hardly any dioxin decomposition occurs in soils and tillage simply disperses the dioxins throughout the soil (distribution effect). This also explains high dioxin concentrations in forests, increased by the trees combing out dioxins from the air and the soil not being worked. The dioxins make their way into the food chain via the soil. However, direct intake into plants, except courgettes, is minimal. Contamination usually occurs via soil particles attached to plants. Therefore, it is recommended that pastoral utilisation be avoided where there are increased dioxin concentrations. The plant – animal foodstuff – cow path leads to the contamination of milk which contributes 30 to 50 % of Germany's human dioxin intake. Children may be exposed to high levels of dioxins stored in female fat. These travel via the placenta into the breast milk. Future measures must therefore be taken to further reduce environmental dioxin contamination.

Measures

Legal regulations for soil protection have been drawn up which reduce inputs into the soil, for example dioxin emissions from incinerators must comply with the limit value of 0.1 ng I-TEQ/m^3 air (17th Federal Immision Control Ordinance 1990 – BimSchV). Sewage sludge may only be applied to soil if the dioxin content is less than 100 ng I-TEQ/kg dry solids (waste sewage sludge ordinance 1997). Federal/*Länder* Working Group on Dioxins recommendations apply to agricultural and horticultural land, and various action values are set out in the land utilisation regulation (Tab. VII 2.2-2).

Tab. VII 2.2-2: *Legal regulations and recommendations for the evaluation of dioxins and furans in soil*

Federal Soil Conservation Ordinance, 12 July 1999: Action values	
Play park areas	100 ng I-TEQ/kg TM
Residential areas	1 000 ng I-TEQ/kg TM
Industry, trade	10 000 ng I-TEQ/kg TM
Federal Government/Länder AG recommendations Dioxins in agricultural and horticultural soil	
No limitations on use	< 5 ng I-TEQ/kg TM
Limitations for pastures[1)]	5 bis 40 ng I-TEQ/kg TM
Limited use	> 40 ng I-TEQ/kg TM

[1)] If contamination level above 5 ng I-TEQ/kg TM, cause to be notified.

Source: *Federal Environment Agency 2005*

[1] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Dioxine-Daten aus Deutschland. Daten zur Dioxinbelastung der Umwelt, 3rd Federal Government/Länder Working Group on Dioxins report; Dioxin-Referenzmessprogramm 4th Federal Government/Länder Working Group on Dioxins. The reports are available in German and English from the UBA portal Persistente organische Stoffe, Dioxine at http://www.umweltbundesamt.de/uba-info-daten/daten/dioxine-dbla.htm.

VII 3 Inputs of harmful substances

VII 3.1 Inputs of air pollutants

The major pathway for air pollutants into soil, vegetation, and surface waters is atmospheric deposition. In the absence of precipitation, direct or "dry" deposition occurs, e.g., sedimentation, adsorption, or turbulent diffusion. Washout of atmospheric pollutants during precipitation (rain and snow) causes "wet" deposition. "Damp" deposition through fog,

dew, and frost is also especially important in interaction with vegetation.

The different physical and chemical properties of airborne impurities mean that they spread to differing extents due to the transport processes and chemical reactions in the atmosphere. Reactive air pollutants such as SO_2, NO_X, and NH_3 typically remain in the atmosphere for a matter of hours or days, during which time they can spread throughout Europe before deposition. The point of deposition can therefore be far distant from the point of emission.

In Central Europe, wet deposition (here rain and fog) is a key process in purifying the atmosphere of air pollutants. The chemical composition of the predominantly acidic precipitation in this region is determined by a large number of gases and particulate matter in the atmosphere (such as SO_2, NO_X and NH_3 and their products).

For some years inputs of acid have been dominant in Germany and in large areas of Europe via inputs of nitrogen. Based on the national average, reduced nitrogen compounds (ammonia/ammonium) alone currently contribute more to the acidification of the ecosystem than sulphur, and ammonia/ammonium especially dominates inputs of acid in heavily contaminated areas. Ammonia/ammonium from agriculture (e.g., intensive animal husbandry) is effectively the most significant acidifying and eutrophying air pollutant in Germany and across large regions of Europe. This trend is set to continue in view of current developments.

Europe-wide emissions and international cooperation (EMEP)

Since air pollution does not cease at national borders, effective environmental protection must also straddle these boundaries. This is especially the case with atmospheric transport of pollutants and the resulting Europe-wide contamination of terrestrial, limnetic, and marine ecosystems. The Geneva Convention on Long-range Transboundary Air Pollution (13 November 1979) established a framework for measuring transboundary air pollution and, through protocols to the convention for setting commitments to reduce emissions (the SO_2, NO_X, VOC, Heavy Metals, POP, 2nd Sulphur, and Multipollutant Protocols). The spread of pollutants within Europe is calculated by the European Monitoring and Evaluation Programme (EMEP).

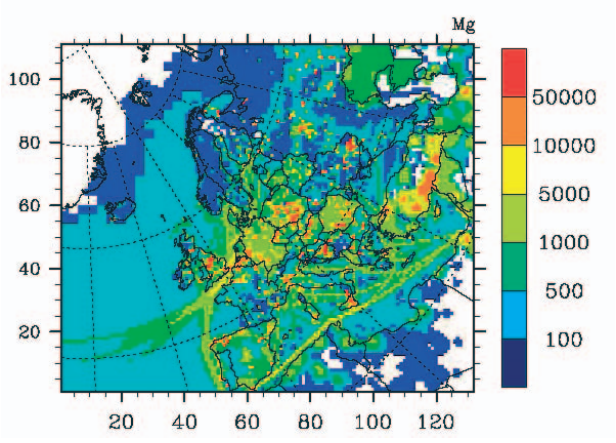
Measuring concentrations and depositions of air pollutants (including collecting, processing, evaluating, and exchanging data), and modelling transboundary transport and deposition of atmospheric pollutants on the basis of emissions and meteorological data provide a scientific foundation for measures to reduce emissions as well as a tool for assessing their effectiveness.

Research concentrates on acidifying components (e.g., sulphur and nitrogen compounds), photochemical oxidants (e.g., ozone), heavy metals, persistent organic pollutants (POPs), and fine dust (Figures VII 3.1-1 to VII 3.1-9).

Long-range transport and deposition of air pollutants

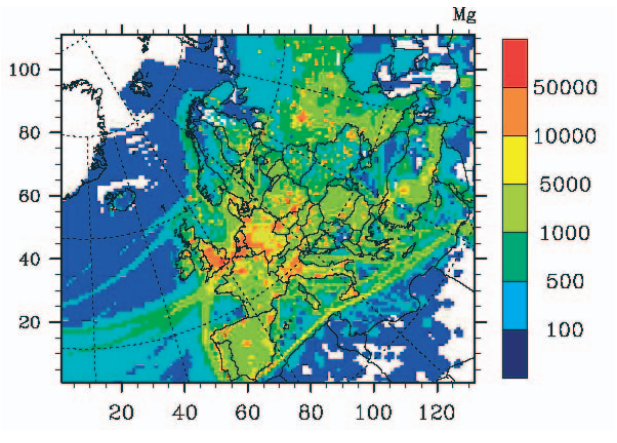
Calculating the spread of air pollutants requires complex atmospheric models, high quality input data, and considerable technical effort. For the first time, EMEP calculated the 2000 transboundary fluxes of oxidised sulphur and nitrogen (S_{ox}, N_{ox}) and reduced nitrogen (N_{red}) using trajectory models which take into account the vertical structure of the atmosphere. Transboundary fluxes of the heavy metals lead (Pb), cadmium (Cd), and mercury (Hg) were modelled for 2001.

Fig. VII 3.1-1: *Europe-wide 2001 sulphur dioxide emissions*



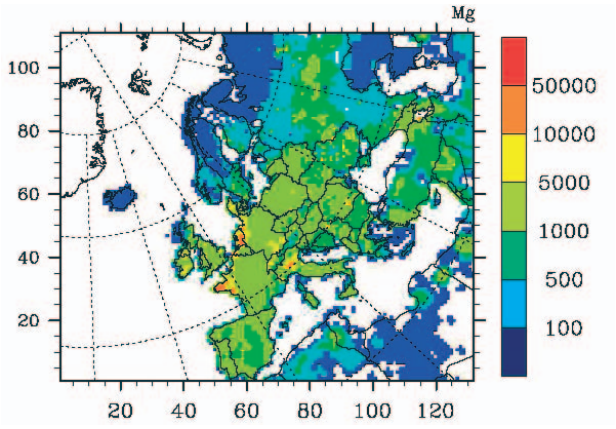
Source: *EMEP 2003*

Fig. VII 3.1-2: *Europe-wide 2001 nitrogen oxide emissions (as NO_2)*



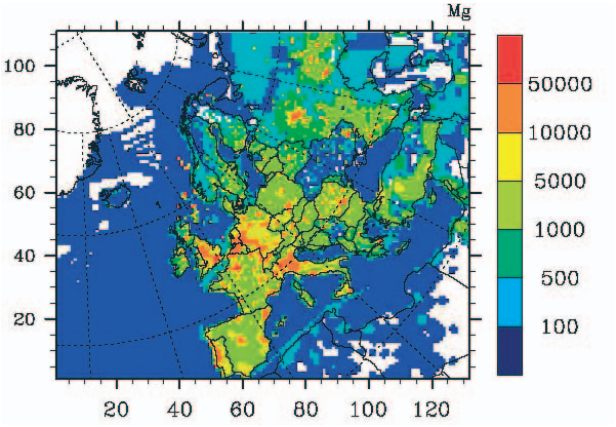
Source: *EMEP 2003*

Fig. VII 3.1-3: *Europe-wide 2001 ammonia emissions*



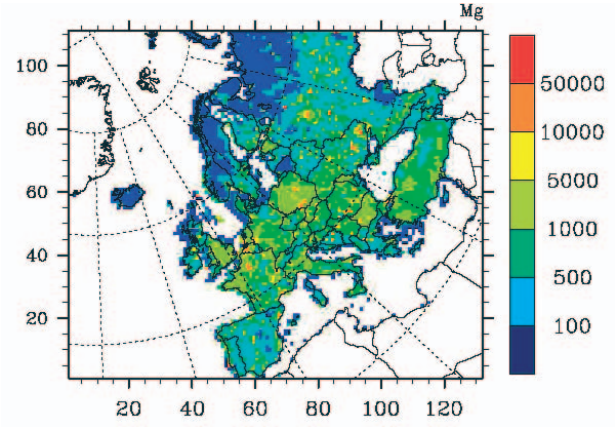
Source: *EMEP 2003*

Fig. VII 3.1-4: *Europe-wide 2001 volatile organic air pollutant emissions (excluding methane, NMVOC)*



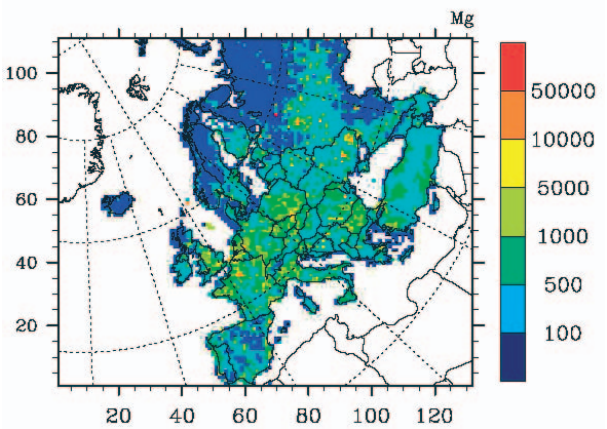
Source: *EMEP 2003*

Fig. VII 3.1-5: *Europe-wide 2001 fine dust emissions (PM_{10})*



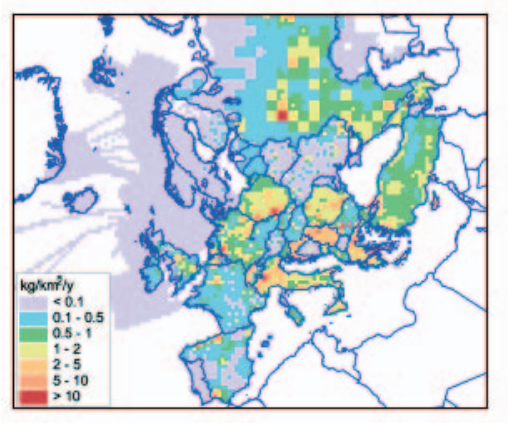
Source: *EMEP 2003*

VII 3.1-6: *Europe-wide 2001 fine dust emissions ($PM_{2,5}$)*



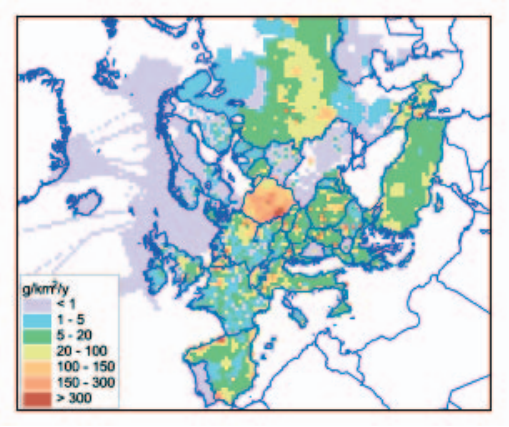
Source: *EMEP 2003*

Fig. VII 3.1-7: *Europe-wide 2002 lead emissions*



Source: *EMEP 2003*

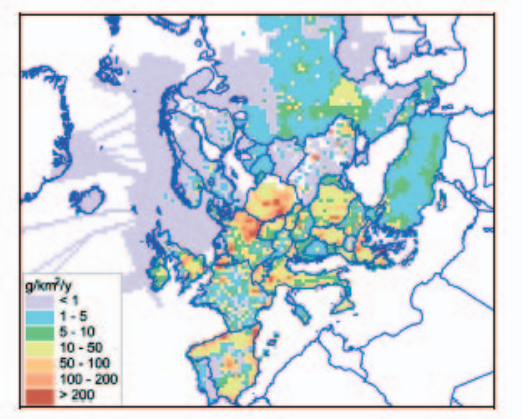
Fig. VII 3.1-8: *Europe-wide 2002 cadmium emissions*



Source: *EMEP 2003*

The calculations are based on depositions of SO_2, NO_x, and NH_3, and of Pb, Cd, and Hg, and on meteorological data. Depositions arising from emissions of SO_2, NO_x, NH_3, Pb, Cd, and Hg in each country are calculated, the data being presented in annual source receptor matrices. Figures VII 3.1-10 to VII 3.1-12 show the import-export budgets for sulphur and oxidised and reduced nitrogen in Germany for 2000.

Fig. VII 3.1-9: *Europe-wide 2002 mercury emissions*



Source: *EMEP 2003*

The continuing development of the EMEP model and improvements in the meteorological and emissions input data mean that more recent calculations of deposition may deviate from earlier results. The figures discussed here cannot therefore be compared directly with previously published data.

According to the preliminary results from the EMEP model, the situation in Germany for 2000 is presented below:

Of the total calculated 346 200 tonnes of sulphur (S) for 2000 (t/a S) deposition, 162 000 t/a S originated from emissions in Germany itself, 184 200 t/a S originated in the rest of Europe (152 300 of which originated in mainland Europe). This represents a mean annual rate of deposition of 0.97 t/km^2/a S. Germany exported 246 800 t/a S to the rest of Europe (168 900 t/a S of which to mainland Europe) (Fig. VII 3.1-10).

Of the total calculated 321 700 t/a oxidised nitrogen (N_{OX}) deposition, 84 200 t/a N_{OX} originated from emissions in Germany itself, 171 600 t/a N_{OX} originated in the rest of Europe (147 700 of which originated in mainland Europe) and a further 65 900 N_{OX} from sources outside Europe. This represents a mean annual rate of deposition of 0.90 t/km^2/a N_{OX}. Germany exported 370 200 t/a N_{OX} to the rest of Europe (259 000 t/a N_{OX} of which to mainland Europe) (Fig. VII 3.1-11).

Of the total calculated 371 500 t/a reduced nitrogen (N_{red}) deposition, 234 600 t/a N_{red} originated from emissions in Germany itself, 136 900 t/a N_{red} originated in the rest of Europe. This represents a mean annual rate of deposition of 1.04 t/km^2/a N_{red}. Germany exported 273 400 t/a N_{red} to the rest of Europe (184 400 t/a N_{red} of which to mainland Europe) (Fig. VII 3.1-12).

Figures VII 3.1-13 to 3.1-15 show the 2001 heavy metal levels for lead, cadmium, and mercury.

Model for total Europe-wide deposition of oxidised sulphur and nitrogen and reduced nitrogen

The EMEP programme calculates the total (wet and dry) deposition over Europe, using atmospheric transport models. Emissions inventories, expressed in the EMEP grid (currently 50 x 50 km^2), are combined with meteorological transport models and parameterised chemical and deposition processes. The MSC-W (Meteorological Synthesis Centre West) in Oslo calculates deposition rates as the averages for elements in the grid used for emissions. The figures show the interpolated results.

Such a model not only calculates the overall deposition but also assigns depositions to specific emissions.

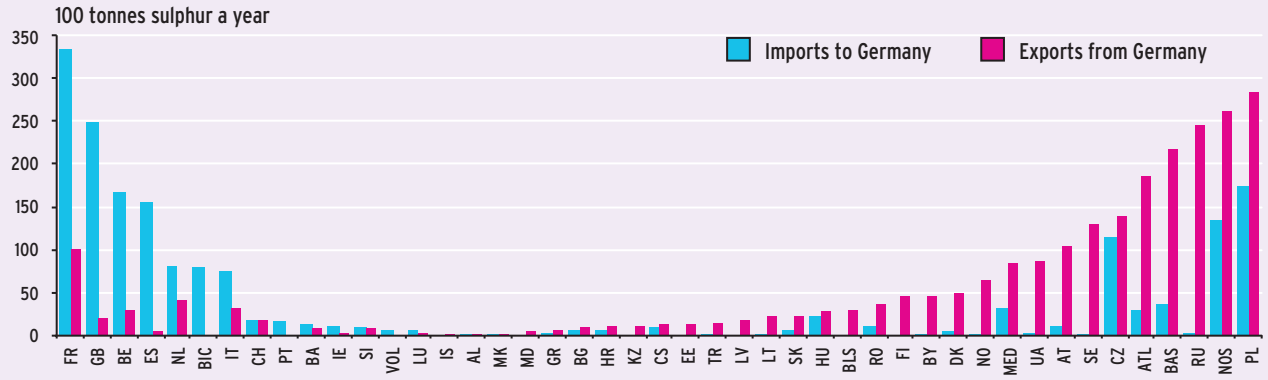
This makes it possible to test the effects of emissions reductions on deposition, for example, in especially sensitive areas.

The model's 2002 calculations for the total deposition of oxidised sulphur were 1–2 g/m^{2}a S in large areas of east and southeast Europe and the Benelux countries, and also for parts of Great Britain, northern Spain, and northern Italy. For Germany, the EMEP model produced depositions of mostly 0.5–1 g/m^2/a S (and 1–2 g/m^2/a S for parts of west Germany). The calculated oxidised sulphur depositions for northern and southwestern Europe were well below this level (0.1–0.5 g/m^2/a). The highest depositions in Europe (above 2 g/m^2/a S) occurred in southeast Europe (e.g., the Balkan Peninsula, Romania, Bulgaria). High depositions of oxidised sulphur were also found on Sicily in 2002, as a consequence of local volcanic activity (Etna) (Fig. VII 3.1-16).

According to the 2002 EMEP calculations total depositions of oxidised sulphur of 0.5–1 g/m^2/a N_{ox} occur in, among other places, Great Britain, the Benelux countries, northern France, Germany, Poland, the Czech Republic, Slovakia, Austria, the west Balkan Peninsula, and Italy. Depositions of oxidised sulphur with values under 0.5 g/m^2/a N_{ox} were however calculated for large parts of western and eastern Europe (for Northern Scandinavia: below 0.1 g/m^2/a N_{ox}) (Fig. II 3.1-17).

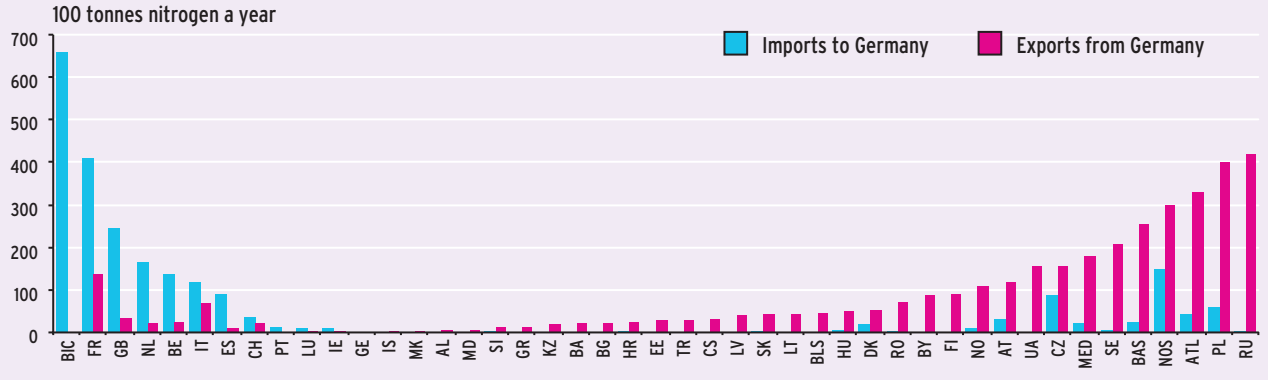
The highest depositions of reduced nitrogen (ammonia and ammonium) for 2002 occurred in the Netherlands, northwest and south Germany, Switzerland, northern Italy, and in parts of France (levels above 1 g/m^2/a N_{red}). The lowest deposition levels of reduced nitrogen were calculated for, among others, northern and southwest Europe (lev-

Fig. VII 3.1-10: *Balance of oxidised sulphur for Germany according to EMAP for 2000*



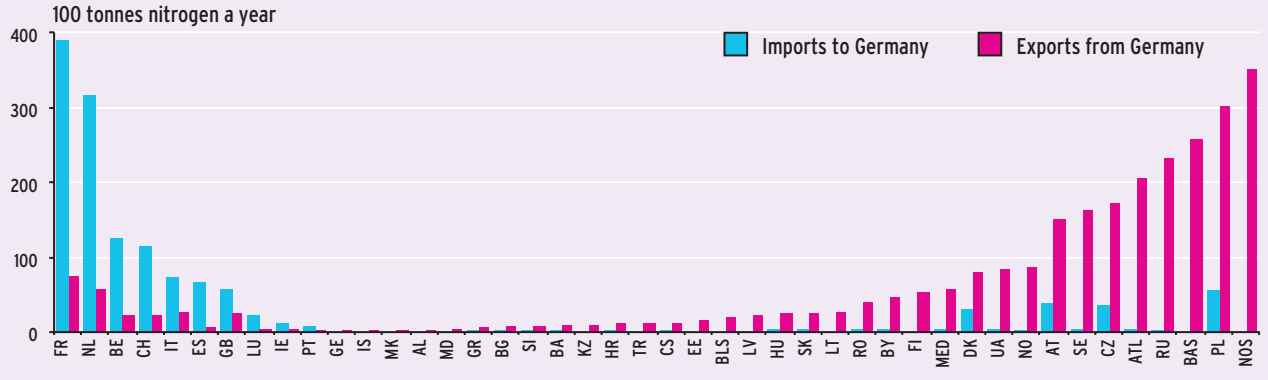
Source: *EMEP 2003 a*

Fig. VII 3.1-11: *Balance of oxidised nitrogen for Germany according to EMAP for 2000*



Source: *EMEP 2003 a*

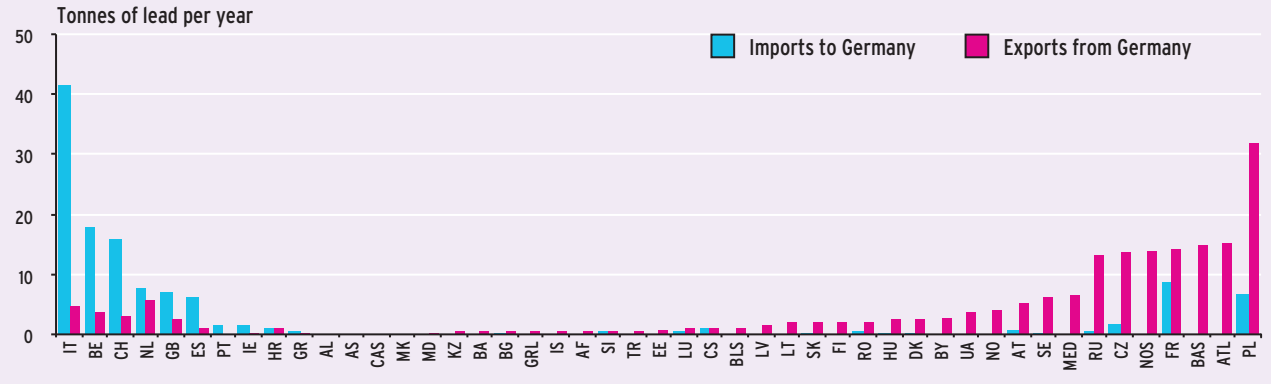
Fig. VII 3.1-12: *Balance of reduced nitrogen for Germany according to EMAP for 2000*



Source: *EMEP 2003 a*

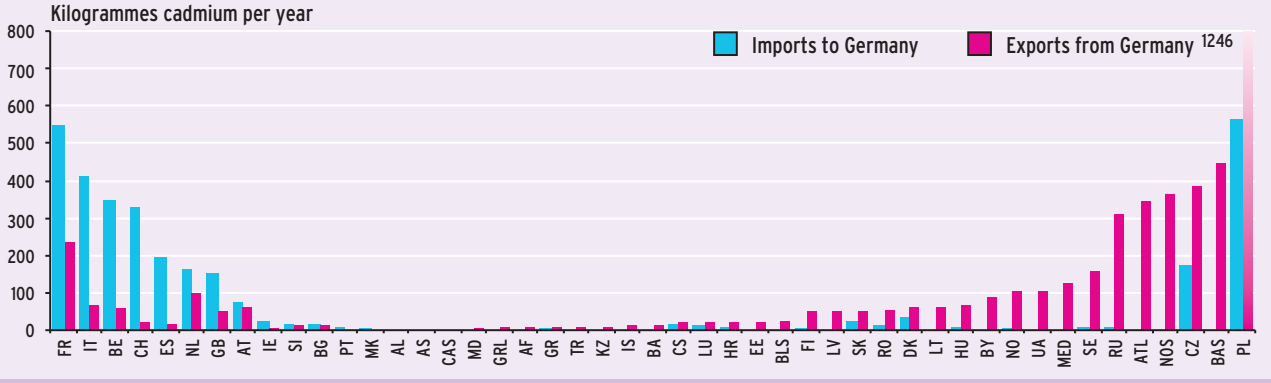
AF	Africa
AL	Albania
AM	Armenia
AS	Asia
AT	Austria
ATL	Atlantic
AZ	Azerbaijan
BA	Bosnia Herzegovina
BAS	Baltic Sea
BE	Belgium
BG	Bulgaria
BIC	non-European sources
BLS	Black Sea
BY	Belarus
CAS	Caspian Sea
CH	Switzerland
CS	Serbia and Montenegro
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
EU	EU
FI	Finland
FR	France
GB	Great Britain and Northern Ireland
GE	Georgia
GR	Greece
GRL	Greenland
HR	Croatia
HU	Hungary
IE	Ireland
IS	Iceland
IT	Italy
KZ	Kazakstan
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Moldavia
MED	Mediterranean
MK	Macedonia
MT	Malta
NL	Netherlands
NO	Norway
NOS	North Sea
PL	Poland
PT	Portugal
RO	Romania
RU	Russia
SE	Sweden
SI	Slovenia
SK	Slovakia
TR	Turkey
UA	Ukraine
VOL	volcanic emissions

Fig. VII 3.1-13: *Lead – 2001 figures for Germany according to EMEP*



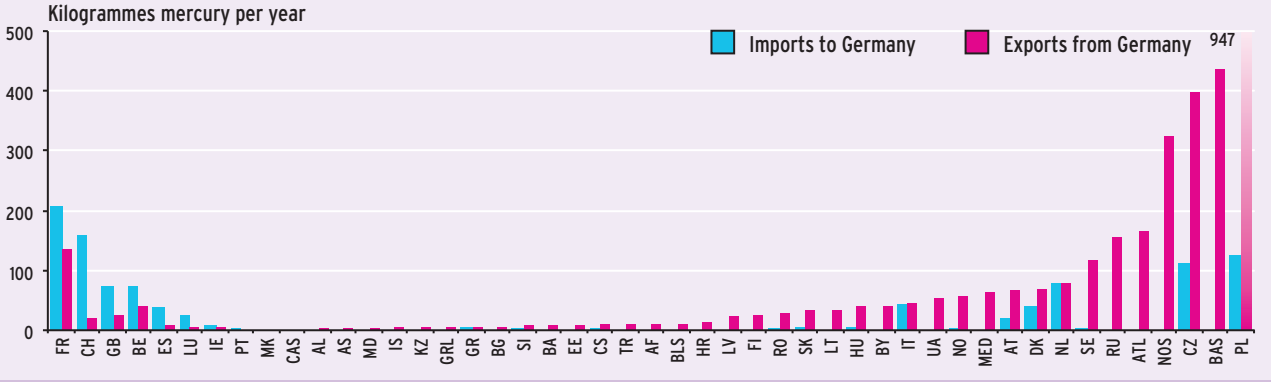
Source: *EMEP 2004*

Fig. VII 3.1-14: *Cadmium – 2001 figures for Germany according to EMEP*



Source: *EMEP 2004*

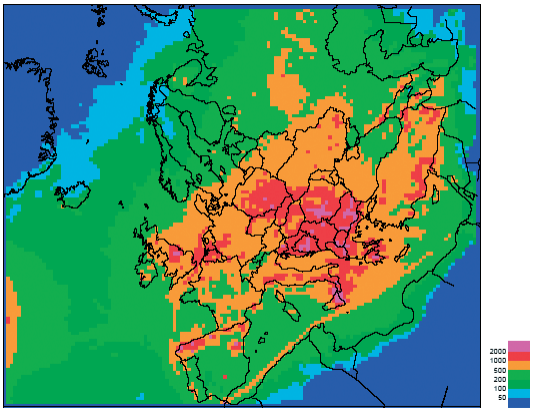
Fig. VII 3.1-15: *Mercury – 2001 figures for Germany according to EMEP*



Source: *EMEP 2004*

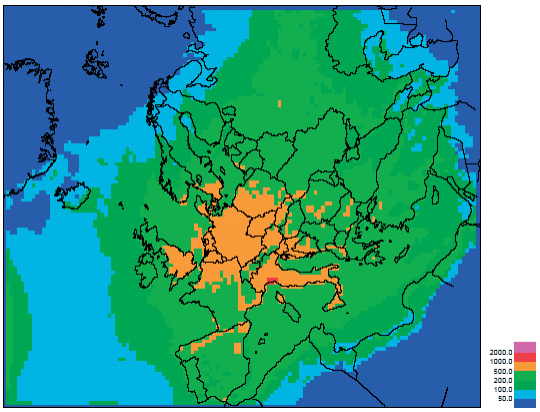
AF	Africa	CS	Serbia and Montenegro	HR	Croatia	PL	Poland
AL	Albania	CY	Cyprus	HU	Hungary	PT	Portugal
AM	Armenia	CZ	Czech Republic	IE	Ireland	RO	Romania
AS	Asia	DE	Germany	IS	Iceland	RU	Russia
AT	Austria	DK	Denmark	IT	Italy	SE	Sweden
ATL	Atlantic	EE	Estonia	KZ	Kazakstan	SI	Slovenia
AZ	Azerbaijan	ES	Spain	LT	Lithuania	SK	Slovakia
BA	Bosnia Herzegovina	EU	EU	LU	Luxembourg	TR	Turkey
BAS	Baltic Sea	FI	Finland	LV	Latvia	UA	Ukraine
BE	Belgium	FR	France	MC	Monaco		
BG	Bulgaria	GB	Great Britain and Northern Ireland	MD	Moldavia		
BIC	non-European sources	GE	Georgia	MED	Mediterranean		
BLS	Black Sea	GR	Greece	MK	Macedonia		
BY	Belarus	GRL	Greenland	MT	Malta		
CAS	Caspian Sea			NL	Netherlands		
CH	Switzerland			NO	Norway		
				NOS	North Sea		

Fig. VII 3.1-16: *Sulphur depositions model for 2002 (in mg/m² S)*



Source: *EMEP 2004 a*

Fig. VII 3.1-17: *Oxidised nitrogen depositions model for 2002 (in mg/m² N)*



Source: *EMEP 2004 a*

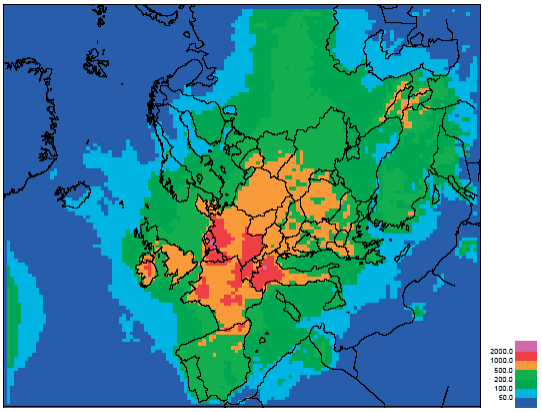
els above 0.1–0.5 g/m²/a N_{red} – for northern Scandinavia below 0.1 g/m²/a N_{red}) (Fig. VII 3.1-18).

Wet deposition of acids and acidifying compounds at UBA measuring stations

Long-term measurements of daily samples in the FEUBA network of measuring stations (Fig. VII 3.1-19) have shown that the concentrations and deposition of a number of ions in precipitation fell significantly between 1982 and 2003.

At the five stations in the old *Länder* (Westerland, Waldhof, Deuselbach, Schauinsland, and Brotjacklriegel), pH values in precipitation rose from approx. 4.3–4.4 to 4.8–5.0 (Fig. VII 3.1-20). A rise in pH corresponds to a fall in the concentration of hydrogen ions (H^+), and rain is therefore less acidic now than in the early 1980s. Although monitoring at the three stations in the new *Länder* (Zingst, Neuglobsow, Schmücke) has only been conducted for 10 years, a fall in pH has also been observed there.

Fig. VII 3.1-18: *Reduced nitrogen depositions model for 2002 (in mg/m² N)*

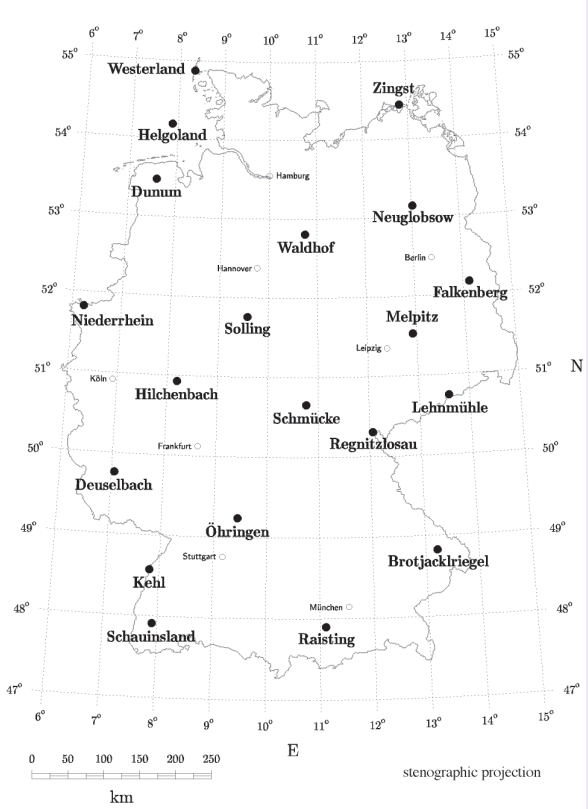


Source: *EMEP 2004 a*

Today's pH values are within a natural range, i.e., that which might be expected in central Europe without the influence of human activity, between 4.6 and 5.6. On the other hand, concentrations of some substances in large areas of central Europe are well above natural levels.

In parallel to the rise in pH values, the total ion content in precipitation, and thereby its specific conductivity, fell significantly at the stations in the old *Länder* between 1982 and 2003, except for West-

Fig. VII 3.1-19: *UBA measuring network deposition measuring points*



Source: *Federal Environment Agency 2004*

erland, where the total ion content of precipitation is more or less due to sea salt, and the fall was therefore only slight. A fall was also observed between 1993 and 2003 at the three stations (Zingst, Neuglobsow, Schmücke) and in the New *Länder* (Fig. VII 3.1-21).

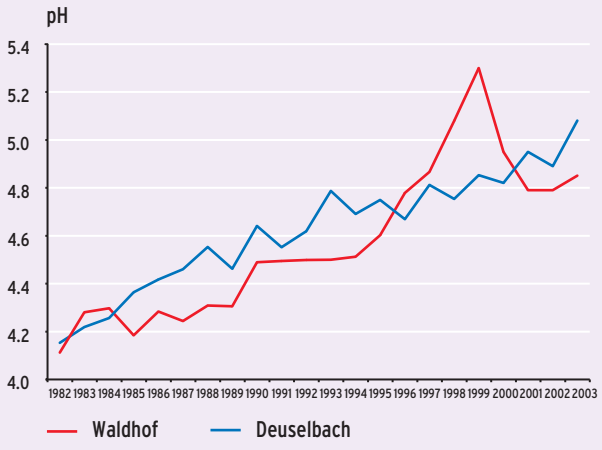
The drop in total ion content of rain water over the past two decades has been accompanied by a change in the regional distribution of different ions. At continental stations (Waldhof, Deuselbach, Schauinsland, and Brotjacklriegel), the percentage shares of H^+ and SO_4^- ions observed in 2003 were lower than those in 1984, while those of NO_3^- and NH_4^+ were higher (although absolute concentrations had fallen). The lower total ion concentrations and the shift in the distribution of ions are essentially due to greater reductions in SO_2 emissions than in NO_x and NH_3.

Concentrations of H^+ and SO_4^- fell most sharply, by 80 % and 70 % respectively, between 1982 and 2003. There was a fall of approximately 20–40 % in nitrate and ammonium concentrations. Figures VII 3.1-22 and VII 3.1-23 show concentrations and depositions between 1982 and 2003 as rainfall-weighted averages of five stations (Westerland, Waldhof, Deuselbach, Schauinsland, and Brotjacklriegel), normalised relative to 1982.

VII 3.2 Agricultural and horticultural soil contamination caused by fertilisers

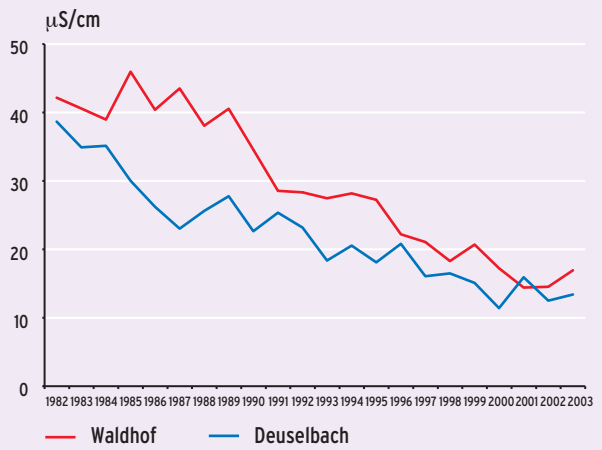
On the basis of decisions reached at the joint Agriculture and Environment Ministers' Conference on 13 June 2001 in Potsdam which states "it must be guaranteed on grounds of precaution, that cultivation practices do not give rise to an accumulation of

VII 3.1-20: *pH value development in precipitation*



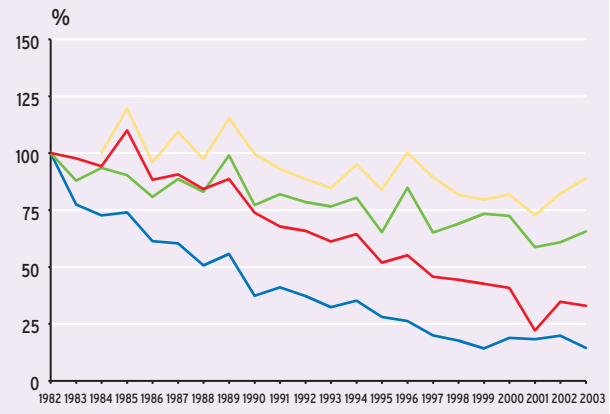
Source: *Federal Environment Agency 2004*

Fig. VII 3.1-21: *Conductivity development in precipitation*



Source: *Federal Environment Agency 2004*

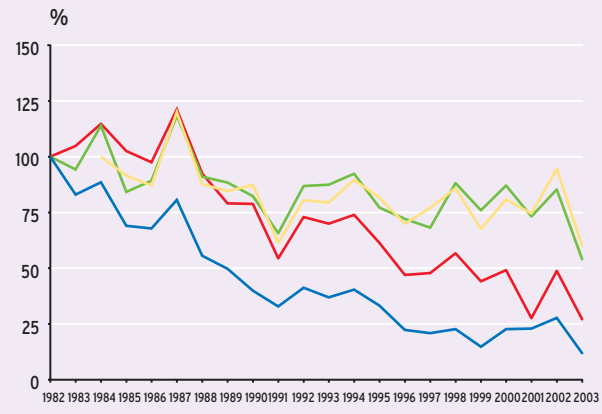
VII 3.1-22: *Development of ion concentrations*



Note: With the weighted annual mean precipitation values from the UBA measuring stations Westerland, Waldhof, Deuselbach, Brotjacklriegel and Schauinsland, normalised relative to 1982

Source: *Federal Environment Agency 2004*

VII 3.1-23: *Wet deposition development*



Note: With the weighted annual mean precipitation values from the UBA measuring stations Westerland, Waldhof, Deuselbach, Brotjacklriegel and Schauinsland, normalised relative to 1982

Source: *Federal Environment Agency 2004*

contaminants in the soil" and the new requirements of the Federal Soil Protection Act, the Federal Environment Ministry (BMU) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMVEL) produced a concept for a uniform assessment of fertilisers on 3 June 2002 – "high quality and safe yields". The calculations for permissible heavy metal levels in the affected materials are based on the soil precautionary values for the individual soil types as a standard for high soil quality. The values of the following control mediums were determining factors, following the "part for part" and "input equals output" principles:

- share remaining in the soil over the long-term,
- plant degradation,
- nutrient content,
- research errors.

Contamination of agricultural and horticultural soil caused by biowaste

Levels of biowaste have risen sharply since the Technical Instructions on Municipal Waste came into effect on 1 June 1993 (Chapter X 2.2). In Germany, approx. 900 biowaste treatment plants process around 12 million t of biowaste a year (including biodegradable agricultural material [1]). The Compost Quality Assurance Organisation (BGK) inspected 436 plants from 2004 using RAL quality controls, (set forth by the Deutsches Institut für Gütesicherung und Kennzeichnung e.V.). The secondary recycled fertilisers produced by these plants are potentially available for agricultural and horticultural organic fertilisation.

Every year, 4.8 million t of biowaste compost and 2.6 million t of biowaste fermentation products are produced. The five most significant sales areas are listed in Table VII 3.2-1 [2].

Tab. VII 3.2-1: *Sales areas for compost*

Sales areas in percent	
Agriculture	39
Horticulture and landscaping	17
Leisure gardens	9
Earthworks	10
Specialized crops	13

Source: *Bergs, C. G. 2000*

Since 1998, compost use in agriculture, forestry and horticulture has been regulated by the Ordinance on Biowastes (BioAbfV), which sets limit values on the heavy metal contents of recycled biowaste, based on quantities applied within a specific period (Tab. VII 3.2-2). If no more than 20 t biowaste per hectare (dry weight) are applied within three years, the limit values in column A apply. These limits correspond to the RAL quality seal for compost (RAL-GZ 251) reference values. If the quantities spread are up to 30 t dry weight per hectare over three years, the limit values in column B apply.

Tab. VII 3.2-2: *Limit values for heavy metals in bio-waste*

in mg/kg TS	A	B
Lead	150.0	100.0
Cadmium	1.5	1.0
Chrome	100.0	70.0
Copper	100.0	70.0
Nickel	50.0	35.0
Mercury	1.0	0.7
Zinc	400.0	300.0

DS = Dry solid

Source: *Ordinance of Biowaste (BioAbfV), 1998*

A study initiated by the Federal Environment Agency (UBA) on compost quality in the plants merged under BGK for 1998 to 2002 [3] obtained the following results: in comparison to levels before the Ordinance on Biowastes came into effect, an increase in quality of over 10 % was established. This is a result of the increase in nutrients and a reduction in lead, mercury, and cadmium. Higher organic matter contents were most often connected to decreasing concentrations of heavy metals. Around 18 % of all plants taking part in the study did not remain within the limit values stated in BioAbfV Article 4 (3), clause 2. In terms of the value recommendations revised by the UBA for an article regulation, 95 % of all plants are anticipated to fulfil the expected quality demands for material recycling (Tab. VII 3.2-3).

Contamination of agricultural and horticultural soil caused by semi-liquid manure

Semi-liquid manure is produced in strawless housing used in modern animal husbandry. Improper application, i.e., application under inappropriate weather conditions and incorrect application amounts can lead to the leaching of easily soluble nutrients in the soil. Table VII 3.2-4 shows the nutrient contents of the different semi-liquid manure types.

Besides nutrients, semi-liquid manure also contains inorganic and organic contaminants. Table VII 3.2-5 shows the heavy metal contents of cow and pig semi-liquid manure. Particularly problematic are high levels of copper and zinc originating in foodstuffs.

Besides heavy metals, semi-liquid manure contains a variety of organic contaminants, originating in animal foodstuffs or housing hygiene.

Under the UBA research programme "Characterisation and evaluation of waste from intensive live-

Tab. VII 3.2-3: *Development of compost quality*

Analysis-Parameter		1991 Average n = 153	1995 Average n = 488	2002 Average n = 376
Germinating seeds	per l FM	0.09	0.19	0.08
Impurities	% TM	0.23	0.16	0.20
Stone	% TM	2.53	1.94	1.74
Heat loss	% TM	36.30	36.50	37.30
Nges	% TM	1.03	1.25	1.52
P_2O_5ges	% TM	0.52	0.63	0.83
K_2Oges	% TM	0.85	1.04	1.26
Mgges	% TM	0.50	0.74	0.84
CaOges	% TM	3.55	4.35	4.79
Nloes	mg/l FM	114.49	235.89	402.10
Ammonium	mg/l FM	505.00	125.41	295.40
Nitrate	mg/l FM	64.00	66.95	92.40
P_2O_5loes	mg/l FM	815.94	942.09	1 068.00
K_2Oloes	mg/l FM	1 952.15	3 149.81	4 101.00
Mgloes	mg/l FM	433.62	243.45	227.00
Lead	mg/kg TM	63.21	59.32	46.40
Cadmium	mg/kg TM	0.79	0.60	0.47
Chrome	mg/kg TM	33.02	26.37	25.30
Copper	mg/kg TM	39.32	45.53	57.70
Nickel	mg/kg TM	18.58	16.28	16.30
Mercury	mg/kg TM	0.25	0.19	0.16
Zinc	mg/kg TM	182.93	196.68	203.70

FM = Fresh weight; TM = Dry weight; n = number of assessments; ges: Total; loes: soluble

Source: *Compost Quality Assurance Organisation 2002*

Tab. VII 3.2-4: *Nutrient contents for different fertilisers[1] in g/kg m_T*

Fertiliser given as:	Nitrogen N	Phosphate P_2O_5	Potassium K_2O
Cow semi-liquid manure	50	23.0	65.9
Pig semi-liquid manure	105	57.7	69.4

[1] According to bibliographical references and Länder surveys; an average content for organic fertiliser derived from these references is given. Please note that the underlying data sometimes obtains quite considerable fluctuations. These are not presented here since they are are negligible with regard to the model differentiations.

Source: *Federal/Länder Working Group on Soil Conservation 2000*

stock farming in various soil types" [4], statistics were recorded for veterinary medical products and substances with pharmacological effects used in the Weser-Ems region. The aim of the project was to assess the extent to which these preparations can lead to harmful changes in the soil and groundwater pollution. The study focused on the quantification of inputs of contaminants into the soil via veterinary medical products and animal feed chemical additives with so-called pharmacological effects.

Tetracycline represents the most significant class of substances, with a 58 % antibiotic level. Sulfanamide (21 %), aminoglycoside (10 %), b-lactam (5 %), and polymixin (3 %) are also noteworthy. 78 % of the tetracycline use is attributable to pig farming.

Exposure assessments under worst-case scenarios for excretion and persistence following EMEA/CVMP revealed final concentrations of approximately 20 ppm in semi-liquid manure (fattening pigs) and 90 ppm in solid manure (fattening turkeys) for once only stand treatment under average dosage. Administration of permitted levels in line with the Use of Fertilisers Ordinance (Dünge VO) obtained PECs (predicted environmental concentrations) in the soil at 0.45 and 0.9 ppm. These are well over the trigger values. Further ecotoxicological studies are being planned in response to such contraventions, in accordance with approval guidelines in effect since 1998 (EMEA/CVMP Guideline).

Tab. VII 3.2-5: *Heavy metal contents for different fertilisers[1]*

Fertiliser	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Cow semi-liquid manure	0.28	7.3	44.5	0.06	5.9	7.7	270
Pig semi-liquid manure	0.40	9.4	309.0	0.02	10.3	6.2	858

[1] According to bibliographical references and Länder surveys; an average content for organic fertiliser derived from these references is given in mg/kg m_T.

Source: *Federal/Länder Working Group on Soil Conservation 2000*

Tetracycline in excrement and urine is characterised by a significant increase up to the last day of administration and then falls back again sharply. Some animals are however still able to excrete significant levels of TC over longer periods. Up to 70 % of the administered active substances were found on the seventh day after administration.

Contrary to the results of other studies [5], tetracycline displayed a high stability in pig semi-liquid manures. The maximum reduction was 50 % over a period of 7 weeks. Chemical concentration, ambient temperature or air entry through occasional agitation had little influence on storage behaviour. In test container sediments rich in solids, the TC concentrations were 3 to 5 factors higher than in the liquid phase.

The Federal Environment Agency research project on "inputs of substances in soils – an assessment of hazard potential", cleaning and disinfecting agents used in agriculture were also examined. In terms of quantity, these use-specific synthetic chemicals occupy third place after commercial fertilisers and plant protection products.

Table VII 3.2-6 presents the results of a poll answered by associations, research institutions, dealers, and manufacturing companies on the quantitative use of cleaning and disinfecting agents in 1997.

- *Cleaning and disinfecting agents:* the most significant group in terms of quantity is cleaning and disinfecting agents for milking plants. It deals with concentrates or powders used in diluted solutions. Sodium chloride and dichlorisocyanurate from milking plant cleaners can lead to additional AOX-contamination in sewage sludge and semi-liquid manure.
- *Teat dip preparations containing iodine:* iodine-based teat dip preparations follow in second place. These are not usually diluted down. Nonylphenolethoxylate from teat dip preparations can lead to maximum nonylphenol levels of 0.9 mg/kg TS in cow semi-liquid manure and nonylphenol concentrations of around 3–4 mg/kg can occur in sewage sludge. This represents a nonylphenol content of around 15 % in sewage sludge.
- *Copper sulphate in hoof disinfection:* the use of copper sulphate powder is estimated at 1000 t/a where a 5–10 % aqueous solution is used in preventative disinfection and hardening of cow hooves. Copper sulphate solution leads to heavy metal contamination of semi-liquid manure and thereby of the soil. 1000 t copper sulphate contains (approximately) 250 t copper which amounts to 7 % (approx. 3500 t) of annual total copper inputs in agricultural soil. Local peak contents can be well over this mean value, in some cases over the alternative sewage sludge limit value of 800 mg/kg TS.
- *Disinfection of livestock housing:* between 800 and 900 t/a livestock housing disinfectants (commercial ready-preparations) are in use. Their commercial concentrations are between 1 and 4 percent volume. Quarternary ammonium compounds (QAC) disinfectants, except those originating in milk plant cleaners and livestock housing, do not lead to toxic risks in cow and pig semi-liquid manure. Poultry semi-liquid manure however can attain QAC concentrations of 100 mg/kg TS.
- *Cyanamide solution for semi-liquid manure disinfection:* in incidents of disease which must be reported, the semi-liquid manure is disinfected using organic chemicals such as formaldehyde, peracetic acid, formic acid, and calcium cyanamide. Moreover, inorganic preparations containing calcium and sodium hydroxide are employed but which are not referred to again in this connection. There are only rough estimates on usage amounts for the substances mentioned above due to irregular utilisation requirements. Permissible annual consumption levels of formaldehyde and calcium cyanamide in semi-liquid manure decontamination are around the 1000 t mark. Approx. 250 t cyanamide is routinely employed for killing pathogenic germs and fly eggs in the semi-liquid manure channel of livestock housing.

Contamination of agricultural and horticultural soil caused by sewage sludge

In 2003 2172 million t of dry solids were accumulated.

Tab. VII 3.2-6: *Cleaning and disinfecting agent groups in agricultural animal husbandry*

Application	t/a	Information sources
Cleaning and disinfecting agents for milking plants	22 000	Milk plant cleaning agent manufacturers
Teat dip preparations containing iodine	3 500	Teat dip preparation manufacturers
Copper sulfate for hoof disinfection	1 000	Primarily chemical dealers
Disinfection of livestock housing	860	Manufacturers of livestock housing disinfecting agents
Organic semi-liquid manure disinfectants	< 1 000	Primarily Hohenheim University
Cyanamide solution for semi-liquid manure disinfection	250	Primarily Hohenheim University

Source: *Kaiser et al. 1998*

These amounts were evaluated as follows:

- agricultural use 44 %
- landscaping 12 %
- composting 10 %
- incineration 23 %
- landfilling 11 %

The sewage sludge regulation [6] stipulates limit values for contaminants in sewage sludge for application on agricultural or horticultural land.

Contaminants:

- heavy metals (lead, cadmium, chromium, copper, nickel, mercury, and zinc),
- polychlorinated dibenzodioxins and dibenzofuranes (PCDD/Fs),
- polychlorinated biphenyls (PCBs),
- total parameters of adsorbable organic halogens (AOXs).

Tables VII 3.2-7 and VII 3.2-8 show the average concentrations of heavy metals and organic compounds in sewage sludge for agricultural use from 1991 to 2003, as well as the corresponding limit values set by the sewage sludge regulation (AbfklärV).

Tab. VII 3.2-7: *Average heavy metal concentrations in agriculturally employed sewage sludge (mg/kg TM)*

	1991–1994	1995	2001	2003	Limit value in accordance with sewage sludge ordinance (AbfklärV)
Lead	93.0	73.0	48.5	48.0	900.0
Cadmium	2.1	1.5	1.1	1.1	10[1)]
Chrome	59.0	52.0	37.4	42.0	900.0
Copper	286.0	277.0	300.6	305.0	800.0
Nickel	31.0	24.0	26.0	27.0	200.0
Mercury	2.1	1.3	0.8	0.7	8.0
Zinc	1076.0	863.0	774.0	746.0	2 500[1)]

[1)] In accordance with AbfkläV, the limit value for light soils with a clay content < 5 % or a pH-Value 5–6 is Cd = 5 and Zn = 2000.

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004*

Compared to the 1991 to 1994 period, average heavy metal contents exhibit a downwards trend (except copper) up to 2003, as do average organic chemical contents in sewage sludge.

Contamination of agricultural and horticultural soil caused by mineral fertilisers

Besides actual nutrients, mineral fertilisers contain variously high levels of contaminants (particularly heavy metals) depending on raw materials and production process.

Tab. VII 3.2-8: *Average concentrations of organic compounds in sewage sludge for agricultural use (mg/kg TM)*

Parameter	1994	2000	2003	Limit value in accordance with sewage sludge ordinance (AbfklärV)
PCDD/F (ng TE/kg TM)	22	9.6	9.5	100
PCB 28	0.015	0.0059	0.0077	0.2
PCB 52	0.015	0.0062	0.0085	0.2
PCB 101	0.024	0.0113	0.0200	0.2
PCB 138	0.039	0.0187	0.0187	0.2
PCB 153	0.039	0.0206	0.0195	0.2
PCB 180	0.026	0.0141	0.0138	0.2
Total PCB		0.0748	0.0835	
AOX	206	175.6	171.9	500

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004*

Various independent studies have been carried out on chemical contamination. The Federal Environment Agency first provided an overview of the different fertilisers in its 1992 study “Heavy metals and other contaminants in fertilisers” [7]. There are no new studies to date. More recent papers dealing with heavy metals in agriculture cite the results of the UBA study [8], [9].

Subsequently, only fertilisers for the main nutrients have been considered.

Nitrogen fertilisers

Pure N fertilisers reveal only low levels of heavy metal contamination. In contrast, high heavy metal contents are expected where P components are mixed into NP and NPK fertilisers, particularly with regard to cadmium, chromium, copper, nickel, and zinc. Heavy metal content is on average lower in NPK fertilisers as the mixed in potash components reveal lower levels of heavy metal contamination, resulting in lower levels of total heavy metal contamination [10].

Heavy metal contents of the main nitrogen fertilisers are listed in Table VII 3.2-9.

Phosphate fertilisers

In view of their impact on soil, differentiation must be drawn between soluble phosphates (for example

Tab. VII 3.2-9: *Heavy metal contents for different nitrogen fertilisers[1] in g/kg m_T*

Fertiliser	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Calcium ammonium nitrate	0.25	8.70	4.00	0.02	3.80	21.40	38.30
Ammonium nitrate – urea solution	0.03	1.30	6.30	0.30	0.20	2.30	
Urea	0.13	0.50	0.50		0.70	0.60	1.90
Mineral. NPK-fertiliser, 15/15/15 and others	3.78	45.80	11.30	0.06	10.90	14.80	116.00
Mineral. NP-fertiliser, 20/20/0 and others	9.15	91.40	21.50	0.02	18.00	5.50	151.00
Limit value in accordance with fertiliser ordinance (DüMV)	**1.5**	**2.0[2]**	**70**	**1**	**80**	**150**	**1 000**

[1] According to bibliographical references and Länder surveys; an average content derived from these references is given. Please note that the underlying data sometimes obtains quite considerable fluctuations. These are not presented here since they are negligible with regard to the model differentiations.
[2] Only applies to fertilisers originating in combustion processes. As Cr(VI).

Source: *Federal/Länder Working Group on Soil Conservation 2000*

superphosphates) and non-soluble phosphates (for example rock phosphates). The various rock phosphates display wide ranges of fluctuation in their heavy metal contents, depending on their rock phosphate deposits. Heavy metal contents in primary deposits (from magma) are lower than those of secondary phosphate deposits (from organic deposits) [11]. Besides high chromium contents in basic slag, a by-product of iron ore smelting with limited uses, P fertilisers can have significantly high cadmium contents.

Two studies were commissioned by the EU Commission to test the health risks and environmental impacts of cadmium in fertilisers, principally P fertilisers in EU Member States. Nine Member States carried out independent studies.

The Scientific Committee for Toxicity, Ecotoxicity and the Environment (SCTEE) study, commissioned by some of the Member States, obtained the following results:

- Only relatively slow accumulation tendencies in soil is anticipated for weak concentrations of cadmium in fertilisers (1...20 mg Cd/kg P_2O_5) or at best a reduction through higher output than input levels over a period of 100 years.
- In contrast, a relatively high accumulation on arable land is estimated for high cadmium concentrations in fertilisers (> = 60 mg Cd/kg P_2O_5) over a period of 100 years.

The results of the EU Member States' independent study on the risk assessments led to the adoption of the SCTEE recommendations. Fertilisers with < = 20 mg Cd/kg P_2O_5 cadmium concentrations do not cause long-term accumulation of cadmium in soil, as long as no other significant input paths exist. Fertilisers with cadmium concentrations of > = 60 mg Cd/kg P_2O_5 result in a greater likelihood of long-term accumulation of cadmium in soil.

Heavy metal levels of the main phosphate fertilisers are listed in Table VII 3.2-10. In accordance with the

Tab. VII 3.2-10: *Heavy metal contents for different phosphate fertilisers[1] in g/kg m_T*

Fertiliser	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Superphosphate	10.8	114	17.2	n. b.	28.8	18.5	236
Triple superphosphate	26.8	288	27.3	0.04	36.3	12	489
various rock phosphates[2]	7.8	168	15.6	n. b.	15.6	1.3	199
Mineral. NPK-fertiliser, 15/15/15 and others	3.78	45.8	11.3	0.06	10.9	14.8	116
Mineral. NP-fertiliser, 20/20/0 and others	9.15	91.4	21.5	0.02	18	5.5	151
Mineral. PK-fertiliser, 0/15/20 and others	7.98	191	19.3	0.08	19.9	14.4	152
Limit value in accordance with fertiliser ordinance (DüMV)	**1.5**	**2 [3]**	**70**	**1**	**80**	**150**	**1 000**

[1] According to bibliographical references and Länder surveys; an average content derived from these references is given.
[2] Depending on origin, there are quite significant cadmium content widths of spread for rock phosphates: 2–80 mg P_2O_5/kg m_T. Only those phosphates with a content below 40 mg P_2O_5/kg m_T are presently used in the fertilser manufacturing process.
[3] Only applies to fertilisers originating in combustion processes. As $Cr^{(VI)}$.

Source: *Federal/Länder Working Group on Soil Conservation 2000*

September 2004 Fertiliser Ordinance, a cadmium limit value of 50 mg Cd/kg P_2O_5 applies in Germany for fertilisers with 5 % P_2O_5 and above.

Potassium fertilisers

Potash ores contain very low heavy metal contents. The problems outlined above regarding high chromium contents in P fertilisers apply to potassic basic slag. Pure potassium fertilisers however only have limited application uses.

Heavy metal levels of the main potassium fertilisers are shown in Table VII 3.2-11.

[1] Körschens, M., Reinhold, J.: Einordnung von Komposten in die „Gute fachliche Düngungspraxis" unter besonderer Berücksichtigung der Humusversorgung landwirtschaftlicher Böden. Unpublished 2004
[2] Bergs C. G. (2000): Rechtliche Grundlagen für die Verwertung von Komposten und anderen Bioabfällen im Landbau, Müllhandbuch, code 6502
[3] Reinhold, J. (2004): Neubewertung von Kompostqualitäten. UBA Texts 15/04
[4] Winkler, C., Grafe, A. (2000): Charakterisierung und Verwertung von Abfällen aus der Massentierhaltung. UBA Texts 44/2000
[5] Kühne und Aghte (1998): Personal communication in Charakterisierung und Verwertung von Abfällen aus der Massentierhaltung, UBA Texts 44/2000
[6] Sewage sludge ordinance (AbfKlärV), 15 April 1992 (BGBl I 1992 page 912; 1997 page 446)
[7] Boysen, P. (1992): Schwermetalle und andere Schadstoffe in Düngemitteln. UBA Texts 55/92
[8] KTBL (1995): Schwermetalle in der Landwirtschaft. Working paper 217
[9], [10], [11],LABO (2000): Kadmiumanreicherung in Böden/ einheitliche Bewertung von Düngemitteln. UMK-AMK-LABO-AG report, presented by 26th ACK.

VII 3.3 Contaminated sites

The Federal Soil Protection Act (BBodSchG) introduced legal definitions for a number of terms connected with contaminated sites:

- suspected sites are lands suspected to contain harmful soil changes.
- sites suspected of being contaminated are former waste disposal sites and former industrial sites that are suspected to contain harmful soil changes or other hazards for individuals or the general public.
- contaminated sites, for example
  - closed-down waste management installations, and other real properties, in/on which waste has been treated, stored or landfilled (old landfill sites), and
  - properties that house closed-down installations, and other properties, on which environmental pollutants have been handled, except for installations that can be closed down only under a license pursuant to the Atomic Energy Act (former industrial sites), that cause harmful soil changes or other hazards for individuals or the general public.
- protection and restriction measures are other measures that prevent or reduce hazards, considerable disadvantages or considerable nuisances for individuals or the general public, especially usage restrictions.
- remediation refers to measures
  - that eliminate or reduce pollutants (decontamination measures),
  - that prevent or reduce spreading of pollutants in a lasting way, without eliminating the pollutants themselves (securing containment measures),
- that eliminate or reduce harmful changes in the soil's physical, chemical, or biological characteristics.

VII 3.4 Registration of contaminated land, risk assessment, site decontamination

Table VII 3.4-1 shows progress made in discovering and processing sites suspected of being contaminated and contaminated sites in Germany.

To facilitate comparison, nation-wide statistics on contaminated sites are being published in line with the following agreed classifications:

Tab. VII 3.2-11: *Heavy metal contents for different potash fertilisers[1)] in g/kg m_T*

Fertiliser	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Min. NPK fertiliser, 15/15/15 and others	3.78	45.8	11.3	0.06	10.9	14.8	116.0
Min. PK fertiliser, 0/15/20 and others	7.98	191.0	19.3	0.08	19.9	14.4	152.0
Potassic basic slag	0.30	928.0	19.0	n. b.	3.0	4.0	9.0
Potassium chloride, 40+6	0.08	3.5	2.9	0.02	1.5	0.5	3.7
Potassium sulphate with Mg, potassium magnesium sulphate	0.11	5.2	3.6	n. b.	4.1	2.5	17.4
Limit value in accordance with fertiliser ordinance (DüMV)	**1.5**	**2.0[2)]**	**70**	**1**	**80**	**150**	**1 000**

[1)] According to bibliographical references and Länder surveys; an average content derived from these references is given. Please note that the underlying data sometimes obtains quite considerable fluctuations. These are not presented here since they are negligible with regard to the model differentiations.
[2)] Only applies to fertilisers originating in combustion processes. As Cr(VI).

Source: *Federal/Länder Working Group on Soil Conservation 2000*

Tab. VII 3.4-1: *Nation-wide overview of contaminated sites statistics*

	As on	Suspected contaminated sites	Old landfill sites (AA)	Abandoned industrial sites (AS)	Contaminated sites	Decontamination complete	Risk assessment complete	Decontamination in progressg	Monitoring
serial number		1	1.1	1.2	2	3	4	5	6
Baden-Württemberg	12/2003	10 118	2 644	7 474	758	878	6 278	562	71
Bavaria	03/2003	13 930	10 193	3 737	1 449	727	3 042	1 427	22
Berlin	02/2004	2 711	857	2 322	439	49	k. A.	69	54
Brandenburg	12/2003	20 080	6 703	13 377	959	2 244	k. A.	59	309
Bremen	06/2003	2 965	55	2 910	101	307	499	56	62
Hamburg	1/2004	2 317	420	1 933	236	347	3 070	54	34
Hesse	03/2004	666	316	350	444	228	582	659	125
Mecklenburg-Western Pomerania	12/2003	8 546	3 648	4 898	642	742	596	256	355
Lower Saxony	02/2004	39 876	8 976	30 900	884	582	965	222	80
North Rhine-Westphalia	12/2001	42 868	18 337	24 642	1 917	2 901	8 915	1 843 675	1 575
Rheinland-Palatinate	k.A.	k.A.	k.A.	k.A.	k.A.	k.A.	k.A.	k.A.	k.A.
Saarland	03/2004	1 807	1 671	136	412	26	588	28	139
Saxony	04/2003	30 073	7 655	22 418	1 630	2 837	7 828	1 151	1 538
Saxony-Anhalt	11/2003	19 443	5 985	13 958	104	617	1 470	44	4
Schleswig-Holstein	12/2002	18 508	2 412	16 096	162	624	1 726	86	k.A.
Thuringia	11/2003	16 650	5 556	11 094	458	489	1 612	109	9

Notes on figures for individual Länder:
(serial numbers relate to tables above.)
Baden-Württemberg: serial no. 6: monitoring figures apply only to decontaminated site aftercare measures.
Bavaria: no footnotes for ID codes. Additional information on agreed official descriptions in accordance with paragraph 9, clause 1 BBodSchG: 4565 (AA 2 032/AS 2 533).
Berlin: serial nos. 1, 2 and 6: Evaluation possible as information in Berlin soil land register but many districts have not yet contributed to this. 5152 of 7894 land register sites are currently classified according to BBodSchG.
Serial nos. 1.1 and 1.2: limited evaluation possible as corresponds to a link between "suspected contaminated sites" and "case category". Duplicate terms cannot be ruled out. Reason: several case categories can apply to one site. The total number of "industrial site" and "old landfill site" case categories is therefore larger than the number of "suspected contaminated sites".
Serial no. 3: Serial no. 3: this information relates to contaminated sites which have been completely decontaminated and cleaned up. The Land of Berlin does not regard this information as discriminatory. Many decontamination measures are carried out path-specifically, on sub-plots and/or accompanied by building work. It is not clear whether the measure, i.e. partial or complete clearance of a site, is superficially responsible for harmful soil changes or contamination. In such cases the figures would rise: partial decontamination: 110, clearance via GW path: 7, clearance of sub-plots: 29.
Serial no. 4: problematic information as current processing progress is being queried. The Land of Berlin regards the information required as unusable and reappears in other information considered more useful in accordance with BBodSchG and BBodSchV: a) cleared of suspicion after suspected harmful soil changes ascertained, b) sites with proven harmful soil changes or contamination.
Information on completed risk assessments of suspected contaminated sites with regard to clearance: a) total area cleared from suspicion: 187, b) clearance with regard to GW path: 42, c) clearance of sub-plots: 48.
Serial no. 5: problematic information as current processing progress being queried. Constant care and updating of the "processing phase" field required.
Brandenburg: serial no. 4: no information as yet due to current ISAL package of questions. No information available on sites cleared of suspicion following risk assessment. Will be possible to publish the missing ID nos. with new software by end of 2004. Additional information on "sites without classification": 1555.
Bremen: figures referring to the current definitions are presently only estimated values. Bremen's contaminated sites land register is currently being reprocessed and restructured.
Hamburg: figures again provisional as the contaminated sites land register database in Hamburg is currently being technically revised. Serial no. 3: excluding protection or restriction measures, including some ongoing decontamination operations; serial no. 4: excluding contaminated sites upon close inspection; serial no. 5: excluding decontamination inspection or planning; not including private measures; serial no. 6: monitoring as completed post-risk assessment or decontamination measure.
Hesse: serial no. 1: sufficient suspicion for site in accordance with paragraph 9, clause 2 BBodSchG. Ascertained by notification. On the stated qualifying date in Hesse, a total of 6.800 old landfill sites were declared and recorded (212 of which with very high risk potential according to previous use or landfill site rating) and 101.682 abandoned industrial sites (20.005 of which with very high degree of risk according to previous use or industrial rating). Risk assessment not yet carried out on all sites. Serial no. 6: monitoring operations figures apply only to decontaminated site aftercare measures..
Mecklenburg-Western Pomerania: serial no. 1: **T**he stated number only covers normal suspected contaminated sites. Serial no.s 2,3,5: figures only recorded since final quarter of 2003, not yet complete due in particular to changes to recording programme contents. Serial no. 6: the stated figure comprises not only the monitoring of contaminated sites but also the monitoring of suspected contaminated sites.
Lower Saxony: serial no. 1.2: the number of suspected contaminated sites to rise because recording has not yet been carried out. Serial no. 3: given figure comprises successfully completed decontamination operations (451) and partially completed decontamination operations (decontaminated sub-plots, 131).
North Rhine-Westphalia: serial no. 1 and 2: figures provided indirectly because NRW does not as yet differentiate between suspected contaminated sites and contaminated sites. The contaminated sites and harmful soil changes technical information system (FIS AlBo) is currently under construction. This will encompass the above differentiation. As part of the annual statistics inspection presently being carried out by the responsible local authorities for soil conservation, discrimination between suspected contaminated sites, contaminated sites and land cleared of suspicion will first be examined. Serial no. 4: figures apply to all completed risk assessments, including sites which have been cleared of suspicion. Serial no. 5: separate information only on either ongoing and completed decontamination inspections or ongoing decontamination because these figures are called up separately and duplicate records caused by summation cannot be ruled out. The current state of progress for each site is in FIS AlBo, enabling definite figures. Serial no. 6: figures represent the sum of the ongoing monitoring operations following risk assessment and following decontamination.
Saarland: no footnotes on the ID codes.
Saxony: all information refers to sub-plots. Serial no. 4: incl. sites cleared of suspicion of contamination on basis of present use. Serial no. 5: completed decontamination inspections. Not possible to state whether decontamination initiated or not. Serial no. 6: figures comprise monitoring operations following guided inspection, close examination and decontamination inspection as well as aftercare for decontaminated sites.
Saxony-Anhalt: no footnotes on the ID codes.
Schleswig-Holstein: serial no. 1: estimated figures for abandoned industrial sites; number of old landfill sites in some cases excluding decontaminated sites. Serial no. 2: figures do not include contaminated sites for which protection and limitation measures only have been arranged. Serial no. 4: no definite figures for completed risk assessments. Monitoring reported for 292 old landfill sites and 112 abandoned industrial sites. This may be a question of when the monitoring was carried out, either during or following decontamination. Serial no. 6: number of monitoring operations following risk assessment cannot be reported separately because the responsible local authorities for soil conservation also report many monitoring operations taking place during risk assessment.
Thuringia: no footnotes on the ID codes.

Source: *Federal Environmental Agency 2004 a*

- sites suspected of being contaminated/former waste disposal sites/former industrial sites,
- risk assessment completed,
- contaminated sites,
- decontamination in progress,
- decontamination complete,
- number of sites being monitored.

The data provided by the *Länder* contains numerous explanations (e.g., references to duplicate terms, data validity limitations, information on estimates ascertained according to land registers for each contaminated site).

Large-scale projects for site decontamination in the new Länder

In order to encourage funding for remediation in transitionally state-owned contaminated industrial sites (Treuhand) and to preserve and create jobs, the Federal Government and the Treuhandanstalt (THA – institution responsible for privatising former east German industry) concluded an administrative agreement in 1992 with the *Länder* of Berlin, Brandenburg, Mecklenburg-West Pomerania, Saxony, Saxony-Anhalt, and Thuringia joint funding of this project. The administrative agreement on the regulation of funding of ecologically hazardous sites was concluded for this purpose.

This regulates proportionate funding of Federal Government/*Länder* measures with the prerequisite that the competent *Land* authorities exonerate investors from the responsibility and costs of any environmental damage caused prior to 1 July 1990, in accordance with the Environmental Framework Act/obstruction siting law. Exoneration granted, the demands enforced on the *Länder* are split 60 (Federal Government) to 40 *(Länder)*. A costs ratio of 75 (Federal Government) to 25 *(Länder)* was set for large-scale ecological projects. These costs are reduced by the sum paid by the purchaser of a THA business.

Under the direction of the Federal Ministry of Finance and the Federal Environment Ministry, a joint Federal Government/THA working group (since January 1995 BvS)/*Länder* was set up which unanimously determined 21 large-scale industrial projects in accordance with the criteria set out in the administrative agreement. The measures and the funding thereof form the basis of the THA obligations towards the investors in accordance with the contaminated site clauses in the respective privatisation agreements.

In order to extend its sphere of application and speed up its implementation, the federal and *Länder* governments agreed in January 1996 that, given certain conditions, the level of federal funding for large-scale remediation projects could be set in advance (as a lump sum), passing the entire responsibility for further treatment of contaminated sites under the large-scale projects, to the respective *Länder*.

Between 1996 and 2000, agreements between the respective *Länder* and BvS for federal funding obligations were concluded for eight large-scale remediation projects (the shipyards in Rostock, Stralsund, and Wismar in Mecklenburg-West Pomerania, TVW project in Rositz and potash mines in the southern Harz and Werra in Thuringia, as well as projects in Mansfeld and Magdeburg-Rothensee in Saxony-Anhalt and Saxonia Freiberg). The large-scale Dresden-Coschütz project came to an end in 2001.

In 1999 the free state of Thuringia was the first *Land* to conclude a general treaty with BvS on definitive funding of old ecologically hazardous sites. The consent principle was annulled upon fulfilment of all federal and BvS funding obligations under the administrative agreement. Responsibility for further implementation is passed to all projects under the administrative agreement, including the use of the substance on the land, without the need for a further agreement with the Federal Government and BvS. Further general treaties were concluded with Saxony-Anhalt and Mecklenburg-West Pomerania in 2003.

Other large-scale projects are underway in line with the present regulation in the Spree industrial area, the *Land* of Brandenburg, the Oranienburg region, the city of Brandenburg, BASF Schwarzheide, PCK Schwedt and the SOW Böhlen and Lauta projects in Saxony.

Decontamination of open-cast lignite coal mines

A further large-scale project “lignite mine decontamination” aims to decontaminate and find other uses for abandoned open-cast mines and industrial lignite refinement sites. This largest single environmental project is being implemented and represented at federal and *Land* level by LMBV (Lausitzer und Mitteldeutsche Bergbauverwaltungsgesellschaft mbH – company regulating reclamation measures in post-mining landscapes).

Since decontamination of open-cast lignite mines began, 7.5 billion EUR has already been made available by the Federal Government and lignite mine *Länder* Brandenburg, Saxony, Saxony-Anhalt und Thuringia, based on an administrative agreement. A total financial framework of 1.7 billion euros has

been set for 2003 to 2007, split 75:25 between the Federal Government and the *Länder*. Approximately 50 % of the original total decontamination area (1200 km^2) is to be converted into agricultural and forestry areas, 27 % into water surface, 18 % into conservation areas, and 3 % into commercial and industrial areas. The impressive lakeland areas emerging in Lusatia and central Germany are attractive leisure and recreational areas.

VII 4 Non-chemical soil conservation

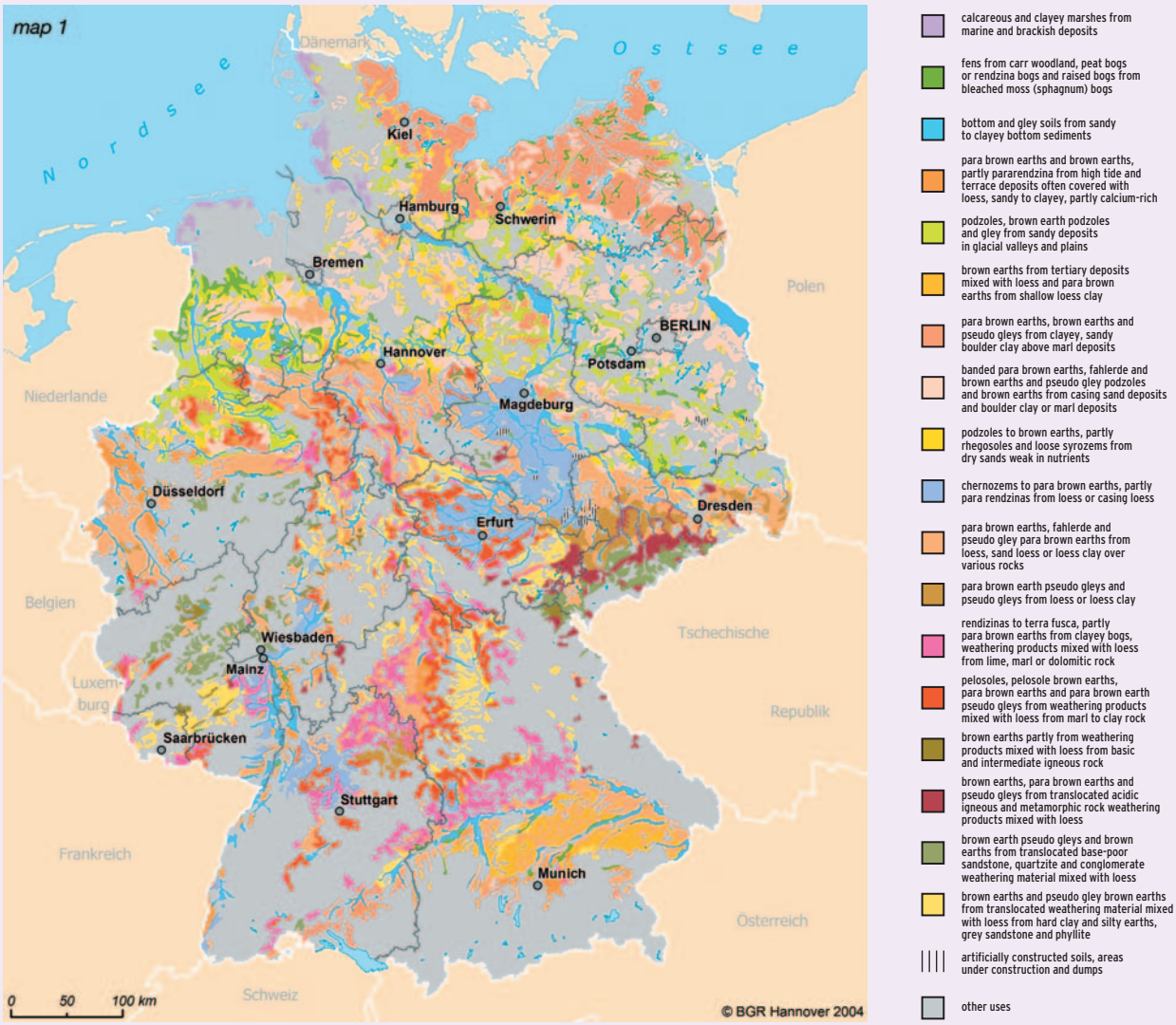
VII 4.1 Erosion risk

The process of soil erosion caused by water is governed by the rain and soil properties, length and inclination of slopes, soil coverage and tillage and the type of erosion control measures. The share of threat exclusively attributable to natural local factors without anthropogenic influence is described as natural erosion disposition or erosion susceptibility.

Soil erosion caused by water on grassland and in forest areas under central European climatic conditions is negligible. Therefore, only areas utilised predominantly for arable farming identified under the CORINE land use model will be taken into account here. In order to ascertain erosion susceptibility caused by water, relief and climate information is invoked alongside soil and land use data. Relief impact is assessed using grid data on degrees of inclination in spatial divisions of 50m. An isoerodent map is used to record erosivity of precipitation on a nation-wide scale, based on long-term precipitation data collected from 139 climate stations.

Figure VII 4.1-1 presents a nation-wide overview of the chief arable soils utilised for farming.

Fig. VII 4.1-1: *Use-specific soil overview map for the Federal Republic of Germany arable land excerpt*

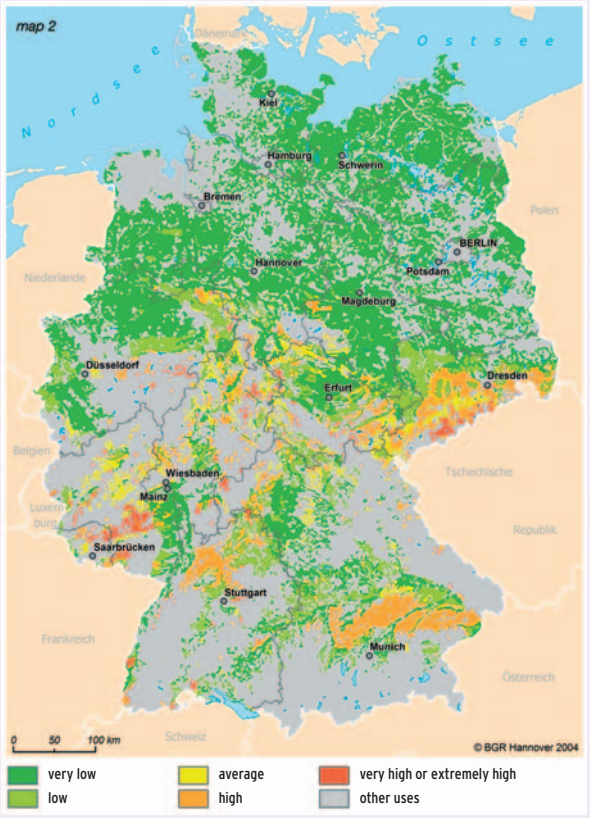


Source: *Federal Institute for Geosciences and Natural Resources 2004*

The data is based on the soil overview map of Germany on a scale of 1:1,000,000 (BÜK 1000), scaled down here to 1:5,000,000 from the Federal Institute for Geosciences and Natural Resources' specialists soil science information system data inventory (FIS-Bo BGR).

As shown in Figure VII 4.1-2, more than 50 % of the assessed areas of the country fall under the very low and low erosion susceptibility classifications. A classification system designed to provide a nation-wide overview portrays northern Germany as comparably undifferentiated and offers no spatial separation between old and young moraine areas, despite variations in morphogenesis. Even in loess dissemination regions, large areas of the Magdeburg Boerde or the Thuringia Basin fall under very low erosion susceptibility because chernozems with favourable structural development and low slope inclinations prevent a higher classification. Soils in sand loess areas reveal slightly higher hazard levels. Focal areas susceptible to water erosion are in the Bavarian tertiary hills, the Erzgebirge and the Erzgebirge foreland, the Kraichgau, the Palatine-Saarland cuesta and the Saar-Nahe hills. It should however be taken into account that viticultural areas are included in the combined classification of arable areas and permanent crops in some areas of southwestern Germany [1].

Fig. VII 4.1-2: *Land threatened with erosion in Germany*



Source: *Federal Institute for Geosciences and Natural Resources 2004*

VII 4.2 Measures

Adaptation in agriculture

Erosion control measures for soil tillage such as ploughing against the slope on hills (contour ploughing), minimal soil tillage, mulch seeding, undersowing of crops or intercropping contribute significantly to the reduction of loss rates. Ways of reduced land management (eg., contour ploughing) and erosion limitation measures can reduce Germany's ascertained potential loss risk by up to a half. Actual annual soil loss varies greatly between different regions and depends on the soil tillage methods of the individual enterprises and possibly on any erosion control measures already implemented. The use-dependent erosion threat calculated using the universal soil loss equation (USLE) must be examined against the background of the respective regional local conditions and the prevailing soil management type. In view of actual threats to soil and a possible need for action, a differentiated on-site examination of the risk of loss is therefore required. Although spatial variability of the erosion risk chiefly depends on local conditions, the amount of soil loss is conclusively determined by type of land cover and implementation of erosion control measures.

[1] Federal Institute for Geosciences and Natural Resources (BGR) 2004

VIII ECOSYSTEMS AND BIODIVERSITY

Ecosystems are units containing all the organisms in a given area as well as their relationships with each other and the inorganic environment. The organisms within an ecosystem constitute a biocoenosis, while the area inhabited by a biocoenosis is called a biotope. In the course of development, more or less stable ecological states regularly occur which are supported by numerous, interlinked material life cycles. Anthropogenic contamination can, depending on its severity, rapidly harm the stability of these ecosystems, and even cause them irreversible damage.

The term "biodiversity" covers three different levels:

- diversity of ecosystems,
- diversity of species, and
- genetic diversity within species.

The world is presently undergoing a dramatic decline in biodiversity, mainly caused by anthropogenic activities. For example, it has been estimated that human influences have accelerated species loss to a rate one thousand to ten thousand times above what is natural. Besides the influences that directly affect biodiversity such a hunting or fishing, mankind particularly alters the abiotic and biotic environmental quality, which then affects the development of biodiversity. To curb the dramatic decline in biodiversity, in 1992 a UN conference on "The Environment and Development" passed a convention on biological diversity which sought to preserve biodiversity, make long-term use of its components, and evenly and justly distribute the benefits that arise from exploiting genetic resources [1]. Ecological consequences should, therefore, be a yardstick for economic and social decision-making. The biodiversity convention obliges nations to develop a biodiversity strategy and to check that their existing plans are compatible with the biodiversity asset.

Since 1995, at the European level, a strategy has been developed to integrate the protection of biodiversity into sectoral policies with the basic aim of halting the loss of biodiversity by the year 2010. In its sixth action programme, the European Union agreed to use the ecosystem approach, whereby the aim is to achieve a balance between conserving and exploiting biodiversity while involving all the relevant areas of society and scientific disciplines [2].

[1] Convention on Biological Diversity (CBD) of the Conference of the United Nations 1992 in Rio de Janeiro
[2] Decision No. 1600/2002/EC of the European Parliament and Council of 22nd July 2002 on the European Community's sixth environmental action programme; Official Journal of the European Union (formerly OJEC) L 242/2 of 10/09/2002

VIII 1 Inventory and threat status

VIII 1.1 Threats to plant and animal species living in the wild

Since industrialisation began in the nineteenth century, the rate of species loss worldwide has accelerated.

According to the International Union for Conservation of Nature and Natural Resources (IUCN), around one-tenth of all bird species and a quarter of mammals in the world are under threat [1]. For these categories of species – less than 10 % of which have probably been studied to date – the share of threatened species could be over one-third.

Of the total number of vascular plants that have been assessed worldwide, around 12 % are under threat [2]. It can be assumed that not all the species that currently exist can be recorded, since many species will have become extinct before they were discovered [1].

In global terms, Germany has particular responsibility for conserving a wide range of species in its national territory. These are species that either exist only in Germany, are clustered here, or are regarded worldwide as threatened and for which Germany is a vital habitat [3]. Germany is also particularly responsible for stocks of species that constitute high-quality, isolated outposts, that possess or show promise of specific genetic characteristics. Germany is also jointly responsible for preserving biodiversity at European and national levels.

According to estimates produced by the Federal Agency for Nature Conservation, ferns and blooming plants have been disappearing at a rate of 31 species per decade since around 1850 [3]. The main reason for the loss of species is direct disturbance of sites, which affects around 540 species. Another is agricultural measures such as the abandonment or intensification of use, primarily on grass- and farmlands that had previously been extensively managed. Other threats include nutrient inputs and barriers to the natural dynamics involved in biodiversity.

The reasons behind the loss of animal species vary according to the species group. However, the main threats to many groups of animal species include

ongoing fragmentation of the landscape, land consumption, channellisation, straightening of waterways and elimination of natural water meadow dynamics, lowering of groundwater levels, acidification, and eutrophication processes. A well-known tool for recording the threat status in terms of species protection are the Red Lists. However, not all indigenous species are included in these lists [4]. The Red List of threatened animals in German includes not only Red Lists for all vertebrates but also many groups of invertebrates. Of around 45 000 indigenous animal species, over 16 000 species (35 %) have had their threat status assessed [5]. Some other animal groups, e.g., soil fauna, should also be assessed in the future [6]. For the Red List of plants, 13 835 species (almost 50 %) of the 28 000 species native to Germany have had their threat status examined and assessed [7]. Of those species that have been studied in Germany, only about 50 % of both plant and animal species are not under threat [8].

[1] International Union for Conservation of Nature and Natural Resources (2004): 2004 IUCN Red List of threatened species; numbers of threatened species by major groups of organisms (1996–2004): http://www.redlist.org [as on 14 December 2004]

[2] Walter, K. S., Gillett, H. J. [Eds.] (1998): 1997 IUCN Red List of threatened plants. – Gland (International Union for Conservation of Nature and Natural Resources) 862 pp.

[3] Federal Agency for Nature Conservation (2004): Daten zur Natur 2004; Münster (Landwirtschaftsverlag).

[4] German Advisory Council on the Environment (SRU): Umweltgutachten 2004, Umweltpolitische Handlungsfelder sichern; Nomos Verlagsgesellschaft

[5] Binot, M., Bless, R., Boye, P., Gruttke, H., Pretscher, P. (Eds.) (1998): Rote Liste gefährdeter Tiere Deutschlands; Bonn–Bad Godesberg: BfN Schriftenreihe für Landschaftspflege und Naturschutz 55

[6] Riecken, U., Binot-Hafke, M., Gruttke, H., Korneck, D. & Ludwig, G (2000): Fortschreibung und Perspektiven von bundesweiten Roten Listen. – BfN Schriftenreihe für Landschaftspflege und Naturschutz 65: 231–255.

[7] Ludwig, G., Schnittler, M. (1996): Rote Liste gefährdeter Pflanzen Deutschlands, Bonn: BfN, Schriftenreihe für Vegetationskunde 28

[8] Federal Agency for Nature Conservation (2003): Rote Liste gefährdeter Tiere; Aktuelle Gefährdungssituation; http://www.bfn.de/03/030101.htm and 03/030102.htm [as on 23 October 2003]

VIII 1.2 Biotope types

According to data provided by the Federal Agency for Nature Conservation, around 500 types of biotope may be distinguished in Germany (excluding purely technical biotopes such as roads, buildings, and landfill sites).

In 1994, the Federal Agency for Nature Conservation (BfN) produced an index of endangered biotopes as a complement to its Red List of endangered species. The extent to which a biotope is at risk is determined by three criteria: the loss of area (LA) and qualitative change (QU), both of which describe the level of the threat to the biotope; the third criterion, regenerative capacity (RE), describes how easily a biotope can recover (Table VIII 1.2-1). The first two criteria are combined to produce regional values for eight regions in Germany. In each case, this has the highest value of either criterion. The average of these eight regional values then provides a measure of how endangered a biotope type is throughout Germany. Regenerative capacity is a significant aspect of a biotope's sensitivity, and can be used to set conservation priorities where two biotopes are similarly endangered. This information can also be used to assess the ability of the countryside and the natural world to absorb the impacts of human intervention.

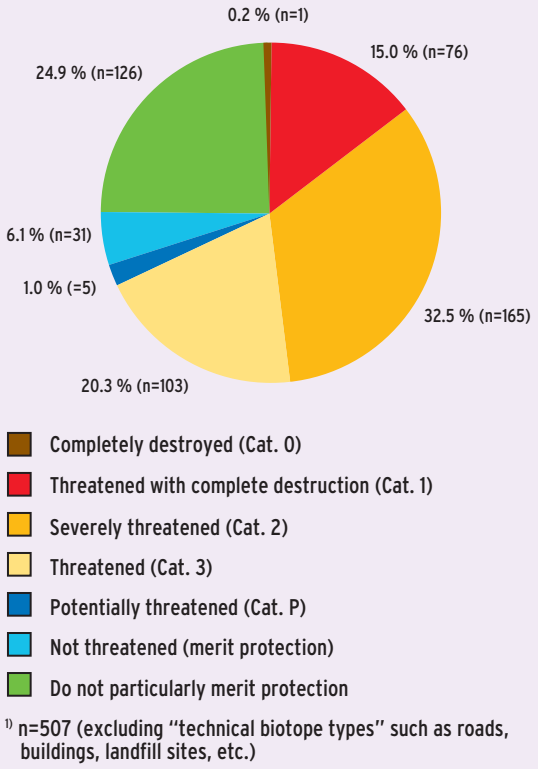
Tab. VIII 1.2-1: *Criteria and categories for the Red List of endangered biotopes in Germany*

Criterion I	Threat from Loss of Area (LA)
0	completely destroyed
1	threatened with complete destruction
2	severely threatened
3	threatened
p	potentially threatened
*	no threat currently assumed
Criterion II	**Threat from Qualitative Change (QU)**
0	completely destroyed
1	threatened with complete destruction
2	severely threatened
3	threatened
*	no threat currently assumed
Criterion III	**Regenerative Capacity (RE)**
N	no regeneration
K	scarce regeneration (> 150 years)
S	regeneration difficult (15–150 years)
B	regeneration possible (up to 15 years)
X	classification not meaningful

Source: *Riecken et al. 1994*

The survey of Germany's biotopes shows that over two-thirds (69 %) of all biotope types are endangered. Figure VIII 1.2-1 shows the distribution of threat categories. The small proportion of destroyed biotopes (0.2 % in Category 0) is not evidence of a favourable overall situation. We know very little about types of biotope which may have existed 100 or 150 years ago, and which have now disappeared without trace, before they could be described. The Category 0 can therefore only record the destruction of those biotopes known to us today. The relatively large share of biotopes threatened with complete destruction (over 15 % in Category 1) demonstrates how, if the present threats to biotopes are allowed to act further, a great number of biotope types will be destroyed completely. About a third of biotope types are severely threatened (Category 2). Only very few could be classified as potentially threatened (1 % in Category P) because the majority

Fig. VIII 1.2-1: *Threat status to Germany's biotope types*[1)]



Source: *Federal Agency for Nature Conservation 2004*

of rare or geographically restricted types of habitat are already explicitly classified as threatened (Categories 1–3).

The overwhelming majority of biotope types currently considered to be free of risk also merit little protection (24.9 % of biotope types), while few types meriting protection were not considered at risk (6.1 % of the survey).

The types classed as "not meriting protection" include all those habitats that have a negative or no positive impact on conservation (intensively farmed land, forests of alien species, mining operations, urban parkland, hypertrophic water bodies, boundary features, etc.).

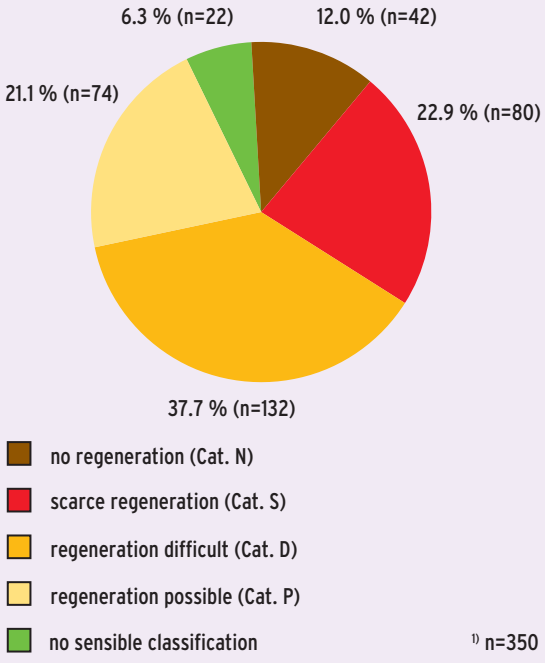
The extent to which a biotope type is threatened depends on such factors as the reproducibility or non-reproducibility of its characteristics, its regenerative capacity and its resilience. In this context, regenerative capacity covers both the biotope's own potential for autonomous regeneration after negative impacts cease and the possibility of regeneration through deliberate human intervention (cleanup, renaturation, recreation of the biotope, etc.).

Regenerative capacity is usually dependent on the required development time (or the required historic continuity) and the ability to recreate suitable abiotic site and general conditions.

The term "local conditions" covers not only classic parameters such as humidity, nutrient levels, etc., but also the specific "general cultural and historic situation" that was responsible for the development of certain biotope types. Regenerative capacity is also influenced by a large number of territorial interrelationships. For example, the accessibility of the areas intended for typical species undergoing recolonisation processes.

Of the endangered biotope types, around 35 % were categorised as having no or scarce regeneration (Categories N or S, see Fig. VIII 1.2-2). It can be assumed that neither natural processes nor specific conservation measures could compensate for losses of these biotopes, at least not within any reasonable period of time. To a slightly lesser extent, this applies also to biotope types where regeneration is difficult (Category D). It is currently thought that regeneration is possible (Category P) within a reasonable time span (up to ca. 15 years) for only 21 % of endangered biotope types. This information is especially important when assessing the medium- to long-term impact of human intervention.

Fig. VIII 1.2-2: *Regenerative capacity of endangered biotope types in Germany*[1)]



Source: *Federal Agency for Nature Conservation 2004*

Because knowledge levels have increased and the threat status of a number of biotype types has altered, a new edition of the Red List for threatened biotype types is planned for 2005.

VIII 1.3 Genetic diversity

Alongside species and ecosystem diversity, genetic diversity is the third component of biodiversity. It refers to the diversity within a species, i.e., the genetic variability between an individual and a population of the same species. Genetic diversity plays a particularly palpable role wherever human usage depends directly on this diversity. This is the case, for example, with cash crop strains and livestock breeds. Breeding processes carried out by mankind have given rise to a large number of sub-species, breeds, and strains that are adapted to, for example, particular cultivation conditions and that also then represent the basis for further breeding processes. The modern agricultural sector also depends on having a sufficient genetic diversity of wild and bred varieties of the species they use, which constitute, for example, a source of new properties providing resistance to pests and diseases.

Sufficient genetic diversity is thought to be essential to the survival of wild species, as a rich gene pool containing sufficient characteristics and combinations of characteristics is required if a species is to adapt to a changing environment (for example due to climate change).

However, relatively little is known about the scale, ecological significance, historic change, and degree of threat in genetic populations. Somewhat more is known about genetic resources for agriculture. Today, genetic variety in central European wild populations is threatened predominantly by anthropogenic influence on the countryside. The loss and fragmentation of habitats due to residential and transport development can destroy, isolate, fragment, and reduce populations. Genetic isolation often reduces diversity within a population, increasing the risk of extinction. The selective effects of other anthropogenic influences, such as pollution, can also reduce diversity.

Genetic diversity among indigenous wild organisms can be corrupted and reduced by importing individuals of the same species from other geographic areas, for example by the rehabilitation or reintroduction of animals, or through plantation or reforestation. This can have serious ecological consequences. For example, if seed stock from elsewhere is used, genes can pass into the indigenous (autochthonal) populations, which could then, for example, alter the bloom date which then affects pollinating insects.

However, the principal tool for promoting genetic diversity among indigenous wild species is in situ conservation, preserving habitats and giving the species protected status. To a limited extent, and for small numbers of wild species, ex situ conservation is also possible, preserving the species outside its natural habitat, for example in the approximately 34 zoological and 90 botanical gardens and arboreta in Germany, or in other collections, such as genetic, seed, or sperm banks.

The Federal Information System on Genetic Resources (BIG), a joint project run by four partner institutions, holds around 150 000 pieces of information online (www.big-flora.de).

The Federal Agency for Nature Conservation (BfN) runs databases on stocks of species (in situ), the distribution, inventory situation and ecology of indigenous wild plants (www.floraweb.de); the Ruhr University of Bochum's (RUB) Botanical Gardens records the plant inventories of Germany's botanical gardens (ex situ) through the Association of Botanical Gardens; the Institute for Plant Genetics and Crop Plant Research in Gatersleben maintains the database of the nearly 100 000 crop plant accessions in the gene bank (in situ) and runs the database for "Mansfeld's World Manual of Agricultural and Horticultural Crops"; the Biological Diversity Information Centre (IBV) at the German Centre for Documentation and Information in Agriculture (ZADI) has databases on specific species of fruit and runs the central database for German plant gene resources (www.zadi.de). See Chapter VIII 3.1 for further information.

VIII 1.4 Species index

In order to document successes and failures in terms of ensuring biodiversity as part of the national sustainability strategy, the Federal Agency for Nature Conservation has developed a species index which currently shows trends in the inventories of 51 selected bird species [1]. They constitute indicator species for the quality of their habitats, as they show trends in inventories of many other species, the quality of biotopes and the suitability of the territory as a habitat.

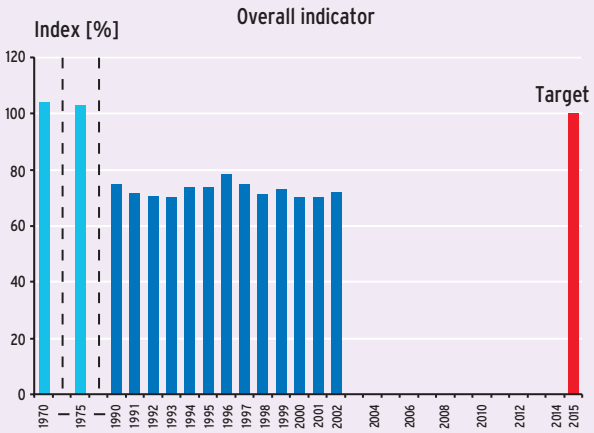
The species were selected based on the need to include the widest possible range of habitats which would represent trends throughout the entire countryside, so the species index is made up of sub-indicators for the main types of landscape and habitat in Germany: agricultural land, forests, residential areas, inland waters, coasts, and the sea. In partnership with the *Länder's* own bird protection institutions and the Federation of German Avifaunists, 10 or 11 bird species were selected for each of the principal habitat types, representing the various charac-

teristics and usages. Work is currently being done on a sub-indicator for the Alps.

To make the success of sustainable interaction with nature and the countryside measurable, a target was specified as the indicator year 2015. This was determined through a committee of experts on each bird species who estimated what inventory could realistically be expected in 2015 if the regulations on nature conservation and the guidelines on sustainable development in the various areas of nature use were properly adhered to (the so-called Delphi Method). Achieving these inventory figures would mean that the target was 100 % achieved.

The sustainability indicator for species diversity shows that the greatest decline in species diversity occurred prior to 1990 (Fig. VIII 1.4-1); this negative trend had been slowed by the early 1990s. Since then, the pattern has remained relatively even, at 70 % achievement of the target. To achieve the 2015 target, land consumption for residential and transport purposes needs to be reduced, ecological farming expanded, and the amended Federal Nature Conservation Act has to be put into practice.

Fig. VIII 1.4-1: *Trends in inventories of the main habitat types for representative bird species*



Source: *Federal Agency for Nature Conservation 2004*

[1] Achtziger, R., Stickroth, H., Zieschank, R.: Nachhaltigkeitsindikator für die Artenvielfalt – ein Indikator für den Zustand von Natur und Landschaft in Deutschland. Angewandte Landschaftsökologie Heft 63, Bonn–Bad Godesberg, 2004. 137 pp.

VIII.1.5 The condition of forests

A number of factors influence the vitality of forest ecosystems. Alongside natural influences, such as weather conditions or insect attacks, there are anthropogenic inputs of pollutants into the forest. All these factors influence each other and can reinforce or weaken the overall condition of the forest. Atmospheric deposition plays a key role. The main sources of air pollution are industrial plants, power stations, traffic, households, private consumption, and intensive livestock farming. Forests are particularly affected by ammonia (NH_3), sulphur dioxide (SO_2), and nitrogen oxides (NO_x). A single pollutant or a complex pollutant combination can affect the overall impact on forest ecosystems in different ways. The most important combinations observed are surplus nitrogen in the entire system, acidification and losses of nutrients in forest soils, and direct damage from ozone. Case studies have also examined changes in the species structure of ground vegetation.

The United Nations Economic Commission for Europe (UNECE) and the European Union (EU) have been monitoring the condition of Europe's forests since the mid-1980s. Changes to the condition of forests over time and space related to natural and anthropogenic stress factors have been recorded over large areas at 6 000 monitoring points distributed systematically throughout the continent. This widespread monitoring system is known as the Level 1 programme. The links between air pollution and damage to forest are studied at 860 permanent observation areas in the most significant forest ecosystems throughout Europe. This intensive observation is known as the Level II programme and is regarded as a supplement to the surveys carried out at Level I. The programme, with its large number of observation areas and 39 participating countries, is one of the world's largest biomonitoring networks.

VIII 1.5.1 Forest Condition in Germany

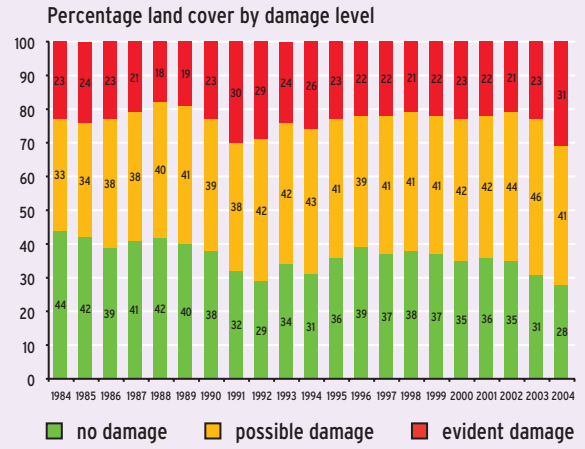
Nationwide observation (Level I)

The crown condition of forest trees has been recorded since 1984; it provides information about the trees' health. The findings of the nationwide crown condition assessment in 2004 (16 x 16 km network) show that forest trees' crown condition in 2004 had declined considerably.

Individual results include [1]:

- The proportion of forest areas with visible crown defoliation (damage classes 2–4) had risen by 8 percentage points to 31 % (Fig. VIII 1.5.1-1 and Fig. "Trends in forest damage – Norway spruce, pine, beech, and oak"). At the national level, this is the greatest increase over the preceding year and, at the same time, the highest level since the time series began in 1984.

Fig. VIII 1.5.1-1: *Trends in forest damage in Germany, all species*



Source: *Federal Ministry of Food, Agriculture, and Consumer Protection 2004*

- The proportion of trees without defoliation fell by 3 percentage points and was at its lowest national level (28 %).
- The warning stage (slight defoliation) stood 5 percentage points lower, at 41 %.
- This situation, though varying in degree from region to region, exists in all the *Länder*. Crown defoliation has particularly increased in southern Germany (Bavaria +15 percentage points, Baden-Württemberg +11 percentage points), Schleswig-Holstein +18 percentage points, and Berlin +16 percentage points.

The national average for crown defoliation has increased for all tree species, though to varying degrees.

- Areas of spruce with visible crown defoliation grew by 8 percentage points and now stand at 35 %. This is the greatest increase observed over the preceding year and, at the same time, the highest level since the time series began.
- The smallest increase (+4 percentage points) was for pine and, with 17 % visible crown defoliation, it continues to be the main tree species with the least crown defoliation.
- The beech suffered the greatest increase in visible crown defoliation – the proportion of damage classes 2–4 jumped by 25 percentage points to 55 %, thus almost doubling. This means that crown defoliation in the beech has been increasing, apart from several brief recovery phases, since 1984. Since the time series began, the ratios have practically reversed – in 1984 the proportion of visible crown defoliation was 13 % (2004: 55 %) and that without crown defoliation was 50 % (2004: 14 %). While it is true that the beech has always recovered during the years that followed massive increases in crown defoliation, it has rarely regained its original levels in the process.
- The 6 percentage points increase in the oak, in contrast, appears relatively moderate, though visible crown defoliation had already risen by 10 percentage points the previous year. This takes the proportion of visible crown defoliation to 45 %.

This major deterioration in the crown condition can be traced to the combined effect of a variety of environmental factors. It is likely that the extraordinary weather conditions in 2003, and the long-term consequences associated with them, have had a major impact.

In 2003, the stress of drought plus elevated ozone levels took their toll on forest ecosystems that were already under considerable pressure from sustained inputs of airborne acids and chemicals. The effects were partly visible in the findings of the 2003 state-of-the-forest survey, but the full extent of the damage suffered by the forests only became apparent in 2004.

Intensive observation (Level 2)

Nitrogen inputs

An average of 20 kg of nitrogen per hectare per annum are currently being input into Germany's forests [2]. Although nitrogen emissions have fallen, the nitrogen input level does not yet appear to have been appreciably affected. An annual input of between 5 and 20 kg of nitrogen per hectare, depending on the site, is currently deemed to be an unobjectionable level for the material life cycle of a forest. However, this critical load threshold is being exceeded at over 90 % of the areas being monitored – more nitrogen is being input than the forest ecosystems can bear in the long term.

Initially, nitrogen boosts forests' vitality and growth, particularly where soils are naturally poor and have been further degraded by anthropogenic use. But when nitrogen inputs are above the critical load for sustained periods, the storage capabilities of the trees, forest soils and ground vegetation are increasingly exhausted, and the original closed nitrogen cycle becomes increasingly unbalanced. Where seepage water in a forest area contains over 5 kg of nitrate per hectare per annum, a signal is being given that the amount of nitrogen present clearly exceeds the ecosystem's needs. Seepage water samples in Level II areas have shown that surplus nitrate is being washed out of every third study area in the country.

To bring nitrogen inputs to forests back below the critical range, there is a need to tighten the targets

Europe set in 2002 for reducing nitrogen emissions, particularly for ammonia. In the agricultural sector, too, improvements are required – e.g., to liquid manure application techniques, to animal foodstuffs, and by reducing over-large livestock inventories. However, until the measures to reduce emissions begin to take effect, the forests need to be adapted to conditions of contamination using forestry interventions. For instance, long-term regeneration procedures and the conversion of purely coniferous forests into mixed forest rich in deciduous trees will help to maintain or expand the nitrogen storage capacity of trees and forest soils where forests are saturated with nitrogen.

If nitrogen inputs cannot be reduced, any sustainable development of our forests and retention of their numerous functions (e.g., drinking water abstraction) will no longer be possible.

Soil acidification

According to the one national forest soil survey (BZE) that has so far been conducted, almost all the forests are now suffering from acidification and nutrient losses in the upper soil areas, to a large degree independently of the initial substrate [2]. The only forest soils examined that were affected to a lesser degree were those locations that are well-buffered by carbonate rock, a mere 9 %.

To document long-term changes in the dilution and transport processes occurring in forest soils, the Level II programme is continuously studying chemical processes in the soil and current acid contamination. Whereas acid deposition was mainly determined to come from sulphur during the 1980s, nitrogen has now become the main acidifier (65 %) in forests.

However, quantities of sulphur that accumulated in forest soils during past decades will remain chemically active there for a long time to come. So the high levels of sulphur in the seepage water in forest areas indicates that considerable amounts of acid continue to be stored in soils despite the significant falls that have occurred in sulphur dioxide emissions since then. These residual sulphur loads can continue to pollute the soil's chemistry and get into the groundwater for decades to come.

Along with sulphur and nitrogen compounds, crucial plant nutrients also often leave forest soils with the seepage water. In 60 % of the Level II areas examined nationwide, more calcium, magnesium, and potassium is being lost than is being returned through deposition. Magnesium, in particular, is important for the nutrition of forest trees.

Increasing soil acidification also means that more and more aluminium ions are being dissolved in the soil water, where they inhibit ingestion and damage tree roots. They can threaten groundwater quality, particularly where forest soils are low in nutrients and porous.

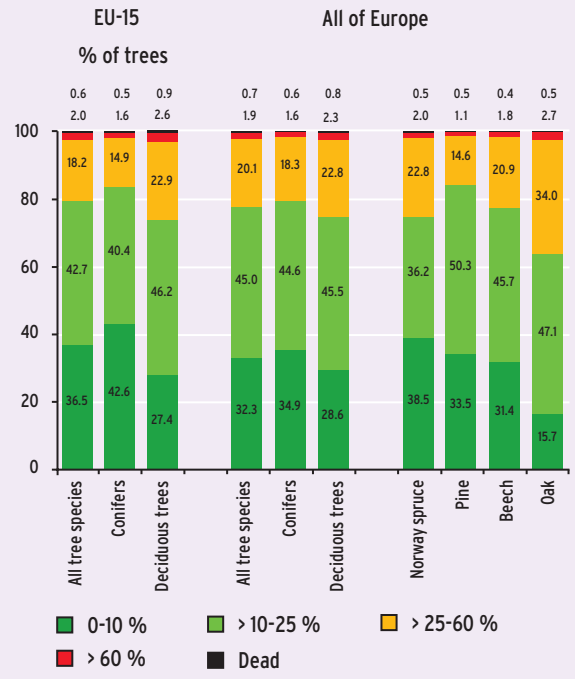
The liming of forest areas threatened by acidification is, when carried out in a correct technical manner, an effective and relatively environmentally friendly method of protecting soil, but it is no panacea. It provides no protection against a lack of potassium caused by acidification and only limited protection against the consequences of excessive nitrogen inputs. The only way to protect forest ecosystems against further acidification is by a sustained reduction in air pollution, particularly nitrogen emissions.

VIII 1.5.2 The condition of forests in Europe

Europe-wide observation (Level I) [3]

23 % of all the trees examined in 2003 were judged to have suffered moderate or severe damage, or to have died. The crown condition in the EU's Member States was a little better than in Europe as a whole. Of the four tree species that are most frequently represented on the plots, the beeches, common oaks, and sessile oaks were most severely affected (Fig. VIII 1.5.2-1).

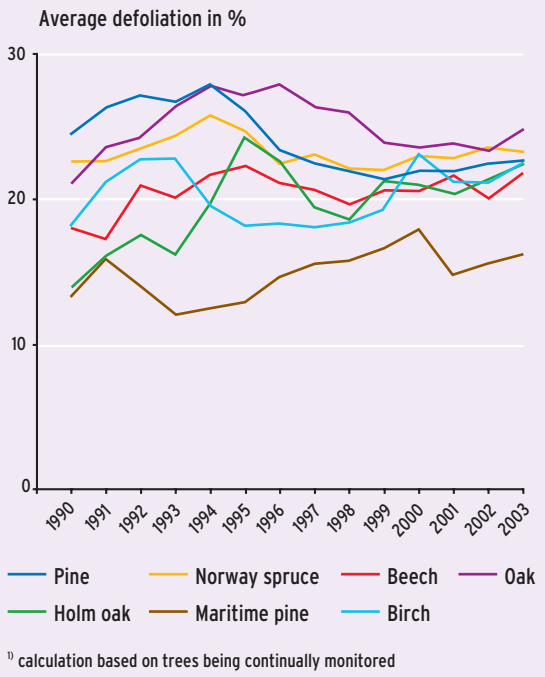
Fig. VIII 1.5.2-1: *Percentage of trees in different needle/leaf loss categories (main tree species) 2003*



Source: *United Nations, Economic Commission for Europe 2004*

Trends in defoliation were studied using the trees that are being continuously monitored. Of these, the silver fir suffered the greatest mean defoliation every year. Apart from this, the mean defoliation fluctuated enormously (Fig. VIII 1.5.2-2). All species suffered the greatest proportion (25.6 %) of damaged and dead trees (damage levels 2–4) in 1995 (not shown in the chart). This figure then fell for the next two years, but since then there has been a continuous, though slower, increase in damage.

Fig. VIII 1.5.2-2: *Trends in the average defoliation among Europe's main tree species*[1)]



[1)] calculation based on trees being continually monitored

Source: *United Nations, Economic Commission for Europe 2004*

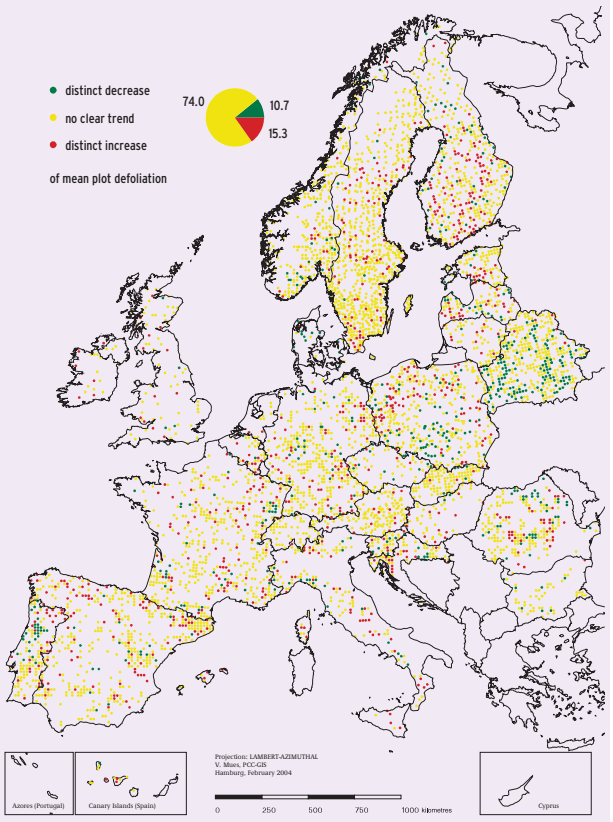
Trends in defoliation in all the tree species on individual plots (Fig. VIII 1.5.2-3) shows that the number of plots with a significant increase from 1994 to 2003 (15.3 %) was higher than the number of plots where there was a decrease of mean defoliation. Areas where a deterioration in the crown condition was observed lie along the northern and western coasts of the Iberian peninsula, southern Finland and the Baltic, the Alpine areas of Austria, Slovenia, and Croatia. The areas where the crown condition has improved are in southern Poland and Belarus.

The damage to the forests is largely attributable to unfavourable weather conditions, biotic factors, and air pollution.

Intensive observation (Level II) [4]

The reduction in sulphur deposition during recent decades has resulted in a fall in sulphur concentrations in the needles of pine and spruce trees. Simu-

Fig. VIII 1.5.2-3: *Trends in defoliation for all tree species between 1994 and 2003 in %*



Source: *United Nations, Economic Commission for Europe 2004*

lations based on emission reductions in line with international agreements predict a fall in sulphur and nitrogen concentrations in the soil solution. However, it will take much longer for the soil solid phase to recover, which means that forest ecosystems will continue to suffer high levels of air pollution for some time yet.

The first outcomes of the ozone measurements carried out on forest areas indicate high ozone concentrations in southern Europe. The needles and leaves of certain main tree species, such as the beech, show visible signs of ozone damage. Furthermore, some species of ground vegetation which were not previously known to be ozone-sensitive are also exhibiting damage.

Early budding and increased growing seasons in spruce are being linked to altered climatic conditions. Across Europe, the annual net carbon accumulation in trees' wood is 5 to 7 times greater than that in forest soils. Extrapolating the figures for all of Europe's forest areas – adjusted for carbon removed by timber harvesting and forest fires – gives an average carbon absorption by forests of 0.1 Gt per annum. Around 5 % of the annual net carbon accumulation is due to nitrogen inputs that boost forest growth.

[1] Bericht über den Zustand des Waldes 2004 – Ergebnisse des forstlichen Umweltmonitorings; BMVEL
[2] Forstliches Umweltmonitoring für den Wald der Zukunft; BMVEL, February 2003
[3] United Nations, Economic Commission for Europe 2004 (UNECE), Federal Research Centre for Forestry and Forest Products (BFH), The Condition of Forests in Europe. 2004 Executive Report, Geneva 2004 (http://www.icp-forests.org/pdf/ER2004.pdf)
[4] Der Waldzustand in Europa; Federal Research Centre for Forestry and Forest Products; BFH, UNECE and the European Commission, Geneva and Brussels, 2003

VIII 1.6 Alpine habitats and biodiversity

Habitats and cultural landscapes

As a source of drinking water and high-quality agricultural and forestry products, as a significant destination for winter and summer tourism, and not least as a place to live, the Alpine region constitutes an important public resource. Closely linked with its importance as a biodiversity hotspot – diversity of landscapes, habitats, and animal, plant and microorganism species as well as diversity of genetic levels – is its usage by man.

Given the complexity of the factors that influence this biodiversity, protecting it and developing the Alpine region over the longer-term requires wide-reaching conservation and development strategies. Attempts are being made worldwide to put national and international regulatory frameworks in place to conserve biodiversity. The Alpine Convention and the Convention on Biological Diversity are of vital importance for the Alpine region.

The Alpine relationships of relief, soil, and climate with their local variations bring about a mosaic of highly diverse habitats and habitat configurations, starting with the montane and subalpine forest communities of the lower hills through to the natural, ancient meadowlands and rocky ground above the timberline and the nival rock zones. Biocoenoses such as scree, moorland, and ravine forests that depend on specific soil and climate conditions have also formed.

Traditional forms of usage, particularly those associated with agriculture and forestry, have responded over centuries to these local conditions and specific ways of using the arable landscape have emerged that have, in turn, led to the development of other types of ecosystem with their own typical species configuration, and thus to increased diversity. These include the cultivation of simple coppice forests and coppice-with-standards forests, developing heliophilous forest types through pasture woodland and summer pastures and mountain hay meadows with varying levels of cultivation intensity below and above the Alpine timberline. In particular, the montane level, which was originally densely forested with tree species that varied both locally and regionally, has acquired a (half-)open landscape character through the creation of summer pastures, and has become far more diverse in terms of its structure and its species mix.

Because of their different forms of management, arable landscapes document the regional arable diversity of the Alpine arc in the same way as forms of construction and settlement and are today regarded as “cultural heritage”. It is precisely these arable landscapes and the ways in which they contrast with the remaining natural Alpine landscapes which make the Alps attractive in terms of contemporary aesthetic interpretations. This is a major reason for the popularity of local recreational activities, tourism, and the attractiveness of the Alps as a commercial location, and is thus a crucial economic factor.

The threat posed by changing patterns of use

Currently, changing patterns of use and the landscape alterations associated with these changes are pulling the Alps essentially in two directions. On the one hand, land is being used in ways that seek to intensify and increase economic revenues while, on the other, usage is being enlarged and even discontinued.

This intensification of usage, on the one hand, and its abandonment, on the other, are causing this culturally-based diversity to be lost and are one of the major causes of lost biodiversity. The many species-rich, open land biotopes in the Alps are particularly affected when usage is abandoned. Keeping landscapes open is not just important for nature conservation reasons but also from the perspective of agricultural policy and tourism. Another threat to biodiversity comes from the growing urban sprawl in the Alpine valleys. The loss and fragmentation of habitats have a number of negative consequences for the preservation of species and biotopes.

In terms of intensified usage, agricultural measures take priority as these are the most significant throughout the region. Intensified agricultural use in the Alps is mainly due to changes in the use of grasslands (e.g., increasing livestock densities, switching between different types of use) and to the proliferation of vegetable, fruit, and viticulture. These lead to the loss of formative landscape elements such as marsh areas, litter meadows, mountain hay meadows and small structures, and the landscape becomes more monotonous.

When, particularly on agricultural land and forest areas, further types of use are superimposed, including large-scale tourism (e.g., ski slopes, equipment to ascend the slopes, car parks, catering, and accommodation), urban sprawl, transport infrastructure, the installation of power cables, and large-scale wind power plants often have a negative aesthetic impact on the landscape and can even destroy the character of the arable or natural landscape.

Enlargement of use in areas devoted to agriculture and forestry result in a natural succession, with various intermediate states, occurring in what was previously an arable landscape has consequences. Below the natural timberline this causes open and half-open landscapes (such as litter meadows, neglected grassland, hay meadows) to revert, depending on the site, to closed forest landscapes that correspond to the potential natural vegetation.

Given these marked and ongoing changes to the landscape, the preservation of arable and natural landscapes constitutes an important task for agrarian policy, nature conservation, and tourism.

Running counter to these landscape changes is the preservation of arable and natural landscapes through arable and landscape schemes, landscape maintenance and the development of regional commercial systems whose aim is to secure these landscapes for the long term.

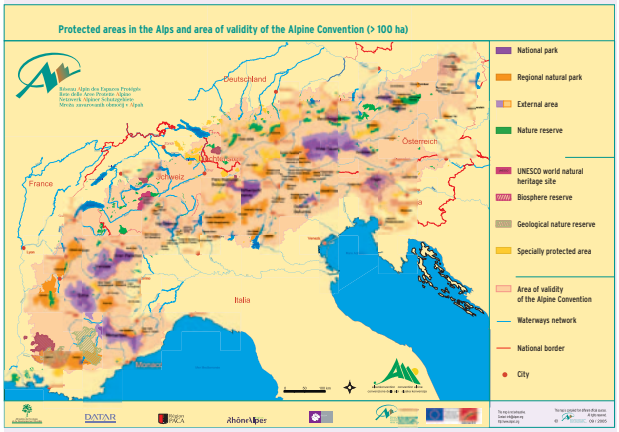
Protected areas

The approximately 300 large protected areas in the Alps that are the traditional nature conservation policy instruments of the Alpine countries also have a vital role to play. The extensive, semi-natural, and relatively thinly-populated mountain groups in the Alps permit, to some extent, protected areas to be uncontroversially designated as areas for nature and landscape conservation. In 2003 in the Alpine region, about 33 000 km^2 (ca. 18 % of the total area) was designated as protected area within various categories. Areas designated as protected often lie on higher ground and can currently only incompletely represent the full range of Alpine habitats. National categories of protected area do not always tally with one another and sometimes, as in Austria and Switzerland, even within a single Alpine country regional laws mean that they are linked to differing matters (Fig. VIII 1.6-1).

Threatened wild animal and plant species in the Alps

The large number of animal and plant species present in the Alpine region reflects both the geographic diversity and the mix of species that has arisen

Fig. VIII 1.6-1: *Protected areas in the Alps and area of validity of the Alpine Convention*



Source: *Network of Alpine Protected Areas 2005*

from different ecological development periods. Ice age species have remained in the alpine and nival regions, while valley areas may often see the presence of species from sub-montane and even Mediterranean areas that have immigrated from warmer climes since the ice age. Human intervention caused other wild and bred species to be introduced to the area. Based on this great species richness, Global Study 2000 listed the Alps as one of the most significant ecoregions on the planet, while the IUCN chose it as one of the world's 234 regions with the greatest plant diversity.

The Alps are home to about 30 000 animal and 13 000 plant species, which is 39 % of all Europe's vascular plant flora. Many indigenous species have become particularly adapted to the conditions in this habitat. Thus it is estimated that around 15 % of the 2 500 plant species that grow above the timberline are endemic – they only occur in these areas.

Extreme living conditions and the close dependence on certain methods of cultivation which are now in decline make these species extremely sensitive to any alteration in these conditions. The main reasons for the decline in wild plant species during recent decades are direct disruptions to their habitats, abandonment of use and reversion to fallow land, and an intensification of use associated with inputs of nutrients and pollutants and the halting of natural dynamics. The diminution or destruction of animal species' part-habitats (e.g., feeding and reproduction habitats, hibernation areas), and restrictions to exchanges between different populations caused by the barrier and isolation effects involved in human activity are the main causes of the decline in wild animal populations.

Systematic efforts to protect species, such as reintroduction and monitoring projects (including bearded vultures in Switzerland, bears in Austria, golden eagles in Germany), and setting up and managing protected areas in the Alps have succeeded in stabilising inventories of certain species.

Threatened livestock species in the Alps

Humans have farmed livestock in the Alps for thousands of years. Selective breeding meant that the breeds in practically every valley were well-adapted to local conditions, and although the inhabitants enjoyed plentiful contact, there was very little exchange of animals.

Given the limited resources, modest veterinary medicine knowledge, harsh climatic conditions, and meagre feed, animals were primarily required to be robust. Livestock diversity was important for the people's survival as it gave them the ability to respond to unexpected events. Stable average output was and continues to be more highly valued in the mountains than high output that is prone to disturbance by external influences.

Although older methods bring in unsatisfactory revenues by today's standards, they possess qualities such as high fertility and resistance to cold and illness that could be of interest in another commercial environment.

Work has been done over generations to develop these traditional breeds which are adapted to man's needs. They are not merely of genetic interest but also represent a valuable cultural asset that is worth preserving.

Throughout the different Alpine countries the preservation status of traditional, threatened breeds varies considerably. Breeds are continually being discovered that are no longer recognised or that have already died out. Currently in the Alps, stocks of over one hundred livestock breeds are under threat and depend for their preservation on measures being taken as swiftly as possible.

In a 2003 study of the Alps published by the Monitoring Institute for Rare Breeds and Seeds in Europe, the first trends towards developing stocks of threatened livestock breeds may be identified.

No general trends can be ascertained from the current data base. A reliable general overview of all the breeds present in the Alpine region is not possible at the moment, as there is no continuous monitoring (Tables VIII 1.6-1 to VIII 1.6-3).

Categories of threat based on the UN Food and Agriculture Organization's (FAO) key:

extinct:	already died out
critical:	< 100 female animals in reproduction
endangered:	100–1 000 female animals in reproduction
vulnerable:	1 000–5 000 female animals in reproduction
rare:	5 000–10 000 female animals in reproduction

Saving endangered breeds depends on the existence of national and, particularly, non-national conservation initiatives, for state initiatives such as stockman awards and conservation schemes usually depend greatly on political decisions and the availability of funding. Private initiatives thrive on the motivation levels of livestock owners and breeders.

In 2003, for the first time, a breed of sheep was able to be released from the monitoring scheme for endangered breeds in the Alps; the "brown mountain sheep", which occurs under five different names in four Alpine countries, had conquered its endangered status. The populations in Germany ("brown mountain sheep") and Switzerland ("Engadine sheep") have long since exceeded the thousand mark. Stocks in Austria ("Paterschaf", "brown mountain sheep") and Italy ("Ultenschaf") are approaching this level. According to the FAO's criteria, stocks are still deemed to be vulnerable and require ongoing state funding, but the risk of extinction has become minimal. Breeders are collaborating across borders and the future of the "brown mountain sheep" appears secure. See Chapter VIII 3 for further measures on the preservation of ecosystems and biodiversity.

VIII 2 Anthropogenic pressures

VIII 2.1 Land consumption and fragmentation

Land consumption

In 2003, residential and traffic areas (SuV) in Germany amounted to 4.44 million hectares, with traffic's share being around 39 %. In the National Sustainability Strategy for Germany in 2002, the federal government set a long-term goal to restrict new SuV areas. The aim is to reduce the national increase in new SuV space from 129 hectares per day (the average figure for 1997 to 2000) to 30 hectares per day by the year 2020. The sustainability council is also calling for new land consumption to be cut to zero by 2050, mainly through recycling land.

Tab. VIII 1.6-1: *Level of threat to recorded cattle breeds*

Threat category	extinct	critical						endangered				vulnerable			rare	
France								↑	↑							
Italy	7	↓						→	↑			→	→	↑		
Switzerland	10	↑										↑	↑		↓	↓
Bavaria		↑						→	↑	↓						
Austria	11	?	?	?	?	?	↓	↑	↑	↑	↓	↑	↓			
Slovenia	3							?								

Tab. VIII 1.6-2: *Level of threat to recorded goat breeds*

Threat category	extinct	critical				endangered					vulnerable						rare	
France		?	↑								↑							
Italy	1	?	?	?		→	↑				?	→	→	→	↑	↑	?	
Switzerland	10	?				↑	↑	↑	↑	↑	→	↑					↑	↑
Austria		?	?	?	?	→	↑											
Slovenia						?												

Tab. VIII 1.6-3: *Level of threat to recorded sheep breeds*

Threat category	extinct	critical								endangered										vulnerable					rare
France		?								↓										↑	↑				↑
Italy	9	?	?	?	↓	↓	→	→	↓	↓	↓	↓	↓	→	→	↑	↑	↑	↑	↓	↓	→	→	→	
Switzerland	10	?								↑	↑	↑	↑							↑					
Bavaria		↑	↑							↑	↑									↑					
Austria	6	?	?	?	↑					?	→	↑	↑	↑						?					
Slovenia										?	?	↑								↑					

A box represents a recorded breed or variety.
↑ Stocks tending to rise
↓ Stocks tending to decline
→ No change in stocks
? Trend in stocks unclear
extinct: breeds, populations or varieties that have died out

Source: *Monitoring Institute for Rare Breeds and Seeds in Europe 2003*

According to the calculations of the Federal Statistical Office, the national additional land consumption for SuV purposes fell from 131 ha/day (1998–2000) to 117 ha/day in 2001, 105 ha/day in 2002 and 93 ha/day [1] in 2003 (see also Chapter VII). This fall can be seen in almost all the *Länder*. In particular, the increase in land used for building and open landscape, which constitutes over half of the growth in SuV, has fallen significantly.

However, a true reversal of the trend cannot be assumed. The decreases are caused primarily by the slump in building investment brought on by economic conditions. Once the economy picks up again, it is likely that land consumption will rise once more. For this reason, it is important that efforts are made to further develop planning, legal, and economic instruments and to translate these into practice so that a truly stable reversal of the trend, i.e. a reduction of new land consumption through SuV areas, may be achieved. This includes the utilisation of the potential of fallow land sites available in many areas. It is also necessary to create public awareness of the problems.

The increase in areas dedicated to SuV came primarily at the expense of agricultural land [1]. Until early 2004, SuV land increased by as much as 12 %, with around 80 % of the growth being due to use for residential purposes. According to UBA calculations [2], almost half of the growth in traffic space is attributable to the building of link roads for new areas of settlement, meaning that the growth in residential areas is directly or indirectly responsible for around 90 % of all land consumption.

Increasing land consumption inevitably goes hand in hand with a loss of high-quality agricultural and forestry soils, further soil surface sealing and a loss of open spaces. New settlements outside urban areas generate additional traffic flows with noise pollution and emissions of pollutants. The link roads mean that further land is carved up and fragmented. All these effects reduce the landscape's recovery function and seriously threaten the habitats of the plant and animal world.

Moreover, the extension of built-up and commercial areas curtails the potential for using the space for

sustainable agriculture, which often depends on a greater need for space if it is to be managed in an environmentally-friendly way.

As part of the federal government's sustainability strategy, a programme of measures is to be worked out that, in its totality, leads to a reduction in and qualitative assessment of land consumption for SuV purposes while taking into account environmental, social, and economic objectives. These include such measures as emphasising the inner development of urban areas in preference to the external development of surrounding areas, and improving the quality of space usage around residential areas and the protection of unfragmented open areas and unspoiled natural scenery. The Federal Building Code, which was altered in 2004 by the European Law Adaptation Act, provides for a stronger soil conservation clause with priority being given to inner rather than outer development, as well as urban redesign measures, particularly the dismantling of structural facilities that have ceased to be used due to the shrinking population.

Land consumption can be managed using a range of instruments and measures.

Thus the funding instruments that favour increases in land consumption and the fiscal advantages such as home ownership grants are to be done away with and the flat rate mileage allowances are to continue to be cut back.

The legal and planning instruments include the Federal Regional Planning Act and the Federal Building Code, both of which were amended on 20th July 2004 by the European Law Adaptation Act [3]. Both legal frameworks anchor the objectives of concentrating settlement activity in certain areas, safeguarding open spaces and protecting nature and landscapes. At the regional planning level, too, tests are planned to verify to what degree binding quantitative targets are both required and legally and practically possible with a view to further stemming the future growth of residential areas.

Under the new Urban Planning Law (§ 171 a BauGB), urban redesign measures can be carried out whereby adjustments can be made in areas affected by major losses of urban planning functions with a view to producing sustainable urban planning structures. Major losses of town planning functions occur particularly where a long-term excess supply of structural facilities for particular uses, especially for residential purposes, either exists or is anticipated. Urban redesign measures ought, above all, to help

- the settlement structure to adapt to the requirements of trends in population and the economy,
- to improve living and working conditions as well as the environment,
- to strengthen inner city areas,
- to put structural facilities that no longer meet needs to new use,
- to dismantle structural facilities for which no new use can be found,
- to provide fallow land and abandoned industrial sites with sustainable urban planning development or with some interim purpose that is compatible with the latter
- to preserve stocks of old buildings in inner-city areas.

Under the draft of a law to improve preventative flood protection, rivers are to be given more space and the sealing of areas in flood zones, particularly in the form of building projects, is to be prohibited in principle. The Federal Soil Protection Act (BBodSchG) [4] passed in 2004 in conjunction with the Federal Soil Protection and Contaminated Sites Ordinance is aimed at protecting soils in the long-term. The key points of a sustainable future strategy in the realm of soil protection are preventing harmful changes to the soil, cleaning up old hazardous sites to create new open spaces, and ground unsealing. A research project based on the authorisation granted by § 5 BBodSchG studied the feasibility of an unsealing ordinance.

The amendment to the Federal Nature Conservation Act [5] which came into force in 2002 includes new regulations that are also significant for managing land usage. These include treating natural resources in a sparing, economical way, an obligation that the *Länder* create a biotope association to protect open spaces which incorporates at least 10 % of the Land's area, and the duty to present comprehensive landscape plans. The *Länder* are to implement these new rules within 3 years.

The fragmentation of the natural landscape

In Germany, land consumption involves not only the conversion of open spaces into sealed areas used for residential and transport purposes, but also the carving up of large areas by traffic routes. While the rail network shrank by 3 000 km between 1991 and 2001, the same period saw the road network grow by 4 500 km [6]. Increasing fragmentation and isolation cause habitats to be lost. In particular, animal species that require a lot of space, such as birds of prey and red deer, depend on open countryside that needs to be as free as possible from being fragmented by settlements and infrastructure. Thus preserving open countryside is closely linked with species diversity in Germany.

It is also important for the human population's experience of nature that areas are preserved without being carved up and without noise pollution. Therefore there is a need to avoid infrastructure, residential and commercial projects, and large tourist infrastructure projects in the vicinity of open countryside and the corresponding accoutrements of natural landscapes.

An indicator developed by the Federal Agency for Nature Conservation defines open countryside as any area that

- is at least 100 km^2,
- is not traversed by any road carrying more than 1 000 vehicles per day,
- is not traversed by any railway line (single or multiple rail) and contains no body of water that covers over half the area.

Open countryside represents an important assessment base for judging the natural landscape situation in Germany and for the transport infrastructure plans of both the federal government and the *Länder*. Recording open countryside also provides a basis for implementing the Council's Directive 92/43/EEC of 21 May 1992 to preserve natural habitats and wild animals and plants [7]. The Directive obliges Member States to draw up a coherent European ecological network of specially protected areas under the label "Natura 2000". This network should aim to safeguard the continuity or, where necessary, recreate a favourable state of conservation for types of natural habitat and the habitats of species in their natural distribution area (Chapter VIII 3.4.2).

In 2003, 21 % of the total surface area of Germany was covered by areas of open countryside at least 100 km^2, many of which are located in the underpopulated parts of the New *Länder* and the mountains (Table VIII 2.1-1). Particularly in the New *Länder*, open countryside is threatened by development. The data available shows that the trend is having a severe impact, particularly in eastern Germany (Brandenburg, Saxony, and Thuringia), where the proportion of open countryside has declined sharply since 1994. Open countryside as a proportion of total surface area is far higher in the east of Germany (13 % in Saxony and up to 53 % in Mecklenburg Pomerania) than in the flat western *Länder* (3 % in North Rhine-Westphalia and 21 % in Lower Saxony).

Smaller areas of open countryside, of under 100 km^2, are also important for local recreation and species protection in high density nodes and around urban areas. Therefore the UBA has proposed [8] that, alongside the policy for areas of open countryside larger than 100 km^2, the number of areas of open countryside greater than 140, 120, 100, 80, and 64 km^2 should remain at the same level as they currently are in each case. Areas of open countryside greater than 100 km^2, in particular, should be treated as quintessential taboo zones.

Nevertheless, the national average figures for open countryside say nothing about the extent to which individual, very large areas of open countryside are being fragmented by new traffic routes into smaller areas that are still larger than 100 km^2. So it seems to make sense to supplement this indicator through an indicator for effective mesh size Meff which can be used to record the Land's average fragmentation

Tab. VIII 2.1-1: *Distribution of open countryside in Germany*

Federal Land[1)]	Inhabitants per km^2 [2)]	Open countryside[3)] (in km^2)	Open countryside (in % of Land area)		Number of areas of open countryside[4)]	
			1998	2003	1998	2003
Baden-Württemberg	299	3 328	11	9	25	22
Bavaria	176	10 775	20	15	76	61
Brandenburg	87	14 625	53	50	80	75
Hesse	288	2 289	12	11	16	14
Mecklenburg Pomerania	75	12 256	54	53	67	63
Lower Saxony	168	10 223	19	21	58	59
North Rhine-Westphalia	530	868	3	3	6	4
Rheinland-Palatinate	204	3 062	16	15	22	19
Saxony	235	2 325	24	13	28	14
Saxony-Anhalt	123	6 378	29	32	34	33
Schleswig-Holstein	179	1 780	10	11	12	12
Thuringia	147	5 476	41	34	36	33
Germany	**231**	**73 541**	**22**	**21**	**480**	**422**

1) Due to their small size, Saarland and the city states do not appear in the table
2) Source: Statistical Offices of the Federal Government and the *Länder* (2004)
3) Total area incl. open countryside spaces that span Land borders
4) Due to some areas of open countryside spanning Land borders, the total of the areas of open countryside in the *Länder* does not match the number of areas of open countryside in Germany

Source: *Federal Agency for Nature Conservation 2004*

level and allow policy objectives to then be proposed [8]. Effective mesh size is a calculated mean for the mesh size of the transport network based on a method devised by JAEGER [9] which takes into account both the size of all the sub-areas and the structure of the fragmentation of the entire area being studied.

[1] Umweltnutzung und Wirtschaft; Bericht zu den Umweltökonomischen Gesamtrechnungen; Federal Statistical Office, Wiesbaden 2004
[2] UBA text 90/03 Reduzierung der Flächeninanspruchnahme durch Siedlung und Verkehr – materials handbook, pages 292/293
[3] Federal Regional Planning Act (ROG) and Urban Planning Law (BauGB), amendment of 20.07.2004 in line with the European Law Adaptation Act
[4] Federal Soil Protection and Contaminated Sites Ordinance (BbodSchG) of 17th March 1998; in effect since 1st March 1999
[5] Nature protection and landscape conservation law (Federal Nature Conservation Act- BNatSchG) of 25.03.2002, BGBl. I S. 1193
[6] Federal Ministry of Transport: Verkehr in Zahlen
[7] Council Directive 92/43/EEC of 21st May 1992 to preserve natural habitats and wild animals and plants (Official Journal No. L 206 of 22/07/1992 pp. 0007–0050)
[8] Reduzierung der Flächeninanspruchnahme durch Siedlung und Verkehr – materials handbook (UBA text 90/03, Berlin, December 2003)
[9] Jochen Jaeger et al: Report of June 2002 (Nr. 214) of the Baden-Württemberg Academy of Technical Assessment; "Landschaftszerschneidung in Baden-Württemberg", presented in a technical discussion of the *Länder* Initiative on Core Environmental Indicators (LIKI) – of 08.09.07.2004

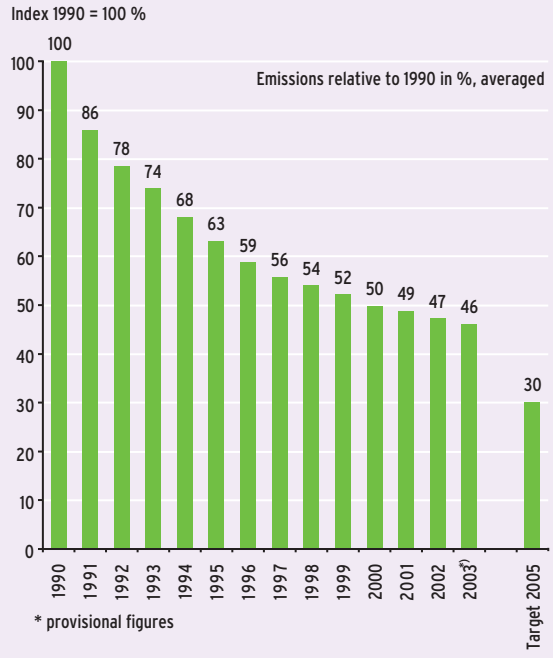
VIII 2.2 Chemical pollution and its effects

VIII 2.2.1 Airborne pollutants and nutrients

Airborne pollutants are a major contributor to the pressure on ecosystems and species diversity. Transboundary acid rain, which has been a known issue since the 1970s, makes it clear that environmental problems can only be countered by international efforts. The UNECE Convention on Long-range Transboundary Air Pollution (LRTAP Convention, signed in Geneva, 1979) was amended by eight international, legally binding agreements (protocols) on air quality management. In the 1980s, protocols were established to establish a programme to monitor and model air pollution (EMEP) and to counter sulphur oxide emissions, and in the 1990s further protocols were passed on tropospheric ozone precursors (NO_x and volatile organic compounds), and heavy metals and persistent organic pollutants (Aarhus, 1998). An integrated approach, with various pollution components (NO_x, VOC, SO_2, NH_3) and their mutual interactions, was considered in order to solve the Europe-wide problem of ground level ozone, acidification and eutrophication due to atmospheric nitrogen inputs. These approaches went into the multi-component Protocol to Abate Acidification, Eutrophication and Ground-level Ozone [1] which Germany signed on 1 December 1999; it specified national ceilings for annual emissions of these pollutants, which the signatories undertook to achieve by the year 2010. After the Gothenburg Protocol to the UNECE Convention, the EC's National Emissions Ceilings (NEC) Directive [2] took a similar approach. Both aim at a reduction of the ecosystem area where critical loads are exceeded by around 50 % by 2010 compared with the reference year of 1990. For Germany, these give the following 2010 national emission reduction targets for the pollutants below compared with 1990: ammonia (NH_3): –27 %; nitrogen oxides (NO_x): –59 %; sulphur dioxide (SO_2) –90 %; volatile organic compounds excluding methane (NMVOC): –68 %.

Following on from the international agreements, the German sustainability strategy [3] specified an average 70 % reduction in air pollution for emissions of SO_2, NO_x, NH_3, and NMVOC by 2010 over the reference year of 1990. To monitor this target, trends in emissions of these pollutants are being recorded as a percentage compared with 1990. The pollutant index shown in Figure VIII 2.2.1-1 shows the mean of these four relative emission trends. The pollution index shows a decline of around 54 % since 1990 in the average emissions of the gases being studied, which equates to a 77 % accomplishment of the indicator target.

Fig. VIII 2.2.1-1: *Airborne pollution index for emissions*



Source: *Federal Environment Agency 2005*

Between 1990 and 2003, desulphurisation of power stations, switching fuels, and legal restrictions on the sulphur content of liquid fuels has enabled sulphur dioxide emissions to be cut by around 90 %. Similarly considerable reductions of around 60 %, were achieved for the volatile organic compounds (excluding methane) in road transportation, mainly due to the catalytic converter technology. This has also contributed – as has the use of denitrification plants in power stations – to the fall in nitrogen oxide emissions, of around 50 %. For ammonia emissions, caused predominantly by the agricultural sector, there were only slight reductions (approx. 18 %) due to reducing animal stocks.

Although pollutant outputs have fallen significantly during recent years, they continue to be too high when measured against the ecosystem's long-term capacity to buffer, store or export inputs without detrimental effects, so-called critical loads. This is particularly the case with air pollution (mainly nitrogen oxides and ammonia) that causes acidification and eutrophication. The impacts of past inputs of sulphur and nitrogen that have been deposited over decades on the soil will remain for a long time to come. Many forest soils, for example, have lost a large part of their base cation nutrients and become acidified. This is accompanied by pollution of seepage water. Ammonia, which soil bacteria oxidises to form nitrate, is also responsible for nitrate pollution in groundwater and thus threatening our drinking water. Air pollutants contribute, along with other factors, to a decline in species diversity.

Further falls in NO_x emissions from road transport can be achieved mainly through reducing HGV emissions (EURO 2–5) and restructuring transport in an environmentally-friendly way.

In the case of solvents (NMVOC), the possibility of using low-solvent or solvent-free products, which exists in all product sectors, needs to be pursued through additional European legislation to restrict solvent content in products.

Other fields of possible action on air pollution could be: energy saving measures, increasing energy efficiency (e.g., through low consumption engines and new propulsion technologies), using regenerative energies, using low-emission fuels and products, and abatement measures in agriculture.

Nutrient intakes and nitrogen surpluses

Excess nutrients (phosphorus and nitrogen (total N)) from agricultural sources mainly end up in water bodies and have far-reaching effects on the balance of nature (acidification, eutrophication, nitrate pollution of groundwater, surface waters, and seas, damage to biodiversity).

While nutrient intakes from point sources (discharged waste water) have been significantly reduced by improving sewage treatment plants' purification performance, inputs from diffuse sources (seepage, runoff, erosion, rainfall) constitute a problem that remains largely unsolved. Nitrogen inputs to bodies of flowing water (around 690 000 t in 2000) are 19 % attributable to point sources, with the greatest proportion (62 %) stemming from diffuse inputs, primarily from agriculture. This volume contributed by the agricultural sector equates to ca. 30 % of the total quantity used as mineral nitrogen fertiliser on arable farmland in Germany. Liquid and mineral fertilisers are added to fields in such great quantities, particularly in areas with high livestock ownership, that they can only be partly used by the plant-life.

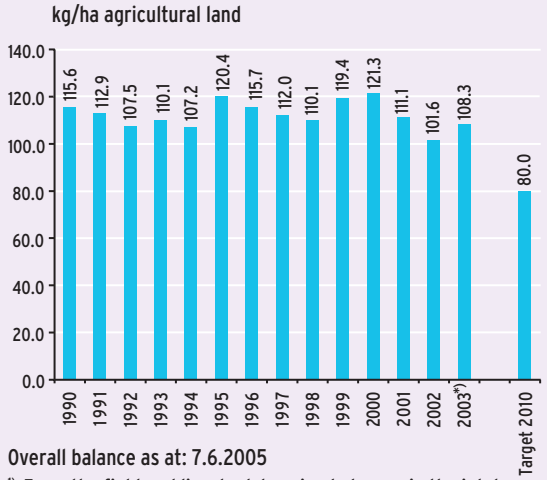
The nitrogen surplus that can be ascertained from an overall nitrogen balance can be used as a measure for potential inputs to groundwater, surface waters and the air. Although nutrient surpluses caused by agriculture have fallen since 1987, intensive fertiliser use and excessive livestock concentrations mean that nitrogen surpluses continue to pollute the environment. Diffuse nutrient sources are highest where excessive livestock numbers are kept in locations where high levels of leaching and runoff are likely. This is the case with nitrogen throughout the northwest of Germany (sandy soils) and in certain parts of the foothills of the Alps (heavy runoff).

The national sustainability strategy [3] aims to reduce the overall nitrogen surplus to 80 kg/ha per annum by 2010. The nitrogen surplus in Germany in 2003 was 108 kg/ha (Fig. VIII 2.2.1-2). No unambiguous trend towards reduced nitrogen surpluses is identifiable in the 1990s. Therefore, if the goal of the national sustainability strategy is to be achieved, substantial political efforts to implement effective measures are required. These must, in particular, lead to a more even distribution of livestock.

A number of regulations, instruments, and measures can help to achieve this target, including:

- increasing the landscape's denitrification capability through using backwater or shutting down drainage systems, wetland restoration, and improving the morphological water structure,
- the regulation on the principles of good practice when using fertilisers (Use of Fertilisers Ordinance, 1996, BGBL),

VIII 2.2.1-2: *Nitrogen surplus (overall balance)*[1)]



Overall balance as at: 7.6.2005

[1)] From the field and livestock housing balance via the intake routes soil, water

*) provisional figures

Source: *Federal Environment Agency 2005 a*

- switching EU agricultural subsidies away from production volumes to grants based on land space,
- improving the training and advice given to farmers,
- Partnerships between farmers and water managers who are working to reduce water pollution caused by agriculture in the federal *Länder*.

VIII 2.2.2 Eutrophication

Eutrophication (excessive fertilisation) is the term given to the accumulation of the plant nutrients nitrogen and phosphorus that occurs in habitats (terrestrial ecosystems and, primarily, closed bodies of water) which causes material life cycles to be altered. These nutrients get into ecosystems via the atmosphere (mainly nitrogen compounds) and water (nitrogen and phosphate fertiliser surpluses from the agricultural sector, discharges of phosphates from plasticiser). Eutrophication is a process that also occurs in an environment untouched by humans, but natural eutrophication takes place over periods of thousands of years, thus permitting biocoenoses to adapt. Anthropogenic eutrophication over a few years or a few decades, however, is too short for adaptation processes, and the biocoenoses are damaged, if not destroyed.

Eutrophying inputs to the ecosystem chronically damage plants as the nutrient balance makes them highly sensitive to natural forces (storms, landslides, and streams of water, landslides), frost and pests. This leads to a loss of biodiversity, and plants, and plant communities that depend on sites where scarcity predominates (most of the species on the Red List) stand no chance of long-term survival under current immission levels – they will be forced out by highly-competitive species that thrive on nutrients (nitrophiles). Since most animal species are associated with specific plant species, the ongoing decline observed in the diversity of plant species in Germany also affects the diversity of animal species.

Nitrogen enters ecosystems from the atmosphere via wet deposition (rain, snow) and dry deposition (gases, particles). Dry deposition rates depend on land usage and are usually larger than wet deposition rates; nitrogen inputs are thus many times greater than via rainfall as recorded by most monitoring networks.

Critical loads for eutrophication

Critical loads for eutrophication are a means of measuring the risk of the damaging effect caused by nitrogen inputs to sensitive ecosystems such as forest, heath, and moorland. In the mass balance used to calculate the critical loads for the eutrophying nitrogen input in forest soils, nitrogen inputs are balanced against the processes that bind nitrogen in the forest ecosystem or remove it without causing damage. It takes into account timber harvests, the long-term binding of nitrogen in the humus layer, denitrification, and the harmless discharge via seepage water.

Under the critical loads approach, ecosystem pollution by active airborne pollutants is shown differentiated by geographical area using GIS. These maps form the basis for planning air pollution control measures in line with the UNECE Geneva Convention protocols.

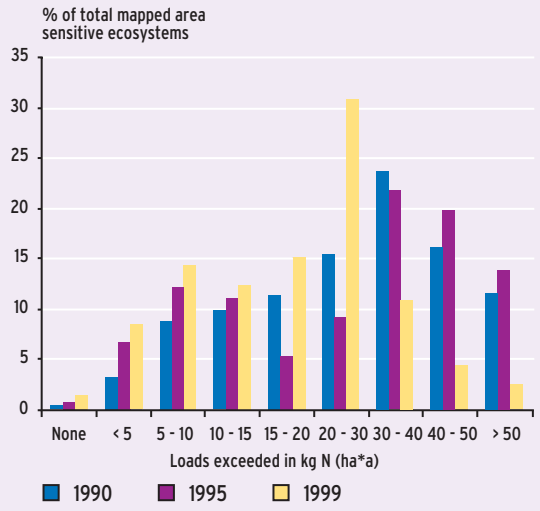
The level of the concentration or deposition tolerated is, in each case, tailored to the characteristics of the ecosystem concerned. As far as current knowledge can tell, where long-term overall deposition rates fall short of the critical load, there is no impact on the ecosystem's structure and function. However, it can take decades before ecosystems react to a critical load being exceeded and, even when levels subsequently fall short of the critical load, it can take centuries before it recovers to its pre-industrial level.

The agreements in the multi-component protocol of the UNECE LRTAP Convention and the EC's directive on emission ceilings (NEC Directive) aim for a Europe-wide reduction in emissions (see VII 2.2.1).

Inputs of airborne nitrogen compounds have either fallen during recent years (nitrogen oxides from industry and transport) or are stagnating at a high

level (ammonia/ammonium from livestock farming). Despite this slight decline in nitrogen inputs, the critical loads for eutrophying nitrogen are still being exceeded over almost all of the area of sensitive ecosystems in Germany (Fig. VIII 2.2.2-1). The agricultural areas of northwestern Germany, in particular, where intensive livestock farming takes place on sensitive soils, are affected by ammonium nitrogen deposition and the resulting exceedance of critical loads. So the improvements concerning eutrophication achieved through international air quality control measures are small compared with the successes attained concerning acidification. Over the next few years, no significant improvement can be expected due, especially, to the fact that ammonia emissions are only falling slowly; further widespread eutrophication in semi-natural ecosystems is likely. In particular, the diffuse nitrogen immissions which predominate in Germany and which eutrophy and acidify soils need to undergo further drastic reductions.

Fig. VIII 2.2.2-1: *Exceeding of critical loads for eutrophication in kg of nitrogen, per hectare, per annum*



Source: *Federal Environment Agency 2005 b*

VIII 2.2.3 Acidification

Analogous to the critical loads for eutrophication, critical loads for acidification specify the potential risk for the harmful impact of sulphur and nitrogen inputs on sensitive ecosystems (e.g., forest). These critical loads are specified as the quantity that can be deposited in the ecosystem per area and period of time without significant damage being caused, according to current knowledge.

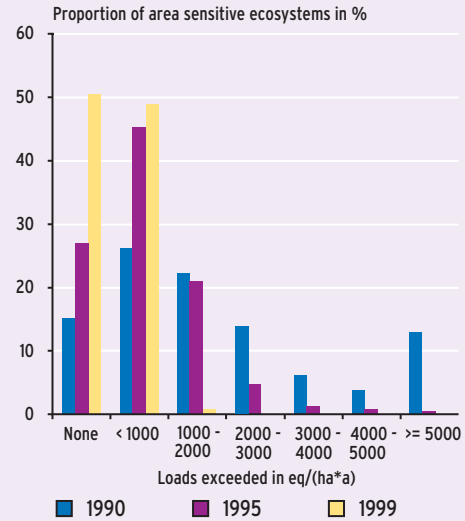
Alongside sulphur dioxide and nitrogen oxides and their by-products, emissions of ammonia into the air (mainly from livestock farming) have an acidifying effect – ammonia/ammonium entering the soil is nitrified there. As soon as the ensuing nitrate is taken away with the seepage water, the soil acidifies.

Acidifying pollutants cause acute and chronic damage to plants (damage to leaves and forest); the soil conditions readjust to a highly unfavourable (acidified) level and can thus help to reduce species diversity. Plants and plant communities that are dependent on neutral soil conditions stand no chance of long-term survival under current immission levels, as they will be forced out by highly-competitive species in the acid milieu.

The acidifying pollutants are often transported over several hundred to a thousand kilometres in the air before they become damaging, so international emission reduction negotiations are required to develop effective, equitable solutions. Under the UN-ECE LRTAP Convention, critical loads are an important basis of European air quality control policy.

Inputs of acidifying pollutants from industry, transport, and agriculture have fallen in recent years, but the critical loads for acidification are still being exceeded over a substantial proportion of the entire area of sensitive ecosystems in Germany (Fig. VIII 2.2.3-1); these areas are still becoming more acidic. Until the mid-1990s, inputs of acidifying substances and instances of the critical loads being exceeded were greatest in the forest areas of Thuringia and Saxony that are close to the emission sources. Since then, though, the maxima are being reached in sensitive soils in the northern German lowlands as a consequence of increased ammonium inputs from agricultural sources (mainly from intensive livestock

Fig. VIII 2.2.3-1: *Exceeding of critical loads for acidification in acid equivalents*



Source: *Federal Environment Agency 2005 b*

farming). These are the regions where critical loads for eutrophication are also being exceeded to the greatest degree. As a result, further emission reduction measures need to be aimed specifically at sources of ammonia emissions (livestock farming).

In the same way that eutrophication is being tackled by the UNECE LRTAP Convention and the EC NEC directive (2001/81/EC), a Europe-wide reduction of the ecosystem area where critical loads are being exceeded is specified. Despite the efforts made to reduce emissions, the critical loads for acidification are still being exceeded.

VIII 2.2.4 Ozone's effects on ecosystems

Ozone has a damaging effect on vegetation. It can lead to a loss of yield and quality (e.g., discolouring and parts of leaves dying), and in the long-term trees become highly sensitive to pests.

A plant's reactions to ozone pollution stem from a number of biochemical and physiological processes that can eventually cause visible damage. Ozone's flow through the plant's stomata determines the impact of the ozone and how damage occurs in the leaves – intake via the leaf's surface is negligible.

Ozone can have three types of effect on plants:

Acute effects occur during or, usually, after brief spells of exposure to a high concentration of ozone and as a result of the plant's high ozone intake rates. These effects are particularly seen in the form of quite visible symptoms such as spots or widespread deterioration of the tissue (necroses) or discolouring (chloroses).

Longer-lasting exposure to relatively low ozone concentrations leads to chronic effects. These also include visible symptoms, e.g. changes to growth (dwarfism, leaf deformation) or, more often, yellowing (chloroses) of individual leaf or needle areas or of entire organs. The pattern these processes takes is often similar to the plant's natural ageing, so it is often expressed in terms of premature or accelerated ageing (senescence).

The third type is the latent effect. Its symptoms are not clearly recognisable or well-characterised. They include changes to biochemical and physiological processes or cellular and sub-cellular structures (e.g., disrupted photosynthesis, the formation of "wrong" metabolic – interim – products, membrane changes), disruption to the function of the stomata, and they can reduce growth and yield. The consequences of these reactions often only appear when other stress factors (drought, infestation etc.) are present and having an effect, and they reduce the plant's output.

Among the more sensitive receptors in Central Europe are the beech, larch, pine and other forest trees, and agricultural crops such as wheat and potatoes.

Due to its elevated concentration during periods of fine weather, ozone is a key substance in what is known as summer smog. Summer smog is characterised by a high concentration of so-called photochemical oxidants such as ozone itself, peroxides, aldehydes, and organic nitrogen compounds. Photochemical oxidants are not emitted directly but are formed in the atmosphere through complex photochemical reactions.

The formation of ground level ozone is associated with precursor substances such as nitrogen oxides (NO_x) and volatile organic compounds (VOC). A major source of emissions of precursor substances is motorised transport, but nitrogen oxides are also emitted from the power station sector in particular, and volatile organic compounds from the use of paints and solvents. There are also some emissions from natural sources.

The altitude and frequency of short-term peak ozone concentrations depends closely on the summer's course.

Particularly high concentrations of ozone are attained periodically during years of long-lasting spells of fine weather in the summer. Periods of summer smog are defined as occurring when ozone levels exceed the level of 180 $\mu g/m^3$ for at least two days over a wide area.

The highly complicated nature of the conditions required to create high levels of ozone pollution from other airborne pollutants means that, despite the decline in emissions of precursor substances that has been observed in Germany since 1990, a reduction in ozone pollution cannot be clearly identified (see also Chapter V 1.4 "Ground level ozone and summer smog").

Critical levels for ozone – figures to protect plants

The International Cooperative Programme for Research on Evaluating Effects of Air Pollutants and other Stresses on Agricultural Crops and Non-woody Plants (ICP-Vegetation) has been in place since 1988, under the UNECE LRTAP Convention. Under the leadership of Great Britain as the coordinating nation, the programme has expanded from the original 8

countries to 22 European countries plus the USA. Over recent years, the programme has played a major role in developing the strategy of "critical levels" for ozone in the area of research into ozone's effects.

Gas experiments carried out on various plant species show that ozone damage (in this case, biomass loss) correlates less with the average concentration over a given period of time than with the frequency of the occurrence of high concentrations. For this reason, critical levels are defined as a cumulated dose – the so-called AOT40 value (Accumulated Exposure Over a Threshold of 40 ppb). All exceedances of an hourly average of 40 ppb (40 ppb equates to 80 µg/m^3) are added together. This total (given in ppb·h) ought not to exceed the critical level of 3 000 ppb·h for agricultural cash crops and 10 000 ppb·h for forested areas. Studies only take into account the period of maximum receptor sensitivity, the main growth phase (in Germany: May to July for agricultural cash crops, April to September for forested areas). The calculation period is limited to daylight hours.

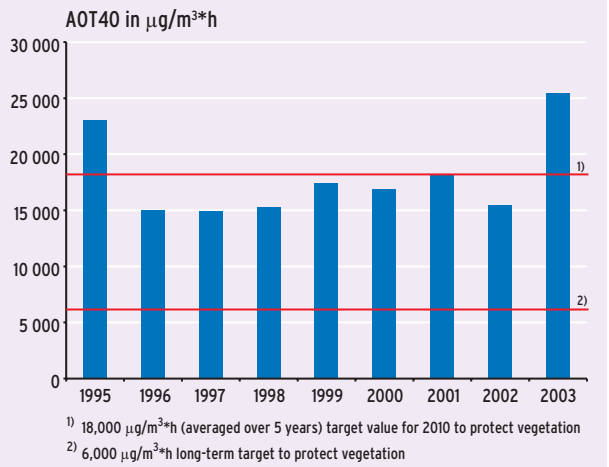
Where the critical levels for vegetation are not exceeded, plants no longer suffer any statistically significant damage. However, it is impossible to make any quantitative statement, e.g., that where the critical level is exceeded by a factor of four there is also a fourfold loss of biomass.

Under the new EC Directive 2002/3/EC [4] the target value for protecting vegetation is an exposure index AOT40 of 18 000 [µg/m^3] h, averaged over 5 years, which is to be attained by 2010. The long-term target for protecting vegetation is to attain the critical level for vegetation (6 000 [µg/m^3] h) over the entire territory by 2020.

Figure VIII 2.2.4-1 shows the AOT40 values for 1995 to 2003 (averages from rural background stations). No clear trend can be identified, and the levels are well above the impact threshold level. The strong influence of meteorological conditions on ozone pollution can particularly be seen in the years 1995 and 2003.

During the summer of 2003 the weather was very unusual, with extremely elevated levels of solar intensity which created highly favourable conditions for ozone formation. A high base level of ozone formed, with peaks in excess of the threshold values (see Chapter V 1.4 "Ground level ozone and summer smog"). The extraordinary pollution did not fully affect the condition of the forests until 2004 [5].

Fig. VIII 2.2.4-1: *Ozone pollution in vegetation – AOT 40 averages from rural background stations*



Source: *Federal Environment Agency 2004*

[1] Achtes Protokoll zum Übereinkommen von 1979 über weiträumige grenzüberschreitende Luftverunreinigung der Europäischen Wirtschaftskommission der Vereinten Nationen (UN/ECE) (abb.: Multi-component – protocol of 30th November 1999: "Protocol to the 1979 Convention on Long-range Transboundary Air Pollution to abate Acidification, Eutrophication and Ground-Level Ozone"

[2] Directive 2001/81/EC of the European Parliament and Council of 23rd October 2001 on national emission ceilings for certain airborne pollutants: Appendix I).

[3] Perspektiven für Deutschland, Unsere Strategie für eine nachhaltige Entwicklung, April 2002

[4] EU Directive 2002/3/EC of the European Parliament and Council of 12.02.2002 on ozone content in the air, adopted in German law by 33. BImSchV of 13.07.2004

[5] Bericht über den Zustand des Waldes-Ergebnisse des forstlichen Umweltmonitorings; Federal Ministry of Food, Agriculture and Consumer Protection, December 2004

VIII 3 Measures to preserve ecosystems and biodiversity

VIII 3.1 The preservation and sustainable use of biodiversity in agriculture

About 7 000 species of plant (ornamental and forest plants excluded) are currently being used by mankind across the world. Of the approximately 3 240 species of blooming plant that grow wild in Germany, almost 1 000 species are regarded as being genetic resources.

Diversity, both between and within species, in agriculture and horticulture is seriously endangered as measures such as industrial production and use, imports from areas with production conditions that are ecologically and economically more favourable, and the relative primacy (resulting from the playing field being levelled through the use of fertilisers and pest management) of intensively-bred, high-yield strains force out the species that were cultivated originally.

A similarly threatening trend has developed with animals. Here, too, there has been a significant decline in breed diversity and genetic variability within breeds since the middle of the last century. This trend is particularly apparent in animal species used in the agricultural sector. As with plants, the reasons can mainly be found in the increasing industrialisation of production and breeding.

International measures

This problem was recognised decades ago at the international level. In 1983 the FAO developed a global system for the preservation and sustainable use of plant genetic resources. The system consists of the international network of ex situ collections, the World Information and Early Warning System (WIEWS) and the global action plan – agreed to in 1996 – for preserving plant genetic resources. The global action plan for the preservation and sustainable use of plant genetic resources for nutrition and agriculture comprises proposals for 20 measurement packages in the areas of in situ conservation, ex situ conservation, the usage of plant genetic resources, and assembly of capacities and institutions. Member states are obliged to implement it, and it is monitored by the FAO.

Similarly, the FAO requires the preservation of old and endangered domestic animal breeds and the creation of sustainable structures within whose frameworks old domestic animals and animal genetic resource populations can be retained and bred in ways that are economically profitable.

European Union measures

At the European level, the integration of biodiversity into the Common Agricultural Policy was largely determined by putting Agenda 2000 into practice. In 2001, the European Community agreed on an action plan to preserve biodiversity in agriculture [1] with a view to anticipating, avoiding, and removing the causes for the significant decline in or loss of biodiversity. This act is related to other international efforts, especially with the international convention on biodiversity. The action plan places great weight on agrarian environmental measures being specifically applied to support agricultural practices that protect nature and the environment in order to preserve the environment and the rural habitat, and to protect Europe's rural heritage. Intensive agricultural practices should only reach a reasonable level of intensification which avoids negative impacts on biodiversity. This includes such measures as reducing the use of fertilisers, introducing extensive production methods, and managing natural resources in a sustainable way. Measures are to be implemented to preserve local breeds and strains and the diversity of the species used in the agricultural sector. The spread of non-indigenous species should be inhibited.

On 24th April 2004, a common plan was agreed – Regulation (EC) No. 870/2004 [2]; this aims to enable financial measures to conserve, characterise, collect, and use genetic resources in the agricultural sector, and to enable information exchange and coordination between Member States and the Commission. The regulation also seeks to improve coordination in the area of the obligations undertaken at the international level regarding genetic resources in agriculture.

National measures

Agricultural practices that protect nature and the environment

Loss of biodiversity – particularly in living beings that can be used in the agricultural, forestry, fishing and food sectors – needs to be countered in order to preserve the genetic basis for future adaptations and the bases for varied nutrition and regenerative resources and renewable energies. Based on a BMVEL strategy for the conservation and sustainable use of genetic resources for nutrition, agriculture and forests, a national technical programme was drawn up. An advisory board for genetic resources was also established with a brief to advise the BMVEL on basic and wide-ranging issues. Moreover, specialist programmes have already been set up for such sectors as forest plants, plants used in agriculture and horticulture, and livestock and fish, within whose frameworks concrete measures have been agreed in collaboration with the *Länder* and participating districts. These efforts form a major part of the federal government's strategy for sustainable development.

National programme for plant genetic resources

The BMVEL (previously BML) worked out a first strategy for plant genetic resources (PGR) as long ago as 1990, and in 1998 this was adapted to the underlying conditions which had been altered by changes in international law. For the individual part-sectors genetic resources for nutrition, agriculture, and forests, this provides for specialist schemes that are components of a comprehensive national programme.

The National Programme for PGR was drawn up by a working group of representatives from the federal government and the *Länder*, universities, research departments and associations under the leadership

of the BMVEL and approved in 2002 by the agrarian ministers' conference. It is aligned with the FAO's global action plan and aims to implement the measures proposed there at national level in a suitable way and should build on existing measures.

To preserve plant genetic resources, the complexity of the initial situation has led to an integrated approach being followed which makes use of in situ conservation, on-farm management, and ex situ conservation. This includes specifics such as

- ensuring the long-term conservation of both wild and cultivated PGR in a way that is scientifically secure and cost-efficient, both in situ and ex situ,
- improving the usability of PGR through suitable measures, such as characterisation and evaluation,
- increasing the diversity of the cultivated plant species and types used commercially in agriculture and horticulture (including ornamental plants),
- making a contribution towards conserving and reproducing ecosystems characteristic of agriculture and horticulture, including fruit growing and grassland ecosystems,
- achieving transparency in the areas of responsibility involved in conserving and using PGR, and
- using the synergies available from stronger partnerships at national and international levels.

The federal government, the *Länder* and individual institutions, committees and actors are to make efforts to ensure that this programme is implemented. In implementing the responsibilities above, particularly in coordinating the measures, the BMVEL, which is driving this programme on behalf of the federal government, has access to support from an advisory and coordination committee for PGR, this committee's expert groups on specific plants and issues, and a secretariat at the Biological Diversity Information Centre (IBV) at the German Centre for Documentation and Information in Agriculture (ZADI).

The *Länder* are supporting the programme by setting up their own internal schemes and by incorporating individual measures into existing programmes.

National programme for the preservation and sustainable use of animal genetic resources (TGR National Programme)

In Germany, the FAO's requirement to preserve old and endangered domestic animal breeds and, in relation to this, to create sustainable structures has been implemented in national law through the law on the convention on biological diversity. This obliges the federal government to report to the FAO on animal genetic resources. In 2002, the FAO received the first German report on the animal genetic resources situation, produced by a project group from the German Society for Animal Production e.V. (DGfZ)'s working committee on the preservation of genetic diversity in agricultural livestock.

This project group also drew up the TGR National Programme. It specifically deals with the status of endangered domestic animal breeds in Germany and aims to clothe breeding, care and conservation in a framework aimed at preserving biodiversity. It places joint consultation and procedural obligations – aimed at achieving the objectives described – on scientists, breeders, associations, clubs, organisations, the federal government, and the *Länder*.

If the task of preserving biodiversity is to be performed, it is important to have precise and comprehensive knowledge about the situation as a whole and about sub-issues and specific facts. For this reason, documentation and information is a major component of the programme and is taken care of by the Documentation Centre for Animal Genetic Resources in Germany (TGRDEU). As well as pure documentation, the TGRDEU is responsible for creating an organisational and information technology infrastructure. This aims to provide permanent monitoring of the status of individual breeds so that any threat to a breed or population can be identified early on and an action plan devised.

Another key part of the programme is to draw up plans for creating and administering a comprehensive cryopreservation system that represents each breed.

All in all, the TGR National Programme means that a framework and plan of action has been put in place for the conservation of gene reserves and genetic resources in Germany. In years to come, this plan needs to be gradually implemented. It is not merely financial and technical difficulties in introducing the planned measures that need to be overcome. Once the required base conditions have been established, there is a need to ensure that, in the long run, all the parties involved – breeder organisations and breeders, private conservation organisations, and experts from the research and management sectors – work constructively together so that animal genetic resources can be preserved and used in a constructive way.

In the research and development area, methods and procedures have been developed over recent years that have enabled molecular biological research to

be used as a basis for obtaining suitable results in terms of describing, assessing, and characterising individual animals and breeds. Efforts to work out breeding programmes for small populations that need to be developed and which draw on a mainly population genetic basis also need to be moved into the research and development sector.

The optimal approach – in situ use – can mostly only finance itself in the case of high-yield breeds. Since the threat has primarily been a result of breeds' economic inferiority, farmers can usually only be moved to keep and use certain breeds through government grants. Funding extensive livestock farming which protects the environment does not automatically result in endangered breeds being used. Funding for landscape management has until now not been linked to the use of indigenous or endangered breeds. French or Scottish breeds, for instance, are often used as suckling cows, but not the native yellow cow or red cow which, moreover, were originally bred as milk breeds.

Funding to farm animals from breeds threatened with extinction are available under the agrarian environmental programme and have also been a great help in stabilising stock levels.

Old livestock breeds cannot be regarded as either generally or particularly suitable for organic-farming or extensive livestock farming methods. Since organic-farming also needs to involve economic viability, the productivity gap to breeds that have been actively bred has become too great. Only in the case of certain breeds, and then normally only when particular niches have been opened up, can a strategy for preserving breeds through using them in organic-farming prove sustainable.

Developing new ways of using old breeds has been successful when done by marketing them under traditional, usually region-related, breed names. It ought not to be overlooked that schemes such as these require excellent organisation and resource-consuming marketing. The prices of these products, which usually need to be well above average, often restrict these types of use to niche markets.

All conservation measures can only be successful when they are safeguarded over very long periods of time. Long-term conservation programmes cannot be built on personal commitment and livestock farmers' idealism alone if the private commitment has involved non-paid work and will continue to be essential.

It is not simply the current status of the public purse that explains why the state cannot be burdened with the conservation of overall genetic diversity in the long term. It is the state's task, above all, to develop strategies for conservation and to then implement them in an exemplary way. And while it may be hoped that future public funding can also be provided for this field, sustained funding of every endangered breed is inconceivable.

[1] Commission presentation to the Council and the European Parliament – *Aktionsplan zur Erhaltung der biologischen Vielfalt in der Landwirtschaft*; COM(2001)162 definitive

[2] Regulation (EC) No. 870/2004 of the Council of 24th April 2004 on a common programme to conserve, characterise, collect and use genetic resources in the agricultural sector and to annul Regulation (EC) No. 1467/94

VIII 3.2 Environmental measures in the agricultural sector and their funding

Supporting the agricultural environment

Because they form a great proportion of Germany's total surface area, agricultural landscapes are particularly significant for the protection of life's natural bases, as they are a major part of our environment, a reservoir for water extraction, and the habitat for many species of wild animals and plants. Therefore, key objectives are to reduce environmental pollution through agricultural use and achieve a sustainable, environmentally-compatible agricultural sector that preserves the overall inventory of resources for future use and removes the pollution that has occurred in the past. The promotion of environmentally-compatible production methods is realised within the framework of agricultural environmental measures.

The legal basis for agricultural environmental support is formed by Regulation (EC) No. 1257/1999, amended by Regulation 1783/2003, on assisting development in rural areas through the European Agricultural Guidance and Guarantee Fund (EAGGF).

At the national level, the *Länder* implement this regulation through their own specifically designed programmes, with the federal government participating in the financing of these measures using the funding base "Market-oriented and locally adapted land cultivation" under the collective task "Improving the agricultural structure and coast protection" (GAK).

Funding is provided for environmentally-compatible cultivation methods, for setting aside areas for environmental purposes for various years, for environmentally- and animal-friendly livestock farming methods, etc. The *Länder* programmes offer a fur-

ther range of Land-specific measures which to some extent include wider-ranging obligations in terms of nature conservation and landscape management with a view to preserving species and habitat diversity.

The financing for the GAK measures is shared between the European Union, the German federal government, and the individual *Länder*. Many of the *Länder* programmes have also now been transferred into agricultural environmental programmes co-financed by the EU. The share of EU co-finance currently stands at 60 %, and 85 % in the new *Länder*.

In 2002, around 310 000 applying farmers received funding of around 689 million euro through the EU, the federal government, and the *Länder* for agricultural environmental measures in Germany (2000: around 400 000 applications, 538 million euro funding). Around 43 % of Germany's grassland and 12 % of its arable area is included in this funding [1].

The area affected expanded continuously after the agricultural environmental measures were introduced in 1993 up until 1997, but since 1998 there has been a slight decline. This trend is mainly explained through the fact that base environmental funding fell significantly. Subsidies for the more demanding agricultural environmental measures on arable land and land worthy of nature conservation have risen with the transition to the 2000 to 2006 funding period. The average funding granted rose from 91 euros/ha in 1998 to 127 euros/ha in 2000. The area funded also expanded again in 2001 (Table VIII 3.2-1). The decline recorded once more in 2002 prevents any conclusion from being drawn about future trends.

Tab. VIII 3.2-1: *Trends in area and funding within agricultural environmental funding*

		1994	1998	1999	2000	2001	2002
Area funded	millions ha	4.5	5.0	4.7	4.2	5.0	4.2
Funding	million euro	415	456	612	538	692	689

Source: *Federal Ministry of Food, Agriculture and Consumer Protection 2004 a*

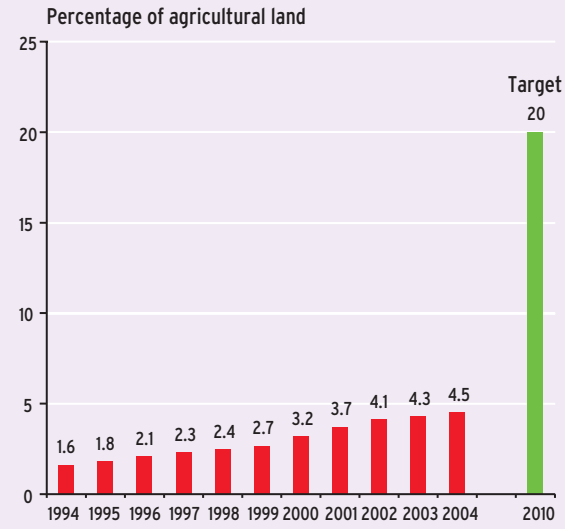
Organic farming

One form of agricultural business funded by the European Agricultural Guidance and Guarantee Fund (EAGGF) which is a particularly good example of protecting resources, the environment, and animals is organic farming. Businesses operating according to the principles of organic farming do not use products such as mineral nitrogen fertilisers and chemical-synthetic pesticides. Animal numbers are restricted based on the farm's size. Cultivation methods aim to avoid environmental pollution by employing nutrient cycles that are as closed as possible. Organic farming is also characterised by animal-friendly livestock farming methods and varied crop rotation.

Organic farming is a major component of an agricultural policy whose mission statement is sustainability – it is a flag-bearer for sustainable agriculture. For this reason, the national sustainability strategy has adopted the percentage of land devoted to organic farming as a key indicator [2].

Late in 2003 in Germany, about 4.3 % of all cultivated land was being farmed according to organic farming principles, with the trend rising to 4.5 % in 2004 (Fig. VIII 3.2-1). This places Germany above the EU average as on 31 December 2003, midway down the table based on the percentage of total national area, behind Austria (12.9 %), Finland (7.2 %), Italy (6.9 %), Sweden (6.8 %), and Denmark (6.1 %) (Chap. II 2.4) [3].

Fig. VIII 3.2-1: *Trends in area cultivated with organic farming methods*



Source: *Federal Agency for Nature Conservation 2004 b*

[1] Federal Ministry of Food, Agriculture and Consumer Protection memorandum, Paper 526
[2] Perspektiven für Deutschland, Unsere Strategie für eine nachhaltige Entwicklung; federal government progress report 2004
[3] Ecology and Agriculture Foundation (2004): Organic Farming in Europe (www.organic-europe.net/europe_eu/statistics.asp) (as at: 31/12/2003)

VIII 3.3 Sustainable forest management

Germany was originally almost entirely covered with forest but, given the fact that the proportion is now 30 %, sustainable forest management is ex-

tremely important for the preservation of biodiversity. Ecological management methods are a prerequisite for the survival and development of the forests' characteristic species and habitat diversity.

The federal government aims to have semi-natural forest management over as much as possible of the forested area used for forestry purposes in Germany (Perspektiven für Deutschland: Unsere Strategie für eine nachhaltige Entwicklung, 2002). State-led measures (e.g., funding, legislation, etc.) greatly assist the achieving of this goal. On the other hand, socially desirable forestry management functions are increasingly being carried out through independent individuals, groups, and institutions. As a private economic instrument to promote forms of forestry that protect nature, are socially-compatible, and provide high economic yields, certification is playing an increasingly important role in determining forest management standards. Certification is a means of supporting the forest owner's ecological objectives where they transcend the minimum legal requirements. In Germany, three forest certification systems currently exist alongside each other – PEFC, FSC, and Naturland. In different ways, these take into account criteria that relate to nature protection. The certification of forest areas under all types of ownership, based on the high quality standards of Naturland, FSC, and PEFC, is proceeding apace.

By late in 2004, almost 70 % of forests had been certified in Germany – 7 million ha based on the criteria of the "Programme for the Endorsement of Forest Certification Schemes" (PEFC), 500 000 ha based on those of the "Forest Stewardship Council" (FSC), and around 60 000 ha based on Naturland's criteria (Table VIII 3.3-1). By acquiring certification based on demanding schemes such as Naturland or FSC, forest owners document their willingness, when managing their land, to take into account the requirements of sustainability and of nature and species protection above and beyond the standards specified by law.

Tab. VIII 3.3-1: *Certified forest areas in Germany*

Area in 1 000 ha	1999	2000	2001	2002	2003	2004
PEFC[1)]	570	1 300	1 700	4 800	6 500	7 000
FSC[2)]	–	120	140	260	450	500
Naturland (FSC certification)	–	–	–	56	56	ca. 60

[1)] Programme for the Endorsement of Forest Certification Schemes
[2)] Forest Stewardship Council

Source: *Federal Ministry of Food, Agriculture and Consumer Protection 2004 c*

VIII 3.4 Protected sites

Placing sites of land and water under protection is a key instrument in conservation. Categories of protected sites are defined in the Federal Nature Conservation Act (BNatSchG), similar laws at the *Länder* level or in international treaties and conventions.

For this reason, parts of a protected site, or even the whole area, may enjoy protection under more than one category. Simply adding together the areas protected under each category is therefore statistically meaningless. In the "Oberlausitz heath and lakelands" biosphere reserve, 43.5 % of the total area has FFH status. The Siebengebirge nature park is also, in its entirety, a nature reserve and currently holds a European conservation diploma. As defined in the BNatSchG, nature parks generally consist of nature and landscape protection areas reserves. Tables VIII 3.4-1 and VIII 3.4-2 provide an overview of data from selected reserves.

The BNatSchG amendment means that, for the first time, a nationwide habitat network system, which is to include at least 10 % of the country (§ 3 BNatSchG), has been made a legal requirement. This aims to make a real contribution towards preserving biodiversity and safeguarding the country's natural heritage. This framework consists of national parks, habitats protected pursuant to Art. 30 BNatSchG, nature reserves, proposed Natura 2000 sites and biosphere reserves or parts of them in so far as they contribute to achieving the above objectives. The expansion of this cross-*Länder* habitat network system will also be helped by the identification of other landscapes that merit protection, e.g., in natural parks or landscape protection areas.

VIII 3.4.1 National protected sites [1]

Nature reserves

Under § 23 BNatSchG, designating an area as a nature reserve is "a legally binding act, aimed at providing special protection to nature and landscapes as a whole, or to parts of nature and landscapes, by virtue of the following reasons:

- to preserve, develop, or recreate biotopes or biocoenoses of certain species of wild fauna and flora,
- for reasons of science, natural history, or national heritage,
- because of the areas' uniqueness, particularity, or singular beauty."

Some 1 047 363 ha were designated as nature reserves in Germany as of 31 December 2003 – 2.9 %

Tab. VIII 3.4-1: *Selected protected areas and special sites in Germany*

Category of special/protected area	Type	Quantity	Area [ha]	Percentage of surface area [%] [1]	As on
Nature Reserve	§ 23	7 278	1 047 363 [2]	2.9	31.12.2003
National park	§ 24	15	194 136 [2] (962 048)	0.54 (2.7) [3]	2/2004
Biosphere reserve	§ 25	14	1 071 225 [2] (1 579 828)	3.0 (4.4) [3]	2/2004
Landscape protection area [4]	§ 26	7 187	10 601 045 [2]	29.7	31.12.2003
Nature park	§ 27	87	7 985 511 [2]	22.4	31.01.2004
Habitats Directive site as per 92/43/EEC	§ 32, 33	4 484	4 120 824 (1 029 120) [5]	8.7	31.12.2004
Bird area as per 79/409/EEC	§ 32, 33	511	3 729 945 (1 169 540) [5]	7.2	31.12.2004
Wetland of international significance (Ramsar Conv.)	Convention	32	841 000	2.3	3/2004
European conservation diploma	CE	8	103 876	0.3	2/2004
European nature reserve [6]	NRO	20	268 408	0.8 [3]	2/2004
IBA (Important Bird Area) [7]	NRO	542	7 938 851 (5 650 907) [2]	15.8	01.07.2002
Strict forest reserve	Various (see text)	824	30 587	0.085	2/2004

[1] Reference: statistical land area (excl. mudflats and marine areas)
[2] Excl. marine and mudflat areas of the North Sea and Baltic Sea
[3] Incl. marine and mudflat areas of the North Sea and Baltic Sea
[4] SL: As on: 31.12.2001
[5] () – of which mud, water, shallows, and marine areas (incl. Lake Constance)
[6] No more registered since 1998
[7] As per SUDFELDT et al. (2002)
Type: Protected areas by BNatSchG with the paragraph specified that defines the category of protected area; other sites given their special status by the Council of Europe (CE) and based on conventions or lists proposed by nature conservation groups (non-governmental organisations – NGOs)

Source: *Federal Agency for Nature Conservation 2004*

Tab. VIII 3.4-2: *Nature reserves in Germany (as of: 31.12.2003)*

State	Number of designated reserves	Table 1	% of the total area	Number of temporarily secured reserves	Area [ha]	% of the total area
Baden-Württemberg	985	81 003	2.3	0	0	0.00
Bavaria	578	156 357	2.2	0	0	0.00
Berlin	35	1 878	2.1	0	0	0.00
Brandenburg [1]	398	176 420	6.0	1	5	0.00
Bremen	17	1 910	4.7	0	0	0.00
Hamburg [2]	28	5 510	7.3	0	0	0.00
Hesse	760	38 805	1.8	5	1 094	0.05
Mecklenburg-West Pomerania [3]	259	68 612	3.0	29	7 985	0.34
Lower Saxony	705	143 045	3.0	0	0	0.00
North Rhine-Westphalia	2 054	149 356	4.4	2	1 232	0.04
Rheinland-Palatinate	508	36 412	1.8	0	0	0.00
Saarland	102	7 017	2.7	0	0	0.00
Saxony	214	49 021	2.7	0	0	0.00
Saxony-Anhalt	198	54 062	2.6	2	1 099	0.05
Schleswig-Holstein [4]	184	43 809	2.8	0	0	0.00
Thuringia	253	34 146	2.1	0	0	0.00
Germany	**7 278**	**1 047 363**	**2.9**	**39**	**11 415**	**0.03**

[1] The "Nationalpark Unteres Odertal" reserve (10 635 ha) is included because the relevant law still applies.
[2] Excl. Wadden Sea
[3] If the marine land area of MWP is added (which is not included in the area recorded in the statistics) nature reserves' share comes to 2.2 % and the temporarily secured reserves to 0.26 %.
[4] The total area of the nature reserves in Schleswig-Holstein is 203 951 ha; this includes 160 142 ha of mud and water areas that are not included as land in the statistics; 151 653 ha of mud and water areas also form part of the "Schleswig-Holsteinisches Wattenmeer" national park.

Source: *Federal Agency for Nature Conservation 2004*

of the total land area. The total area designated as nature reserves has risen by ca. 27 % since 1997 (824 161 ha). Information about sites temporarily designated as nature reserves by five *Länder* indicates that an additional area in the order of 0.03 % of the total land area also has nature reserve status.

Two-thirds of nature reserves cover less than 50 ha, and only ca. 14 % cover 200 ha or more. The average size of a nature reserve is 144 ha (Data base: nature reserve areas excluding the mudflats and North and Baltic Sea areas). A total of 159 reserves are 1 000 ha or larger.

The extent to which a nature reserve can fulfil a protective function depends not least on its size, as the size of nature reserves varies from *Land* to *Land*. In hilly and mountainous areas (e.g., Rhineland-Palatinate, North Rhine-Westphalia, Hesse, and Baden-Württemberg), and in small *Länder* (Saarland, Berlin) the designated nature reserves are smaller, while they are far larger in the lowlands of northern Germany.

Furthermore, the forms of use that the ordinances permit to nature reserves can restrict the quality of the reserves and the implementation of the respective conservation goals. Such forms of use particularly include various types of leisure activity, agriculture and forestry, water management, and transport.

National parks

Under § 24 BNatschG, National parks are "areas requiring uniform protection where:

- the area concerned is large and of singular character,
- the criteria defined for nature reserves apply to the greater part of the area concerned, and
- most of the area has not been affected by human intervention at all, or only to a limited extent, or is suited to developing into a condition or being developed into a condition that ensures that natural processes can take course with minimal hindrance."

A priority objective of the national parks is to preserve and allow natural processes and natural dynamics with minimal disturbance. The economic exploitation of natural resources through agriculture, forestry, water management, and hunting and fishing is more or less prohibited and only possible if it is consistent with conservation goals. Where the park's conservation aim so allows, national parks should be used for scientific study, and for learning about natural history, and the inhabitants' interaction with nature.

National parks are designated by the *Länder* in consultation with the Federal Environment Ministry and Federal Ministry of Transport, Construction and Housing (BMU and BMVBW) (§ 22 Article 4 Clause 2 BNatSchG). The previous version of the BNatSchG amended in 2002 now permits so-called "developing national parks" to be designated where efforts are being made to achieve a state where natural dynamics prevail. This facilitates the designation of new national parks in Germany. Many of the existing national parks are currently still "developing national parks", i.e., they fulfil the criteria for undisturbed natural development only for certain parts (the core area). Appropriate measures, documented in management plans, seek to create the conditions required, so that, in the future, priority is given to natural, dynamic processes across most of the sites' area. The IUCN's guidelines for Category II (a protected site set up mainly to protect ecosystems and for recreational purposes) specify that, if the site is also to be recognised as a national park by international standards, at least 75 % of the total area should be in a largely near-natural state and be subject to no use that runs counter to the conservation aim.

There are currently 15 national parks in Germany, and between 2002 and 2004 their total area increased from 947 859 ha to 962 048 ha (Table VIII 3.4.1-1). This is particularly due to the designation of the new Eifel (North-Rhine Westphalia) and Kellerwald-Edersee (Hesse) national parks in 2004. In relation to Germany's statistical surface area, which excludes marine territories, the total area of the national parks comes to 0.6 % of federal land. Rhineland-Palatinate and Baden-Württemberg do not yet have national parks.

Despite the fact that little remains of Central Europe's original nature, Germany still has a number of sites that are suited to national park status. In particular, various beech forest ecosystems, which are the main component of Germany's natural vegetation, ought to be included in the protected sites framework. Given Germany's responsibility for protecting these ecosystems, further parks ought to be designated. As the military abandons certain areas used for exercises, further options could well emerge.

Landscape protection areas

Landscape protection areas are legally protected areas where, under § 26 BNatSchG, "special protection of nature and landscapes is warranted for the following reasons:

- to preserve, develop or recreate the functional capacity of natural systems, or the natural re-

Tab. VIII 3.4.1-1: *National parks in Germany (February 2004)*

National Park (federal Land)	Year established	Total area [ha]	Principal protected habitats
Bavarian Forest (BY)	1970	24 250	Mixed mountain forest, highland spruce forest, moor land, mountain streams, block scree
Berchtesgaden (BY)	1978	20 808	Alpine rocky slopes, grass and shrubland, sub-alpine, montane and sub-montane forests, mountain meadows, lakes
Schleswig-Holstein Wadden Sea (SH)	1985	441 500 of which ca. 97.7 % water[1)]	Tidal mudflats, foreland salt marshes
Lower Saxon Wadden Sea (NI)	1986	277 708 of which ca. 91.8 % water[1)]	Tidal mudflats, salt marshes and dunes on the East Friesian islands
Hamburg Wadden Sea (HH)	1990	13 750 of which ca. 97.1 % water[1)]	Tidal mudflats in the estuary of the Elbe, strong influence from brackish water
Jasmund (MV)	1990	3 003 of which ca. 22 % water[1)]	Beech forests on chalky sites, chalk cliffs, Baltic Sea near the coast
Upper Harz (ST)[2)]	1990	8 900	Highland spruce forests, beech forests, moor land, mountain heaths, block scree and rock formations
Saxon Switzerland (SN)	1990	9 292	Wooded gorges, xerophile forest, sub-montane forest
Mueritz National Park (MV)	1990	31 878	Pine and beech forest, alder and birch groves, lakes and moor land
West Pomeranian Boddenlandschaft (MV)	1990	80 500 of which ca. 84 % water[1)]	Reed flats, various coastal features, forests
Harz (NI)[2)]	1994	15 800	Upper montane pine forests, beech forests, moor land, rivers and streams
Lower Oder valley (BB)	1995	10 635	Water meadows, bayous, reed beds, wet grasslands
Hainich (TH)	1997	7 600	Mixed deciduous and beech forests, various stages of succession, some wide disparities in age structure
Eifel (NW)	2004	10 700	Atlantic-type, acid soil mixed beech woods, forests (kaolin to sub-montane), spring areas, stream valleys
Kellerwald-Edersee (HE)	2004	5 724	sub-montane, acidic soil beech forests, rocky dry cliffs, seminatural rivers and streams, oligotrophic forest meadows
Total area incl. North Sea and Baltic Sea[1)]:		962 048 ha	
Total area excl. North Sea and Baltic Sea[1)]:		194 136 ha (ca. 0.54 % of federal territory)	

[1)] Only relates to the water that is not included as land in the statistics
[2)] There are plans to combine the Harz (NI) and Upper Harz (ST) national parks

Source: *Federal Agency for Nature Conservation 2004 a*

sources' ability to regenerate and be used in a sustainable way,
- because of the diversity, singularity and beauty, or the particular cultural and historic importance of the landscape, or
- because of the area's special importance for recreation."

Compared with nature reserves, landscape protection areas are usually larger sites with fewer restrictions on use.

Change is regulated with a view to preserving the site's character. Agriculture or forestry may be restricted in order to prevent the loss of such character, or if they run contrary to the conservation aims.

There are 7 181 landscape protection areas with a total area of ca. 10.6 million ha, which equates to ca. 29.7 % of federal territory (31 December 2003) (Table VIII 3.4.1-2).

Nature parks

Under § 27 BNatSchG, nature parks are "areas earmarked for uniform development and maintenance which comply with the following conditions:

- the area involved is large in size,
- it consists mainly of landscape protection areas or nature reserves,
- it is particularly suitable for recreational purposes because of its landscape assets, and efforts are being made to attract sustainable tourism,

Tab. VIII 3.4.1-2: *Protection areas in Germany (31.12.2003)*

Land	Quantity	Area [ha]	% of the total area
Baden-Württemberg	1 498	791 372	22.1
Bavaria	701	2 058 648	29.2
Berlin	48	10 931	12.3
Brandenburg	112	1 120 786	38.0
Bremen	26	8 043	19.9
Hamburg	42	15 264	20.2
Hesse	147	920 532	43.6
Mecklenburg Pomerania [1]	137	642 666	27.7
Lower Saxony	1 436	969 881	20.4
North Rhine-Westphalia	2 212	1 591 613	46.7
Rhineland-Palatinate [2]	100	551 453	27.8
Saarland [3]	135	101 796	39.6
Saxony	173	532 220	28.9
Saxony-Anhalt	74	641 235	31.4
Schleswig-Holstein	282	272 152	17.3
Thuringia	58	372 453	23.0
Germany:	**7 181**	**10 601 045**	**29.7**

[1] Real land area (incl. sovereign waters) MV: 3 090 180 ha; protection areas as a % of MWP then 20.8 %.
[2] As many protection areas intersect, the total area is not a sound basis for the actual area of protection areas in the Land
[3] As at: 31.12.2001

Source: *Federal Agency for Nature Conservation 2004 a*

- it is earmarked for recreational purposes under regional planning requirements,
- it is used to preserve, develop, or recreate a landscape characterised by many types of use and its species and biotope diversity, and efforts are made to achieve sustainable, environmentally-compatible land use which serves this purpose,
- it is particularly well-suited to promoting sustainable regional development."

In line with the basic legal provisions whereby nature parks have mainly to be landscape protection areas or nature reserves, they fulfil not only a recreational but also a conservation function. In the absence of other regional laws, the intensity of the conservation is defined by the rules of the nature reserves and landscape protection areas of which the nature park consists. In their nature park strategies and statutes, the *Länder* have a variety of emphases. Designating a nature park enables some large-scale ecological analysis.

Since their objective is to link the conservation and use of landscapes, nature parks perform an important function as part of integrated, sustainable, regional development. At the European level, a charter has been specially drawn up for tourism in protected areas. During 2001/2002, this European charter's relevance for Germany's nature parks was tested in three example parks (Frankenwald, Steinhuder Lake, and Usedom Island) in a project called "The European charter for sustainable tourism in protected areas – the task and opportunity for Germany's nature parks".

On 31 December 2004, the 87 nature parks in Germany covered a total area of almost 8 million ha (ca. 22.4 % of Germany's total surface area) (Table VIII 3.4.1-3). Several nature parks are currently passing through legal procedures.

Tab. VIII 3.4.1-3: *Nature parks in Germany (31.01.2004)*

Land	Number of parks	Area [ha]	% of the total area
Baden-Württemberg	7	1 060 695	29.7
Bavaria	16	2 054 615	29.1
Berlin	1	4 008	4.5
Brandenburg	11	711 627	24.1
Bremen	0	0	0.0
Hamburg	0	0	0.0
Hesse	10	660 179	31.3
Mecklenburg-Pomerania	5	245 000	10.6
Lower Saxony	12	794 186	16.7
North Rhine-Westphalia	14	1 002 584	29.4
Rheinland-Palatinate	6	425 510	21.4
Saarland	1	129 669	50.5
Saxony	2	185 500	10.1
Saxony-Anhalt	4	307 738	15.0
Schleswig-Holstein	5	196 000	12.5
Thuringia	1	208 200	12.9
Germany	**95** [1]	**7 985 511**	**22.4**

[1] There are 87 parks in all. Of which 8 straddle two *Länder*.

Source: *Federal Agency for Nature Conservation 2004*

Nature parks as a percentage of the total area rose by 20 % (ca. 1.3 million ha) within the six years between 1998 and 2004. Within the nature parks, protected areas cover ca. 60.8 % of the total area. The average percentage of nature reserves in eastern Germany's nature parks (9.1 %) is much greater than that in western Germany's nature parks (ca. 3.0 %). The state sponsorship of many eastern German nature parks can be accompanied by regional planning and nature conservation benefits compared with non-state forms of organisation.

Strict forest reserves

Strict forest reserves are wooded areas which are allowed to develop undisturbed. In the forest areas where all forestry use and other interventions are excluded, the "primeval forests of tomorrow" will develop.

Strict forest reserves are particularly suitable for researching natural biotic processes of the forest. As uninfluenced reference area where the natural processes of ageing, decay, and regeneration (rejuvenation) can be observed over the long term, they are, at the same time, indicator areas for "near-nature" that can be compared with commercial forests. For the long-term conversion of the surrounding, often less-natural areas to near-natural forests, strict forest reserves, with elevated levels of biodiversity and typical species stocks are important "germ cells" for new colonisation and recolonisation. Simultaneously, as part of wide-ranging environmental observation, they constitute reference sites for the ecosystems that are heavily influenced by human activity. Together with national parks and the core areas in biosphere reserves, forest reserves form part of an international system of strictly protected forest sites. As elements of FFH- and bird protection areas, many of them have been included in the European Natura 2000 network of sites.

Systematic designation of natural forest reserves began with the European Conservation Year in 1970. The goal is to build up a representative system of unmanaged forest sites, taking into account (natural) indigenous forest communities and aiming for an even distribution of reserves across forest growth zones. Because Germany naturally would be largely covered by beech and mixed beech forests, more than 50 % of all the strict forest reserves assigned to any forest community type contain these beech forest associations, which can be highly diverse in character.

In 1989, there were 420 designated strict forest reserves (with an area of 9 670 ha) in the former federal territory and 143 sites in the former GDR (with 4 870 ha). Since 1989, the number of strict forest reserves has risen from 563 (with an area of ca. 14 540 ha) to 824 sites (with ca. 30 587 ha) (Table VIII 3.4.1-4). Since 1989, 233 natural forest reserves have been designated in the western German *Länder*. In the eastern German *Länder* (28 reserves newly designated since 1989), as in some western German *Länder*, the process of designation is not yet concluded. In the eastern *Länder*, older "total reserves" are also taken into account. These remain to be assessed to see whether they meet the criteria for strict forest reserves.

The legal basis of strict forest reserves varies among the different *Länder*. In some they are based on state forest law or nature conservation law, in others upon forest administrators' voluntary commitment, or on a long-term contractual basis. Similarly, the name given to strict forest reserves varies from

Tab. VIII 3.4.1-4: *Numbers and sizes of strict forest reserves in Germany (December 2001, with later reports from the Länder up to February 2004)*

	Distribution by size [ha]											
Land	< 5	5–0	10–20	20–50	50–100	> 100	Average area [ha]	Number	Total area [ha]	Total forest area [1 000 ha]	% reserve in total forest	Conservation status (see below)
BW	6	6	23	18	27	22	60.9	102	6 215	1 345	0.46	a), b)
BY	2	9	27	73	29	10	42.1	150	6 316	2 411	0.26	a), b)
BB	4	5	14	12	4	2	29.4	41	1 206	1 093	0.11	a), b)
HH	0	2	1	1	0	0	12.8	4	51	4,5	1.13	a), b)
HE	0	2	4	18	3	3	40.9	30	1 228	840	0.15	a), b)
MV	1	6	8	5	5	6	50.3	31	1 559	497	0.31	a), b), c)
NI	4	5	26	39	24	6	42.3	104	4 399	1 070	0.41	a), c)
NW	4	13	36	15	4	1	19.6	73	1 429	916	0.16	a), b), d)
RP	6	12	5	25	9	3	33.9	60	2 035	805	0.25	a), b), c)
SL	0	1	2	4	3	1	68.3	11	751	90	0.83	a), b)
SN [1)]	1	3	3	11	3	1	36.2	22	797	513	0.16	a), b)
ST	0	2	3	16	6	2	66.3	29	1 923	474	0.41	a), b)
SH	37	30	30	16	5	1	13.6	119	1 614	152	1.06	a), b), c)
TH	9	10	16	7	4	2	22.2	48	1 064	515	0.21	a), b)
Total/ Average	**74**	**106**	**198**	**260**	**126**	**60**	**37.1**	**824**	**30 587**	**10 726**	**0.29**	

[1)] excl. the Saxon Switzerland national park

a) under the Land's nature conservation laws
b) under the Land's forest laws
c) Voluntary commitment by forest authorities
d) Contractually based

Names for strict forest reserves in the *Länder*: BW: banned forest; SH, NW, SL, SN, ST: strict forest cells; NI, BB: strict forests; TH: strict forest parcels; BY, HE, MV, RP: strict forest reserves; HH: protected forest

Source: *Federal Agency for Nature Conservation 2004 a*

Land to Land – natural forest parcels, natural forests, natural forest cells, banned forest, natural forest reserves, or protected forest.

For beech and mixed beech forests, a minimum size of ca. 50 ha is sought, but this size is only achieved in around 20 % of all cases.

In some *Länder*, strict forest reserves are designated as smaller special research sites within larger areas which are completely protected from human intervention ("total reserves", e.g., in Brandenburg and Saxony). Some strict forest reserves are located in national parks or the core areas of biosphere reserves.

As well as spatial deficits in the system (the Pfalz forest, Buntsandstein-Schwarzwald), a number of strict forest are located in areas with extreme edaphic conditions, while others contain forest communities with a strong human influence and may be too small. Thus, almost half (46 %) of all strict forest reserves are smaller than 20 ha, with the result that the fringe effects caused by surrounding activity are often so great that there are hardly any untouched areas within the boundaries of the strict forest reserve. Therefore, a sufficient size of the sites is to be sought, so that natural processes take place undisturbed and semi-natural conditions can emerge.

[1] Federal Agency for Nature Conservation (2004): Daten zur Natur 2004; Münster (Landwirtschaftsverlag).

VIII 3.4.2 International protected areas

Biosphere reserves

Under § 25 BNatSchG, biosphere reserves are "areas earmarked for uniform development and maintenance which comply with the following conditions:

- they are large and characteristic for certain types of landscape,
- the prerequisites for nature reserves are met over substantial parts of their area and the criteria defined for landscape protection areas are largely met in the remaining area,
- the site is particularly used to preserve, develop, or recreate a landscape characterised by traditional, diverse forms of use and the species and biotope diversity that has developed there over time, including wild forms and formely bred or cultivated forms of economically used or usable animal and plant species, and
- the site is used to develop and test examplary methods of economy that are particularly protective of the natural resources."

Under national legislation, biosphere reserves should not be confused with UNESCO biosphere reserves. Biosphere reserves have been recognised under the UNESCO "Man and the Biosphere" (MAB) programme since 1976. The international label "biosphere reserve" is awarded on the basis of the "Statutory Framework of the World Network of Biosphere Reserves (UNESCO 1995, 1996). Biosphere reserves aim to develop, test, and, in the long-term, implement strategies whereby humans and nature may coexist in harmony in the sense of developing in a way that is ecologically, economically, and socio-culturally sustainable. In January 1999, the World Network of Biosphere Reserves consisted of 440 areas in 97 countries (January 2004).

According to the Statutory Framework of the Word Network the functions of a biosphere reserve are:

- preserving natural or relatively untouched ecosystems in a core area, an area under strict legal protection, where only natural processes and natural dynamics are permitted,
- conserving and enhancing cultural landscapes and their biological and aesthetic variety, as produced through sustainable land use,
- developing land use models that are ecologically, economically, and socio-culturally sustainable, and that give the human inhabitants a long-term base to earn their livelihood and that foster and exemplify a balanced relationship between humans and the biosphere (Deutsches MAB-Nationalkomitee 2004),
- establishing sustainable forms of life and commerce,
- providing resources for ecosystem-research and environmental monitoring,
- environmental education and public relation.

As models of sustainable development, biosphere reserves make a contribution to national implementations of international agreements such as Agenda 21 and the Biodiversity Convention.

UNESCO has already recognised 14 biosphere reserves in Germany, with a total area of 1 579 828 ha (see Table VIII 3.4.2-1). To achieve the various objectives, biosphere reserves are divided into three zones.

In a biosphere reserve's core area, which can be made up of more than one sub-area, nature should be allowed to develop with as little disturbance as possible by human intervention. Here, protecting natural or near-natural ecosystems is the main priority.

The buffer area is used to preserve and maintain ecosystems that have been created or are influenced

Tab. VIII 3.4.2-1: *UNESCO biosphere reserves in Germany (February 2004)*

Biosphere reserve (Land)	Size [ha] Total	Core area	Buffer area	ransition area	Year designated
Vessertal-Thuringian Forest (TH)	17 098	437 (2.6 %)	2 024 (11.8 %)	14 637 (85.6 %)	1979
Bavarian Forest [1] (BY)	13 329	10 224 (76.7 %)	3 105 (23.3 %)	–	1981
Schorfheide-Chorin (BB)	129 161	3 648 (2.8 %)	24 103 (18.7 %)	101 410 (78.5 %)	1990
Berchtesgaden [1] (BY)	46 742	13 896 (29.7 %)	6 948 (14.9 %)	25 898 (55.4 %)	1990
Schleswig-Holsteinisches Wadden Sea [1] (SH)	285 000	85 500 (30.0 %)	199 500 (70 %)	–	1990
Rhoen (BY, HE, TH)	184 939	4 199 (2.3 %)	67 483 (36.5 %)	113 257 (61.2 %)	1991
Spree Forest (BB)	47 509	974 (2.1 %)	9 334 (19.6 %)	37 201 (78.3 %)	1991
South-East Ruegen (MV)	23 500	349 (1.5 %)	3 204 (13.6 %)	19 947 (84.9 %)	1991
Pfaelzerwald (RP)	177 000	3 739 (2.1 %)	49 261 (27.8 %)	124 000 (70.1 %)	1992
Lower Saxon Wadden Sea [1] (NI)	240 000	130 000 (54.2 %)	108 000 (45.0 %)	2 000 (0.8 %)	1992
Hamburg Wadden Sea [1] (HH)	11 700	10 530 (90.0 %)	1 170 (10.0 %)	–	1992
Oberlausitz heath and lakelands (SN)	30 102	1 124 (3.7 %)	12 015 (39.9 %)	16 963 (56.4 %)	1996
Elbe river landscape (BB, MV, NI, SH, ST)	342 848	7 220 (2.1 %)	61 726 (18.0 %)	273 902 (79.9 %)	1997
Schaalsee (MV)	30 900	1 709 (5.5 %)	7 905 (25.6 %)	21 286 (68.9 %)	2000
Total	**1 579 828**	**273 549**	**555 778**	**750 501**	

[1] also a national park

Source: *Federal Agency for Nature Conservation 2004 b*

by human intervention. The buffer area shields the core area from negative interventions. The prime aim is to preserve extensively used cultural landscapes that contain a broad spectrum of varied habitats for many species of flora and fauna – including endangered species – that are typical to that type of natural landscape.

The transition area is a place for people to live, work, and relax. Its aim is to develop forms of economy that meets the demands of both human society and natural environment in equal shares (definitions according to LANA 1994 in AGBR 1995).

According to the "International Guidelines for the World Network of Biosphere Reserves", the status of each biosphere should be reviewed periodically every ten years by the relevant national advisory and coordination authority (the MAB national committee in Germany). The biosphere reserves of the mid-Elbe, the Bavarian Forest, and the Vessertal-Thüringian Forest were inspected in 2001, those at Schorfheide-Chorin, Berchtesgaden, and the Spree Forest in 2002, and the sites at south-east Rügen, Pfälzerwald, and the Rhön in 2003.

The German MAB national committee certified that the 14 Germany biosphere reserves were making progress and operating efficiently. The following optimisation requirements were identified:

- more intensive communication of the biosphere reserve concept; improvement of the local population's identification with "their" biosphere reserve,
- greater promotion of sustainable regional development and promotion and bundling of research in the biosphere reserves.

Biosphere reserves are particularly suitable for setting up sustainable land management schemes and regional marketing structures for sustainably produced products. In the Rhön biosphere reserve, for example, the marketing of regional products such as the Rhön sheep, old apple varieties, and biosphere cattle has helped to preserve the species diversity of the cultural landscape. Organic farming is now carried out on 25 % of the land in the Schorfheide-Chorin biosphere reserve. In the Rhön biosphere reserve, 10.6 % of the agricultural land is farmed organically (the percentage of organically farmed land in Germany was 4.5 % in 2004) [1].

Ramsar areas (wetlands of international importance, especially as waterfowl habitats) in Germany

Signatory states to the Ramsar Convention have committed themselves to maintaining and supporting wetlands – habitats on which many species-rich plant and animal communities depend. The Ramsar sites in Germany satisfy the following criteria:

- regularly visited by at least 1 % of the population of a wader or water bird species, or
- regularly visited by 20 000 individuals of a population of a wader or water bird, or
- habitat for a large number of threatened plant and animal species.

Further criteria are:

- especially valuable for preserving genetic or ecological diversity, or
- habitat for scientifically or economically significant plants or aquatic or land animals.

Germany has designated 32[1] such sites, with a total area of 841 000 ha (Table VIII 3.4.2-2) [1], Of which, 80 % is accounted for by mudflats and water in the North and Baltic seas. On average, 40 % of all this area is under protection as a nature reserve or national park. Plans are proceeding to designate the Upper Rhine and expand the Lech-Danube confluence. The Muehlenberger Loch area on the Lower Elbe has been reduced by 95 ha due to the building of an industrial facility.

Areas protected under the EU Birds Directive

On 2 April 1979, the European Council approved Directive 79/409/EEC on the conservation of wild birds – the Birds Directive. It regulates direct human intervention, including hunting of bird species meriting protection (listed in three Annexes), but it also provides protective measures aimed at maintaining, recovering, and creating habitats for bird species which are listed in Annex I or which regularly visit such habitats. These habitats may also be classified Special Protected Areas (SPAs). Since the Habitats Di-

[1] The three partial area of the Lower Saxony Wadden Sea which were previously reported as a single area are now counted individually in accordance with international specifications.

Tab. VIII 3.4.2-2: *Internationally significant wetlands in Germany (January 2004)*

No.	Site name	Area [ha]	Land	Date
1	Wadden Sea, Elbe-Weser Triangle	38 460	NI	26.02.1976
2	Wadden Sea, Jadebusen and western Weser estuary	49 490	NI	26.02.1976
3	Wadden Sea, East Friesian Wadden Sea and Dollart	121 620	NI	26.02.1976
4	Lower Elbe between Barnkrug and Otterndorf	11 760	NI	26.02.1976
5	Elbe meadows between Schnakenburg and Lauenburg	7 560	NI	26.02.1976
6	Duemmer	3 600	NI	26.02.1976
7	Diepholzer Fen Lowland	15 060	NI	26.02.1976
8	Lake Steinhuder Meer	5 730	NI	26.02.1976
9	Lower Niederrhein	25 000	NW	28.10.1983
10	Muenster leaching fields	233	NW	28.10.1983
11	Schluesselburg barrage weir on the Weser	1 600	NW	28.10.1983
12	Rhine between Eltville and Bingen	475	HE/RP	26.02.1976
13a	Lake Constance: Wollmatinger Ried – Giehrenmoos	767	BW	26.02.1976
13b	Lake Constance: Mindelsee at Radolfzell	310	BW	26.02.1976
14	Danube meadows and Donaumoos	8 000	BY	26.02.1976
15	Lech-Danube confluence	230	BY	26.02.1976
16	Ismaning reservoir and fish pond complex	955	BY	26.02.1976
17	Lake Ammersee	6 517	BY	26.02.1976
18	Lake Starnberg	5 720	BY	26.02.1976
19	Lake Chiemsee	8 660	BY	26.02.1976
20	Lower Inn between Haiming and Neuhaus	1 955	BY	26.02.1976
21	East shore of Greifswalder Bodden, west coast of Ruegen and Hiddensee	25 800	MV	31.07.1978
22	Krakower Obersee	868	MV	31.07.1978
23	East bank of the Mueritz	4 832	MV	31.07.1978
24	Lake Galenbeck	1 015	MV	31.07.1978
25	Lower Oder valley near Schwedt	5 400	BB	31.07.1978
26	Lowlands of the Lower Havel and Lake Guelp/ Lake Schollen	8 920	BB/ST	31.07.1978
27	Peitz pond landscape	1 060	BB	31.07.1978
28	Helma Reservoir Berga-Kelbra	1 453	ST/TH	31.07.1978
29	Hamburg Wadden Sea National Park	13 750	HH	01.08.1990
30	Schleswig-Holstein Wadden Sea	299 000	SH	15.11.1991
31	Muehlenberger Loch	580	HH	09.06.1992
32	Aland-Elbe lowlands and Jerichow Elbe meadows	8 605	ST	21.02.2003

Source: *Federal Agency for Nature Conservation 2004*

rective was passed, clauses 2, 3 and 4 of Article 6 of the Directive, on protection, apply to European bird sanctuaries. These replace the provisions in Article 4 Clause 4 of the Conservation of Wild Birds Directive.

By the end of 2004 in Germany, 511 bird areas (Special Protected Areas, SPA) had been registered by the *Länder* under the EC Directive on bird protection, as had 2 areas in the country's exclusive economic zone. Registration has not yet concluded in all the *Länder*, so the table summarising registration should be interpreted with care. As of 31 December 2004, 511 sites with a total area of ca. 2.56 million ha (ca. 7.2 % of the land area) plus ca. 1.17 million ha of mudflats and sea had been registered (Table VIII 3.4.2-3). Because it has not fully implemented the Conservation of Wild Birds Directive, Germany is facing legal action for breach of contract.

Tab. VIII 3.4.2-3: *Classified Special Protected Areas in Germany (31.12.2004)*

Land	Number of SPAs	Total area of SPAs [ha]	Proportion of total area in *Länder* [1] [%]
Baden-Württemberg	73	174 149 (+5 624) [2]	4.9
Bavaria	83	545 179	7.7
Berlin	5	4 979	5.6
Brandenburg	12	242 542	8.2
Bremen	8	7 120	17.6
Hamburg	7	2 265 (+12 015) [2]	3.0
Hesse	60	311 096	14.7
Mecklenburg Pomerania	15	272 032 (+157 386) [2]	11.7
Lower Saxony	60	288 068 (+246 796) [3]	6.1
North Rhine-Westphalia	25	153 190	4.5
Rheinland-Palatinate	50	162 682	8.2
Saarland	15	12 184	4.7
Saxony	10	78 282	4.3
Saxony-Anhalt	32	170 612	8.3
Schleswig-Holstein	45	91 000 (+747 719) [2]	5.8
Thuringia	11	45 025	2.8
Germany excl. EEZ	**511**	**2 560 405 (+1 169 540)** [2,3]	**7.2**

[1] Proportion relates to the area of the Land given in the Statistisches Jahrbuch (1999)
[2] Plus mudflats, water, shallows, and marine areas based on the Land's figures
[3] Plus mudflats, water, and marine areas based on BfN calculations

Source: *Federal Agency for Nature Conservation 2004 c*

Many bird areas harbour protected assets (habitat types and species) that are protected under the Habitats Directive and which therefore also qualify for FFH status.

The vast majority of classified SPAs also enjoy protection, either partially or entirely, as designated sites under the BNatSchG (see above). The protection of bird species and their habitats does not therefore necessarily require the protection afforded by a nature reserve, since designation as a landscape reserve, or simply maintaining or altering land management practices, may be adequate for the purpose of preserving bird species.

Areas protected under the EU Habitats Directive

The Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) created the first comprehensive framework for species and biotope conservation at the EU level. The FFH Directive seeks to maintain biodiversity in the areas of the European Union to which it applies (currently 25 Member States plus the exclusive economic zone in the marine area up to the 200 nautical mile line). To this end, Article 2 (2) seeks to "maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest". Therefore, a "coherent ecological network" called "Natura 2000" is being set up to preserve, and where necessary, to enhance habitats and species which merit special protection by the EU (Table VIII 3.4.2-4).

The Habitats Directive lists 218 habitat types (Annex I, of which 91 are in Germany) and 873 species (Annex II, of which 134 are in Germany, and 19 thereof are deemed to be extinct or endangered) as being of community interest and for which a system of protected areas must be established. The Annexes are regularly adjusted to suit scientific advances, e.g., when the EU expands, most recently through 10 new Member States (the eastern enlargement) in May 2004. The precise data and formats that are required to register a site are regulated by a standard data sheet (97/266/EC), and a registration map is also required. This is the first time that habitat protection has been made the focus of European conservation efforts for the 91 biotope types or complexes that Annex I deems to exist in Germany.

As well as habitat protection (Articles 3–10), the Habitats Directive contains a number of special species protection regulations (Articles 12–16) and various additional provisions that serve an ambitious nature conservation policy:

- establishes purely nature conservation-based criteria for selecting and evaluating sites (Annex III),
- reporting obligations linked with effectiveness controls, every six years under Article 17,

Tab. VIII 3.4.2-4: *Status of reserves' applications for "Natura 2000" in the EU (05.07.2004)*

Member State	Conservation of Wild Birds Directive: Designated SPA [2]				Fauna-Flora Habitats Directive: pSCI application [3]			
	Number	Area [1 000 ha]		Terrestrial proportion as % of the total area	Number	Area [1 000 ha]		Terrestrial proportion as % of the total area
		Terrestrial	Marine			Terrestrial	Marine	
Belgium	229	296.4	0.0	9.7	278	301.5	18.1	9.9
Denmark	112	253.6	971.0	5.9	253	317.6	795.9	7.4
Germany	497	2 290.9	917.1	6.4	3 535	2 495.6	719.0	7.0
Finland	452	2 286.1	551.1	6.8	1 660	4 279.1	514.2	12.7
France	153	1 030.5	211.0	1.9	1 216	3 717.9	490.6	6.8
Greece	151	1 329.8	40.5	10.1	239	2 164.3	599.8	16.4
Great Britain	252	1 413.5	37.7	5.8	605	1 598.2	902.6	6.5
Ireland	131	200.4	81.0	2.9	413	755.0	338.6	10.7
Italy	503	2 446.9	39.6	8.1	2 256	4 417.3	222.7	14.7
Luxembourg	12	13.9	0.0	5.4	47	38.3	0.0	14.8
Netherlands	77	519.7	491.3	12.5	141	395.5	355.3	9.5
Austria	94	927.5	0.0	11.1	164	887.4	0.0	10.6
Portugal	50	933.4	62.2	10.1	94	1 601.2	49.0	17.4
Sweden	509	2 563.1	301.7	6.2	3 902	5 784.4	583.3	13.9
Spain	417	7 784.8	54.2	15.4	1 381	11 412.0	523.6	22.6
European Union (EU-15)	**3 639**	**24 290.7**	**3 758.3**	**7.6**	**16 184**	**40 165.4**	**6 112.8**	**12.5**

[1] The figures for European Bird Protection and Habitats Directive sites cannot be added together; the percentages for "Natura 2000" as a whole are not yet available throughout the EU
[2] SPA: Special Protection Areas – European bird sanctuaries
[3] pSCI: Proposed Sites of Community Importance – under the Habitats Directive

Source: *European Commission 2004*

- a general monitoring obligation for natural habitats and wild species of community interest (Article 11),
- provisions on habitat networking (connecting landscape elements, Article 10),
- promotion of research (Article 18),
- special rules for checking that plans and projects correspond to requirements, with precisely regulated exceptions if the site is adversely affected (Article 6 (3) and (4)),
- rules on financing (Article 8),
- associated expert groups (habitats committee, scientific working party).

Unlike the case with Germany's "classic" nature conservation instruments for protecting sites (e.g., nature reserves), the Habitats Directive protects the listed habitat types and species in the Annexes on a case-to-case basis for the sites registered, so it is immaterial whether an adverse effect occurs within the registered site or outside it (external protection). On the other hand, sub-areas of the registered site that neither contain an Annex I habitat type nor are used by Annex II species are not protected by the Habitats Directive. So the protection granted to sites registered for protection under the Habitats Directive is not fully comprehensive but differs according to the site, thus enabling more flexible implementation.

The legal implementation largely provides for a reliance on the existing Federal Nature Conservation Act categories for protecting areas, but other administrative regulations and nature conservation laws can also be used.

Under the constitutional division of responsibilities, the bodies charged with implementing the technicalities of the Habitats Directive are the *Länder*'s nature conservation departments and the country's Exclusive Economic Zone. However, to implement the Habitats Directive, there is a need for procedures to be agreed on and all site applications to be evaluated at the national level. The Federal Agency for Nature Conservation assumes this coordinating role, and deals with monitoring, reporting obligations, and the drafting of evaluation proposals from a national perspective for all the *Länder*.

The registration procedure passes through three stages. Once the *Länder* have delimited and proposed sites, they are assessed on a national basis. Next, the Member State forwards their proposed Sites of Community Interest (pSCI) to the European Commission. There is then a second assessment stage at EC level, when the integrity of the "Natura 2000" network is evaluated for each Annex II species and every habitat type in the Habitats Directive, taking into consideration the seven biogeo-

Tab. VIII 3.4.2-5: *Proposed Special Areas of Conservation in Germany (31.12.2004)*

Land	Proposals under Art. 4 (1) of the Habitats Directive to the EU (pSCI[1])		
	Number	Area [ha]	Proportion proposed[2] [%]
Baden-Württemberg	363	230 871 (+3 582)[3]	6.5
Bavaria	674	645 420	9.2
Berlin	15	5 435	6.1
Brandenburg	620	333 106	11.3
Bremen	9	2 470	6.1
Hamburg	15	5 249 (+13 742)[3]	7.0
Hesse	585	208 978	9.9
Mecklenburg Pomerania	230	287 308 (+181 546)[3]	12.4
Lower Saxony	172	281 878 (+261 588)[4]	5.9
North Rhine-Westphalia	513	183 440	5.4
Rheinland-Palatinate	120	248 240	12.5
Saarland	118	26 325	10.3
Saxony	270	168 661	9.2
Saxony-Anhalt	263	178 586	8.7
Schleswig-Holstein	270	124 274(+568 662)[4]	7.9
Thuringia	247	161 463	10.0
Germany excl. EEZ	**4 484**	**3 091 704 (+1 029 120)[3,4]**	**8.7**

[1] Proposed Sites of Community Importance – under the Habitats Directive
[2] Proportion relates to the area of the Land given in the Statistisches Jahrbuch (1999)
[3] Plus mudflats, water, shallows and marine areas based on the Land's figures
[4] Plus mudflats, water and marine areas based on BfN calculations

Source: *Federal Agency for Nature Conservation 2004 c*

graphic regions (Pannonian – since May 2004 – Mediterranean, Macaronesian, Boreal, Alpine, Atlantic, and Continental – of which Germany shares in the last three). The final stage consists of the sites being designated as Special Areas of Conservation (SAC) by the Member States. However, the protection regulations of Article 6 of the Habitats Directive apply as soon as the proposal is sent to Brussels. The obligation to check for adverse effects, as prescribed by Article 6, also applies to potentially suitable Habitats Directive sites until the registration procedure is concluded.

To date, implementation of the Directive has varied between Member States. Within Germany, the situation regarding registration differs widely. Table VIII 3.4.2-5 shows that, so far, 8.7 % of Germany's land area has been proposed as a Habitats Directive site. Mecklenburg Pomerania and Rhineland-Palatinate have led the way by each proposing over 12 % of their surface area. Once the intended applications registered with the EU in November 2003, and other improvements to correct the outstanding failings in registration have been carried out, the proportion of national territory registered will rise to ca. 9.3 %. It appears likely that Baden-Württemberg, Brandenburg, Saarland, and Thuringia will all have applied to register at least 10 % of their total area. As of May 2004, the federal government had applied for eight Habitats Directive sites in its Exclusive Economic Zone, which equates to almost 30 % of the area of Germany's EEZ.

[1] Federal Agency for Nature Conservation (2004): Daten zur Natur 2004; Münster (Landwirtschaftsverlag).

IX UTILISATION OF NATURAL RESOURCES

IX 1 Use of extracted materials and energy sources

There are numerous ways in which social and economic factors place demands on the environment:

- The environment serves as a source of renewable and non-renewable resources that are used, sometimes at no cost, as inputs for the production of goods and provision of services.
- It is used as a sink for the discharge of pollutants and residuals that are created by manufacturing processes and by the use and consumption of manufactured goods.
- The environment provides the habitat for human life and human activity.
- It can also be considered to be "consumer goods" in its function as a place of recreation.

Doing business in line with the principle of sustainability requires dealing with nature as carefully as possible so that future generations may too enjoy an intact environment. The extraction and utilisation of a raw material is always associated with factors such as the transfer of materials, emission of pollutants, and consumption of materials, energy, and land. These factors all have a negative effect on the environment, which means that raw materials must be used sparingly and efficiently. Technical innovations make an important contribution in this regard, as these can help to decouple resource use from economic growth. The push for modernisation brought about by such innovations serves to improve the competitiveness of the German economy and ensures growth and employment.

However, increases in efficiency can only lead to success if increasing production and rises in levels of traffic and consumption do not erode the gains.

The utilisation of the environment as a source of resources can be measured by considering corresponding input factors, such as consumption of raw materials and energy (Chapter IX 1.1 and Chapter IX 1.2), as well as the type and intensity of land use. If these individual quantities, which are measured in physical units, are put in the context of economic performance, then productivity values can be calculated to provide indicators of the efficiency of using natural input factors. This is similar to the way in which the input factors labour and capital are considered in economics.

The productivity value of an input factor indicates the level of economic performance that is produced for one unit of that input factor.

$$\text{productivity} = \frac{\text{gross domestic product (real)}}{\text{input factor}}$$

As such, productivity can be used to express how efficient a national economy is in its use of labour, capital, and nature. The factors cannot be directly compared with each other due to their varying composition and functions. However, the observation of trends over longer periods of time can provide information on how the relationship between the factors has changed. It should also be noted that in calculating productivity values, the actual overall performance of a given economic activity is referred exclusively to the corresponding production factor, even though the product consists of the combined effect of all production factors. The productivity indicators should therefore only be considered to provide rough guidance.

The Federal Statistical Office publishes an annual report titled "Environmental-Economic Accounting" (http://www.destatis.de/allg/e/veroe/proser4senv_e.htm) which discusses the interactions between economic activity and the environment.

IX 1.1 Use and productivity of raw materials

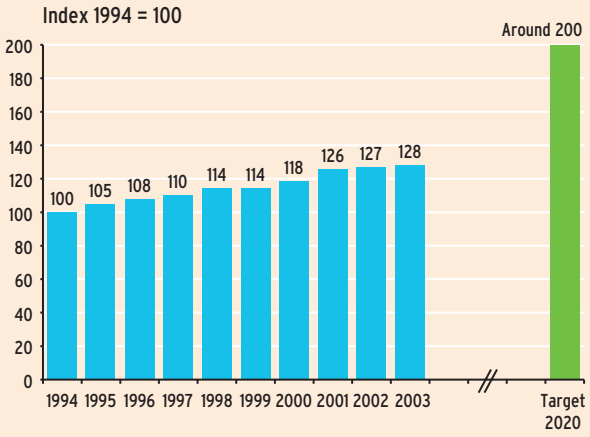
The Federal Government has set out a target in the national sustainability strategy [1] to achieve a doubling of raw material productivity by 2020, as compared to 1994 figures.

The calculation of raw material productivity is made using the relationship between the gross domestic product expressed in 1995 prices (billions of euro) and the extracted abiotic raw materials used that come from domestic natural resources, plus imported abiotic goods (Mio t) [2]. This ratio is represented as an index value, with the reference year of 1994=100.

Raw material productivity increased by around 28 % between 1994 and 2003 (Fig. IX 1.1-1 and Tab. "Employment of environmental factors for commercial purposes"). This increase can be attributed to the avoidance of waste, the improved life-cycle management for raw materials, and the increased use of renewable raw materials. The increase in raw material productivity in recent years has also been influ-

enced by the reduced use of materials by the construction industry due to economic pressures and the lower capacity available from the black coal and lignite mining industries.

Fig. IX 1.1-1: *Raw material productivity (gross domestic product in 1995 prices/raw material extracted and imported*[*])*



*) Extraction of used abiotic raw materials and import of abiotic goods 1997–2003: partially estimated

Source: *Federal Statistical Office 2004*

In order to achieve the target specified in the national sustainability strategy, an absolute annual increase in raw material productivity of around 3.9 percentage points is necessary. An average absolute annual increase in efficiency of 3.2 percentage points was achieved in the period from 1994 to 2003. The increase in productivity was however lower in 2002 (+1.4 percentage points) and 2003 (+1.6 percentage points).

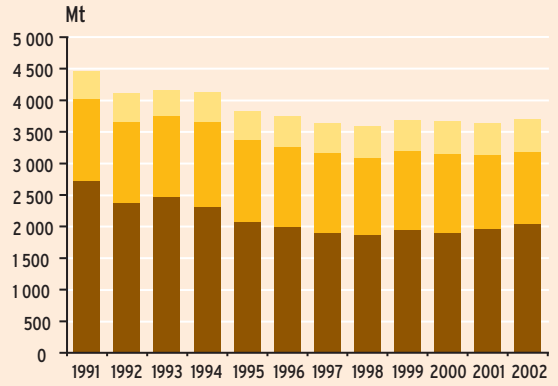
It is therefore an imperative that additional efforts be made if the targets specified in the sustainability strategy are to be met. It must be taken into consideration that further efforts are required to ensure that the rate of increase in productivity achieved in the past will be maintained. It can be assumed that those economising measures that seem relatively simple have been implemented first; the effort required to raise the productivity of the natural resource input factors will therefore increase as time progresses unless there are timely technological breakthroughs.

Depending on the targets that have been set, there are two way of monitoring the use of natural resources: either the trends in productivity can be considered, with the emphasis on increasing efficiency, or the trends in quantities used can be looked at, with the emphasis on achieving an absolute reduction in materials used.

Material, energy, and land consumption are important criteria for determining the environment-related optimisation potential with regard to operational and product-based environmental protection (Chapter IX 1.2 and Chapter VII 1.2). Sector-specific material flow analyses are used to identify particularly material intensive processes and products for which it will be advantageous to identify potential savings and substitution possibilities. Life-cycle management provides important contributions to raw material productivity, as every reuse or recycling of products and materials reduces the level of consumption of primary raw materials (Chapter X 1.1 and Chapter X 2.1).

The trends in material flow between 1991 and 2002 show that the overall material throughput in the German economy was reduced during the 1990s. The quantity of material extracted, excluding gases and water, but including materials imported from other countries, fell by 760 Mio t (18 %) to around 3 690 Mio t. In 2002, approximately 45 t of material per person was extracted for commercial purposes. This also includes unused materials, such as the overburden from lignite mining (Fig. IX 1.1-2).

Fig. IX 1.1-2: *Extracted and imported materials in Mio t*[1)]



1) Some results are provisional. – Since 2001 data on imports has been collected in accordance with the SITC. Comparison with figures from previous findings is therefore only possible to a limited extent. Totals do not include oxygen, nitrogen, and air.

Source: *Federal Statistical Office 2004 a*

The decline in overall use of materials in Germany between 1991 and 2002 is essentially the result of the substantial reduction in the amount of overburden from lignite mining, brought about by the decrease in lignite output in the New *Länder*. On average, for every tonne of lignite produced, almost ten times the quantity of overburden is created. This major reduction in lignite overburden means that the amount of unused material extracted has

been reduced by approximately a quarter, falling from 2 714 Mio t to 2 036 Mio t. The unused material (excluding that from the overburden from mining operations) includes other materials that accrue as a result of raw material extraction or other economic activities.

The amount of extracted raw material that was used in 2002 was 1 140 Mio t – 163 Mio t (–12.5 %) less than in 1991. Used raw material includes mainly stone and earth, as well as energy source material (abiotic) and agricultural and forestry materials (biotic).

Alongside the reduction in domestically extracted raw material that was used there was also an increased quantity of imported goods. The amount of imported material in 2002 was 80 Mio t (+15.6 %) higher than in 1991. Most significant in this increase was the 49 Mio t rise in the quantity of imported energy source materials (this refers to raw materials and semi-prepared products such as coke). The largest reduction was in the amount of domestic hard coal and lignite that was extracted, with this being replaced by imported energy source materials. Nonetheless, the increased quantity of imported energy source materials in terms of tonnage was considerably lower than the decreased quantity of domestically extracted energy source materials (136 Mio t).

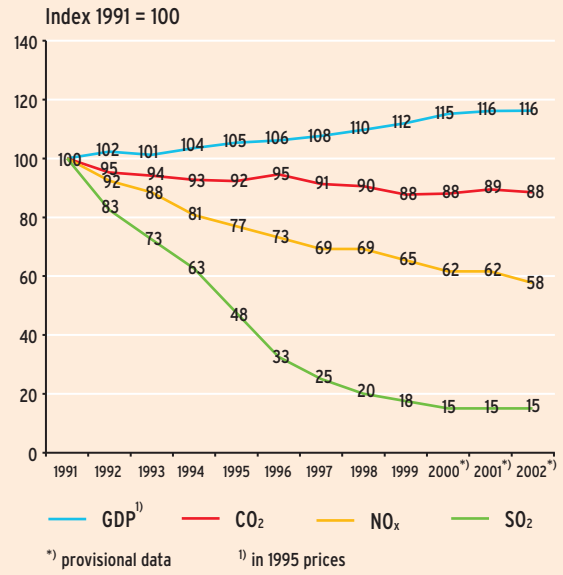
The environmental impacts associated with the degradation and conversion of energy source materials and other raw materials, such as the negative effects on landscapes, ecosystems, soil, bodies of water, and the air, has consequently been displaced to other countries to a corresponding degree.

The quantity of solid and gaseous material discharged into the environment (excluding exports) decreased by around 18 % from 4 446 Mio t in 1991 to 3 582 Mio t in 2002.

Most important is the significant reduction during this period in emissions to the atmosphere and the corresponding decrease in demands on the environment as a sink for climate gases and airborne pollutants. The major factors here were a change in the energy source material mix, i.e., a varied composition of energy source materials (petroleum, natural gas, hard coal and lignite, atomic energy, etc.), and measures for flue gas cleaning, particularly in the case of SO_2.

If the developments described here are compared to the increase in gross domestic product, which went up by 16.3 % from 1991 to 2002, then it can be seen that there has been a substantial decoupling of economic growth from the use of natural resources. That means that we are considerably more efficient in our consumption of natural resources (Fig. IX 1.1-3).

Fig. IX 1.1-3: *Economic trends and selected airborne pollutant emissions*



Source: *Federal Statistical Office 2004 b*

[1] The Press and Information Office of the Federal Government (Ed.), Perspektiven für Deutschland. Unsere Strategie für eine nachhaltige Entwicklung, Berlin 2002
[2] "Abiotic raw materials" comprises fossil fuels as well as the stone and earth that consists of minerals or the remains of organisms.

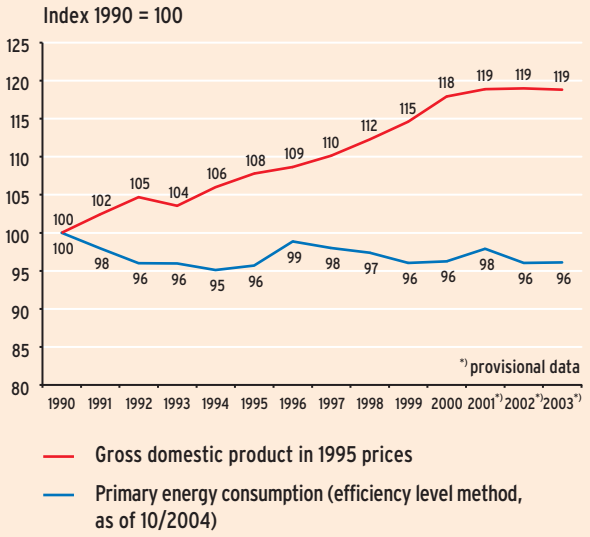
IX 1.2 Productivity of energy applications

The primary energy consumption in Germany between 1990 and 2003 tended towards a slight decrease. The fall in consumption amounted to around 4 %. Deviations from the general downward trend were mainly due to the impact of climatic conditions (increased energy requirements for heating in cold winters). Overall economic performance increased by 19 % in the same period.

This means that since the time of the first oil price shock, the continued decoupling of energy consumption from economic growth has been possible (Fig. IX 1.2-1).

The efficiency with which primary energy sources are used in the economic process is measured in terms of energy productivity. The target specified by the Federal Government in the national sustainability strategy is a doubling of energy productivity by 2020, based on 1990 levels. In order to meet this target, the energy productivity must be increased by an average of 3.3 % annually. The energy productivi-

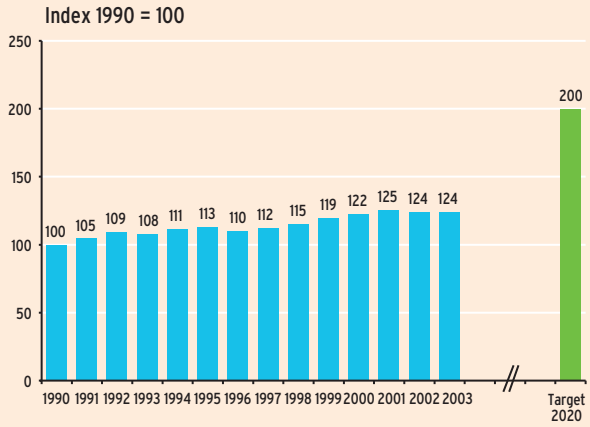
Fig. IX 1.2-1: *Economic trends and primary energy consumption*



Source: *Federal Environment Agency based on German Institute for Economic Research, Federal Statistical Office, Working Group on Energy Balances 2004*

ty in Germany rose by about 24 % between 1990 and 2003 (Fig. IX 1.2-2). This corresponds to an average annual increase of around 1.9 %.

Fig. IX 1.2-2: *Energy productivity*



Source: *Federal Environmenl Agency based on German Institute for Economic Research, Federal Statistical Office, Working Group on Energy Balances 2004*

It can therefore be seen that the energy productivity in recent years has not developed as much as necessary to meet the target. In order to achieve the target, increased efforts and further modernisation measures are required in all sectors (power stations, transport, private households, and industry).

The decisive factors in the increase in energy productivity that has been achieved to date were: the restructuring process in the New *Länder*, the improvements in efficiency of power stations, and the development of energy-saving measures all areas of economic activity. Stricter requirements relating to the insulation of new buildings have led to lower consumption of energy for heating. The energy use in the transportation sector (fuel consumption) has also been noticeably reduced since 2000.

IX 1.3 Water resources and their utilisation

Hydrologic balance for Germany

Though Germany as a whole has sufficient supplies of water available, there are also certain regions of Germany that experience water shortages and only have limited usable groundwater resources. Urban agglomerations are particularly affected by demand for water exceeding supply. Long distance water supply lines are used to compensate for the difference between areas of water shortage and areas with excess water available. Long distance water supply lines are located primarily in Bavaria, Baden-Württemberg, Lower Saxony, Saxony, Saxony-Anhalt, Thuringia, the Ruhr area, and the Frankfurt/Main region.

When looking at the hydrologic balance of a region, the complete biological water balance must be considered; this is generally represented using measures of rainfall depth, flow intensity, and evaporation. The data that represents the potentially available water supply and the renewable or internal water resource is determined using various calculation methods. Data on the available water supply has been collected as a long-term average over about 30 years (Tab. IX 1.3-1).

Utilisation of water resources

Statistical data accounts for an overall utilisation of water resources in Germany of about 38 billion m^3 in 2001. This corresponds to approximately 20 % of the potentially available water supply.

Thermal power plants use about 24.8 billion m^3 of water from their own supplies as cooling water for the provision of energy to the public.

Mining and manufacturing industries represent the second largest consumer of water, drawing around 7.8 billion m^3 for industrial purposes.

The amount of water supplied to the public in 2001 was approximately 5.4 billion m^3.

In terms of the total amount of water extracted from 38 billion m^3, this gives the following percentage distribution: Thermal power stations, 65.3 %;

Tab. IX 1.3-1: *Hydrologic balance for Germany in billion m³*

Water resource management figures[1]	Mean 1961–1990	Mean 1961–1990[7]	1990	1995	2000	2001	2002
Atmospheric precipitation	307[6]	278	273	309	294	307	343
Inflow from upper subbasins	71	71	57	83	78	84	87
Outflow originating from German federal territory	117	117	82	132	111	109	151
Evaporation	194	165	174	175	177	175	186
– of which evaporation from water consumption	*3.9*	*3.9*	*4.5*	*4.5*	*4.5*	*4.5*	*4.5*
Evapotranspiration	190	161	169	170	172	171	181
Change in water reserves[2]			18	3	7	23	6
Freshwater resources[1]	**Mean 1961–1990**	**Mean 1961–1990[7]**	**1990**	**1995**	**2000**	**2001**	**2002**
Long-term freshwater resources[3]	188	188					
Renewable water resources[4]	188	188	161	222	201	221	249
Internal water resources[5]	117	117	104	139	122	136	161

1) rounded
2) Atmospheric precipitation – runoff originating from German federal territory – evaporation
3) Difference between mean atmospheric precipitation and mean evapotranspiration, averaged over several years
4) internal water resources + inflow from upper subbasins
5) atmospheric precipitation – evapotranspiration
6) Precipitation value corrected for systematic measurement error
7) Using uncorrected atomspheric precipitation values. Individual years should be set in relation these values
italics = estimated values

Source: *Federal Institute for Hydrology 2004*

mining and manufacturing industries, 20.5 %; public water supply, 14.2 %.

Compared to 1991, the total water usage in 2001 has fallen by slightly over 8.3 billion m³. The largest proportion of this decrease has come from thermal power plants (4 billion m³) and industrial water usage (3.2 billion m³), followed by public water usage (1.1 billion m³) (Fig. IX 1.3-1).

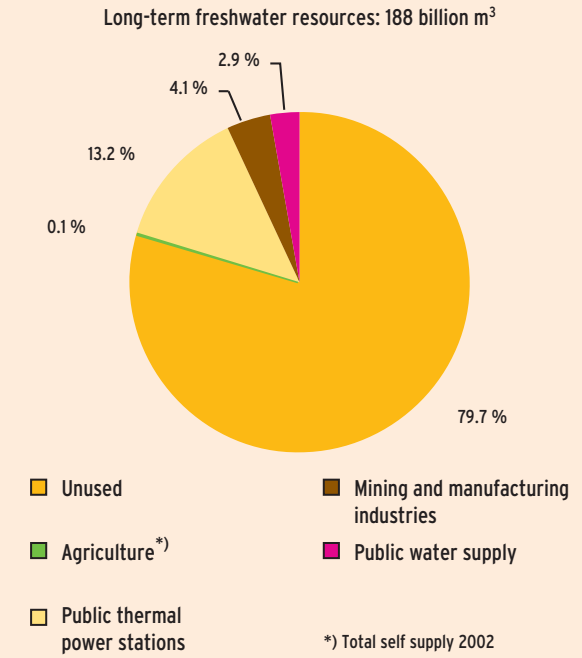
The total amount of water collected independently for agricultural purposes was 0.142 billion m³. In total 0.149 billion m³ of water from independent and third party sources was used for irrigation purposes, covering a land area of about 235 000 ha. The amount of water used by the agricultural sector is heavily dependent on the amount of atmospheric precipitation. Overall, the amount of water used for agriculture in Germany is relatively insignificant.

Public water supply

The public water supply in Germany was provided by a total of 6 560 companies in 2001 (including 5 260 companies that extracted water themselves); the majority of drinking water was extracted from groundwater and springs (74 %). The remainder of the water demand was provided from surface water and bank filtrate (Tab. IX 1.3-2).

The amount of water supplied to end-users fell by around 17 % between 1991 and 2001. During the same period, requirements were placed on the water companies to appreciably reduce water losses,

Fig. IX 1.3-1: *Freshwater resources and water use in Germany, 2001*



Source: *Federal Statistical Office; Federal Institute for Hydrology 2004*

for example from broken and leaking pipes. In 1998 the amount of water lost was 600 million m³, however the losses had been reduced to about 530 million m³ by 2001. Approximately 1 billion m³, or 21 %, of the total quantity of water provided by the public water supply network is used by industry and commercial enterprises each year. The primary consumers of the water are households and small com-

Tab. IX 1.3-2: *Public water supply by source*

		1991	2001
Water supply companies, total	Number	6 953	6 560
of which have independent sources	Number	–	5 260
Water extraction			
Total	Million m^3	6 515.5	5 409.0
Groundwater and spring water	Million m^3	4 692.7	4 010.7
Bank filtrate	Million m^3	392.6	280.4
Surface water[1)]	Million m^3	1 430.3	1 117.8

– No data

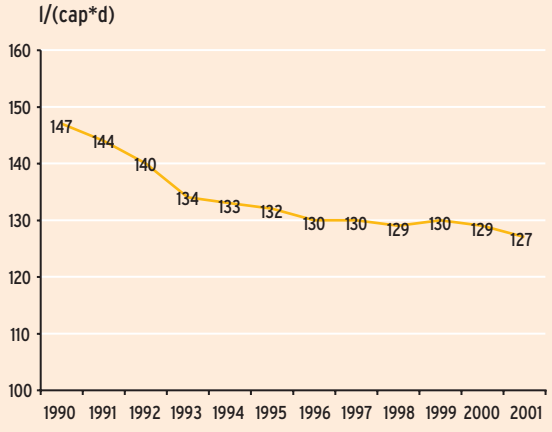
[1)] Lake and/or dam water, river water and accumulated groundwater (systematic surface water seepage, genuine groundwater and, if applicable, bank filtrate)

Source: *Federal Statistical Office 2003*

panies, using 79 % of the supply; for technical reasons it is generally not possible to differentiate between the two groups.

The proportion of the population of Germany that is connected to the public water supply in Germany is 99 %. This means that is possible to calculate the per-head consumption of drinking water per inhabitant, per day. The calculated water consumption of 147 l per person per day (l/p/d)in 1990, the value had decreased to 127 l in 2001 (Fig. IX 1.3-2). The average value varies quite considerably between the individual *Länder*, however. The maximum value of 152 l/p/dwas seen in Schleswig-Holstein, with the minimum value of 87 l/p/dseen in Thuringia (Fig. IX 1.3-3).

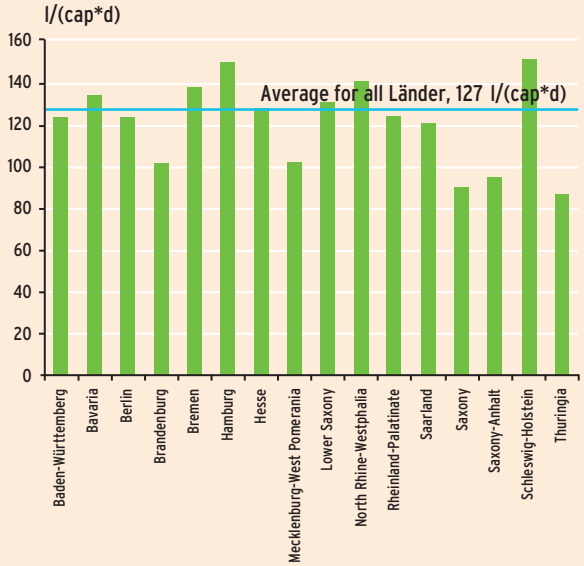
Fig. IX 1.3-2: *Specific water consumption in households and small businesses*



Source: *Federal Statistical Office 2003 a*

It should be noted that this data also includes the water consumption from small businesses (Tab. IX 1.3-3). The Bundesverband der deutschen Gas- und Wasserwirtschaft e.V. (BGW) estimates that the consumption by small businesses is, on average, about

Fig. IX 1.3-3: *Specific water consumption in households and small businesses, distribution between Länder, 2001*



Source: *Federal Statistical Office 2003 a*

Tab. IX 1.3-3: *Public water supply to end-users, self supply by waterworks, water losses*

		1991	2001
Water supplied	Million m^3	5 747.9	4 773.9
to end users	*l/p/d*	*200*	*160*
of which			
Households and small businesses	Million m^3	4 127.8	3 779.1
	l/p/d	*144*	*127*
Commercial companies and other consumers[1)]	Million m^3	1 620.2	994.8
Consumption by waterworks for own use	Million m^3	142.7	133.5
Water losses[2)]	Million m^3	758.0	529.7

[1)] other consumers: e.g. hospitals, schools, authority bodies, municipal establishments, Federal Armed Forces, agricultural enterprises. Water supplied to commercial companies, 1991 1,045.0 million m^3; to other consumers, 1991: 575.1 million m^3. Due to changes in the frame of survey, the statistics from 1998 onwards designate data for commercial companies and other consumers as a total.

[2)] Actual losses (e.g., broken pipes) and apparent losses (measurement error), as well as statistical differences

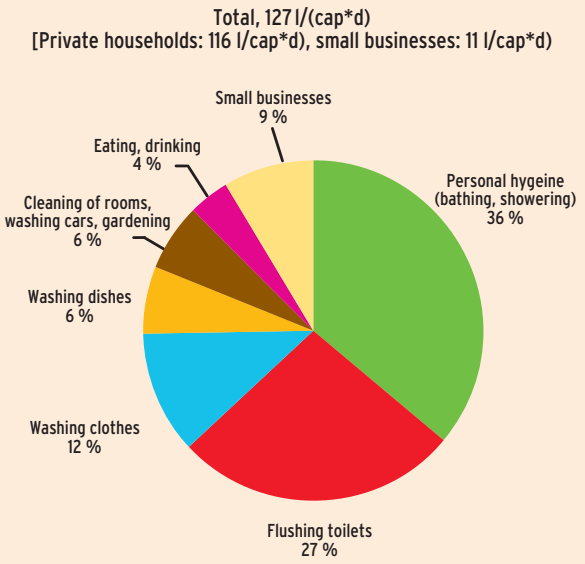
Source: *Federal Statistical Office 2003*

9 % of the supplied quantity. This corresponds to a water volume of 11 l pp/pd. By comparison, private households consume an average of 116 l/p/d (Fig. IX 1.3-4).

According to provisional calculations by the BGW, the amount of water consumed by households and small businesses rose to 130 l/p/dduring the hot year of 2003 [1].

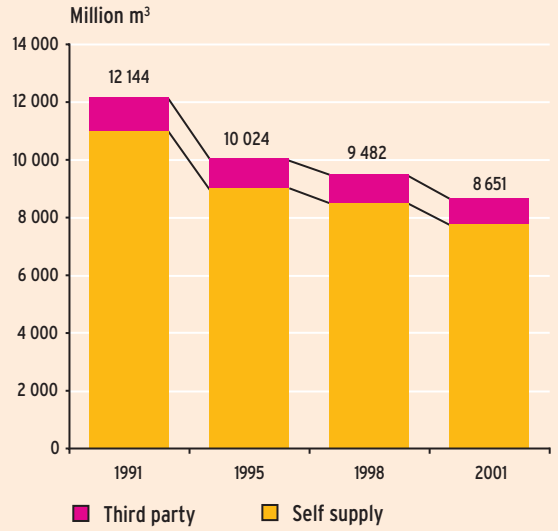
[1] Bundesverband der deutschen Gas- und Wasserwirtschaft e.V. (BGW), http://www.bundesverband-gas-und-wasser.de/bgw/indexflash.html (Issued: 16.03.2005)

Fig. IX 1.3-4: *Water use in households, 2001 (average values, referenced to the water supplied to households and small businesses)*



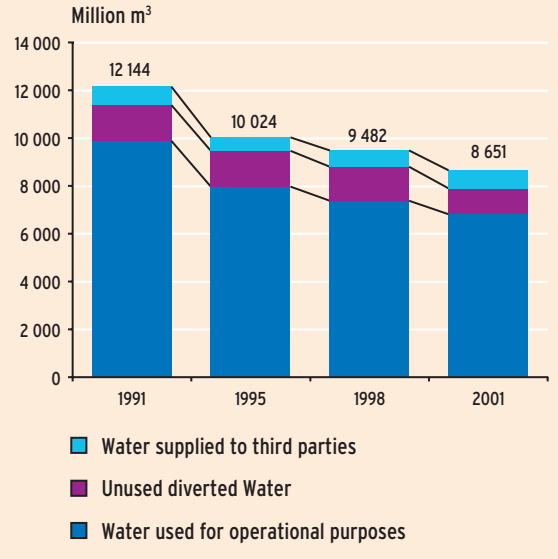
Source: *Bundesverband der deutschen Gas- und Wasserwirtschaft e.V. 2002*

Fig. IX 1.3-5: *Water supply in mining and manufacturing industries*



Source: *Federal Statistical Office 2003 b*

Fig. IX 1.3-6: *Water use in mining and manufacturing industries*



Source: *Federal Statistical Office 2003 b*

Water use in mining and manufacturing industries

In 2001 the mining and manufacturing industries extracted 7.8 billion m^3 of water, which was around 29 % less than the amount taken from independent supplies in 1991. In 2001 an additional quantity of approximately 0.38 billion m^3 was taken from the public network, with a further 0.51 billion m^3 drawn from other operators and facilities (Fig. IX 1.3-5 and Fig. IX 1.3-6).

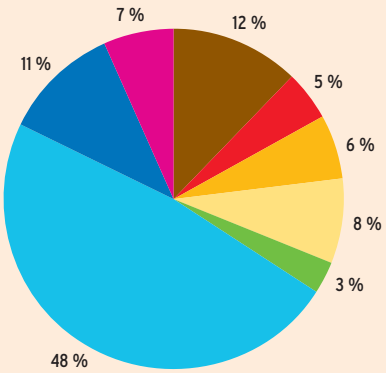
The main sources of water used as independent supplies are surface water, providing around 5 billion m^3, and groundwater, providing 2.1 billion m^3.

The amount of fresh water used in production processes was 6.8 billion m^3. This represents a reduction of 31 % compared to 1991 levels. Technological developments in recent years relating to circulation and cascade systems have led to an increase in the amount of water that is reused during these operations (Tab. "Multiple use of water by the mining and manufacturing industries, 2001"). This has increased the ratio of the total water volume used to the amount employed for commercial purposes. The so-called utilisation factor varies considerably between different commercial sectors, from 1.0 in the leather industry to 22.1 in the vehicle construction industry. In 1991 the overall utilisation factor in the mining and manufacturing industries was 4.2, whereas in 2001 it was 4.9. This means that water used by the mining and manufacturing industries is used almost five times.

In other words, the water input of 6.8 billion m^3 represents an actual volume of 33.6 billion m^3 of water.

The volume of water used also varies significantly between the various branches of the industry. Almost half (48 %) of the water is required for the chemical industry. This is the most water intensive sector, requiring a fresh water input of 3.3 billion m^3, followed by mining, metal production, and the paper trade, which use between 0.8 billion m^3 and 0.5 billion m^3 of fresh water (Fig. IX 1.3-7).

Fig. IX 1.3-7: *Distribution of all water used for operational purposes in the mining and manufacturing industries, 2001*



Coal mining, extraction of peat, extraction of petroleum and natural gas

Ore mining, quarrying of stone and earth, other mining

Foodstuffs industry and processing of tobacco

Paper, publishing and printing industry

Coking plants, mineral oil processing, manufacture and processing of nuclear fuels and fission materials

Chemical industry

Production and processing of metals, manufacture of metal products

Other

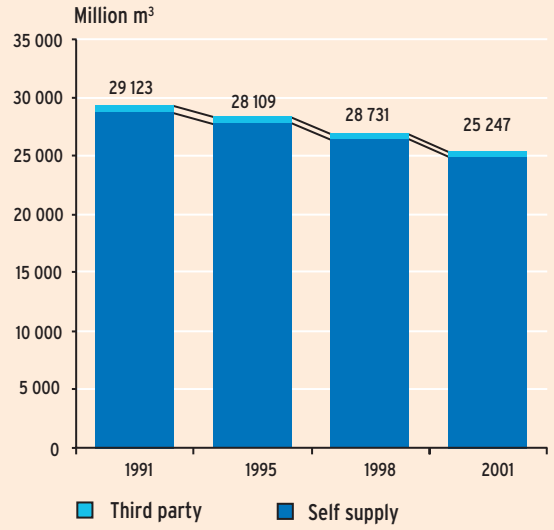
Other: e.g., leather industry, wood trade, textile and clothing industry, manufacture of furniture, recycling, manufacture of rubber and plastic goods, glass industry, processing of stone and earth, manufacture of machinery and equipment, manufacture of electrical goods, construction of vehicles

Source: *Federal Statistical Office 2003*

Water utilisation by thermal power stations for public supply

Thermal power stations for public supply were the largest consumers of water resources in 2001, using a volume of 25.2 billion m^3 of water (Fig. IX 1.3-8), which was around 4 billion m^3 less than in 1991. Up to 99 % of the water demand is met from surface water sources.

Fig. IX 1.3-8: *Water supply for thermal power stations supplying the public network*



Source: *Federal Statistical Office 2003 b*

The majority of the water is used for cooling purposes and is returned to the river system after use (see Chapter VI 4.5). About 8 % of the total volume of cooling water that was diverted in 1998 was first passed through in-house recooling systems [1].

Thermal power stations were also able to achieve savings compared to 1991, mainly using technological measures. In 2001 almost 4 billion m^3 (around 14 %) less water was used than in 1991.

The volume of water extracted is approximately one-third of the volume that is used (Tab. "Multiple use of water by thermal power stations supplying the public grid, 2001"). This has been achieved in part through the use of sophisticated water-saving technologies with diverse multiple-use and circulation systems.

[1] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; Federal Environment Agency: Wasserwirtschaft in Deutschland. Part 1: Grundlagen, Bonn 2001 (Reihe Umweltpolitik), p. 27

Productivity of water utilisation in environmental accounting

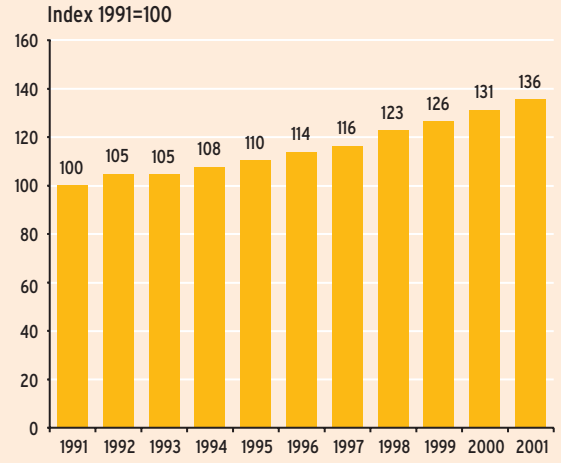
The water statistics do not take into consideration water use by some commercial sectors, such as the agriculture and service industries, or only publish the data relating to these after a period of time has elapsed.

When determining the total amount of water extracted from the environment for a given year in order to calculate water productivity, the environmental accounting by the Federal Statistical Office makes use of further information from official statistics, as well as publications from scientific institutes, associations, and organisations.

The calculation for 2001 showed that around 43.9 billion m^3 of water was extracted for commercial purposes. In 1991, the figure was 51.2 billion m^3.

This clear reduction (-14.3 %) in the period between 1991 and 2001 was achieved alongside an increase in economic performance of 16.1 %. This implies that water is being used with increasing efficiency. The ratio of gross domestic product to water extracted shows a continuous increase (Fig. IX 1.3-9).

Fig. IX 1.3-9: *Water productivity*



Source: *Federal Statistical Office 2004*

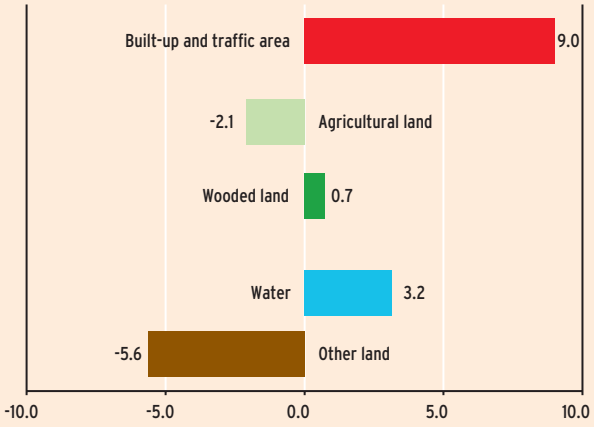
IX 2 Trends in residential and transport-related land use and land productivity

Land is a limited resource that is used by humans in numerous different ways. Between 1993 and 2001 the amount of agricultural land in Germany decreased (–4 084 km²), whereas the amount of land covered by forest and water increased slightly (778 km² and 248 km² respectively). In contrast to this, the built-up and traffic area remains the most dynamic growth area for land use (it increased by 3 634 km² between 1993 and 2001). Nonetheless, the daily increase in land use did fall for three consecutive years from 2000 (Chapter VII 1.1 and Fig. IX 2-1).

The amount of land claimed for residential and transport-related use in 2003 was 44 750 km², compared to 40 305 km² in 1993. The land productivity, that is the ratio of gross domestic product generated to built-up and traffic area, was 3.3 % higher in 2003 than it was in 1993. Around 44.5 million euro per km² of built-up and traffic area was generated, however a decrease in land productivity has been recorded since 2000 (Fig. IX 2-2).

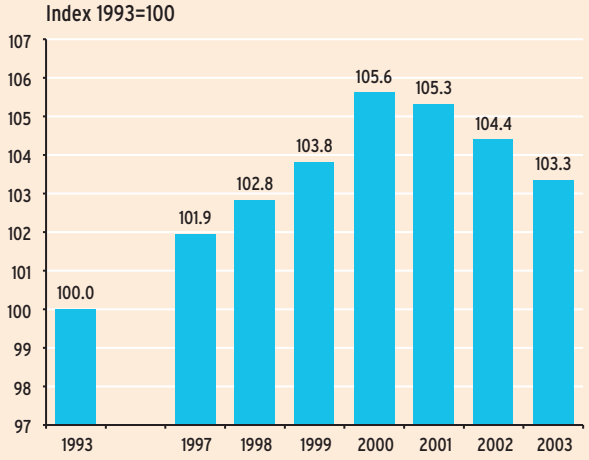
The reason for this decrease lies in the continued, albeit slower, expansion of the built-up and traffic area since the downturn in the economy in 2000 (Fig. IX 2-3).

Fig. IX 2-1: *Trends in land use in %, 1993 to 2001*



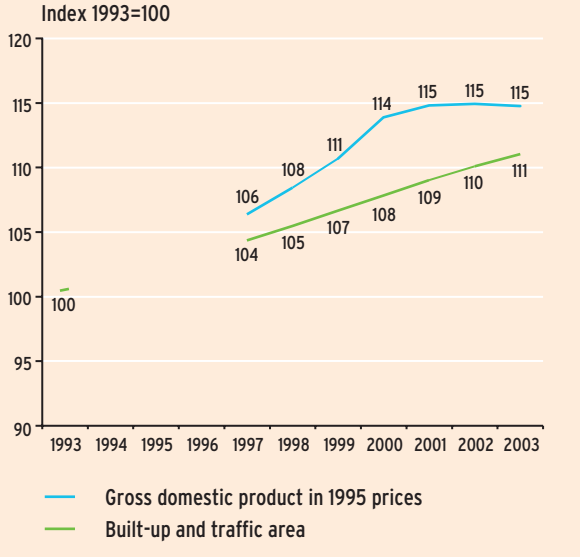
Source: *Federal Statistical Office 2003 c*

Fig. IX 2-2: *Land productivity*



Source: *Federal Statistical Office 2004*

Fig. IX 2-3: *Trends in built-up and traffic area and gross domestic product*



Source: *Federal Statistical Office 2004*

If the way in which land is utilised is studied in detail, then two contrary trends can be seen to have occurred. First, the amount of residential land within towns that is unused has increased during the timeframe under consideration. According to estimates from the Federal Statistical Office, the amount of this so-called "residential brownfield" or fallow land area grew by around 12.7 ha per day between 1993 and 2001 [1]. At the same time, additional land close to towns has been "used" for residential purposes, i.e., released as available for building planning. The large amount of cost-effective "greenfield" building land that has been made available has made it difficult in many regions to reuse fallow areas within towns [2]. This continual expansion of land used for residential purposes, combined with weak economic development and a declining or stagnant population in some regions, has led to lower utilisation of necessary infrastructure, such as pipework infrastructure, public transport, schools, and day care centers (kindergartens). In those regions with declining populations, the costs associated with this must be allocated to increasingly few inhabitants. This means that sustainable and economic land consumption for residential and transport-related purposes also has fiscal and social implications.

[1] Federal Statistical Office, Umwelt – Umweltproduktivität, Bodennutzung, Wasser, Abfall. Tabellenteil zum UGR-Pressebericht 2003, Tab. 2, Wiesbaden 2003 (http://www.destatis.de/download/d/ugr/tabugr03.pdf)

[2] Federal Environment Agency, Reduzierung der Flächeninanspruchnahme durch Siedlung und Verkehr – Materialienband, UBA-Texte 90/03

X WASTE MANAGEMENT

A sustainable policy for the protection of natural resources attaches great importance to closed material life cycles. The principles of life-cycle management are set out in the Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (Kreislaufwirtschafts- und Abfallgesetz – KrW-/AbfG) (radioactive waste falls under the Atomic Energy Act). Priority is given to the highest possible degree to the effective use of materials taken from nature in order to prevent waste originating at source. The aim is to decouple the amount of waste from economic growth. Unavoidable waste should be reused as new raw material in industrial production or processed in such a way so as to allow it to be stored as environmentally compatible "inert" (neutral) slag.

X 1 Waste generation

X 1.1 Amounts of waste generated according to waste statistics

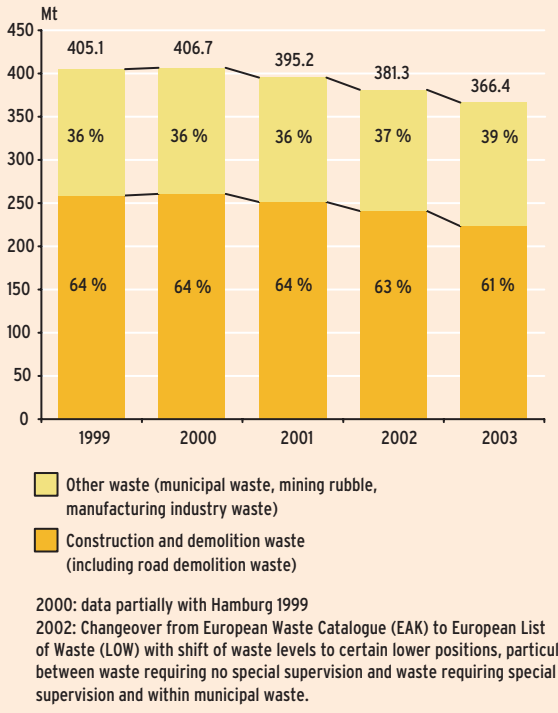
While interpreting the following figures on the main individual waste streams, note that there is no direct correlation between waste statistics and an actual recording of waste amounts. Respective levels of consumed waste, primarily from waste disposal plant operators, have been recorded since 1996. The Federal Statistical Office has integrated the volume of waste figures using a computer model. Double counts cannot be completely avoided.

Limitations to the comparability of data arise for the period under consideration due to the changeover from the materials-oriented waste register of the Working Group of the Federal States on Waste (LAGA), a document used up to 1998, to the predominantly origins-oriented European Waste Catalogue (EAK), used after 1999). This has led to waste levels being shifted to certain positions lower down on the scale, particularly in the case of municipal, manufacturing, trade, construction, and demolition waste. In 2002, the EAK was replaced by the European List of Waste (LOW), which resulted in shifts within municipal waste as well as between waste not requiring any special supervision and that requiring special supervision. In contrast to previous years, waste requiring special supervision has been treated as one of the waste types presented below since 1999 and evaluated separately for information only.

Furthermore, since 1999 manufacturing and trade has disregarded waste levels treated in-house, while recovery and disposal continue to be recorded.

The most quantitatively significant waste category "construction and demolition waste (including road demolition waste)", which made up the majority of waste amounts in 2003 (223.4 Mt – 61 %), plays a key role in closed substance-cycle waste management. Spoil, the majority of which is recycled, made up the largest share in this waste category (Chapter X 2.2). A significant amount of the remaining mineral construction waste is also recovered. Construction and demolition waste trends run largely parallel to economic trends in the construction trade (Fig. X 1.1-1 and Tab. "Amounts of waste generated").

Fig. X 1.1-1: *Amount of waste generated*



2000: data partially with Hamburg 1999
2002: Changeover from European Waste Catalogue (EAK) to European List of Waste (LOW) with shift of waste levels to certain lower positions, particularly between waste requiring no special supervision and waste requiring special supervision and within municipal waste.

Source: *Federal Statistical Office 2005*

49.6 Mt (approximately 14 %) of the waste amounts were attributable to municipal waste in 2003. This is the most important group after construction waste.

58 % of municipal waste was recovered in 2003 (Chapter X 2.1).

Domestic waste made up 43.9 Mt (almost 90 %) of municipal waste in 2003.

Domestic waste from public household refuse collection and trade wastes (not requiring any special supervision), so-called residual waste amounted to approximately 209 kg/cap. in 1999, and 192 kg/cap. in 2003. In addition there was approximately 37 kg/cap. of bulky (household) waste in 1999, 32 kg/cap. in 2003. Altogether this amounted to 246.37 kg/cap. in 1999, 224.37 kg/cap. in 2003.

In contrast, waste collected separately for recovery (compostable waste from the organic waste bin and other categories collected separately, not requiring any special supervision) nevertheless amounted to approximately 195 kg/cap. in 1999 and as much as 306 kg/cap. in 2003. However, compostable garden and park waste, first included in 2002, (47 kg/cap.) was an important contributory factor here.

Altogether, 441 kg/cap. of domestic waste (not requiring any special supervision) were generated in 1999 and 532 kg/cap. in 2003.

The total quantity of waste from private households has therefore been rising since the end of the 1990s. This is largely attributable to the effects of amended statistical methods.

49 % of domestic waste was recycled in 1999, and 61 % in 2003.

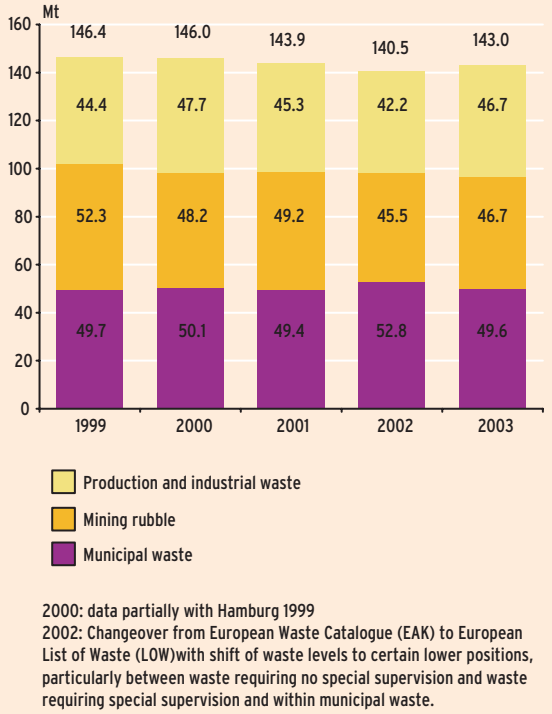
Mining rubble made up approximately 13 % (46.7 Mt) of the quantity of waste in 2003, mainly from lignite mining. The majority of mining rubble is stockpiled. The decline in mining rubble is in line with the falling demand for coal.

Approximately 13 % of waste came from production and industry in 2003. This amounted to 46.7 Mt (Fig. X 1.1-2 and Tab. "Amounts of waste generated").

Waste requiring special supervision has been separately statistically evaluated for information only since 1999. Approximately 5 % of the volume of waste came under this waste stream in 2003 (1999: 3.3 %). It was principally accumulated within the industrial and construction trade. 28 % of it was recycled in 2003 (Chapter X 1.2).

Germany's economic performance had been slowly improving since 1999, and then stagnated, while the total quantity of waste decreased (Fig. X 1.1-3). The intensity of waste, or the total volume of waste measured against trends in gross domestic product (1995 prices) decreased by 13 percentage points from approximately 212 kg/thousand EUR to approximately 184 kg/thousand EUR (Fig. X 1.1-4).

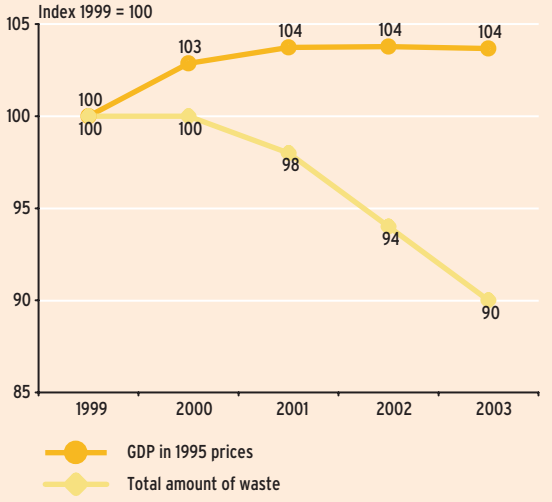
Fig. X 1.1-2: *Amount of waste generated – "other waste"*



2000: data partially with Hamburg 1999
2002: Changeover from European Waste Catalogue (EAK) to European List of Waste (LOW)with shift of waste levels to certain lower positions, particularly between waste requiring no special supervision and waste requiring special supervision and within municipal waste.

Source: *Federal Statistical Office 2005*

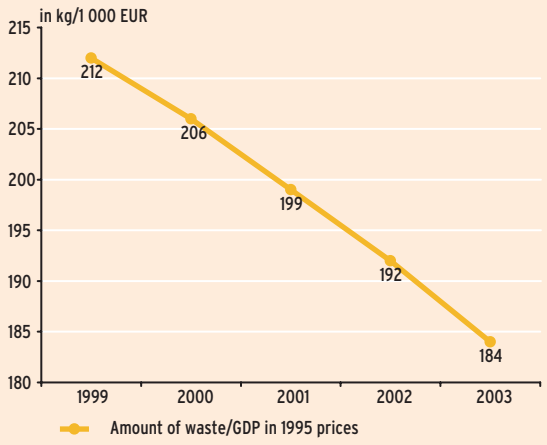
Fig. X 1.1-3: *Decoupling waste generation from economic growth*



Source: *Federal Statistical Office 2005 a*

The non-recoverable share of waste volume is to be disposed of in an environmentally sound manner. Before final disposal, organic waste must be mechanically-biologically or thermally treated for it to be made inert and thus to reduce leaching and the release of landfill gas. Landfilling of organic waste which has not been pre-treated has no longer been permissible since the middle of 2005. Strict air quality management standards apply to incineration plants (Chapter X 2.1, Chapter X 3.2)

Fig. X 1.1-4: *Waste intensity*



Source: *Federal Statistical Office 2005 a*

Further waste statistics information from the Federal Statistical Office can be accessed on the Web at http://www.destatis.de.

X 1.2 Generation of waste requiring special supervision (hazardous waste)

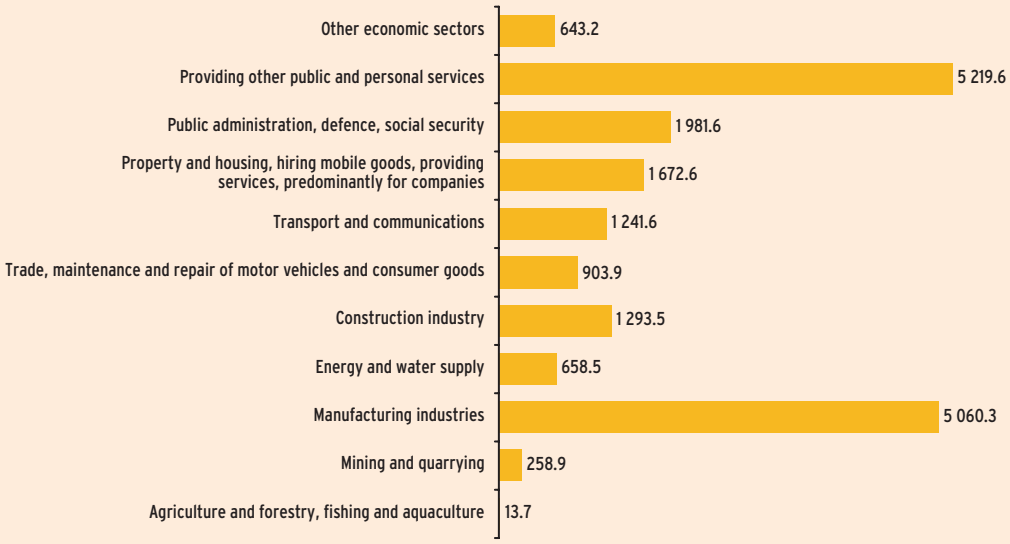
The prevention, recovery and disposal of waste are to be supervised by the competent authorities under paragraph 40 KrW-/AbfG; paragraph 41 provides that all waste disposal requires supervision. Particular requirements apply to the disposal of hazardous waste from manufacturing and other companies or public institutions which especially poses a risk to health, air, or water according to type or composition. The same applies to recoverable waste where particular substance properties make special requirements necessary for recycling (recoverable substances requiring special supervision, listed in ordinances).

In the *Länder* where there is an obligation to deliver or surrender, the waste producer must inform its waste disposal authority of the type, amount and composition of the waste and of the foreseen disposal plant. The authority then allocates a suitable plant for disposal of the waste.

Until the end of 2001, the "Ordinance on Ascertaining Waste Requiring Special Supervision" regulated which waste types were to be classed as hazardous. This was replaced by the "Ordinance on the Implementation of the European Waste Catalogue" (Waste Catalogue Ordinance – AVV) on 1 January 2002, which marked waste requiring special supervision with an asterisk (*). This rating is often taken from hazardous substances legislation.

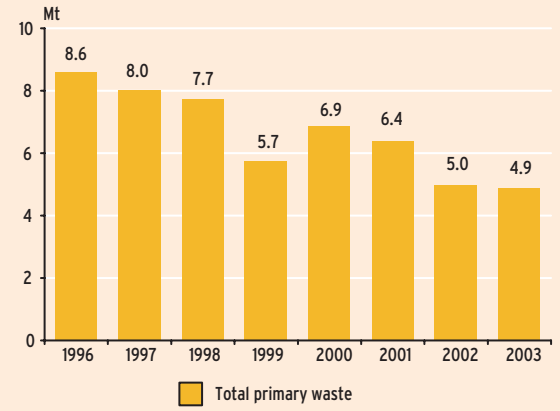
The survey of waste requiring special supervision is partly based on the examination of the proof procedure tracking forms (Fig. X 1.2-1). The appropriate authorities are obliged to provide the statistical offices with information. This however provides neither for recording of waste disposed of in-house (Fig. X 1.2-2) nor for transboundary waste levels (exports and imports). Double counts must be taken into account when ascertaining the original volume of waste (primary waste). "Hazardous waste" taken from company A to treatment plant B must be accompanied by a tracking form. Transporting new waste (secondary waste) which originated in treatment plant B as primary waste to disposal plant E must also be recorded on a tracking form.

Fig. X 1.2-1: *Origin of waste requiring special supervision (tracking form) 2003 in kt*



Source: *Federal Statistical Office 2005 b*

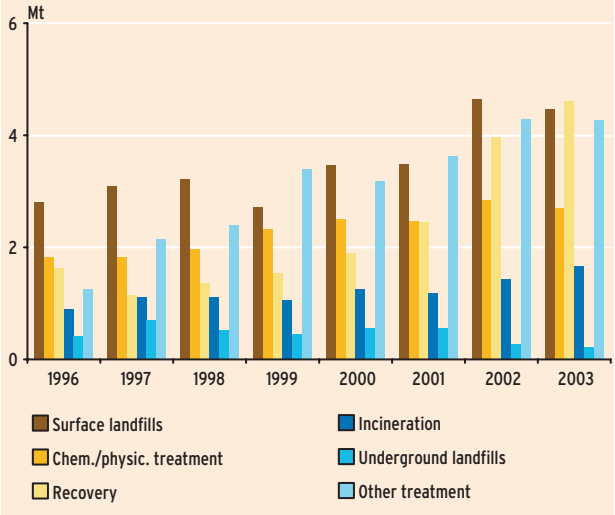
Fig. X 1.2-2: *Amount of waste requiring special supervision not recorded on tracking forms (operators with own disposal plants)*



Source: *Federal Statistical Office 2003*

Although the amount of primary waste is useful for commenting on quantity trends or assessing waste prevention measures, only actual waste streams are meaningful for concrete disposal planning measures. Finally, waste which is first treated and then dumped requires corresponding treatment plant and landfill capacities. In turn, increasing (pre-)treatment of waste gives rise to growing demand for treatment capacity if the amount of (primary) waste does not increase (Fig. X 1.2-3).

Fig. X 1.2-3: *Destination of waste requiring special supervision (tracking form) (excl. imports and exports)*



Source: *Federal Statistical Office 2004*

Waste properties can also alter while inside the treatment plant. For example, filtration dust requiring special supervision can develop from domestic waste not requiring special supervision in a domestic waste incineration plant. Likewise, waste not requiring special supervision can develop from waste requiring special supervision (e.g., acidic residues) in neutralization plants.

X 1.3 Management of radioactive waste and spent nuclear fuel elements

In accordance with paragraph 9a of the Atomic Energy Act, it is the responsibility of the producer of radioactive residual products to have them harmlessly recovered or disposed of as radioactive waste.

All waste management activities are subject to supervision by the authorities, enacted via the atomic law authorities of each Land. In the case of waste generated in the controlled area in nuclear power plant operations, the operator draws up a waste programme which is presented before the responsible supervisory authorities. The operator minimizes the volume of radioactive waste by way of suitable management and appropriate planning of plant revisions. The nuclear power plant operators carry out the treatment, conditioning, and disposal of radioactive waste with partial support from specialized industrial companies.

The accumulated radioactive waste is separated according to activity and material as soon as it is produced. This is done with the primary aim of unconditionally or conditionally recycling the largest possible share following a clearance measurement and in some cases obligatory decontamination. If it is not possible to remain below the stated limit values, at least the clearance criteria for disposal as conventional waste are to be accomplished.

The clearance levels for radioactive materials with minor activity and the clearance process are set out in the new ordinance of the protection against radiation hazards (StrlSchV). This ordinance sets around 300 radionuclide mass-specific clearance levels for solids and liquids, clearance of buildings and plots of land and clearance for disposal on domestic waste landfills or in an incineration plant, based on the 10 µSv concept. Clearance is carried out by the authorities. The required clearance measurements are carried out by the operator and are subject to supervision by the appropriate Land authorities, who also carry out control inspections.

The pre-treatment of radioactive waste serves to minimize volumes and convert raw waste into manageable, conditionable intermediary products ready for final disposal. All radioactive waste is separated as soon as it is produced and documented according to type, content, and activity. The separating criteria and requirements for the collection, ascertaining the activity and documentation are given in Appendix X

of the Radiation Protection Ordinance (StrlSchV). This enables the party causing the waste to supply information at any time on the processing progress, activity, and whereabouts of all radioactive waste.

Pre-treatment, conditioning, and packaging of radioactive waste is carried out in the nuclear power plants in line with professional procedures and as sensibly as possible. Requirements for eventual final storage are taken into account as far as possible for each foreseen conditioning. Pre-treatment equipment (e.g., for concentration, separation, pressing and packaging) is available in all nuclear power plants. For example, non-combustible fluid waste is concentrated and non-combustible solid waste compacted with high-pressure presses. Conditioning for final storage is often carried out by contractors who have access to mobile equipment (e.g., in-drum drying plants for fluid concentrates or remotely controlled underwater dismantling equipment for medium activity waste) who bring it to the nuclear power plants. Incineration of combustible waste and conditioning (cementing) of the ashes produced is carried out by contractors in external plants. The conditioned bundles of terminal waste are returned to the nuclear power plants and either stored there or taken to central (external) temporary storage facilities.

Data compilation on radioactive waste from nuclear power plants

Every year, the Federal Office for Radiation Protection (BfS) surveys incidental radioactive waste in Germany. The amount and stocks of radioactive waste from nuclear power plants are also ascertained. In Germany, basic differences are drawn between radioactive waste with heat generation and that with negligible heat generation. Table X 1.3-1 shows data covering the 1996 to 2001 period.

Storage of spent nuclear fuel elements

Spent nuclear fuel elements are initially stored in wet storage ponds at the nuclear power plants and later in temporary storage planned in the vicinity (Tab. X 1.3-2) or are already in facilities put into operation. Among these is the on-site temporary storage facility in Lingen and the interim storage facilities in Neckarwestheim, Philippsburg, Biblis, and Krümmel.

Undercriticality and cooling of combustible elements in wet storage ponds and protection from external influences are ensured. In accordance with approval conditions, a capacity exceeding the atomic load is to be kept free at all times – with the exception of the Stade nuclear power plant – in order to allow the complete unloading of the nuclear reactor at any time. The internal storage capacities may not, in principle, be used for all power plants, with the exception of the double block plants Neckarwestheim and Philippsburg. Operation of an additional wet storage tank set up previously in the earthquake-proof emergency building external to the reactor building was approved in 1998 in the Obrigheim nuclear power plant. Nuclear fuel elements were first stored here in 1999.

Table X 1.3-3 contains amalgamated figures on approved storage capacities – stocks of spent and partially spent nuclear fuel elements and free storage capacities for all nuclear power plants in operation at the time (heavy metal content per nuclear fuel element is plant-dependent) – for the 1997 to 2001 period. Nuclear fuel elements used in the reactor cores are also given. Temporary storage of spent nuclear fuel elements in wet storage was detailed for the last time in Germany in May 2003 in the report "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" [1].

The spent nuclear fuel elements may be taken to a central interim storage facility used by all power plants and to others in France and Great Britain for reprocessing until the intended temporary storage facility in the vicinity goes into operation. Transport tank loading is carried out in the storage ponds. The tanks leave the nuclear power plant in the form

Tab. X 1.3-1: *Radioactive waste stocks from respective nuclear power plants in operation on 31 December in m^3*

	Amount of waste[1]											
	(non-heat generating)						(heat generating)					
	1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001
Untreated residual and intermediate products	7 671	6 183	6 075	5 252	6 886	7 974	390	390	–	–	–	–
waste conditioned on nuclear power plant premises[2]	5 926	5 325	4 540	4 865	4 986	5129	1	1	1	6	6	6
year conditioned[2]	3 174	2 048	1 561	1 238	623	827	–	–	–	5	–	–

[1] Amount and stocks from nuclear power plants closed down or taken out of operation are not included in these figures.
[2] Figures in m^3 Container volumes

Source: *Federal Office for Radiation Protection 2002*

Tab. X 1.3-2: *Requested and approved temporary storage facilities located in vicinity (as of: 26 November 2004)*

Nuclear power plant	Type of storage facility	Application date	Mass HM [Mg]	Parking spaces	Approval/ Supplementary approval issued	Mass HM [Mg]	Parking spaces
Biblis A and Biblis B also for Mülheim-Kärlich	Temporary storage facility location Interim storage facility	23.12.1999 30.11.2000	1400 300	135 28	22.09.03* 20.12.01/16.04.03**	1400 300	135 28
Brokdorf	Temporary storage facility location	20.12.1999	1000	100	28.11.03*	1000	100
Brunsbüttel	Temporary storage facility location Interim storage facility	30.11.1999 15.08.2000	450 140	80 18	28.11.03* not yet notified	450	80
Grafenrheinfeld	Temporary storage facility location	23.02.2000	800	88	12.02.03*	800	88
Grohnde	Temporary storage facility location	20.12.1999	1000	100	20.12.02*	1000	100
Gundremmingen B and Gundremmingen C	Temporary storage facility location	25.02.2000	2250	192	19.12.03*	1850	192
Isar 1 and Isar 2	Temporary storage facility location	23.02.2000	1500	152	22.09.03*	1500	152
Krümmel	Temporary storage facility location Interim storage facility	30.11.1999 15.08.2000	800 120	80 12	19.12.03* 20.06.03*	775 120	80 12
Lingen (Emsland)	Temporary storage facility location	22.12.1998	1250	130	06.11.02*	1250	130[1)]
Neckarwestheim 1 and Neckarwestheim 2	Temporary storage facility location Interim storage facility	20.12.1999 20.12.1999	1600 250	151 24	22.09.03* 10.04.01/20.12.02**	1600 250	151 24
Philippsburg 1 and Philippsburg 2	Temporary storage facility location Interim storage facility	20.12.1999 20.12.1999	1600 250	152 24	19.12.03* 31.07.01/17.02.03**	1600 130/250	152 12/24
Stade	Temporary storage facility location	20.12.1999	300	80	Appliation withdrawn		
Unterweser	Temporary storage facility location	20.12.1999	800	80	22.09.03*	800	80

* further approval steps to follow
** Process concluded
[1)] For 125 containers loaded with nuclear fuel and 5 containers with negligible heat generation

Source: *Federal Office for Radiation Protection 2004*

Tab. X 1.3-3: *Temporary storage of spent nuclear fuel elements in wet storage in all nuclear power plants on 31 December*

Storage capacity	1997		1998		1999		2000		2001	
	Quantity	(t HM)	Quantity	(t HM)	Quantity	(t HM)	Quantity	(t HM)	Quantity	(t HM)
approved total capacity	20 843	6 575	21 865	6 877	21 865	6 877	22 037	6 965	21 247	6 613
spent and partially spent nuclear fuel elements[1)]	6 442	2 289	7 382	2 582	8 410[2)]	2 931[2)]	9 614[2),5)]	3 278[2)]	10 373	3 474
free capacity[3)]	5 982	1 840	6 288	1 909	5 570	1 606	4 898	1 382	3 849	1 004
Nuclear fuel elements in reactor core[4)]	6 473	1 898	6 473	1 898	6 473	1 898	6 473	1 900	6 473	1 902

[1)] Partially spent nuclear fuel elements can be used again
[2)] Data from Federal Radiation Protection Office surveys
[3)] Parking spaces used for unloading reactor core and for other operational purposes not included in calculation
[4)] Spent fuel elements from the Mülheim-Kärlich reactor core are in wet storage ponds
[5)] An additional total of 126 nuclear fuel elements in either transport or transport/storage containers have been made available on the plant premises

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004*

of wet transports (Great Britain) or dry transports (France). In accordance with the agreement between the Federal Government of Germany and the utility companies dated 14 June 2000 and signed 11

June 2001, no more transports for reprocessing are foreseen as from 1 July 2005. Delivery of irradiated nuclear fuel elements from nuclear power plants to reprocessing plants was banned as from 1 July 2005 in accordance with an amendment to the atomic law in 2002.

To minimise future transports of spent nuclear fuel elements, nuclear power plant operators requested the erection of on-site temporary storage facilities for all 13 locations (excluding Mülheim-Kärlich) from 1998 to 2000 and authorisation (1st authorisation steps) was granted by the end of 2003 for all on-site temporary storage facilities and all interim storage facilities with the exception of Brunsbüttel (Tab. X 1.3-2). In the case of the interim storage facility in Brunsbüttel, the applicant had not reached a decision in 2003. The application for the on-site temporary storage facility in Stade was withdrawn due to the premature closure of the power plant.

These temporary storage facilities are concerned with dry storage for spent nuclear fuel elements predominantly in CASTOR transport and storage tanks. The capacity of this storage facility is measured to allow it to take all spent nuclear fuel element stocks by final closure of the power plant. This also enables storage as well as closure of the power plant until the final storage facility goes into operation by around 2030. In order to avoid short-term storage bottle necks, the Biblis, Brunsbüttel, Krümmel, Neckarwestheim, and Philippsburg power plants have requested additional temporary storage possibilities (interim storage facilities) within a capacity of between 12 and 28 storage tank storage spaces. The Federal Office for Radiation Protection is responsible for approval of the temporary storage facility.

Disposal

The Atomic Energy Act forms the legal basis for disposal. In accordance with this, nuclear power plant disposal measures are carried out thus:

- intermediate storage of spent nuclear fuel elements in central (external) temporary storage facilities and as swiftly as possible to on-site temporary storage facilities on the power plant premises, and eventual direct final storage of nuclear fuel elements,
- reprocessing of spent nuclear fuel elements, accounting for the fact that delivery of irradiated nuclear fuel elements from nuclear power plants to reprocessing plants is permissible up to 30 June 2005 at the latest, and recovery of returned nuclear fuel and proper disposal of radioactive waste thereby generated in Germany,
- conditioning, intermediate storage and eventual final storage of radioactive waste from the operation and closure of nuclear power plants.

The Morsleben final storage facility was in operation until September 1998 for final storage purposes of low- and medium-radioactive waste. The plan fixation procedure for the Schlacht Konrad final storage facility was concluded in May 2002 with an official declaration decree. There are currently four complaints filed against the decision, preventing its completion. Exploration of the Gorleben salt dome shall be stopped for at least 3, at most 10 years. The Federal Government plans to make available a final storage facility for all radioactive waste by around 2030. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) convened the final storage locations selection procedure group which is working on a traceable procedure for the selection of suitable final storage locations based on sound criteria and delivered this to the BMU in December 2002. The BMU now intends to translate the results into legal regulations.

Until a final storage facility goes into operation, the operator's disposal precautions shall be carried through by way of temporary storage verifiction as from 1 July 2005.

[1] http://www.bmu.de/files/behandlung_brenn.pdf

X 2 Waste recovery

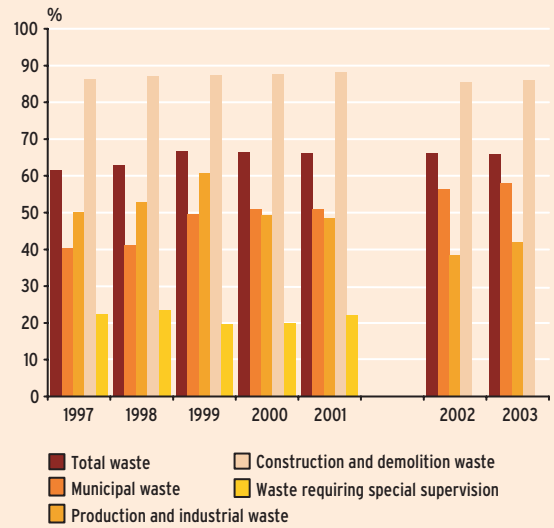
Sustainable development requires decoupling of resource use from economic growth. The efficiency strategy can only be successful in the long-term if increasing production and higher consumption levels do not sap efficiency gains. Waste prevention and increased recovery are key to this. Finally, waste management must dissociate itself from its special role in an "end-of-pipe" mentality associated with the cheapest possible waste disposal in an affluent society and instead continue to develop as a source for the procurement of raw materials and production of goods.

X 2.1 Recovery rates for main waste streams

In interpreting the following figures on the individual main waste streams it should be noted that in the timeframe under consideration, several adjustments to the survey and additions to the recorded levels of waste types were made. Respective waste levels, primarily those generated by waste disposal plant operators, have been recorded since 1996.

Limitations on data comparability for the period considered come to light in the changeover from the materials-oriented waste register of the Working Group of the Federal States on Waste (LAGA) used until 1998, to the origins-oriented European Waste Catalogue (EAK), used from 1999. This led to waste levels being shifted to certain positions lower down on the scale, particularly in the case of municipal waste, manufacturing and trade waste, and construction and demolition waste. In 2002 the EAK was replaced by the European List of Waste (LOW) which resulted in shifts within municipal waste as well as between waste not requiring any special supervision and waste requiring special supervision. Up to and including 2001, waste requiring special supervision was listed as a separate waste stream; in the 2002 figures it was included under other waste types (Fig. X 2.1-1 and Tab. "Amount, removal and recovery of waste, 1999–2003").

Fig. X 2.1-1: *Recovery rates for main waste streams*



1998: Hamburg with data from 1997
from 1999: Changeover from European Waste Catalogue (EAK) with shifts to certain positions lower down on the scale (municipal, manufacturing, trade, construction, and demolition waste)
2000: Hamburg with data from 1999
2002: Introduction of European List of Waste (LOW) with shifts between waste not requiring any special supervision and that requiring special supervision as well as within municipal waste.
Waste requiring special supervision: Waste requiring special supervision included in main waste streams from 2002 onwards.

Source: *Federal Statistical Office 2005*

A further disruption in the 1998 to 1999 time period in terms of manufacturing and trade waste exists because after 1999, waste levels processed in-house are no longer taken into account, while recycling and disposal continue to be recorded.

Over half of all municipal waste is recovered. This puts Germany well above the average European Union recovery rate (26 %) [1].

The recovery rate for manufacturing and trade waste rose at first and then fell to below the 1997 level during the course of conversion of statistical waste classification from the Working Group of the Federal States on Waste (LAGA) list to the EAK waste register. It is presumed that the rise is attributable to statistical effects.

Construction and demolition waste amounts to around 60 % of the volume of Germany's waste. Recovery of this waste has been at a high level for many years.

[1] European Commission report to the Council and to the European Parliament on the Implementation of Community Legislation (Waste Framework Directive 75/442/EEC, Hazardous Waste Directive 91/689/EEC, Waste Oils Directive 75/439/EEC, Sewage Sludge Directive 86/278/EEC and Packaging and Packaging Waste Directive 94/62/EC) for the 1998–2000 period, KOM (2003) 250 conclusive as from 19 May 2003, page 20

X 2.2 Recovery of selected waste types

The following investigates more closely the recovery of selected waste streams in Germany.

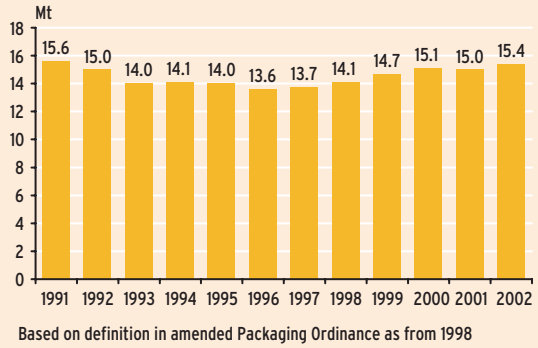
Packaging consumption and recycling of packaging waste

Based on EU Directive 94/62/EC on Packaging and Packaging Waste dated 20 December 1994, the Federal Government is obliged to convey data on consumption and recycling of packaging to the European Commission as from 1997 by way of annual reports.

Based on surveys, pilot surveys, and independent surveys by the Gesellschaft für Verpackungsmarktforschung, (GVM) in Wiesbaden, data on packaging consumption and packaging recycling trends in Germany is available for the 1991 to 2002 period. According to this data, annual packaging consumption fell between 1991 and 1996. It rose again between 1997 and 2000. Following a negligible decrease in 2001, packaging consumption rose again in 2002 (Fig. X 2.2-1). Over the entire period, paper/paperboard/cardboard packaging made up the largest share in terms of mass, followed by glass, wood/cork, synthetic material and other packaging materials (Table "Packaging consumption trends"). In 2001, 79 % of Germany's packaging waste was recycled. This data shows that packaging consumption has been successfully disassociated from general economic growth and that recycling of packaging waste has increased sharply.

Trends in packaging waste reflect both the effects of the Packaging Ordinance (VerpackV) and changes in packing material supplies based on cur-

Fig. X 2.2-1: *Packaging consumption trends*



Source: *Gesellschaft für Verpackungsmarktforschung mbH 2004*

rent market trends. Differentiations can be drawn between the individual trends. For example, glass packaging supplies have decreased steadily in comparison to 1991 (reducing weights, replacing glass drinks packaging with cans, cartons and synthetic bottles), while there has been a clear increase in paper, synthetic and wood packaging supplies (sharp increase in corrugated cardboard, cardboard and solid fibre board as well as in wood for transport packaging, strong growth in synthetic packaging; predominantly in disposable synthetic bottles).

Packaging made from glass, tinplate, aluminium, synthetic and paper, paperboard or carton including composite material for each material base accounted for 81 % of packaging consumption in 2001, of which 58 % in turn was accounted for by private end users. This means that packaging from these materials in this sector, for which the Packaging Ordinance states material recycling rates, accounted for almost half of total packaging consumption. Consumption by private end users reveals similar trends to packaging consumption in general, yet consumption for 2002 published by GVM is lower than that published for 1991. Good results were attained for packaging waste recycling by private and end users. The recycling levels doubled between 1991 and 2002. Strong growth in recycling was in aluminium and synthetic packaging, where recycling rates of 5.1 % for aluminium (including aluminium-based composites) and 3.1 % for synthetic (including plastic based composites) in 1991 had grown to 71.5 % and 54.7 % respectively in 2002 (Tab. X 2.2-1).

Under paragraph 6.3 of the Packaging Ordinance, all packaging waste generated by private end users is collected and recycled by the Dual System (DSD). From 1993 until the end of 2002, a total of 51.34 Mt were recovered. The DSD is required to demonstrate compliance with recycling quotas set out in the Packaging Ordinance, and was able to meet or exceed all quotas during this period. With the 1998 amendment to the Packaging Ordinance, not only

Tab. X 2.2.-1: *Recycling of retail packaging – private final consumers*[1)]

in kt	1991	2000	2002	2003[2)]
Consumption **Glass**	3 817.3	3 318.0	2 895.8	2 684.2
Recycling levels	2 049.7	2 709.2	2 466.4	2 320.2
Recycling rate in %	***53.7***	***81.7***	***85.2***	***86.4***
Consumption **Tin plate**	740.8	645.9	635.2	495.8
Recycling levels	250.6	515.3	521.2	436.9
Recycling rate in %	*33.8*	*79.8*	*82.0*	*88.1*
Consumption **Aluminium**	84.5	79.3	81.9	76.8
Recycling levels	4.3	60.3	58.5	55.8
Recycling rate in %	***5.1***	***76.0***	***71.5***	***72.6***
Consumption **Synthetics**[3)]	976.9	1 120.9	1 380.4	1 354.3
Recycling levels	30.0	651.1	755.1	784.3
Recycling rate in %	***3.1***	***58.1***	***54.7***	***57.9***
Consumption **Paper**[3)4)]	1 834.2	1 992.6	2 049.4	2 080.4
Recycling levels	514.0	1 541.9	1 659.6	1 640.9
Recycling rate in %	***28.0***	***77.4***	***81.0***	***78.9***
Consumption **Liquids packaging**	193.0	218.1	227.2	246.9
Recycling levels	N/A	134.3	144.0	159.1
Recycling rate in %	***N/A***	***61.6***	***63.4***	***64.4***
Consumption **Total**[5)]	7 646.7	7 374.8	7 269.9	6 938.4
Recycling levels	2 848.7	5 612.1	5 604.9	5 397.2
Recycling rate in %	***37.3***	***76.1***	***77.1***	***77.8***

1) based on definitions in amended Ordinance on the Avoidance of Packaging Waste as of 1998
2) GVM forecast
3) incl. composite material for each material base
4) excl. liquids packaging
5) quoted packaging materials only

Source: *Gesellschaft für Verpackungsmarktforschung mbH 2004*

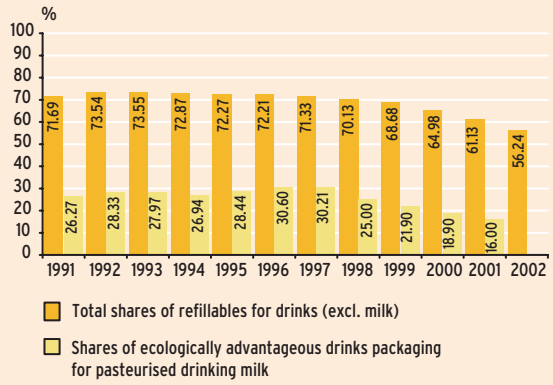
manufacturers and distributors who belong to the DSD (which handles disposal for them and provides proof of having met the quotas), but also those who dispose of waste themselves are now required to demonstrate quota compliance (paragraph 6.1-2).

Refillable drink packages are subjected to special protection under the Packaging Ordinance due to their ecological profitability. The share of refillables on the drinks market are for this reason to be the subject of annual surveys and published by the Federal Government, in accordance with paragraph 9 of the Packaging Ordinance.

According to paragraph 9 of the Packaging Ordinance at least 72 % of drinks (excluding milk) is to be packaged in refillable containers. The share of refillables (excluding milk, without vats > 5 l, post and premix) in Germany was already large in 1991 (71.69 %). After an increase and leveling off in 1992 and 1993, the trend has been downwards since 1994. In 1997, the refillable quota failed to meet the 72 % set out in the Packaging Ordinance for the first time, and it fell further in 1998. Since then, the share of refillable packaging in Germany has been falling (Fig. X 2.2-2). In accordance with the Packaging Ordinance, mandatory deposits on disposable drink packages came into effect after falling short of the quota again on 1 January 2003. The beer, mineral water and fizzy drink sectors have so far been affected as their specific respective refillable shares have sunk to below the 1991 level, despite taking into account unavoidable statistical errors (Tab. X 2.2-2). 2003 surveys show that this backwards trend was stopped by the introduction on 1 January 2003 of mandatory deposits on disposable drink packages and the refillable share rose again.

The refillables share of pasteurised drinking milk in Germany has been falling after brief growth between 1991 and 1996. The 1998 amendment to the Packaging Ordinance raised the refillable quota for pasteurised drinking milk from 17 % to 20 %, including polythene tubular bags as well as refillable packaging. Calculated on this basis, the quota in 1997 was easily met, with a total share of 30.21 %. This share has been decreasing since 1998. The legal quota for ecologically friendly milk packaging was not met for the first time. Only 16 % of pasteurized drinking milk was packaged in ecologically friendly packaging (Table X 2.2-3 and Figure X 2.2.-2).

Fig. X 2.2-2: *Shares of ecologically advantageous drinks packaging*



Source: *Gesellschaft für Verpackungsmarktforschung mbH 2004 a*

Paper consumption and waste paper recycling

In 2003, paper consumption per capita in Germany was 224 kg, producing a total consumption of 18.5 Mt Waste paper supplies, i.e., the quantities of waste paper collected by the waste paper industry and private or local authority waste management, and then returned to the paper industry or exported, was 13.6 Mt in 2003, a recovery rate of 73.7 % (Tab. X 2.2-4). The German paper industry recovered 12.4 Mt of waste paper (Fig. X 2.2-3). The share of waste paper inputs to total domestic paper production (waste paper utilization rate) was 64.5 % or 19.3 Mt in 2003. The share of waste paper supplies in areas such as corrugated paperboard production or newspaper exceeds 100 %, since sorting residues and any impurities harmful to paper quality must be removed before waste paper is processed (Table X 2.2-5). Only slight increases are expected for these types. There is a strong possibility of increase in waste paper supplies for newspapers and office and administrative paper, but also tissue, presupposing an increase in consumer demand.

Tab. X 2.2-2: *Total refillable shares for drinks (excluding milk) in %*

Drinks sector	1991	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Drinks in total (excluding milk)	71.69	73.55	72.87	72.27	72.21	71.33	70.13	68.68	64.98	61.13	56.24	63.74
Mineral water	91.33	90.89	89.53	89.03	88.68	88.31	87.44	84.94	80.96	74.03	68.33	72.98
Fruit juice and other drinks without CO_2	34.56	39.57	38.76	38.24	37.93	36.81	35.66	34.75	33.62	33.16	29.46	25.40
Soft drinks with CO_2	73.72	76.67	76.66	75.31	77.50	77.76	77.02	74.90	66.96	60.21	53.97	66.09
Beer	82.16	82.25	81.03	79.07	79.02	77.88	76.14	74.83	72.81	70.84	67.99	89.24
Wine	28.63	28.90	28.54	30.42	28.66	28.10	26.20	26.75	25.03	25.41	25.29	24.62

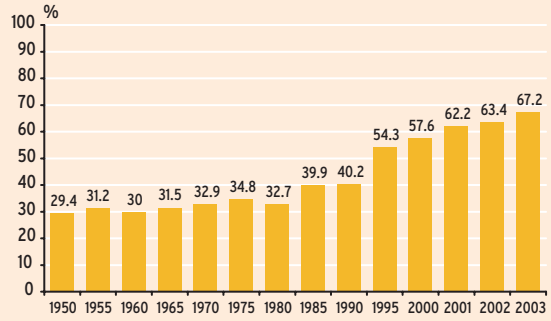
Source: *Gesellschaft für Verpackungsmarktforschung mbH 2005*

Tab. X 2.2-3: *Shares of ecologically advantageous packaging for pasteurized drinking milk in %*

	1991	1996	2000	2001
Total pasteurized drinking milk	26.27	30.60	18.90	16.00
Reusable	24.17	20.10	11.80	11.50
Tubular bag	2.10	10.50	7.10	4.40

Source: *Pack Marketing GmbH 2004*

Fig. X 2.2-3: *Waste paper recycling rate*[1)]



1) old *Länder* up to 1989, Germany from 1990
Waste paper recycling rate: Waste paper/paper consumption

Source: *Verband Deutscher Papierfabriken e.V. 2004*

Due to the increase in waste paper supplies, the German paper industry has succeeded in reducing specific sources of environmental pollution. For example, mean energy supplies for manufactured paper fell from 3.4 million wh/t in 1990 to 2.6 million wh/t in 2003. Put in perspective, this success was offset by increases in production over the same period: total energy supplies rose from 190 PJ (1990) to 260 PJ (2003). This attributes particular significance to moderating paper use in terms of continued positive environmental impacts.

The Federal Environment Agency is investigating the quantitatively significant graphic paper sector – i.e., paper used for newspapers, magazines, writing, or photocopying paper – for environmental impacts caused during its life cycle and the environmental relief potential of the use of waste paper in the production process. The most important results are:

- manufacturing waste paper is considerably more environmentally compatible than using fresh fibres from wood raw material.
- taking Light Weight Coated (LWC) news paper as an example, a comparison between LWC papers containing waste paper and that exclusively based on wood speaks clearly in favour of waste paper products: particular advantages can be seen in the impact categories of demands on natural areas, greenhouse potential, scarcity of fossil fuels, photo-oxidant potential (summer smog), aquatic and terrestrial eutrophy potential and in the ecotoxicity (environmentally toxic) and human toxicity (toxic for people) indicators.
- Recycling waste paper in order to manufacture new paper is considerably more environmentally compatible than burning waste paper for energy. Disposal of waste paper on landfill sites is the worst solution in terms of environmental protection.

Increased waste paper recycling is more favourable for almost all impact categories considered. This applies to the scarcity of fossil fuels, greenhouse potential, summer smog, acidifying potential, and overfertilisation of soils and waters. The advantage of greenhouse potential, which has top priority in terms of environmental policy, is stressed here. Another advantage to waste paper recycling is that more wood remains in forest areas and as a result the natural area potential, or the share of forest areas less intensively cultivated by man, are able to grow.

Glass recycling

In 2003, a total of 7.279 Mt of glass and mineral fibre were manufactured in Germany. Container glass was one of the main products with approx 4.207 Mt and flat glass with 1.572 Mt.

Tab. X 2.2-4: *Paper production, consumption and waste paper consumption*

		1990	2000	2003
Paper production in Germany[1)]	Thousand t	12 773	18 182	19 310
Import	Thousand t	6 931	9 818	9 949
Export	Thousand t	4 243	8 907	10 742
Paper consumption in Germany[1)]	Thousand t	15 461	19 093	18 517
Amount of waste paper[1)]	Thousand t	6 803	13 677	13 643
Waste paper consumption[1)]	Thousand t	6 212	10 992	12 449
Waste paper return rate[2)]	%	**44.0**	**71.6**	**73.7**
Waste paper processing rate[3)]	%	**48.6**	**60.4**	**64.5**
Waste paper recycling rate[4)]	%	**40.2**	**57.6**	**67.2**

1) Survey basis altered after 1985
2) Waste paper return rate: Amount of waste paper/paper consumption
3) Waste paper processing rate: Waste paper consumption/paper production (excl. consumption for waste paper material export)
4) Waste paper recycling rate: Waste paper/paper consumption

Source: *Verband Deutscher Papierfabriken e.V. 2004*

Tab. X 2.2-5: *Waste paper processing rates in Germany in %*

	1995	2000	2003
Corrugated cardboard raw paper	109	108	108
Foldable box carton	81	82	77
Other packaging paper and cardboards (excluding protective cardboard)	73	71	76
Total packaging paper and card	**95**	**95**	**97**
Newspaper	113	117	115
Other graphic papers incl. natural newspaper	9	18	21
Printing and press paper, office and administration paper	**33**	**37**	**43**
Toilet paper	**70**	**74**	**75**
Paper and cardboard for technical and specialized uses incl. protective card	**46**	**41**	**38**
Total processing rate for waste paper and cardboard types[1)]	**58**	**60**	**65**

[1)] Waste paper consumption % for paper and cardboard production (as from 1996 incl. MarktAP material)

Source: *Verband Deutscher Papierfabriken e.V. 2004*

Glass can basically be recycled and reprocessed into new products indefinitely. Since recycled glass melts at lower temperatures than the raw materials for glass production, every 1 % of recycled glass used reduces the energy consumption of the melting process by 0.2 to 0.3 %. Glass recycling therefore reduces considerably the environmental pollution associated with glass production (e.g., CO_2 emissions), and saves landfill areas, alongside the obvious savings in raw materials (quartz sand, soda, lime).

Production waste (e. g., rejects) has traditionally been recycled by glass manufacturers, although there are technical and economic limits to the use of waste glass, depending upon the quality requirements (e.g., impurities, colour) for specific products.

Container glass

Each glass manufacturing branch has specific quality requirements for the conditioned cullet. In container glass production, for which recycled glass has become the major input, the ceramics, stone, and porcelain fraction must be below 25g, the non-ferrous metals fraction below 5g per tonne of recycled glass. There are also minimum requirements on the content of ferrous metals and organic impurities (e.g., paper and synthetics). The requirements for the colour purity of the cullet entail especially high technical efforts. To produce white container glass with 50 % cullet a colour purity of 99.7 % is required. Discoloured inputs to brown glass production must remain at a ratio of 8 % or lower, and only green glass can contain up to 15 % discoloured cullet. The conditioning of cullet is a fully automated process. For technical and economic reasons, colour sorting requires that the recycled glass is collected separately by colour.

A further basic prerequisite for returning container glass to the melting process in order to manufacture new bottles and other glasses is that the collected glass is well-sorted. A pre-sorting done by the consumers is absolutely necessary. Flat glass, car glass, crystal glass and above all refractory glass such as laboratory glass, ceramic glass, Pyrex etc. are difficult to sort out in glass recycling processes and can lead to significant losses in production or to the enrichment of heavy metals in the container glass cycle, e.g., in the case of lead crystal glass.

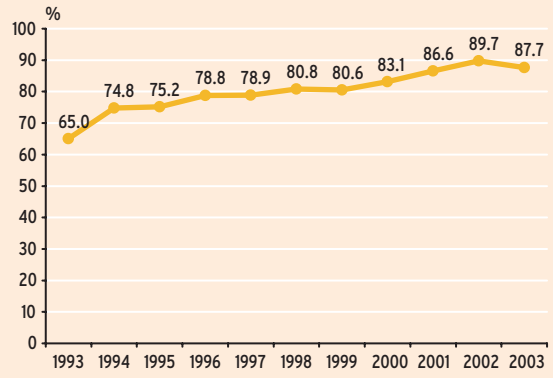
The mean cullet fraction amounted to 46 % in brown glass production, 51.4 % in white glass and 74 % in green glass in 2003. The peak value – around 70 % for white and brown glass or around 90 % for green glass – depends on the individual furnace, the glass color, and the melting technique.

A nation-wide collection system for container glass was set up in 1974. The glass is most commonly collected in separate bins for white, brown, and green glass, with over 300 000 glass recycling bins currently in use, one container for each 600 to 800 citizens

27.8 kg of glass per household were collected in 2003.

Container glass recovery in 2003 attained a quota of 87.67 % (Figure X 2.2-4 and Table “Waste glass collection and recovery in the German container glass industry”).

Fig. X 2.2-4: *Container glass recycling*



Source: *Gesellschaft für Glasrecycling und Abfallvermeidung mbH 2004*

Flat glass

Quality requirements are especially high for plate glass (e.g., that used in buildings or vehicles), and the flat glass industry therefore recycles predomi-

nantly only its own cullet or well-sorted cullet from the glass processing industry. Collection systems for recovering well-sorted and pure flat glass products have recently been established, especially in the processing industry. Glass which does not meet the purity requirements must undergo a pre-treatment process, which is currently available at ten pre-treatment plants. Cullet fractions whose quality makes them unsuitable for flat glass manufacture can be used in the production of container glass, mineral wool, sandpaper, or glass objects, for example.

The German association for Secondary Raw Materials and Waste Disposal (bvse) estimates that approximately 495 000 t of waste flat glass was produced in the construction and vehicles industries in 1998, of which some 60 % (300 000 t) was recovered.

The End-of-Life Vehicle Regulation which came into force on 1 April 1998 had no quantitative impact on glass recovery quotas within the automobile industry as the regulation did not cover compulsory glass removal or recycling. The majority of potential glass obtained from the automobile scrapping process was then, as now, disposed of along with lightweight fraction obtained during the shredding process.

The 2000 EU End-of-Life-Vehicle Directive necessitated amendments to the End-of-Life Vehicle Act. The amended regulation – now the End-of-Life Vehicles Ordinance – covers compulsory glass removal and recycling in accordance with the EU Directive. In line with this, glass must be removed and recycled.

At its 81st session the Working Group of the Federal States on Waste (LAGA) agreed that this requirement is set to be fulfilled if the total recycling quotas cited in the directive and the ordinance are met as from 2006. Due to this broad interpretation of the ordinance text, the recquirements for the dismanteling companies to remove and recycle flat glass is not fulfilled.

According to the bvse, the flat glass availability from dismantling companies have further decreased since the LAGA decision. Of around 75 000 t glass from end-of-life vehicle disposal, only approximately 5 000 t (7 %) was recycled in 2002. Also, due to stagnation in the construction industry, full use cannot be made of the available plants for processing used sheet glass products for furnace shards, in spite of a corresponding demand for raw materials in the glass industry.

Cathode ray tubes

Between 5 and 6 million colour television sets are sold each year. Add to this colour monitors.

The average use life for television sets is between 10 and 12 years.

The main fraction of the total weight of television sets or monitors is the cathode ray tube which is mainly made of glass.

Some 525 000 t of glass are used annually to produce cathode ray tubes (CRTs) for monitors and television sets in the EU. Three specialist manufacturers are active in this sector in Germany, with a circa 69 % market share.

Colour CRTs are made up of four different types of glass:

- *the screen*, or panel glass, is the main component of a cathode ray tube. The panel glass used is a barium strontium silica glass (8–13 % BaO, 2.2–8.8 % SrO). It also contains antimony (0.2–0.6 % Sb_2O_3),
- *the funnel*, or cone, requires glass with a high lead oxide content (20–24 %, depending on the year of manufacture and origin of the CRT). Modern appliances may well contain traces of strontium and barium,
- *the neck* requires lead glass (28–30 % lead oxide).
- The panel and the funnel are joined with a *glass frit*, a lead borate glass (approximately 80 % PbO).

In terms of quantity, only the panel and the funnel are relevant for recycling purposes. A CRT weighs between 5 and 20 kg, with the two glass types in a proportion of about 2/3 to 1/3 respectively.

The directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on Waste Electrical and Electronic Equipment (WEEE) came into force on the 13 February 2003 with the publication in the European Union official journal.

The directive includes a minimum recycling quota for waste electrical and electronic equipment containing CRTs of 75 % of the average weight of each piece of equipment. The re-use and recycling quota for components, materials and matter must attain at least 65 % of the average weight per piece of equipment. Fluorescent coating is to be removed. The EC-directive will be implemented nationally as a federal statutory ordinance.

Environmental friendly recycling of spent picture tubes still causes problems. Available cullet capacities for the production of CRT glass have not yet been exhausted due to high demands on processed waste glass shards. Of Europe's estimated annual cullet volume of approximately 500 000 to

700 000 t, only approximately 30 000 t of cullet were made use of in Germany in 2003, mainly for funnel glass.

Returning cullet to the melting process is advantageous in reducing energy demands for melting and considerably decreases the use of lead oxide.

In the mid-term, the implementation of improved sorting process techniques should contribute to a sharp increase in cullet supplies in funnel glass and panel glass manufacturing.

If recovered in other processes than those for CRT production, especially in view of the high lead content in funnel glass, care must be taken to prevent CRT glass from diffusely distributing heavy metals throughout products and contaminating normally heavy metal-free products and material cycles, since product use (use risk) and post-use product disposal (disposal risk) must be taken into account when considering the general good.

Discharge lamps

Around 100 million discharge lamps are currently in use in Germany. They are of a particular environmental concern due to their mercury content.

Mercury in spent discharge lamps:

- standard fluorescent tubular lamps < 15.0 mg
- single layer triple-band tubular fluorescent lamps < 7.5 mg
- compact fluorescent lamps < 7.0 mg
- high pressure discharge lamps < 30.0 mg
- special emitters 1.5 g

The new EU Directive on waste electrical and electronic equipment also aims towards a standardized disposal level for discharge lamps (recovery quota at least 80 % of average lamp weight).

The end-cap separation process is implemented for processing tubular discharge lamps. It allows large-scale clean separation of glass, metals, and fluorescents.

Compact fluorescent lamps and non-tubular fluorescent lamps (ring- and u-shaped) are dismantled by a shredding process. The quality of the cullet from the shredding process is usually insufficient for the manufacture of new lamp glass.

The companies cooperating under the Lamp Recycling Working Group (AGLV) of the German Electrical and Electronic Industry (ZVEI) process around 30 million spent discharge lamps per year.

Member companies monitor the environmental compatibility of the recycling processes and check material flows with an inspection and certification process. However, mass flow verifications have not been published, yet.

According to information from lamp glass manufacturers, full use of the available recycling capacities in lamp glass production is far from being made.

It should be taken into account that in all recycling options fluorescent lamp glass absorbs mercury via diffusion processes when in operation and depending on processing quality, dust containing mercury remains on the cullet.

For example, mercury can be released unchecked into the environment during storage via the effect of acidic media or during melting.

Mercury content in the processed glass of spent fluorescent lamps is usually between 4 and 6 mg/kg glass.

Cullet from the processing of lamp rejects in the manufacturing plants reveal an Hg-content of approximately 1 mg/kg.

With this in mind, lamp glass should only be used in processes that meet immission control legislative guidelines. According to No. 5.2.2 of the Technical Instructions on Air Quality Control (TI Air) dated 24 July 2002, mercury emissions (class 1) in waste gas may not exceed mass flow of 0.25 g/h or mass concentration of 0.05 mg/m^3.

In the near future mercury content in fluorescent lamps will decrease further. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment stipulates the following maximum per lamp mercury levels:

- compact fluorescent lamps 5 mg
- tubular fluorescent lamps (for general use)
  - halophosphate: 10 mg
  - normal-life triplephosphate: 5 mg
  - long-life triplephosphate: 8 mg

Generation and disposal of synthetic waste

In Germany, one of the world's largest synthetics manufacturers, some 10.6 Mt synthetics were processed in 2003, more than 60 % of which were thermoplastics

- polythene (PE): 2.74 Mt,
- polyvinyl chloride (PVC): 1.59 Mt,

- polypropylene (PP): 1.72 Mt and
- polystyrene (PS): 0.42 Mt.

Around 15 % of the total processed quantities were other thermoplastics, such as polyamide (PA), polycarbonate (PC), styrene copolymers (ABS, SAN), or polythene terephthalate (PET), while just under 25 % were duroplastics. PET revealed the highest growth rate in comparison with 2001.

The largest supply area for synthetics was again packaging – 33 % (2001: 29.5 %) of synthetics treated in Germany were supplied for this purpose. The construction industry continues to occupy second place with 23.5 % (2001: 24.5 %). Further significant supply areas were the vehicle manufacturing industry with 9 % (2001: 9 %) and the electral/electronics industry with 7.5 % (2001: 7.5 %). Together, these four areas consumed over 70 % of the supplied synthetics.

Synthetic waste arises during the manufacture of moulded synthetic products, semi-manufactured and final products, and after their use. Around 4 Mt of synthetic waste were produced in Germany in 2003. Of this, 1.42 Mt was allotted to PE alone, 0.49 Mt to PVC and 0.43 Mt to PP. Approximately 2.34 Mt synthetic waste were recovered, 1.67 Mt disposed of via landfills or incineration. The total recovery quota amounted therefore to over 58 % (Table X 2.2-6).

Tab. X 2.2-6: *Amount and recovery rate for synthetic waste according to origins of waste 2003*

	Amount of waste in 1 000 t	Amount recovered in 1 000 t	Recovery rate in %
Synthetics production	86	81	94.2
Synthetics processing	802	710	88.5
industrial end use	1 402	714	50.9
private end use	1 715	833	48.6
Total	**4 005**	**2 338**	**58.4**

Source: *CONSULTIC Marketing & Industrieberatung GmbH 2004*

Recent studies have shown that recovery rates differ widely according to the origins of the waste. The waste recovery rate for synthetics generation and treatment were 94 % and 89 % respectively. In contrast, only 50 % of post-consumer waste from industrial end use and households was recovered. The most significant difference between the recovery rates is mainly attributable to increased contamination and mixing of post-consumer waste.

In Germany, 94 % of the 1.67 Mt synthetic waste disposed of in 2003 originated from commercial and private use. From an environmental point of view, it would be advisable to examine the suitability of this synthetic waste for recycling in order to fraction off suitable synthetic waste types and recover them effectively, despite processing and recycling difficulties caused by contaminated synthetic waste (see Table "Recycling and disposal levels of synthetic waste from the post-consumer sector").

Evaluation of waste balances for the *Länder* according to separately collected waste electrical and electronic equipment from private households

Waste electrical and electronic equipment includes products with widely varying useful lives, retail prices and profiles of use. Owing to the broad product palette, the mix of harmful and valuable materials is hard to analyse with regard to the environment. Some particularly pollutant-rich components are mercury switches, PCB capacitors, CRTs, polyurethane foam containing CFCs, or printed circuit boards.

Proper disposal of waste electrical and electronic equipment includes removing components which contain pollutants and extracting recyclable fractions, such as precious and other metals or synthetic fractions.

The European Union passed two directives in January 2003 with the aim of reducing environmental pollution caused by waste electrical and electronic equipment under manufacturers' product responsibility.

The European directive dated 27 January 2003 on waste electrical and electronic equipment (WEEE) [1] came into force on 13 February 2003 with its publication in the European Union official journal. All Member States are to transpose this directive into national law within 18 months. Important aspects of the directive:

- separate collection, treatment and recycling of WEEE and setting collection goals and recovery quotas,
- free right of return for private households and distributors,
- product responsibility for the treatment, recycling, and environmentally sound disposal of equipment lies with the manufacturer.

The directive sets out the following key points which are to be fulfilled by 31 December 2006:

- equipment is divided up into 10 categories, each of which is to produce recycling and recovery quotas by the above mentioned deadline:
  - bulky domestic equipment (refrigerators, washing machines, etc.),

- small domestic equipment (toasters, clocks, etc.),
- IT and telecommunications equipment (computers, printers, telephones, etc.),
- entertainment equipment (TVs, stereos, etc.),
- lighting equipment (fluorescent tubes, low energy lamps, sodium vapour lamps, etc, excluding living space lighting and light bulbs),
- electric and electronic tools (drills, sewing machines, etc.),
- toys, leisure, and sports equipment (electric railways, video games, gambling machines, etc.),
- medical equipment (e.g., dialysis machines),
- monitoring and controlling equipment (e.g., smoke detectors, thermostats),
- automatic vending machines (e.g., drinks machines).

- An average of at least 4 kg per resident per year is to be recorded separately in the case of used equipment from private households (collection quota for private household equipment).

Priority is to be granted to the re-use [2] of intact equipment. For all equipment not re-used, recycling quotas [3] of between 70 % and 80 % or 50 % and 80 % [4] depending on category, are to be attained by 31 December 2006. Furthermore, concrete waste equipment processing methods for the reduction of contamination are to be carried out, e.g., removing picture tubes from TV sets or separating brominated synthetic parts (more details on this in "Glass recycling").

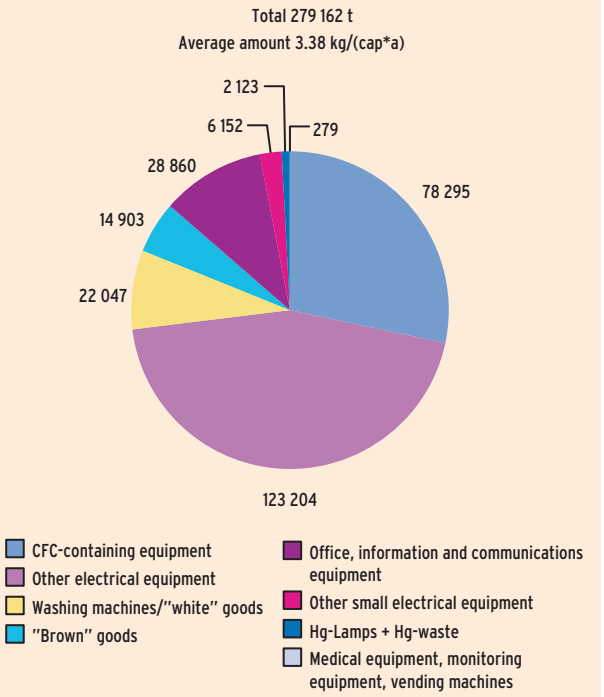
Directive 2002/95/EC on use restrictions of certain hazardous substances in electrical and electronic equipment (ROHS) [5] also regulates the use of certain heavy metals and chemicals in WEEE recently put on the market as from 1 July 2006.

In accordance with the WEEE law [6], consumers will be able to return their used WEEE to communal collection points in the future, free of charge. Manufacturer responsibility begins with collecting waste equipment from these collection points. Taking on responsibility means that the manufacturer takes care of the processing and recovery of waste equipment and fulfils recovery and recycling demands.

Waste balances for all *Länder* were evaluated against this background from the point of view of "separately collected waste electrical equipment". In February 2004 current information on separately collected waste electrical equipment was requested from all Länder to enable updating. The levels provided only explain the scale of waste electrical equipment separately collected up to the present time since no statistical support for the data could be put together. Furthermore, it is not possible to provide separate information on waste electrical equipment collected from other return points (trade, manufacturers,...).

Figure X 2.2-5 "Recorded amount of waste in t for waste electrical equipment for Germany in 2002" contains the overall figures on waste balances for Germany. The complete evaluation of the document is to be taken from the Table "Recorded amount of waste for electrical equipment from waste balances provided by the *Länder* in t". The evaluation has given rise to numerous problems:

Fig. X 2.2-5: *Recorded amount of waste for waste electrical equipment in 2002 (tonnes)*



Source: *Federal Environment Agency; IFEU Institute 2003*

- data collection was carried out in different ways by the separate *Länder*. Even cooling equipment containing CFCs is not always clearly identifiable in the waste balances. The levels of waste equipment collected from bulky (household) waste are not always clearly indicated.
- depth of the data according to equipment category also differs.
- waste balance is sometimes recorded in tonnage, sometimes according to number of items, sometimes calculated using average tonnage weight. If number of items is given in the balances, the calculation of levels is based on speculation.

Moreover, separately collected amounts from private households are not to be equated with separately

processed amounts. No figures are available for the total collected and recovered waste equipment from private and non-private households.

Overall, the data situation does not justify statistically sound statements.

As regards this current unfavourable data situation, the following data on the collection of waste equipment must be ascertained in the future:

- separately collected waste equipment from private households
- total amounts of waste equipment separately collected from private and non-private households for each category.

The Federal Environment Agency has sponsored a research project [7] in preparation for the Federal Government's duty to provide regular reports and the documentation of quotas, according to which the basic structure of a monitoring system is to be developed.

Further information on WEEE and ROHS and on WEEE law can be found under http://www.bmu.de.

[1] Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)

[2] "Re-use" describes measures where WEEE or their components are used for the same purpose for which they were designed, including the further use of equipment or its components which are taken to return points, distributors, recycling companies, or manufacturers (Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), Article 3 (d))

[3] Applicable processes in accordance with Appendix IIB of Directive 75/442/EEC (Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), Article 3 (f))

[4] "Recycling" describes the reprocessing of waste material carried out as part of a production process for the original purpose or for other purposes, excluding energy recovery, i.e., the use of burnable waste for energy generation via direct incineration with or without other types of waste, but where heat is recovered (Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), Article 3 (e))

[5] Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (ROHS)

[6] Law on market placement, return and environmentally compatible disposal of WEEE (electrical and electronic law – ElektroG) dated 16 March 2005, German Civil Code (BGB)1. I, No. 17 dated 23 March 2005

[7] Ermittlung von Verwertungskoeffizienten für die Fraktionen und Bauteile zur Dokumentation von Quoten auf der Basis von Artikel 7 der EU – Richtlinie zur Verwertung von Elektroaltgeräten (WEEE), UBA Texte 51/04, Berlin 2004 (free of charge in Germany only) http://www.umweltbundesamt.de/uba-info-medien/dateien/2825.htm)

Battery return and recovery

Battery market

In Germany, over 1 billion batteries and accumulators are placed on the market each year. This corresponds to 30 000 t in weight a year. The number of starter batteries (accumulators) amounts to approximately 14 million.

Of those primary batteries placed on the market in Germany, approximately 70 % are imported, mainly by manufacturing firms themselves. The remaining 30 % are produced by one manufacturer in Germany. Altogether, approximately 85 % of primary batteries placed on the market are imported or produced by only four manufacturers.

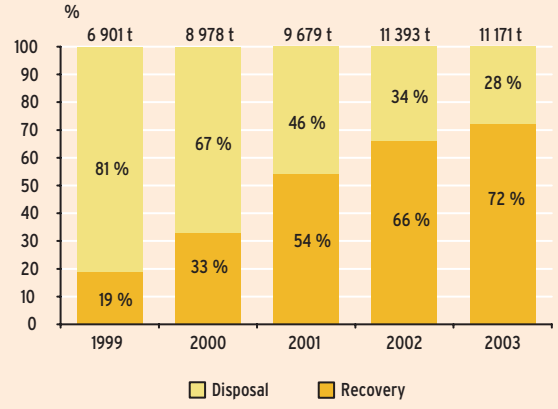
The German market for rechargeable batteries (secondary batteries) is considerably more diverse in terms of suppliers. Besides eight major suppliers who together represent a market share of around 70 %, there is a very high share of other suppliers who are mostly difficult to identify, if at all. The import share of these batteries amounts to 84 %. Only 16 % are manufactured in Germany.

Battery return and recovery

The Battery Ordinance [1] came into effect on 1 October 1998. In 2003, 11 557 t batteries were returned via the Batteries Collection System (GRS Batteries).

The recycling share, which remained at 19 % in 1999, was increased to 72 % by 2003. 8 039 t batteries were recovered. 3 132 t batteries, mainly unsortable battery mixes and non-UV coded AlMn batteries were disposed of at hazardous waste dumps (Fig. X 2.2-6).

Fig. X 2.2-6: *Share of recovered batteries in battery disposal*



Source: *Stiftung Gemeinsames Rücknahmesystem Batterien 2004*

EU Directive 98/101/EC was transposed into national law by the first ordinance on the amendment of the Battery Ordinance. As a result the mercury content in batteries is decreasing. Recycling opportunities for spent batteries have therefore considerably improved.

The collection and recycling quota for starter batteries amounts to almost 100 %.

[1] BattV – Battery Ordinance (Ordinance on the collection and disposal of spent batteries and accumulators) 2 July 2001 announcement (BGBl. I page 1486, amended via law dated 9 September 2001, BGBl. I page 2331)

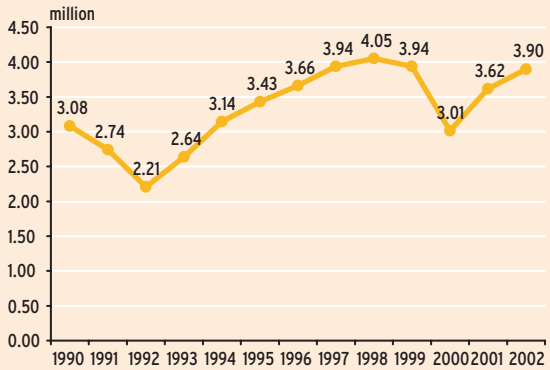
End-of-life vehicle (ELV) volumes and recycling

The precise number of end-of-life vehicles awaiting disposal in Germany is not known. This type of waste has as yet been covered only very roughly in official waste statistics. Annual statistics from the federal motor transport authorities – the Kraftfahrt-Bundesamt (KBA) where vehicles are licensed and registered under seven groups, provide an important basis for estimating ELV scrap production. According to the KBA, the most common reasons for registering vehicles as off-road are scrapping and export.

Since the reasons of the last owners for getting rid of the cars are not recorded, estimating the number of vehicles awaiting disposal is difficult. The share of permanent exports of used goods vehicles, in particular, is thought to be very high. The inadequate data also means that the number of licensed used vehicles cannot yet be determined precisely. Estimates are that some 30–50 % of final off-road notifications result in a vehicle awaiting disposal.

This section uses off-road notifications at the KBA as a rough indicator of ELV scrap production (Fig. X 2.2-7).

Fig. X 2.2-7: *Final deregistration of vehicles*



Source: *Federal Bureau of Motor Vehicles and Drivers 2003*

The Working Group on end-of-life vehicles' (now dissolved) monitoring report for the 1 April 1998 to 31 March 2000 period estimated the volume of end-of-life vehicles in Germany for the 1997 to 1999 period at approximately 1.1-1.7 million units per year. The final share of weight to be disposed of for an end-of-life vehicle was estimated by the study group (ARGE-Altauto) at 18–22 %, as relative to the corresponding 100 % motor vehicle registration weight.

Both of these trends have counteractive influences. Registrations are increasing: for example, the number of cars newly registered between 1987 and 1998 rose from approximately 2.9 million to approximately 3.7 million and from 120 to 237 thousand for heavy goods vehicles. In line with this, subsequent registration cancellations are also increasing, which raises the total quantity of end-of-life vehicles. On the other hand, increasing used car exports are reducing this volume. Reliable forecasts are therefore not available. Current data on the annual new registrations and deletions are available from the KBA.

In the future data on quantities and recovery of end-of-life vehicles will improve greatly. In 2004 the first survey on end-of-life car approval and recovery in disassembling companies was carried out under the Environmental Statistics Act. The shredders survey was improved and geared towards providing figures on vehicle recovery.

The EU Directive on end-of-life vehicles (2000/53/EC) and the German end-of-life vehicles ordinance calls for a recovery quota (including energy recovery) of 85 % of unladen weight and a recycling quota of 80 % as from 2006. These quotas apply to the total amount. They do not have to be attained for each vehicle.

Almost 100 % recovery and recycling of metallic parts from end-of-life vehicles is carried out by way of highly effective shredder separation and in subsequent sorting steps (magnetic separators, current separators, swim-sink systems).

The main problems in end-of-life vehicle recovery are currently the recycling of synthetic materials, glas,s and shredder light fraction (SLF) which occurs during the shredding process, which amount to approximately 25 % of the vehicle's original weight.

Synthetic materials and glass can be recycled in principle. The problem is the expenditure required for dismantling and sorting. There are sufficient recycling capacities in Germany for glass from end-of-life vehicles and for dismantled synthetic materials. End-of-life vehicle guidelines and ordinances call for glass and large synthetic parts to be dismantled for material recovery.

The enforcement of these regulations was however deferred until 31 December 2005 in a LAGA decision at its 81st session in September 2003. In accordance with this, these regulations are considered fulfilled if the required quotas are maintained from 2006 onward. Until 2006, the dismantling of glass and material parts or high quality recycling of non-metallic shredder output must therefore be strictly enforced. The latter is currently still being disposed of.

Mechanical sorting processes or energy recovery are possible in principle for processing or recycling SLF. Various mechanical processes are currently being worked on. These processes are based on separation in various material flows with various applications (e.g., reducers for blast furnaces, sewage sludge drying aids, or extensive inert mineral residues for waste filling). Separation of metallic residues is also being optimized. One example is the so-called VW-Sicon process which has not yet been implemented in Germany.

The only large-scale recycling process realized to date (February 2004) in Germany is synthetic gas production at the "Black Pump" secondary raw material recycling centre (SVZ).

Recycling of building waste

Building waste is quantitatively the most significant waste group (Chapter X 1.1).

Construction, architect and engineer associations, demolition companies and building trade workers combined under KWTB, an environmental umbrella organisation for the construction sector, made a voluntary commitment in 1996 to halve the 1995 quantity of stored recyclable building waste (except spoil) by 2005.

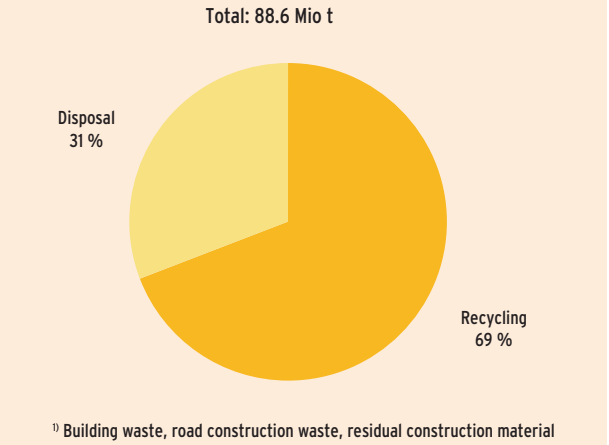
KWTB submitted the third monitoring report on the construction industry's voluntary commitment (report period 1999 to 2000) to the Federal Environment Ministry in November 2003.

According to the report, approximately 89 Mt building waste (except spoil) was accumulated during the 1999/2000 report period, of which 61 Mt (69 %) was recovered and approximately 27 Mt (31 %) was disposed of on landfill sites (Fig. X 2.2-8).

The amounts recycled are mostly used in road construction (Fig. X 2.2-9).

The life-cycle management body for construction is aiming for a further reduction in residual construction material waste by way of separating recyclable fractions on the building site.

Fig. X 2.2-8: *Amount and disposal of construction waste[1] 2000*



Source: *Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (KWTB) 2003*

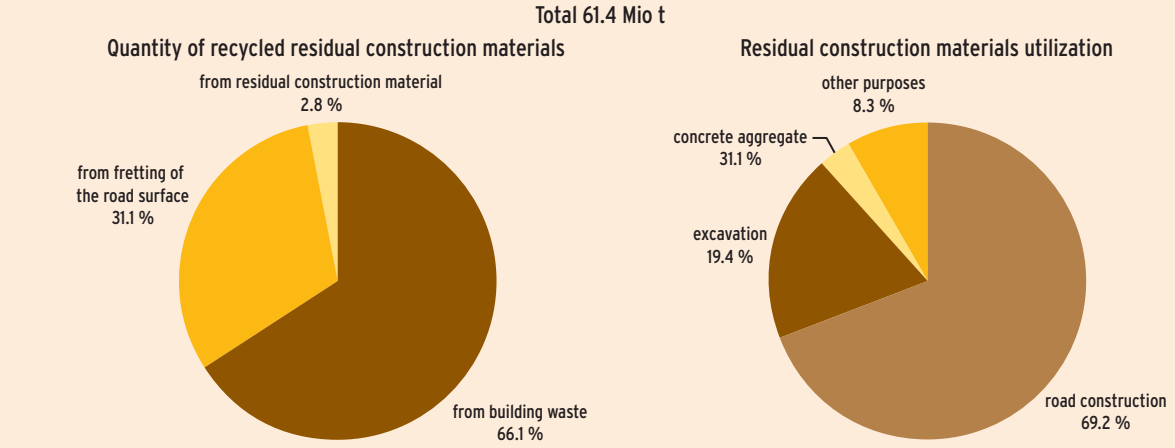
In addition, the demolition, construction, and recycling industries depend on the development of innovative demolition and processing techniques which ensure the highest possible recycling rate for the maximum possible equivalent utilisation purpose in line with sustainable construction engineering.

The majority of spoil and stone was recovered in 2000 (Fig. X 2.2-10).

Recycling mineral waste in landfills

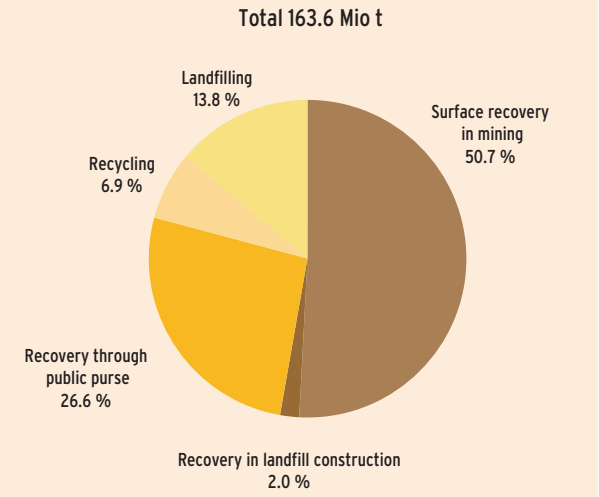
Although waste disposal is the main purpose of landfills, waste reclamation is also possible through engineering measures if primary raw materials are replaced by waste utilisation. Such engineering measures include the manufacture of sealing and drainage layers for the required surface profile or restoration layer. Mainly mineral waste such as building waste, spoil, and road construction rubble is recycled in this way, though considerable amounts of material will be required for closing down landfills. Inadequately equipped or landfills filled to capacity were closed down in large numbers in the run-up to 1 June 2005. The number of domestic waste landfills (now landfill class II) decreased between 2000 and June 2005 from 358 to 162. Almost 200 former domestic waste landfills have been closed down and require the use of large amounts of material for environmentally compatible closure. In order for these measures to ensure that the waste recycling is carried out properly and harmlessly and that deceptive recycling is prevented in accordance with the Waste Avoidance, Recycling and Disposal Act (KrW-/AbfG), the Federal Government passed the "ordinance on the recovery of waste in landfills" (BGBl. I, no. 46/2005, page 2252), effective as of 1 September 2005.

Fig. X 2.2-9: *Recycling of residual construction materials (excluding soil and stones) 2000*



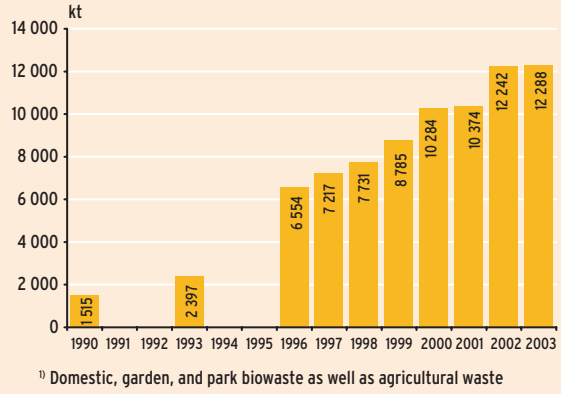
Source: *Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (KWTB) 2003*

Fig. X 2.2-10: *Amount and disposal of soil and stone 2000*



Source: *Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (KWTB) 2003*

Fig. X 2.2-11: *Biologically degradable material delivered to biowaste processing plants*[1)]



1) Domestic, garden, and park biowaste as well as agricultural waste

Source: *Federal Statistical Office 2004 a*

Collection and treatment of bio-waste

Separate collection and recycling of biogenic waste began about 20 years ago. Since then there has been a constant rise in the amount of treated biowaste (Fig. X 2.2-11). According to figures from the Federal Statistical Office [1], around 12.3 Mt biogenic waste was biologically treated, i.e., composted or fermented in Germany in 2003. These amounts cover domestic, garden and park biowaste as well as agricultural waste in composting and incinerating plants.

If domestic waste alone is taken into account, around 3.4 Mt were collected and recovered. Around 90 % of this was recycled in composting plants, 10 % of domestic biowaste was fermented in alkaline fermentation plants.

The Federal Statistical Office recorded nation-wide figures for over 1 500 composting and fermenting plants treating biogenic waste. These figures include the majority of agricultural alkaline fermentation plants and small private composting plants, a total of around 900 biowaste treatment plants. This also reflects the German quality standards group's estimate. Around 75 of these plants are fermentation plants which also produce biogas during the biowaste treatment process.

Separate collection of biowaste has a considerable influence on amounts and combination of residual waste. Residual waste levels are reduced by a third as a result of the separation of biowaste. At the same time, waste is separated from wet components, for example by mechanical sorting, which greatly facilitates subsequent residual waste treatment. See Chapter VII 3.3 for quality of collected waste and generated compost.

[1] Federal Statistical Office, http://www.destatis.de/download/d/um/entsorgung2003.pdf (29.08.2005)

X 3 Waste disposal

Unavoidable waste should be re-used as new raw material in industrial production or processed in such a way so as to allow it to be stored in an environmentally sound manner. Waste destined for final deposition is therefore to be mechanically-biologically or thermally treated to greatly reduce levels of seepage water and landfill gas being released from landfills. Strict environmental standards apply to incineration plants and mechanical-biological treatment plants.

X 3.1 Waste management

Municipal waste management facilities

Municipal waste management facilities in Germany are operated by the responsible local or municipal authorities and by private companies. They comprise landfill sites, thermal treatment plants, composting plants and others, such as waste separation plants, recycling plants, building waste reclamation plants, and mechanical-biological or chemical/physical treatment plants.

The facilities are supplied by local authority waste collection (which may be outsourced to private companies), by retailers, business and industry, as well as by private persons. Production waste is treated and disposed of by the industry itself, but it may also be sent to public facilities. Total waste quantities delivered to public landfill and thermal treatment or compost plants are shown in Figure X 3.1-1.

While a decrease in deliveries to landfill sites has been ascertained for the 1996 to 2003 period, there has been a constant increase in deliveries to incinerator plants and composting plants.

Waste management by companies

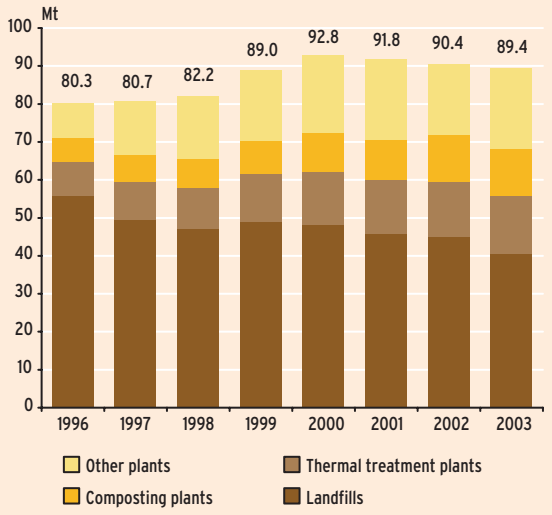
Companies may dispose of their own waste, and that of third parties, either completely or partially in their own facilities.

As in the municipal waste management sector, a fall in landfill disposal can be found, although the quantities of waste disposed of in waste incineration plants has risen by a factor of 2.6.

Other waste management

Underground stowage: Extraneous waste is disposed of as stowage in many mines in Germany. The waste is predominantly mineral which must fulfil certain quality criteria. In 1996, just under 0.97 Mt of extraneous waste was stowed in mines; in 2003 the amount was slightly higher (1.24 Mt).

Fig. X 3.1-1: *Waste disposal in waste management industry facilities*



Excluding waste requiring special supervision
1998: excluding Hamburg
2003: provisional figures
Other plants: Chemical-physical processing plants, shredding plants, Mechanical-biological waste treatment plants, soil treatment plants, other processing plants

Source: *Federal Statistical Office 2005 c*

The mining regulation which came into effect on 30 October 2002 regulates requirements in terms of type and coordination of waste recovered from mining as well as safety of the mines concerned.

Surface filling: considerable quantities of mineral waste are used to fill in decommissioned open-cast or strip mines (for raw materials such as lignite, sand, gravel, and clay).The majority of the waste is soil excavation. The quantities used here increased by about a third between 1996 and 2000 to around 98 Mt and fell again to 82.8 Mt by 2003.

Stockpiling in the mining industry: Exploring for, extracting, treating, and processing mineral ores produces mineral waste which must be disposed of. The greatest share of mining rubble is produced during coal mining; smaller quantities originate in potash and rock-salt extraction. The total amount produced in 1996 was 54.3 Mt, which fell to 46.7 Mt in 2003. The waste has been stockpiled (Tab. X 3.1-1).

X 3.2 Disposal rates for main waste streams

In interpreting the following figures on the individual main waste streams it should be noted that in the period considered several adjustments to the survey and additions to the recorded levels of waste types were made. Respective waste levels, primarily

Tab. X 3.1-1: *Waste disposal in selected waste disposal plants (delivery in 1 000 t)*

	1996	2000	2003
Waste incineration plants	**13 177**	**20 457**	**23 177**
of which: Waste management industry	8 970	13 920	15 217
in-house disposal[1)]	1 905	4 167	5 352
waste requiring special supervision	2 302	2 370	2 608[2)]
Mechanical/biological residual waste treatment plants	**551**	**1 246**	**1 509**
Landfills	**78 565**	**67 089**	**59 040**
of which: Waste management industry	55 619	48 183	40 562
in-house disposal	18 326	13 845	13 346
waste requiring special supervision	4 620	5 061	5 132[2)]
Composting plants	**6 554**	**10 284**	**12 286**
Underground landfilling	**1 482**	**1 685**	**1 238**
Surface landfilling of decommissioned open-cast or strip mines	**73 521**	**97 996**	**82 817**
Stockpiling	**54 308**	**48 187**	**46 689**

[1)] including furnaces
[2)] provisional figures

Source: *Federal Statistical Office 2005 d*

from waste disposal plant operators, have been recorded since 1996.

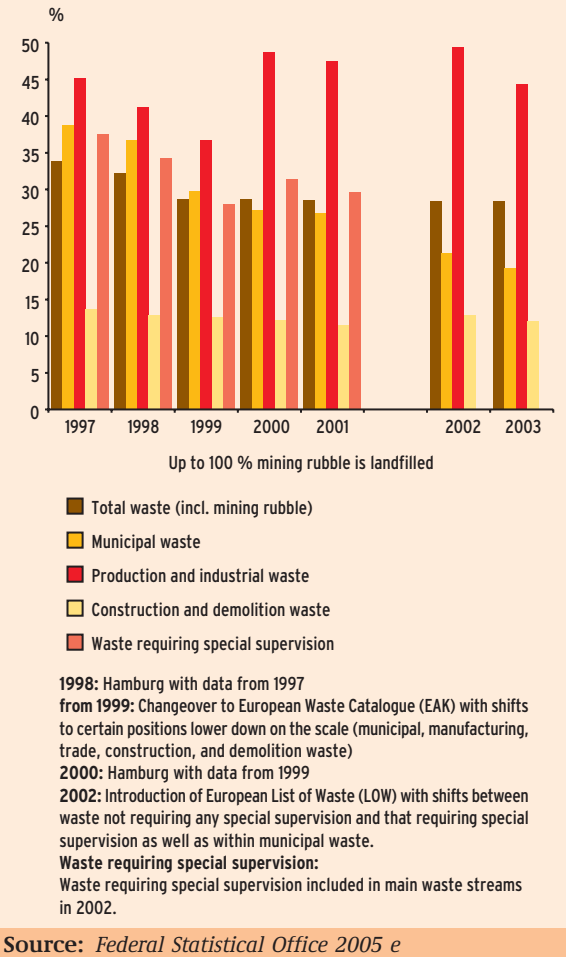
Limitations on data comparability for the period considered come to light in the changeover from the materials-oriented waste register of the Working Group of the Federal States on Waste (LAGA) used through 1998, to the origins-oriented European waste catalogue (EAK), used from 1999. This led to waste levels being shifted to certain positions lower down on the scale, particularly in the case of municipal waste, manufacturing and trade waste and construction and demolition waste. In 2002 the EAK was replaced by the European List of Waste (LOW) which resulted in shifts within municipal waste as well as between waste not requiring any special supervision and waste requiring special supervision. This caused an interruption in the time period: Up to and including 2001, waste requiring special supervision was listed as a separate waste stream; in the 2002 figures it is included under other waste types (Fig. X 3.2-1).

Furthermore, waste levels treated in-house have not been taken into account since 1999. Recovery and disposal continue to be recorded.

Altogether, waste disposal on landfills in the time period dealt with fell from 34 % (1997) to around 28 % (2003) of the amount of waste. Mining rubble is included in these figures. This waste category is almost exclusively dumped and so makes up the majority of the total dumped amounts. If mining rubble is not included in the rate disposed of on landfills calculation, 22.5 % of the amount of waste would still go to landfills. In 2003 it was 15.6 %.

Dumping of municipal waste which has not been pre-treated has been banned since 1 June 2005. By 2020 municipal waste dumping is to be completely stopped and prevention and recovery attained to the most comprehensive level possible. This calls for the establishment of concrete action goals in legal standards and the development of corresponding technologies (e.g., sorting technology), in order to allow the goals to be attained. Between 1997 and 2003 the dumping rate for municipal waste was reduced by almost half.

Fig. X 3.2-1: *Landfill rates for main waste streams*



Source: *Federal Statistical Office 2005 e*

The inconsistent dumping rate course for production and industrial waste is not currently meaningful due to specific missing time periods. The waste register changeover possibly contributes to the implausible course.

X 3.3 Waste disposal plants

Thermal waste treatment plants

Thermal treatment plants for residual municipal waste

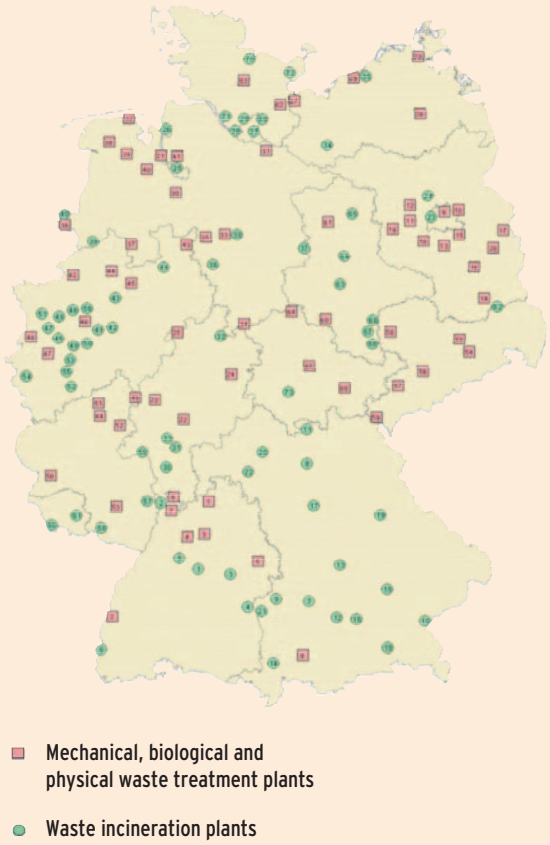
In 2003, 60 residual waste thermal treatment plants were operating in Germany, with an annual approved capacity of some 14 Mt. Triggered by the coming into force of the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001) on 1 June 2005 the Working Group of the Federal States on Waste (LAGA) surveyed incineration capacities to be available in 2005. The survey resulted in 72 waste incineration plants with an annual capacity of around 17.8 Mt currently being operated or in advanced planning stages in Germany (Fig. X 3.3-1 and Tab. X 3.3-1).

All existing waste incineration plants have energy utilisation (electricity, process steam, district heating). The total fuel use efficiency is around 47 % on average for all plants. Existing plants could produce much higher levels of energy, especially in the form of heat, if the basic conditions at the plant locations in terms of energy transfer opportunities were improved. Sewage sludge from municipal waste water treatment plants is combusted together with municipal waste in 8 plants. All plants are equipped with flue gas cleaning which complies with the 17th Pollution Control Ordinance (BimSchV). Most operate without producing sewage. Incineration ash is generally recovered. Ferrous and non-ferrous metals are separated from the ash and recycled.

Currently the only large-scale pyrolysis treatment plant for residual waste has been operating in Burgau (in Bavaria, near Ulm) since 1987, with an annual throughput of some 25 kt.

In future, energy recovery from waste combined with mechanical-biological treatment could become a significant factor. This combination places priority on a material flow-specific waste disposal, whereby the recovery process is optimized to suit each waste fraction. This way, only good combustible waste arrives at the incinerator; materials that are recycable are separated before incineration.

Fig. X 3.3-1: *Treatment plants for municipal waste for the implementation of the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities*



Source: *Federal Environment Agency 2004*

Tab. X 3.3-1: *Domestic waste incineration trends*

	Number of plants	Waste throughput capacity in 1 000 t/a	Average throughput capacity per plant in 1 000 t/a
1990	48	9 200	191
1992	50	9 500	190
1993	49	9 420	192
1995	52	10 870	202
1998	53	11 900	225
2000	61	13 999	230
2005[1)]	67	16 900	252
2007[1)]	72	17 779	247

[1)] Estimated values

Source: *Federal Environment Agency 2004*

Sewage sludge incineration and drying plants

According to the Federal Statistical Office around 2.4 Mt sewage sludge dry solids from communal sewage treatment plants were accumulated in Germany in 2001. 555 kt were incinerated, corresponding to 23 %. According to a survey carried out in spring 2004 available capacities for the incineration of communal sewage sludge were over 1.2 Mt in 2003 (Tab. X 3.3-2).

Tab. X 3.3-2: *Incineration capacities for municipal sewage sludge*

	Number of plants	Incineration capacity t/a
Mono-incineration plants	17	480 000
Co-incineration in MVAs	8	60 000
Co-incineration in coal-fired power plants	25	658 000
Co-treatment in coal gasification	1	40 000
All	**51**	**1 238 000**

Source: *Federal Environment Agency 2004 a*

The development of co-incineration in coal-fired power plants is the predominant contributory factor in recent years' increase in incineration capacities. Incineration in mono-incineration plants for sewage sludge and co-incineration in waste incineration plants has seen little expansion in recent years. It is therefore expected that more sewage sludge will be co-incinerated in power stations and industrial plants (e.g., cement plants) in the future.

Pre-drying is often required for the incineration of sewage sludge, depending on the selected incineration process. Around 70 sewage sludge drying plants are in operation in Germany for this purpose. The current annual capacity is approximately 340 kt sewage sludge dry solids.

Material recycling takes up the largest share in sewage sludge disposal. In 2001, 57.5 % of the accumulated agricultural sewage sludge was used in agricultural recovery or for composting. The share of unrecycled sewage sludge taken to landfills was about 6.6 %.

According to requirements under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001), sewage sludge may be sent to landfills only after thermal treatment or mechanical-biological co-treatment along with residual waste as of June 2005.

There are increasing reservations from the environmental and agricultural camps regarding the agricultural recycling of sewage sludge (Chapter VII 3.2). It is to be expected that the requirements on sewage sludge quality will increase in the future meaning that ever-decreasing amounts will be materially recycled and a larger share will have to be incinerated.

Hazardous waste incineration plants

The total combustion capacity at the 8 public sector and 24 company incineration plants for hazardous waste (5 of the company plants are available for the public sector) in Germany is currently approximately 1.25 Mt/a, yet only 0.8 Mt/a of this is currently in use.

This capacity is not expected to increase due to additional plants in the near future. There is a trend towards reducing capacity at some locations.

Alongside these facilities, there is a further plant where hazardous waste is treated in a thermal gasification process.

Mechanical-biological treatment plants (MBAs) for residual waste

In accordance with the requirements of the Biological Waste Treatment Plants Ordinance (Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and from Biological Waste Treatment Facilities (AbfAblV, 2001) 30th Federal Immission Control Ordinance (30. BimSchV), Annex 23 of the Wastewater Ordinance), mechanical-biological waste treatment is only permissible in MBAs with high technical standards which fulfil strict waste gas control and treatment requirements. The Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities renders important requirements in the technical instruction on recovery, treatment and other municipal waste disposal methods (Technical Instruction on Municipal Solid Waste,– TI Si) legally binding, covering landfills, particularly their technical equipment, quality of waste to be disposed of and its maximum transition period. Additional requirements are also being set on the quality and landfill technique of mechanical-biologically treated waste. According to the state-of-the-art in the case of municipal waste, these requirements can only be fulfilled inline with currently available technologies, using thermal or mechanical-biological pre-treatment.

According to a survey carried out by LAGA, 66 MBAs with a total capacity of around 7.1 M t/a will be available as from 1 June 2005 (Fig. X 3.3-1).

Storage of waste on landfills

The Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001) prohibits the storage of untreated waste failing to fulfil the landfill classification criteria by 1 June 2005 at the latest. This supports the identical waste treatment requirement in the Technical Instruction on Municipal Waste (TI Si, 1993) and invests it with higher legal standing. In line with this, exemptions are no longer permissible.

Prior to 1 June 2005 many exemptions still in existence could only be approved in case sufficient treatment capacities were unavailable. For example, well over half of domestic and trade waste was stored on landfills without pre-treatment in 2000. Of the approximately 34 Mt residual waste in need of treatment, only approximately 14 Mt was thermally treated and approximately 2 Mt mechanical-biologically treated. There was still a considerable additional treatment capacity demand to be met by 1 June 2005 through the construction of new plants (waste incineration plants and mechanical-biological waste treatment plants) and the co-use of combustion sites (energy from waste recovery).

In addition to the 34 Mt mentioned above, around 28 Mt predominantly mineral or industrial residual waste were stored on landfills accessible to the public in 2000.

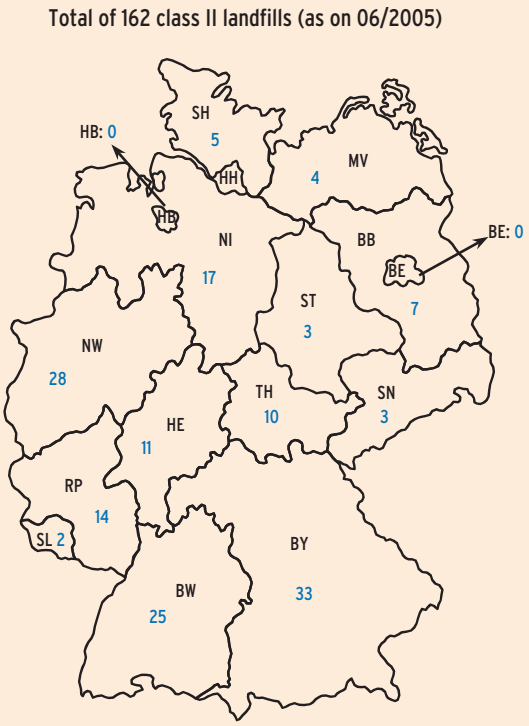
TI Si requirements on upgrading landfills (TI Si, no. 11) have been increasingly complied with in recent years. Alongside operating requirements and setting up leachate purification equipment, this essentially involves capturing, treating and, where possible, recycling landfill gas. This destroys methane, a greenhouse gas, and produces energy. Landfill sections which are already full are to be covered over, for the most part, temporarily, to allow the deposited waste to settle first and prevent any rupturing of the final surface sealing.

The sharp fall in waste dumping over recent years has led to overcapacity in landfills in Germany. When pre-treatment of waste becomes obligatory, which is always linked with a reduction in quantity, this will increase. This provides an opportunity to prematurely shut down sites which fail to comply with the TI Si while maintaining adequate disposal capacity. This would be obligatorily regulated by both of the AbfAblV and the Landfill Ordinances. Sites which do not comply with the ordinances were to be shut down in line with this by 1 June 2005 and under certain conditions by 2009 at the latest. This will result in significant relief to the soil, groundwater, and atmosphere.

In addition, this will bring an end to the competition between landfill sites erected in an effort to meet TI Si requirements, and those which do not fulfil those requirements.

Like the TI Si, Part 1 of the Technical Guidelines on Waste (TI So, covering hazardous waste) requires that hazardous waste be treated before being sent to final disposal. Strict assignment criteria for landfill disposal apply to all sites, even old ones. Amendments to the KrW-/AbfG (2001) and the Landfill Ordinance (2002) made the requirements of the TI So and the TI Si legally binding. The requirements of the EU Landfill Directive will be integrated into the Landfill Ordinance. Alongside existing technical, operational and site requirements, in TI Si and TI So, new requirements will be introduced, such as requiring a level of expertise and competence for landfill operators and sufficient financing to ensure safe and proper after-care for 30 years, or a payment scheme to cover all costs (Fig. X 3.3.-2).

Fig. X 3.3.-2: *Distribution of class II landfills (formerly: domestic waste landfills) across the Länder*



Source: *Federal Environment Agency 2005*

Climate-compatible waste management

Scientific findings in recent years have clearly shown that the pre-treatment of waste implemented under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001) protects not only soils and waters from contaminant inputs, but also makes a significant contribution to climate protection through utilisation of its energy potential and substitution of primary fuel.

The treatment of waste prior to storage leads directly to a sharp decline in methane emissions from landfills. Waste treatment is already obtaining considerable CO_2 credits through careful management and is thereby contributing to attainment of the ambitious national goal of reducing greenhouse gases within the framework of the Kyoto Protocol.

According to recent calculations by the Federal Environment Agency [1], methane emissions from landfill sites will fall from at least 1.5 Mt in 1990 by around two thirds to 0.5 Mt in 2004. This is synonymous with a decrease of around 21 Mt CO_2 equivalents. This fulfils the goal set under the October 2000 German Climate Protection Programme, to reduce methane emissions from landfills to around 0.5 Mt by 2005. This is achieved by reducing stored amounts of degradable waste and through improved thermal pre-treatment in waste incineration plants (MVAs) as well as through extensive landfill gas collection in accordance with the standards under either the Technical Instruction on Municipal Waste or the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities.

The complete cessation of storage of untreated biologically degradable waste since 1 July 2005 will lead to a further 0.1 Mt decrease in methane emissions from landfills by 2008, 0.4 Mt by 2012, synonymous with 2.1 Mt and 8.4 Mt CO2 equivalents. Compared to 1990, this corresponds to a reduction of over 90 % in methane emissions from landfills in Germany.

Pre-treatment measures also contribute to climate protection themselves: since 50 % of municipal waste has biogenous origins, its use for energy is climate neutral. In addition, larger amounts of fossil fuels can be substituted through the efficient use of energy from the remaining organic components rich in caloric value. Direct use of waste in MVAs and co-incineration waste, which is separated or separately collected in MBAs (RDF = refuse derived fuel) are considerations. According to Federal Environment Agency calculations, besides the effects of the landfilling ban for organically degradable waste, at least a further 3.7 Mt CO_2 a year can be saved through the utilisation of waste for energy.

Of this amount, around 2.2 Mt is accounted for by the co-incineration of waste components rich in caloric value as replacement fuel in industrial plants and power stations (RDF) and around 1.5 Mt by the incineration in MVAs of approximately 3 Mt of waste, landfilled to date. The expected lessening effect from co-incineration is around 22 %, related to the 10 Mt CO_2, must be saved by energy and industrial sector in line with the emission trading by 2012. The lessening effect attributable to incineration in MVAs is around 17 % of the CO_2 reduction the additional remaining sectors like private households, trade, transport etc. have to realize by 2012.

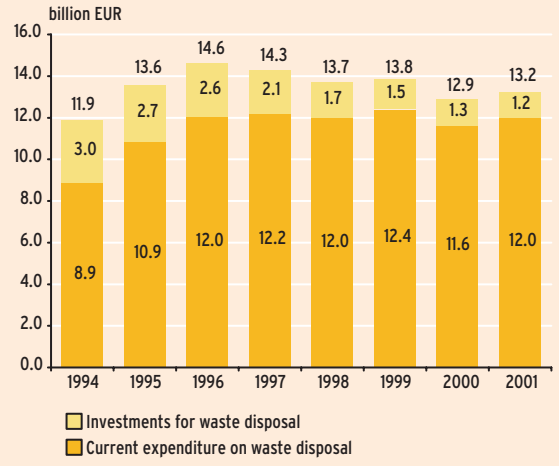
[1] Federal Environment Agency, German Greenhouse Gas Inventory 1990–2002, National Inventory Report 2004. Report presented under the United Nations Framework Convention on Climate Change, Berlin 2004

X 4 Environmental protection expenditure on waste management by manufacturing industry, government and privatised public companies

The Federal Statistical Office records what the public sector and private industry spend on environmental protection. Further information, e.g., the combined sum spent by all sectors, is available in Chapter V 2 “Environmental protection expenditure on air quality management by manufacturing industry, government and privatised public companies”.

42 % of overall expenditure on environmental protection in 2001 (13.2 billion EUR) was spent on waste management. Investments constituted approximately 9 % of this expenditure. In 1994 it was still 25 %. 91 % went towards current expenditure (Fig. X 4-1).

Fig. X 4-1: *Investments and current expenditure for waste disposal in the production industry[1)], in the public sector and privatised public companies in current prices*



[1)] Current expenditure in the production industry: Excl. fees and charges for disposal services by third parties

Source: *Federal Statistical Office 2004 b*

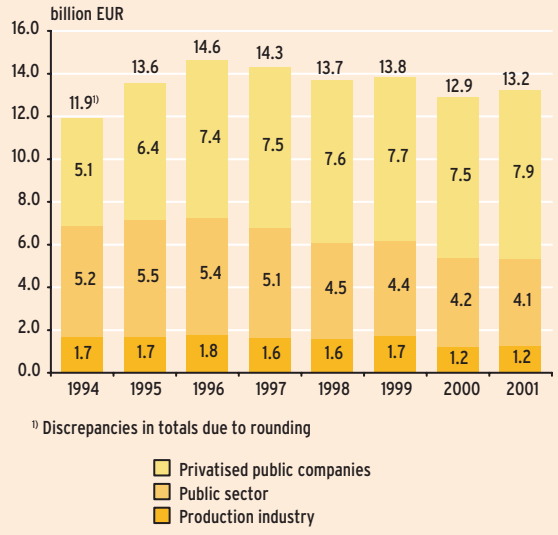
The vast majority of expenditure (about 60 %) was supplied by privatised public companies in 2001, mainly owner-operators of the waste disposal plants. Government supplied a further 31 % for waste disposal. The remaining 9 % came from manufacturing industry companies (Fig. X 4-2).

X 5 Transboundary movements of waste

Legal framework

After many years of effort to bring some order to the transboundary movement of waste, primarily

Fig. X 4-2: *Environmental protection expenditure for waste disposal in the production industry, in the public sector and privatised public companies in current prices*



Production industry: Excludes construction industry and expenditure for integrated environmental protection measures Privatised public companies: Waste disposal companies outside public budget, where government funds provide at least 50 %

Source: *Federal Statistical Office 2004 b*

waste exports from industrialised countries to the developing world, a complex system of regulations has recently been developed. The most important regulations are:

- the international Basel Convention, now with more than 160 signatory states,
- The OECD Council Decision on the control of transboundary movements of waste for recovery,
- the EC Waste Shipment Regulation, which applies directly with the force of law in all EU countries,
- the German Waste Movement Act.

Distinctions must be drawn, not only between imports and exports, but also between hazardous and non-hazardous waste. The most important regulations applicable to waste for disposal are:

- within the EU, there is a preference for self-sufficiency in waste disposal at EU and national levels, as well as for waste disposal close to the point of origin.
- movements between EU states are only permitted after obtaining written permission.
- exports of waste to non-EU countries, with the exception of Iceland, Liechtenstein, Norway, and Switzerland (EFTA-countries), are prohibited.
- waste imports for disposal to EU member states require a licence if the exporting country is a member of EFTA, signatory to the Basel Convention, or if bilateral agreements exist between the countries in question. Imports from any other country are prohibited.

Waste transferred for recovery is subject to significantly less restrictions – primarily to ensure transport safety and to verify the plausibility of the recovery method. The most important regulations applicable to waste for recovery are:

- movement of waste between EU states is subject to notification if the waste is hazardous. Most non-hazardous waste may be transported without notification with the exception of a transition period in the case of some new Member States.
- Exporting hazardous waste from the EU for recovery requires notification, providing the importing country is an OECD member. Exporting to other countries is prohibited. Exporting non-hazardous waste does not generally require notification unless any one state requires that certain types of waste be handled as hazardous waste.
- waste imports for disposal within the EU require a licence if the exporting country is a member of EFTA, signatory to the Basel Convention, or if bilateral agreements exist between the countries in question. Non-hazardous waste can be shipped without notification.

Environmental goals in transboundary movement of waste

Both German and EU law require that waste be avoided, and that recycling or re-use be given priority over disposal, and this should also apply to transboundary movement of waste.

Under EU law, wastes are considered as goods, and therefore enjoy the right to freedom of movement within the EU. The free movement of goods, including transboundary movement of waste, may not be restricted unless it fails to meet certain essential (e.g., environmental) requirements.

Recycling waste can help conserve limited resources of raw materials if conducted in an economically and environmentally acceptable form. Waste must be allowed to be moved across national borders for this purpose.

On the other hand, transboundary shipment of waste for disposal is only practical when, for example, the cross-border route to disposal facilities is significantly shorter, or there are no adequate disposal facilities in the state where it was generated.

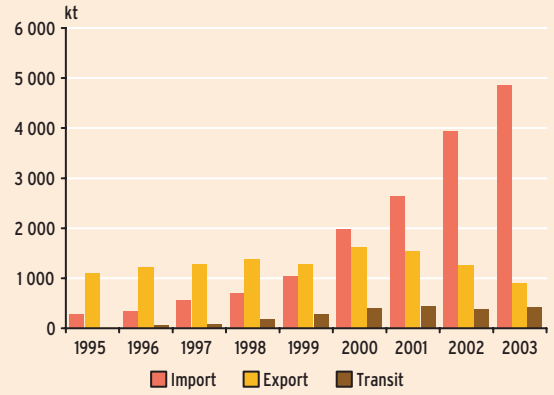
Transhipment of waste into states which do not possess the technical means to treat it without risk to the environment and their citizens must be prevent-

ed. The prohibition on exporting hazardous waste in non-OECD countries has been enforced by law since January 1998.

Trends in waste quantities

In recent years, the levels of imported waste requiring notification have experienced a sharp increase (Fig. X 5-1). It amounted to 4.9 Mt in 2003. It was 3.9 Mt the year before. The majority of the imports went to North-Rhine-Westphalia. Exports only continued to outweigh imports in Baden-Württemberg and the Saarland (Fig. X 5-2). Over half of the waste came from the Netherlands, where disposal fees have experienced a sharp increase. The export of waste requiring notification decreased in recent years and came to around 900 000 t in 2003. More waste requiring notification has been imported than exported since 2000.

Fig. X 5-1: *Import, export, and transit of waste requiring notification 1995–2003*



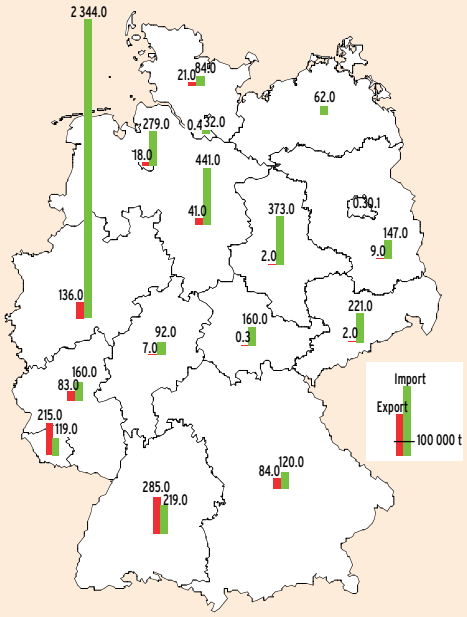
Source: *Federal Environment Agency 2004 b*

To compare: foreign trade statistics reveal import levels of over 10.3 Mt for waste not subject to notification. Exports, on the other hand, come to 15.4 Mt (Fig. X 5-3 and Tab. "Foreign trade of waste not requiring notification in kt 1991–2003"). Here, exports clearly outweigh imports, yet with a decreasing tendency.

The predominant types of disposal for imported waste requiring notification in 2003 were energy recovery (1.2 Mt), thermal treatment in incineration plants (400 000 t), recovery of metals (500 000 t), use as fertiliser in agriculture (340 000 t), landfilling (120 000 t), storage in underground landfills (500 000 t) and use as mining material (190 000 t). Approximately 800 000 t were subjected to pretreatment such as sorting and conditioning.

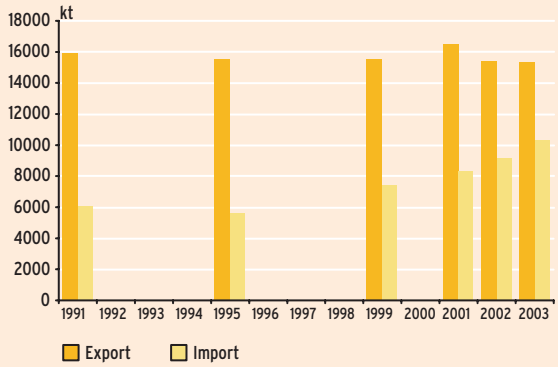
Amounts of metal recovered are an important factor in exports (260 000 t). Dumping on overseas landfills in contrast is very low (900 t). A total of only 61 000 t were exported for final disposal, all other exported waste was recovered. (Tab. X 5-1)

Fig. X 5-2: *Import and export of waste requiring notification 2003 according to Land in kt*



Source: *Federal Environment Agency 2004 c*

Fig. X 5-3: *Foreign trade of waste not requiring notification*



Source: *Federal Statistical Office 2004 c*

Monitoring – illegal waste movement

Intensive monitoring of waste exports and clear regulations for offences have resulted in no serious cases of illegal waste export during recent years. Punishments start from fines of up to 50 000 EUR for irregularities to three years' imprisonment for a criminal offence and up to ten years for particularly serious cases.

Tab. X 5-1: *Trends in the transboundary movement of waste (waste requiring notification) according to country categories 1995–2002 in kt*

	Export		
	1995	**2000**	**2003**
EU countries	821	1 370	823
EFTA countries	42	53	54
other OECD countries	24	1	2
Poland, Hungary, Czech Reublic [1]	0	1	1
Other countries	3	Export ban since January 1998	
Waste according to Article 17(3) of the EC Waste Incineration Ordinance [2]	208	203	28
Total	**1 099**	**1 628**	**906**
of which recovered	**938**	**1 541**	**843**
of which disposed of	**161**	**87**	**64**
	Import		
	1995	**2000**	**2003**
EU countries	188	1 772	4 555
EFTA countries	82	165	250
other OECD countries	3	3	2
Poland, Hungary, Czech Reublic [1]	5	35	24
Other countries	2	9	15
Total	**281**	**1 985**	**4 854**
of which was recovered	**212**	**555**	**4 223**
of which was disposed of	**69**	**429**	**631**

[1] Poland, Hungary and the Czech Republic have been OECD members since 1996 but did not adopt waste legislation agreements until some time after

[2] Waste which may normally be freely handled but is subject to a licencing obligation due to bilateral agreements with the respective import country

Source: *Federal Environment Agency 2004 d*

Glossary

acceptable daily intake	A measure of the quantity of a chemical which, it is thought, can be consumed daily over a lifetime without harm
accumulation	A build-up of harmful substances in an environmental medium, plants, or animals
old landfill	A landfill site that was operating or had applied for a permit at the time the Technical Instruction on Municipal Solid Waste came into effect
anthropogenic	Man-made
building waste	Minerals from construction activities, including with negligible amounts of foreign matter
benthos	The collection of organisms living on or in seas and lakes, consisting of animals and plants both fixed and capable of movement Benthos is made up of an extremely wide variety of organisms, depending on the depth, type of bed, water quality, temperature, etc. In many areas, the benthic zone, i.e., the habitat of the benthos, is composed of sediment. These may be of geogenic origin or attributable to dead creatures or their remains.
biowaste	Native and derivative, bio-degradable, organic waste matter contained in municipal waste (e.g., organic kitchen waste, garden waste)
biological indicators	Creatures or habitats that change in reaction to pollutant loads
biota	The combined flora and fauna of a region
biotope	Area characterised by particular types of plants and animals (e.g., a humid area) with typical environmental factors (e.g., climate)
biocide	Chemicals used to combat pests
spoil	Earth or rock material that is uncontaminated, naturally grown, or already used
recycling container	A common container, sited centrally, where recyclable waste can be separated and collected
chlorophyll	Chlorophyll (leaf green): A mixture, occurring in all green plants, of chlorophyll a (blue-green) and chlorophyll b (yellow-green), which, along with carotins and xanthophylls, is present in the chloroplasts of plant cells
CO_2 equivalent	Indicates the concentration of a gas related to its greenhouse effect compared with CO_2 as a reference substance (CO_2 = 1)
Cyprinidae	Fish of the carp/minnow family
DENOX systems	Equipment used to reduce nitrogen oxide
landfill gas	Gas primarily consisting of methane and carbon dioxide, but which also contains toxic trace materials; it is formed in the dumping site body as a result of biological decomposition processes

deposition	The depositing of pollutants from the air. A distinction is drawn between dry deposition, e.g., dust deposits, and wet deposition, e.g., the entry of pollutants via rain water.
Dobson unit	Unit indicating the ozone concentration in a column above the earth's surface. A Dobson unit equates to an ozone layer thickness of 0.01 mm at a pressure of 1 atm and a temperature of 0 °C. The ozone content is typically in the range from 300 DU to 400 DU, depending on the geographic breadth and the time of year
effective dose	Sum of the weighted average equivalent doses in the individual organs and tissues of the body. The weighting factor is determined according to the relative contributions of the individual organs and tissues to the total radiation risk of the person under whole body exposure.
emission	Air pollution (gases or dust), noise, rays, heat (e.g., waste heat from cooling towers), vibrations or similar, emitted into the environment by a (stationary or mobile) piece of equipment or by-products
final energy	The energy available to the end user after transformation and transport procedures (e.g., electricity from the socket, petrol in the tank)
endocrine	Chemical (e.g., hormone) secreted in the blood circulation system
endocrine disruptors	Chemicals that affect the hormone system, often having an estrogenic, anti-androgenous effect
erosion	The displacement of earth along the surface, caused by water and wind. While water erosion only occurs on slopes, wind erosion mainly affects flat surfaces.
eutrophic	A body of water with high primary production (oligotrophic, mesotrophic). The reason is usually a high concentration of nutrients, particularly phosphate.
eutrophication	The enrichment of water with nutrients caused by human activity constitutes eutrophication. This causes an acceleration in the growth of algae and higher forms of plant life, and leads to an undesirable disruption of the habitats present in the water and to the quality of the water. If the sea becomes overfertile, this can cause greater algae growth, displacements of species composition, and lack of oxygen due to the bacterial decomposition of dead algae.
Global Warming Potential (GWP)	The potential for global warming that a chemical has in relation to CO_2 over a given period, usually 100 years (GWP CO_2 = 1)
Helsinki Protocol	1. A sulphur protocol; agreed to in 1985, signatories undertook to reduce SO_2 emissions by 30 % by 1993 in comparison to 1980
herbicide	A chemical substance used to destroy weeds
background content (of a soil)	Comprises the soil's basic geogenic content and the ubiquitous distribution of materials as a consequence of different deposits in the soil

immissions	Releases of air pollutants, noise, vibration, radiation, or heat into the environment. The main measurements taken are the concentration of a pollutant in the air and, with dust, the amount that falls on a given surface area in a day. The Technical Instructions on Air Quality Control specify immission limits for a range of pollutants.
immission rate	The quantity of gaseous pollutants released into an environmental medium during a given unit of time
immission values	Statistical indicators used to assess pollutant immissions (percentile, annual averages). To avoid damage to the environment, immission values ought not to be exceeded. When assessing immissions, the immission values specified by the first general administrative regulations of the Federal Immission Control Regulation (technical guidelines for air pollution prevention) should be observed in order to avoid health risks and to avoid significant harm or nuisance. Moreover, the immission values laid down by the 22nd Federal Immission Control Act are legally binding.
ingestion	The taking in of chemicals along with food
inhalation	The taking in of chemicals as one breathes
incorporation	The intake of chemicals into the human body
insecticide	A chemical used to kill insects
ionising radiation	Ionising radiation occurs as either electromagnetic rays, such as X-rays and gamma rays, or particle rays, such as alpha, beta, and neutron rays. It is characterised by possessing sufficient energy to ionise atoms and molecules, i.e., to produce positively and negatively charged particles from electrically neutral atoms and molecules When it passes through matter (e.g., through a cell or an organism) the ionising radiation releases energy. If this is great enough, it can cause serious radiation damage.
ischaemic	Having an inadequate blood supply
sewage sludge	Materials containing water that can be separated from sewage by sedimentation. In a sewage treatment plant, sewage sludge accumulates in different stages.
contamination	Impurity caused by pollutants
macrozoobenthos	See zoobenthos
median	In a series of figures sorted by size, the reading that halves the series
metabolite	Metabolites are the many different types of decomposition products, formed either biochemically or enzymatically in organisms, both from higher-molecule natural precursors and from foreign matter added externally (drugs, plant protection products, and all sorts of poisons). The latter are also converted into metabolites in special decomposition processes.
nutrients	Sea water – Biologically present inorganic compounds of nitrogen (nitrate, nitrite, ammonium), phosphorus (phosphate) and silicon (silicate). Nutrients, along with different trace metals, are essential for plant production (primary production). Nutrient concentrations vary according to the season, with high values in the winter and low values when plankton blooms in the springtime.

OH radical	The hydroxyl radical, an important atmospheric oxidising agent, determines the atmosphere's self-purification capability
oligotrophic	Low in nutrients
ozone, ground-level	A colourless, poisonous gas (O_3) or, at −183 °C, a dark-blue liquid. It is created by intense sunlight in the atmosphere. It is a powerful oxidising agent and a component of "summer smog".
Ozone Depletion Potential (ODP)	The ozone depletion potential of a chemical in comparison to the CFC R-11 (ODP R-11 = 1)
persistence	Measurement of the lifetime of a chemical compound that is decomposed by chemical, physical, or biological influences (e.g., sunlight, bacteria in soil). Chemically stable, persistent elements remain part of the environment for years.
percentile	Statistical value that a particular percentage of the results of a sample comply with (e.g., a 95^{th} percentile is the value that only 5 % of the sample exceed)
pesticide	Plant protection product used to combat animal and plant organisms
phenology	The study of the seasonal timing of developmental stages in animals and plants
photolysis	The decomposition of chemical compounds caused by light
photochemical oxidants	Chemical reaction products that occur in the atmosphere under the influence of intensive sunlight, primarily from the precursors nitrogen oxides and hydrocarbons, and which possess oxidising properties. Ozone, peroxyacetylnitrate (PANs) and nitric acid are the main representatives of this group. As the primary substance of this highly-reactive gas mixture, and for reasons related to measuring technology, it is usually only the ozone content that is defined
pH value	Measurement that defines the acid, neutral, or basic character of watery solutions, represents the negative base 10 logarithm of the molar concentration of hydrogen ions. The pH value scale ranges from 1 to 14 – a pH-value of 7 indicates a neutral solution.
phytoplankton	Plant organisms of plankton, mainly algae, but also cyanobacteria and other phototrophic bacteria. The phytoplankton carries out primary production in the pelagial in the sea and freshwater.
plankton	The entire body of floating and swimming organisms in the pelagial in the sea and inland waters, insofar as they can be moved by the water. Plankton comprises different organism groups – bacterioplankton, phytoplankton, and zooplankton.
primary energy	The energy in fuels – mainly natural, such as black coal, lignite, crude oil, and natural gas – available to meet the need for energy.
buffer	Usually a solution of weak, dissociated acids or bases that are capable of absorbing added hydrogen ions or hydroxyl ions by transforming them into the undissociated state, whereby the pH value remains largely constant
pyrolysis	The decomposition of chemical compounds through heat

radioactive substances	Materials that contain radionuclides
radioactivity	The property possessed by certain chemical elements including nuclides of emitting particle or gamma rays from their atomic nucleus without any external influence
radionuclides	Unstable nuclides that dissociate into other nuclides when they emit rays
red list	The official list of threatened species in Germany, constantly under review by experts. The red lists identify all the native animal and plant populations whose stocks are endangered or which are threatened with extinction.
salmonids	Fish of the salmon family
sound level	Noise pollution is physically specified as a sound level using the decibel (dB) logarithmic unit. To simulate the complex effects on human hearing, the frequencies are also read. This A-reading gives a sound level with the unit dB(A).
sediment	Water deposits consisting of particles of solid matter, often involving animal or plant organisms
seepage water	Pollutant-rich water held in a landfill body, formed from the waste's own humidity and infiltrated precipitation, which is gathered in the drainage system above the basic seal and fed into a seepage water purification plant
smog	Term formed by combining "smoke" and "fog" and characterised by high levels of air pollution. A distinction is drawn between winter and summer smog. Winter smog mainly occurs during inversions when air pollution accumulates in the lower layer of the atmosphere (particularly SO_2 and dust). Summer smog, or "photosmog", occurs during periods of fine weather in the summer as a result of photochemical reactions between ozone precursors. Unlike with winter smog, the air pollutants that cause summer smog are not emitted into the atmosphere directly from machinery, but form there.
radiation exposure	The effect of ionising rays on the human body or its parts
stratosphere	The layer of air that extends up to 50 km above the troposphere
suburbanisation	The displacement of populations from cities to the surrounding area
tide, tidal range	Biolog. issues: tidal zone, litoral, tidal range.
tidal range:	The difference between the sea's high and low tides. The water's rise from low tide to high tide is known as the flow, or flood, in contrast to the ebb, which refers to the drop from high tide to low tide. The entire process consists of a flow and the subsequent ebb, and is called the tide.
trajectory model	A model that traces the transportation path, in time and space, of a chemical released into the atmosphere from the air to the source of the emission
greenhouse gases	Chemicals involved in the development of the man-made greenhouse effect

trophy	Trophy is the intensity of photoautotrophic (plant) production in water (primary production). Trophy is a key term in limnology and oceanography, as biomass can only be directly stored through photosynthetic light energy.
troposphere	The lowest atmospheric level, up to a height of approx. 10 km
UV(B) radiation	A particular range within the broad spectrum of sunlight responsible for sunburn in humans that can lead to acute or chronic skin and eye damage.
UV index	The highest daily value for the UV radiation which causes sunburn
fermentation	A biological decomposition process in an oxygen-free environment (anaerobic process); predominates within the landfill body; landfill gas occurs through fermentation.
acidification of the soil	Acids and acidifers entering the soil causing the buffering capability of the soil and stone to be exceeded and render irreversible damage
pre-chain emissions	The upstream emissions, from extraction, transport, production, etc., from using a product
coenose	A group of different organisms that are dependent on one another. Coenose are distinguished by various criteria and named accordingly: The entire community of all living creatures in a biotope is the biocoenose.
zoobenthos	All the creatures that always or temporarily inhabit the bed of the water between the bank or coastal area and deep waters.

Abbreviations

AA-EQS	Annual Average Environmental Quality Standard
ABl.	Official Journal
ACEA	European Automobile Manufacturers Association
ADI	Acceptable Daily Intake
AGEE Stat.	Working Group on Renewable Energies Statistics
AOX	Absorbable Organic Halides
ARGE	Working Group for Maintaining the Cleanliness of the Elbe and Weser
AVV	Waste Incineration Ordinance
BaP	benzpyrene
BBodSchG	Federal Soil Protection Act
BGBl	Official Gazette
BHKW	District Heating Plant
BImSchG	Federal Imission Control Act
BImSchV	Federal Immission Control Ordinance
GDP	Gross Domestic Product
BMVBW	Federal Ministry of Transport, Building and Housing
BNatSchG	Federal Nature Conservation Act
BSB_7	Microorganisms' biochemical oxygen demand when decomposing organic substances within seven days
CIE	International Commission on Illumination
CT	Computer Tomography
dB(A)	Decibel (frequency curve (A))
DDD	Dichloroethane
DDE	Dichloroethylene
DDT	Dichloroethane
DEHP	Di(2-ethylhexyl) phthalate
DIN	German Industrial Standard (also: Deutsches Institut für Normung e. V.)
DSD	Dual System Germany
DSP	Diarrhetic Shellfish Poisoning
DTPA	Di-ethylene-triamino-penta-acetic acid
DU	Dobson Unit
EEG	Act on Granting Priority to Renewable Energy Sources (Renewable Energy Sources Act)
EFTA	European Free Trade Association
EMEP	European Monitoring and Evaluation Program
EnEV	Energy Saving Ordinance
ERP	European Recovery Program
EU	European Union
EUR	Euros
Ew	population
Pop	Population
CFC	Chlorofluorocarbon
FW	Fresh Weight
GEP	Regional Development Plan
CTS	Commerce, Trade and Services
GuD	Gas-Fired and Steam Power Plants
GWP	Global Warning Potential
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HELCOM	Helsinki Commission
H-FBKW	fluorohydrocarbons
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
ICAO	International Civil Aviation Organization
IEA	International Energy Agency

IPCC	International Panel on Climate Change
I-TEQ	International Toxicity Equivalent (for PCDD/F)
IUCN	The International Union for the Conservation of Nature and Natural Resources
JAMA	Japan Automobile Manufacturers Association
N/A	Not Applicable
KfW	Reconstruction Loan Corporation
KAMA	Korea Automobile Manufacturers Association
KrW-/AbfG	Waste Avoidance, Recycling and Disposal Act
LABO	Federal/*Länder* Work Group on Soil Conservation
LAGA	Working Group of the Federal States on Waste
LAWA	Working Group of the Federal States on Water Issues
LEP	Regional Development Plan for a Federal State
LF	Area used for agricultural purposes (includes fields, litter meadows, gardens, orchards, specialised crops)
LSG	Landscape Conservation Area
LUCF	Land Use Change and Forestry
LWC	Light Weight Coated
MAC-EQS	Maximum Allowable Concentration Environmental Quality Standard
MAK	Maximum Workplace Concentration
MBA	Mechanical-Biological Waste Treatment Plant
MEHP	Mono-2-Ethylhexyl Phthalate
MUDAB	Database of the Marine Environment
MVA	Waste Incineration Plant
NF	Non-Ferrous
NH_x	Reduced Nitrogen Compounds
NO_x	Nitrogen Oxides
NSG	Nature Reserve
NTA	Nitrilotriacetic Acid
ODP	Ozone Depletion Potential
OECD	Organization for Economic Cooperation and Development
ÖPNV	Public Transport
OSPAR	Oslo-Paris Commission
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzodioxin
PCDF	Polychlorinated Dibenzofuran
PCP	Pentachlorophenol
PES	Primary Energy Supply
PM	Particulate Matter
POP	Persistent Organic Pollutants
RAL	Committee of the German Reich for Terms and Conditions of Sale, now: German Institute for Quality Assurance and Certification
RöV	Ordinance on Protection against Injuries caused by X-rays
RROP	Regional Planning Programme
HM	Heavy Metals
SSK	(German) Radiation Protection Commission
SUP	Strategic Environmental Audit
SuV	Residential and Traffic Area
SVE	Declaration of Voluntary Commitment
TI	Technical Instructions
TI Air	Technical Instructions on Air Quality Control
TBT	Tributyltin
TEQ	Toxicity Equivalent
DW	Dry Weight
GGE	Greenhouse Gas Emissions
DM	Dry Matter
TPT	Triphenyltin
TREMOD	Transport Emission Estimation Model

Tri	Trichloroethane
DS	Dry Substance
UMTS	Universal Mobile Telecommunications System
UN ECE	United Nations Economic Commission for Europe
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UStatG	Environmental Statistics Act
VOC	Volatile Organic Compounds
WBGU	German Advisory Council on “Global Change”
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization
WMO	World Meteorological Organization
ZuG	Allocation Act

Units

Prefixes:

m	million	= 10^6
bn	billion	= 10^9
p	pico	= 10^{-12}
n	nano	= 10^{-9}
µ	micro	= 10^{-6}
m	milli	= 10^{-3}
k	kilo	= 10^3
M	mega	= 10^6
G	giga	= 10^9
T	tera	= 10^{12}
P	peta	= 10^{15}

Units of time:

h	hour
d	day
a	year (annum)

SI Derived Units

W	1 W (watt)	= 1 J/s	Power
J	1 J (joule)	= 1 W•s (watt second)	Energy, Work, Heat Quantity
PJ	1 PJ (petajoule)	= 34.120 t CE (coal equivalents)	
T	1 T (tesla)	= 1 Wb/m^2	Magnetic Induction
Sv	1 Sv (sievert)	= 1 J/s	Dose Equivalent
Bq	1 Bq (Becquerel)	= 1/s (nuclear decay/second)	Radioactivity

Concentration measurements in aqueous samples

			Example
% percent	1 %	= 10 g/l	One sugar cube (2.7 g) in 2 cups of coffee (270 ml)
‰ (per mill)	1 ‰	= 1 g/l	One sugar cube in 2.7 l
ppm (parts per million)	1 ppm	= 1 mg/l	One sugar cube in 2,700 l (milk tanker)
ppb (parts per billion)	1 ppb	= 1 µg/l	One sugar cube in 2.7 mil. l (ship tanker) or 1 mg/m^3
ppt (parts per trillion)	1 ppt	= 1 ng/l	One sugar cube in 2.7 bil. l (Lechstausee lake) or 1 $µg/m^3$

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