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Emissions reduction for priority and priority hazardous substances of the Water Framework Directive

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16. Kurzfassung

Wichtiges Ziel der im Jahr 2000 verabschiedeten Wasserrahmenrichtlinie (WFD) der Europäischen Union ist das Erreichen des guten chemischen Zustands der Oberflächengewässer. Nach Artikel 1(c) sind dazu „spezifische Maßnahmen zur schrittweisen Reduzierung von Einleitungen, Emissionen und Verlusten von prioritären Stoffen“ umzusetzen. Für die prioritären gefährlichen Stoffe sind Einleitungen, Emissionen und Verluste zu beenden oder schrittweise einzustellen. Ziel des Projekts war es deshalb zum einen die Emissionssituation für die 33 prioritären Stoffe zu analysieren und Vorschlägen zur Emissionsbegrenzung unter besonderer Berücksichtigung der Situation in Germany zu erarbeiten. Zum anderen waren die auf EU-Ebene laufenden Arbeiten fachlich zu begleiten und zu unterstützen einschließlich der rechtlichen Prüfung der Vorschläge der EU-Kommission.

Zur kompakten Darstellung der Informationen und Daten für die 33 prioritären Stoffe wurden stoffspezifische Datenblätter erarbeitet. Die Relevanz der Stoffe für Germany wurde ausgehend von vorliegenden Monitoring-Ergebnissen, der aktuellen Verwendung und der Emissionssituation bewertet. Für die in Germany relevanten Stoffe wurden die wichtigen Emissionspfade im Einzelnen analysiert. Darauf aufbauend wurden nationale Handlungsoptionen identifiziert und beschrieben.

17. Schlagwörter
prioritäre Stoffe, prioritäre gefährliche Stoffe, Regelungen, Monitoring, Produktion, Verwendung, Emissionen, Emissionsminderung, Schwermetalle, Pflanzenschutzmittel, Maßnahmen, Flussgebietsmanagement, Datenblätter

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16. Abstract

An important goal of the EU - Water Framework Directive (WFD) is to achieve a good chemical status of surface waters. According to Article 1(c) "specific measures for the progressive reduction of discharges, emissions and losses of priority substances" must be implemented. For the priority hazardous substances, discharges, emissions and losses must be stopped or phased-out. Therefore the goal of this project was, on the one hand, to analyse the emission situation of the 33 priority substances and to work out propositions to limit emissions, taking particular account of the situation in Germany. On the other hand, the goal was to technically monitor and support the ongoing work at EU-level, including a juridical examination of the EU-Commission's proposals.
Substance-specific data sheets were compiled for the 33 priority substances in order to present the information and data in a compact form. The relevance of the substances for Germany was evaluated based on the existing monitoring data, current use and emission situation. The important emission paths were analysed in detail for those substances relevant in Germany. Subsequently, national options for action were then identified and described.

17. Keywords
priority substances, priority hazardous substances, regulations, monitoring, production, use, emissions, emission reduction, heavy metals, pesticides, measures, river basin management, data sheets

18. Price	19.	20.

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Summary

Background

The Water Framework Directive (WFD) requires that surface waters in Europe must reach a good status by 2015. The prerequisite for this is achieving a good chemical status. In the general objective of the Directive it is stated that greater protection and improvement of the aquatic environment is targeted by implementing, among other things, specific measures to progressively reduce discharges, emissions and losses of priority substances and by stopping or phasing out discharges, emissions and losses of priority hazardous substances. The Commission is to work out propositions for limits. According to Article 16, these should have been presented at the end of 2003. The WFD also provides that limits are to be set independently by the Member States themselves if no agreement has been reached at Community level by the end of 2006.

Objective

The objective of the project was to analyse the emission situation for the 33 priority substances and to elaborate proposals for limiting emissions under specific consideration of the situation in Germany. Another goal was to technically monitor and support the ongoing work at EU level, including a juridical examination of the EU Commission's proposals.

Work at EU level

With regard to possible measures to limit emissions at EU level, first of all, emission sources and discharge paths were identified and assessed with respect to their relevance (source screening). The classification scheme used to do so employs 3 categories: emission sources or paths of category 1 may result in or contribute to the potential failure of WFD objectives; for the sources of category 2 there is not enough quantitative information available and emissions are assigned to category 3 which do not contribute to the potential failure of WFD objectives. There were considerable delays in the work at EU level compared to the timetable foreseen by the WFD: the Commission only presented a "Draft for consultation – non-paper" with regard to a directive on quality standards and emission controls in summer 2004. The Directive proposal, which has been clearly amended in comparison to this, was only published in July 2006.

Legal aspects

From a legal perspective, the Draft Directive had to be measured against the standards of the WFD and general Community law. The proposed Directive is inadequate in this respect. In particular, in contrast to the guidelines of the WFD, it dispenses with Community law regulations for emission control. Instead of laying the foundation for greater harmonization at EU level, it actually results in the abolition of currently existing regula-

tions on emission control at EU level. This is only countered by the suggestion made by existing EU law that the Member States have the obligation to pass emission control measures at national level. It also contains provisions to monitor compliance with these obligations by the Member States. However, on the one hand, these lag behind the obligations to be monitored; on the other hand they are superfluous given the lack of relevant obligations.

Data sheets priority substances

Substance-specific data sheets were compiled to present the available information for the 33 priority substance in a compact form. These data sheets contain information on the following issues:

- Nomenclature and substance features,
- substance specific regulations,
- monitoring results,
- production and application,
- emission situation,
- approaches for emission abatement measures and
- literature.

Relevance of the priority substances in Germany

The relevance of the substances results in part from the available monitoring results on the pollution of German waters. Whereas there are detailed data for some of the substances (e.g. heavy metals), there are comparatively few checks for others (e.g. short-chain chloroalkanes, brominated diphenyl ethers, octylphenols). Therefore, when assessing the relevance, the existing information on production, application and emission situation was evaluated as well. The evaluations showed that, at present, the four heavy metals, the group of polycyclical aromatic hydrocarbons, the plant protection products (PPP) diuron and isoproturon as well as the tributyltin compounds are relevant for Germany. Not relevant according to this assessment are the plant protection products chlorfenvinphos and endosulfane, the chlorinated compounds hexachlorobutadiene, pentachlorobenzene and trichlorobenzene, the chlorinated solvents (1,2-dichloroethane, dichloromethane, trichloromethane) as well as pentachlorophenol and benzene. It is not possible to make a definite classification for the other substances.

Analysis of the emission situation of relevant substances/substance groups

The emission pathways (urban areas, municipal sewage plants, industrial discharges, agricultural areas, old hazardous sites/abandoned mines, products, atmospheric deposition) were analysed in detail for the substances classified as relevant for Germany.

When doing so, attention was paid to the emissions relevance (assessment of available emission data), existing ongoing emission-relevant measures and to additional starting-points for emissions reduction. The resulting emission focal points as well as possible starting points for mitigation measures are summarized in Table 7–2.

Identification of options for additional national activities

Finally, national options for action were described against the background of the main emissions identified and possible reduction measures for the individual substances relevant in Germany. The following were considered in detail:

- Urban areas: stormwater management (desealing, treatment, stormwater infiltration)
- Municipal sewage plants: advanced wastewater treatment in large municipal sewage plants (membrane filtration, adding activated carbon)
- Industrial discharges: advanced wastewater treatment in relevant sectors
- Agricultural areas: measures reducing erosion, mitigation of pesticide emissions, pollution in fertilizers
- Historical pollution/abandoned mines: emission mitigation in abandoned mines, pollution due to contaminated water sediments or sediments in ports
- Products: substance restrictions, restrictions on imported products, substitutes/reduction measures in the construction industry
- Atmospheric deposition or air emissions: emission mitigation in transport, industrial plants and domestic fuel use.

1 Introduction

The essential goal of the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 which was adopted in 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive, abbreviated in the following to: WFD) of the European Union is to achieve a good chemical state of surface waters. Under Article 1(c), "specific measures for the progressive reduction of discharges, emissions and losses of priority substances (PS)" are to be implemented. For the priority hazardous substances (PHS), discharges, emissions and losses are to be stopped or phased out within 20 years after the measures cited have been adopted at Community level. The list of priority and priority hazardous substances was established in Decision No. 2455/2001/EC of the European Parliament and of the Council of 20.11.2001. It encompasses a total of 33 substances / substance groups. 14 substances were grouped in a third category to be reviewed as possible priority hazardous substances.

More details on the specific measures to be decided are set out in Article 16 (6) among others: Accordingly, the Commission is to work out proposals for controls and "it shall identify the appropriate cost-effective and proportionate level and combination of product and process controls for both point and diffuse sources and take account of Community-wide uniform emission limit values for process controls". Under Article 16 (10), the daughter directives of Directive 76/464/EEC must also be examined. In addition, Article 10 establishes the combined approach for point sources and diffuse sources used to control discharges to surface waters. The best available techniques, the emission limit values or - for diffuse impacts – the best available environmental practices according to the relevant EU Directive which are listed in detail in the WFD are to be considered.

In the timetable set out in the WFD, a good state of surface waters is to be achieved by the year 2015, (Article 4 (1)a)[1]. For the PHS, the timetable for achieving the targets must not exceed 20 years after adoption of the Commission's proposals. The controls to implement the combined approach for both point and diffuse sources are to be set and/or carried out by the Member States by 2012. The Commission's proposals should be presented by the end of 2003 according to Article 16. If no agreement has been reached at Community level by the end of 2006, the Member States should establish emission controls themselves.

1 In Article 4 (4), this deadline can be extended by two further updates of the river basin management plan.

For Germany, the project "Identification of the sources of priority substances pursuant to Article 16 of the Water Framework Directive and Estimation of their Discharges into the German Aquatic Environment" was conducted by the Fraunhofer ISI together with the Fraunhofer IME (Böhm et al., 2002). Within the scope of this project, among other things, up-to-date data and information were compiled on the production and use of the substances in Germany and, as far as possible the quantities discharged into water were estimated. Furthermore, important starting points for measures to mitigate water pollution were able to be identified. This work formed the starting point of the study described here.

2 Project objective

Within the general framework outlined above, it was the aim of this project to analyse the emission situation of the 33 priority substances of the WFD and to come up with suggestions for emission controls. An additional objective was to scientifically monitor and support the work at EU level.

The work involved was divided into the following stages:

- Updating and supplementing the existing results on the priority substances,
- identifying emission control measures under particular consideration of the situation in Germany,
- monitoring and supporting the work at European level on the analysis of the emission situation and identification of emission mitigation methods,
- juridical examination of the EU Commission's proposals,
- workshop with final expert discussions[2].

The priority substances are very diverse in their use and formation, emission pathways, share of emissions into water as well as with regard to the quality and coverage of the available information. Therefore it made sense to group the substances together in several sets which shared some of the aspects cited (e.g. common area of application or origin, similar use/emission pathway, common data sources, comparable abatement possibilities) (Table 2–1).

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2 The presentations of the workshop conducted on 30.05.2006 are documented and available at http://www.umweltbundesamt.de/wasser/themen/stoffhaushalt/ws-prio-stoffe.htm.

Table 2–1: Classification of the priority substances according to substance group and categorization as priority hazardous (A), to be reviewed as priority hazardous (B), priority (C)

Heavy metals and their compounds
(A): Cadmium, mercury (B): Lead (C): Nickel
Polycyclic aromatic hydrocarbons
(A): PAH (hundreds of individual substances), with 5 typical representatives (B): Anthracene, naphthalene (C): Fluoranthene
Chlorinated compounds – solvents
(C) 1,2-dichloroethane, dichloromethane, trichloromethane (chloroform)
Chlorinated compounds – mainly intermediate products
(A): Hexachlorobenzene, hexachlorobutadiene , pentachlorobenzene (B): Trichlorobenzene (1, 2, 4-trichlorobenzene)
Pesticides
(A): Hexachlorocyclohexane (γ-Isomer, lindane) (B): Atrazine, chloropyrifos, diuron, endosulfane, isoproturon, simazine, trifluralin (C): Alachlor, chlorfenvinphos
Individual compounds with particular significance
(A): Brominated diphenyl ethers (pentaBDE), C_{10-13}-chloroalkanes, nonylphenols, tributyltin compounds (B): Diethylhexylphthalate (DEHP), octylphenols, pentachlorophenol (C): Benzene

3 Work at EU level

Within the scope of the Water Framework Directive, important tasks were set for the field of priority substances which were assigned different deadlines by the EU Commission. The most important points are:

- Developing a proposal for classifying the priority substances in question (by 20.11.2002),
- Proposal for quality standards and emission control measures (by 20.11.2003) and
- Review of the first list of priority substances (by 20.11.2005).

To support the work, an Expert Advisory Forum on Priority Substances and Pollution Control - EAF[3] as well as additional groups of experts were appointed in order to be able to involve Member States, specialist institutions, industry and environmental organisations in the work. With regard to possible emission control measures, to start with, the sources and pathways of the emissions were identified (source screening). As part of the supporting work conducted, "Royal Haskoning" (Netherlands) developed a general scheme to systematically distinguish the different emission sources and pathways. This approach, described in Table 3–1, is very different in parts from the approaches developed in Germany to calculate the emissions of nutrients and heavy metals (Behrendt et al., 1999; Böhm et al., 2002; Fuchs et al. 2002). The most important differences are a split between diffuse and point source emission routes (classification of the emissions occurring in run-off discharge in combined or separate systems as point source emissions), the differentiation by actual emission source in the emission routes S6 and S7 (materials – households/consumption), consideration of other emission pathways (e. g. drainage and deep groundwater, accidents, waste treatment) and the detailed analysis of emissions into the atmosphere as the cause for the atmospheric deposition of pollutants.

Based on this classification scheme, the relevance of the different emission pathways for the 33 priority substances or substance groups was then assessed. A distinction was made between the following 3 categories in order to do so:

- **Category 1:** Emission source/pathway may result in or contribute to potential failure of WFD objectives;
- **Category 2:** insufficient information
- **Category 3:** Emission source/pathway does not contribute to potential failure of WFD objectives.

3 This Forum is to continue in the future within the scope of the Common Implementation Strategy (CIS) as a working group with the contents substance selection, monitoring, quality standards, emission sources and emission control.

The evaluation consisted of several run-throughs. The Member States were involved in this process and were given the opportunity to suggest changes to the evaluations or to comment on them.

An additional work task was to compile the already existing control or emission mitigation measures at European level as well as additional measures which are being developed and which could also influence the emission situation of the respective substances.

Among other things, this project accompanied this work and commented on and supplemented the working papers. In particular, it submitted the information available for Germany on the emission situation of the individual substances.

Overall, the work at EU level was subject to considerable delays compared with the timetable foreseen in the WFD. In summer 2004, a "Draft for consultation - non-paper" was presented by the Commission for a Directive on quality standards and emission controls in the field of water policy which was commented on by the Member States (see Chap. 4). The final draft Directive was postponed several times by the Commission and was only submitted in July 2006. The WFD stipulates that the Member States are to establish controls themselves if no agreement has been reached at Community level by the end of 2006.

Table 3–1: Pattern used at EU level of emission sources/pathways

Diffuse emission sources	S1	Atmospheric deposition on the water surface
	S2	Drainage and deep groundwater
	S3	Agricultural activities (due to leaching, erosion, direct drainage)
	S4	Transport and infrastructures without connection to sewers (ships, trains, automobiles and airplanes and their respective infrastructures outside the urban area)
	S5	Accidental spills
	S6	Release from materials/constructions in areas without connection to sewers
Point sources	S7	Discharges in sewage effluents or storm water as a result of run off buildings and constructions in paved urban areas (including run off from agricultural fields connected to sewer system)
	S8	Discharges in sewage effluents or storm water as a result of to households and consumer use
	S9	Industrial activities
	S9.1	Small and medium point sources as direct or indirect emitters (non-IPPC installations)
	S9.2	Large point sources as direct or indirect emitters (IPPC installations)
	S10	Solid waste treatment
	S10.1	Landfills
	S10.2	Incineration
	S11	Losses from historically contaminated soils
	S11.1	Historical pollution of sediments
	S11.2	Historical pollution from contaminated land
	S12	Geogenic sources
Emissions to the atmosphere	A1	From agriculture and forestry
	A2	From traffic and infrastructure
	A3	From buildings
	A4	From households and other consumer use
	A5	From industry IPPC categories
	A6	From industry SME and other non categories
	A7	From waste disposal/treatment areas (landfills etc.)
	A8	From contaminated land (historical pollution)
	A9	From other emission sources

4 Legal aspects

4.1 Starting point

The objective of this project was to support the German party in the negotiations within the scope of the legislative procedure for passing an EU Directive in the domain of the law on water.

The legal necessity of introducing a legislative procedure for a Community law instrument in the domain of water results from the obligation of the European Commission pursuant to the WFD to submit proposals for

- quality standards for the concentration of priority substances in surface waters, sediments or biota (Article 16, (7) WFD) as well as
- emission control measures for priority substances which, in the case of priority hazardous substances, should consist of the cessation or gradual phasing-out of the emissions by about 2025 (Article 16 (6) and (8), phrase 1 WFD).

At the same time, a review should be made of all the environmental quality standards and emission control measures contained in the adopted individual guidelines which were based on the Council Directive 76/464/EEC of 4 May 1976 concerning pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Article 16 (10) WFD). The obligation of the European Commission to initiate the legislative procedure is met in Article 16 (1) WFD. This plans the adoption of specific measures against the pollution of water by the European Parliament and the Council as presented by the Commission.

Irrespective of the obligation to submit the first proposals by 15 December 2003 (Article 16 (8) phrase 1 WFD in conjunction with Decision Number 2455/2001/EC of the European Parliament and the Council of 20 November 2001 establishing the list of priority substances in the field of water policy and amending the Directive 2000/60/EC), the European Commission did not actually initiate a legislative procedure until 17 July 2006 with the adoption of the proposal for a Directive of the European Parliament and the Council on environmental quality standards in the field of water policy and to amend the Directive 2000/60/EC (COM(2006) 397). The presentation of this draft was preceded by other draft proposals in June 2004 ("non-paper"), April ("flying draft") and December 2005 as well as May 2006. The last of these drafts was adopted with minor changes by the Commission on 17 July 2006.

4.2 Evaluation

4.2.1 Drafts

The European Commission only partly fulfils its obligations under Article 16 WFD. True, it does perform its obligation in Article 16 (7) WFD to submit proposals for quality standards for the concentration of priority substances in surface waters, sediments or biota, but it does not keep its obligation under Article 16 (6) and (8) WFD to propose emission control measures at **community level**. Neither the non-paper nor the flying draft nor the draft of December 2005 contains any such relevant suggestions. This is not altered by the fact that the Commission actually suggests this in Article 1 of the respective drafts.

In spite of this, it is still planned to abolish existing community law emission control regulations. As a result, it is proposed that not only should there be no new regulation concept at Community level, but that already existing community law regulations should be lifted, leading to a renationalization of part of the *aquis communautaire* water law.

Nevertheless, the European Commission is not suggesting – at least not in so many words – the cancellation of Article 16 (6) and (8) phrase 1 WFD. Legally, this would have been possible. Therefore the European Commission's obligation under Article 16 (6) and (8) phrase 1 WFD would still apply, even if the European Parliament and the Council of the European Union accept their proposal. In the draft papers of April and December 2005, a community law regulation is not ruled out in the long term. Here, it is planned that the Member States will be obliged under certain circumstances to submit proposals for community regulations to the European Commission. There are legal qualms about such an amendment to the legislative procedure as stipulated in primary law. It is especially questionable whether the obligation of the Member States does not contradict the equilibrium of those involved in the legislative procedure which was laid down in the EC Treaty. This would give rise to the set-up that Member States would have substantial obligations to co-operate in the run-up to the introduction of a legislative procedure but would not have the right to initiate a legislative procedure themselves on account of the initiative monopoly of the European Commission. Accordingly, the draft of June 2004 only planned for an exchange of information of the measures taken by the Member States.

At the same time, the **Member States** are obliged, basically to the same extent that the WFD obliges the European Commission, to submit proposals for emission control and cessation measures, to include emission control and cessation measures within the scope of their national action plans. The proposals of April and December 2005 restrict themselves to repeating the wording of Article 16 WFD.

Monitoring and reporting obligations are planned as **control measures**.

4.2.2 Proposal

Neither does the proposal adopted by the Commission on 17 July 2006 contain any propositions for community law emission control measures corresponding to the requirements of Article 16 (6) and (8) phrase 1. In contrast to the preceding drafts, this is clearly stated. Among other things, the European Commission refers to already **existing** community law regulations for emission control to justify distancing itself from this issue. This argument is not tenable either with regard to content or timing. With regard to content, it is not valid since the emission control regulations cited by the European Commission do not meet the quality standards of the WFD. The argument is not tenable in terms of timing either since the European Commission cites emission control regulations which already existed before the WFD came into effect. For instance, the European Commission refers to IPPC Directive which does contain measures for emission control, but which does not contain measures for the gradual phasing out of emissions of priority hazardous substances demanded by the WFD. Furthermore, the European Commission had already submitted a proposal for an IPPC Directive before the WFD became effective. Therefore it cannot be assumed that the EC has already fulfilled its obligation from Article 16 (6) and (8) phrase 1 WFD. The other arguments presented by the EC against the regulation of emission control measures at Community level are not convincing either. Contrary to the view held by the European Commission, regulating emission control measures at community level is not in conflict with the **subsidiarity principle**. In the domain of trade measures, for example, the subsidiarity principle is not applied since this concerns an exclusive competence of the European Community. Other things can also only be prevented by regulations at Community level such as competitive distortions which, in the absence of community law guidelines, could otherwise give rise to divergent measures at the level of the Member States. There are also good arguments that the **principle of proportionality** does not conflict with a regulation. In particular, the European Commission’s reason that the costs linked with a regulation are disproportionate is tenuous. In any case, the end result of the assessment of the principles of subsidiarity and proportionality matches the estimation of the European Parliament and the Council of the European Union at the time of adopting the requirements contained in Article 16 WFD.

The waiving of existing community law regulations on emission controls is planned in the drafts and the proposal and thus, effectively, a renationalization of part of the *aquis communautaire* water law.

In the proposal the European Commission does not suggest – at least not in so many words – the abolishment of Article 16 (6) and (8) phrase 1 WFD so that its obligation under Article 16 (6) and (8) phrase 1 WFD would still apply, even if the European Parliament and the Council of the European Union accept their proposal.

Unlike the drafts, the obligation to take emission control measures to the extent in Article 16 (6) and (8) S. 1 WFD is not delegated to the **Member States**. As a result the existing obligations of the Member States to regulate and implement emission control measures remain unchanged. These concern the following. The Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (IPPC Directive) contains the obligation to make the issue of installation authorizations (environmental permits) dependent upon compliance with the best available techniques among others. Article 11 (3) g and h WFD in connection with paragraph (7) WFD stipulates that Member States should include measures to control emissions from point and diffuse sources in their national programmes by 23 December 2009 and implement these by 23 December 2012. On top of this, the Member States are obliged in accordance with Article 16 (8) phrases 2 and 3 WFD to establish emission control measures for the main sources of emissions to surface waters, if no agreement has been reached on time at Community level. Article 4 (1) a) iv) WFD clarifies the obligation of Member States to implement the provisions to reduce and cease emissions of priority substances which have either been adopted by the Community institutions based on Article 16 (1) and (8) phrase 1 WFD or by the Member States based on Article 16 (8) phrases 2 or 3 WFD. These provisions lag behind the substantive requirements made by Article 16 WFD concerning the regulation of emission control measures by the Community institutions. In particular, Member States are not forced to implement regulations to phase out emissions. The Member States bear the risk of litigation for the implementation conforming to European law. If emission control measures were regulated at Community level, the risk of litigation would be reduced to the extent that national measures would no longer be implemented if community regulations exist.

The proposal also contains **control provisions** aiming to control Member States' compliance with the obligations.

In Article 4 (5) of its proposal, the European Commission controls whether the Member States have fulfilled their reduction and cessation obligations by 2025 under Article 4 (1)a) iv) WFD. This is simply a concrete expression of the general monitoring obligations of the European Commission in its role as guardian of Community Law which was not contained in the drafts.

It should be pointed out that the reduction and cessation obligations referred to in Article 4 (1) a) iv) WFD are limited to the Member States having to implement regulations to reduce and cease emissions of priority substances if these have either been made by the Commission based on Article 16 (1) and (8) S. 1 WFD or by the Member States based on Article 16 (8) S. 2 or 3 WFD. If neither Community nor the Member States set reduction or cessation obligations, which they are not absolutely bound to do, the implementation obligation of the Member States from Article 4 (1) a) iv) WFD becomes invalid and thus also the planned monitoring of the implementation by the European Commission.

Even if the Commission or the Member States make provisions and the Member States thus have an obligation to implement them, the proposal stipulates that implementation will only be monitored in 2025. In this respect, it should be noted that under Article 11 (7) WFD the Member States are obliged to put the measures contained in their national programmes into practice by 22 December 2012. This obligation would be eroded by the stoppage until 2025.

According to Article 4 (1) to (4) of the proposal, the Member States are also obliged to compile and deliver an inventory of the emissions, discharges and losses of relevant substances to aid the European Commission in carrying out their monitoring obligations.

4.3 Options

Within the legislative procedure, Germany has the possibility to influence the substantive design of the Directive within the limits of Article 251 EC. Alternatively, there is the possibility to demand of the European Commission under Article 232 EC within the scope of a complaint for failure to act the submission of a proposal containing community law emission control measures corresponding to the requirements of the WFD. Independently of this, once the deadline of 22 December 2006 has passed, Germany is obliged under Article 16 (8) S. 1 WFD to set control measures for the main emission sources for all surface waters which are affected by these emissions, as far as no agreement at Community level has been reached. This obligation applies in addition to the obligation under Article 4 (3) g) and h) in conjunction with (7) WFD, to plan and implement emission control measures within the scope of the national programme of measures.

4.4 Position of the German Federal Government

The German federal government has commented on the proposal. The researchers involved in this project provided support for the German presentation. The Federal government favours the introduction of a community level concept of emission control measures. Accordingly it argues on the one hand in favour of adopting suitable provisions for emission control and cessation in the proposal (obligation to comply with the best available technologies also on the part of operators of non-IPPC installations, limiting emissions of diffuse sources according to the best environmental practice, substance regulations with regard to phasing out emissions of priority hazardous substances, setting up an information exchange). On the other hand it rejects the suggestion to waive existing community emission control regulations if these are not replaced by equally effective substitutes at community level. In addition, it supports the monitoring provisions contained in the proposal and demands congruence with the provisions, compliance with which should be controlled. With regard to setting environmental quality standards, it demands modifications and greater specifications.

5 Priority substance data sheets

Within the scope of the research project "Identification of the sources of priority substances pursuant to Article 16 of the Water Framework Directive and Estimation of their Discharges into the German Aquatic Environment", all the data available in 2001/2002 on the production and use as well as the emission situation of the 33 priority substances were recorded in detail and evaluated (Böhm et al., 2002). These assessments were continued and the results updated accordingly. Due to the significance of the priority substances for water protection and management as well as some other environmental areas, numerous additional studies have since been published. Among others, the following are cited:

- Risk assessments within the scope of the EU Chemical Risk Assessment: cadmium (Final draft, 2003), octylphenol (2005), SCCP (update, Draft 2003 and Final Draft 2005), trichloromethane (Draft, 2003), anthracene (Draft 2003), DEHP (Final Draft), penta-, octa-, decaBDPE (Final); coal tar pitch (Draft);
- OSPAR documents on hazardous pollutants (e.g. on cadmium, 2004; octylphenol, 2004; trifluralin, 2005; trichlorobenzene (update, 2005);
- EU level work partly in preparation for or as background to new regulations: Community Strategy concerning Mercury (COM(2005) 20 March 2005), POP-Ordinance (2004), Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and PAH in the atmosphere, amendment of the battery directive, PAH concentration in plasticizer oils and tyres (2005), restrictions on trichlorobenzene (2005), limit on the cadmium content of fertilizers, strategy for the sustainable use of pesticides (2006);
- Inventory records of the German *Länder*;
- results of new research projects: e. g. UBA texts 19/05: emissions of Cu, Zn and Pb; MUNLV-NRW: studies on the emission and elimination of hazardous substances in municipal sewage plants; BUWAL: Cd concentrations in zinc products;
- Results of the European emission inventory EPER (European Pollutant Emission Register) for the year 2001;
- Information from industrial associations and companies.

The data were compiled in substance-specific data sheets (see Annex) in order to present the up-to-date information on the priority substances in a compact form. These data sheets are also published on the Internet. The general layout of the data sheets is described in Table 5–1.

Table 5–1: General structure of the data sheets on the priority substances

1	**Nomenclature and substance properties**	• CAS number, IUPAC name, EINECS number • Atomic weight, molecular weight • Physical state, colour • Chemical-physical substance properties (water solubility, density, vapour pressure, etc.) • Degradability • Bioaccumulation • Toxicity/ecotoxicity
2	**Substance-specific regulations**	• Related to emissions to water and water quality • Related to emissions to air • Related to emissions to soil • Related to emissions from commodities • Classification and labelling
3	**Monitoring results**	• Analytics (determination method, determination limits) • results of inventory measures of the German *Länder* and the River Basin Communities • other results water/sediment, waste water, sewage sludge • where necessary data on air pollution as well
4	**Production and use**	• Production in Germany/Europe • Applications in Germany/Europe
5	**Emission situation**	• water-relevant emission pathways, emission amounts
6	**Approaches for emission mitigation measures**	• Results of the EU projects • additional approaches for measures
7	**References**	

6 Relevance of the priority substances in Germany

The significance of the 33 substances classified as priority substances or substance groups at EU level varies for Germany. Substance selection was based on the COMMPS method (**C**ombined **M**onitoring-based and **M**odelling-based **P**riority **S**etting), for which water concentration measurements (monitoring data) were available throughout the EU, or, model-based data if an insufficient amount of measured data were available (modelling data). Decision number 2455/2001/EC in 2001 established the list of substances. The majority of the data used originate from the period 1994 to 1998.

In order to be able to make an up-to-date assessment of the relevance of the substances for Germany, two aspects were analysed for each substance:

1. Assessment of the available information with regard to production and use as well as the emission situation in Germany (→ What volume of emissions can be expected for the respective substance in Germany?)
2. Assessment of current monitoring data (→ What is the current level of pollution of German waters with regard to the priority substances?)

The evaluation under 1 is of particular relevance for those substances for which there are insufficient (e.g. due to insufficient or varying methods of analysis) or disputed (different results in different river basins) monitoring data.

6.1 Production, use and emissions in Germany

For the substance groups classified in Table 2–1, a summary was made of the most important information on use, emission-relevant regulations and emission situation. More detailed data are contained in the respective data sheets (see Annex).

Heavy metals (Hg, Cd, Pb, Ni):

- ***Use:***

Nickel and lead, but also cadmium and mercury are still being used in Germany in large quantities. The very wide range of applications in different fields in the past has since been largely curtailed for Cd and Hg. For Hg, the most important application in terms of quantity is chlor-alkali electrolysis. Apart from this, Hg continues to be used in dental treatment, fluorescent lamps and mercury batteries. Ni/Cd batteries are the most important application for Cd. It occurs as an accompanying element of zinc as well as in phosphate fertilizers due to Cd impurities in the ores used to extract the phosphate. The number of relevant applications of lead is much larger: among others it is used in batteries/storage batteries, semi finished materials, alloys, the construction industry, cars, munition, fishing and scuba diving. The most important areas of nickel application are steel coating and the manufacturing of nickel alloys. Apart from these, nickel is also used in batteries/storage batteries, catalytic converters and pigments.

- ***Regulations:***

Corresponding to the many different areas of application there are a very large number of regulations which restrict the use (e. g. Prohibition of Chemicals Ordinance and Ordinance on Dangerous Substances, Fertilizer Ordinance, Battery Ordinance, Electrical and Electronic Equipment Act, EU End-of-life Vehicle Directive) or the emission volumes (Wastewater Ordinance, Wastewater Charges Act, Sewage Sludge Ordinance, Federal Immission Control Acts, EU Water Protection Directive, etc.).

- ***Emission situation:***

It is not possible to accurately assign the resulting emissions to the different applications given the high degree of interlinking of the various product, wastewater, exhaust gas and waste pathways. However, within the work of Fuchs et al. (2002) and Böhm et al. (2002), a balance sheet of the relevant emission pathways for a total of 8 heavy metals was able to be determined. The most important emission pathways according to this are the high emissions from urban and agricultural areas as well as from municipal sewage treatment plants. To a much lower extent, industrial wastewater treatment plants, atmospheric deposition and historical pollution also contribute to a pollution of surface waters in Germany (see Chap. 7.1).

- ***Relevance:***

To sum up, there is a high relevance of all four heavy metals for Germany with regard to use and the current emission situation.

Plant protection products (alachlor, atrazine, chlorfenvinphos, chloropyrifos, diuron, endosulfane, hexachlorocyclohexane, isoproturon, simazine, trifluralin):

- ***Use:***

The substances or the relevant products are partly manufactured in Germany and used predominantly as plant protection products in agriculture but also in gardens and parks. Some substances are also used as biocides on a small scale.

- ***Regulations:***

EU/national regulations for plant protection products (Pesticide Directive or Plant Protection Products Ordinance).

- no (longer) permitted: alachlor, atrazine, chlorfenvinphos (31.12.2007 is the deadline for essential use), endosulfane, HCH, simazine;
- (still) permitted: isoproturon, trifluralin, diuron, chloropyrifos (authorization until 31.12.2015 for 2 products).

Possible authorizations for chloropyrifos in biocide applications (as an insecticide, miticide and products against other arthropods)[4] and diuron[5] (as an anti-fouling, earthenware preservative, film preservative and masonry preservative) are currently being examined at EU level.

- ***Emissions:***

According to existing emission estimates, the most important emission pathways are agricultural areas, municipal sewage plants and atmospheric deposition. The main emission source is estimated to be a non-determined use of plant protection products (PPP) and farmyard run-offs in which pesticides are emitted to the municipal waste water system when cleaning the application equipment if the water used for washing is not properly disposed of (discharge via the sewage plant as point source). Soil erosion continues to be seen as a relevant diffuse source. Other point sources, in comparison, e.g. the manufacture of plant protection products, are rated as less relevant for Germany (EAF 2003a).

- ***Relevance****:*

Of the active substances permitted in Germany, isoproturon is classified as particularly relevant because of the high quantity used and its application to unplanted fields. Diuron, trifluralin and chloropyrifos are also permitted in Germany and the EU. In the monitoring by the *Länder*, which identified isoproturon and diuron as relevant, some other priority pesticides were also identified whose use is no longer permitted in Germany.

Chlorinated interim products (hexachlorobenzene, hexachlorobutadiene, pentachlorobenzene, trichlorobenzene):

- ***Use:***

The substances hexachlorobutadiene, pentachlorobenzene and hexachlorobenzene are no longer manufactured or used in Germany according to existing information. Hexachlorobenzene was included in the list of substances in Annex A of the Stockholm Agreement on persistent organic pollutants (POPs), for which a ban on production and application is planned. This ban was implemented within the European Union in the EU Ordinance 850/2004.

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[4] Review until 2008

[5] Review as anti-fouling product until 2008, other applications until 2010

Trichlorobenzene is only produced in Europe by Bayer AG in Germany, which only supplies the product to customers who have to confirm in writing before delivery that they will only use the substance as an interim product. It is used to manufacture plant protection products, pigments and colours.

- ***Regulations:***

The compounds are strictly regulated in both Germany and the EU (Ordinance on Plant Protection Applications, Wastewater Ordinance, 2005/59/EC restricting the use of trichlorobenzene). The EU Ordinance 850/2004 forbids the production and use of hexachlorobenzene. Hexachlorobutadiene is a POP-candidate under the UN-ECE POP protocol.

- ***Emissions:***

To a small extent, these chlorinated interim products can occur as a by-product of chlorine chemistry. Within the work on the POPs, an emission inventory is currently being developed for unwanted emissions of HCBs. Furthermore, as a result of previous applications or production sites there are some contaminated sites or contaminated river sediments which may result in pollution of the environment and water. In addition, within the national action plan on POPs, Germany reports that about 1,500 kg of hexachlorobenzene are emitted each year due to the use of fog-generating munitions for training purposes in the military (BMU, 2006). These emissions should cease in the medium term due to the use of alternative substances.

Trichlorobenzene was previously frequently used in open applications such as transformer oils in combination with PCB (banned in Germany since 1984) or as a carrier in the textile industry (no longer used according to CSTEE). Trichlorobenzene also occurs during decomposition of lindane in the environment.

- ***Relevance:***

These substances only have minor relevance for Germany with regard to their use and emissions. This relevance is expected to decrease still further in the future due to the existing extensive restrictions and the measures planned to cut the remaining emissions.

Chlorinated solvents (1,2-dichloroethane, dichloromethane, trichloromethane):

- ***Use:***

1,2-dichloroethane, dichloromethane and trichloromethane are produced in large quantities in Germany and used mainly as interim products in synthesis processes. Other applications are as industrial solvent and extracting agents. A smaller share is used for solvent applications in non-industrial fields (especially dichloromethane as a paint stripper to remove coatings).

- ***Regulations:***

In wastewater, these solvents are generally recorded and regulated via the Wastewater Ordinance (AbwV) in the sum parameter AOX. For air emissions, there are restrictions based on the Federal Immission Control Act (BImSchG) such as, e.g. the 31^{st} BImSchV (implementation of the VOC Directive) or the German Technical Instructions on Air Quality Control (TA-Luft).

- ***Emissions:***

The use as a solvent is estimated to be the main emission source. Some of the trichloromethane used as a solvent is discharged into surface waters via wastewater (EU-RAR 03) and into the atmosphere. The bulk of dichloromethane is emitted to the air from open applications. Atmospheric deposition can be classified as low. Direct emissions are expected to continue from the production and use as interim products as well as from waste disposal.

- ***Relevance:***

All three substances are classified as relevant for Germany with regard to the amounts used and the emission situation.

Polycyclical aromatic hydrocarbons, PAH (anthracene, fluoranthene, naphthalene, PAH):

- ***Use:***

Of the group of polycyclic aromatic hydrocarbons, only anthracene, naphthalene and, in very small amounts, fluoranthene are manufactured in Germany. They are used to produce dyes and as interim products.

The use of creosote as a wood preservative has been greatly restricted in the past and is only permitted in some commercial and industrial applications.

- ***Regulations:***

The emissions to water are restricted in the Wastewater Ordinance (AbwasserV Annex 46, coal coking). The Air Quality Directive 2004/107/EC regulates the PAH alongside Cd, Hg and Ni. The restriction directives for creosote (2001/90/EC) and PAH in plasticizer oils and tyres (2005/69/EC) are translated into German law via the German Chemicals Prohibition Ordinance (ChemikalienverbotsV).

- ***Emissions:***

So far, there are no complete emission estimates for water; these are currently being compiled in an ongoing UBA research project.
There are low emissions to water from production processes. The emissions to the environment take place primarily as a result of combustion processes (domestic fuel use, industrial furnaces, transport) and via the atmospheric deposition into water. Another source of emissions is due to historical contamination such as creosote-treated wood or tar-oil paints used in the past for under water steel constructions or ships.

- ***Relevance:***

The PAH have high relevance because of their high emissions to the atmosphere with subsequent deposition.

Other individual compounds ($C_{10\text{-}13}$-chloroalkanes, pentachlorophenol, benzene, nonylphenols, octylphenols, tributyltin compounds, brominated diphenyl ethers, DEHP):

- ***Use:***

In the past, **short-chain chloroalkanes** ($C_{10\text{-}13}$-chloroalkanes or short-chain chloroparaffins SCCP) were used among others as high pressure lubricant additives in metal working, degreasants in the leather industry, flame proofing agents for example in textile and rubber applications as well as softeners/binding agents in paints, sealants and adhesives. Restrictions were placed on the first two fields of application in 2002, to take effect from 2004; the total amounts used have been decreasing clearly over the last few years at EU level. Short-chain chloroalkanes have not been produced in Germany since 1998 and are only being used in very small quantities. However, certain amounts are still occurring via imported products. In addition, medium-chain chloroalkanes contain up to 1 % short-chain chloroalkanes.

Nonylphenols are used to produce adhesives and varnishes as well as providing the base material for the manufacture of nonylphenol ethoxylates (NPEO), which are used as tensides or emulgators in large quantities in a wide variety of applications. Due to national and EU restrictions, however, there has been a clear drop in the amounts used. **Octylphenol** is only used in small amounts in Germany. In the EU, an important application is its use as an adhesive hardener in the rubber for tyres.

The by far most important, albeit now strongly restricted, area of application of t**ributyltin compounds** is their use in anti-fouling paints for ships. In the past, these compounds were also used as disinfectants or biocides for wood preservation or in products such as leather, paper and textiles. Emissions may also result from production–related tributyltin impurities in mono- and dibutyltin compounds.

The use of **pentachlorophenol** (PCP) as a wood preservative/fungicide has been prohibited in Germany since 1989. The concentration of PCP in the environment is decreasing. Possible emission sources include previously treated or imported products (e. g. leather).

Benzene is the most important basis for the aromatic interim products in the chemical industry (styrene, cumol) as well as for the group of cyclo-aliphatic compounds (cyclohexane). Benzene is a component of carburettor fuels.

Brominated diphenyl ethers (BDEs) are used as additive flame-proofing agents in synthetics and textiles. Whereas penta- and octa-BDE, which are classified as PHS, have been banned since 2004, the use of deca-BDE is still permitted.

While in the 90s, **DEHP** was the most important PVC softener in the EU in terms of the quantities used (more than 500 000 tons per year), since its legal classification as toxic to reproduction, Category 2, (in 2001), it has increasingly been replaced by the non-classified longer-chain phthalates DINP and DIDP. Other, minor uses are for sealants, paints and varnishes.

- ***Regulations:***

There are national or EU restrictions on several substances:

- 2002/45/EC: application ban on short-chain chloroalkanes[6] in metal working and leather; due to the results of the updated Risk Assessment (BRE, 2005), further restrictions are to be placed on the use of SCCPs.
- 2000/69/EC: stipulates limit values for benzene (and carbon monoxide) in ambient air.
- 98/70/EC: regulates the quality of petrol and diesel fuels and stipulates a maximum concentration of 1 % benzene.
- 2002/62/EC and 782/2003: application ban on organostannic compounds on ships to implement the ban by the International Maritime Organisation IMO on organostannic compounds acting as biocides in anti-fouling paints: ban on active TBT coatings from 1 July 2003; from 1 January 2008, ships with active TBT coatings will no longer be allowed in EU ports.
- 2003/53/EC: restrictions on the marketing and use of nonylphenol and nonylphenol ethoxylate for various applications, among others cleaning, textile processing and pesticides and biocides.
- 2003/11/EC: production, application and import ban on pentabromodiphenyl ether, octabromodiphenyl ether.
- 2005/84/EC: restriction on the marketing and use of phthalates in toys and childcare articles.

There are other additional emission controls in different sectors applied via the Wastewater Ordinance.

6 also referred to as short-chain chlorinated paraffins (SCCP)

- ***Emissions:***

There are no detailed emission calculations available for the majority of these substances. It is therefore difficult to make any estimates since diffuse emissions are caused by (imported) products (e. g. in textiles, electrical appliances) and there is a so-called “depot effect” due to the long useful lives of individual product groups so that previous past use may still cause present emissions. Nonylphenol estimates of Böhm et al. (2002) show that the largest emission amounts are caused by emissions into domestic wastewater from imported textiles. Emissions of octylphenol in Germany are thought to be caused mainly by the OPEO contained in NPEO products. Emissions are produced from tributyltin compounds being used as anti-fouling coating products, not only during the service period but also during cleaning and maintenance work. As a result, emissions will only be completely reduced after already existing coatings containing TBT have been completely replaced. An Annex to the Wastewater Ordinance specifically concerning shipyards is currently being compiled. In contrast, the emissions from contamination in mono/dibutyltin compounds are much lower.

There are diffuse emissions of plastic additives such as DEHP to the environment especially from plastic products used outdoors (roofing plastic, lorry and tent covers, underseal) caused by them being eluted from the matrix as a result of exposure to the weather or being vaporized or dispersed as fine particles with a large surface area as a result of product wear and tear. Additives are also discharged or washed out from indoor applications (flooring, textiles) or emitted to the atmosphere (flooring, vinyl wallpapers). The waste resulting after use represents another emission source.

Benzene is emitted as a VOC in waste gas both from fuel infrastructure and the chemical industry.

- ***Relevance:***

➢ Nonylphenols have high relevance for Germany because of the large quantities used and the amounts released from imported products. This is at least partly true also for the octylphenols which may be present as impurities in nonylphenol compounds.

➢ In spite of the decreasing share of DEHP in the softener market, the amount used is still high due to the widespread diffusion of soft-PVC products.

➢ Benzene has high relevance due to the large production amount and its application as a petrol ingredient.

➢ The relevance of tributyltin compounds is decreasing for Germany because of the existing restrictions on their use which have since come into force.

- Following the ban on penta- and octabromodiphenyl ether, the relevance of emissions from products still in use should gradually diminish. In contrast, the relevance and emissions of decabromodiphenyl ether remains unclear, in particular due to imported goods.
- The C_{10-13}-chloroalkanes and pentachlorophenol only have minor relevance because of the small quantities involved and the existing and expected regulations.

Table 6–1 summarizes the most important information on use and emission situation for the individual substances.

Table 6–1: Overview of the most important uses and emission sources for the priority substances in Germany

Priority substance	Significant applications in Germany	Emissions
Lead	Storage batteries, semi finished products, alloys; construction industry, vehicles, hunting/fishing/diving sports	Heavy metals MONERIS:
Cadmium	Batteries, (stabilizers, alloys) accompanying element of Zn, fertilizer	- urban/rural areas
Nickel	Steel, Ni-alloys, batteries, Ni-plating, catalysts	- municipal/ind. sewage plants
Mercury	Chlor-alkali-electr., mercury batteries, fluorescent lamps, dental treatment (→crematoria)	- atmospheric deposition, historical pollution, …
PAH (anthracene, fluoranthene naphthalene, PAH)	PAHs are formed in combustion processes; creosote (local emission); tar oil paints (ships, corrosion prevention); anthracene, fluoranthene, naphthalene: dyes, interim product	mainly via atmospheric deposition
1,2-dichloroethane	Interim product in vinyl chloride production	in D emissions (air and water) from production of basic chemicals and waste treatment
Dichloromethane	industrial solvent and extracting agent, 10% as paint stripper to remove coatings	Emissions from use as solvent (metal working), air emissions from open applications (atm. deposition estimated as low)
Trichloromethane (chloroform)	Interim product and solvent	Emissions from use as solvent via wastewater and air pathways
Hexachlorobenzene	POP; no production, no use	Emissions from use of fog-generating munitions; historical pollution of sediments/sites; by-product
Hexachlorobutadiene	no production, no use	By-product chlorine chemistry
Pentachlorobenzene	no production, no use; (source material for quintocene; prohibited in D since 1992)	historical pollution/sediments
Trichlorobenzene	Production; used as interim product	
Alachlor	not licensed in D	

Priority substance	Significant applications in Germany	Emissions
Atrazine	not licensed in D	
Chlorfenvinphos	not licensed in D	
Chloropyrifos	license for 2 products until 2015 as PPP; under review as biocide	
Diuron	license in D as PPP, under review as biocide	
Endosulfane (alpha-endosulfane)	not licensed in D	
Hexachlorocyclo-hexane (HCH)	no longer permissible for licensing in EU since 2002	historical pollution In D a point source water direct (manufacturing inorganic basic chemicals)
Isoproturon	permitted in D	diffuse emissions via farming, increased by illegal/improper use, point emissions from farmyard run-offs
Simazine	prohibited in D	
Trifluralin	permitted in D	
Benzene	large volume interim product, component of carburettor fuel (gasoline)	atmospheric deposition
Brominated diphenyl ether	flame proofing agent; since 8/2004 ban on marketing and use for penta- and octaBDPE (incl. products); decaBDPE in products	diffuse emissions DecaBDPE via imported products
C10-13-chloroalkanes	flame proofing agents, softeners; EU-wide restriction 2002/45/EC; no production in D	diffuse emissions via imported products, depot effect
Di(2-ethylhexyl) phthalate (DEHP)	PVC softener	emissions from PVC-processing, sewage plants, diffuse emissions via products and old products
Nonylphenols	Adhesive, varnishes; NPEO as tenside; restriction on use through 2003/53/EC	Emissions via NPEO (tenside); imported textiles; via PPP
Octylphenols	no longer produced in D; only very minor use	Emissions via impurities in NPEO
Pentachlorophenol	HSM/fungicide; prohibited since 1989	historical pollution, emissions via imported products, depot effect
Tributyltin compounds (kation)	Anti-fouling paints: prohibited through 782/2003 and 2002/62/EC (implementation of IMO ban);	direct emissions during anti-fouling applications; shipyards; low emissions due to impurities in mono-/dibutyltin compounds

6.2 Monitoring results

Some of the priority substances have long been the subject of pollution studies of surface waters. There are correspondingly detailed monitoring results available for these substances for Germany (e.g. heavy metals, PAHs, plant protection products). Other substances have not been examined more closely within the scope of water protection and management or have not been able to be studied in sufficient detail because of inadequate methods of analysis (e.g. short-chain chloroparaffins, brominated diphenyl ether, nonyl- and octylphenol). A review was made of the existing pollution situation for surface waters within the inventories of the German *Länder* for the Water Framework Directive. Some additional studies were started to do so. LAWA conducted a *Länder* survey in 2005 on the results of the inventory records with regard to the priority substances. In this survey, one of the questions was how the *Länder* assess the relevance of the priority substances based on the quality standards contained in the Draft of June 2005 (Table 6–3 shows how the quality standards developed throughout the various draft papers). The results of the *Länder* survey (according to Lehmann, Vietoris, 2006) are summarized in Table 6–2. This shows the number of *Länder* classifying each substance as relevant (exceeds quality standards) or non-relevant. A total of 14 *Länder* participated in the survey, 12 provided data about their inventory records, 7 or 9 *Länder* information about the quality standards proposed in June 2005. It should be noted that different methods of analysis and assessment were used to some extent as well as different evaluation criteria. The Table also indicates the availability of sufficiently sensitive analysis methods.

In order to make full use of all the available monitoring results in Germany, the results of the river basin management organizations or commissions as well as the German national report on the implementation of the Directive 76/464/EEC and its daughter directives (UBA, 2005) were evaluated, too. The results are also shown in Table 6–2. Based on the existing monitoring results, an overall evaluation was made of the relevance of the priority substances for Germany. A question mark “?” was entered for substances for which there is insufficient data either because of a lack of adequate analysis procedures or unclear results.

Table 6–2: Overview of the monitoring results for the priority substances in Germany (results of the 2005 *Länder* survey according to Lehmann, Vietoris, 2006: figures show the number of German *Länder*)

	Results of *Länder* survey 2005			other monitoring results[7]	Overall assessment
	inadequate analysis	Inventory record[8]	EQS – June 2005[9]		
Lead		! (10)	! (7)	! (a, b, c, d, f)	!
Cadmium		! (10)	! (5)	! (a, b, c, d, e, f)	!
Nickel		! (7)	! (6)	! (a, b, c, f)	!
Mercury		! (7)	! (7)	! (a, b, c)	!
Hexachlorobenzene	4	!/- (3/6)	!/- (5/3)	! (b, c)	?
Hexachlorobutadiene	3	- (11)	- (5)	-	-
Pentachlorobenzene	3	- (6)	- (4)		?
Trichlorobenzene		- (8)	- (5)	-	-
PAH **- Anthracene** **- Fluoranthene** **- Naphthalene**		! (7) !/- (5/7) ! (11) !/- (3/9)	!/- - (8) ! (5) - (5)	! (a, b, d, d, e) ! (a) ! (c, d) ! (a)	!
C_{10-13}-chloroalkanes	14	no data	no data		?
Pentachlorophenol		- (11)	- (5)		-
Benzene		- (10)	- (7)	-	-
Nonylphenols	4	- (5)	- (6)		?
Octylphenols	3	- (5)	!/- (4/3)		?
Tributyltin compounds	7	! (5)	no data	! (b, c, d, e)	!
Alachlor	4	!/- (3/3)	- (7)		?
Atrazine		!/- (5/5)	- (6)	! (a, b; c)	?
Chlorfenvinphos	3	- (4)	- (7)		-
Chloropyrifos	4	!/- (3/3)	- (4)	! (c, d)	?
Diuron		! (6)	! (6)	! (a, b, d)	!
Endosulfane		- (7)	- (5)		-
Hexachlorocyclohexane		!/- (3/7)	- (6)	! (b,d)	?
Isoproturon		! (7)	! (5)	! (a, b, f)	!
Simazine		!/- (4/5)	- (7)	! (a, d)	?
Trifluralin		!/- (2/3)	- (6)		?
1,2-dichloroethane		- (10)	- (7)	-	-
Dichloromethane		- (10)	- (8)	-	-
Trichloromethane		- (11)	- (9)	-	-
Brominated diphenyl ether	7	no data	no data		?
DEHP	5	no data	no data		?

!: relevant; ?: unclear; -: not relevant; no data: no statement possible

7 a: UBA, 2005; b: IKSR, Rhine; c: IKSE/ FGE Elbe; d: FGE Ems; e: FGE Oder; f: FGE Danube

8 Data from 12 *Länder*

9 Data from 7 - 9 *Länder*; data on heavy metals with reservations (total water sample); data on PAH vary according to indiv. substances

Table 6–3: Development of the quality standards (AA-EQS: average value, MAQ-EQS: maximum value) for the priority substances in the different drafts to the daughter directive (respective quality standard for inland waters)

		2004		June 2005		Dec. 2005		June 2006	
No.	**Substance**	**AA-EQS**	**MAQ-EQS**	**AA-EQS**	**MAQ-EQS**	***AA-EQS***	***MAQ-EQS***	***AA-EQS***	***MAQ-EQS***
(1)	Alachlor	0.3	0.7	0.3	0.7	0.3	0.7	0.3	0.7
(2)	Anthracene	0.1	0.4	0.1	0.4	0.1	0.4	0.1	0.4
(3)	Atrazine	0.6	2.9	0.6	**2**	0.6	2	0.6	2
(4)	Benzene	1.7	49	*10*	*50*	10	50	10	50
(5)	Pentabromodiphenyl ether	0.0005	1.4	0.0005	1.4	0.0005	**0.006**	0.0005	*n.a.*
(6)	Cadmium	0.2	1.5	0.2	1.5	0.2	1.5	**0.08-0.25***	**0.45-1.5***
(7)	C10-C13-chloroalkanes	0.4	1.4	0.4	1.4	0.4	1.4	0.4	1.4
(8)	Chlorfenvinphos	0.06	0.3	*0.1*	0.3	0.1	0.3	0.1	0.3
(9)	Chloropyrifos	0.03	0.1	0.03	0.1	0.03	0.1	0.03	0.1
(10)	1,2-Dichloroethane	10	1180	10	**120**	10	120	10	*n.a.*
(11)	Dichloromethane	20	1900	20	**240**	20	240	20	*n.a.*
(12)	DEHP	1.3	-	1.3	**15.6**	1.3	-	1.3	*n.a.*
(13)	Diuron	0.2	1.8	0.2	1.8	0.2	1.8	0.2	1.8
(14)	Endosulfane	0.005	0.01	0.005	0.01	0.005	0.01	0.005	0.01
(15)	Fluoranthene	0.09	0.9	*0.1*	*1*	0.1	1	0.1	1
(16)	Hexachlorobenzene	0.0004	0.05	0.0004	0.05	**0.0002**	**0.002**	*0.01*	*0.05*
(17)	Hexachlorobutadiene	0.003	0.6	0.003	0.6	0.003	**0.04**	*0.1*	*0.6*
(18)	g-HCH (lindane)	0.02	0.04	0.02	0.04	0.02	0.04	0.02	0.04
(19)	Isoproturon	0.3	1.3	0.3	1.3	0.3	**1.0**	0.3	1.0
(20)	Lead	0.4	2	*2.1*	*2.8*	2.1	2.8	*7.2*	*n.a.*
(21)	Mercury	-	0.07	**0.05**	0.07	0.05	0.07	0.05	0.07
(22)	Naphthalene	2.4	80	2.4	**28.8**	2.4	28.8	2.4	*n.a.*
(23)	Nickel	1.7	-	1.7	**20.4**	*3.8*	**13.6**	*20*	*n.a.*
(24)	Nonylphenols	0.3	2.1	0.3	**2**	0.3	2	0.3	2
(25)	Octylphenols	0.06	0.13	0.06	0.13	*0.12*	0.13	**0.1**	*n.a.*
(26)	Pentachlorobenzene	0.003	1	*0.007*	1	0.007	**0.08**	0.007	*n.a.*
(27)	Pentachlorophenol	0.2	1	0.2	1	*0.4*	1	0.4	1
(28)	PAH			0.1				n.a.	*n.a.*
	Benzo(a)pyrene	0.05	0.05	0.05	0.05	0.05	*0.1*	0.05	0.1
	Benzo(b)fluoranthene	0.03	0.1	0.03	0.1	0.03		0.03	*n.a.*
	Benzo(k)fluoranthene		0.1		0.1				
	Benzo(ghi)perylene		0.1		0.1				
	Ideno(1,2,3-cd)pyrene	0.016	0.1	*0.02*	0.1	**0.002**		0.002	*n.a.*
(29)	Simazine	0.7	3.4	*1*	*4*	1	4	1	4
(30)	Tributyltin compounds	0.0001	0.002	*0.0002*	0.002	0.0002	0.0015	0.0002	0.0015
(31)	Trichlorobenzene	0.4	50	0.4	**48**	0.4	**4.8**	0.4	*n.a.*
(32)	Trichloromethane	12	270	12	**144**	**2.5**	**30**	2.5	*n.a.*
(33)	Trifluralin	0.03	1	0.03	**0.9**	0.03	**0.4**	0.03	*n.a.*

*depends on hardness of water
n.a.: not applicable

= increased standards (light blue) *= lowered standards* (orange)

6.3 Summary of the emission analysis and the monitoring results

The chart shown in Table 6–4 was compiled based on existing information about application and emission situation on the one hand and the monitoring results on the other.

Table 6–4: Relevance of the priority substances for Germany

Name	Classification	Application in D	Emissions in D	Results monitoring	Relevance
Heavy metals					
Lead	p	!	!	!	!
Cadmium	ph	!	!	!	!
Nickel	p	!	!	!	!
Mercury	ph	!	!	!	!
PAHs					
PAHs (anthracene, fluoranthene, naphthalene, PAH)	p/ph	!	!	partly: !	!
chlorinated compounds – solvents					
1,2-dichloroethane	p	!	!	-	-
Dichloromethane	p	!	!	-	-
Trichloromethane	p	!	!	-	-
chlorinated compounds – interim products					
Hexachlorobenzene	ph	-	?	?	?
Hexachlorobutadiene	ph	-	-	-	-
Pentachlorobenzene	ph	-	-	?	-
Trichlorobenzene	p	-	-	-	-
Pesticides					
Alachlor	p	-	-	?	?
Atrazine	p	-	-	?	?
Chlorfenvinphos	p	-	-	-	-
Chloropyrifos	p	!	!	?	?
Diuron	p	!	!	!	!
Endosulfane	ph	-	-	-	-
Hexachlorocyclohexane	ph	-	?	?	?
Isoproturon	p	!	!	!	!
Simazine	p	-	-	?	?
Trifluralin	p	!	!	?	?
Individual compounds					
Benzene	p	!	!	-	-
Brominated diphenyl ether	ph	(-)	?	?	?
C10-13-chloroalkanes	ph	-	?	?	?
DEHP	p	!	!	?	?
Nonylphenols	ph	!	!	?	?
Octylphenols	p	(-)	!	?	?
Pentachlorophenol	p	-	-	-	-
Tributyltin compounds	ph	!	!	!	!

p: priority; ph. priority hazardous (as of Draft July 2006); !: relevant; ?: unclear; -: not relevant

7 Analysis of the emission situation of relevant substances/substance groups

The need for additional emission abatement measures is examined here for the substances or substance groups assessed as relevant for Germany in Chapter 6.3 and further possible approaches are identified where necessary. A differentiation is made between the most important emission sources or emission pathways. As far as possible, an evaluation is made of the relevance of the emission pathways with regard to the total burden from this pollutant or pollutant group. For the relevant emission pathway/source, important current measures are listed which could alter the emission situation in the future. The following emission pathways or sources are regarded:

- urban areas,
- municipal sewage treatment plants,
- industrial discharges,
- agricultural areas,
- historical pollution / disused mines,
- products and
- atmospheric deposition including air emissions.

7.1 Substance group: Heavy Metals

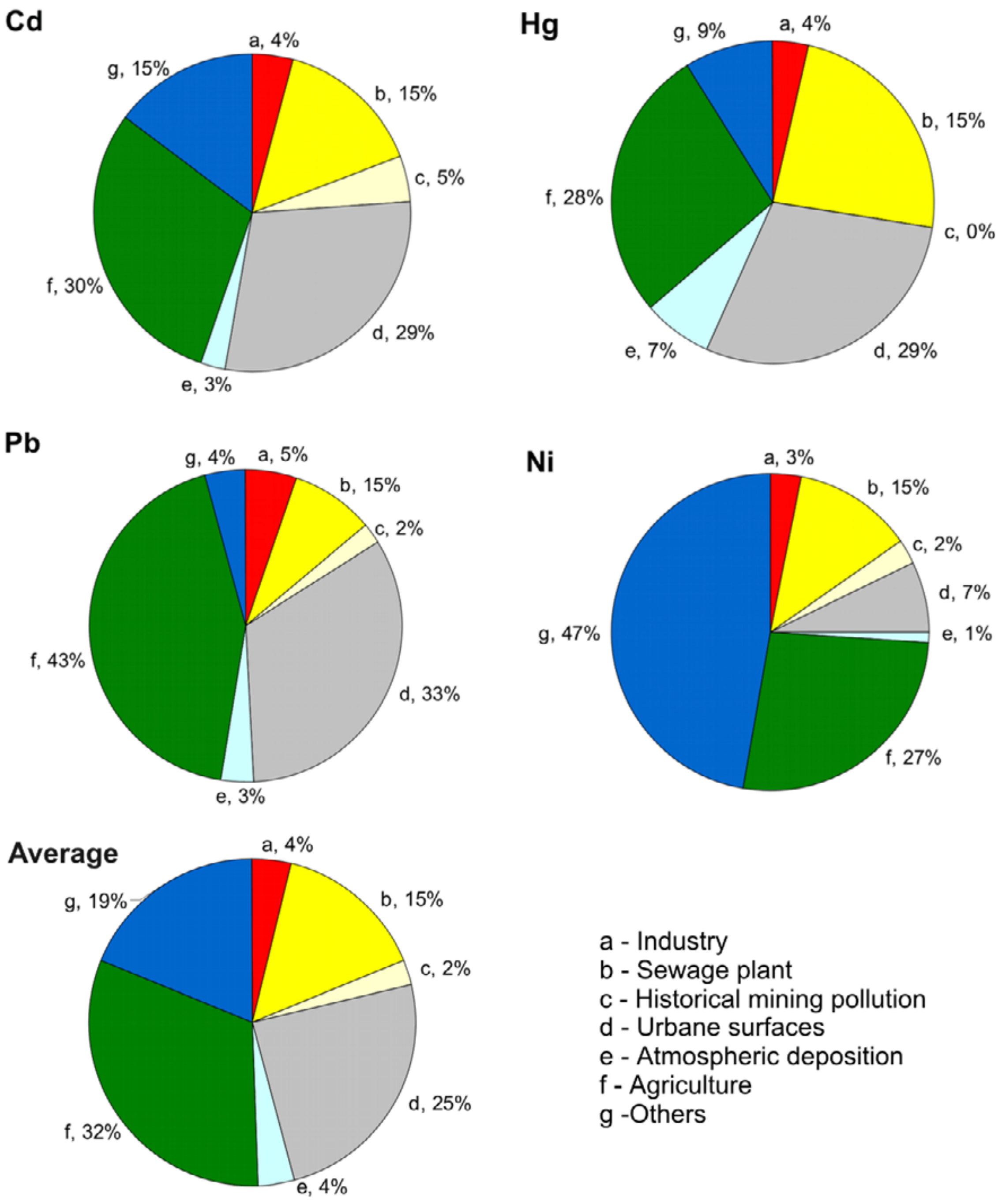
As already described in Chapter 6.1, many different emission sources play a role in the heavy metal pollution of surface waters (domestic and industrial wastewater, air emissions with atmospheric deposition, emissions via products etc.). All the above named emission pathways are therefore relevant for this substance group and are taken into account below.

Emission pathway: urban areas

- ***Emission relevance:***

The work at EU level evaluating the relevance of the various emission pathways (see Chapter 1) resulted in the four heavy metals being classified as Category 1 (emission source/pathway may result in or contribute to potential failure of WFD objectives) or Category 2 for Hg (insufficient information) for this domain (emission pathways S7 and S8 are to be regarded here). The emission balance for releases of heavy metals to German surface waters is illustrated in Figure 7–1 (see Fuchs et al., 2002, Böhm et al., 2001). According to this, the emission pathway "urban areas" has particular significance for all four heavy metals; on average 25 % of the emissions to water occur via this route.

Figure 7–1: Emissions of the four heavy metals to surface waters in Germany – shares of the most important emission pathways (according to Fuchs et al., 2002)



- **Important current measures:**

No measures are currently being implemented at international or national level in this domain.

- **Additional approaches:**

Technologies to reduce the emissions from this domain are available. Under the heading of “stormwater management” these include infiltration and desealing measures (avoidance of stormwater) as well as measures to improve stromwater treatment (see Hillenbrand, Böhm, 2004; Hillenbrand et al., 2005). New technologies have been developed and tested in the past few years which make treatment possible in both decentralized, local facilities as well as (semi) centralized ones (decentralized filter systems, soil filters, etc.). Heavy metals can be eliminated to a large extent using these methods which also have other additional positive effects: retention of other pollutants such as, e. g. PAHs as well as particulate substances, increased groundwater formation or reducing the danger of flooding. Preparations are currently being made at national level for a new Annex to the Wastewater Ordinance for the domain of “Storm water pollution control" which is to contain requirements for run-off management for new building developments.

Emission pathway municipal sewage plants

- ***Emissions relevance:***

With regard to classification at EU level, the emission pathways S7 and S8 are also relevant here for which the four heavy metals were classified as 1 (except for Hg which was classified as 2). For Germany, there is an average share of 15 % for this emission route (see Figure 7–1).

- ***Important current measures:***

The implementation of the Drinking Water Directive 98/83/EC and the 2001 Amended Drinking Water Ordinance require lead pipes to be replaced for the drinking water supply, since otherwise it is not possible to comply with the lead limit value. If the lead concentration in drinking water is lowered, the lead pollutant load discharged to waters via the emission pathway "municipal sewage plants" can also be reduced. In Germany, efforts have been made by the water suppliers for many years to replace any existing lead installations. Therefore it can be assumed that there is only a small remaining abatement potential for Germany with regard to the resulting lead emissions to water.

- ***Additional approaches:***

In biological wastewater treatment, heavy metals can be eliminated to a considerable extent and organically bound in sewage sludge. According to Fuchs et al. (2002), the average efficiencies for a sewage plant with a mechanical and an activated stage are 60 % (Cd), 75 % (Hg), 84 % (Pb) and 43 % (Ni); for a plant with additional P-elimination these are around 73 % (Cd), 79 % (Hg), 88 % (Pb) and 63 % (Ni). The remaining heavy metals in the purified wastewater are present as partly dissolved particles and partly adsorbed into particles. New processes such as, e. g. membrane filters or activated carbon filters make it possible to completely remove any particulate substances still contained in the outflow. This can further reduce the emissions of heavy metals. At present, it is not clear by how much since there is a lack of more specific studies on possible increases in the degree of efficiency. Additional effects of these processes include the elimination of other pollutants such as e. g. organic trace elements and wastewater disinfection.

Emission pathway industrial discharges

- ***Emissions relevance:***

While this emission pathway was evaluated to be relevant at EU level ("1"), the results in Figure 7–1 show that its relevance for Germany is comparatively low, on average only 4 %. The reason is that intensive efforts have already been made in Germany for several decades to lower the emissions from industrial operators (for comparison: the share of industrial direct emitters for the four heavy metals regarded here was 35 % on average in 1985).

- ***Important current measures:***

The most important current measure regarding industrial emissions is the implementation of the IPPC Directive 96/61/EC. Under this ruling, certain industrial and agricultural activities have to be authorized (granted an environmental permit) by the competent authorities. The granting of permits is dependent on the use of the best available technology (BAT). Since 30, October 1999, it is mandatory for new installations and those which have undergone substantial changes to comply with permit requirements. Existing installations have to fulfil the requirements from 30 October 2007. The degree of implementation varies widely in the different Member States: In total, only about 40 % of the existing installations have been issued a permit in line with the IPPC procedure (European Commission, 2006). For Germany, however, this percentage was already 83 % as of June 2005 (EC, 2006).

- ***Additional approaches:***

Article 16 (2) of the IPPC Directive plans an exchange of information between Member States and the industries concerned on best available techniques in the individual sectors. The results of the information exchange are to be laid down in so-called Best Available Techniques Reference Documents (BREFs) to be published by the European Commission and which are to be taken into account when specifying licensing requirements. The BREFs include sector-specific descriptions of wastewater treatment technologies and, if applicable, also figures on the pollutant concentrations achievable in wastewater with the individual techniques. So far, however, the various priority substances have only been partly addressed when compiling the BREFs. Information about heavy metals is the most frequent; in contrast, other pollutants are hardly ever mentioned. The BAT information exchange is a continuous and dynamic process. The IPPC Directive intends the Commission to publish the results of the exchanges of information every 3 years. Work is currently being done on the first revisions. One way to mitigate emissions from industrial installations would be to better integrate priority substance requirements when reworking the BREFs. This applies to both water and air emissions.

Apart from those installations subject to the IPPC Directive, there are other non-IPPC operations to consider. These are mainly in sectors which do not fall under the IPPC Directive such as, e.g. dental treatment in which mercury emissions occur because of the use of amalgam. Here, it would be possible to extend the IPPC Directive to sectors with an EU-wide relevance regarding the emissions of priority substances or at least initiate an information process comparable to the work on the BREFs for IPPC installations.

A national approach to further reduce the emissions from direct and indirect industrial dischargers could be to update the sector-specific requirements stipulated in the Annexes to the Wastewater Ordinance. In general, these requirements were compiled at the end of the 80s/beginning of the 90s. The progress achieved in the meantime in both end-of-pipe wastewater treatment techniques and process-integrated techniques, for example those based on advances in membrane technology, would make it possible to lower the emission limit values where required. Figure 7–2 shows the significance of the various sectors based on an evaluation of the results of the European emission inventory, EPER, for 2001. According to this, the predominant share of heavy metal emissions stems from organic and inorganic basic chemicals. However, as mentioned above, due to efforts made in the past, only the remaining small share of emissions from this field in total emissions has to be considered. This is also shown when comparing the industrial emissions in Germany with the total emissions within the EU which were calculated using the EPER results (see Figure 7–3). Accordingly, the share of direct emissions to water (lead has the highest value of 13 %) is clearly below the share of population (21.7 %) or the share of GDP (23.4 %) which are used as comparative values.

Figure 7–2: Results of the European emission inventory for heavy metal emissions in Germany (EPER, 2001)

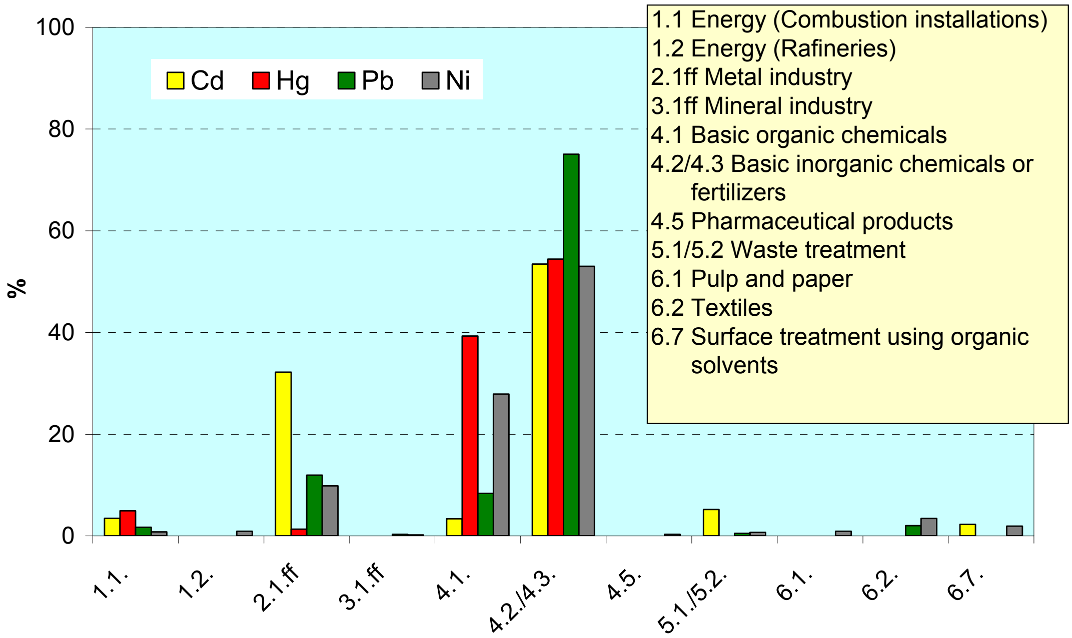
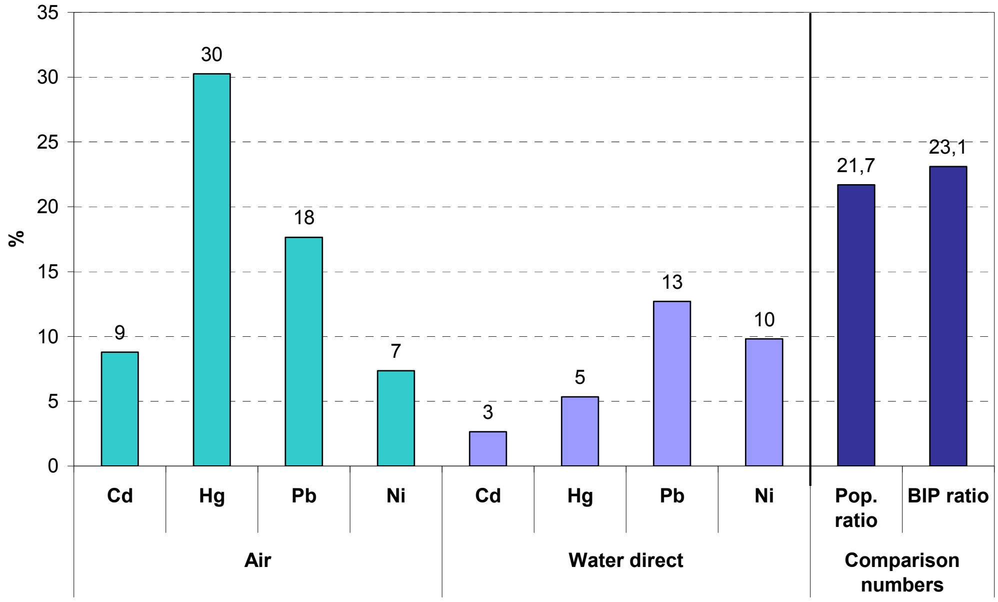


Figure 7–3: Results of the European emission inventory: share of heavy metal emissions in Germany in total European direct emissions for air and water (EPER, 2001; the share of population and GDP is shown for comparison)[10]



10 The high share of Hg air emissions is probably a result of incomplete reports of individual Member States regarding Hg emissions from combustion and waste incineration plants.

Emission pathway agricultural activities

- ***Emission relevance:***

The emission pathway "agricultural activities" (S3) was classified as relevant (Category 1) in EU studies for all four heavy metals. The emission inventory for Germany resulted in an average share of 32 % for the 4 substances (see Figure 7–1). Thus the highest emissions originate in this domain. The calculations distinguish between emissions due to erosion, drainage and surface run-off, although the emissions due to erosion clearly predominate (see Fuchs et al., 2002).

- ***Important current measures:***

Significant efforts are being made both at EU and national levels to tighten the quality requirements of agriculturally used sewage sludge for this emission pathway. The existing limit value for heavy metals is expected to be lowered. Specifically with regard to cadmium, greater restrictions on the concentration permitted in mineral fertilizers are being discussed: in 2003 the EU Commission proposed 60 mg/kg within 5 years to start with followed by a drop in the limit value to 20 mg/kg in 15 years. So far, however, no agreement on a corresponding regulation has been reached at EU level. In Germany, the change in the Fertilizer Ordinance of September 2004 (BGBl. I No. 57, p. 2767) means that the valid cadmium limit value is 50 mg Cd/kg P_2O_5 for fertilizers from 5 % P_2O_5. With respect to the heavy metal load discharged to water via agriculturally used land, it should be noted that measures limiting concentrations in fertilizers only have an indirect and delayed effect (via the medium-term reduction of heavy metal concentrations in the upper soil layers) and that the reduction potential made up of the shares of corresponding fertilizers in the soil is limited in total.

- ***Additional approaches:***

According to the results of the emission calculations, carrying out measures to reduce erosion in areas at risk is the most important approach for mitigating heavy metal emissions. Key measures include, for example, mulch seeding or nurse crops, adapting crop rotation, soil-preserving tillage and minimizing mechanical tillage of the soil. Because of the additional pollutant concentrations in the upper soil (e. g. residues of plant protection products, phosphorus, other heavy metals), these techniques can bring about other positive additional effects. From the viewpoint of farmers, the most important effect beyond these is the retention of fertile soil.

Emission pathway historical pollution/disused mines

- ***Emission relevance:***

The work at EU level understood both contaminated sediments in water as well as contaminated soil as falling under the emission pathway S11 (contaminated soils, historically contaminated land). The evaluation resulted in lead and nickel being classified as "1", and cadmium and mercury as "2". It was not possible to calculate the emissions via contaminated sediments and soil within the surveys for Germany but the emissions from disused mines have been recorded. In 2002 these results showed an average share of 2 % (see Figure 7–1). These data are still very incomplete, however, since numerous discharge ducts are not officially registered or there are no measurements available for the discharges. Within a specialist discussion (UBA, 2006), the previous findings for this sector were compiled and it was shown that emissions from disused mines may represent the dominant emission source for individual bodies of water or river basins. As a result, this emission pathway has high relevance at least from a regional perspective.

- ***Additional approaches:***

When looking at reducing the emissions from disused mines there is the basic problem that usually very large volumes of water and low pollutant concentrations are involved. Despite this, treatment methods have been developed which are used, for example, to specifically eliminate uranium. Active and passive systems are possible which have to be adjusted to the respective wastewater and treatment requirements. Depending on the system chosen and the quality of the pit water, high elimination rates are achievable (Morin et al., 2006).

Emission pathway products:

- ***Emissions relevance:***

Water emissions due to products were not collected separately either in the EU work or the emissions inventory for Germany. At EU level, different products were identified (e. g. lead shot, lead fishing weights, tyres with regard to nickel emissions) which are of particular significance for the individual emission pathways classified as relevant (e. g. S3: agricultural activities, S4: transport, S7 and S8: municipal wastewater and stormwater). Hillenbrand et al. (2005) also prepared balance sheets for the water and soil pollution caused by various applications of the heavy metals lead, copper and zinc. As a result, specific emissions can be assigned to individual substance applications (e.g. applications in the automotive or construction industry).

- ***Important current measures:***

Among other things, the use of lead-free brake pads and balance weights is required for all type-approved vehicles after 1 July 2003 by the EU End-of-life Vehicles Directive (2000/53/EC). However, it will take several years for the changes to be completed in the vehicle stock. A strategy to reduce the risks for the environment and human health has been worked out for mercury at EU level (Communication "Community strategy for mercury", COM (2005) 20 - Official Journal C 52 of 2 March 2005). A proposal to ban measurement and control instruments containing Hg (including thermometers) has since been presented by the Commission. Other measures to reduce mercury emissions, ban Hg exports, promote international measures, etc. are to follow. Batteries are the most important application for cadmium. The 91/157/EEC Batteries Directive, most recently amended in 1998, is currently being reworked. It is planned to set minimum collection rates (25 % by 2012, 45 % by 2016) and prohibit batteries containing more than 0.005 % mercury or more than 0.002 % cadmium. However, exceptions to this ban include alarm systems, medical equipment and electrical tools, by far the most important field of application for Ni/Cd storage batteries. The Directive was planned to enter into force in 2006 and be implemented by the Member States within 2 years.

- ***Additional approaches:***

Measures to reduce product-related emissions have to address individual applications. Application bans or restrictions are based on European law to a large extent that has to be implemented by the Member States. Alongside these, "softer" measures such as information measures or voluntary commitments can also be realized at national level. For the heavy metals which count as priority pollutants, there are various relevant fields of application, e. g.:

- substituting lead in the construction industry (where necessary conjointly with other heavy metals),
- lead replacements in hunting, fishing and diving sports (lead munition, lead fishing weights, diving weights),
- manufacturing brake pads without the use of heavy metals.

For the priority hazardous mercury and cadmium, there is the following additional problem: Applications of these heavy metals have been greatly restricted over the past few years because of their high toxicity and there was a clear drop in the amounts still being used. On the other hand, both substances occur during recycling as well as zinc processing (cadmium) or when chlor-alkali facilities based on the amalgam procedure are shutdown (mercury). The amounts released in conversion from the amalgam to the membrane process this way may lead to a drop in the market prices and internationally to uncontrolled applications linked with increased emissions. In 1994, the Enquete-Commission "Protection of humanity and the environment" suggested treating cadmium as a waste product as a way of removing it from the economic cycle (Enquete, 1994).

Emission pathway atmospheric deposition/air emissions:

- ***Emission relevance:***

Emissions to water via atmospheric deposition were classified as relevant with "1" for all four heavy metals at European level. Air emissions from industry contributing to air pollution and thus indirectly to atmospheric deposition were also classed as "1". For Germany, the calculations showed an average share of 4 % direct emissions due to atmospheric deposition onto water surfaces. However, the indirect emissions of pollution from air via surface run-offs from urban and agricultural areas also have to be considered. As a result this emission pathway has high relevance.

- ***Important current measures:***

The Directive 2004/107/EC sets target values for cadmium and nickel for air quality (and for PAHs and Arsenic in addition to this). To comply with these targets, Member States are to implement all the cost-efficient measures available. There is no emission target value stipulated for mercury, but reference is made to the Mercury Strategy of the EU. In addition to this, measurements are to be made of the air concentrations and deposition. It cannot be foreseen at present to what extent this Directive will bring about a reduction of air pollution and thus a reduction in atmospheric deposition.

The IPPC Directive 96/61/EC is another important measure currently being put into practice (see also the comments on "Emission pathway industrial discharges"). Under this ruling, certain industrial and agricultural activities have to be authorized. Since 30 October 1999, new installations must employ the best available techniques (BAT) to obtain a permit. Existing installations have to meet the requirements from 30 October 2007. It should be taken into account that pollutant transport across national borders plays a large role with regard to the level of atmospheric pollution and therefore any clear improvements here can only be achieved internationally.

In Germany, the Ordinance on Large Combustion Plants and Gas Turbine Installations (13th Ordinance under the Federal Immission Control Act) was amended in July 2004 and introduced an emission limit value of 0.03 mg Hg/m^3 for combustion plants when using solid fuels. Existing installations must comply with this value from 1.11.2007 or from 2011 for recently retrofitted ones. According to the results of the European emission inventory, combustion plants > 50 MW account for more than 50 % of the mercury air emissions in Germany. Reichart (2005), however, assumes that the new mercury limit value can be met without specific measures to remove mercury. It is therefore unclear to what extent Hg emissions in Germany will really be reduced.

- ***Additional approaches:***

Small combustion installations (below 50 MW) represent another important air emission source for Hg. According to the European emission inventory, this sector's share is estimated at 16 % in total emissions at EU level (although there are significant uncertainties here with regard to the emission factors and fuels used; AEA Technology/NILU –Polska, 2005). Within the scope of the EU work on the priority substances, mercury emissions from wood-burning stoves and from crematoria were specifically highlighted. For wood stoves, the German Federal Environmental Office has presented proposals to amend the 1 BImSchV[11] with the aim of reducing the emissions of particulate matter. To do so, the upper limit for emissions is to be dropped from 15 kW to 4 kW. Increased type testing requirements are being suggested for small single-room stoves below 8 kW.

According to OSPAR (2006), 36 kg Hg are emitted from crematoria each year in Germany: 17.7 kg from 105 crematoria using technologies to capture mercury and 18.3 kg from 21 sites without specific technologies. The emission requirements for crematoria are regulated in the 27 BImSchV, which does not include any regulations for mercury so far. However, local or regional standards are set to some extent.

7.2 Substance group: polycyclical aromatic hydrocarbons

Polycyclical aromatic hydrocarbons are formed during incomplete combustion of practically all organic substances, e. g. forest fires, domestic fuel use, combustion engines, barbecuing or smoking[12]. Accordingly, air is the most significant emission source and thus the relevant emission pathways are "atmospheric deposition", "urban areas" and "municipal sewage plants".

Emission pathway atmospheric deposition

- ***Emissions relevance:***

In 1994, the sectors with the largest PAH air emissions were estimated to be domestic stoves with 932 t/a, wood impregnation processes with 529 t/a, installations producing non-ferrous metals and aluminium (258 t/a), emissions from wood treated with creosote (213 t/a), iron and steel production (140 t/a) and the transport sector (146 t/a). Less relevant were industrial and power station furnaces (3.2 t/a) and waste disposal facilities (0.03 t/a).

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11 Bundes-Immissionsschutzverordnung (First Federal Immission Control Act)

12 Smoking was discovered to be an excellent predictor for the concentration of PAH metabolites in the urine of test persons in the 1998 Umwelt (Environmental) Survey, while the influence of road transport, which is frequently cited in the literature, was not found (Bernigau et al., 2004).

- ***Important current measures:***

Due to the implementation of Directive 2004/107/EC as a daughter directive on air quality, indirectly, it then became necessary to reduce the emissions of PAH (alongside Cd, Hg, Ni) in order to comply with the target value of 1 ng/m3 BaP (total content in the PM10 fraction averaged over one calendar year). The Directive 1999/30/EC also has an impact on PAH emissions since it sets limit values for particulate matter (PM10).

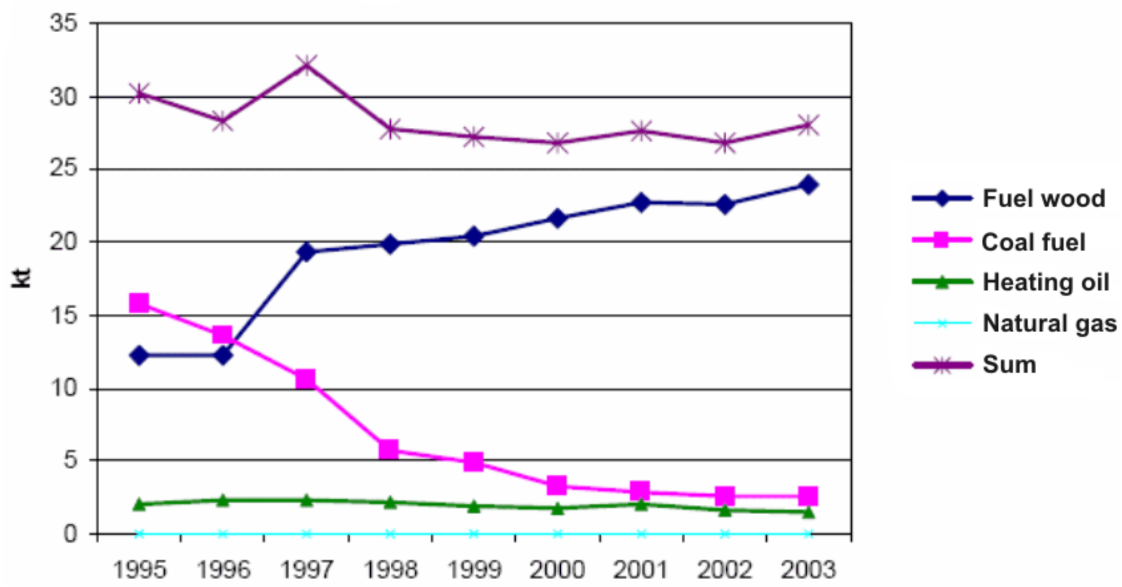
Industrial air emissions are regulated by the German TA Luft[13]. Its implementation has resulted in a considerable reduction in the particulate emissions in Germany, especially from industry and power stations. The TA-Luft sets a limit value of 0.05 mg/m^3 for carcinogenic substances of Category I such as benzo[a]pyrene.

- ***Additional approaches:***

While the amount of PAH from industry have fallen, the emissions due to domestic fuel use have not decreased as expected. The reason, according to studies of the Federal Environmental Agency, is that even though there has been a drop in the number of coal-fired heating systems in Germany, in the same period, wood-fired heating grew so much that the total emissions of particulate matter have remained the same (see Figure 7–4). The Federal Environmental Agency is therefore pushing for an amendment of the 1 BImSchV with the objective of lowering the limit for emission requirements from 15 kW to 4 kW and proposing increased standards during type testing for small single-room stoves below 8 kW. The reduction potential is given as being 40 % of the particulate emissions up to 2020 based on energy use (UBA, 2006).

13 "Technical Instructions on Air Quality Control", a well known air pollution control regulation.

Figure 7–4: Development of emissions of particulate matter from installations of the 1st BImSchV (UBA, 2006)



Emissions pathway urban areas

- ***Emissions relevance:***

Most violations of the EU air quality limit values occur on main roads: diesel vehicles account for 20 to 50 per cent of the pollution here (local traffic exhaust fumes and tyre abrasion plus local municipal background pollution plus particulate matter emitted elsewhere and transported over long distances). The data found in studies on PAH in road surface run-off is characterized by a high range of fluctuation (Welker, 2005).

- ***Important current measures:***

Restrictions on commercial and industrial applications were passed for creosote (2001/90/EC). Due to the restriction of PAH in extender oils and tyres (2005/69/EC), there is a medium-term reduction potential of 6 to 8 tons (BMU, 2004).

In diesel vehicles, diesel particle filters manage to reduce the particulate mass by over 90 % and the number of particles by almost 100 %.

- ***Additional approaches:***

Lowering the PAH in diesel fuel would also result in lowered emissions for older diesel engines. In modern engines, the PAH emissions are independent of the diesel concentrations which are currently max. 11 wt% PAH (CONCAWE, 2005).

Measures concerning the treatment/infiltration of stormwater such as those which can be used for other particle-bound pollutants like heavy metals also have a high reduction potential for PAH. For dissolved organic substances such as phenanthrene and fluoranthene, infiltration of road surface run-off is thought to be problematic since these display high mobility in contrast to the heavy metals and therefore the infiltration water has a negative effect both 1 m below the infiltration systems as well as in the water unsaturated to saturated transition zone (Mertsch, 2005).

Emissions pathway municipal sewage treatment

The wastewater from municipal sewage plants only carries a small load of PAH since elimination rates here exceed 90 % and the concentrations in influent are usually below the threshold of detection as recent publications also confirm (Getta, 2005; Ivashechkin, 2005).

Emissions pathway industrial discharges

Among the industrial direct emissions to water, according to EPER, the largest PAH amounts are caused by companies of the inorganic and organic basic chemicals sector, whose emissions are assigned to metal production (2.1-2.6) and the treatment of hazardous wastes (5.1/5.2) under the IPPC, see Figure 7–5. In the EU, textile production (6.2) is relevant as well as chemicals (4). 46 % of the air emissions in Germany stem from the production of carbon/electro graphite and 41 % from cement/glass production.

In total, the share of industrial emissions caused by Germany is 8.2 t in air emissions which corresponds to approx. 3.2 % of EU emissions; for water emissions (direct), this share is 1.3 % and (indirect) 0.4 % (see Figure 7–6).

Figure 7–5: Evaluation EPER data for PAH: shares of the various industrial sectors in direct emissions to water 2001

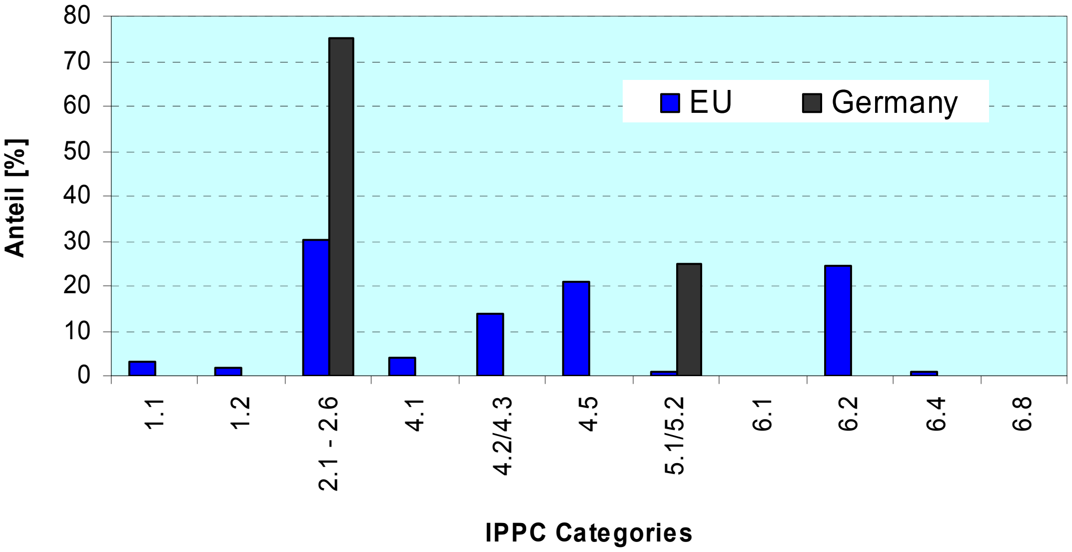
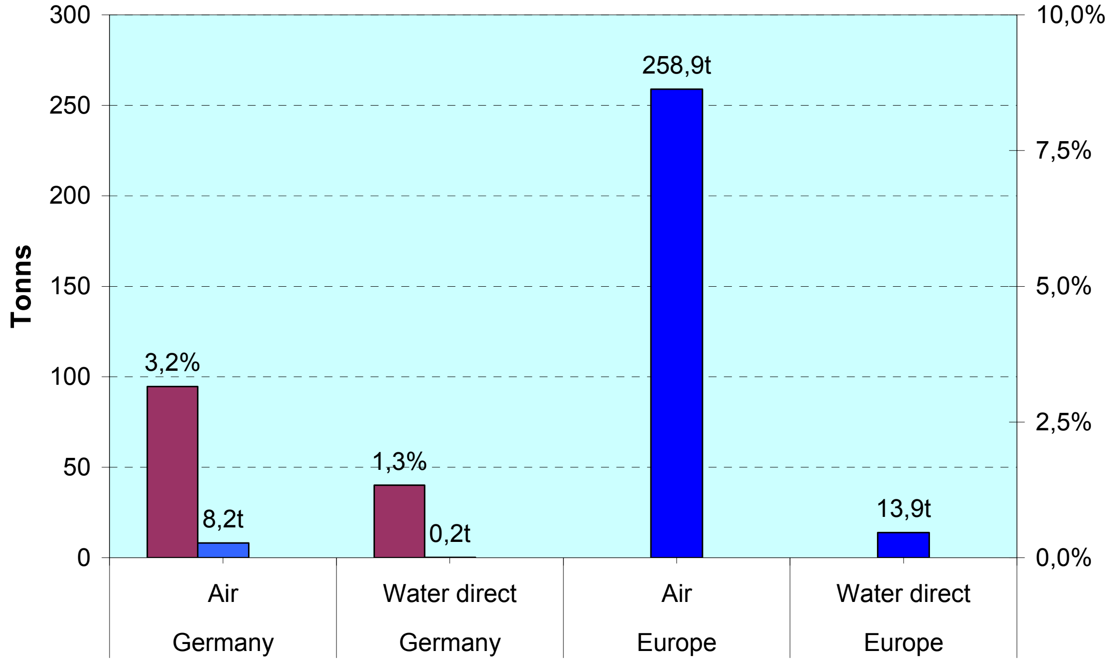


Figure 7–6: EPER: Industrial PAH in the EU and in Germany (EPER data 2001)



- ***Important current measures:***

An important ongoing measure in the field of industrial PAH emissions is the implementation of the IPPC Directive 96/61/EC, under which certain industrial and agricultural activities have to obtain a permit from the authorities.

- ***Additional approaches:***

The exchange of information using the BREFs is a continuous and dynamic process. In line with the IPPC directive, the results of the information exchange are to be published every 3 years. Work is currently being done on the first revisions. One way to lower emissions from industrial plants would be to better integrate the emission requirements for the priority substances when reworking the BREFS. This applies to both water and air emissions.

Emissions pathway products

Although the use of PAH has been greatly restricted in various products such as Frisbees (BVS, 2006), tar-based adhesives, tar based paints used as anticorrosion protection (Rütgers, 2005), softeners in rubber products and in other specialized products such as moth balls, older, used products continue to cause emissions to the environment and to water. On top of this, there are still the emissions from new products containing considerable amounts of PAH. PAH are frequently found in products with rubber handles such as torches, window-wipers or tools, in some cases even in the percentage range (Test, 2006).

Bitumen now used for road construction contains far fewer PAHs (by the factor 3,000 to 10,000) than the tar previously used, but since aerosols and vapours containing PAH are released at higher processing temperatures of 180 C, bitumen is processed at reduced temperatures. At temperatures below 80°C there are practically no emissions from bitumen and even at 150°C, there are still only approx. 1 mg/h (Rühl, 2006).

- ***Important current measures***

Restriction guidelines for creosote (2001/90/EC) and PAH in extender oils and tyres (2005/69/EC). These were transposed into German law via the German Chemicals Prohibition Ordinance (ChemikalienverbotsV). There are voluntary commitments for Frisbees.

- ***Additional approaches:***

Legal limit values for the PAH content in products other than tyres. Information campaigns could be conducted by consumer protection organisations to raise consumer awareness for products containing PAH with suspicious smell and haptic properties.

7.3 Substance group plant protection products (PPP)

To protect cultivated plants and optimize crop yields, plant protection products are widely used in agriculture in open applications but also, e.g. in parks, where their toxic effect is used to combat harmful organisms or unwanted, rival plants. Emissions from agricultural areas are particularly emphasized, but those via municipal sewage plants are also estimated as especially relevant. Here, the plant protection products enter the municipal wastewater system via farmyard run-offs. There have also been traces of banned substances in the monitoring results. This may be due to historically contaminated sites, permitted applications in neighbouring countries or illegal use as well as past pollution.

Emissions pathway municipal sewage treatment:

- **Emissions relevance:**

It is difficult to estimate the water emissions via farmyard run-offs, but these are - depending on the region involved – classified as highly relevant for Germany. They are caused by improper disposal and cleaning of the spreaders used to distribute the plant protection products. For instance, for the river basins Rhine, Main, Nidda and Ruhr, the estimated share of point sources due to farmyard run-offs in total emissions is 70-90 % due to the structurally-related above average high density of spreading equipment here (BMU, 2006a, Bach et al., 1999). For the priority substances isoproturon, diuron and simazine, the total emissions from point sources for the year 1994 based on the estimated total active substance annual loads are

Isoproturon:	> 4000 kg/year (estimated active substance total annual load > 6000 kg)
Diuron	> 1700 kg/year (estimated active substance total annual load > 2500 kg)
Simazine	> 1200 kg/year (estimated active substance total annual load > 1800 kg)

(Böhm et al. 2002). Whereas simazine is not listed in Annex I of the Directive relating to Plant Protection Products and is therefore no longer permitted in the EU, this emission pathway is still assumed to be highly relevant for isoproturon and diuron. In contrast it is unclear how significant the emissions from farmyard run-offs are for the authorized substances chloropyrifos and trifluralin.

- ***Important current measures:***

Discharging the water used to clean farm equipment directly into the municipal sewage system is not in line with the permitted conditions governing the use of plant protection products. However, these restrictions are often ignored. Infringements could be sanctioned, but they are very difficult to prove.

- ***Additional approaches***

The main approaches are measures to inform and motivate users. These include specialist advice, documentation requirements and raising the level of handling competence. Corresponding approaches are already contained in the German Reduction Programme in Chemical Plant Protection. Offering further incentives might encourage the correct disposal of cleaning solutions loaded with pesticides.

Emissions pathway industrial discharges:

- **Emissions relevance:**

Some of the relevant plant protection products are manufactured in Germany. Nevertheless, the relevance for the corresponding emission pathways is estimated to be low (EAF 2003).

- ***Important current measures***

In future, isoproturon and diuron will be recorded in the European Pollutant Release and Transfer Register (PRTR).

Emissions pathway agricultural areas:

- **Emissions relevance:**

Along with farmyard run-offs, this pathway has high relevance, too. Emissions to surface waters occur via spray drift, drainage, surface run-off and erosion. Quantitative estimations for isoproturon, which is a plant protection product classified as a priority substance and the most relevant in terms of quantity, result in emissions of more than 2000 kg/year from diffuse sources. These emissions are made up of

Spray drift:	approx. 20 kg isoproturon per year
Drainage:	approx. 950 kg isoproturon per year
Surface run-off:	approx. 1200 kg isoproturon per year.

The emissions via surface run-off from agricultural areas for trifluralin and diuron are estimated at 1kg trifluralin per year and 4-14 kg diuron per year in line with the lower amounts used. There are no quantitative estimations available for chloropyrifos because of insufficient data (EAF 2003[14]).

Misuse of plant protection products or deviations from the basic principles of the professional code of practice and the specific conditions governing their use (in Germany, the Plant Protection Act[15]) increase the amount of emissions: If, for example, the minimum distance to water bodies is not complied with, the quantities used based on area are exceeded or if guidelines for the period of application, soil conditions or angle of slope are not taken into account, increased surface run-off or soil erosion may occur.

Individual checks conducted or organized by the authorities, soil and water tests as well as leaf samples show that, in certain regions, both the legally binding water protection measures are being violated and prohibited or unauthorized plant protection products used. However, because of insufficient data it is unclear to what extent misuse could be the cause for the observed negative effects on groundwater and aquatic ecosystems, or whether licensing procedures are inadequate. A research project of the Federal Environmental Agency aims to clarify and document any possible misconduct and practical problems (BMU, 2005).

- ***Important current measures*:**

There are already detailed conditions for the application of plant protection products (type, plants, amount, season etc.) linked with the authorization of the products. Other specifications concern the expertise of the users and the suitability of the equipment. There are also guidelines to reduce soil erosion. Support measures and compensation payments for leaving fields fallow or for doing without fertilizers and chemical plant protection aim to support/motivate the users financially and to compensate for loss of earnings (e. g. funding for measures to aid the environment, generate quality and animal welfare as part of the Common Agricultural Policy of the EU (CAP)).

So far, it cannot be judged how effectively the Plant Protection Product Act has been implemented by the Plant Protection Services of the *Länder* since there are hardly any reports available with usable results (NABU, 2001; BMU, 2005, status February 2005). The data presented so far, however, suggest that better implementation could have decreased the emissions to water.

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14 There are also estimations for emissions via agricultural areas available for lindane (72 kg/year, data base 2000) and simazine (130 kg/year, based on consumption 1993). Due to the application bans which have since been passed, these figures should diminish and any remaining emissions will only be due to historical pollution.

15 See also the conditions governing the use of isoproturon, diuron, chloropyrifos and trifluralin in the respective data sheets.

Incorrect applications also occur because of a lack of knowledge or uncertainty about the amount really necessary based on economic efficiency. Existing reduction programmes start by trying to raise the level of expertise and optimize pesticide use (good agricultural practice). This includes introducing improved appliance technology. Projects in the direction of integrated plant protection aim at applying non-chemical plant protection products (BMVEL, 2005).

- ***Additional measures*:**

If the soft measures of the Reduction Programme do not manage to achieve effective control of the emissions of priority PPP, then a further tightening of the permit requirements at national level could be considered. As well as further restrictions on use, the implementation of which would have to be guaranteed by appropriate enforcement, another option is to restrict the group of users so that, e. g. only correspondingly qualified specialist firms would be allowed to distribute the products.

Emissions pathway historical pollution:

- **Emissions relevance:**

The remaining stocks of no longer permitted PPP may contribute to pollution if their owners do not dispose of them correctly. It is suspected that, especially in the Eastern European Member States of the EU, there are substantial amounts of no longer permitted pesticides stored under sometimes inadequate conditions. Even in Germany, pesticides occasionally surface which are no longer authorized and sometimes past their use-by date (BMU, 2005). Nothing is known about the amount and relevance of these historical loads with regard to the priority pesticides of the Water Framework Directive.

- ***Important current measures:***

Under the existing community law regulations governing hazardous waste, these stored stocks of pesticides must be disposed of in an appropriate manner. Violations of the statutory provisions must be minimized by suitable enforcement and appropriate sanctions.

7.4 Tributyltin compounds

The most important application of tributyltin compounds is in anti-fouling products such as paints which are used to prevent ship hulls or other materials submerged in water from being colonized by sessile organisms. The most important emission reduction measures therefore concern the manufacture, processing and disposal of anti-fouling paints and the products themselves. Pollution loads in water sediments, especially in ports, are also linked with this. Other applications of TBT compounds, e. g. as wood preservatives, only play a minor role, in Germany at least. In smaller amounts, emissions can also be given off by production-based tributyltin impurities contained in mono- and dibutyltin compounds. These less toxic butyltin compounds are mainly used as stabilizers in various plastics (polyurethane, polyester, PVC etc.) which therefore contribute to the TBT content in very different products via which there are emissions to the environment due to leaching (for example in domestic wastewater) (see assessments in Böhm et al., 2002).

Emissions pathway urban areas and municipal sewage treatment plants

- **Emissions relevance:**

Within the work carried out at EU level, the relevant emission pathways S7 und S8 were classified as "1" (may result in or contribute to potential failure of WFD objectives). The other uses of TBT compounds (e.g. as wood preservatives or as biocides in very different areas of application) may also be relevant as well as the emissions caused by impurities in other organotin compounds. However, apart from the application as an anti-fouling product, the other uses of TBT have been irrelevant in Germany for several years (see UBA, 2000; Böhm et al., 2002). The quantities emitted via TBT impurities into water were also estimated as small for Germany with approx. 20 to 40 kg/a (Böhm et al., 2002), so that these emission pathways have only minor relevance for Germany.

- ***Important current measures*:**

There are no measures currently being implemented at either the international or national level.

- **Additional approaches:**

The risks from various organotin compounds to human health and the environment are currently being assessed at European level. Based on the results achieved, the applications or emissions in the relevant areas could be limited through substance restrictions.

Emissions pathway industrial discharges

- **Emissions relevance:**

Smaller as well as larger industrial operations have been classified as relevant with regard to future compliance with the quality targets at European level. Particular attention is drawn to shipyards and possible emissions during the application and removal of anti-fouling products. There is no information available on the emitted loads either for the EU or Germany. In spite of the future ban on the use of TBT compounds in anti-fouling applications (see below), ship coatings containing TBT will continue to be used for several years in shipyards due to the planned transition periods.

There are no emission restrictions at European level for the industrial production and intermediate processing of TBT compounds or other organotin compounds which may give rise to TBT compounds during their manufacture. The largest emission of organotin compounds stem from the metal industry according to the results of the European Emission Inventory for 2001. In Germany, the wastewaters of the various sectors are not permitted to contain organotin compounds under the regulations of the Wastewater Ordinance (production of coating materials, water treatment).

Table 7–1: Results of the European emission inventory for 2001: emissions of organotin compounds in Europe and in Germany

Organotin compounds		European Union						Germany						% D in EU
		Water direct		Water indirect		Total		Water direct		Water indirect		Total		
IPPC	Source category	kg/a	%	kg/a	%	kg/a	%	kg/a	%	kg/a	%	kg/a	%	
2.1.ff	Metal industry, roasting and sintering installations, metal production	2420	86.1			2420	76.1							0
4.1.	Organic basic chemicals	322	11.5			322	10.1	322	100			322	58.1	100
4.5.	Pharmaceuticals			232	63.2	232	7.3			232	100	232	41.9	100
5.3./ 5.4.	Disposal non-hazardous waste	69.5	2.47			70	2.19							0
6.7.	Appliances for treating surfaces using organic solvents			135	36.8	135	4.2							0
	Σ	**2811.5**	**100**	**367**	**100**	**3179**	**100**	**322**	**100**	**232**	**100**	**554**	**100**	**36**

- ***Important current measures*:**

There are no measures being enforced apart from the implementation of the TBT ban which is described in more detail below.

- **Additional approaches:**

Restrictions concerning the discharge of TBT compounds could be applied when implementing the IPPC Directive. So far, however, shipyards are not included in this ordinance's scope of application. For the other relevant sectors regulated by the IPPC Directive, the particular relevance of the TBT compounds should be taken into account when compiling/reworking the BREFs (papers describing the best available techniques). In Germany, work is currently being done on an Annex to the Wastewater Ordinance specifically concerning shipyards.

Historical pollution/disused mines

- **Emissions relevance:**

The emissions pathway S11 "Emissions from historically contaminated soil" was classified as relevant with "1" with reference to contaminated port sediments. Some loads due to contaminated sediments in port areas were also identified within the inventory records in Germany (MUNLV, 2005).

- ***Important current measures*:**

There are no measures currently being implemented at international or national level.

- **Additional approaches:**

As part of the normal maintenance measures, sediments have to be removed at regular intervals from ports and shipping routes. In order to be able to target priority removal of especially polluted sediments, first of all chemical analyses have to be conducted to determine the pollutant situation. Here not only TBT-based pollution is important but also other priority substances such as e.g. hexachlorobenzene, for which water sediments are cited as the reason for exceeding quality targets.

Products

- **Emissions relevance:**

The emission pathways S4 (transport and infrastructure) and S5 (accidents) were classified as relevant based on the use of TBT compounds as anti-fouling products. Estimates show that this application causes by far the largest emissions and that TBT is continuously and directly released to water due to leaching processes, (emission rates between 0.1 and 2.8 µg/l; Krinitz/Stachel, 1999).

- ***Important current measures*:**

The ban by the International Maritime Organization IMO on the use of organotin compounds as anti-fouling paints is being implemented within the EU via the EU regulations 2002/62/EC and 782/2003. Accordingly, active TBT paints have been banned since 1 July 2003. From 1 January 2008, ships with an active TBT coating will no longer be allowed in EU ports.

- **Additional approaches:**

One starting point for further measures in the field of products concerns the reduction of TBT impurities in other organotin products. The ongoing work at EU level assessing the risks to human health and the environment from various organotin compounds should be taken into account here.

7.5 Overview

The results of the substance group-specific studies are summarized in Table 7–2. The important main emission points are marked in the upper part of the Table. In the bottom part, various starting-points for emission mitigation measures are listed, divided into those at EU and those at national level.

Table 7–2: Emission focal points and possible starting points for emissions reduction

	Municipal discharges		***Industrial emissions***		***Agriculture***	***Products***	***Historical pollution***		***Air emissions***
	municipal sewage plants	*urban areas*	*IPPC-installations*	*other plants*			*Disused mines*	*Sediments*	
Lead	**X**	**X**	**X**	**X**	**X**	**X** (building products, hunting, fishing, diving)	**X**	**X**	**X**
Cadmium	**X**	**X**	**X**		**X**				**X**
Nickel	**X**	**X**	**X**		**X**	**X** (brake pads, tyres)	**X**	**X**	**X**
Mercury	**X**	**X**	**X**	**X**	**X**				**X**
PAHs	**X**	**X**				**X** (tyres)		**X**	**X** (flue gas)
Tributyltin compounds			**X**	**X**		**X**		**X**	
Diuron	**X**	**X**		**X**	**X**				
Isoproturon	**X**		**X**	**X**	**X**				
Starting points for measures EU:	- Extending requirements under 91/271/EEC	- Extending requirements under 91/271/EEC	- better integration of priority substances into BREFs -Isoproturon/ Diuron in PRTR	- Info process similar to BREFs; - Sectors: dental treatment, shipyards, etc.	- fertilizer requirements (ongoing) - BEP, Thematic Strategy, CAP	- general measures re (imported) products (substitution, migration rates); - Extending 98/8/EC - vehicles (PAH, nickel)			- Particle filter (ongoing) - combustion systems - Info process similar BREFs; (crematoria, domestic fuel)
Starting points for measures D:	- advanced requirements	new Annex to Wastewater Ordinance (in preparation)		see EU (shipyards: in prep.)	- fertilizer requirements - measures to reduce erosion - application restrictions - Info/BEP user	- Info measures for lead, nickel etc. - public procurement - labelling criteria - vehicles (PAH, nickel)	- disused mines requirements	- polluted water sediments	- funding measures via taxes - combustion plants (Hg) - domestic fuel use

8 Identification of additional national options for action

Based on the status of work done so far at EU level and the discussion processes up to now, it can be assumed that measures to limit emissions should be conducted in addition to the EU daughter directive or rather its implementation at national level. According to the results of Chapter 7, the most important potential starting points for national emission reduction measures are:

- Urban areas:
  - stormwater management: desealing, treatment, stormwater infiltration
- Municipal sewage plants:
  - advanced wastewater treatment in large municipal sewage plants (membrane filtration, activated carbon supplements)
- Industrial discharges:
  - advanced wastewater treatment in relevant sectors
- Agricultural areas:
  - measures reducing erosion
  - lowering pesticide emissions
  - lowering the pollutant loads in fertilizers
- Historical pollution/disused mines:
  - emissions mitigation in disused mines
  - pollution due to water sediments or sediments in ports
- Products:
  - substance restrictions (e. g. reduction of lead use in fishing, diving and hunting sports, heavy metal applications in brake pads)
  - restrictions on the use of relevant substances in imported products (examples: NP and OP as well as SCCP in textiles)
  - substitutes/abatement measures in the construction industry
- Atmospheric deposition / air emissions:
  - emissions reduction from transport
  - emissions reduction from industrial installations and the use of domestic fuel.

These starting points are analysed and assessed in more detail in the following.

8.1 Measures for stormwater management: desealing, infiltration and stormwater treatment

- ***Description***

Considerable substance loads are discharged into water via stormwater running off sealed surfaces. The main sources for these substances in the run-off water include atmospheric deposition due to air pollution, road traffic, contaminations such as e. g. plant residues and animal excrement, as well as emissions from surfaces actively affecting run-off such as e. g. roofing and façade materials. If stormwater is channelled into a combined sewer system, it must also be considered that, should the capacities in the sewers be exceeded, the combined water then released represents a mixture of rainwater and sewage.

Various approaches are possible to reduce the pollutant emissions to water due to stormwater discharge:

a) avoidance of pollutants entering the rainwater to be discharged, e. g. by improving air quality (see Chapter 8.7) or by substituting the substances in the relevant products (see Chapter 8.6),

b) the decentralized (pre) treatment of rain run-off from roofs or streets before its discharge to the sewer system,

c) decoupling surfaces from the sewer system by desealing and run-off infiltration measures as well as

d) improved treatment of the combined water or stormwater from combined/separate sewer systems for example via retention soil filters which can be used in both combined and separate systems.

Existing technologies for approaches b) to d) are described in more detail below.

on b) Decentralized (pre)treatment of rain run-off:

Various decentralized processes have been developed in the last few years to treat run-off, especially from roofs, which should be used in buildings with large metal roofing surfaces (made of copper or zinc). The specialized technical requirements here result from the widely varying loads involved: both the hydraulic loads (volume of rain) and the substance loads fluctuate very strongly (high substance concentrations to start with - the so-called "first flush effect"). An overview of the various systems currently available has been compiled within the scope of a research project of the Federal Environmental Agency (see Table 8–1).

Some specialized infiltration systems are used for road surface run-off since this contains a much higher share of particle-bonded pollutants in comparison to run-off from roofs. For example, retention soil filters are used (see below) or sedimentation systems with low hydraulic loads (Kasting, 2004). The use of sack filters is being tested for preliminary purification as is a multi-stage process with a filter basin which achieves extensive retention of particles and heavy metals through a combined sand/adsorbent layer (Hermann, 2005; Hilliges et al., 2005; Gretzschel et al, 2003).

on c) Decoupling surfaces (desealing, run-off infiltration):

Surfaces can be decoupled from the sewer system by desealing surfaces and allowing infiltration of the precipitation falling on them. In this way, the infiltration is retained in the natural local hydrological cycle which reduces the burden placed on sewers, sewage plants and water bodies (reduction of hydraulic peak loads). Within the scope of an ecological stormwater management concept, corresponding measures should be coordinated with measures for (decentralized) storage and (throttled) discharge. There are different systems available such as, e. g. surface, depression or gravel filled drain trenches, which vary greatly with regard to the amount of land they require. The water is basically purified using the filtration effect of the different soil layers, especially the planted topsoil. Substances which are not biodegradable, or not readily so, accumulate in the soil. Protecting groundwater against pollutants is an important objective when designing such infiltration systems. Experiences made so far and the resulting technical recommendations for sizing such systems are described in the German guideline DWA-A 138 (Planning, Construction and Operation of Facilities for the Percolation of Precipitation water, 2004) and the data sheet ATV-DVWK-M 153 (Handlungsempfehlungen zum Umgang mit Regenwasser, 2000). The most important requirements of the A138 are:

- run-offs from sealed surfaces are to be graded as harmless, tolerable and not-tolerable based on the substance concentrations. Not-tolerable run-offs should be discharged into the sewer system or infiltration allowed only after suitable pretreatment.
- Infiltration via underground infiltration systems should only be done with harmless precipitation run-offs.

Table 8–1: Overview of the currently available systems for decentralized treatment of roof run-off (supplemented based on Hillenbrand et al., 2005)

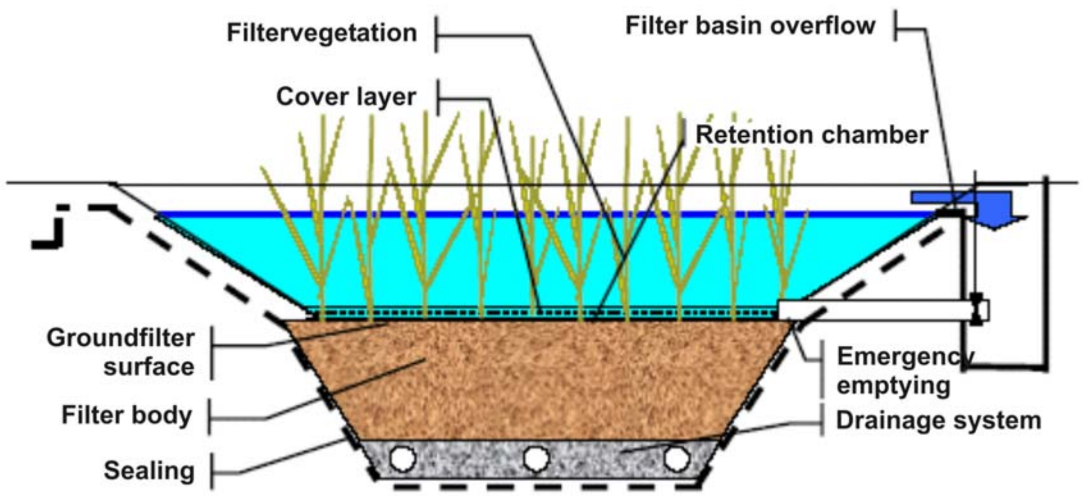
Supplier/ developer	Process technology	Experiences	Costs
HydroCon / Huber AG	concrete filter in concrete shaft with subsequent infiltration (via trench or drop-shaft); can be connected to sewer system	first systems in operation since summer 2003 ; tested in a R&D project (Dierkes/Gelhaus, 2006)	Construction costs: approx. 3 €/m² (one shaft for up to 500 m²: 1500 €; additional costs compared to conventional manholes: approx. 700 €) (when designed as a drop shaft includes the infiltration system; for larger areas or difficult soils plus the costs for trench; to some extent with installation) Operating costs: Concrete filter: approx. 300 to 400 € (lifespan: about 5 to 10 a); additional regular silt clearance
Mall Umweltsysteme/ KME	2-stage filter system in 1 (up to 500 m² roof area) or 2 concrete shafts (up to 1000 m²): Mud capture and filter cartridge (zeolite)	first systems in operation since summer 2003; being tested in a R&D project	Construction costs: approx. 7 to 15 €/m² (including infiltration; without installation) Operating costs: Filter cartridge: approx. 500 € (lifespan: about 2 to 5 y); additional regular sludge removal
KME	Downpipe filter for direct installation in stormwater pipes for areas up to 150 m² (up to 250 m² in development); assembly: prefilter and two-part filter body	first systems in operation; being tested in a R&D project	Construction costs: approx. 5 to 7 €/m²; Operating costs: Lifespan of filter cartridge approx. 2 to 3 a (approx. 200 - 250 €); additional simple cleaning of the prefilter
Plants in Austria (e. g. Purator)	3-stage filtration systems (sedimentation stage, suspended solids filter and adsorption filter) in two concrete shafts one behind the other with integrated infiltration	various systems have been operated for several years	approx. 4 to 19 €/m² (incl. infiltration; without installation) Operating costs: Lifespan of filter strongly depends on general conditions; rough estimate of costs: approx. 100 € per year
Entwicklungen TU München	System HydroCon with other filter media (klinoptilolith or polypropylene beads) (Athanasiadis, 2006)	being tested in a R&D project	so far only rough estimate possible for investment costs (approx. 4 to 8 €/m²);
EAWAG Schweiz	Infiltration shafts with additional filter fleece and adsorption filter layer (granulated iron hydroxide)	still under development	

- Run-offs from roofs covered with uncoated lead, copper and zinc are classified as tolerable and can be discharged to surface infiltration systems after suitable pretreatment or if necessary even without pretreatment (wide infiltration). Underground infiltration of precipitation run-offs from uncoated coverings of copper, zinc or lead is not allowed on principle.
- Rainwater from roofs with normal shares of uncoated metals (copper, zinc, lead) can be infiltrated in underground systems, but it must always be checked whether pretreatment is necessary according to the guidelines set in ATV-DVWK M 153. The metal shares in the total horizontal projection of the roof area may not exceed 50 m².

on d) Treatment of combined water and stormwater:

So far, stormwater overflow tanks have mainly been used in combined systems to cope with the discharge of rain/storm water. These tanks act as retention areas, temporarily storing some of the combined water and transferring this in a controlled way to the sewage plant, the rest is released into the receiving water as overflow. The substance load emitted to the water is reduced due to the interim storage and the settlement processes in the tanks. In separate systems, the discharged stormwater is generally not treated. Soil filter systems (also known as "constructed wetlands") have been employed recently in both combined and separate systems and are capable of achieving a high level of purification (see DWA, 2005a; LfU, 1998). These systems consist of a rain retention basin and a secondary filter basin (see Figure 8–1), so that many different drainage processes occur in parallel (separation of solids, adsorption, filter effect, biological breakdown processes) which all contribute to the purification of the water.

Figure 8–1: Structure of a soil filter system for advanced run-off treatment (DWA, 2005a)



- ***Target achievement / Reduction potential***

Estimates exist of the pollutant loads for heavy metals discharged to water via urban surfaces (on average 25 % across the four priority heavy metals, see Chapter 7.1). The main share is caused by the discharge of combined water and stormwater from combined and separate systems. These quantities determine the total reduction potential of the measures which, however, will only be able to be realized in the long term because of the long lifespan of the water infrastructure systems involved. Detailed evaluations of the effects and costs of the described stormwater management measures appear in Hillenbrand et al. (2005) and Hillenbrand/Böhm (2004). Sieker et al. (2006) list numerous concrete examples with more detailed information about the method and important frame conditions.

According to the results available so far, the decentralized treatment of roof run-off (b) can achieve a very high degree of pollutant elimination. An elimination rate of over 90 % is expected for heavy metals based on the test results available from individual demonstration systems (see Helmreich, 2003).

Decoupling surfaces from the sewer network by desealing or seepage (infiltration) measures (c) means completely avoiding the emissions to water via the sewers. Nevertheless, these measures do not mean avoiding the emissions in total, since the pollutants removed from the water enter the soil and either remain there permanently depending on the degradability of the substance involved or may even enter the groundwater.

The treatment of combined water and stormwater (d) in retention soil filter systems effects an extensive removal of solid substances (and the pollutants attached to them) as well as heavy metals if suitable filter materials are used because of the adsorption processes taking place (DWA, 2005). A high level of retention can also be expected for organic micropollutants in addition to this (e. g. PAHS), but there are no detailed studies of this to date. In stormwater overflow tanks, in contrast, only partial retention of the pollutant loads can be achieved since a proportion of the combined water continues to be released and is only partially treated depending on the process technology present.

Alongside the elimination of priority pollutants, stormwater management measures have other co-benefits, which can heavily influence the decision in favour of this approach. These include the removal of other pollutants and nutrients (phosphorus, nitrogen, other organic and inorganic micropollutants), reducing the hygienic and hydraulic burdens on the water serving as the receiving water as well as improving local/regional hydrological cycles where infiltration/desealing measures are concerned (increasing the formation of groundwater, reducing flooding; Sieker, 2006; Helmreich et al, 2005; Krejci et al, 2003 and 2004; ATV-DVWK, 2003).

- ***Costs and efficiency***

Cost data are listed in Table 8–1 for the systems described under b) - decentralized (pre-) treatment of rain run-off (investments between 3 and 19 € per m^2 sealed surface; operating costs up to 100 € per year). Since there has only been limited experience with the systems up to now, the data on operating costs are based mainly on manufacturers' estimates.

The costs of measures to decouple surfaces (desealing, stormwater infiltration) as well as for treating combined water and storm water depend heavily on the prevailing local conditions. The following all play a major role:

- soil conditions,
- amount of precipitation,
- land prices,
- urban structure,
- ground slope,
- size of system and
- type and condition of existing sewers.

Hillenbrand/Böhm (2004) provide a summarized assessment of the many surveys in this field. The investments for stormwater overflow tanks are between 500 and 1,500 € per m^3 tank volume, the specific costs for soil filter systems are about half this plus the costs for the preliminary treatment stage. The operating costs of stormwater overflow tanks and soil filter systems are generally low. Possible savings in the sewer network and sewage plants can be offset against the necessary costs for decoupling surfaces. As a result there is a wide margin of resulting total costs. Under favourable general conditions, it is even possible to make overall cost savings. This is especially true for newly developed areas. Here it is often possible to dispose of stormwater locally in a cost efficient way, indeed in the majority of comparative analyses documented in the literature, this is even cheaper than conventional disposal.

- ***Instruments***

Up to now, there are no national guidelines on stormwater management. However, a new Annex to the Wastewater Ordinance is currently being compiled for "Stormwater" which should stipulate standard requirements. This annex targets new development areas. The Federal building code contains one additional general guideline in § 1a paragraph 1 which stipulates that land use has to be economical and soil sealing is to be avoided as far as possible. The relevant rules and standards compiled by the German Assocation for Water, Wastewater and Waste (Deutsche Vereinigung für

Wasserwirtschaft, Abwasser und Abfall; DWA) are also particularly significant. These papers are recommended for application by various *Länder*. In several *Länder*, the decentralized management of stormwater has been given priority through the regional water laws. These give priority to infiltration, irrigation or local rainwater discharge prior to sewer connection as far as this is compatible with public welfare. At local level, concrete demands can be made of stormwater management for example within the scope of urban land use planning and when defining development plans. The instrument of wastewater charges could be used as an additional approach. Calculating the wastewater levy could include the emission of priority pollutants caused by discharging polluted stormwater.

8.2 Advanced municipal sewage treatment

- ***Description***

In accordance with the legal requirements, the objective of municipal wastewater treatment is the extensive elimination or separation of the organic substances recorded in the parameters BSB_5 or COD as well as the nutrients nitrogen and phosphorous in larger plants. However, a wide range of both organic and inorganic (micro) pollutants are still left in the effluent and are discharged to water in this way. This emission pathway has particular significance for the heavy metal loads in surface water (see Chapter 7.1). Technical processes for improved treatment of municipal effluents have been developed and commercially tested in the last few years: membrane technology deserves special mention here, but also filtration methods using activated carbon. These technologies are able to improve the elimination rates of municipal wastewater treatment plants with regard to various priority substances.

Membrane technology is a physical separation process which filters out particles of varying size depending on the size of the pores on the membrane. Corresponding to the separation dimensions, a distinction is made between micro-, ultra- and nanofiltration and reverse osmosis. In industry, membrane technology is already used on a large scale to separate substances as well as to treat wastewater. It has only been used in municipal sewage treatment for a few years; the first large-scale plant began operation in Germany in 1999 (Wastewater Treatment Plant Rödingen). Table 8–2 shows the plants currently operated in Europe.

Table 8–2: Sewage plants with membrane filtration in Europe as of 2004 (based on Engelhardt, 2004)

Land	Sewage plant	Pop.	Status	System	Operator
Germany	Rödingen	3,000	1999	Zenon	Erftverband
	Markranstädt	12,000	2000	Zenon	Kom. Wasserw. Leibzig
	Büchel/Bickenbach	1,000	2000	Kubota	Aggerverband
	Knautnaundorf	900	2001	Huber	Kom. Wasserw. Leibzig
	Altenberge	1,000	2001	Huber	Gemeinde Altenberge
	Simmerath	750	2003	Puron	WVER
	Monheim	9,700	2004	Zenon	Gemeinde Monheim
	Nordkanal	80,000	2004	Zenon	Erftverband
	Waldmössing	18,000	2004	Zenon	Gemeinde Schermbeck
	Seelscheidt	11,000	2004	Kubota	Aggerverband
	Konzen	9,200	u.c.	Kubota	WVER
	Rurberg/Woffelsbach	6,500	u.c.	Kubota	WVER
	Markkleeberg	30,000	u.c.	Zenon	Kom. Wasserw. Leibzig
	Merkendorf	250	u.c.	Kubota	Zweckverb. Zeulenroda
	Glessen	9,500	planned	open	Erftverband
Nether-lands	Maasbommel	500	2002	Zenon	Rivierenland
	Varsseveld	23,000	u.c.	Zenon	Rijn & Ijssel
	Hilversum	200,000	planned	open	DWR
Switzer-land	Säntis	<8,000	2000	Zenon	Säntis Schwebebahn
	Schwägalp	780	2002	Huber	Säntis Schwebebahn
	Uerikon	9,000	u.c.	Zenon	Gemeinde Uerikon
Austria	St. Peter ob Jdgb.	1,500	2002	Mitsubi-shi	Rotreat GmbH
Italy	Brescia	46,000	2002	Zenon	unknown
England	Porlock	3,000	1998	Huber	Wessex-Water
	Swanage	23,000	2000	Kubota	Wessex-Water
	Campletown	24,000	2001	Kubota	Scottish Water
	Lowestoft	46,000	2002	Zenon	Anglian Water

u.c. = under construction

The particular advantages of the membrane method of wastewater treatment are (see DWA- Fachausschuss KA-7, 2005; MUNLV, 2003):

- complete retention of solids and, as a result, an improved outlet quality with respect to the parameters COD and BSB_5; hygienic effluent (i. e. filtration and decontamination system in one stage); outlet quality not affected by floating sludge, bulking sludge or foam formation (improvement of operational safety),

- the demands made of advanced wastewater treatment concerning the protection of water and groundwater can be fulfilled because of the high purification capacity (e. g. lower pollutant concentrations, avoidance of floating sludge),
- it is easy to expand plants because of its modular nature, and it can be used in both large, municipal wastewater treatment plants and small, decentralized ones.

Drawbacks include

- the higher operating costs caused by the higher energy costs and higher maintenance costs of the membrane modules,
- the more complex, mechanical preliminary treatment necessary to protect the membrane,
- the additional demands made of the process control as well as
- the greater sensitivity of the membrane to shock loads.

Membrane technology can be applied at two points: integrated into the activated stage to substitute conventional final clarification for separating the activated sludge (membrane activated sludge process), or downstream after conventional final clarification for advanced treatment of the effluent.

Micro- or ultrafiltration membranes are used in membrane separation activated sludge processes. According to information of the DWA-Fachausschuss[16] KA-7 (2005), the maximum separation limit is 0.4 µm, but modules are sometimes used with a pore size down to 0.04 µm (Voßenkaul, 2005). Flat sheet or hollow fibre membranes are used. There are operational advantages for membrane separation activated sludge treatment compared with conventional sewage plants since higher concentrations of dry solids can be suspended in the aeration tanks and thus higher concentrations of micro organisms. As a result, not only does the conventional final sedimentation stage become superfluous, but the activated stage can also be scaled down.

The most important reason for using membranes downstream from a conventional sewage plant is usually the obvious improvement in effluent quality, especially the high sanitary level of the effluent (ISA/MUNLV, 2006). Complete separation of all solids is achieved by the membranes. In addition, pollutants, micro organisms and even viruses can be retained to the extent that they are attached to larger particles. For sensitive waters, water to be used for recreational purposes (e. g. bathing), or water used as service water, the increased requirements are able to be met using membrane separation technology (e. g. Theiss et al., 2005). Möslang (2005) reports 8 local sewage

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plants with downstream "tertiary treatment" which had been constructed by system supplier Zenon Membrane Solutions by the end of 2005. In Germany, experiences have only been made with a few large-scale systems. According to ISA/MUNLV (2006), 3 plants are currently being operated – sometimes within research and development projects (Geiselbullach, Merklingen, and Bondorf-Hailfingen). Membrane separation technology has the advantage over water disinfection using ultraviolet treatment, ozonisation or chlorination in that no unwanted by-products are formed.

The use of activated carbon in a secondary adsorption stage in municipal sewage plants has recently been the subject of study in Baden-Württemberg (Neifer/Krampe, 2006; Metzger et al., 2005). The aim was to provide evidence for the possible improvements in the effluent outlet quality. However, there are no such large-scale municipal plants being operated up to now; in comparison to membrane technology, this process is still at an earlier stage of technology development.

- ***Target achievement / Reduction potential***

Particulates are separated to the largest possible extent in accordance with the functional principle of membrane technology. This also removes any pollutants adhering to these particles. For example, heavy metals or PAHs show a high adsorption tendency. So far, however, there are no detailed studies available on the additional elimination capacity of membrane technology in municipal sewage plants. In the context of work accounting for pollutants in sewage plants, Schäfer/Hofmann (1997) mention that the dissolved share of lead was 2/3 in final effluent with a concentration of 3 µg/l. The estimates made in Böhm et al. (2002) assumed that, for the heavy metals, a share of between 30 and 70 % can be additionally eliminated by membrane filtration.

In principle, activated sludge plants with membrane filtration can also improve the elimination of organic, non-readily degradable pollutants. This is achieved as a biocenosis is formed in a plant with a high sludge age which is better adapted to pollutants in low concentrations. This aspect is being examined especially in connection with the emissions of endocrine substances from municipal sewage plants (Schröder, 2003; Hegemann et al., 2002; Schiewer et al., 2001).

Besides the retention of priority pollutants, other additional water-relevant effects should be noted which may be of relevance within the scope of a comprehensive river basin management:

- wastewater disinfection (especially relevant if the water continues to be used, e. g. for recreational purposes),
- removal to the greatest extent possible of particulate substances and the phosphorous bonded to them (due to the reduction of particulates in wastewater also de-

crease in the formation of sludge and sediment in the water, i e. improvement of natural habitats),

- improved degradability when using membrane biology with regard to organic trace elements at least corresponding to the share adsorbed by particulates as well as
- possible further use of the purified wastewater as service or process water.

Tests made on the use of activated carbon with subsequent sand filtration showed a clear reduction of trace elements by an average 80 % (Neifer/Krampe, 2006). For the substance group of iodinated X-ray contrast agent, an average elimination rate of 75 % was achieved if 10 mg/l were added and about 90 % if adding 20 mg/l (Metzger et al., 2005).

- ***Costs and efficiency***

In comparison to conventional municipal sewage plants, activated sludge treatment with membranes greatly improves effluent outlet qualities (see Table 8–3). The additional investments required for this consist of the actual membrane itself, more powerful aeration, chemical and dosing systems as well as more complex mechanical preliminary treatment. These costs are set against savings due to possibly being able to do without the final clarification stage and part of the aeration tank volume – because higher solid concentrations are possible in the activated stage. In addition, there may be advantages for membrane separation activated sludge treatment due to the simplified possibilities for sludge stabilization as well as the reduced space required so that the investments may already be comparable depending on the given local conditions (Wedi, 2005; ISA/MUNLV, 2006).

Table 8–3: Performance data of activated sludge membrane separation systems in comparison with conventional activated sludge systems (Dohmann et al. 2002)

Parameter		**Conventional activated sludge system**	**Membrane separation activated sludge system**
Solids (suspended solids)	mg/l	10 – 15	0
CSB	mg/l	40 – 50	< 30
N_{tot}	mg/l	< 13	< 13
P_{tot} (with simult. precipitation)	mg/l	0.8 – 1.0	< 0.3
Microbiological quality		hygienically questionable	bathing water quality
Mixed liquor suspended solids	g/l	< 5	< 20
Spec. electricity consumption	kWh/m³	0.2 – 0.4	0.7 – 1.5

The membranes themselves account for a large share of the total investment. However, there has been a clear drop in costs in the last few years due to learning and economies of scale effects. The results of relevant surveys of the Fraunhofer ISI conducted among various system suppliers are shown in Figure 8–2 (Hillenbrand, Hiessl, 2006). A further drop can be expected in the future too. Technical simplifications are also expected regarding the mechanical equipment and its incorporation into the total system (DWA-Fachausschuss KA-7, 2005).

The costs of the membrane play a significant role since the service life of the membrane is generally much shorter than the depreciable life of the machine technology. The attempt is being made to reduce the costs of replacing membranes by both lowering the specific membrane costs and lengthening the service period (target: 7 to 10 years). Energy costs (specific total energy consumption approx. 0.8 to 1.6 kWh/m³, sometimes even up to 2.0 kWh/m³, compared to 0.3 to 0.5 kWh/m³ in conventional systems without water disinfection; DWA- Fachausschuss KA-7, 2005; Krampe/Laufer, 2005; Wedi, 2005; ISA/MUNLV, 2006) and the costs of the chemicals required also play an important role in the operating costs. Table 8–4 gives an overview of the various cost shares of membrane activated sludge systems which makes it obvious that the cost for replacing the membrane is of overriding significance. A comparison of operating costs based on quotes showed operating costs of 0.24 to 0.25 €/m³ for the largest currently operated municipal membrane activated sludge plant (KA Nordkanal) which are approx. 15 % higher than the conventional solution (0.20 to 0.22 €/m³, Engelhardt, 2002).

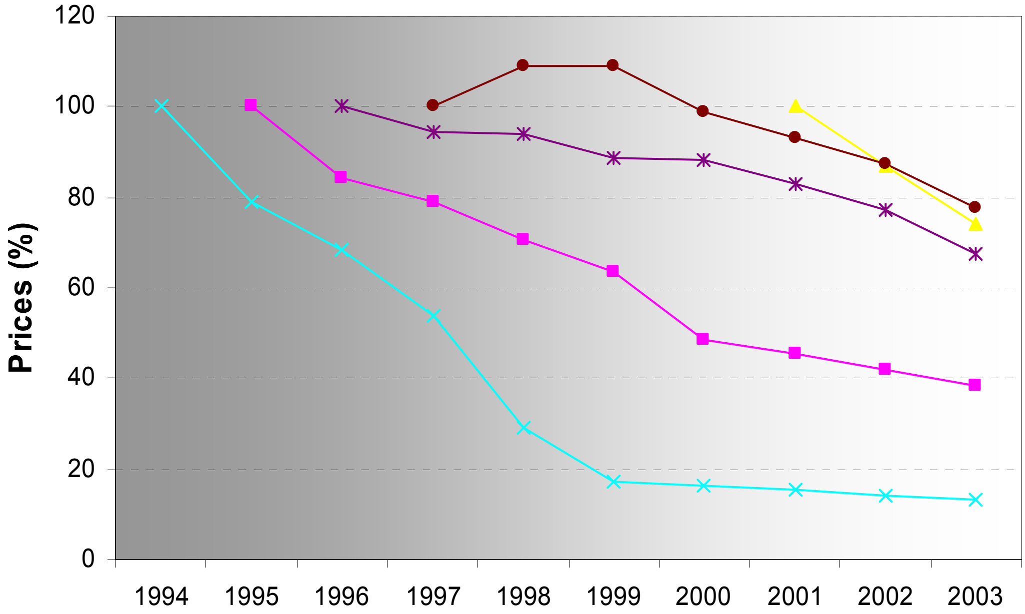
Table 8–4: Overview of the various cost shares of activated membrane plants (DWA- Fachausschuss KA-7, 2005)

		Costs [Ct/m^3]	**Category*1)**
Crossflow-aeration	0.20 – 0.75 kWh/m^3	2.0 – 7.5	O
Permeate/recirculation	0,08 – 0.10 kWh/m^3	0.8 – 1.0	O
Additional aeration demand	0.08 – 0.10 kWh/m^3	0.8 – 1.0	O
Chemicals	0.20 – 1.10 €/m^2 a	0.3 – 1.8	O
Membrane replacement	10 – 5 a	13.3 – 26.6	C

*1): O = operating costs; C = capacity cost

Electricity: 10 Ct/kWh; resultant sewage 90 m^3/(resident ● a), spec. membrane area: 1.5 m^2/resident, usual market costs for H_2O_2, acids and bases, membrane costs 80 €/m^2

Figure 8–2: Price developments of membrane modules (microfiltration/ultrafiltration) based on the example of several selected manufacturers (Hillenbrand, Hiessl, 2006) [17]



The costs of introducing a downstream membrane stage lie between 0.25 €/m³ and 0.42 €/m³ filtrate according to results of pilot studies (Dittrich et al., 1998). First estimates place the costs of an activated carbon treatment including grit filtration at about 10 Cent pro m³ or at 6 Cent if a grit filter is already fitted (Neifer/Krampe, 2006).

- ***Instruments***

The standards set for municipal wastewater treatment in Germany are regulated in Annex 1 of the Wastewater Ordinance. This annex contains requirements for the parameters BSB_5 and COD as well as for the nutrients nitrogen and phosphorus. In addition, specific water protection requirements can be taken into account when issuing plant permits, for example where particularly sensitive receiving water is concerned. Subsequent utilization requirements (bathing water, other recreational activities) also have to be considered. In this case, increased or additional limit values can be stipulated.

17 relative, based on cost at market introduction and corrected for inflation.

8.3 Industrial emissions

- ***Description***

Within the work at EU level, the wastewater emissions of industrial installations were assigned to category 1 for numerous priority substances (may result in or contribute to the potential failure of WFD objectives), among others for the four heavy metals, the PAHs, the tributyltin compounds and isoproturon classified as relevant for Germany based on the results in Chapter 6.3. The evaluation for the heavy metals shows, however, that the emissions in Germany are comparatively low when set against the pollutant amounts at EU level and that the share of industrial direct emitters in total emissions is also low. The background to this are the existing sector-based minimum requirements stipulated in the annexes to the Wastewater Ordinance in Germany, most of which were compiled in the 80s and subsequently implemented in the scope of water management authorization procedures. The IPPC Directive has also already been implemented to a large extent in Germany: already existing installations have been given until 30.10.2007 to obtain a permit, as of June 2005, the level of implementation in Germany was 83 %, at EU level, in contrast, only about 40 % (European Commission, 2006).

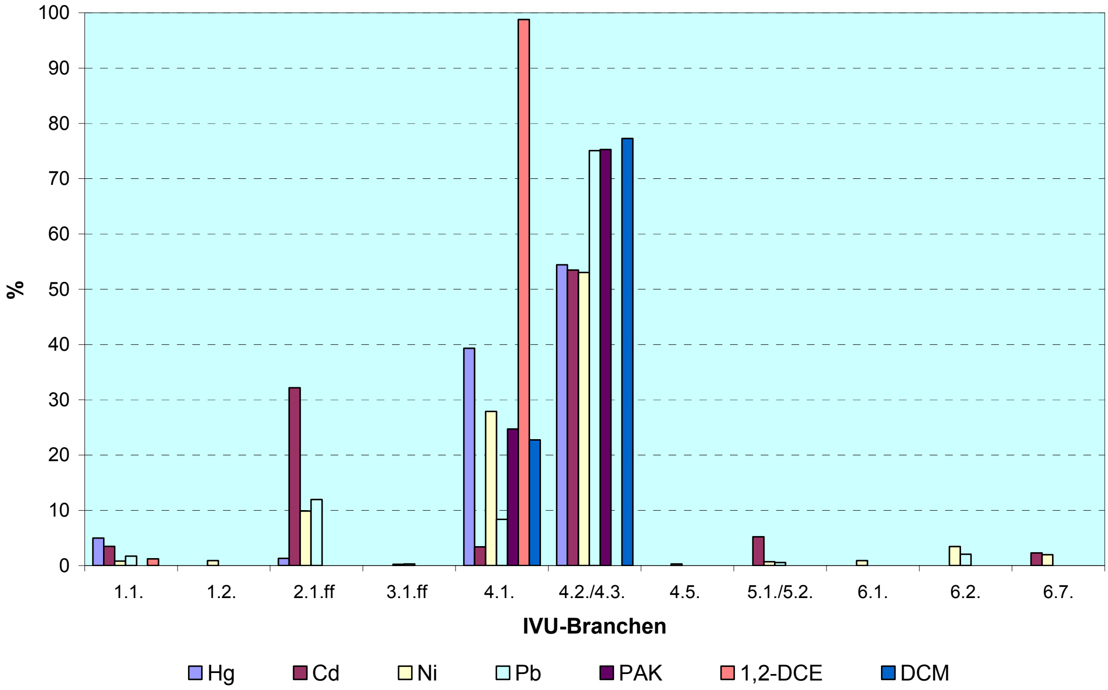
An amendment of the legal requirements made of industrial wastewater treatment in Germany is currently being discussed for various reasons, among others aiming to simplify the ordinance structure and achieve better implementation of EU directives (UBA/BMU, 2004). This should also consider additional aspects, especially cross-media aspects resulting from the IPPC Directive and the adoption of other chemical parameters resulting from the Water Framework Directive, among others. According to Veltwisch (2005) and Hahn (2004), action will be necessary since the state of technology described in the BREFs for implementing the IPPC Directive goes beyond the previous standards set in Germany in the Wastewater Ordinance. Some additional aspects are also listed (e. g. water conservation, closed-loop water recycling).

- ***Target achievement / abatement potential***

A review of recent literature in this field as well as of the BREF papers compiled for the various sectors shows that considerable efforts have been made in the past few years to develop and implement new methods of industrial wastewater treatment. The focus has been on the reduction of pollutant emissions and the advanced treatment of (partial) water flows to close in-house water circulations (DWA, 2005b; Frost&Sullivan, 2005; Rosenwinkel/Brinkmeyer, 2004; Schönbucher, 2004; Hasler, 2003; Quentmeier/Räbiger, 2003; Rappich, 2003). Process developments have taken place, e. g. in the chemical industry (Lebek et al., 2005; Spänhoff/Hagen, 2004; Schipolowski et al., 2003; Forstmeier, et al.; 2003), the paper industry (Gehlert/Wienands, 2005; Althöfer/Feuersänger, 2005; N.N., 2005; Schmid et al., 2004, Paulitschek/Rösler, 2003) and the textile industry (Döpkens et al., 2003; Brüß/Richter, 2003). The studies show that obvious improvements with regard to effluent quality and also the recyclability of the wastewater can be achieved, especially by combining different process techniques (membrane process, advanced oxidation processes, biological processes). However, as already pointed out above, it should be borne in mind that the share of water emissions due to industrial direct dischargers only make up a small proportion for the majority of the substances regarded here. For the heavy metals, for instance, the existing data show a share of 4 % on average (see Figure 7–1).

Regarding the significance of the various sectors in Germany, an evaluation was made of the priority substances recorded so far in the European Emission Inventory (Figure 8–3). According to these, by far the largest amounts of emissions originate from the chemical industry sector (4.1: basic organic chemicals; 4.2/4.3: basic inorganic chemicals or fertilizers).

Figure 8–3: Sector-based evaluation of the European Emission Inventory for Germany



- ***Costs and efficiency***

The processes or process combinations to be used in the individual sectors vary widely. As a result it was not possible to make any general statement about the specific costs involved. However, it is true to say that due to the combination of several process stages and setting up water cycles in the plants, the water flows involved become much more complex. The integration of the relevant measures in existing plants and locations is therefore sometimes difficult and costly and can frequently only be tackled in the course of necessary larger reinvestments. This also leads to the water infrastructure of companies or larger operational facilities increasingly being entrusted to external service providers.

- ***Instruments***

The Annexes of the Wastewater Ordinance are one way to lower industrially-related priority substance emissions to water. Within the scope of the amendment currently being discussed, extended requirements for the priority substances could be taken into account.

8.4 Agricultural areas

Due to the application of plant protection products, agricultural areas represent an emission source for priority pesticides. But other priority substances such as heavy metals are also discharged to water from agricultural areas via leaching processes and soil erosion. The problem of soil erosion is less acute in central and western Europe than in southern countries in which damages due to erosion occur on a catastrophic scale but even in Germany, areas in hilly regions are potentially exposed to erosion at an angle of slope of only 2-6 % if the protective plant cover is removed and the land is cultivated (DG Agri 2005).

Other emissions are caused by the use of fertilizers contaminated with cadmium.

8.4.1 Reducing the emissions of plant protection products from agriculture

- ***Description***

Due to the widespread, open application of plant protection products and biocides, the substances used can make their way into surface waters. Authorization of the active ingredients is regulated at European level, but any products containing these substances also have to be permitted in the Member States in which they are to be applied.

The authorization incorporates obligations aiming to guarantee that the pesticides, "*when properly applied for the purpose intended, they are sufficiently effective and have no unacceptable effect on plants or plant products, no unacceptable influence on the environment in general and, in particular, no harmful effect on human or animal health or on groundwater;*" (91/414/EEC). Evaluating substance-based risks is reliant on having a good data basis with respect to substance features, environmental behaviour and application practices. As a result, the risk characterization and the measures derived from this may harbour remaining assessment uncertainties.

The obligations include professional application of the plant protection product in accordance with the regulations. The products are only allowed to be used in approved application areas for designated crops and specific pests, whereby a minimum distance to surface waters has to be complied with. The “professional code of practice” has to be complied with which includes the restriction to the "necessary amount", the choice of suitable, safe equipment as well as the proper disposal of any leftover solutions or cleaning liquids.

Temporary contamination is caused by non-authorized active substances with residual terms or by the illegal use of old products or products purchased abroad. Permanent contamination arises from permitted substances if these are not handled in accordance with the guidelines associated with the permit but in view of the assessment uncertainties, this cannot be ruled out even if the product is applied correctly.

In spite of extensive regulations, the majority of emissions can still be traced back to misuse, overuse and farmyard run-offs. Important starting points to reduce emissions are therefore mainly in the field of supportive and motivating measures for users and in enforcement. Corresponding measures constitute one component of the Thematic Strategy on the Sustainable Use of Pesticides of the European Commission as well as The Reduction Programme Chemical Plant Protection of the BMELV18. This also includes the promotion of integrated plant protection and organic farming so that the use of chemical PPP is diminished or even avoided completely. Supportive measures and compensation payments provide users with financial incentives. The subsidies which form part of the Common Agricultural Policy (CAP) should also be taken into account here. To this end, there has been a partial decoupling of income aids from production in Germany since 2005. The aim is a gradual conversion to a regional model by 2013 in which there will be unified regional premium payments for arable land and grassland.

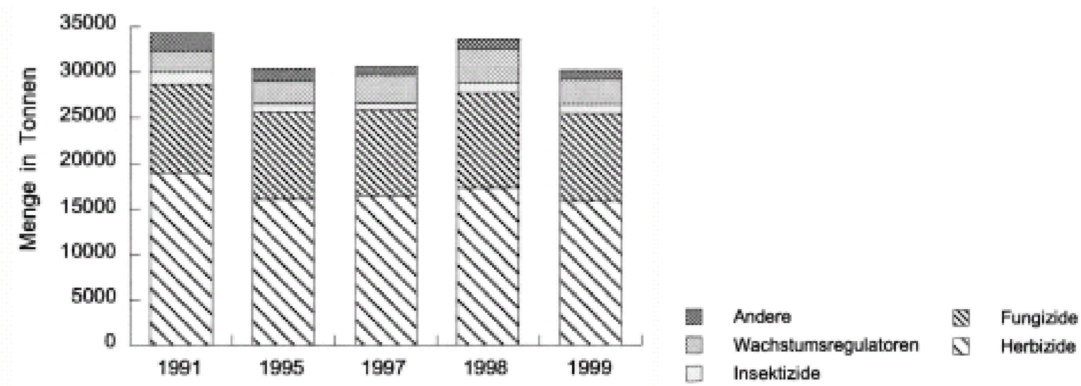
18 Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft (German Federal Ministry of Food, Agriculture and Consumer Protection)

- ***Target achievement / Reduction potential***

The Water Framework Directive's non-authorization of 6 of the 10 priority pesticides can be seen as one vital measure to cease emissions in this area, among them endosulfane and lindane, which are classed as priority hazardous substances. Small amounts of these substances are sometimes still permitted in medicinal applications[19]. The problem posed by historical pollution and illegal imports is difficult to estimate for these substances.

With respect to licensed pesticides, it can be noted that sales of plant protection products in Germany has remained at a high level of over 30,000 tons for more than ten years (see Figure 8–4). Approx 30 tons of plant protection products (not only priority substances) are discharged annually to surface waters (BMU, 2006a). The loads in groundwater and the frequency of limit value violations did not change significantly between 1990 and 1998 (LAWA, 2004).

Figure 8–4: Pesticide use in Germany 1991 – 1999 (PAN (2002)): Source: Biologische Bundesanstalt für Land- und Forstwirtschaft[20]



The misuse mentioned continues to result in relevant substance emissions of the authorized priority pesticides, especially from farmyard run-offs.

19 e. g. under the EU-POP Ordinance (850/2004) Annex I there is an exception for the use of lindane (HCH) as an insecticide in human and animal applications until 31.12.2007.

20 German Federal Biological Research Centre for Agriculture and Forestry

- ***Costs and efficiency***

The detailed conditions attached to the permit are obviously not having the intended effect since they are not controlled (cannot be) to a sufficient degree through a system of monitoring and sanctioning of violations. The competence demanded so far is also obviously not sufficient to restrict the use of pesticides to the "necessary amount".

The training and advice given to farmers, agricultural labourers, seasonal labourers and other users therefore constitute an essential component of measures to reduce the risks to the environment and human health. In the discussions "towards a thematic strategy on the sustainable use of pesticides" the suggestion has also been made to finance these measures in part via funds raised by levies on PPPs (EESC opinion 2003).

Measures to protect the environment and preserve soil structure and an application which goes beyond good professional practice are – not only with respect to plant protection products – often associated with additional work and expenditure. At the same time, cuts in profits are to be expected. Even if farmers may profit in the long term from sustainable land management methods, financial subsidies or compensation for profit losses due to agri-environmental measures are incorporated into the agri-environmental programmes. For instance, the budget for promoting voluntary agri-environmental measures in the EU amounted to over 2000 million Euro in 2003. In Germany, which has been promoting agri-environmental measures since 1994, the 2003 budget was almost 400 million Euro, whereby 39 % of the areas used for agriculture in Germany are covered by agri-environmental measures. The EU finances measures with up to 85 % depending on the relevance of the region (DG Agri 2005).

In an Impact Assessment of *The Thematic Strategy on the Sustainable Use of Plant Protection Products,* the costs for farmers, industry and the authorities were compared with the expected benefits. Even if farmers would have to bear the lion's share of the costs, the economic advantages predominate for this group, too, in addition to health benefits[21] (see Table 8–5; EU Commission, 2006a).

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21 It should be borne in mind that the benefits in such considerations are generally very difficult to calculate in monetary terms since, e. g. the value of the improved health of farmers and the population or the perservation of a rich diversity of plant and animal life can only be defined indirectly via avoided costs or as a non-material value.

Table 8–5: Costs and benefits of the Thematic Strategy Plant Protection Products (EU Commission, 2006a)

	Benefits	**Costs**	**Balance**
Farmers	+ 1100 to 1440 M€ (of which 770 – 1100 M€ saved costs for PPP) + reduced health risks	725 M€ per year in total for: - training: 250 M€ - adaptation and control of sprayers: 90 M€ - equipment maintenance: 40 M€ - purchasing new certified appliances: 2-4.5 M€ - detailed documentation of application: 2 M€ as well as - additional working hours: 210 M€ - additional consultation service: 130 M€ which can be compensated under rural development measures	+ 380 to 710 M€/year + reduced health risks
Industry	+ 3000 jobs: - 1700 – 2000 jobs in manufacturing and distri-bution, - additional jobs in logis-tics, training and certifica-tion, testing, control and servicing the sprayers and advisory services	300 – 670 M€ per year in total - between 770 and 110 M€ per year due to lost sales - due to proper management of chemicals and containers (possibilities of compliance due to addi-tional advice services and development of innovative products)	+ 670 - 300 M€/year + 3000 jobs + greater competi-tiveness
Authorities of the Mem-ber States	+ 200 M€ per year from reduced health and envi-ronmental costs + 180 jobs + positive impacts on humans and the environ-ment	9 M€ per year for data collection on PPP sales and applications.	+ 191 M€ per year + 180 jobs + positive impacts on humans and the environment

In Germany, total pesticide use is still high (see target achievement) and has clearly not been significantly reduced by the measures up to now. It should be noted, however, that this volume is almost impossible to check since, so far, only the German Federal Biological Research Centre for Agriculture and Forestry (Biologische Bundesanstalt für Land- und Forstwirtschaft) is obliged to register sales of pesticides (§19 PflSchG), from which the use of PPP can only be indirectly calculated. To observe the development of pesticide use over time and evaluate the efficiency of the measures, it would be necessary to organize the consecutive collection of correspondingly differentiated, application-based data.

- ***Instruments***

The Reduction Programme of the BMVEL incorporates various instruments, e. g. (BMVEL 2005):

- **Treatment index as a measure for the intensity of PPP use.** Treatment indices are to be introduced to orientate the application of chemical plant protection products towards the "necessary amount" more strongly than has been done so far. The necessary amount describes the intensity of PPP necessary to guarantee the cultivation of crops against the background of economic efficiency. The treatment index corresponds to the number of applications taking into account reduced application rates and partial area treatments for a specific crop and a specific plant protection effect (e.g. herbicide, fungicide, insecticide). It is calculated using a nationwide network of representative farms. The treatment indices should serve as an indicator for the intensity/frequency of use and are able to mirror trends if surveyed on an annual basis. The necessary amount can be defined at regional level within a target corridor around the average respective treatment index. Initial values for treatment indices were derived from the results of the NEPTUN-Study (2000).
- **Plant protection risk indicators to determine risk trends.** The treatment index does not include any risk factors as input. In the medium term, therefore, plant protection risk indicators should be developed which mirror the probability of a risk due to the use of pesticides. The prerequisite for this are representative data on the uses of PPPs.
- **Hot spot management.** "Hot spots" are fields of action defined by time and space in which, among others, risks may occur due to the application of PPPs which cannot necessarily be foreseen when authorizing the PPP. These include, e. g. commercial scale applications, high frequency of use in connection with critical frame conditions (e. g. heavy rainfall). These should be identified and targeted, tailored measures developed for risk mitigation.
- **Forecast methods and computer-based decision aids**. To support the targeted use of pesticides and avoid unnecessary treatments, computerized forecasting and warning services are already being used today. These instruments have to be developed and improved.
- **Promotion of farming methods without or with lower pesticide use.** Promotion of organic farming and integrated production. As well as the existing financial measures, these instruments are also reliant on improved information and advice.
- **Improving control of the use and sales of pesticides.** It is the responsibility of the *Länder* to control PPP use. An additional national system of control aims to improve the transparency of plant protection and aid risk management.

8.4.2 Measures reducing erosion

- ***Description***

The discharge to surface water of PPPs, heavy metals and nutrients due to soil erosion and soil particles being washed away in surface run-offs are estimated as very relevant (BMU, 2006a). The prerequisites should be created for preventative soil protection based on the German Soil Protection Act.
The prevention of soil compaction and soil erosion is also part of good agricultural practice. Erosion-reducing land management methods include crop rotation considerations, the use of cover crops and avoiding overworking the soil (sowing into the remains of the previous crop without ploughing). In areas which are at risk from erosion (compacted soils or inclines), round-the-year soil cover is preferred (mulch seeding). This is especially relevant regarding the use of herbicides such as isoproturon, which are specifically applied to keep the soil plant-free during interim periods (e. g. for root crops) and thus encourage soil erosion. Water and wind breaks are created by reintroducing embankment hedges (so-called breaks) to structure open fields. In winegrowing areas, there is the possibility to use cover crops to create green corridors between the rows of vines.

Many of these measures are linked with more work and/or higher costs which can be counterbalanced by corresponding financing measures.

- ***Target achievement / Reduction potential***

The actual annual soil erosion varies widely with region and depends on how the soil is worked and on any measures conducted to prevent erosion. Since the loss of the fertile topsoil is irreversible, measures have to aim at avoiding or mitigating erosion in areas at risk. In general, an increase in agricultural soil preservation (measures aiming to prevent soil erosion) can be observed (HGF 2002). So far, there has been no documented change in the established indicators for soil erosion.

- ***Costs and efficiency***

Funding measures to decrease soil erosion are an integral part of the agri-environmental programmes and should not be regarded in isolation from other measures (see Chapter 8.4.1). The increased costs for working the land or for sowing catch crops are set against the costs from the loss of the fertile topsoil if no erosion-reducing measures are conducted[22].

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22 Neither the costs of the immediate consequences of erosion nor the benefits from preserving topsoil were taken into account in Table 8-5. These costs – including the losses for agriculture, the detrimental effect on the water balance/supply and flooding damage – are estimated at 280 million Euro per year by the European Environmental Agency, and the soil recultivation costs for a period of 15 to 20 years are estimated at approx. 3 billion Euro (DG Agri 1999).

- ***Instruments:***
  - The competent ministries of the *Länder* offer farmers information and guidelines to educate them about soil erosion and suitable measures. There are individual implementation guidelines available for the Soil Protection Authorities[23].
  - Using the German version of the universal soil loss equation (ABAG), farmers and government officials can calculate the rate of erosion. The maximum tolerable soil loss for deep soil of high quality is given as 10 t soil per hectare per year or about 0.6 mm topsoil. For shallow soil of poor quality, this figure is 1 t soil per hectare per year[24].
  - Soil surveys and GIS data[25] are used to develop evaluation criteria on a regional (*Länder*) level. Indicators include the level of cover and the degree of slope. Specific measures for soil preservation can be identified, recommended and promoted once individual erosion risks have been assessed.

8.4.3 Decreasing pollution in fertilizers

- ***Description***

Some of the fertilizers used in farming show high concentrations of heavy metals (especially cadmium in mineral fertilizers) which accumulate in the ground and to some extent in plants, and which may be released into water through drainage and soil erosion. The heavy metal emissions decrease per hectare and year on the affected areas in the order shown: sewage sludge > organic fertilizer (from cattle/pig farming) > chemical fertilizer.

Cadmium emissions have also been reduced due to the 1997 introduction of a maximum limit for nitrogen of 170 kg N/ha for agricultural crop land in the Fertilizer Ordinance. A further reduction was achieved with the enforcement of the Sewage Sludge Ordinance (AbfKlärV 1992). By applying regular controls of the valid limit values for heavy metals, e. g. the average concentration of cadmium in agriculturally used sewage sludge (limit value 10 mg/kg dry matter) fell by 94 % from 21 mg/kg (1977) to 1.3 mg/kg (2000) (BMU, 2001).

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23 e. g. Saxony: http://www.umwelt.sachsen.de/lfug/boden_10051.html, Mecklenburg-Western Pomerania: http://www.lung.mv-regierung.de/dateien/bodenerosion.pdf, Brandenburg: http://www.zalf.de/home_zalf/download/soz/grano_infoblatt3.pdf, Lower Saxony: http://www.schweizerbart.de/pubs/books/bgr/nachhaltig-184100023-desc.html, Bavaria:

24 http://www.lfl.bayern.de/iab/bodenschutz/06558/index.php

25 GIS data on nationwide potential soil erosion are available from the Bundesanstalt für Geowissenschaften und Rohstoffe, Sektor Boden (German Federal Institute for Geosciences and Natural Resources, Sector Soil Resources).

The amended German Fertilizer Ordinance (Ordinance concerning the application of fertilizers, soil additives, culture substrates and plant additives based on the principles of good professional practice when using fertilizers, 10 January 2006) stipulates limit values for the cadmium content for soil additives and culture substrates. At EU level, limit values are being aimed at for cadmium in phosphate fertilizers.

8.5 Historical pollution/disused mines

8.5.1 Emissions reduction in disused mines

- ***Description***

In the existing inventory records for heavy metals, disused mines represent an emission source with unclear significance. In mines which are no longer actively operated and which may be historical structures, the resulting pit water can enter surface waters which sometimes show very high heavy metal concentrations due to the processes taking place underground.

This subject was discussed by specialists within a research project in February 2006[26]. Although the workshop managed a better estimate of the particular relevance of these emission sources, one remaining uncertainty concerns the fact that, although several large disused mining facilities have been examined, there is no systematic overview of the emissions, especially those from smaller disused mines. Furthermore, generalizations are difficult since disused mines vary greatly in their specific features; in isolated cases, the water may even be suitable for drinking water reclamation. Overall, mining emissions of cadmium, for example, make up approx. 10 % of the total emissions to German surface waters according to ongoing surveys to date.

There are passive and active systems for emissions from disused mines which can be used to treat pit water.

- ***Target achievement / Reduction potential***

There is a large reduction potential for point sources as shown by the example of the Burgfeyer disused lead mine and the river Erft. The tunnel water from the Burgfeyer mine discharged the largest share of the pollutant loads of zinc and cadmium into the river Erft, see Figure 8–5 (Christoffels, 2006).

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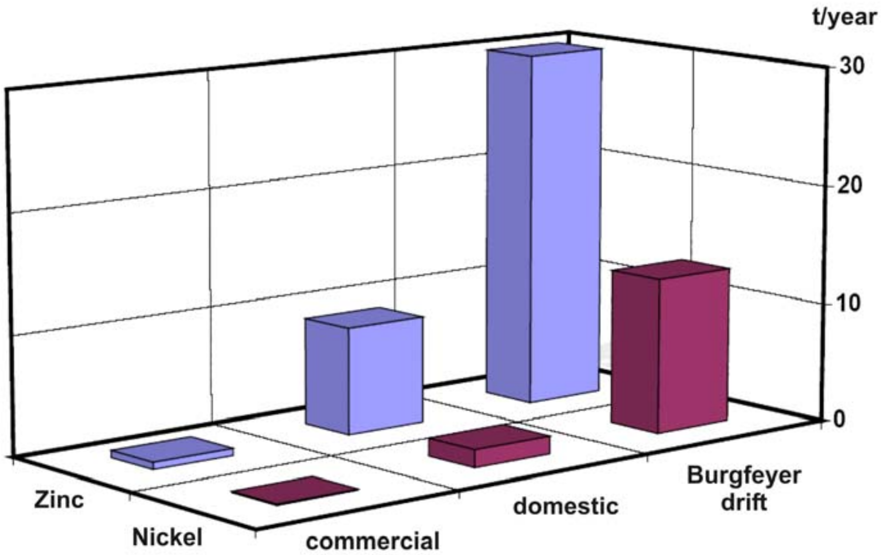
26 The presentations are available in German on the homepage of the German Federal Environmental Agency under "Stoffhaushalt der Gewässer": http://www.umweltbundesamt.de/wasser/themen/stoffhaushalt/schwermetalle-bergbau.htm

The choice of treatment depends on many parameters such as throughput, concentrations, seasonal changes, space required, cleaning performance, costs and others. In principle, every system is an individual one, tailor-made for a specific location (Brown et al. 2002).

Figure 8–5: Heavy metal emissions in the catchment area of the River Erft (Christoffels, 2006)



- ***Costs and efficiency***

Active systems are characterized by the continuous use of energy and chemicals. These are very precise, reliable technology processes in which almost complete reactions take place. According to a current study, the running costs are about 0.27-2.24 $/m^3$ and the mean investment costs 4.5 million US$ as an average over 21 systems (Morin & Hutt, 2006).

Passive systems: In order to be able to clean contaminated pit water cost effectively in the long term, it is necessary to apply methods with the lowest possible investment and maintenance costs. Various passive cleaning systems have started operation recently in Great Britain and Germany (e. g. anoxic limestone drains, open limestone channels, constructed wetlands, reactive barriers, large surface filters, RAPS[27]) (Wolkersdorfer/Younger, 2002). The cleaning rates are e. g. 74 to 93 % for iron in RAPS systems and 21 to 97 % in wetlands. The costs are cited as 0.11 to 12 Euro/ m^3 (0.08 £ to 8.1 £) (Brown et al., 2002).

27 A RAPS Reducing and Alkalinity Producing System combines an anaerobic wetland and a closed limestone drain.

- ***Instruments***

A survey is required in Germany which comprises data covering the location, the respective pollutant loads and any measures begun.

8.5.2 Pollution due to water sediments/sediments in ports

- ***Description***

There is currently no standard procedure for dealing with contaminated sediments in Germany. This is partly due to the amounts occurring: while more than 40 million tonnes have to be dredged in tidal rivers and coastlines to keep shipping routes free, only irregular, selective dredging is necessary inland.

Administrative directives exist for shipping lanes[28]. However, when dredging is carried out, attention is not often paid to the body of water as a whole in the sense of the WFD. In one report of the Technical University Hamburg-Harburg for the port of Rotterdam, five "areas of concern" were identified along the course of the Rhine in Germany. In these areas including, for example, the weirs on the Upper Rhine, pollutants can be mobilized from the dredged sediments which are detrimental for downstream riparian Rotterdam (Heise et al., 2004). In spring 2005, for instance, dredging at the Iffezheim weir had to be stopped after a sample measurement showed 700 µg/m^3 HCB concentrations in the suspended sediment, three times the longstanding annual average value of 225 µg/m^3 (Huber, 2005).

- ***Target achievement / Reduction potential***

The cheapest option is usually to remove contaminated sediments from water and clean them[29]; the most expensive is a thermal treatment to immobilize pollutants. For the latter, average costs of 45 Euro/m^3 are cited (SedNet, 2004). Unpolluted fractions can be separated from the sediments.

- ***Costs and efficiency***

There are various methods available to separate polluted fine-grained particles of organic and inorganic substances from utilizable gravel and sand. These are associated with considerable costs. One well-known plant is the METHA Treatment Plant in Hamburg; here 50 % of the sediment can be used as building material after treatment, the other half has to be disposed of. The costs are shown in Table 8–6.

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28 Directives on dredged material handling in coastal waters (HABAK) and in inland waters (HABAB).

29 In so-called mud harrowing, the fine-grained sediment at the bottom is churned up using compressed air so that it is removed by the current.

Table 8–6: Costs of various dredging treatments (HTG, 2006)

Option	Range (€/m³ in situ sediment)
Relocation costs heavily dependent on volume and distance to be transported	1.5 – 5
Subaquatic disposal in Netherlands Plant capacities between 1.5 und 150 million m³	approx. 5 - 15
METHA Treatment plant (Separation and dewatering) incl. operation, personnel, capital costs Throughput capacity METHA-plant approx. 1 million m³ in situ sediment per year	approx. 18
Upland disposal such as silt mounds in Hamburg installed volume around 700,000 m³, in situ sediment per year and mound	10 - 20
Treatment and disposal in Bremen incl. planning, construction and operation, staff, annual volume around 300,000 m³ /a	25 - 30
Operation and maintenance of the industrial dredged material and disposal plant in Rostock (longitudinal fractionating by flow) Fee up to marketable condition for average annual volume of 150,000 m³	8 - 9
Dewatering and ripening in the Netherlands	11 - 25

- ***Instruments***

As has already been demanded by SRU, the German Council of Environmental Advisors (SRU, 2004), there should be specific legal regulation of this topic. The SRU believes the HABAK/HABAB to be a good foundation for this. It further recommends assigning the relocation and disposal of dredged material in water more strongly to the water law management regime of the Water Framework Directive – which of course would have to be extended to cover the sea – in order (1) to formally secure closer cooperation between national and regional governments in the sense of a joint dredged material management, (2) to make sure the latter adhere strictly to the quality objectives of the Water Framework Directive or to the limit values derived from these and otherwise (3) to demand safe disposal on land without harming the environment.

8.6 Products

8.6.1 General aspects concerning products

- ***Description***

Emissions of priority substances from widely used products (manufactured items) can represent pollution loads which have impacts on both health and the environment. Especially where long-lived products in outdoor applications are concerned, small amounts of substances are continuously and directly released to the environment by leaching processes and are discharged into surface waters via atmospheric deposition, urban areas and sewage plants. These emissions may accumulate to considerable loads if substances like heavy metals are involved or others which are not readily degradable in the environment.

a) Substitution priority substances in products

There are substance-specific restrictions for certain products in individual cases if this is seen as necessary based on the risk assessment (inclusion in Directive 76/769/EEC or the Chemicals Prohibition Ordinance: e. g. PBDE, SCCP, PCP, TBT, heavy metals), or if substances are prohibited by regulations relating to the disposal of specific end-of-life products (ELV[30], RoHS[31]: certain heavy metals and PBDE). These also usually include an import ban on products containing these substances.

There are also effective approaches which contribute to emissions reduction for substance applications in products for which a general ban does not seem appropriate. Legally classifying a substance as toxic may also result in alternatives being used (example, legal classification of DEHP in 2001 as category 2, toxic to reproduction, SubChem 2006).

Guidelines and recommendations specific to one sector or even one company may also boost the search for alternatives. Partially publicly-funded research projects look for substitute substances for general or for specific applications and these are evaluated regarding their technical suitability.

Other approaches are the establishment of labels or standards which are only issued to products which do not contain certain substances with specific properties. These make use of market mechanisms. Government agencies can support this by specifically requesting the relevant criteria in public procurement processes. Companies and public authorities use these and other measures within the scope of an integrated product policy.

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30 ELV= Directive 2000/53/EC on end-of life vehicles.

31 RoHS = Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Non-regulative measures or voluntary commitments on the part of industry are usually not able to prevent these substances entering the national or European market through imports of preparations or manufactured goods. Here, only consumer demand can lead to pollutant-free or low pollutant products prevailing on the market. Information instruments such as labels or mandatory declarations can contribute to this process.

b) Measures to reduce emissions of priority substances from products
Different from restricting priority substances in products, from which they may be emitted, product safety requirements or other product-related requirements from different areas often address the emission behaviour of the products. For example standards were drawn up within the implementation of the Construction Products Directive which ensure that products do not exceed predetermined emission values (e. g. the AgBB scheme [32]or standards for flooring materials) or set certain minimum requirements with regard to the degradability and toxicity of elutable substances (e. g. DIBt criteria[33]).

In general, product quality standards contribute to emissions reduction. Ultimately, the loss of functional additives or contaminants is not a desired function of the products, but an unwanted side-effect which may even impair the durability or appearance of the products (e. g. PVC sheets which swell and become brittle as a result of UV radiation; Ahrens et al 2003). These requirements can put pressure on imported products by influencing demand.

The result of the different requirements is not always the substitution of the priority substance. Emissions can also be lowered by reducing the mobility of the substance in the product or by creating a barrier through appropriate sealing measures (e. g. sealed PVC flooring, plastic-coated lead diving weights). In these cases, corresponding disposal measures have to ensure that the substance is not able to enter the environment once the product becomes waste (targeted collection and disposal e. g. of batteries, end-of-life vehicles, waste electronic equipment, and PVC window frames).

With imported products, there is the general difficulty of monitoring compliance with legal specifications – as far as these exist. Violations of substance bans in products can usually only be uncovered by targeted analyses which tend to be complex and are only conducted on the basis of random samples or if there is already cause for suspicion. There are no legal grounds for action if only national or European voluntary

32 Ausschuss zur gesundheitlichen Bewertung von Bauprodukten – AgBB (Committee for the health-related evaluation of building products).

33 DIBt Leaflet on the assessment of the impacts of construction materials on soil and groundwater (DIBt 00).

agreements or standards exist[34]. Consumers in the EU have the opportunity here to influence overseas suppliers by avoiding specific substances or making compliance with industrial standards part of bilateral contract conditions. Even here, monitoring mechanisms are necessary to guarantee compliance with the agreements (Heitmann et al. (2006)).

- ***Target achievement***

Prohibited substances are generally no longer used in newly manufactured products. However, violations are frequently uncovered in products imported to Germany. A quick drop in product-based emissions cannot be expected for durable products.

With regard to non-prohibited applications, the effects of measures can best be estimated by looking at the market development of the substances. This is relatively easy to do in the case of DEHP, whose share in the total softener market has fallen sharply since 2001 (from 42 % in 1999 to 25 % in 2003[35]). For other substances, it is not as easy to assign the specific quantities used to their applications in manufactured items.

For some manufacturers or traders, replacing substances which are particularly hazardous to health in their products is an important objective which is documented in order to prevent disclosure scandals which may damage their business. This aspect plays an important role in consumer-oriented fields where there is a desire to positively influence public relations, e. g. in textiles (Öko-Tex 100) and automobile industry.

- ***Costs and efficiency***

Substituting substances in products or manufactured items with the objective of minimizing possible risks usually involves additional adaptations. This means, costs are incurred not only if the substitutes themselves have a higher price (which, however, may fall again due to increased demand for such products), but also if preparations, processes or machines have to be adapted to the changed properties of the substitute. This may have an impact on several stages of the value added chain depending on the complexity involved. Sector-specific certification mechanisms such as those in the automobile or aircraft industries may prove an obstacle here if the complex certification procedures have to be run through again once a substance has been changed (Ahrens et al., 2004).

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34 The example of chewable toys made of soft PVC made this very clear. Whereas the majority of European manufacturers of these products replaced the softener DEHP, which was classified as toxic to reprodcution, a Greenpeace campaign provided evidence of the high concentrations of this substance in imported products (GP, 1997).

35 ECPI 2004, European Council for plasticisers and intermediates.

Substance bans in products are certainly the most effective incentive for substituting priority substances as long as they include imported goods as well. At the same time, they are often very controversial because of their high economic impacts and difficult or costly to implement if a risk to the environment and/or health has not been clearly acknowledged. Furthermore, in the sense of a harmonized EU market, they only make sense if implemented as EU-wide restrictions.

Voluntary programmes raise the quality of products manufactured domestically but cannot be transferred to imported ones.

In contrast, depending on their binding force, the standards developed by industry represent a high incentive for companies to fulfil them. They may become binding for imported products at the same time if there is a corresponding market demand requiring this.

- ***Instruments***
  - **Substance bans:** ban on the marketing and use (including import) of specific substances (Directive 76/769/EEC or the Chemicals Prohibition Ordinance). Further restrictions on the use of DEHP with regard to the environmentally-relevant emissions are being discussed at EU level.
  - **Substitution obligations:** obligation to test and use alternatives as far as economically reasonable (e. g. German Ordinance on Hazardous Substances[36]).
  - **Voluntary commitments of industry**: to avoid a threatened extensive substance ban.
  - **Voluntary labels or declaration obligations:** inform customers where necessary about the environmental quality of a product such as the absence/presence of certain pollutants and thus exert influence on the market.
  - **Product standards**: standards can also be set with regard to the pollutant content or the pollutant emissions during use.

36 Gefahrstoffverordnung

8.6.2 Product-related measures concerning the use of lead in the construction industry

Description

Within the research project "Discharges of copper, zinc and lead to water and soil - analysis of the emission pathways and possible emission reduction" (Hillenbrand et al., 2005), the use of lead in the building sector was investigated in detail with regard to the resulting lead discharges to the environment and possible emission reduction measures. Lead, which is used in open applications in buildings, occurs mainly in the form of lead sheets for small area applications such as lead flashings (skirting) in chimneys, valley flashings, ridges, facades and skylights as well as in connections and reinforcements. In contrast, large-area roofing applications (usually historical buildings) only comprise less than 5 % of the lead sheets used. According to the available studies, the relevant erosion rates for the resulting lead discharges range from 2.37 to 8.0 $g/(m^2 * a)$ for exposed areas and from 0.52 to 0.97 $g/(m^2 * a)$ for small, integrated applications.

Various alternatives are available to replace lead sheets in their unprotected, weathered function such as coated materials, other metals like stainless steel or aluminium or even plastic in roof construction elements which have to be prefabricated. In the "Guideline for the Construction Industry" it is pointed out that the use of unprotected lead sheets is not possible in the applications to which the guideline applies (Hoffmann, Rudolphi, 2005).

Target achievement / Reduction potential

Lead emissions can be completely avoided by doing without lead sheets. Within the scope of the above mentioned research project, the emissions caused for Germany due to this application field were estimated in total: approx. 25 t of lead per year are emitted to the environment, about 17 t/a into surface water via the roof run-off discharged into the sewer systems. Concerning the reduction potential, however, it should be taken into account that substituting already installed material is difficult and costly and generally only possible when renovation work is being carried out. Due to the long service periods of the relevant building components of up to 50 years, this means that the reduction potential able to be achieved in the short term is clearly below the above mentioned figures.

In the construction industry, alongside lead, the heavy metals copper and zinc are also used. Here, there are also various possibilities available to substitute or reduce emissions. Copper and zinc are not actually included in the list of priority substances, but the valid target objectives of the LAWA are sometimes exceeded to a considerable extent in Germany. If measures to reduce lead emissions were coordinated with comparable measures concerning copper and zinc, the environmental or water discharges of these heavy metals could also be reduced as an additional effect.

Costs and Efficiency
The costs of the alternative materials are roughly the same as the elements made of lead depending on the application. Larger differences may occur in the costs of installation, however, since lead has specific advantageous features (easy to form and handle). However, the components for which lead sheets are used only make up a small share of the total costs for the roof or façade area. Therefore, the use of lead is already often dispensed with.

Instruments
A broad mix of instruments has already been established concerning the reductions of atmospheric emissions. Often, rapid market diffusion of the most efficient reduction technology is made possible by changing the legal requirements in combination with incentives (tax rebates as is the case with particle filters). The legal framework should be adapted for wood-fired stoves/crematoria. The efficiency of the wood stoves can probably also be increased by standards/labels.

So far, there are no regulatory measures on the use of lead in the building sector in Germany. The above mentioned “Guideline for the Construction industry” limits the use of lead in open applications. At local level, the use of heavy metals or the infiltration of run-off from roofs with metal coverings is sometimes restricted in the legally binding land-use plans. Since there are alternatives available to substitute lead sheets and the reason for using the heavy metals is more due to a lack of awareness of the problem among the relevant actors (architects, builders, tradesmen), a reduction of the emissions could be achieved through more advanced information measures at least in the medium to long term. The guideline mentioned is a first step in this direction.

8.6.3 Product-related measures concerning the use of nickel in brake pads

Description
Conventional brake pads are composed of metals to a large degree: iron and copper comprise the main component of most pads with a share of approx. 40 to 50 % (Rauterberg-Wulff, 1998). Other heavy metals are also present in lower concentrations such as e. g. lead, zinc, chrome and nickel. How these are combined, however, fluctuates greatly (see overviews in Hillenbrand et al., 2005; Wander, 2004). Wander (2004) determined average concentrations for nickel of 372 mg/kg in cars and 338 mg/kg in lorry brake pads. Brake pads are designed as wear parts; the annual volume of used brake pads from passenger cars and small commercial vehicles is estimated at 26,000 t by the Verband der deutschen Reibbelagindustrie (VRI)[37].

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37 Cooperation of the German friction material manufacturers

The requirements of the EU End-of-life Vehicle Directive 2000/53/EC made it necessary to switch to lead-free brake pads. This switch has since taken place to a large extent; lead brake pads are only still being offered for older vehicles. In the meantime, heavy metal-free brake pads are also being supplied but so far these are not used to equip new vehicles, but only to supply the aftermarket sector. According to manufacturers' data, a combination of mineral and ceramic fibres is being used as the substitute.

Target achievement / Reduction potential
Environmental emissions can be completely avoided by using brake pads made without heavy metals. With regard to copper, the main component, the emissions caused to the environment by this application are estimated at 928 t per year and the associated copper discharges to water at approx. 102 t per year (Hillenbrand et al., 2005). Corresponding to the much smaller nickel concentrations in the brake pads compared to copper, the expected emission reduction potential for nickel is also smaller.

Costs and efficiency
The prices of the heavy metal-free products currently available on the aftermarket are roughly equivalent to the prices of conventional products. However, if they were also used to equip new vehicles as well, substantial extra costs would arise due to the additionally necessary development work, tests and authorization procedures.

Instruments
The demands for a switch to lead-free brake pads were couched in an EU regulation specifically targeting the recovery of end-of-life vehicles. Other especially toxic heavy metals such as mercury and cadmium were also tackled within this regulation. There were no requirements adopted with regard to water-relevant substances such as nickel or copper. Other possible starting points to promote the use of heavy metal-free products are information measures or agreements with industry on procedures (voluntary commitments).

8.7 Atmospheric deposition or air emissions

In principle, the air emissions of priority substances have many varied sources, especially when they are used in very diverse applications like the heavy metals or when they are only formed in equilibrium reaction during combustion reactions. While existing legal requirements such as the TA-Luft[38] have already resulted in a reduction of the pollutants emitted to the air by large industrial installations, the challenge today is often that relevant emission quantities are produced by many individual small plants. It is often harder to control these small facilities as shown by, e. g. the number of times the exceptions allowed for particulate matter under the Air Quality Directive 1999/30/EG are exceeded (or the 22 BImSchV).

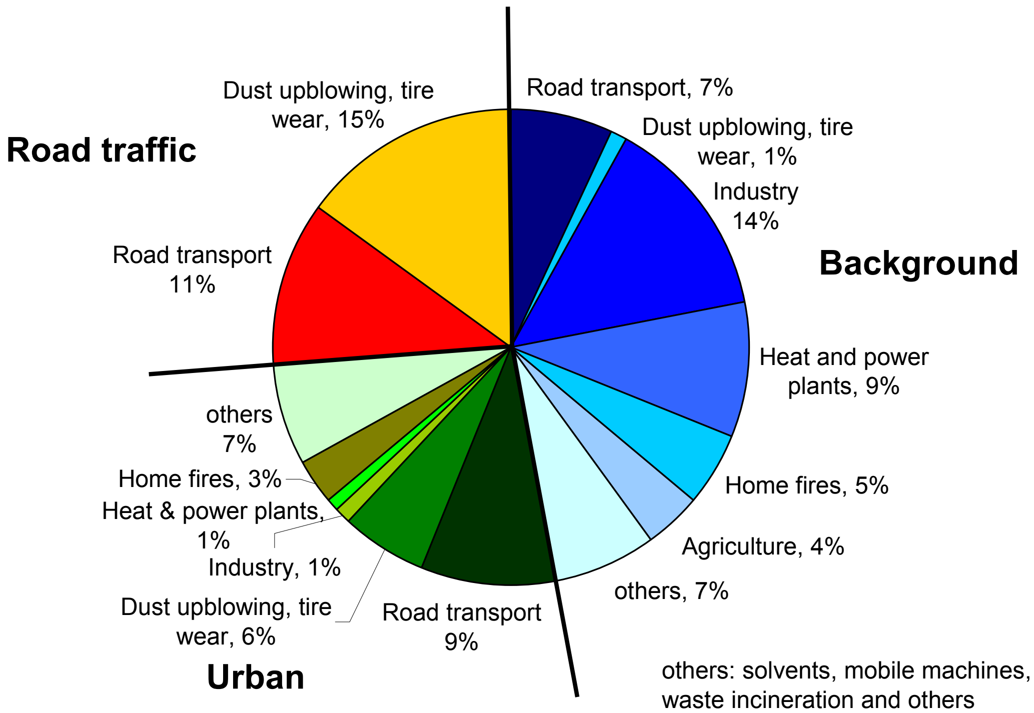
- ***Description***

Both integrated measures and end-of-pipe technologies are suitable technologies to reduce airborne pollutant emissions. Measures used to reduce particulate matter (PM10) have particular significance for the priority substances, since PM adsorbs both heavy metals and PAH.

According to tests, for instance made at a measuring point on a road in Berlin, the particulate emissions from traffic amounted to approx. 49 % (22 % of this due to road dust resuspension and wear and tear). These are comprised of local road emissions, emissions from local municipal sources and background emissions (see Figure 8–6). Particle filters could be used in other sectors as well after their widespread introduction into motor vehicles, for example in stationary motors used in the construction industry or in engines in leisure boats.

38 Clean Air Guideline

Figure 8–6: Shares of the individual emission sources in particulate matter (John et al., 2004)



Where particulate matter is concerned, the emissions from small wood-fired stoves have actually surpassed the emissions from traffic (see Table 8–7).

Table 8–7: Annual emissions PM10 in kilotons (preliminary figures, Feb. 2006)

PM10 emissions in kt	**2002**	**2003**
Small wood-fired stoves in households and small businesses	22.7	24.0
Road traffic (combustion only)	25.4	22.7

With regard to mercury air pollution, combustion plants are of primary relevance. By introducing efficient flue gas cleaning methods, emissions of mercury, but also PAH could be avoided. In the BVT data sheet on large combustion plants (GFA), a 90 % capture rate for mercury is cited as achievable when using hard coal if flue gas desulphurisation is operated alongside an electrostatic filter and selective catalytic reduction for NO_x removal; for operation without SCR, the data sheet cites a value of up to 75 %; for lignite-fired large combustion plants 30 – 70 %. SCR is state-of-the-art in Germany for large combustion plants; whereas the EU Directive for Large Combustion Plants does not contain any limit value for mercury, Germany has introduced one in the amendment of the 13 BImSchV in 2004, which has to be met by existing plants from

01.11.2007 or from 2011 by recently retrofitted plants (see 7.1). It still has to be examined to what extent this will actually substantially lower mercury emissions in Germany. It should be noted that adaptations should be implemented before the next new investment phase in large combustion plants which Forst and Sullivan have forecasted to be from 2008 in a market study for Germany (Frost & Sullivan, 2006).

For smaller combustion plants, the general requirements of No. 5.2.2 of the TA Luft 2002 are valid to some extent with a limit value of 0.05 mg/m^3 set for thallium and mercury respectively. In other combustion plants such as those in refineries, in the glass, cement or metal industries, SCR systems are not widespread according to BVT information sheets, but frequently only installed in pilot systems.

As well as the combustion plants recorded in the EPER, crematoria represent another main source for mercury emissions, mainly due to amalgam fillings. At present, under the 27 BImSchV, there are only emission limits for crematoria for carbon monoxide, total carbon, particulate matter and dioxins/furans. Effective mercury capture can be achieved using specialized flue gas cleaning methods (use of sorbents such as activated carbon, limestone etc.).

- ***Target achievement / Reduction potential***

Particle filter: The planned mandatory European emission standard, Euro 5, will introduce a PM limit value in the order of approx. 2.5 mg/km. This represents a fuel exhaust category for diesel passenger cars which will make diesel particle filter technology obligatory (otherwise diesel cars would not be able to comply with the PM limit), and should lower particulate emissions from cars by approx. 36 % between 2004 and 2010[39] (Lahl and Steven, 2004).

Domestic fuel use: The Federal Environmental Agency estimates that particulate matter emissions could be reduced by approx. 40 % by 2020 by amending the 1 BImSchV with the objective of tightening limit values and extending the scope of the BImSchV to include appliances with low capacity as well as by better information of the operators (UBA, 2006a).

Combustion plants: The share of combustion plants > 50 MW in Hg air emissions is over 50 % according to the results of the European Emission Inventory for Germany.

39 This assumes a 40 % share of newly registered diesel cars and that after this that all newly registered diesel cars undercut the cited limit value by 10 % in 2006, 30 % in 2007 and 60 % in 2008.

The emissions from combustion plants < 50 MW also make a substantial contribution to total air emissions. According to AEA Technology/NILU –Polska (2005), the share at EU level is about 16 %. The emitted loads calculated for Germany result in a share of 32 % in the air emissions reported to EPER.

Crematoria: According to OSPAR (2006), 36 kg Hg are emitted each year from crematoria in Germany: 17.7 kg from 105 crematoria in which mercury separation technologies are used and 18.3 kg from 21 facilities without specific technologies. These emission amounts could be reduced using improved flue gas cleaning methods.

- ***Costs and efficiency***

Particle filter: So-called open filter systems (flow through filters with 30-50 % efficiency) are suitable for converting older vehicles. These are expected to cost between 400 and 600 Euro[40].

Crematoria: According to OSPAR (2003), depending on the type of furnace involved, the costs of additional emission abatement measures lie between 27,270€ and 48,180€ per year ("cold start furnace") or between 45,460 € and 74,550 € per year ("hot start furnaces"). Related to the avoided mercury emissions, specific costs result of 50 to 73 €/g Hg and 100 to 145 €/g Hg, respectively.

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