Integrated Environmental Monitoring

Concept and Implementation

Umwelt Bundes Amt
für Mensch und Umwelt

Contents

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Preface

The concept of integrated environmental monitoring presented in this brochure was developed at the request of the Bavarian State Ministry for Regional Development and Environmental Affairs and the Federal Environmental Agency with additional participation by the Environmental Ministries of the federal states of Hesse and Thuringia.

Integrated environmental monitoring

- supplies instructions to the federal states about how to more effectively use their measurement networks and monitoring programmes,
- provides detailed approaches for better harmonisation of data collection,
- offers suggestions for integrating data analysis,
- makes it possible to more effectively use a limited financial budget, and
- can be implemented by the federal states step by step.

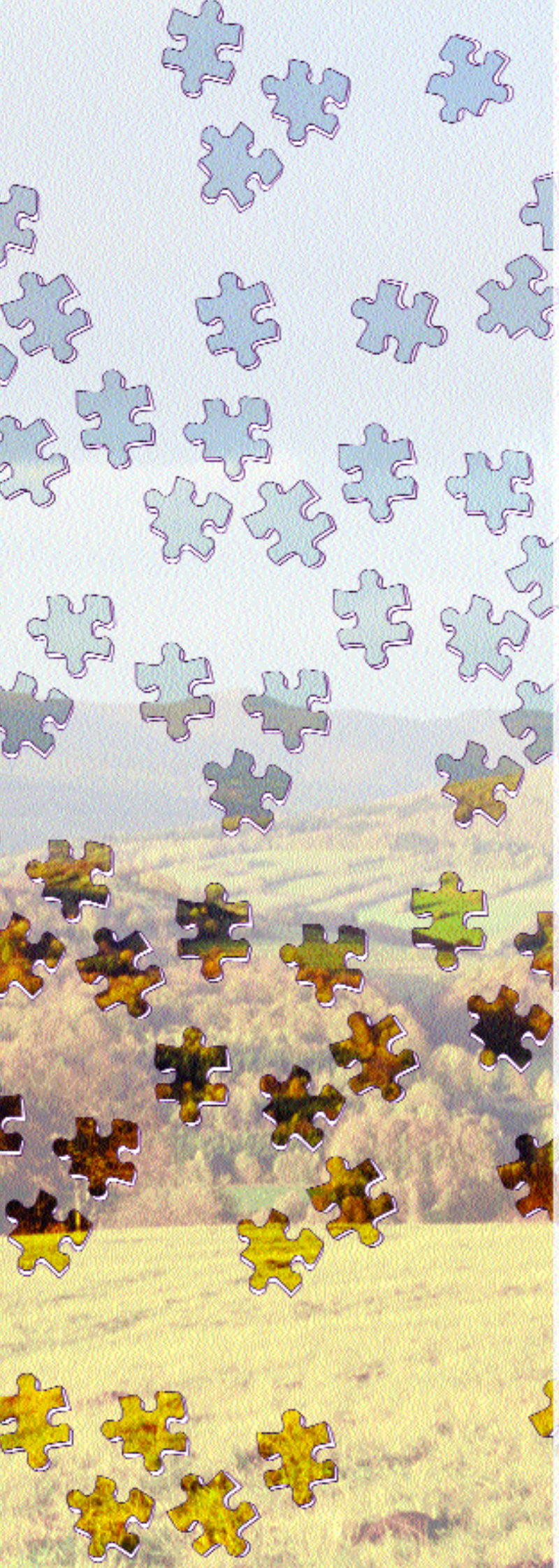
In the future, the results of integrated environmental monitoring are to be used more effectively to make clear the need for action in the environmental field and to support performance reviews of measures of environmental policies.

The Situation

Due to global environmental changes the environmental risks are increasing and leading to higher demands on environmental monitoring. This requires the development of guidelines to evaluate the environmental changes monitored. Besides the criterion »human health«, i.e. the physical and mental well-being of humans, the resource »natural balance« has gained increasing importance recently, since the natural balance is affected by both local impacts and the effects of »global change«.

Evaluation guidelines for the assessment of an impact on the natural balance have had a strong sectoral orientation in the past. They referred e.g. to the protection of a specific animal or plant species or to certain selected ecosystems such as forests which were assessed as being particularly endangered. Existing criteria for the assessment of endangerment are based on scientific justifications but reach their limits if more complex conditions are analysed.

An adequate evaluation of the condition of the natural balance largely depends on the quality of the information available. Integrated environmental monitoring supplies usable modules for tackling this task.



The large number of sectorally organised monitoring activities of the federal states and government provides a wealth of valuable information which is essential for the inventorisation of environmental changes and their evaluation.

The wide array of individual results and reports needs to be integrated into a single coherent picture of the environmental situation both in Germany as a whole and in the states individually.

Therefore an integrated overview of all activities is the prerequisite for

- comprehensive environmental monitoring closely co-ordinated between the federal government and states
- broad based public support for the implementation of recommendations resulting from the monitoring.

The Council of Environmental Advisors stated in its 1990 Special Report on »General Ecological Environmental Monitoring«:

»Environment [is] a complex system that cannot be sufficiently influenced and modified by the existing sectoral instruments; these often lead only to an environmental problem being transferred from one medium to another.«

Integrated environmental monitoring

Environmental monitoring views the environment as a holistic system and looks at its structures and processes in the context of causes and effects.

Stronger coordination and integration of monitoring activities between the federal and state governments

- increases the options for analysis and evaluation of environmental data and
- helps to draw a more consistent picture of the environmental situation and its obvious and insidious changes.

The Council of Environmental Advisors stated in its 1990 Special Report on »General Ecological Environmental Monitoring«:

»We understand environmental monitoring as an activity, that has to encompass [...] the individual environmental sectors or environmental media such as air, water, soil, animals and plants, some parts of which have already been examined intensively for a long time. Therefore it is a matter of integrating environmental monitoring on a systemic or ecosystemic basis.«

Integrated environmental monitoring

... will better coordinate and concentrate existing monitoring activities and improve their meaningfulness	... therefore no new monitoring programmes need to be established
... will be initially implemented in select monitoring areas	... therefore no area wide monitoring programme implementation is required
... defines itself by an integrative data analysis	... therefore it is more than a harmonised cross media data collection.

Integrated environmental monitoring provides a new quality of environmental reporting by illustrating causes and effects of environmental changes beyond the limits of environmental media and sectors.

The development of integrated environmental monitoring is incorporated into the activities of the federal government and the states to establish an environmental monitoring beyond media and sectors.
The project has been initiated by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and by the Federal Environmental Agency (UBA). It was carried out and assisted by the Federal Agency for Nature Conservation (BfN).

Through the projects listed below both BMU and UBA have provided important groundwork for the implementation of environmental monitoring across media and sectors:

»Environmental Monitoring Programmes of Central Government - Integration of the Monitoring Programmes of Other Resorts« (in German), UBA - Texte 73/98: Systematic compilation of the environmental monitoring programmes and their aims, run by federal institutes outside the BMU.

»Conception for Integrated Environmental Monitoring - Pilot Project for Biosphere Reserves« (in German), UBA-Texte 32/97: Development of conceptional bases for the establishment of integrated environmental monitoring.

Modular System for »Integrated Environmental Monitoring«

Integrated environmental monitoring is essentially based upon the existing monitoring programmes and measurement networks of the federal and state governments. It uses the data collected routinely for its integrating evaluation programmes.

Integrated environmental monitoring is to be incorporated into the existing system of monitoring programmes. Its methodological concept makes it possible to implement the programme in modules. The conditions to establish an integrated environmental monitoring will be different in each federal state and in each selected focus area.

The methodological concept of integrated environmental monitoring consists of single »modules«. The institutions responsible for integrated environmental monitoring can implement them one after another in self-defined order.

The »modular monitoring system« enables the beginning of integrated environmental monitoring - without additional inventories or fundamental changes to administrative structures and organisational processes.

The Modules

Questions

Inventorisation of environmental problems and of changes of fundamental ecosystem processes

Problem based approach

Cause-effect hypotheses about environmental changes
- for a national reference area
- for a regional reference area (focus areas of integrated environmental monitoring)

System theoretical approach

Functions of the ecosystem
- hypotheses about functionality and performance of ecosystems

Results

Answers to current social and political questions

Updating / Continuation

Adaptation of hypotheses and continuation of trends on the basis of monitoring results

Presentation

Seeing, understanding, evaluating

Environmental reporting
Requirements and ideas

Parameters / data

Data base of integrated environmental monitoring

Core Data Set of integrated environmental monitoring
Compilation of parameters for integrative ecosystem analyses

Spatial correlation

From point to area

Process recommendations
Presentation of methods to test the representativity of measurement networks and to spatially generalise monitoring and evaluation results

Evaluation concept

Tools for integrating evaluations

Collection of methods
Compilation of evaluation methods for proven, complex and integrating evaluations with medial orientation

Data based approach

Integration

'Down to earth' integrated environmental monitoring - using what exists

Combination with the environmental monitoring programmes of federal government and states

Use of existing evaluation guidelines: environmental quality targets and environmental standards

The UNESCO Rhön Biosphere Reserve: Pilot Project Area

The Biosphere Reserve stretches across several states and serves as a project area for the implementation of integrated environmental monitoring.

The goal of the pilot project is to investigate how existing measurement and monitoring programmes can be better utilised in terms of integrated environmental monitoring: This requires closer co-ordination and harmonisation of monitoring activities, also across state borders. The Rhön Biosphere Reserve creates an opportunity to explore the requirements, potential and limits of such a harmonisation in co-operation with the state agencies and institutions of Bavaria, Hesse and Thuringia.

Biosphere Reserve priority tasks encompass applied research and environmental monitoring as defined in the »Criteria for Acceptance and Testing« and the »Guidelines for the Protection, Maintenance and Development of Biosphere Reserves in Germany«. The results of environmental monitoring provide a basis for evaluating the success of the management measures used to implement guidelines and achieve the protection and development goals of the Biosphere Reserve.
They contribute to environmental reporting for the public.

UNESCO recognised the Rhön area as a biosphere reserve in 1991. The area comprises a total of 184.939 ha. 40% of the reserve is located in the state of Bavaria, 34% in Hesse and 26% in Thuringia.

The Rhön is a rural area with limited economic resources and weaknesses in its employment structure. Infrastructural and administrative differences in the three parts of the Rhön date back to century old differences between the administrative units. The area is naturally diverse due to varied natural features such as topography, geology and soils in addition to the multiple types and intensities of land use.

The Rhön area is of great significance in terms of its cultural and landscape history since traditional land use types are still existing - in contrast to other low mountain ranges.

Grazing concepts are to secure migrating shepherdry in the Rhön area. This type of land use is essential for the preservation of low maintenance grassland.

Problem Based Approach

Answers to current social and political questions

The start of integrated environmental monitoring is, on the one hand, marked by questions that can only be answered by the measurement and monitoring results and, on the other hand, by environmental problems whose development trends need to be forecasted.

Is species diversity decreasing?

Is the problem of summer smog getting worse?

Will high quality drinking water become scarce in the future?

The history of existing environmental monitoring programmes is full of such questions. Today, environmental monitoring programmes are primarily used to review the success of environmental policy goals and for the fulfilment of reporting duties - and they have their origin in the perception and expounding of environmental changes through society, policies and industry.

Examples of environmental problems:

	Water	Air
Perception of the environmental problem	Pollution of surface water bodies in the early sixties	First reports on forest dieback in broadcasting and television end of 1981
Introduction of the duty of reporting	Order on the Biodegradability of Detergents 1962, Detergents Law 1975	Order to introduce Forest Damage Inventories on state level
Start of environmental monitoring activities	Publication of the first LAWA Water Quality Map 1975	Start of the Federal Forest Damage Inventory in 1984

So far, environmental monitoring has had a strict medial and sectoral orientation and therefore needs a systematic analysis of cause-effect links in which environmental problems are embedded. This makes it often difficult to evaluate the success or failure of measures of environmental policy on the basis of monitoring results.

The extension of the Forest Damage Inventory by the Inventory of Soil Conditions in Forests (BZE) and the establishment of Areas for Environmental Controlling in Forests (LEVEL II) make clear that environmental problems cannot be sufficiently analysed by solely considering phenomena.

It is rather necessary to settle the following questions:

How do the factors change which are responsible for environmental changes such as the input of acid-forming substances into the air?

What are the consequences of forest soil acidification for ground water quality and for biodiversity?

The forest damage inventory is developing in an exemplary manner. Its results act as an incentive for other environmental fields to make proposals for an integrating data evaluation – covering different media wherever possible – in the context of integrated environmental monitoring.

For the exemplary establishment of integrated environmental monitoring ten problem areas supposed to be relevant have been selected for which about 180 individual cause-effect hypotheses have been developed. These hypotheses not only present causes and effects of environmental changes but also outline possible development trends in Germany.

Environmental research provides new scientific insights; the political and economic framework is changing and public perception of environmental changes and problems is also subject to changes. This means that the cause-effect hypotheses are also dynamic and need to be regularly updated.

Which environmental problems should integrated environmental monitoring deal with?

Problem area 1
Eutrophication and acidification of terrestrial ecosystems and effects on biocoenoses

Problem area 2
Accumulation of toxic substances in terrestrial ecosystems, effects on biocoenoses

Problem area 3
Physical soil degradation (soil erosion, soil sealing and damage through soil compaction), effects on ecosystems and their biocoenoses

Problem area 4
Eutrophication and acidification of ecosystems of surface water bodies, effects on biocoenoses

Problem area 5
Accumulation of toxic substances in ecosystems of surface water bodies, effects on biocoenoses

Problem area 6
Changes of the structure of surface water bodies, effects on the biocoenoses of the water bodies and peripheral zones

Problem area 7
Changes of the biodiversity and their effects

Problem area 8
Climatic changes and their effects on ecosystems and biocoenoses

Problem area 9
Changes of the vertical ozone distribution (summer smog and stratospheric ozone depletion), effects on ecosystems and biocoenoses

Problem area 10
Changes of the land use, effects on ecosystems and biocoenoses

The selection of the environmental problem areas to be dealt with in integrated environmental monitoring is closely orientated to the environmental problems listed in national reporting (»Data on the Environment« of the Federal Environmental Agency and »Data on the Nature« of the Federal Agency for Nature Conservation), in the reporting of the federal states and in the reports of important committees consulting political institutions (Council of Environmental Advisors, Scientific Advisory Council for Global Environmental Affairs of Central Government, Enquête-Committee »Protection of the Earth Atmosphere«). Additionally the selection was influenced by international treaties (such as the Kyoto Protocol and the Montreal Protocol), dealing with the solution of specific global environmental problems.

Integrated environmental monitoring is to be established in Germany in selected focus areas. They are to be situated both in rural areas and in more industrialised regions in order to gain a general overview of the environmental situation in Germany.

The development in the focus areas can significantly differ from the trends generally supposed for the whole of Germany. Further, specific local topics and problems with spatially limited causes and effects can play a major role. Therefore the states, regions and areas committed to the establishment of integrated environmental monitoring are interested in the decision factors for the necessary consequences of environmental policies.

This means that the cause-effect hypotheses formulated for the whole of Germany have to be regionalised for each focus area of integrated environmental monitoring.

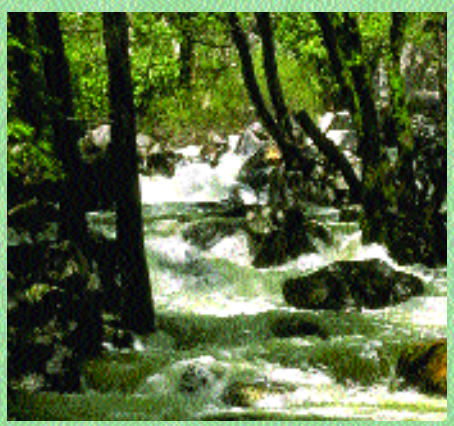
The formulation of regional cause-effect hypotheses is a joint process of all participants of integrated environmental monitoring. In the Rhön Biosphere Reserve it was actively designed by representatives of the state authorities of Bavaria, Hesse and Thuringia together with the Biosphere Reserve Administration and private operators of measurement networks.

In a framework concept a guiding principle for the Rhön Biosphere Reserve has been established with all social groups and is further elaborated, e.g. in communal working groups. This guiding principle provides orientation and helps to identify the questions and problems to be dealt with in integrated environmental monitoring.

One of the central problems in the Rhön Biosphere Reserve is the continuous retreat of agriculture. With the abandonment of the agricultural use the openness of landscape cannot be secured anymore. This will have negative impacts on the structural and biological diversity of the Rhön landscape.

Problem area 4: Eutrophication and acidification of ecosystems of surface water bodies, effects on biocoenoses

Cause-effect hypotheses for the spatial area Germany - extracts -	Cause-effect hypotheses for the Rhön Biosphere Reserve - extracts -
Causes	
...With improved waste water treatment (both in communal and in private sewage treatment plants) the focal theme of water pollution will shift from clearly defined sources to more diffuse sources, with particular impact from agricultural substances. The tendency towards a reduction of phosphorus and nitrogen inputs in water bodies will continue, however still with regional differences. The inputs into water bodies caused by agricultural fertilisation reached their peak in the middle of the eighties and decreased until the year 2000 (inter alia due to better-directed fertiliser application). Diffuse nitrogen input into water bodies will stabilise at the present level over the next years.	... Over the next years new sewage plants will be constructed and the operation of existing plants will be optimised. Additionally further measures will be carried out to reduce diffuse input into the streams and rivers of the Rhön Reserve. Measures for the preservation of low maintenance grassland and for the conversion of arable fields into grassland along the streams, rivers and lakes will additionally reduce the diffuse input of nutrients into water bodies.
Effects on the environment	
The trend towards an improvement of the water quality in the (large) streams and rivers (as regards eutrophicating substances) will continue, in particularly as regards phosphate and ammonium nitrogen. The reduction of nitrate, however, will happen very slowly, since it will take years until the nitrogen applied through agricultural fertilisation will reach the large rivers. Reductions of the fertiliser amount therefore will only be noticeable after years. The improvement of the water quality of the rivers will contribute to the current trend of an increased species diversity in the (large) rivers and streams. This trend will be particularly noticeable in the eastern part of Germany where numerous water bodies only just started to (biologically) regenerate. By contrast, this trend will slow down in the western states since major pollution sources have already been removed and additional qualitative improvements will require large expending (e.g. measures to reduce the pollution of water sediments, enforcement of international co-operation to the quality of cross-boundary streams and rivers, renaturation of the water structure towards more natural conditions). ...	The decrease of direct and diffuse nutrient input due to the measures listed above will lead to a significantly higher oxygen content in streams and rivers. In wide areas the water quality will reach again class I-II on the long term. Owing to the lower nutrient load of rivers and streams populations of animal species depending on a high oxygen content of the water and typical for upstream waters of the Rhön Reserve are protected.



System Theoretical Approach

Link between integrated environmental monitoring and ecosystem research

Article 1 of the Federal Nature Conservation Act states: »The conservation, preservation and development of nature and landscapes, both in populated and non-populated areas, shall be such as to effectively serve the following purposes:
1. to maintain the efficiency of the balance of nature,
[...]
as a basis for mankind´s existence and as a prerequisite to recreation in nature and in landscapes.«

The Council of Environmental Advisers indicates in its 1991 Special Report on »General Ecological Environmental Monitoring« that environmental monitoring is to serve the early recognition of environmental changes. Even before changes of ecosystems are evaluated and described as environmental problems it should be possible to plan and implement counteracting measures on the basis of the results of integrated environmental monitoring.

The early recognition of environmental changes, however, is very demanding. It includes for example the wide array of chemical compounds reaching the environment in numerous ways and influencing the balance of materials of ecosystems and their biocoenoses. Therefore only few substances can be selected for the concrete monitoring of the dispersal of these substances and their metabolites in environmental media and for the identification of their effects in the context of integrated environmental monitoring.

The responsibility for making provisions can best be fulfilled if environmental monitoring succeeds in describing the functionality and performance of ecosystems and their changes with the least possible number of parameters. This requires an understanding of the fundamental principles of ecosystem functions.

The presentation of these principles in the context of the system theoretical approach is based on the findings of ecosystem research which has made fundamental contributions to the analysis of ecosystem processes and functions.

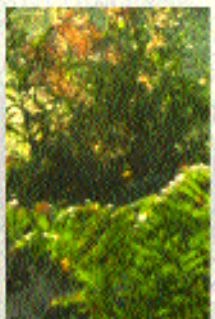
The system theoretical approach complements the problem based approach to integrated environmental monitoring with questions such as:

Are the nutrient storage capacities of ecosystems changing?

Is there an increase to be seen in the output of substances (e.g. into groundwater or atmosphere) or is the cycle of materials within the system more or less closed?

Is the system developing towards a stronger differentiation of its structures, i.e. is the number of trophic levels (in the food-chain) increasing?

Semi-natural ecosystems can be used as a reference for the evaluation of these changes. There are indications that natural systems with virtually no human influence optimise certain processes and functions (such as regulation functions) and hence reduce risks (such as loss of energy or materials or surplus production).



The system theoretical approach also formulates hypotheses analogous to the problem based approach. To these hypotheses parameters are assigned which are supposed to particularly well depict the ecosystem processes described.

The system theoretical approach only partly leads to the identification of new, so far unknown or hardly common measurement factors or monitoring parameters. It rather focuses on parameters and data already recorded in many programmes but possessing a key-function for process changes in ecosystems that so far has not been recognised or stressed.

Early recognition of environmental changes

A decreasing pH value shows for example the acidification of a soil or an aqueous solution (e.g. precipitation, ground water or subsoil water). If the pH value has decreased significantly it usually is too late for counteracting measures. Then only expensive liming measures can either slow down or stop a further acidification process.

The insidious early stages of acidification cannot exactly be recorded by measuring the pH value. Early warning parameters are rather sinking storage capacities of the environmental media which can be identified by measuring the cation exchange capacity of the soil or the acid-base-capacity of an aqueous solution. Although the pH value can be easily measured and therefore would be suitable for frequent measuring it would be more valuable in the sense of the precautionary principle to measure cation exchange capacity or acid-base-capacity.

Hypothesis on the ecosystem function "storage capacities"

Quantity and quality of flowing densities and close-circuit-systems are significantly influenced by the storage capacity of the ecosystem compartments. Of particular importance for the characterisation of the development condition of ecosystems is the storage of biomass in different ecosystem compartments. This can be changed short- or long-term by changing outer framework conditions and/or interference into the ecosystem structure. During uninfluenced development ecosystems have the tendency to increase the storage of biomass. Changes of the storage capacity in ecosystems therefore characterise the transition to a new (desired or undesired) development stage of the ecosystem. The absorption capacity corresponds with threshold values above or below which rapid changes occur in the ecosystem dynamics if exceeded or fallen below.

Data Based Approach

"Down to earth" integrated environmental monitoring - using what exists

The inventories of pre-existing federal, state and private measurement networks and monitoring programmes form the cornerstone of integrated environmental monitoring. Their meaningfulness must be strengthened by better networking, data exchange between institutions and integrated data analysis.

Prerequisite for this step is an understanding of the goals and structures of these programmes and measurement networks and of the data they collect.

The state and federal guidelines and standards that have been established for the harmonisation of data collections in medially and sectorally orientated environmental monitoring are suitable starting points for the initiation of an integrated monitoring programme.

Particularly since the early nineties, inter-state, central government and state working groups have endeavoured to improve the co-ordination and harmonisation of current measurement and monitoring activities (such as the inter-state working group 'water' LAWA or 'soil' LABO). They have developed guidelines, brochures and standards with proposals and recommendations about which parameters should be inventoried in the programmes and which methods should be applied.

The programme of integrated environmental monitoring takes up these recommendations, discusses them critically and sometimes adds new knowledge or developments. The data based approach therefore is – in addition to the problem based and the system theoretical approach - the pragmatic path to integrated environmental monitoring.

Examples of guidelines for the standardisation of monitoring programmes

BMELF 1997

Permanent Monitoring Areas for Environmental Control in Forests
LEVEL II – Methods Manual

LAWA 1998

Atmospheric Deposition – Guideline for Monitoring and Analysis of Precipitation Composition

LABO 2000

Soil - Permanent Monitoring – Establishment and Operation of Permanent Soil Monitoring Areas

LAWA 1993

Guidelines for Monitoring and Analysis
Part 3 – Groundwater Composition

DVWK 1992

Drawing and Analysis of Groundwater Samplings, DVWK-Regulation 128

DVWK 1999

Methods for the characterisation of ground water quality, DVWK-Scripts 125

LAWA 1997

Streams and Rivers of the Federal Republic of Germany – LAWA Investigation Programme in the federal states of Germany

Working Group Bioindication / Impact Determination 1997

State-wide Inventorisation of Immission Impacts with Bioindicators

Evaluation guidelines for integrated environmental monitoring: Environmental quality targets and environmental standards

Like all other already existing measurement and monitoring programmes integrated environmental monitoring depends on evaluation guidelines for the interpretation and evaluation of the data.

From the general quality targets for the protection of processes and functions of ecosystems, as for example formulated in the Federal Nature Conservation Act or in the »World Conservation Strategy« from the International Union for Conservation of Nature (1980), general indications can be derived for the basic orientation of environmental monitoring programmes. For integrated environmental monitoring these have been taken up in the system theoretical approach. Concrete requirements for the selection of the parameters to be investigated and starting points for the evaluation of monitoring results, however, do not follow from these general aims.

This means that the programme of integrated environmental monitoring – such as other monitoring programmes and measuring networks - must refer to the existing medial environmental quality targets and environmental standards. Parameters already existing for such evaluation guidelines are of particular value for integrated environmental monitoring.

Therefore, integrated environmental monitoring also contributes to the implementation control of quality targets and standards which have been mandated by law or policy.

Examples for medial environmental standards

Air

Limit values, standards and guide values for the protection of air quality

- Federal Immission Control Act (BImSchG), ordinances and 4th Administrative Regulation under the BImSchG, smog ordinances
- Technical Instructions on Air Quality Control (TA Luft)
- EU Framework Directive on Ambient Air Quality (Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management)
- Critical Levels and Critical Loads of the UN/ECE

Soil

Trigger and action values, and particularly precaution values, under the Federal Soil Protection Act and the Federal Soil Protection Ordinance

Groundwater

- Limit and guide values under the Drinking Water Ordinance
- Insignificance thresholds (trigger values) of the LAWA from 1999
- Revised version of 1998 of the EC Drinking Water Directive
- WHO guide values for drinking water from 1993

Surface water

- EU Water Framework Directive (2000/60/EC)
- Quality targets for the protection of inland surface waters from hazardous substances (LAWA, 1997 and 1998)
- Quality targets of the International Commission for the Protection of the River Rhine (IKSR 1993) and of the International Commission for the Protection of the River Elbe (IKSE 1998)
- Classifications of the biological and chemical water quality
- EC Surface Water Directive (75/440/EEC)

Environmental monitoring programmes and measurement networks in the UNESCO Rhön Biosphere Reserve

In the course of the pilot project Rhön Biosphere Reserve the monitoring programmes and measurement networks were analysed within the Reserve and its vicinity. The meta-data were collected and saved using a digital questionnaire (ACCESS format) containing information on

- the measuring or the programme surveying institution,
- goals and tasks of the programme,
- parameters inventoried and measuring frequency,
- inventorisation methods applied and
- measures of quality control.

The digital questionnaire has already been used in other states to investigate current activities of environmental monitoring. It allows a standardised and harmonised organisation of the meta-data on the monitoring programmes and measurement networks.

In the Rhön Biosphere Reserve and its closer surroundings about 900 measurement points have been established, supervised by 22 different institutions. They include state agencies and state offices of Bavaria, Hesse and Thuringia, the three Biosphere Reserve administrations, the Federal Agency for Nature Conservation, the German Meteorological Service as well as private and public scientific institutions.

Questionnaire of the Federal Environmental Agency to put in meta-data on the monitoring programmes and measurement networks

Measuring points and monitoring areas in the Rhön Biosphere Reserve and its vicinity

A large part of the data collection in the Rhön area concentrates on a single environmental medium or refers to only one question. Only few of the monitoring programmes are laid out across media or sectors.

Environmental monitoring in the Rhön Biosphere Reserve and its vicinity, with medial orientation and across several media

	Medially orientated (only one medium)	Data collection of two media	Data collection of three media	Data collection of at least four media
Number of processes	51 (82,3%)	6 (9,6%)	1 (1,6%)	4 (6,5%)
Number of measuring points	828 (96,7%)	18 (2,5%)	1 (0,1%)	6 (0,6%)

Core Data Set

Data Base of integrated environmental monitoring

The Core Data Set is the common data base which is used for all analyses and evaluations performed in the context of environmental monitoring. It is a collection of all the necessary parameters to answer the following questions:

- How are the environmental problems developing?
- Are fundamental ecosystemic processes changing?

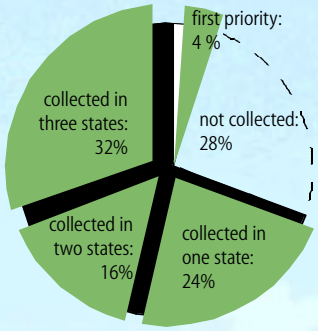
A large amount of the data required for the integrating analyses can be provided by the monitoring programmes and measurement networks already running. In the same way data from measuring points and monitoring areas further away can be estimated by transmission or generalisation processes or they are derived from other data by model calculations.

The data of integrated environmental monitoring can either be directly measured or they are estimated by modelling.

The nearly 500 parameters of the Core Data Set are classified into four priority levels in order to provide the groundwork for a phased implementation of integrated environmental monitoring.

UNESCO Rhön Biosphere Reserve: Contribution of the current measurements and monitoring to the Core Data Set

From the parameters listed in the Core Data Set about 75% have been collected in at least one of the programmes operated in the Rhön Biosphere Reserve. This means that there is no inventorisation in the Rhön area for about 25% of the parameters so far; only 4% of these parameters, however, have been classified to the first priority level.



This means:

- For the three states focal monitoring activities can be identified.
- The Core Data Set can almost fully be operated by the existing monitoring programmes and measurement networks.

From the results of this analysis, however, it is not clear if the spatial dispersal of the measurement points and monitoring areas provides favourable conditions for an integrating analysis of data from different measurement networks. The explanations on spatial correlation (cf. page 28) can provide relevant information.

Additionally, the fact has to be considered that the data from the different measurement networks cannot be fully compared with each other. The different aims and goals of the monitoring programmes, the varying running periods and also the differing equipment of the data-collecting institutions lead to a high variety of collection methods.

It is the aim of integrated environmental monitoring to overcome the heterogeneous data collection in short to medium term by conversion processes. Over the long term the data collection itself is to be harmonised. The concept »integrated environmental monitoring« includes proposals for such a harmonised data collection, mainly referring to guidelines and standards of inter-state workings groups and joint government-state working groups.

Diversity of methods in monitoring programmes and measurement networks - Examples

Methodological variations of individual monitoring programmes often concern rather the taking and processing of samples than the analytics. In the field of soil monitoring, for example, there are significant differences as regards the sampling depth and the treatment/pulping of the samples.

In the field of deposition measurements the comparison of data from different measurement networks was very difficult due to the use of different deposition collectors. In general only a far-reaching standardisation of collection techniques can guarantee the comparability of the results of different measuring points and networks.

Evaluation Concept

Collection of methods - tools for integrating analyses

Most of the anticipated insights to be gained through integrated environmental monitoring are expected to arise from comprehensive evaluation of the existing data sets and not so much from harmonised data collection or the restructuring of existing measurement networks.

Although data collection by federal and state authorities can usually be regarded as more or less secure from an organisational (and financial) point of view, many places lack the capacity to make full use of the data's potential. State representatives continuously point out that even without additional collections, significantly more findings could be derived from the existing data sets.

A model

Connected with the LEVEL II programme specific efforts have been made over the last months towards a harmonised data evaluation. In the context of integrated environmental monitoring these work should help to instigate an integrating data evaluation also for other sectors and as crosscutting as possible.

Based on these findings an »evaluation concept« was developed for integrated environmental monitoring. This concept can be described as a collection of methods. Additional content should be added to this collection over time. However, the collection does not only contain methods for a complex and highly integrated data analysis, it also offers simple procedures that are already used by data collecting agencies or can be relatively easily integrated into their day to day activities.

Integrated environmental monitoring must be established in close co-operation with the data collecting and evaluating agencies of the states and federal government. However this also means that agencies can only participate in data analysis relative to their financial and human resources.

The evaluation concept is a flexible tool which makes concrete suggestions for the development of data evaluation methods.

The goal is to extend and maintain the collection of methods for a wide range of users.

In the Rhön project

- possible methods of data handling in integrated environmental monitoring have been collected,
- the links with the questions of integrated environmental monitoring have been shown,
- exemplary evaluations of the data sets available for the Rhön area have been conducted.

Steps of data handling	Contents of the collection of methods in the concept »integrated environmental monitoring«
Data checks	Compilation of possible methods of quality control
Data processing	Overview of existing methods of data processing (e.g. development of indicators)
Data evaluation	
Formation of time sequences	Overview of common methods to establish time sequences
Analysis of spatial data distribution patterns	Information on the options and limits of data interpolation and on the use of geostatistical methods
Evaluation of the combination of several parameters of an area (either medially limited or across media)	Overview of common evaluation methods: Compilation of routine evaluations of the states and of methods from research projects
Complex evaluations with the support of ecosystemic models	Overview of models that can be employed in integrated environmental monitoring

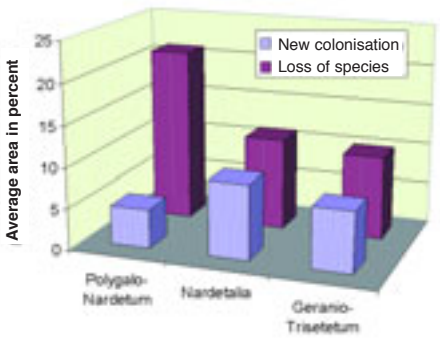
Evaluation methods with increasing complexity

Integrating data analysis – an example

In the Rhön Biosphere Reserve biotic data have been inventoried for many years, in particular in the Nature Reserve ‚Lange Rhön'. An extended data evaluation, however, especially the combination with the results of abiotic inventories, has hardly taken place so far due to a poor exchange between the different monitoring programmes.

In the Rhön project floristic and plant-sociological data from the years 1970/71 and 1998 have been analysed in order to show the possibilities for the analysis of already existing data. The analysis included the development of indicator species for nutrient-poor sites and possible influences of agricultural use as well as nitrogen input from the air.

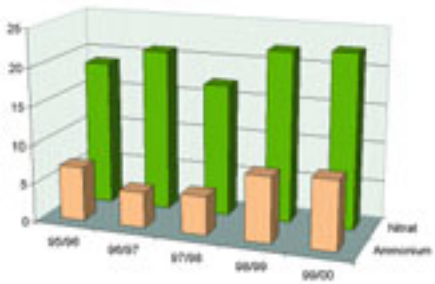
Analyses on the basis of ecological indicators illustrated that the nitrogen content increased slightly over the period of observation. Likewise the indicator species for nutrient-poor sites clearly decreased on the species-rich grassland associations characterised by mat-grass (Nardetalia) between 1970 and 1995 whilst this decrease could not be noticed in other plant associations such as meadows characterised by yellow oat-grass (Trisetalia) which depend less on nutrient-poor site conditions.



Average area with loss of species (columns in the background) and new colonisation of indicator species for nutrient-poor sites (in the foreground) between 1971 and 1996 for species-rich grasslands with mat-grass (Polygalo-Nardetum, left column), for further associations of mat-grass grasslands (Nardetalia, columns in the middle) and for meadows with yellow oat-gras (Geranio-Trisetetum, right columns).

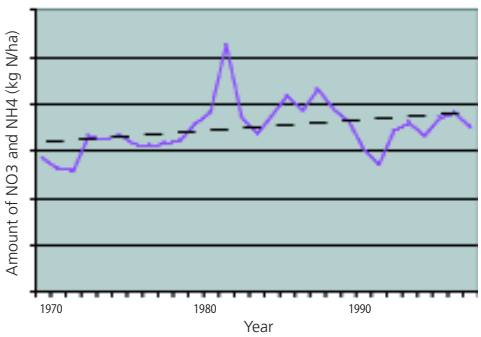
The results indicate that the nutrient availability has increased at the investigated sites. Possible reasons are in particular agricultural land use and nitrogen input from the air. First it seemed reasonable to explain the decrease of the indicator species for nutrient-poor sites with the going fallow of the sites, since a lacking draw-off of biomass nutrients can lead to nutrient accumulation. According to other investigations, however, the farmed area of cultivated grassland increased by about 25% from 1984 to 1993, i.e. the amount of fallow land decreased. Therefore it seems plausible to at least partly attribute the decrease of indicators for nutrient-poor sites to atmospheric nitrogen-input.

Concerning nitrogen deposition continuous measurements in the nature reserve 'Lange Rhön' only exist from 1995 onwards. Therefore there are no respective data parallel to the plant-sociological data. Inventories after 1995, however, show a slight increase of nitrogen deposition in the Rhön area. Probably this trend has already started earlier and might be a possible reason for the decline of the indicator species.



Nitrogen deposition* at the forest measuring station 'Ellenbogen' (Thuringian part of the Rhön area) from 1995 to 2000 (*preliminary, unchecked and unpublished data from the Thuringian State Institute of Forestry).

Changes of the nitrogen content in the soil over the last 30 years have been simulated parallel to the analysis of available data on deposition using a model of water balance and material flow (WASMOD). The simulation shows an increase of the nitrogen and ammonium content for the grassland areas of the 'Lange Rhön'. The model results confirm the speculation that the vegetation changes of the grasslands characterised by mat-grass can be partially put down to increased nitrogen input from the air, leading to an increase of nutrient availability in the soil.



Simulation of nitrogen and ammonium contents in the soil of grassland areas in the nature reserve 'Lange Rhön' in the catchment area of the river Streu from 1969 to 1997 by WASMOD

Models as an aid to integrating data evaluations

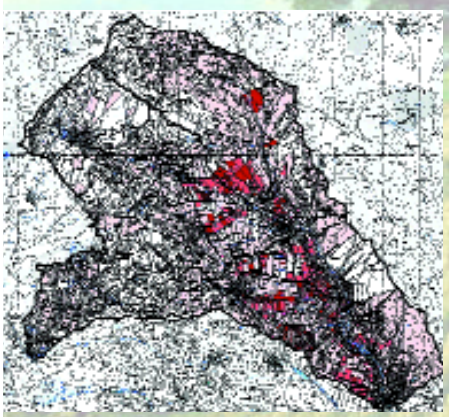
Computer based models can provide valuable assistance in both data management and complex data analysis.

Models can:
- interpolate areal data from point data,
- combine data of different quality into a single analysis process,
- simulate future developments by changing input parameters,
- calculate data for parameters that are difficult to collect, thereby reducing expenditures for data collection.

Note: Models can never replace data collection and their application requires competent supervision.

During the Rhön project the model of water balance and material flow (WASMOD) was applied using the example of a catchment area (river Streu). The model was solely fed with existing data. The modelling encompassed both hydrological processes in the area (such as surface run-off) and data on the balance of nitrogen and carbon (such as the nitrogen discharge with seeping water).
With the help of WASMOD additionally different scenarios have been calculated. They simulate possible effects on the water and material balance if
- grassland would go fallow, leading to an extension of the forest,
- grassland farming would be intensified,
- the amount of sealed surface would increase,
- methods of integrated farming would gain broader acceptance amongst the farmers.

These simulation results support management decisions in the Rhön Biosphere Reserve.

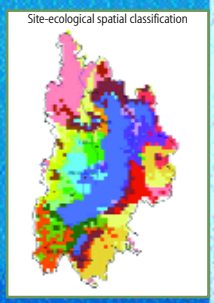


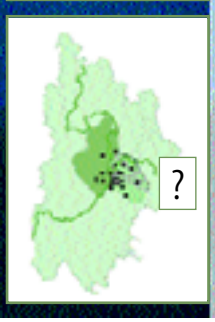
Detailed depiction of modelled nitrogen discharge with seeping water

Spatial Correlation

From point to area

The demanding concept of integrated environmental monitoring will not be implemented everywhere in Germany. »Demanding« in this context, however, does not mean a significant increase of surveying in the selected observation areas. On the contrary, it addresses a comprehensive data analysis across media and sectors.





Spatial correlation in integrated environmental monitoring	**Methodological approach using the example of the Rhön area**
• Selection of appropriate focus areas which seem to provide particularly favourable conditions for the establishment of integrated environmental monitoring	• Localisation of areas with a dense monitoring infrastructure • Selection of representative monitoring areas on the basis of an »ecological land classification« for Germany, produced with geostatistical methods
• Generalisation of data from existing monitoring programmes and measurement networks in order to gain area-wide information for the selected focus area	• First orientation of the spatial distribution of measurement stations and monitoring areas on the basis of the ecological land classification • Use of geostatistical methods like "Kriging" and "Variogramm-Analysis" to interpolate between measurement stations and the production of estimated data in a statistically sensible way
• Localisation of sections within the focus area where more comprehensive ecosystemic analyses can be conducted	• Catalogue of criteria for the selection of suitable river catchment areas: e.g. existing monitoring infrastructure, available level data, representative site conditions and land use dispersal, area size, conditions of precipitation and run-off (hydrological site analysis)
• Identification of sites where possibly complementing data could be collected	• When using geostatistical methods: Identification of spatial areas where information density is very high or too low, supplementing of the existing measurement points with additional stations or restructuring of existing networks • When using models for data analysis: Identification of sub areas with noticeable variations, then verify modelling results through short-term measurements at individual sites.

Site-ecological spatial classification of Germany:

In order to link the measurement programmes of federal states and government an »ecological land classification« throughout Germany was developed, at the request of the Federal Environmental Agency and the Federal Statistical Office. It classifies the Federal Republic of Germany into squares of 2 x 2 km approximately homogenous in terms of selected site conditions – especially in terms of their Potential Natural Vegetation.
For the classification the geostatistical CART – Method (Classification and Regression Trees) was applied.

River catchment areas as sections for intensified ecosystemic analyses:

Integrated environmental monitoring includes the high demand to identify not only structural but also functional changes of ecosystems. From this demand requirements follow for the selection and delineation of the monitoring areas. Water catchment areas are functionally defined units allowing large-scale considerations of the balances of water, materials and energy. They provide suitable starting-points for a data collection and analysis across media.

Environmental Reporting

Seeing, understanding, evaluating

Environmental reports have the task to regularly inform about the state and development of the environment. The reporting of federal government and states is to fulfil duties of reporting arising from legal regulations, from the German membership in international organisations and from the participation in international programmes.

In §1 of the Environmental Information Law free access is regulated to environmental information available at the authorities. According to this law federal government has the duty to publish reports on the condition of the environment in Germany every four years.

Further, Germany has the duty of reporting towards the European Union in the context of conventions and directives.

Environmental reports are geared to different target groups and duties of reporting. They are based on data collections from different monitoring programmes and measurement networks and deal with different environmental topics.

The discussion on a stronger orientation of environmental monitoring and integrating data analysis across media and sectors has instigated new developments in environmental reporting. The European Environment Agency is recently structuring its reports according to the DPSIR-Indicator Approach (driving forces – pressure – state – impact – response), hence discussing environmental changes in their cause-effect context. In the future the publication 'Data on the Environment' is to be built up in a similar structure.

Target groups of environmental reports

- Politicians as decision-makers: For them environmental reports present an essential basis for decision-making when measures for the preservation or improvement of the state of the environmental are to be developed and reviewed
- Staff of land planning authorities and other specific authorities on state and federal level who need detailed information on changes of the environment and their causes.
- Researchers and planners requiring environmental information for research and planning projects.
- The interested public such as journalists, representatives of public environmental institutions as well as environmental organisations and individuals.

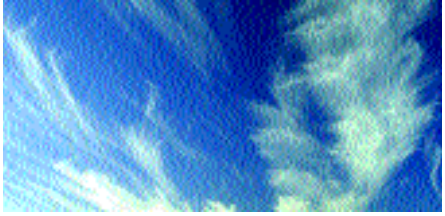
Depending on the addressee the environmental information has to be individually processed for the report, i.e. it has to be summarised and graphically illustrated.

The reports on the results of integrated environmental monitoring will have to be integrated into the environmental reports of federal government and of the states.

The integrating evaluations in the context of integrated environmental monitoring are to provide ideas to more closely link causes of environmental changes with their effects when environmental information is presented.

In the Rhön project an exemplary environmental report was developed which

- takes up the structure of cause-effect hypotheses of integrated environmental monitoring,
- evaluates the environmental changes with view to the regional development goals and regional environmental quality targets that have been formulated for the Biosphere Reserve,
- provides concrete suggestions for the planning and implementation of management measures in the Rhön Biosphere Reserve, and
- demonstrates gaps of knowledge and information which are to be closed by additional research and environmental monitoring.



Implementation

First steps have been taken

Implementation of integrated environmental monitoring is essentially a state responsibility. States can draw on the extensive pool of experience gained from their previously conducted projects. In the Rhön project an extensive review was conducted of the procedures chosen in the single modules. The processing steps that make up each module of integrated environmental monitoring were then compiled into a methodological manual.

- Integrated environmental monitoring can only be established through close co-operation among the data collecting institutions: the existing monitoring network always provides the foundation of integrated environmental monitoring.
- Because conditions and requirements differ in each state there is a »patent concept« for the implementation of integrated environmental monitoring but no »patent recipe«. Each monitoring programme has its own history, each state its own environmental policy goals and reporting duties, and significantly different administrative structures.
- The concept »integrated environmental monitoring« is to be understood as a modular system that can be implemented step by step. The single modules are elements of a harmonisation also across state borders but they can be assembled individually for any case of application.

Proposals for first steps to implement integrated environmental monitoring

Completion of the investigations into the current monitoring programmes and measurement networks
Where are data collected, by whom, and what are the goals? Which parameters are investigated and which methods are applied? In several states results from investigations already conducted can be used, or only an updating is necessary.

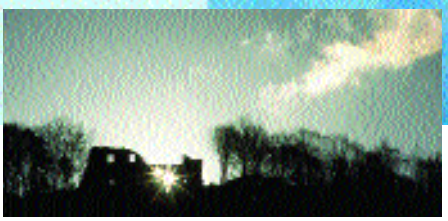
Answering of the questions for integrated environmental monitoring, development of regionalised cause-effect hypotheses
Which problems seem to be particularly relevant and should be intensively investigated during integrated environmental monitoring, which environmental aims have been formulated, which duties of reporting are to be fulfilled?

Selection of focus areas for the establishment of integrated environmental monitoring
Which spatial areas are particularly suitable for detailed analyses in the framework of integrated environmental monitoring, where is the existing monitoring infrastructure particularly dense, where can the relevant questions be investigated best?

Completion of the collection of methods for data evaluation
Which analyses are conducted in the data collecting institutions routinely, which analyses have been developed and tested in research projects, which approaches to integrating data analysis are already existing?

Research into environmental reporting
Which types of environmental reporting are being practised by the different institutions, are there starting points for integrating environmental reporting and how can they be extended?

Analysis of the communication structures
Between which institutions are data and experiences exchanged, how is this exchange organised/ institutionalised, which starting points does it provide for more extensive co-operation?



Over the last years and months activities to implement a better co-ordinated and integrating environmental monitoring have also started in other states, partly instigated by the pilot project »Rhön Biosphere Reserve«. The detailed conception of »integrated environmental monitoring« was conducted in close co-operation with all these projects. This exchange contained both experiences and parts of methodological concepts.

Integrated Environmental Monitoring in Biosphere Reserves of Brandenburg

For the biosphere reserves »Schorfheide-Chorin« and »Spreewald« a concept for integrated environmental monitoring has been developed. Focus ecosystems for detailed environmental monitoring have been selected and indicators, parameters and methods defined. Monitoring areas were established in 28 ecosystems of forests, in 7 of arable fields, in 10 of bogs, in 9 of grasslands, in 30 of lakes and in 30 ecosystems of rivers and streams. Particularly the selection of parameters was closely co-ordinated with the Core Data Set of integrated environmental monitoring. Beyond existing data collections additional monitoring was conducted in the areas established, and other permanent monitoring systems were integrated into the analyses (UBA, LUA Brandenburg, DWD (German Meteorological Service)). The results are processed for regional environmental reporting.

Client
Landesanstalt für Großschutzgebiete des Landes Brandenburg
(Brandenburg State Department for Large Conservation Areas)
Term
1997-2001
Project coordination
Fachhochschule Eberswalde (Prof. Dr. V. Luthard), Waldkunde-Institut (Prof. Dr. G. Hofmann), Institut für angewandte Gewässerökologie in Brandenburg (14544 Seddiner See), Bio-Test GbR (15518 Eggersdorf)
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Internet: http://www.fh-eberswalde.de/lanu/lanu.htm

Integrated Environmental Monitoring Schleswig-Holstein

For the project »Integrated Environmental Monitoring in Schleswig-Holstein« already in 1995 a working group across institutions was established. Together with the State Agency for Nature and Environment they are to provide the preconditions for a functioning system of integrated environmental monitoring in Schleswig-Holstein. Within the project proposals were developed for the optimisation of the existing measurement programmes, of the use of financial and personal resources, of the data flow and of the use of IT-instruments. The establishment of integrated environmental monitoring followed closely the methodological conception of integrated environmental monitoring of the Rhön project.

Client
Ministerium für Umwelt, Natur und Forsten des Landes Schleswig-Holstein
(Ministry of Environment, Nature and Forestry Schleswig-Holstein)
Term
since 1995
Project coordination
Landesamt für Natur und Umwelt des Landes Schleswig-Holstein, Stabsstelle Integrierter Umweltschutz
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Environmental Monitoring Baden-Württemberg

The State Office for Environmental Protection in Baden-Württemberg is working on the establishment of an environmental monitoring system since 1999. Presently the »Concept for Ecological Environmental Monitoring in Baden-Württemberg«, developed in this context, is being systematically implemented. Also in 1999 a »Pilot Project for Integrating Ecological Environmental Monitoring - Model Development for Interpretation of Cross Media Measured Data« was commissioned with the aim to produce a model for the cross media linking of data from sectoral and medial measurement networks.

Client
Ministerium für Umwelt und Verkehr in Baden-Württemberg
(Ministry for Environment and Traffic, Baden-Württemberg)
Term
1999 – end of 2001 (pilot project)
Project coordination
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Trilateral Wadden Sea Monitoring

The concept on Trilateral Monitoring and Assessment Program (TMAP) in the Wadden Sea of Germany, Denmark and the Netherlands was developed in the years 1992 and 1993. The parameters were selected on the basis of hypotheses, ecological aims and relevant questions. In January 1994 the implementation of parts of the parameter set has started, basing on the already existing national monitoring programmes and on the integration of the monitoring of breeding and migrating birds and of common seals. In the following years the concept was continued and developed by the Trilateral Monitoring and Assessment Group (TMAG), founded in 1994. The results of the ecosystem analysis of many years in the wadden sea have been integrated into the formulation of the TMAP (Trilaterally co-ordinated data management and exchange via Internet, TMAP Data Unit).

Client
Trilateral Governmental Conferences (TGC) – Minister for Environment and Energy (Denmark), Federal Minister for the Environment, Nature Conservation and Nuclear Safety (Germany), Minister of Agriculture, Fisheries and Nature Management (The Netherlands)
Term
since 1994
Project coordination
Common Wadden Sea Secretariat (CWSS) and Trilateral Monitoring and Assessment Group (TMAG)
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http://www.nationalpark-wattenmeer-sh.de
http://www.mu.niedersachsen.de/Nationalparke/index.htm

Information on the Rhön Project

The long version of the final report to the F+E Project 109 02 076/01, requested by the Bavarian State Ministry for Regional Development and Environmental Affairs (BayStMLU) and by the Federal Environmental Agency (UBA) »**Modellhafte Umsetzung und Konkretisierung der Konzeption für eine ökosystemare Umweltbeobachtung am Beispiel des Biosphärenreservates Rhön**« (»Examplary implementation of the conception for integrated environmental monitoring in the Biosphere Reserve Rhön«) can be inspected in the library of the BayStMLU and the UBA (in German). It is to be published shortly. Further information under http://www.umweltbundesamt.de.

Secondary Literature

- Schönthaler K., Kerner H.-F., Köppel J. & Spandau L. 1994: »Konzeption für eine Ökosystemare Umweltbeobachtung, Pilotprojekt für Biosphärenreservate«. Finalreport R+D project No. 101 04 0404/08, unpublished, under contract to the Federal Environmental Agency.
- Schönthaler K., Kerner H.-F., Köppel J. & Spandau L. 1997: »Konzeption für eine Ökosystemare Umweltbeobachtung, Wissenschaftlich-fachlicher Ansatz«. UBA-Texte 32/97, Berlin, 45 S.
- Internal research to compile documentation on sectoral and integrated monitoring programmes under the responsibility of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Federal Environmental Agency, unpublished)
- »Entwicklung eines Modells zur Zusammenführung vorhandener Daten von Bund und Ländern zu einem Umweltbeobachtungssystem«: Research to compile information on environmental monitoring activities of the federal states, formulation of proposals for the spatial integration of datasets from different monitoring programmes (CONDAT 1998, SCHRÖDER et al. 1999)
- »Grundsatzpapier Naturschutzorientierte Umweltbeobachtung« (AKNU 1999): Development of ideas for the collection of data relating to nature conservation (under the "Ökologische Flächenstichprobe" programme, among others) and for comprehensible reporting on nature conservation
- Landesumweltamt Nordrhein-Westfalen (LUA NRW): Umwelt NRW - Daten und Fakten, Essen 2000

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