Pilot project on environment and health rapid risk assessment in secondary rivers of the mean and lower Danube basin: methodology and application

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Introduction

In January 2000, a huge spill of cyanide, a highly toxic substance for human beings and the environment, occurred in Baia Mare (Romania). The spill flowed into the local river, then to the Tisza River in Hungary and finally into the Danube, interesting other countries (Federal Republic of Yugoslavia, Romania and Bulgaria). The spill caused extensive damage to river fauna and enormous problems for potable use of the water.

This dramatic event raised the urgent need to increase the level of awareness of the institutions and the population about the risks connected to specific industrial activities, especially inside a river basin with potential transboundary effects.

With this purpose, the Italian Ministry for the Environment (Department for global environment, international and regional conventions) launched a pilot project in April 2000 in coordination with the World Health Organization (WHO), with the endorsement of European Environment and Health Committee (EEHC). The project was entirely financed by the Italian Ministry for the Environment and Territory (IMET).

Scope

The Pilot Project proposes, implements and tests an integrated approach (methodology) to an environment and health rapid risk assessment, in case of severe industrial accidental events coming from highly hazardous industrial or abandoned sites, within selected geographical areas in the mean and lower course of the Danube river.

The Rapid Environmental and Health Risk Assessment (REHRA) methodology aims primarily to the identification of immediate and acute consequences of an accidental sudden release of harmful substances by active industrial plants. The methodology is designed with a view towards the priority of sites as recommended and identified by the Governments of Hungary, Romania and Bulgaria.

Basic structure

The basic structure of the methodology may be divided into the following three main elements or headings:

- Site Hazard Index and Ranking;
- Site Environment and Health Risk Assessment and Ranking;
- Environment and Health Vulnerability Index.

The first and the second element jointly lead to the rapid assessment required, while the third element supplies the implementation team with additional information, in order to verify the coherence of the assessment made.

Site Hazard Index and Ranking

It represents the likelihood of occurrence of an accident in the chemical facility. The index, SHI, is calculated on the basis of the following contributions:

- Hazardous sites inventory;
- Dangerous substances classification and inventory;
- Natural hazards inventory;
- Site hazard index and ranking.

Site Environment and Health Risk Assessment and Ranking

It represents the overall risk of the site; it combines the SHI (likelihood) and the effective, simplified consequence analysis. The index (SRI) calculation may be divided into three steps:

- Environment and health classification and inventory around the site;
- Rapid evaluation of the consequences of an accident for environment and health;
- Site rapid risk assessment and ranking.

Environment and Health Vulnerability Index

It represents the estimate of vulnerability of the territory surrounding the site. The index, GEHVI, is based exclusively on environmental and health aspects of the territory and may be calculated following three steps:

- Population vulnerability index;
- Environment vulnerability index;
- Economical vulnerability index.

The first two indexes (SHI and SRI) compose the main structure of the methodology, with final definition of the risk.

The third index (GEHVI) is an auxiliary control parameter. It is not linked to the actual risk but gives an indication of the degree of vulnerability of the surrounding region, that is the susceptibility of being harmed by an accidental release in the industrial site.

All indexes are composed by specific sub indexes, all normalised between 0 and 10.

Composition between indexes are:

- SUM, in case the sub indexes represent two or more independent events (the occurrence of each single event is sufficient to determine the risk);
- PRODUCT, in case the sub indexes represent two or more dependent events (the risk is generated only in correspondence to the concomitant occurrence of each event).

The overall structure of the methodology, with reference to the main three elements, is represented in Figure 1.

Data gathering

Collection of good and representative data is a crucial aspect that influences the results. In order to simplify this operation specific check lists have been developed, with the indication of the minimal set of information required and detailed explanation.

In order to fulfil the aim of rapidity, the set of necessary information has been reduced to a minimum, selecting among data most easily available both for industry and local authority.

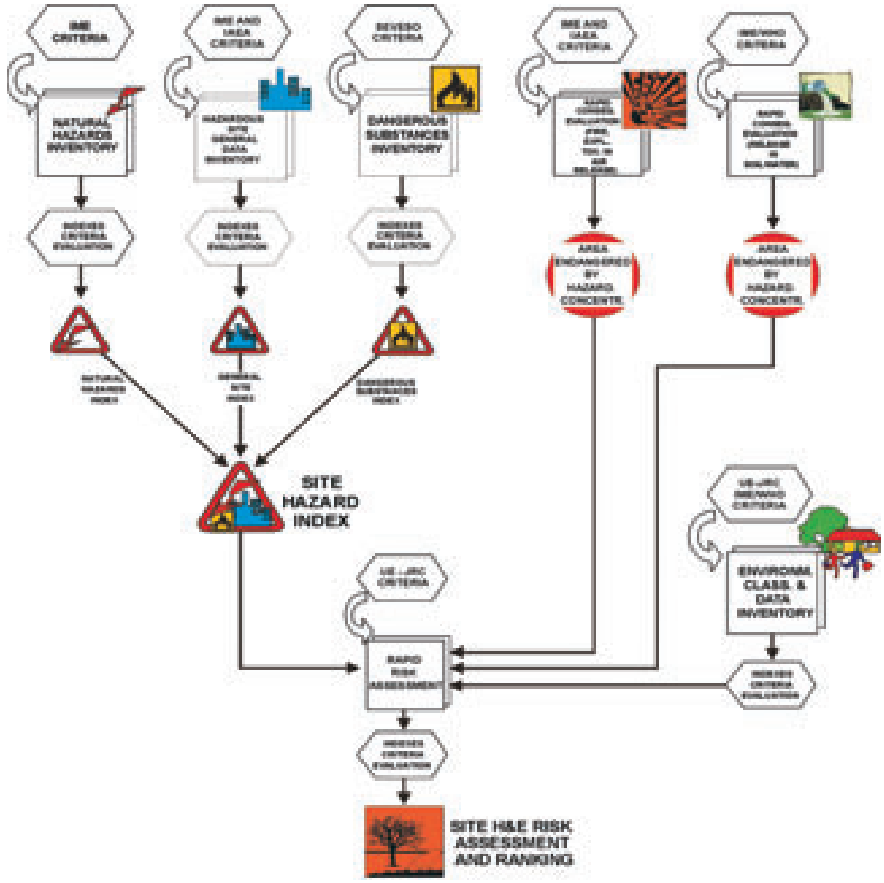

Figure 1. REHRA main scheme

Risk and Vulnerability Ranking

All three indexes (SHI, SRI and GEHVI) are ranked with a unique ranking scale, reported in following table:

Index value	Degree
from 0 to 1,6	low
from 1,6 to 3,6	moderate
from 3,6 to 6,4	high
from 6,4 to 10	very high

Table 1. Indexes' ranking scale

The choice of non linear scale function, normalized between 1 and 10, has been done to comply with the formulas adopted in the definition of main sub indexes. In this sense a quadratic distribution has been judged as more representative of the index.

In order to select most suitable distribution, different criteria of variability have been tested on several existing and known installations (ranging from small to huge facilities).

Bulgarian implementation

The Bulgarian implementation was launched during the REHRA methodology presentation, in Sofia, on 15 January 2001. A number of Technical Meetings and Site Surveys were then organized:

- REHRA methodology training course, 21-23 February 2001, Sofia;
- Software translation, 7 March 2001, Cortona;
- Organization of test on local industries, 2-3 April 2001, Sofia;

- First site visit, 23-24 April 2001, Bulgaria;
- Second site visit, 9-10 May 2001, Bulgaria;
- Final discussion on results, 6-7 June 2001, Sofia.

Industrial site selection for test cases

The first implementation needed a selection of industrial sites that could cover different typology of plants and dangerous substances.

The main criteria on which selection has been made are the following:

- Different typology of productive plants, in order to cover maximum variety of hazard;
- Different typology of dangerous substances handled, in order to cover maximum variety of application;
- Site located under different Regional Inspectorates, in order to involve different teams.

Four sites have been selected:

- "Kremikotvzi", Sofia, a huge metallurgical complex, with a large unit processing coal tar for the production of aromatic hydrocarbons;
- "Chimko", Vratza, a typical chemical plant, producing ammonia and fertilisers from ammonia;
- "Orgachim", Ruse, fine chemistry plant, producing plasticizers, adhesives and pigment;
- "Sviloza", Svhistov, chemical plant for production of pulp from timber.

Results

The following table reports the final classification of the various indexes:

	SRI		GEHVI	
	Value	**Classification**	**Value**	**Classification**
Chimko - Vratza	4.53	High	7.07	Very high
Sviloza - Svishtov	3.68	High	6.44	Very high
Kremikotvzi - Sofia	2.78	Moderate	4.76	High
Orgachim - Ruse	2.21	Moderate	5.81	High

Table 2. Results of SRI and GEHVI in Bulgaria implementation

The following map represents location of the plants and the related indexes comparison.

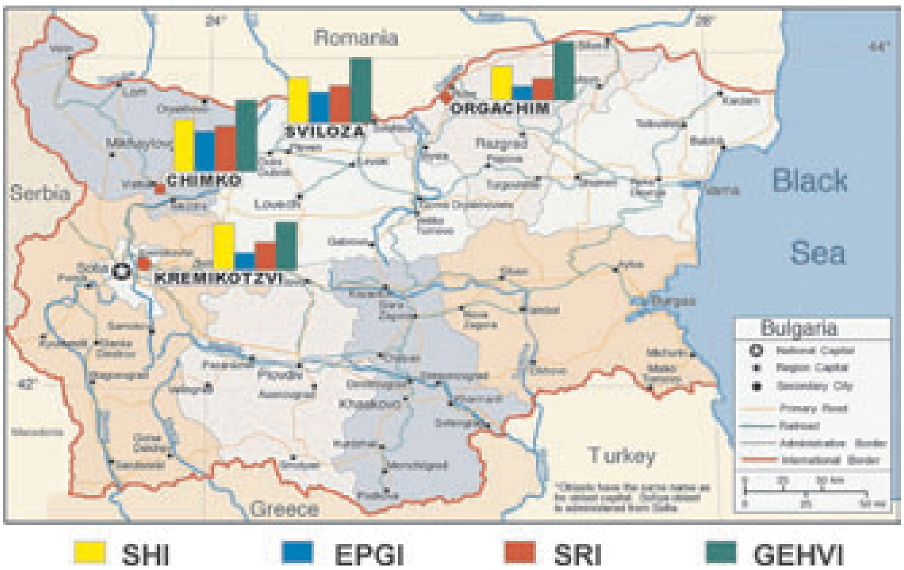

Figure 2. Map of results for different industrial sites

Emergency and prevention measures

The final step of risk evaluation and ranking is the proposition of a set of possible emergency and prevention measures that might have a role in the overall risk reduction. Proposed measures are based on the calculated results and on the evidences of the survey held in every industrial site.

The following picture details the nature and typology of proposed measures for each site.

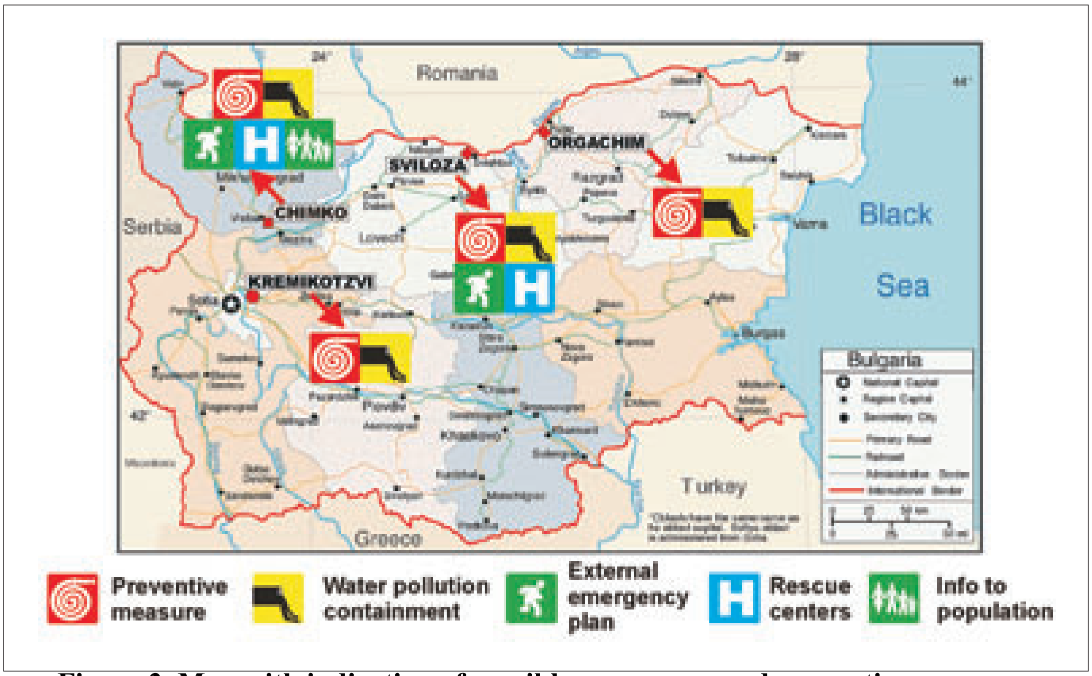

Figure 3. Map with indication of possible emergency and prevention measures

From the analysis of the proposed maps, it is possible to identify most critical sites, both in terms of indexes and in measures for risk reduction.

In particular it is important to underline those sites which need external emergency plans and rescue centres, since the potential accidents might influence areas outside the industrial site fences.

Conclusions on test

- The methodology application is quite rapid and does not require information and data too difficult to be gathered;
- The software has been judged friendly and simple by local users;
- The results of the risk ranking appear to be consistent with the dangers represented by the investigated sites and reasonably coherent with the tests made on well-known installation samples already made;
- The application of the methodology appears to allow an effective and rapid risk ranking among several establishments;
- The results allow local authorities to decide some urgent and immediate actions, awaiting for more detailed (if required) investigations;
- Technical training on the following tasks is recommended:
  - Dangerous substances classification and labelling;
  - Basic risk analysis and consequences modelling;
  - General prevention and mitigation measures.

References

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Bilateral Latvian-Lithuanian Lielupe River Watershed Management Demonstration Project 2000 - 2002

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Under the Great Lakes / Baltic Sea Partnership programme launched in 1999 and supported by the United States of America Environmental Protection Agency, Region V as well as Ohio River Valley Water Sanitation Commission (ORSANCO), the bilateral Latvian - Lithuanian Lielupe River Watershed Management Demonstration Project has started in 2000. The long-term objective of the partnership programme is to help the Baltic countries to build capacity for watershed management to better protect water resources and to meet the requirements of the EU Water Framework Directive (WFD) [1], adopted in late 2000.

The goal of the Lielupe River Watershed Management Demonstration Project is to establish cooperation between Lithuania and Latvia in the field of water basin management regarding the Lielupe watershed.

The main objectives of the project are:

- To evaluate the state of the art regarding river basin management according to the WFD and to estimate possibilities to achieve the Directive's requirements;
- To determine status of the basin and to identify existing environmental problems in the transboundary context, as well as needs for additional information;
- To develop a Joint Water Basin Management Demonstration Plan and an Action Plan, as a part of it;
- To develop a model for a Joint Lielupe River Basin Management Commission and involvement of stakeholders.

In 2001, the Joint Water Basin Management Demonstration Plan was prepared, being the first one in the process of cooperation between Latvia and Lithuania. The plan is taking into account the completed PHARE project "Multi-Country Pilot Project on the Protection and Management of Transboundary Rivers in the Baltic Region" reports (2000) and the WFD requirements, as far as possible, and the latest information related to the Lielupe River basin. Concise and more divulgative version of the Plan is a basic tool for communication with stakeholders in the watershed. The Plan consists of 11 chapters, including introduction, maps and additional information in the annexes to certain chapters. The Plan describes:

- Geography of the Lielupe River basin, including information on industry and agriculture;
- National environmental protection priorities;
- Legal acts and Government decisions in the field of environmental protection, legal acts, which regulate environmental monitoring activities, laws and regulations governing the water resources quality;
- The Government institutions in the field of environmental protection and water management as well as institutions performing environmental monitoring;
- The water quality monitoring system in Lielupe River basin;
- Pollution, sources and characteristics (point sources and non-point sources);
- Quantitative and qualitative properties of surface water in the Lielupe River basin;
- Main environmental problems in the Lielupe River basin;
- Proposals concerning development of uniform water quality classification in the Lielupe River basin;
- Proposals concerning creation of a model for the Joint River Management Commission, including definition of its objectives;
- Proposals on establishment of mechanisms for information exchange between Latvia and Lithuania on the common Lielupe watershed.

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, published in the Official Journal L 327 of 22/12/2000.

Geography of the Lielupe River basin

The Lielupe River basin extends between 22°40' and 25°57' eastern longitude and 55°38' and 56°58' northern latitude. It covers approximately 17,600 km^2, of which 8,662 km^2 are located in Latvia and 8,938 km^2 in Lithuania. According to the WFD, this is a very large river basin (> 10,000 km^2). The Lielupe River has two major branches: the Musa River, 164 km in length, of which 140 km in Lithuania, 18 km in Latvia and 6 km along the border, and the Memele/Nemunelis River, approximately 199 km in length, of which 113 km in Latvia. The confluence of these rivers in Latvian territory shapes the Lielupe River, the length of which is 119 km. The Lielupe River flows into the Baltic Sea, in the Gulf of Riga.

Protected areas account for about 4.4% of the Lielupe basin territory in Lithuania and for about 9.2% in Latvia. Approximately a total of about 843,000 inhabitants live within the borders of the basin: 58% or 485,000 on the Lithuanian side and 355,000 on the Latvian side.

The basin's soils are the most fertile in Latvia, and one of the most fertile in Lithuania. Thus the agricultural activities are widely spread here.

Monitoring systems

Main conception and objectives of environmental monitoring and water quality monitoring systems in both countries are very similar. The monitoring network in the Lielupe River basin consists of surface water and groundwater quality and quantity monitoring network, monitoring of point sources, monitoring of bathing water quality and agricultural run-off monitoring. The first step in the development of transboundary water management is to have a reliable information system and to create a mechanism for information exchange. In this chapter, it was indicated that information systems in both countries are not sufficiently developed and required strengthening.

The legal basis for cooperation of Latvia and Lithuania in the field of environmental protection is the Agreement between the Government of the Republic of Latvia and the Government of the Republic of Lithuania on Co-operation in the Field of Environmental Protection, signed in Birzai, on 1 October 1999.

The Protocol between the Joint Research Center and the Lithuanian Hydrometeorological Survey, under the Ministry of Environment of the Republic of Lithuania, and the Latvian Hydrometeorological Agency, under the Ministry of Environmental Protection and Regional Development of the Republic of Latvia, on cooperation in the field of information exchange and environmental monitoring on common Lithuanian-Latvian surface waters was signed in November 2001.

Characteristics of pollution sources

Point sources

It is evident that in the Lielupe River basin (on both sides – Latvian and Lithuanian parts) towns are the main point sources. Number of point sources (dischargers) of direct discharges into receiving waters had varied from 638 to 510 in the Lielupe River basin from 1996 to 2000. 565 point sources were registered in 2000.

In the Latvian case, the Lielupe basin contributes approximately 7% of total waste-water discharge of the country, coming next after the Daugava River basin, and in the Lithuanian case it is about 4%. In general, about 55-60% of total inhabitants in the Lielupe River basin and about 77-80% of the urban population are connected to the central sewage system and waste-water treatment plants.

In the 1990s, due to liquidation of many enterprises and decrease in water abstraction and consumption, the total amount of waste water within the Lielupe basin decreased.

Remarkably, amount of discharged waste water and pollution depend on population and level of industry development in towns. Provisory re-calculations of Biochemical Oxygen Demand (BOD) show insignificant increase of BOD permanent pollution load in the catchment in 2000.

The difference in emissions is not big between countries but data statistic shows bigger nutrient, oil products and heavy metals permanent pollution load from Lithuania. This could be explained by the larger urban area and developed industry or could be due to difference in methodology of data statistic in Latvia and Lithuania.

Non-point sources

Diffuse pollution is mainly contributing to eutrophication of both Lielupe River basin and Gulf of Riga, since rivers transport to the sea land-born nutrients.

The main indicators characterizing the diffuse pollution load are land use (in particular, total area of arable land), number of livestock (farming intensity), usage of fertilisers, plant protection chemicals and manure. The main problem of precise estimation and evaluation of diffuse load is lack of data on different diffuse pathways and furthermore some of the used data are based on assumptions.

The Lithuanian part of the Lielupe watershed contributes to 6,368 tons of nitrogen and 94 tons of phosphorus per year, of which load from forests and semi-natural areas (as natural background) is 542 tons of nitrogen and 18 tons of phosphorus. Pollution from arable land is correspondingly 5,414 tons of N and 59 tons of P yearly, but gardens and pastures accounts for 412 tons of N and 17 tons of P.

As regards Latvian part of the Lielupe River basin, total diffuse pollution load is 4,205 tons of nitrogen and 104 tons of phosphorus per year, of which load from forests and semi-natural territories (as natural background) contributes to 1,054 tons of N and 30 tons of P. Pollution from arable land is correspondingly 2,615 tons of N and 51 tons of P per year, but gardens and pastures accounts for 536 tons of N and 23 tons of P. The potential diffuse pollution from agricultural lands is much more than the pollution coming from point sources, especially in the case of nitrogen.

Quantitative and qualitative properties of surface water in the Lielupe River basin

The Lielupe River basin does not have large discharge sources (lakes, ponds). Therefore the river, especially in its upper reaches, becomes very shallow during dry periods, while it very quickly and widely overflows during spring melts and heavy showers. Most of the river run-off comes from combined surface/sub-surface run-off (up to 95%), including snowmelt water that cannot infiltrate into deeper layers because of the frozen soil. A smaller part of the discharge is generated from groundwater (up to 5%).

It is known that the hydrochemical regime of a river depends upon the conditions regarding the formation of the river flow and waters feeding the river, i.e. climatic conditions and hydrological peculiarities of a particular year.

Water quality in the Lielupe River basin is monitored at 37 river's quality monitoring stations – 21 in Lithuania and 16 in Latvia.

The water quality is worse in the part of the basin situated in Lithuania, despite the fact that emissions of waste water do not differ essentially. This is likely to be associated with low dilution of waste water in the shallow upper reaches of the river basin.

The water quality partly improves towards the border with Latvia, yet it doesn't meet good quality standards, and in the Sidabra River the water quality remains bad.

Sometimes bad water quality in the Lielupe estuary is due also to low oxygen concentrations in bottom horizons within the periods of wind-induced surges from the Gulf of Riga, when exchange of gasses and nutrients is hampered.

Following the existing assessment system and according to the measurements for 1996-2000, with respect to different parameters, 1 to 25% of samples taken in the Latvian part of Lielupe basin do not meet good quality standards for cyprinid waters. In Lithuania, the maximum allowable concentration, depending on a particular parameter, has been exceeded in 30 to 80% of the samples. In Latvia, the water quality is mostly determined by the minimal oxygen concentration, at some sites also by ammonium, the breakdown product of decomposition of organic matter, but in Lithuania, by the minimal oxygen as well as high BOD and ammonium concentrations.

Determination of main environmental and related problems in the Lielupe River basin

Since many years, general environmental problems in the Lielupe River Basin have been:

- Transboundary pollution from Lithuania (big cities are situated on banks of small rivers and a big amount of waste water exceeds the self-cleaning ability in rivers);

- Diffuse pollution, mainly contributing to eutrophication, since a big part of Lithuanian catchments and the Zemgale region in Latvia are high-developed agricultural areas with intensive agricultural production;
- Pollution from point sources, caused by inadequate and insufficient treatment of waste waters;
- Modifications of rivers due to land reclamation;
- Poor biodiversity of river fauna in almost the whole watershed;
- Drinking water does not meet requirements due to local natural peculiarities of groundwater and/or poor condition of pipelines and inappropriate farming practices;
- Only a few landfills have facilities to treat leachate or are connected to a sewage system.

Joint Latvian-Lithuanian surface water classification system

To make a common Lielupe Basin management plan, it is very important that both countries assess status of Lielupe basin using the same criteria. The first attempt to compare water quality data in the Lielupe basin was to find a starting point for the elaboration of a common classification. The requirements of the EU Freshwater Fish Directive [2] (FFD) were used as a starting point for development of the chemical surface water classification system, as the parametric values provided in the Directive are already included in both Latvian and Lithuanian classification systems. At a later stage, during the implementation of the WFD, the classification system shall be amended to include biological quality elements and maybe additional hydrochemical parameters.

In both national classification systems, parametric values describing "good ecological quality" comply with the mandatory (imperative) values for salmonid and cyprinid waters set in FFD. The definition and requirements for other classes (high, moderate, poor and bad) in Lithuania are elaborated to be part of the later transposition of the WFD.

Proposals concerning the creation of the Joint River Basin Management Commission, including definition of its objectives

All issues concerning formation of coordinated policy on the Lielupe River basin management are considered by the Joint River Basin District Management Commission, an authority which:

- Works temporarily on the principle of sessions, once every three months (or other frequency);
- Is established and operates on the principle of parity (Latvia-Lithuania).

The executive committee is formed by two appointed chairmen from both countries, which nominate others members of the commission.

The members of the commission are participants from:

- Ministry of Environment and other ministries, involved in water management, as well as Ministry of Foreign Affairs;
- River Basin District Administration (River Basin Management Units);
- Regional Environmental Boards;
- Large municipalities;
- NGOs;
- Large enterprises.

Upon request, working groups of experts can be appointed.

This Plan allows evaluating the watershed problems in the transboundary context and will help policy makers of both countries to implement necessary coordinated measures according to the WFD.

The Joint Lielupe River Basin Management Demonstration Plan was presented to stakeholders in both countries and stakeholders' suggestions will be included in the Joint Action Plan. The Joint Action Plan for the Lielupe River Basin will provide basis for future actions.

[2] Council Directive 78/659/EEC of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support fish life, published in the Official Journal L 222 of 14/08/1978.

How to influence more effectively? Public participation: legal basis and new technologies

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The importance of public participation in water management has been internationally recognised: Principle 10 of the Rio Declaration on Environment and Development (United Nations Conference on Environment and Development, Rio de Janeiro, 1992), the United Nations Economic Commission for Europe (UNECE) Convention on Transboundary Watercourses and International Lakes, the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention, 1998), the UNECE Guidance of public participation in water management and compliance with agreements (2000), the EU Water Framework Directive. [1]

There are many legal bases for public participation process, but there is no guarantee that public participation in the management of international water will automatically ensue.

Technological change emerges within all contexts of our lives, and in turn reshapes the institutions of governance, the economy, and society on both national and international levels. The last decade has been characterized by the rapid development of new technologies across a wide range of fields. Access to new technologies is distributed very unevenly within and among nations.

The Internet does promise something new for administrative governance. By eliminating geographical barriers, it also has the potential to allow Government to reach out to, and hear from, people who would not normally participate in person. With its networking capabilities, the Internet can also connect citizens to each other, making it easier to organize and act on shared concerns.

Currently more than 150 agreements on transboundary waters exist in the European region. In August 1997, an intergovernmental Agreement on the Protection and Sustainable Use of Transboundary Water Bodies between Estonia and the Russian Federation was signed. It was done in accordance with the UNECE Convention for the Protection and Use of Transboundary Waters and International Lakes. Scope of this Agreement are the transboundary waters of the Narva River basin, including Lake Peipsi. The Narva River is the outlet from Lake Peipsi to the Gulf of Finland. The agreement established the Estonian-Russian Joint Commission on Transboundary Waters for the coordination of activities on implementation of the agreement. The Lake Peipsi - Narva River basin is the biggest international lake in Europe, shared between Estonia, Russian Federation and Latvia.

Commissions on transboundary waters, like the Estonian-Russian Joint Commission of Transboundary Waters, have primarily a coordinating and advisory task. They may prepare plans and programmes and new treaties, but after adoptions by the Joint Commission, they still have to be adopted by the bordering countries. Joint Commissions may oversee implementation of the plans, programmes and treaties, but implementation remains the responsibility of the countries themselves.

This paper examines the impact of the Internet on public participation in environmental decision-making and focuses on how the organizations dealing with the transboundary watershed of Estonia and Russian Federation are using the Internet to engage citizens. The organizations' sites may be the source of ideas and experience that anticipate how environmental governance will change over the next decade.

Of particular interest were opportunities for on-line access; that is, the ability of the public to do on-line what they had in the past only been able to do in person, on the phone, via mail, or not at all.

Each web site was reviewed with regard to seven elements, separated into two categories. The first four elements cover information provision – that is, the one-way presentation of information from the agency to the public. These elements were:

- On-line access to laws and regulations;

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, published in the Official Journal L 327 of 22/12/2000.

- On-line access to information on general environmental problems;
- On-line access to information on Lake Peipsi basin conditions;
- Information about opportunities for on-line and off-line public participation.

The second category was interactive participation, which refers to the ability of the public to interact on-line with agency personnel as well as with other citizens. The interactive elements examined were:

- The opportunity for citizens to provide input to the agency on-line;
- The ability to comment on regulations and strategies on-line; and
- The ability to communicate with other citizens on-line.

The review and evaluation process focused exclusively on water resources and on the Lake Peipsi basin. For each site, the review and evaluation process focused on the main home page and each page immediately accessible by a link from the home page. Sites were given a score of high, medium, or low for each of the seven elements discussed above. The results of the web site survey are shown in Table 2.

To understand what issues the Estonian-Russian Joint Commission on transboundary water (Joint Commission) is facing on environmental cooperation and public participation mechanisms, we spoke with environmental experts from Estonia, Russian Federation and Sweden. The questions were general and open-ended in nature, and were designed to gain an understanding of what interviewees felt on transboundary water management and the Joint Commission work in the Lake Peipsi - the Narva River basin. Many of those interviewed were the representatives of the Joint Commission. The results of the interviews are grouped below:

- Nowadays the Estonian-Russian Joint Commission is committed to implementing the general principles of the EU Water Framework Directive and to work out a general Plan for Lake and River Basin Management following the guidelines outlined in the EU Water Framework Directive in Estonia as well as in the Russian Federation side. It could be a good opportunity for both countries on capacity building and for developing new regulations, methodologies and norms for environmental protection and monitoring issues;
- The Joint Commission has a separate Working Group on Cooperation with International and Non-Governmental Organizations and Local Authorities (WGonC). Last year, the Joint Commission web site was established under the coordination of the NGO Peipsi Center for Transboundary Cooperation which is a lead organization in implementation of plans of the WGonC;
- One of the parts in the Management Plan for the Lake Peipsi basin will be a plan on public participation. Before the development of the public participation plan, information exchange inside the Joint Commission and outside should be improved;
- The public participation in transboundary water needs a clear understanding of the stakeholders and interested groups, and first cooperation will be established with the local authorities in both countries;
- The experiences of others transboundary freshwater basins will be used in the development of the Management Plan for the development of Lake Peipsi basin, e.g. the Great Lakes and Lake Geneva.

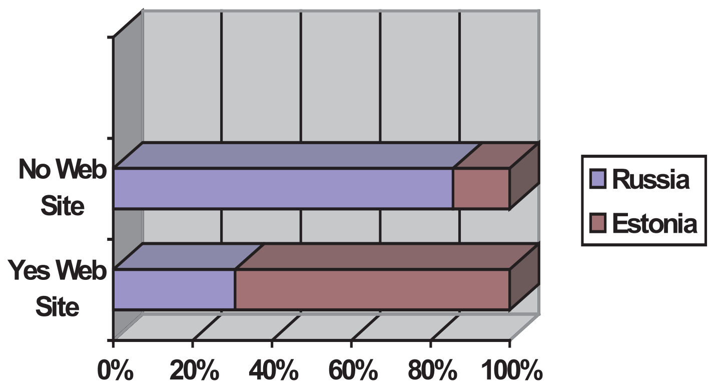

Table 1. The amount of web sites of environmental organizations in Estonia (20 organizations) and in the Russian Federation (20 organizations) who are connected to environmental activities in the Lake Peipsi - the Narva River watershed

Conclusion and discussion

Overall, the research results suggest that electronic interaction in environmental decision-making is in an early phase. However, not all governmental (federal and regional) environmental agencies have web sites and opportunities for on-line interaction with Government and other relevant organization and possibilities among citizens are quite limited. Overall, it appears to be a good time for organizations to learn from each other how to employ basic participatory features and to experiment more broadly with on-line engagement.

State agencies appear to be in an early, experimental phase in deploying the Internet to engage citizens on environmental issues. However, it was encouraging that not all environmental departments in Estonia and northwest of the Russian Federation have web sites. Overall, organizations seem more advanced, and more comfortable with providing environmental information to their citizens than they are with providing opportunities for on-line interaction. Relatively few agencies have quality opportunities for interactive electronic public involvement.

In addition to providing new ways to communicate with the public, on-line initiatives are changing the demands placed on bureaucracies. Providing a seamless face to the public increases pressure for internal coordination and cooperation. Externally, the demands of various stakeholders – the general public, environmental non-profit groups, the regulated community and legislators – are forcing agencies to be strategic in their use of resources for on-line efforts.

Estonia has stated its willingness to become a member of the European Union. For that purpose it is necessary to align national laws in order to give effect to the entire body of EU law. The purpose of the approximation process of environmental legislation is to ensure full alignment of the national environmental law and the administrative system to be in full compliance with the European Union requirements.

The EU Water Framework Directive (WFD) will be the central tool for the future environmental management of transboundary river and lake basins in Europe and, in particular, of the Lake Peipsi - Narva River basin. The implementation of the EU Water Framework Directive with consultations and recommendations through Internet and on-line public participation and discussion of implementation at the State level could be an important part in all countries.

The research indicates that the use of the Internet by environmental organizations in the Lake Peipsi basin could improve public participation. Now is the time for organizations to take stock of their own efforts and learn from each other about best practices as they deal with an increasingly wired public.

There are, however, some practical problems with organizing public participation at the level of international basins. Community and stakeholders involvement in decision-making process at the level of the Lake Peipsi transboundary watershed is complicated since:

- There is not one Government to manage international waters and the bordering States have different water management legislation and institutional structure;
- There are different communication forms and languages and cultural background;
- Countries do not have harmonized strategies;
- There are insufficient capacity and lack of coordination to strengthen public participation;
- Communication is weak not only between public of different countries, but also between environmental experts and environmental educational institutions inside the Joint Commission and outside.

Despite all efforts, it may be impossible to reach everybody. In larger international basins, public participation at the international level will most likely remain limited to a few large (international) NGOs and well-organized interest groups. Consequently, public involvement at the basin level can be a valuable supplement to public participation at the national level, but it can never replace it. In our case, the Estonian-Russian Joint Commission on transboundary water will be a leader to propose the vision on public participation in the Lake Peipsi basin. The role of Internet and on-line participation possibilities will be included in the public participation strategy.

Management of transboundary water means cooperation between not only national Governments in the basin but also between sub-national Governments and local authorities. Private interests and NGOs play a very important role as well. NGOs can influence the governmental bodies both at the international and national level. Moreover, they can address international bodies directly, either at their own initiative or at the request of the body concerned.

Table 2. Web survey on access to environmental information and public participation.

High = High Med = Med Low = Low	Access to laws and regulations	Access to information on general environmental problems	Access to information on the Lake Peipsi basin conditions	Public participation on-line and off-line	Ability to input to the agency on-line	Ability to comment on regulations and strategies on-line	Ability to communicate with other citizens on-line
Stockholm Environmental Institute Tallinn Centre (SEI-Tallinn)	High	High	Med	Med	High	High	Low
Meteorological and Hydrological Institute, Estonia	High	High	High	Med	High	Med	Low
Estonian Environment Information Centre (EEIC)	High	High	High	Med	High	Med	Low
Estonian Fund for Nature	High	High	Low	Med	High	Low	Low
Friends of the Earth-Estonia	High	Med	Low	High	High	Med	Low
Estonian Ministry of Environment	High	High	Med	Med	Med	Med	Low
Tartu County environmental department, Estonia	High	Med	Med	Med	High	Med	Low
Estonian Water Association	High	Med	Med	Med	High	Low	Low
Polva County environmental department, Estonia	High	Med	Med	Med	Med	Low	Low
Geological Survey of Estonia	High	Med	Med	Med	Med	Low	Low
Environmental Protection Institute, Estonia	Low	Med	Low	Med	Med	Low	Low
Institute of Zoology and Botany, Estonia	Med	Med	High	Med	Med	Low	Low
Võrtsjärv Limnological Station, Estonia	Med	Med	Med	Med	Med	Low	Low
Peipsi Info and Volunteer Center, Estonia	Med	Med	Med	Med	Med	Low	Low
Lake Peipsi Area Development Foundation, Estonia	Low	Low	Low	Low	Low	Low	Low
The Peipsiveere Development Agency, Estonia	Low	Low	Low	Low	Med	Low	Low
Natural resources and ecology of Russian Federation	High	High	Low	High	High	High	High
Ministry of Natural Resources of Russian Federation	High	Med	Med	High	High	High	Med
Transboundary Environmental Information Agency	High	High	Low	High	High	Med	High
Russian Federal Service For Hydrometeorology and Environmental Monitoring ROSHYDROMET	High	Med	Med	Med	High	Med	Low
North-West Inter-Regional Territorial Administration of Gydrometeorology and Environmental Monitoring	High	Med	Med	Med	Med	Med	Low
State Committee of Environmental Protection, Russian Federation	High	Med	Low	Med	Med	Med	Low
St. Petersburg Hydrometeorological University	Med	Med	Med	Med	Med	Low	Low
St. Petersburg University, Faculty of Geography	Low	Low	Low	Low	Med	Low	Low
Peipsi Center for Transboundary Cooperation	High	Med	Med	Med	High	Low	Low
The Estonian-Russian Transboundary Water Commission	High	Med	Med	Med	High	Low	Low

Computerised decision support tools in water management: a selective overview

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Introduction

Effective and efficient water management at different levels requires the best possible knowledge of existing actors, programmes, techniques and methods used, available tools and documentation, results of research and training opportunities. This information is usually fragmented, dispersed, heterogeneous and not easily accessible, even today when Internet technology is available to more and more users. Therefore several efforts have been recently made by various international or national bodies aimed at rationalisation of information flow, in order to make this information and knowledge readable, easily accessible, and available, and thus create a sound basis for decision-making. To that end, several tools were developed and made available to water specialists either commercially or free of charge, ready for downloading from the Internet. They belong to the broad category of Decision Support Systems (DSS) with integrated models and information management systems (IMS). This paper gives a short description of selected tools.

Definitions

DSS: Decision Support System is a means of collecting data from many sources, integrating and analysing them in order to provide decision makers with sound and justified options. DSS is usually supported with various modelling tools.

MODEL: a simplified description of a system to assist calculations, forecasts and predictions. Modelling at catchment level can integrate the hydrological, technical, ecological and environmental, economic, social, institutional and legal aspects of water problems into a coherent framework.

SDSS: Spatial Decision Support Systems are computer tools in which the technologies of both Geographical Information Systems (GIS) and DSS are applied to aid decision makers with problems that have a spatial dimension.

MODSS: multi-objective DSS provides the frame for integration of various kinds of data in phases. Results of each phase are subject to consultations with potential stakeholders:

- Issue identification;
- Management options identification;
- Establishment of decision criteria;
- Data acquisition;
- Decision support process.

IMS: Information Management Systems are electronic tools that arrange, store, exchange and process data and information. Geographical Information Systems (GIS) and Bibliographic Information Systems are typical examples of IMS.

Description of selected DSS tools

Criteria of selection

The following criteria were applied for the selection of DSS tools for this brief overview:

- Policy oriented;
- Developed in the form of black-box, or ready made software;
- World-wide easily available or accessible to any interested user;
- Universal, world-wide applicable tool (not country specific or catchment oriented);
- Already applied in more than one country;
- Recommended or used by an international organization.

WEAP – Water Evaluation and Planning System

WEAP is a computer tool for integrated water resource planning. It provides a comprehensive, flexible and user-friendly framework for policy analysis. Operating on the basic principle of water balance accounting, WEAP is applicable to municipal and agricultural systems, single sub-basins or complex river systems. WEAP can address a wide range of issues, e.g. sectoral demand analysis, water conservation, water rights and allocation, priorities, groundwater and stream simulation, reservoir operations, hydropower generation, pollution tracking, ecosystem requirements and project cost-benefit analysis. The wide scope of issues addressed is placing WEAP among SDSS and MODSS category.

Developed by Stockholm Environmental Institute – Boston Tellus Institute in cooperation with Hydrogeologic Engineering Centre of the US Army Corps of Engineers.

Applied in several countries in various World Bank projects.

Information at: http://www.seib.org.

PODIUM – Policy Dialogue Model

PODIUM is a software tool for planning of food and water safety.

It is used on a country scale to assist in the determination of future policy with regard to food and water resources. It allows to develop alternative scenarios of potential demand and supply of water and food till year 2025. It has been used during the development of the World Water Vision prior to the 2nd World Water Forum in The Hague, March 2000. It is a classic DSS.
Developed by the International Water Management Institute (IWMI).

Recommended by the International Commission on Irrigation and Drainage (ICID) to its member countries.

Information at http://www.iwmi.org.

WaterWare: a water resources management information system

WaterWare is an integrated model-based information and decision support system for water resources management. WaterWare integrates results of the Eureka project EU 487 and other research and technology development projects.

WaterWare is implemented in an open, object-oriented architecture. It supports the seamless integration of databases, GIS, models, and analytical tools into a common, easy-to-use framework. This includes a multimedia user interface with Internet access, a hybrid GIS with hierarchical map layers, object data bases, time series analysis, reporting functions, an embedded expert system, and a hypermedia help-and-explain system. WaterWare, through performance of scenario analysis, may address various issues of water quality and quantity and related engineering, environmental and economic aspects. WaterWare includes simulation and optimisation models and related tools, such as:

- A rainfall / run-off and water budget model;
- An irrigation water demand estimation model;
- A graphical river network editor;
- Dynamic and stochastic water-quality models;
- A groundwater flow and transport model;
- A water resources allocation model;
- An expert system for environmental impact assessment.

WaterWare is a modular and data driven system. It can be configured for customised installation with different sets of models and tools. Through shared data formats, and the respective filter programs, third-party tools can be used with the system for special tasks, for example image processing or statistical analysis of observation data.

The number of issues addressed and the powerful modular open architecture are placing WaterWare in leading position within SDSS category.

Developed by ESS Environmental Software and Services, Austria.

Applied in the River Thames, England, Lerma - Chappala basin, Mexico, West Bank and Gaza, Palestine, Kelantan River, Malaysia.

Information at http://www.ess.co.at.

ToolBox – a DSS tool for integrated water resource management

A very unique tool initiated and developed by the Global Water Partnership (GWP) in order to draw together a wealth of experience and expertise in integrated water resource management (IWRM) field worldwide.

ToolBox is structured in two main parts: policy guidance and operational tools. The tools are presented as a series of categories and the information for each tool is prepared in a standardised format.

The categories of ToolBox instruments

A The enabling environment

A1 Policies – setting goals for water use, protection and conservation
A2 Legislative framework – water policy translated into law
A3 Financing and incentive structures – allocating financial resources to water needs

B Institutional roles

B1 Creating an organizational framework
B2 Institutional capacity building – developing human resources

C Management instruments

C1 Water resources assessment – understanding resources and needs
C2 Plans for IWRM – combining development options, resource use and human interaction
C3 Demand management – using water more efficiently
C4 Social change instruments – encouraging a water-oriented civil society
C5 Conflict resolution – managing disputes and ensuring sharing of water
C6 Regulatory instruments – allocation of water use limits
C7 Economic instruments – using value and prices for efficiency and equity
C8 Information management and exchange – improving knowledge for better water management

ToolBox might be viewed as a dynamic and continually updated library of knowledge and tools with open structure, oriented towards practical aspects of IWRM. ToolBox falls into IMS category although its concept is very unique.

Developed by the Global Water Partnership – ToolBox development team.

Recommended by the GWP and its regional Committees and donors as World Bank.

Information at http:// www.gwpforum.org.

Status of Estonian rivers in the Lake Peipsi basin

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According to the EU Water Framework Directive [1], water bodies are classified on the basis of the chemical status in five classes: High, Good, Fair, Poor and Bad. The overall objective of the Water Framework Directive is the achievement of a good status for all waters by December 2015. Good surface water status means that both the ecological status and the chemical status of water bodies are at least good.

The ecological status is determined by biological, hydromorphological and physico-chemical quality elements. Hydromorphological indicators characterize abiotic conditions of rivers. Physico-chemical quality elements indicate the cause of pollution and give the possibility to quantify pollution loads. Biological parameters generally indicate the long-term impact of pollution.

The chemical status classification of Estonian rivers has been worked out on the basis of biochemical oxygen demand and dissolved oxygen as the main indicators of organic pollution, and nutrients as eutrophication indicators (Table 1).

Parameter	Unit	Class I High	Class II Good	Class III Fair	Class IV Poor	Class V Bad
pH		6-9	6-9	6-9	6-9	<6-9>
Saturation of dissolved oxygen	%	>70	70-60	60-50	50-40	<40
BOD_7	$mgO_2\ l^{-1}$	<3.0	3.0-5.0	5.0-8.0	8.0-10.0	>10.0
NH_4^+	$MgN\ l^{-1}$	<0.1	0.1-0.3	0.3-0.45	0.45-0.6	>0.6
N_{tot}	$MgN\ l^{-1}$	<2.0	2.0-3.0	3.0-4.0	4.0-5.0	>5.0
P_{tot}	$MgP\ l^{-1}$	<0.05	0.05-0.08	0.08-0.12	0.12-0.16	>0.16

Table 1. Water quality classification of Estonian rivers

The classification is based on the principle that class I or "high status" is characterized by quality elements of waters in undisturbed conditions. For class II, waters of "good status", some human impact is allowed, but water should correspond to the requirements of "good status". These quality elements take sufficiently into account those factors that influence the water quality of Estonian rivers. In this case, the main problems are the high content of organic substances in water and, due to that, the reduced content of dissolved oxygen (influence of insufficiently treated waste water) as well as progressive eutrophication characterized by a high content of nitrogen and phosphorus compounds.

Average annual values are frequently used to estimate water quality. Mean values, however, do not describe water quality to a sufficient extent. Standard deviation is the second most commonly used characteristics. A percentile value is, however, most suitable for a general characterization of data. Percentiles can be calculated as weighted mean values and compared with average and standard deviation.

To evaluate the classifications, concentrations of pollutants in the rivers have been calculated. The calculation of the parameters is based on estimates of the 10 percentile of the normal distribution for dissolved oxygen and on the 90 percentile of the log-normal distribution for the other parameters. These

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, published in the Official Journal L 327 of 22/12/2000.

percentiles mean that in 90% of the measurements the concentration is less than the specific level or the concentration can be above this value only in 10% of cases.

The present level of biological oxygen demand (BOD_7) in most of the rivers of the Lake Peipsi basin is quite low compared to the 1980s (Loigu *et al.* 2001) when amounts of waste water discharged into the rivers were the highest. The biochemical oxygen demand of natural river water, which is not directly influenced by human activity is as a rule less than 3.0 mgO_2/l. BOD_7 values of 3-5 mgO_2/l indicate moderate human impact and concentrations above 5 mgO_2/l indicate obvious pollution. BOD_7 levels in the rivers of the Lake Peipsi basin were generally classified as good or fair during the last decade (Figure 1). The fluctuation of annual 90% values is also quite low, which shows the effectiveness of waste-water management in towns and villages in the basin.

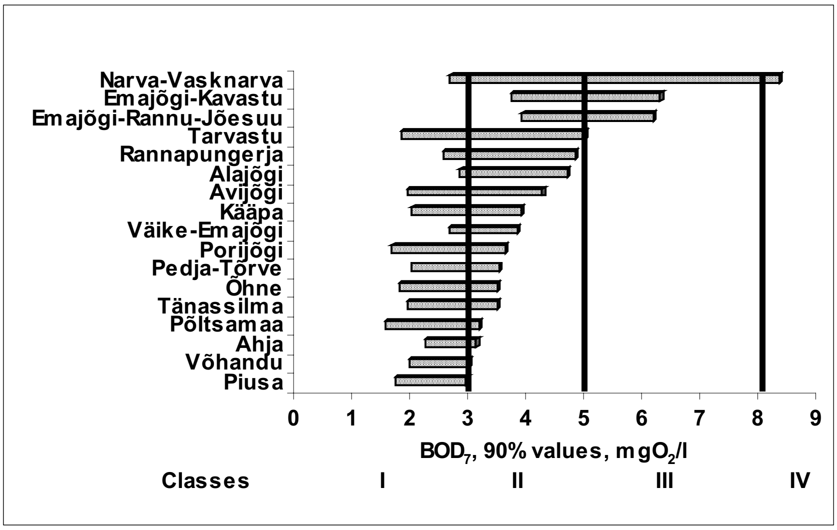

Figure 1. Variability of annual BOD_7 values (by 90-percentile) in rivers of the Lake Peipsi basin in 1992-2001

The rather high BOD_7 in the Emajõgi River, especially at the outlet of Lake Võrtsjärv, is caused by the high content of organic matter in Lake Võrtsjärv. The concentration of BOD_7 at the Rannu-Jõesuu station is even noticeably higher than at the Tartu station, and a typical seasonal pattern can be observed. BOD_7 at the Rannu-Jõesuu station is the highest in summer during the period of intensive photosyntesis due to the decomposition of phytoplankton. Rivers discharging into Lake Võrtsjärv are nutrient-rich. Organic matter produced in this highly eutrophic lake is the main factor causing relatively high biochemical oxygen demand and organic nitrogen and phosphorus concentrations in the Emajõgi River. Therefore, the high level of BOD_7 at the Rannu-Jõesuu station does not indicate direct organic pollution. The content of inorganic nitrogen and phosphorus at the outlet from Lake Võrtsjärv (the Emajõgi River at the Rannu-Jõesuu station) is low, because it is transferred to organic nitrogen and phosphorus during the photosyntesis process in the lake. As a result of phytoplankton degradation, upstream biochemical oxygen demand in summer-autumn (5-7 mgO_2/l) can be even higher than downstream at the Kavastu station, near the Tartu waste-water outlet.

One of the main problems of Estonian water protection is the eutrophication of surface waters caused by the increased load of nutrients of anthropogenic origin. The eutrophication level of the lakes depends on the nutrient content in the rivers. The nitrogen level in the Estonian rivers is still quite high, although the content of nitrogen has decreased in most rivers in recent years due to decreases in agricultural pollution load. The concentration of nitrates was the highest in 1985-1987 when the use of fertilizers was very intensive and when major part of them was leached into surface waters (Loigu and Leisk, 1996). The level of agricultural production and also nitrate concentration was the highest in 1984-1988, while by 1995-1999, which was the period of low agricultural production, the nitrogen level in rivers has decreased (Figure 2).

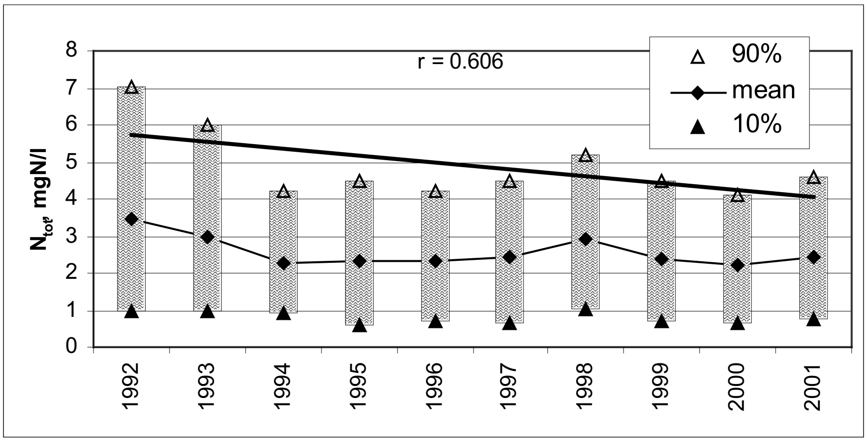

Figure 2. Content of total nitrogen in rivers in 1992-2001

The critical content of total nitrogen, above which the eutrophication of rivers starts, is 2.5 mgN/l (Loigu, 1992). The mean concentration in the reference rivers was 1.5 mgN/l and in 98% of all samples the content of total nitrogen was lower than the critical value.

The percentage of organic nitrogen is high at the Rannu-Jõesuu station at the beginning of the Emajõgi River. The content of mineral nitrogen in Lake Võrtsjärv is low as mineral nitrogen is transformed into organic nitrogen in the process of photosyntesis that takes place in the lake (Loigu and Leisk, 1989), total nitrogen consists mainly of organic nitrogen (average value 72%) and the content of nitrates is higher only during spring flood periods (Figure 3).

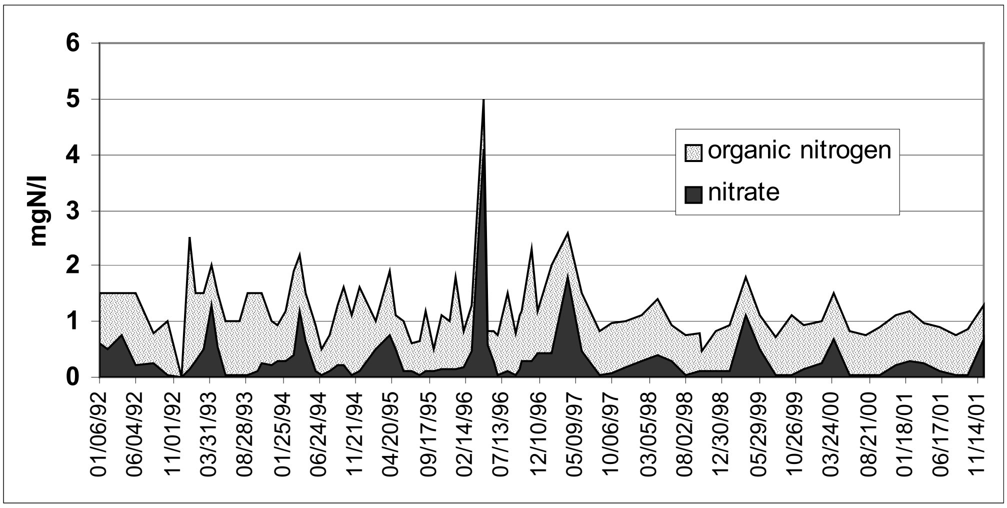

Figure 3. Content of nitrogen at the Rannu-Jõesuu station in the Emajõgi River

The variability of total nitrogen in rivers is quite high; during the last decade, water-quality classifications of some rivers varied between fair and bad. The 90% value of total nitrogen is higher than 3 mgN/l in most rivers in the basin (Figure 4).

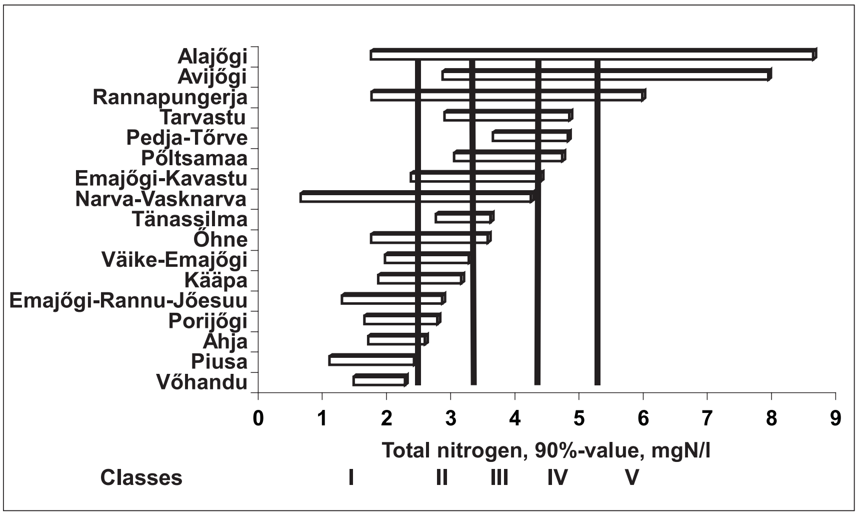

Figure 4. Variability of annual total nitrogen value (by 90-percentile) in rivers of the Lake Peipsi basin in 1992-2001

The main element limiting primary production in Estonian surface waters is phosphorus. The background value for phosphorus in rivers is less than 0.05 mgP/l. The highest permissible value of total phosphorus preventing eutrophication is 0.10 mgP/l (Loigu, 1992). The average content of total phosphorus in reference rivers in 1992-2001 was 0.05 mgP/l. The content of phosphates in the background rivers of the Lake Peipsi basin has continuously decreased: it was high in 1979-1982 (Loigu and Leisk, 1989) and later decreased significantly; the present level is typical of all Estonian reference rivers. The variability of phosphorus values is presented in Figure 5.

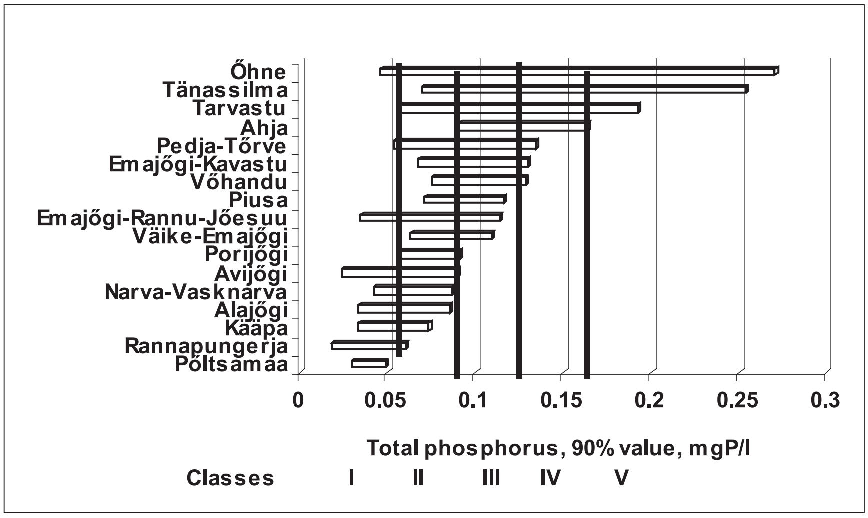

Figure 5. Variability of annual total phosphorus value (by 90-percentile) in rivers of the Lake Peipsi basin in 1992-2001

The Tänassilma River is the recipient of waste water from the city of Viljandi. In the city, there are several small food processing industries that have no separate waste-water treatment plants with phosphorus removal and all waste water is discharged into the river. However, the use of better technology and decreasing amounts of waste water have improved the water quality of the river (Figure 6).

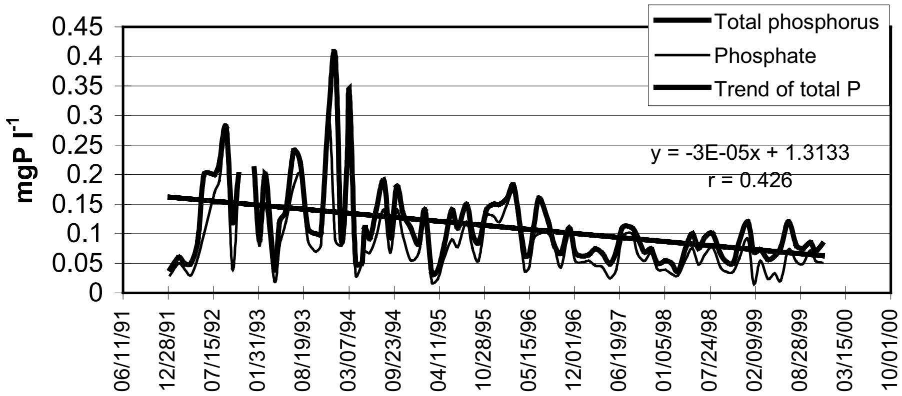

Figure 6. Content of phosphorus in the Tänassilma River in 1992-1999

Since 1987, the working group on river biology of the Institute of Zoology and Botany (IZB, Estonian Agricultural University) has been collecting data on biological variables of Estonian rivers in the framework of an extensive hydrobiological investigation. The data portray a very representative spatial coverage: over 250 rivers and 633 river reaches; but the data are seasonally restricted to late June and July. The variables of interest include dissolved oxygen, pH, chemical (COD) and biological (BOD) oxygen demand, contents of chlorophyll *a* and phaeopigments in the water and bottom sediments, phytoplankton biomass, bacterioplankton, microphytobenthos, macro vegetation and benthic invertebrates.

To assess the pollution status of the rivers, the working group on river biology used the saprobity of rivers, which was evaluated on the basis of three parameters: 5-day biological oxygen demand (BOD_5), abundance of saprobic bacteria and indicator species of bottom invertebrate fauna (Table 2). Various literature data were used and adjusted to assess the indication value of benthic invertebrate species.

	O	β-M	α-M	P
BOD_5 (mg O_2 l^{-1})	≤ 3	3.1-5.0	5.1-10.0	> 10
Saprobacteria (cells • 10^3 ml^{-1})	< 1	1-5	5-10	> 10

Table 2. Assessment criteria of sabrobity of Estonian rivers based on the classical 4 categories: O - oligosaprobity, β-M - β-mesosaprobity, α-M - α-mesosaprobity, P - polysaprobity

According to BOD_5 data, most of the river reaches in the Lake Peipsi catchment area were oligosaprobic (Table 3). However, using the abundance of saprophytic bacteria, most of the rivers (83%) belong to the β-mesosaprobic class. The discrepancy in saprobity status, using the three different variables, is remarkable. During an inter-calibration study in 25 rivers and 174 river reaches all over Estonia, the following statements can be made: In rivers with a relatively low sabprobity status, indexes based on BOD_5 and benthic invertebrates fauna are in general agreement. In strongly polluted rivers, indexes based on saprophytic bacteria and BOD_5 agree even better than indexes based on invertebrate fauna and BOD_5. The overall recommendation is to use all three variables, as none taken separately can lead to reliable assessments of the water quality. However, it is important to note that, for example, bottom fauna and bacterioplankton perceive the water quality in very different time scales. If we ask for long-term (e.g. annual) integration, benthic macrofauna should be the parameter of choice. Short-term fluctuations in the water quality should better be reflected through the much more dynamic bacterial plankton.

	O	β-M	α-M	P
BOD_5	112 (59.9)	50 (26.7)	25 (13.4)	-
Saprobacteria	17 (9.1)	155 (82.9)	9 (4.8)	6 (3.2)

Table 3. Distribution of river reaches of the Lake Peipsi catchment between saprobity classes. Number in parenthesis denotes the percentage in the particular class out of the total 187 river reaches (77 rivers)

During 1985-1999, qualitative macroinvertebrate samples were collected from Estonian Rivers by H. Timm (Võrtsjärv Limnological Station, IZB). To assess the quality status of the rivers, the British Average Score Per Taxon (ASPT) was used. The method (Armitage et al., 1983) lists macroinvertebrate families present in the sample and determines the score of each family. The ASPT index is the mean score of all the scoring families. ASPT values are positively correlated to organic pollution and/or general ecological quality (Armitage et al., 1983; Johnson, 1999). Table 4 shows the investigated rivers from the Lake Peipsi catchment, the corresponding ASPT score and associated quality status (Johnson, 1999). Polluted and unpolluted sites within a stream are not separated in calculations, neither are the upper and lower reaches of small streams.

Stream	n	mean ASPT	Quality
Piusa	16	6,0	intermediate
Võhandu (upstream of Lake Vagula)	17	6,5	high
Võhandu (downstream of Võru Town)	10	5,9	intermediate
Võhandu (Räpina)	2	5,1	low
Väike Emajõgi (upper)	12	6,4	high
Väike Emajõgi (Tõlliste)	2	7,0	very high
Väike Emajõgi (Pikasilla)*	2	4,7	low
Õhne (upper)	5	6,4	high
Õhne (Roobe)	2	6,8	high
Õhne (Suislepa)	1	6,5	high
Tarvastu	3	5,7	intermediate
Emajõgi (upstream of Tartu Town)	30	5,2	low
Emajõgi (downstream of Tartu Town)	29	4,1	very low
Pedja (upstream of Jõgeva Town)	6	5,9	intermediate
Pedja (downstream of Jõgeva Town)	6	5,5	intermediate
Preedi	3	5,7	intermediate
Põltsamaa (upstream of Endla Nature Reserve)	58	4,4	very low
Põltsamaa (downstream of Endla Nature Reserve)	4	5,8	intermediate
Oostriku	1	5,6	intermediate
Porijõgi	18	6,0	intermediate
Ahja (upper)	11	5,6	intermediate
Ahja (Lääniste)	1	6,3	high
Kääpa	11	5,5	intermediate
Avijõgi	8	6,0	intermediate
Rannapungerja	4	5,3	intermediate
Tagajõgi	3	5,9	intermediate
Alajõgi	1	5,3	intermediate
Total number of samples	266		
Mean ASPT		5,7	intermediate

Table 4. Mean ASPT values and quality estimates (after Johnson, 1999, for small streams)

In most cases, the ASPT index revealed medium biological quality. The Emajõgi River (downstream of Tartu) and the upper course of the Põltsamaa River showed very low quality, probably caused by human activities. Possibly the quality status can be somewhat underestimated due to smaller sample-size-naked-eye sorting of the animals in the field, as compared to laboratory stereomicroscope sorting by Johnson (1999).

In order to combine the various data on Estonian rivers, we applied the subindex (SI) method to the hydrobiological data set of the IZB working group on river biology. This procedure faced two inherent incompatibilities, which we had to ignore. First, to calculate the 90 percentiles, the SI method requires large time series (that are typical to monitoring station) from the same site. As the data in the hydrobiological data set are not continuous, but just single measurements, percentile calculation was not possible. Second, as the hydrobiological data were representative of the summer stage only, and not for the whole year – as assumed by the SI method – we most likely face a systematic error in the results. Consequently, the present exercise should only be treated as a first approach to combine the various data on Estonian rivers.

Based on the above calculations, we found that high, good, fair, poor and bad chemical status could be assigned to 59%, 22%, 9%, 8% and 2%, respectively, of the river reaches in the Lake Peipsi basin. This distribution of the river reaches between the different quality classes is clearly different from the respective distribution in the chemical monitoring data set from 1992-1999, and may be caused by inherently different nature of the two data sets.

As a next step, we investigated how the available biological parameters relate to the index-based quality classes. The screening of the available biological variables revealed that the number of saprophytic bacteria in the water gave a reasonably good agreement with the index-based quality status (Figure 7). As the index-based water-quality status was based on very short-term measurements, it is perhaps not surprising to see a good correspondence with the abundance of saprophytic bacteria. This result is in accord with the assumption that short-term fluctuations in the water quality should be reflected in the very dynamic bacterial plankton with short turnover times.

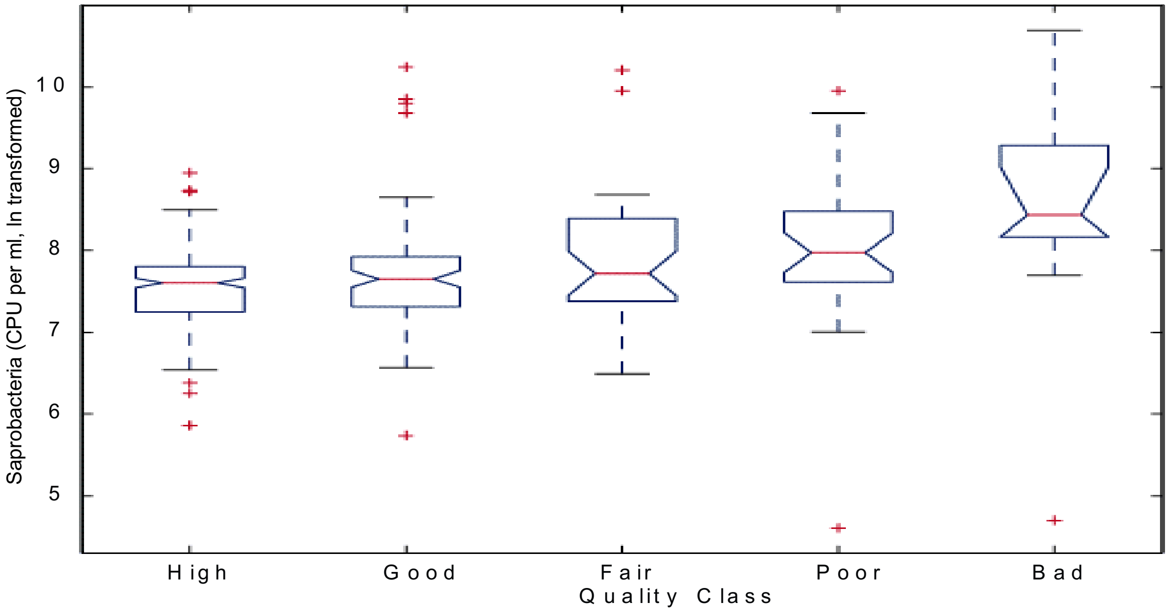

Figure 7. Box and whiskers plot of the abundance of saprophytic bacteria (colony forming units ml^{-1}; ln-transformed) in different classes of water quality in the rivers of the Lake Peipsi catchment. The horizontal lines of the boxes show the lower quartile, median and upper quartile values; whiskers show the extent of the rest of the data, and crosses show the outliers. Box notches represent a robust estimate of the uncertainty about the means

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Improvement of the ecological situation of Vistula Lagoon

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Introduction

In 1994-1997, extensive studies, including monitoring and modelling of hydrodynamic and water quality of Vistula Lagoon (Figure 1), have been carried out under the project "Prioritising hot spot remediation in the Vistula Lagoon catchment".

The project was financed by the Polish Committee of Scientific Researches and by the Danish Environmental Protection Agency. The participating institutions were:

- Former Water Quality Institute and Danish Hydraulic Institute (now DHI Water and Environment), Denmark;
- Geomor Co. Ltd., Gdańsk, Poland;
- P. P. Shirshov Institute of Oceanography, Kaliningrad.

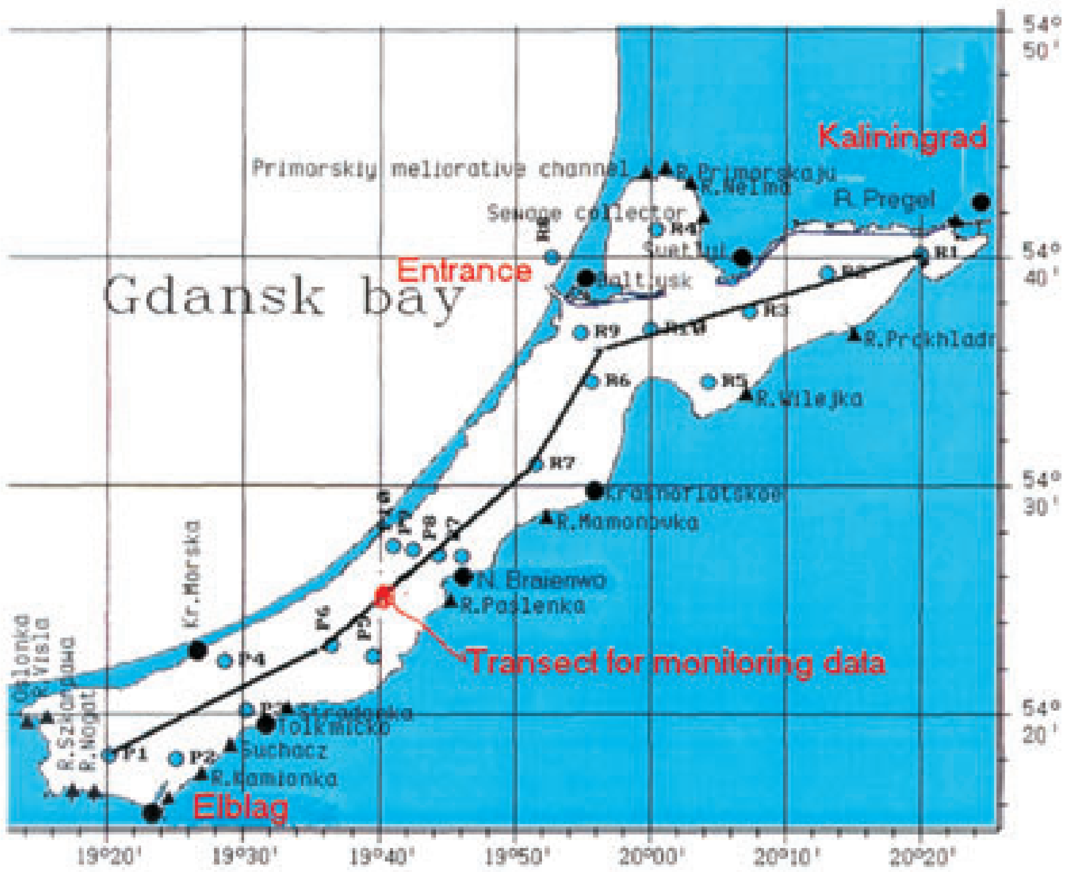

Figure 1. Map of Vistula Lagoon

Environmental state of Vistula Lagoon

Based on the review of the monitoring data and on the monitoring programme conducted during the project, the conclusions below have been drawn with respect to water quality in the lagoon and the load of nutrients:

- Vistula Lagoon is a eutrophic system, with high concentrations of algae and suspended matter resulting in a high turbidity and consequently a low light penetration;
- Submerged bottom vegetation is sparse and only found in shallow waters due to the low light penetration;
- The monitoring data showed increasing eutrophication/pollution in transects from the entrance towards Kaliningrad in the Russian part and from the entrance towards Elblag in the Polish part of the lagoon;
- In general water quality is worst in the Polish part of the lagoon, partly due to the nutrient load from Polish cities and rivers (Elblag, Pasleka) and partly due to the restricted water exchange with the Baltic Sea;
- Experiments show that the growth of algae (phytoplankton) in the Russian part of the lagoon is inhibited by the amounts of available phosphorus in the lagoon in April. From May to October, the nitrogen level controls the phytoplankton growth;
- In the Polish part of the lagoon the nutrient levels are so high that bioassays show no real limitation by phosphorus and only a weak limitation by nitrogen.

From the Russian side 12,200 tons of nitrogen and 2,140 tons of phosphorus were discharged annually. From the Polish side respectively 3,870 tons of nitrogen and 440 tons of phosphorus. Despite the fact that the amounts of nutrients discharged from the Russian side is 4 to 5 times higher than the discharge from the Polish side, the water quality was found to be better in the Russian part. This is due to the water exchange through the entrance with the Baltic Sea close to Kaliningrad.

Hot spots

The Russian "Hot Spots" accounted for 3,400 tons of nitrogen and 975 tons of phosphorus annually, whereas the Polish "Hot Spots" accounted for 745 tons of nitrogen and 170 tons of phosphorus annually.

The Russian "Hot Spots" consisted of industrial and domestic waste water from the city of Kaliningrad including two paper process industries. The Polish "Hot Spots" consisted of domestic waste water from several cities and towns of which Elblag, Braniewo and Malbork and Nowy Staw are the biggest.

Plans exist for reducing the loads from Hot Spots of Kaliningrad by 1,600 tons of nitrogen and 700 tons of phosphorus annually. Model calculations carried out have provided the following forecasts assuming implementation of the plans:

- The water quality significantly improves in Primorsk Bay and in the central part of the Gulf of Kaliningrad when the Russian Hot Spots are reduced according to the existing plans;
- The positioning of the planned outlet from the central treatment plant in the navigation channel is not optimal, as the load reductions will not benefit the populated areas near the city of Kaliningrad;
- If possible, it should be considered to move the outlet from the treatment plant in Kaliningrad to a position further out, closer to the entrance to the Baltic. It is recommended to set up a local fine grid model to identify the optimal position of the outlet from the treatment plant, balancing the costs involved against the environmental benefits;
- About 75% of the nitrogen load to the lagoon comes from Russian sources, but only small improvements in water quality are found in the Polish part of the lagoon, when reducing the Russian Hot Spots.

Since 1994, a remedial action programme for the Polish Hot Spots has been implemented. By year 2000, it is expected to reduce the loadings from the Polish side by 450 tons of nitrogen and 106 tons of phosphorus per year. Model calculations carried out show that:

- The water quality will be improved considerably in the Polish part of the lagoon, whereas the effect on the Russian part is minimal;
- The Polish part of the lagoon is ecologically more sensitive to pollutants, due to a longer retention time of the water than in the Russian part of the lagoon;
- The above conclusions are based on the assumption that the nutrient loadings from non-point sources remain at the present level, below 6 kg N/ha/year. If in future Polish farmers intensify their use of fertilisers to the level found in intensive farmed areas in the European Union, the increase in the non-

point load may easily reach the amount of nutrient now being reduced from Hot Spots. Focus should therefore be on the future development of the non-point pollution from agricultural land.

Plan of action for the Polish catchment

For the Polish part of the lagoon the existing treatment plants are already under renovation and upgrading, and some have already been completed. The present water tariffs for water supply and waste-water discharge do not directly reflect the actual investment and running costs for water supply and waste-water systems, respectively. But together they are of the same order of magnitude as the total costs for both systems.

The present plan for renovation and upgrading of existing treatment plants was prepared in 1994, under the assumption that the discharges from Kaliningrad have a major impact on the environmental conditions of the Polish part of Vistula Lagoon.

The model evaluations of the impact of the Russian pollution reduction scenarios and the impact of the remedial plan for the Polish treatment plan from 1994 revealed that the Russian pollution discharges have a minor impact in the Polish part of the lagoon.

Realising that additional local pollution discharge reductions are necessary to improve the ecological conditions in the Polish part of the lagoon, further model studies have been carried out in Poland by the Gdańsk Regional Water Board Management, financed by the former Elblag Voivodship Fund for Environmental Protection and Water Management.

The model studies identified and evaluated a number of scenarios and a general assessment of the possibilities for improving the ecological state of Vistula Lagoon was carried out and discussed on the basis of the modelling results. The obtained basic recommendations concerning the general directions in the water-quality management in the Vistula Lagoon catchment are as follows:

- To further reduce the nutrient loads to the Vistula Lagoon from the point and non-point sources. Inhibition of the eutrophication processes in the Polish part of the Vistula Lagoon may only be achieved by reducing the nitrogen and phosphorus loads from the Polish part of the catchment;
- To improve the waste-water treatment technologies. Cities in which the population exceeds 10,000 inhabitants should use mechanical-biological-chemical treatment. Other towns should use mechanical-biological treatment;
- To ensure sustainable development of agriculture in the Elblag region and other parts of the catchment. This development should incorporate professional agricultural consulting (related to fertilising) and the introduction of good agricultural practices;
- To specify measures aiming at the reduction of non-point nutrient run-off from agricultural areas. The expected future nutrient loads from agriculture will be the major threat for the Vistula Lagoon ecosystem;
- To carry out further studies concerning the Vistula Lagoon ecosystem including mathematical modelling of the Vistula Lagoon. Such studies significantly reduce the risk of undertaking non-effective decisions and the costs of such studies are relatively low in comparison with the achieved results.

These recommendations will represent a basis for the elaboration of action plans to reduce pollution sources from the Polish catchment to the Vistula Lagoon beyond year 2000.

Further studies

As it was recommended, further studies should be performed aiming to:

- Analyse existing monitoring systems;
- Assess long-term changes in water quality and biota;
- Apply mathematical models to assess the impact of carried out investments on ecological status of the Lagoon as well as to formulate necessary investments to fulfil the Water Framework Directive [1] recommendations.

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, published in the Official Journal L 327 of 22/12/2000.

That is why an application to join running MANTRA-East project (Integrated Strategies for the Management of Transboundary Waters on the Eastern European Fringe – The pilot study of Lake Peipsi and its drainage basin) has been submitted.

It is expected that the extended part of the project will start in August 2002 and will cover the following tasks:

- Evaluation of criteria for assessment of ecological status in a Water Framework Directive context;
- Analysis of trends in water quality and biota in the Vistula Lagoon;
- Development of a tool for the estimation of the transfer, retention and losses of nutrients in Pasleka River basin (one of the main tributary to Vistula Lagoon);
- Evaluation of the consequences of river basin inputs to Lagoon water quality and fish – a modelling approach;
- Dissemination of results to end-users – Regional Water Management Board in Gdańsk, Regional Sea Fisheries Inspectorate in Gdynia, Kaliningrad Specialized Marine Inspection, Committee of Natural Resources in Kaliningrad.

European Centre for River Restoration (ECRR) and its importance for transboundary water management

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Introduction

The European Centre for River Restoration (ECRR) was established in 1995 as part of a joint demonstration project between Denmark and the United Kingdom. In March 1999, the official constituting meeting for the ECRR was held in Silkeborg, Denmark. [1]

Water systems are under increasing pressure, due to the continuous growth in demand for water for all purposes. Also climate change and an increased focus on biodiversity have enhanced the necessity for sustainable and integrated water management. These developments and the entry into force of the Water Framework Directive (WFD) [2] have given momentum to the European Centre for River Restoration and the role it aims to play. The need for exchange of information and learning from each other exists on a Pan-European scale. The importance for Central and Eastern European countries is recognised because they have to implement the Water Framework Directive as part of the enlargement or approximation process.

ECRR supports the development of river restoration as an integral part of sustainable water management throughout Europe, by connecting people and organizations working on river restoration.

ECRR Strategy

The strategy of the Centre includes the following elements:

- ECRR facilitates access to any type of practitioners of the network through a web based matching service to allow and encourage the sharing of experience on river restoration and building of idea;
- ECRR reinforces the development of this learning community through the organization of conferences, study tours, training courses, workshops, etc. and the delivery of newsletters;
- ECRR facilitates access to information on research, planning, implementation and monitoring on river restoration through the development of a web site;
- ECRR facilitates establishment of national networks on river restoration;
- ECRR polls the users to identify how the network can be improved.

The success will be measured by web site hits, successful matches (cooperation, capacity building), member feedback (inquiry, workshop discussions), practitioners' contributions to newsletters and the number and quality of conferences, meetings, workshops, etc.

ECRR and the Water Framework Directive (WFD)

The WFD provides new tools into European water policy, covering the whole water cycle, attending a holistic approach to water status assessment and passing across all administrative borders. In order to achieve this, the WFD puts forward the following main principles:

- Freshwater management must be carried out on the basis of River Basin Management Plans;
- In order to define objectives, the concept of "good water status" is defined on the level of biological, hydrological and chemical quality that has to be reached in a catchment area.

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[1] For more information, see web site: www.ecrr.org.

[2] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, published in the Official Journal L 327 of 22/12/2000.

In addition to this, the WFD puts great emphasis on economic instruments to help meet environmental objectives, and on public participation in local water policies and planning. Integration with other policies and Directives, especially with the Convention on Biological Diversity, is important.

With the aim of enhancing sustainable integrated water management, on the basis of river basin plans, capacity building and exchange of information should occur in all European countries at all levels. ECRR perfectly suits the key elements of the Water Framework Directive (WFD) and its implementation strategy. ECRR wants to play an important role in networking and facilitating the exchange of experiences and best practices of integrated river management projects in Europe. ECRR focuses on scientific, technical and practical questions related to the WFD, not institutional aspects.

ECRR and its importance for transboundary water management

Most of the (major) rivers in Europe are transboundary rivers. The idea of river basin management is not new. Also without the WFD, the importance of teamwork in a river basin district had already become obvious in former times of disasters, e.g. environmental accidents or floods. For example, international policy across many river basins is coordinated by International Commissions, e.g. the International Commission for the Protection of the Rhine (ICPR), the International Commission for the Protection of the Danube River (ICPDR) and the International Working Group for Flood Protection. Moreover, various bilateral working agreements and/of projects exist at national, regional and local level.

The ECRR is a network, in which all practitioners have the opportunity and responsibility to make the centre work. A close contact between practitioners, both nationally and internationally, should be established for the exchange of information through newsletters, homepages and meetings. The ECRR facilitates and encourages the establishment of national networks (so-called national centres), especially in Eastern European countries. The national networks will function as focal points for individuals and organizations working on river restoration. The (international) ECRR and the national networks work complementary and support each other.

Mobilization of pollutants from Oder River sediments

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Mobility of contaminants

In the surface layer of riverbank sediments, contaminants accumulate in the interstitial water and may be released by changing hydrological, biological, and hydrochemical conditions. The present study examines interstitial waters and sediments from the River Oder to quantify the non-point inputs of priority contaminants. The assessment of contaminant mobilization is also needed for decision-making regarding the use and storage options for sediments in the context of maintenance dredging and construction works in the River Oder (LAGA, 1996).

Generally, Oder sediments, which were analysed in 37 samples from three example areas – the headwaters, the region around Glogow, and the area near Widuchowa, downstream of the inflow of the River Warta (BfG, 2001) –, showed different elution behaviour regarding P and N compounds and toxic elements depending on the method applied.

In previous studies, increased levels were observed in pore-waters (Müller and Heininger, 1996). Results on the relationship between concentrations in surface waters and in sediments are not yet available.

The relationships between concentrations in interstitial waters and in surface waters show for the majority of elements a high coefficient of determination, while the sensitivity factors vary between 0.4 for Zn and 29 for As. For nutrients, it is probably not possible to determine a definite relation because of the manifold microbiological processes. Comparative analyses of concentrations in interstitial waters and solids did not find reliable relations.

Usually, the heavy metal portion that can be mobilized is determined according to the German standard DIN 38414-S4 to decide on the usability of dredged sediment material. As the mobility of metals depends strongly on the matrix of the sediment or the solids, it is reasonable to compare the results of several elution methods.

Depending on the buffering capacity of the sediments, anaerobic decomposition of organic carbon into organic acids lowers the pH from 8 to 6, or even less, associated with the mobilization of contaminants such as trace metals (Paschke et al., 1999). For this reason, the pH-stat method (Obermann and Cremer, 1992) is used additionally. For the standard analyses, 100 g of sediment related to dry weight are treated with one litre elution agent for 24 hours (DEV, 2000).

Mobilization of nutrients from solids

Because of various biological and diffusion processes in sediments and the associated accumulation/ depletion of nutrients in pore waters, these waters contribute in different degrees to short-term releases, especially of nitrogen.

On average, 45% of the eluated nitrogen in Oder River sediments (whole samples) originates from the interstitial water and 55% from the dry matter, if the DIN 38414-S4 method is employed. Conversely, merely 20% of the eluated phosphorus comes from the interstitial water in the DIN process. Because of the different compositions of pore waters mentioned above, there are marked regional differences in the releases from materials sampled in the example areas.

In eluates of Oder sediments obtained by the pH-stat method, on average 30% of both nitrogen and phosphorus originate from the pore water. The generally higher mobilization of N compounds from solids at pH 4.5 may be explained by solution processes of hydroxides and ion exchange. Ammonium may be released at pH 4.5 from the aqueous phase. Under the conditions of pH-stat tests, large amounts of iron and manganese are released. Possibly, the mobility of phosphorus is inhibited under these conditions by precipitation of metal phosphates.

The method according to DIN 38414-S4 analysed N_{total} levels in eluates between 1 and 20 mg N/l, the pH-stat method determined even N_{total} levels up to 40 mg N/l. On average, due to the lowering of pH to 4.5, about 50% more of nitrogen may be released from the sediments, i.e. the system of solids plus interstitial water (see Table 1).

On the contrary, in the pH-stat method, the mobility of phosphorus compounds at pH 4.5 is about 50% less than in the DIN method. In extreme cases, up to 0.3 mg P/l (pH-stat) and 0.9 mg P/l (DIN 38414-S4) were found in eluates of Oder River sediments.

Table 1. Nutrient levels in eluates of Oder River sediments from the example areas in comparison with the longitudinal section of the whole river

	Headwater		Glogow		Widuchowa		Oder (total)	
	N (mg/l)	**P** (mg/l)	**N** (mg/l)	**P** (mg/l)	**N** (mg/l)	**P** (mg/l)	**N** (mg/l)	**P** (mg/l)
DIN 38414 Median	6.0	0.26	6.4	0.18	7.9	0.21	5.9	0.18
pH-stat 4.5 Median	4.1	0.10	8.7	0.09	10.9	0.14	6.9	0.10

So far, no correlation was discovered in the elution of nitrogen and phosphorus compounds between the contents of solids and the amount of substance eluated from the solid matter. The mean structural parameter 20 µm fraction and the total organic carbon of the sediments from the example areas are not in a direct relation with the amount of eluated nutrients.

Moreover, the high and variable portions of nutrients in the interstitial waters require the adjustment and discussion of the standard methods of elution, so that the release potential of the sediments can be estimated. For the consideration of the physico-chemical sorption and desorption processes, the nutrient levels in the eluate are corrected for the portions of the interstitial water.

Mobility of metals and arsenic

Table 2 compares the results of elution with deionized water and at pH 4.5.

The relation between the eluate concentration according to DIN and the pore-water concentration shows for the elements functions with a coefficient of determination above 0.7. However, the sensitivity factor b ($y = a + b*x$) varies between 0.02 for Cu and 0.9 for Ni.

Table 2. Mean metal levels in eluates of Oder River sediments from the example areas according to DIN 38414 and pH-stat (pH 4.5)

		DIN 38414			pH 4,5		
		Headwater	**Glogow**	**Widuchowa**	**Headwater**	**Glogow**	**Widuchowa**
As	(µg/l)	1.0	7.5	2.5	1.1	25.8	22.4
Pb	(µg/l)	1.6	1.3	1.8	0.5	0.7	0.7
Cd	(µg/l)	< 0.5	< 0.5	< 0.5	1.0	1.5	3.9
Cr	(µg/l)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Cu	(µg/l)	5.0	6.4	3.7	7.6	16.8	5.2
Ni	(µg/l)	2.1	10.9	7.1	66.2	295.6	241.6
Hg	(µg/l)	0.04	0.04	0.08	0.05	0.05	0.03
Zn	(µg/l)	28	117	74	799	6,998	5,230

Figure 1 shows an example for the dependence of the DIN results on pore-water concentration for Zn.

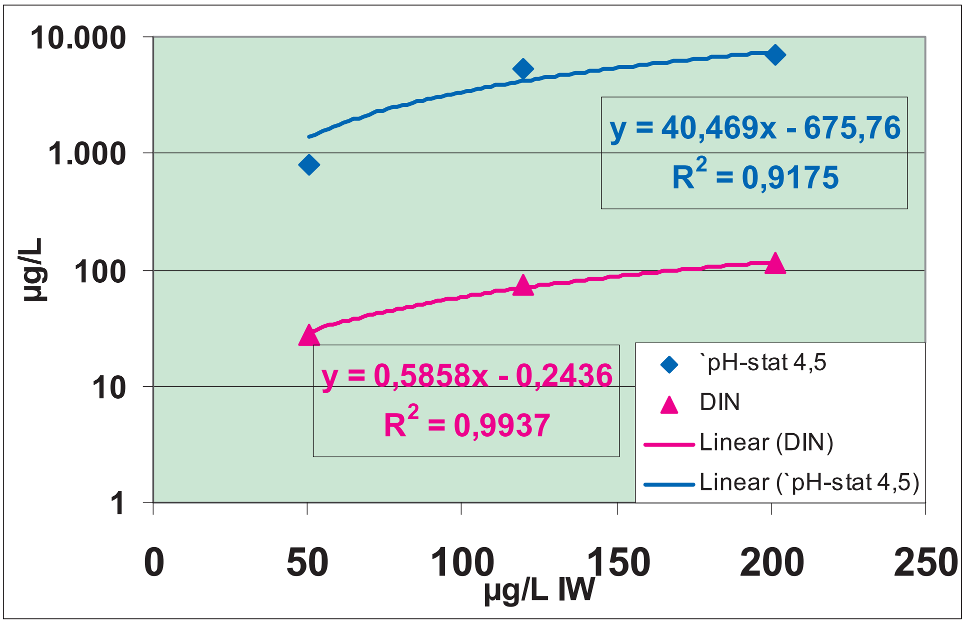

Figure 1. Zn elution according to DIN and pH-stat as a function of interstitial water (IW)

The relation between pH-stat concentration and interstitial water (IW) concentration has for the elements and nutrients coefficients of determination above 0.88, with sensitivity factors between 0.002 for P and 40 for Zn (see Figure 1).

The dependence of the Zn concentration on pH is shown in Figure 2.

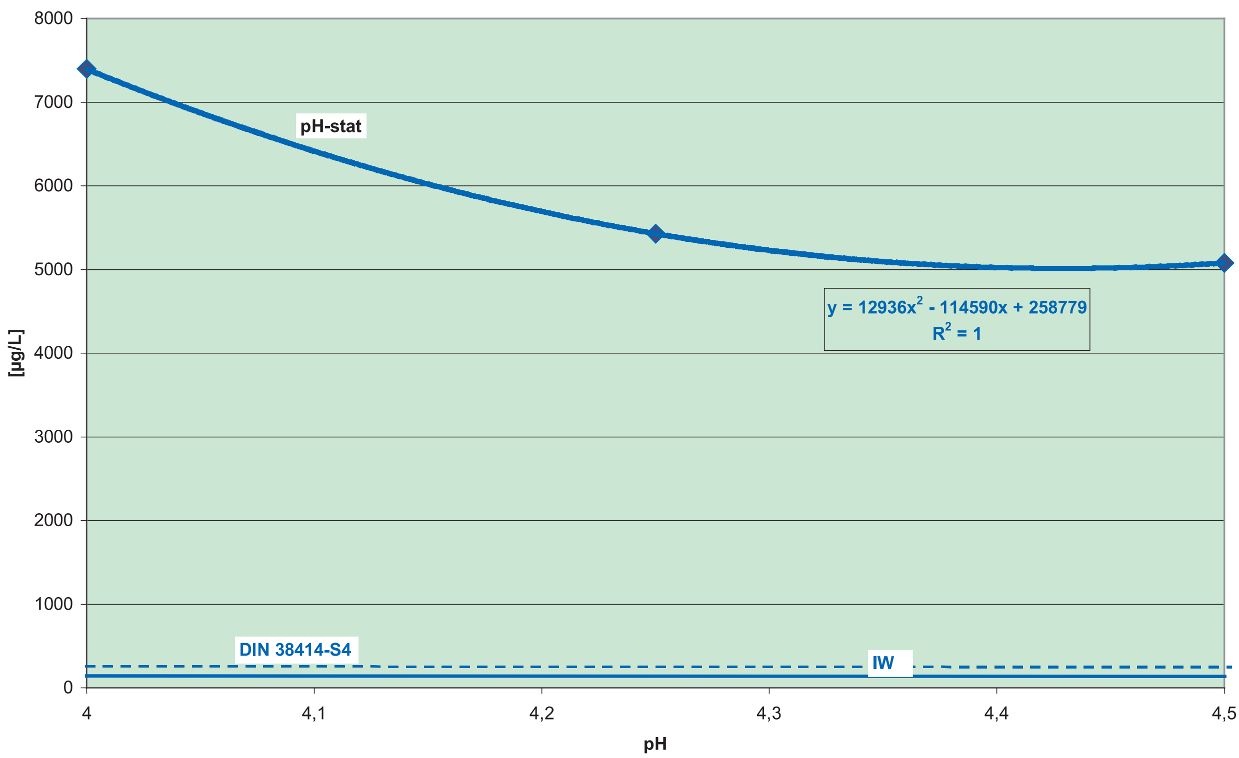

Figure 2. Zn concentration in dependence on pH

Summary

To summarise, it can be noted that the mobility of contaminants depends on the concentration in the interstitial water, which is influenced in the case of the elements by the concentrations both in the surface water and in the sediments.

According to the LAGA assessment scale, sediments or eluates obtained by the DIN 38414-S4 method from the Oder headwater region can be rated as safe with regard to the relevant elements. In the river reach near Glogow, sediments must be grouped into landfill class Z 1.2 due to the amount of eluated substance for Zn, Hg and As. Eluates from the region of Widuchowa are to be classified in class Z 1.1 because of their Hg and Zn levels. Because of their ammonium concentration as measured by the DIN 38414-S4 method, the Oder River sediments analysed are acceptable for use as construction material with certain restrictions and safety precautions according to the applicable regulation in Germany (LAGA, 1996).

Lowering of pH in the pH-stat method affects in particular the mobility of zinc, nickel, and arsenic. Their mobility is increased by the factors 50, 25, and 10, respectively, against that found by the DIN S4 method. The behaviour of elements under low pH conditions is exemplified for Zn. With lowering pH, the mobility of elements increases and surpasses the concentrations in pore water and the release according to DIN by some orders of magnitude. Under acid conditions, increase of concentration by 50% can be expected for nitrogen and a decrease by 50% for phosphorus.

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