



## **4th EurAqua Technical Review**

### **Let the fish speak**

**The Quality of Aquatic Ecosystems as an Indicator for Sustainable Water Management**

**23-24 October 1997**

**Bundesanstalt für Gewässerkunde, Koblenz, Germany**

### **Summary and recommendations**



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## 1. Introduction

### Background

The yearly Technical Reviews are a basic activity of *EurAqua*. They are aimed to specify the research needs in the field of water management at European scale. Contributions to the Technical Reviews consist of national country papers. At the Technical Review, they are presented, discussed and areas for European freshwater research are being identified, within the chosen theme.

The summary and recommendations will be published, together with national contributions, in Proceedings in 1998.

In the field of water management and research, important developments are taking place. With regard to research, preparations for the 5th Framework Programme RTD (FP5) are the most important activity. With the help of the Task Force Environment Water, research priorities for the years 1998-2003 have been identified. It is of utmost importance that the preparations of the FP5 are being provided with sound research needs from professional point of view. The information is addressed to DG XII and to national representatives involved in the preparation of the FP5.

In the field of water management, preparations for the Framework Directive on Water are at full speed. These preparations take place at DG XI, in dialogue with the member states. Research needs in this process are being identified, e.g.:

- how to design river basin management
- how to design the link between water quality standards and emissions to water.

### Objective

The aim of the 4th *EurAqua* Technical Review is to provide the European Community with suggestions for research needs that will support water management on river basin level on a European scale. The title "*Let the fish speak*" focuses on the aquatic life as the starting point for the assessment of the quality of aquatic system, for research and for management. The TR shall provide information on how the aquatic system can optimally be supported by management and how management measures interfere with each other and with the aquatic system. It must be mentioned that the Technical Review does not focus exclusively on fish. Fish is one of the bio-indicators for the health of aquatic ecosystems.

The main topic is divided into three subtopics, both for the country papers and for the discussions at the TR:

- **water quality**
- **water quantity, geo-morphological and structural changes**
- **synthesis**



## **2. Effects of water quality on ecosystem health**

Chairman: E. Klaghofer, (BWA, Austria)  
Rapporteur: R. Uijterlinde, (RIZA, the Netherlands)

Introductions by:

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Several topics were discussed at the workshop. The problem fields "eutrophication" and "toxic substances/endocrine disruptors" were considered as Europe-wide water quality problems, for which additional research is needed. A third topic, water quality problems arising from acidification, was particularly brought forward as a regional problem by the Scandinavian countries.

The discussion further focused on indicators for monitoring and assessment, scaling up and research for management, as issues for European research.

### Eutrophication

Between nutrient sources, the diffuse source "agriculture" was mentioned to be the biggest problem, both from scientific as from managerial point of view. Although both European (Nitrate Directive) as national policies have been developed, nutrient loads to water resources are still causing problems, both for green as for blue green algae. The nutrient input from agricultural sources is complex and needs further research.

The eutrophication processes are still insufficiently understood. Specific attention should be paid to the phosphor-dynamics in aquatic systems, the (absolute and relative) role of nitrogen, the interaction between various trophic levels, the interaction between nutrients and toxic substances and the role of infochemicals.

Research related to management is needed: relating water resources to land use, getting a better understanding of the lacking behind response of water quality improvement when nutrient loads are being reduced. The role of fish management needs further attention.

### Toxic substances, endocrine disruptors

Research in the field of effects of pesticides and other hazardous substances on freshwater biota needs continued priority. Especially effects at population and ecosystem-level are still hard to indicate. Moreover, a joint approach in this respect is lacking. Elaboration of a joint approach would have priority.

In the discussion, special attention was also paid to complex mixtures and synergetic effects of substances. It still appears a long way from lab experiments to real predictions.



Two topics were considered to have insufficient attention in European water research: toxic effects of cyanobacteria and the complex field of endocrine disruptors.

Indicators and indices for monitoring and assessment of ecological water quality. Water quality indicators and indices vary widely throughout Europe, as was shown from the presentations. This appears also a major problem in preparing the European Framework Directive on Water Resources, especially in defining "Good Ecological Quality", the aim for all European waters.

Considerable scientific effort is needed to be able to compare indicators and indices for ecological water quality, related to biodiversity.

#### Scaling up

In all discussed problem fields (eutrophication, acidification and hazardous substances) it appears difficult to scale up individual results. A change in research priority:

\* from monodisciplinary to multidisciplinary (e.g. combining pelagic and benthic subsystems),

\* from ecotopes to gradients and regions (e.g. research at river basin level)

with help of adjusted models would further support management of water resources.

#### Management

More and more it becomes necessary to calculate the effects of management measures on water resources beforehand. Decisions should be supported by models, including the ecological and socio-economic systems, aiming at making socio-economic scenario's based at the calculated effects on water resources. An increased support for this kind of (secondary) research at European and river basin level would very much be appreciated.

### **3. Effects on changes in quantity, flow regime, morphology of bed rivers on ecosystem health**

Chairman: M. Benedini, (IRSA, Italy)

Rapporteur: J.M. Male, (CEMAGREF, France)

Introductions by:

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Mr. L. van Poucke (IUPWARE, Belgium)

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Mr. W. Wagner/Mr. A. Peter (EAWAG, Switzerland)

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Mr. M. Benedini (IRSA, Italy)

#### Austria

Austria centred their presentation on the accumulation of sediments in reservoirs, dams and basins. The main issue raised was the negative effects on the environment of flushing of reservoirs.



After defining the terms of draw down, flushing and reaming of reservoirs, the speaker presented a case study, the flushing of Margaritze dam in Carinthia, which had had a very negative impact in 1995. We were then presented how Austria has been setting up a series of planning measures and recommendation which are now being implemented. No specific research need was underlined by the speaker.

#### Belgium

Belgium presented two short speeches. The first one centred on the hydrometrical network on Flemish rivers and presented the monitoring activities presently carried out by Univ. of Gent. The second one, which better fitted the topic of the technical review, dealt with the implementation of fish-ladders as an example of environmental river management. Some details were given about how to design V-shaped fish-ladders and how to implement them on the field. No specific research need was underlined by the speaker.

#### France

France first gave an overview of the French legal context and regulatory changes which have occurred since 1992 (new water Act, SDAGE, SAGE). Then a short presentation was made on how the French water agencies will assess the quality of water, using the so called Water-SEQ tool. The speaker then presented two research needs which he thought are a priority. The first one is that studying ecosystem health imposes the definition of hierarchical methods i.e. adapted to several scales in space and structuring processes. The second one is that the regional scale looks the most appropriate to compare pristine - if available - and present situations of an aquatic ecosystem because water regime and morphology form the real physical sensitivity framework in which different functional validations can be done (habitat). Other research needs and strategy for future are described in the country paper.

#### Switzerland

After presenting a list of research needs, the Swiss speaker Announced that he would focus on the reaction of fish to loss of longitudinal connectivity through artificial or natural falls and barriers. He showed a first case study, a 6,5m high dam on river Toess and showed how the fish diversity is affected when you compare upstream and downstream (23 species below, 12 species above). The speaker also detailed the case of a tributary of river Toess and showed how a small man-made weir (40 cm appr. ) can have negative effects on fish migration. He concluded insisting that there is little documentation on effects of such obstructions and that further research is needed on this topic.

#### Germany



Germany presented 3 papers.

The first speaker (BfG) explained how difficult fish can reproduce in regulated rivers, which becomes a bottleneck for many species. He illustrated this situation with two examples: many suitable gravel spawning sites have been lost or become inaccessible due to river regulation and backwaters are also greatly reduced in number and quality in most river systems. Then, he showed how human actions have tried to change the effects of river works: construction of fish passages, artificial spawning sites like man-made side channels and artificial structures such as breakwaters. He concluded saying a few words about the ICPR "Salmon 2000" programme. No research needs were mentioned in the speech.

The second speaker (BfG) proposed a new method to measure ecosystem integrity. He promoted the use of a "pragmatic theoretical" ecology and explained an ataxonomic approach based on the energy equation and the continuity equation that may end up with a tool for environmental diagnosis.

The third speaker (IGB) shows how a noticeable improvement of water quality could be achieved between 1976 and 1995 and he took an example in Germany based on the water quality maps. He then stressed that, on the other hand, biocoenoses have not been developed accordingly and promoted an integrating holistic approach to study the associated phenomena. He stressed that the Environmental impact assessment acts derives from a 1985's European directive increasingly take this into account. Further research needs are detailed in the country paper.

### Italy

The speaker announced that he would highlight only two research priorities out of those presented in the country paper. The first one is the need of improving the scientific background for minimum acceptable flows (MAF) criteria. He recalled that an Italian law imposes to maintain MAF in rivers and streams, but because of the diversity of morphological and hydrological conditions together with the diversity of man's intervention, there is a serious need to define a set of criteria applicable to each condition. The second one is based on the experience of the "Po Project" of the Po River Authority and stresses the need to improve the climatological and hydrological measurements (better knowledge of drought conditions, more reliable flow measurement procedures), as well as the need to know the quantity of water withdrawn and discharged (compulsory metering in domestic, urban, industrial and agricultural uses).



### Discussion

The presented papers showed that the speakers had stressed very different topics and it was difficult to point out a topic of common interest based only on the speeches delivered during the workshop. A short discussion then took place and the following major ideas were highlighted:

A discussion was held about the definition of a state of reference. It was agreed on that in most cases, nobody knows what the original State of a river was, before recent man interventions. Is there an absolute value of a "good" statute of the river? A Greek speaker mentioned that most Greek rivers have a 19th century biodiversity level, as not or not much altered by human activities, whereas a Dutch speaker recalled that 60% of his country would be under the sea if ancient conditions were restored! It was added that trying to understand the most important functions of ecosystems should be more relevant than trying to reproduce the past conditions.

Another speaker explained that rather than talking about an ideal state of reference, a pragmatic approach should be more appropriate to improve the quality of an ecosystem, based on two criteria: avoid non-reversible states and try to restore rivers as socially acceptable as possible, which means that the public is both not opposed to it as well as ready to pay for it.

The other questions which have been raised, and less discussed, are the following:

- It is common to consider that we should combine socio-economic needs and ecology... but how is it possible to actually combine them? Is it possible to give a monetary value on every piece of an ecosystem(the answer being no)? Can cost-benefit approaches be adapted to all situations?
- Do we have examples of integrated water management, or is it only a concept on the paper?

## **4. Synthesis**

Chairman: W. B. Wilkinson, (UK) Rapporteur: W. Wagner, (CH)
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Following the presentation of the technical papers in the preceding parts of the technical review, and the detailed discussions relating to these, a discussion was held on the synthesis of water quality, water quantity and ecosystem health. This attempted to draw together some of the key issues which emerged during the presentations and previous discussions and to identify gaps in knowledge and possible research priorities. Some 34 scientists from 14 European countries were involved in the debate.



## 1. Baseline Information and “Natural” Freshwater Systems

Baseline information on physical habitats and aquatic ecosystems is essential for the assessment of the quality of the present situation and as a basis for the design of appropriate management options. For a holistic view of the aquatic system, baseline information distinguishing between flowing waters and stillwaters, wetlands, springs, ground water etc. has to be available. Knowledge of the links between ecotops and the physical habitats is also essential.

Such information is only available in some well monitored regions, but, generally it is lacking. Moreover, the comparability of the information is not always satisfactory. There is therefore still a major need to collect and exchange baseline information in a co-ordinated way at local, regional, national and European level.

Pristine freshwater conditions/habitats are often considered as the goal of conservation for restoration measures. Yet, due to human activities and heavy land-use changes over the last decades, pristine conditions are today limited to very few locations and regions within Europe. In situations where restoration to natural conditions is required, such natural conditions often have to be deduced from a knowledge of reference systems. However, often natural or pristine conditions can not really serve as a target for restoration activities. Pristine conditions exclude any influence of mankind on the water systems. This is practicably impossible in most of Europe today. Therefore restoration measures have to take into account the different interests and influences and often have to aim at a balance between the different interests so as to reach an acceptable solution to all.

Restoration measures should encourage developments in the aquatic systems which lead towards a more favourable or “natural” situation and therefore to an improvement of the ecosystems. Such measures can include end-of-pipe technologies such as waste water treatment and improvements of the freshwater physical habitats (e.g., changing the physical characteristics of a river by providing side of channel lakes or ponds, etc.) as well as management of the water system (e.g., active control of flow, storage, etc.). They must take into account conflicts of interest between the many water users as well as social, economic and legal issues.

## 2. Understanding Freshwater Ecosystem Response

The response of an ecosystem and its organisms to both chemistry (workshop A) and quantity/morphology (workshops B) are far from being fully understood. The following tables were prepared during the plenary discussion. They identify topics where there is presently lack of knowledge and understanding and thus may define areas where research is needed. It was recognised that the exercise of attempting to rank issues in this way has limitations and, due to the restricted time, could not be comprehensive. However, it was considered that the output from the Group discussion does give a good indication of where the main uncertainties in our knowledge lie.

**2a. Understanding freshwater ecosystem response to chemical pollutants**

	N	P	Pesti- cides	other Organ. 1)	Metals	Acidity	Cyano Toxins
Vertebrates	*	*	*** 5)	***			**
Invertebrates	*	* 3)	** 5)	**		*	**
Macrophytes	*	*	**	**			
Algae	** 2)	*** 4)	*	*(*)		* 2)	
Micro-Organisms	**	**	**	***			
Whole Ecosystem	***	***	***	***	* 6)	**	**

\* low priority

\*\* medium priority

\*\*\* high priority

1) e. g. hormones

2) priority of northern countries

3) indirect effects

4) bioavailability

5) sublethal effects

6) speciation and availability

**2b. Understanding freshwater ecosystem response to water quantity and morphology**

	Flow Regime Depth	Sediment and Bed Condit.	Backwaters, Refuges	Temperature etc.
Vertebrates	*** 1)	***	**	*
Invertebrates	**	***		**
Macrophytes	**	**	**	*
Algae	***			**
Micro-Organisms		*		**
Whole Ecosystem	***	***	**	***

\* low priority

\*\* medium priority

\*\*\* high priority

1) priority of southern countries



In summary, the main gaps in knowledge, relating to the impact of chemical pollutants on ecosystem health, are identified as organic compounds, mainly pesticides and oestrogen like substances. The effect of such substances on the vertebrates is of particular concern, but is poorly understood. Work is also needed on invertebrates and micro-organisms. The movement of phosphorous through catchment systems and into freshwaters, and its discharge from sewage works, is leading to eutrophication problems. However, the processes controlling its mobilisation and availability are poorly understood. This was identified as an area where more research is required. It was recognised that a great deal of research has been undertaken on acid rain and that many of the processes are now well understood, but some of the northern countries consider that there is still the need for additional work, particularly in relation to predicting the recovery of fluid systems following the imposition of control measures on atmospheric emissions.

Also the effects of water quantity, water regime and geomorphological-structural changes on vertebrates, invertebrates macrophytes and algae are not sufficiently understood. It was recognised that some excellent results had been reported during the scientific presentations on the use of engineering solutions to restore aquatic biodiversity and, in particular, fish populations, e.g., river bank side refuges. Nevertheless, more work is needed to explore the generality of these very effective local solutions.

Another major research need which emerged concerns the links between the different chemical and physical changes and the ecosystems as a whole. There is much information on the reactions of one species or of a group of species to chemical or physical changes, but little is known as to how a "natural" ecosystem with its many internal dependencies, reacts.

### 3. Indicators for a Health Ecosystem

This EurAqua Technical Review focused on the issue of whether the quality of aquatic ecosystems can serve as an indicator for sustainable water management. With its working title "Let the fish speak", the fish was selected as one possible indicator.

An aquatic ecosystem can be characterised by chemical, biological and physical parameters. Yet, within each monitoring program only a selected number of chemical, biological or physical parameters can be measured. The question therefore is to choose the most efficient and meaningful indicators for ecosystem health.

In the past, monitoring has been based mostly on chemical measurements of water quality. In many countries target levels were set for various chemical compounds. Yet these target levels have often been set without sufficient knowledge about the effects of the chemical conditions on the ecosystems as a whole. The target levels often were the result of pragmatic and/or political decisions based for example on toxicity data for selected organisms. On the other hand the value of chemical indicators is always dependent of the analytical methods available. Only those compounds which can be readily analysed can be used as indicators.



If the target levels lie towards the lower end of the range of the analytical capability, then time consuming intercalibration exercises are often necessary. Micro pollutants are both a present and future threat to aquatic ecosystems, but the precise measurement technique skills necessary for the accurate determination of concentration are not always available.

Biological indicators have gained importance mainly in the last decade. They have the advantage of giving direct insights into some aspects of ecosystem health. However, an enormous diversity of methods are being applied, differing both on the trophic level and the criteria of the analysis (e.g. biochemical biomarkers, abundance of species, behaviour tests, etc.). This makes it nearly impossible to compare the results of the different studies. On the other hand, methods standardised for one specific region, can not always be applied in another region because of differing conditions. For Mediterranean countries for example, methods developed in the northern European countries have to be adjusted. A complete set of standard methods, covering all of Europe, may therefore prove to be difficult or impossible to establish. One possible solution could be the “ecoregion approach”. This has been proposed in the Framework Directive of the EU.

Biomarkers can be a useful tool to assess ecosystem quality since they should give integrated information of a range of differing ecosystem conditions over time. However, this high level of integration may make it difficult to identify the ecological relevance of the different factors and thus limit the value of biomarkers in their use in the design and management of sustainable freshwater ecosystem options.

Finally habitat quality can also be used as a meaningful indicator for ecosystem health. For running waters the structures of bed and shorelines, water regime, water temperature etc. strongly influence the conditions of the ecosystem. Different methods to assess these “ecomorphological” parameters have been proposed. A common understanding has however not yet been reached. Also climatic parameters, which in the future may show marked variation because of global climate change, can have a pronounced effect on ecosystem health and they should therefore also be included in monitoring schemes.

#### 4. Science/Technology - Transfer

It was recognised during discussions that scientists often have difficulty in communicating their important findings in relation to ecosystems sustainability to the user community.

The following points were identified:

- The end user community is often very wide, extending from fellow scientists, to water managers with a local problem, to policy makers at a regional or national level.
- Potential end-users are seldom involved during the research phase and therefore have no “ownership” of the results.
- In general, the scientific community does not have the inclination or skills to translate the results of research in a manner which can be readily understood by the end-users.



The implementation of the scientific results would be improved if the “isolation” between natural and engineering sciences could be overcome. Many of the EU member States find it unacceptable for their scientists to produce high quality and relevant research results which are obscure to, and cannot be picked up by, potential users. To ensure the relevance and effectiveness of our research, it will be necessary to involve the socio economists as well as potential users in an active way during the whole of a research programme, from the preparation to the implementation phase. Scientists should communicate more effectively and work in a partnership with society and end-users.

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