



Integrated water management for the Rhine river basin, from pollution prevention to ecosystem improvement

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The river Rhine has been in humanity's use for many centuries for a variety of activities. However, in our time, considerable changes in the course and the natural conditions of the river and the increasing use of the river for the discharge of wastewater has caused serious floods and major ecological problems. Since 1950, the International Commission for the Protection of the Rhine (ICPR) acts as the coordination point between the states bordering the Rhine for the development of programmes for river protection. The Sandoz disaster in 1986 was a turning point in the approach of the ICPR and the starting point for the present strategy of integrated riverbasin management. Recent developments have indicated the success of the current approach. © 1997 United Nations. Published by Elsevier Science Ltd

The Rhine is one of Europe's major rivers and one of the best known. For many centuries the Rhine served as an important shipping route, as well as being a source of food and valuable water. The Rhine was also a crystallization point for human settlements and a source of inspiration for poets and writers. Modern day industrial development in North Western Europe took place mostly on the banks of the river Rhine.

From its source in Switzerland, the Rhine flows via France, Germany and the Netherlands into the North Sea (Figure 1). Compared to other well-known rivers, for instance the Mississippi (6200 km long, 3900 000 km² catchment area) the dimensions of the Rhine are not spectacular. With its 1320 km length and 200 000 km² catchment area the Rhine is only the 3rd largest river of Europe. Its great importance to Europe is of a different order. Already in Roman times, many important cities developed on the banks of the Rhine. Today, more than 50 million people live in the Rhine catchment area. The Rhine is Europe's most heavily trafficked shipping channel, connecting the world largest sea port, Rotterdam, with the world largest inland port, Duisburg. Vast industrial complexes are built along the river, for example in the Ruhr, Main and Rijnmond areas. Most of Europe's important chemical plants can be found along the Rhine.

Rhine water is used for industrial and agricultural purposes, for the generation of energy, for the disposal of municipal wastewater, for recreational activities and

to provide drinking water for more than 20 million people. Furthermore the Rhine is the natural habitat of a diverse vegetation and many bird, fish and other species.

Conflicting interests, ecological and environmental problems

It stands to reason that so many disparate claims on the river must give rise to conflicts and problems. Problems include declining water quality, damage to the river ecology and high water levels causing floods.

As early as 1449, an astonishing decline in fish catches was registered as a result of overfishing and pollution. The legislative response to these problems, the so called 'Strasbourg Regulations' is considered to be the first international initiative to protect the Rhine ecosystem.

Between 1817 and 1874 the German engineer Tulla planned and implemented a major 'correction' to the Upper Rhine (Figure 2). The slowly meandering course of the river was altered to a straighter path. The intended results of the scheme were *inter alia* to protect people living on the banks of the Rhine against floods and epidemics, improve navigability of the river and to make the alluvial areas available for agriculture. Although the plan was brilliantly conceived, it could not foresee the many negative hydrological and ecological side-effects that would follow. Further 'corrections' to the river bed were undertaken in the 20th Century; the length of the river from Basel to the border of Hesse in northern Germany has been shortened by a total of over 80 km. As a result of these

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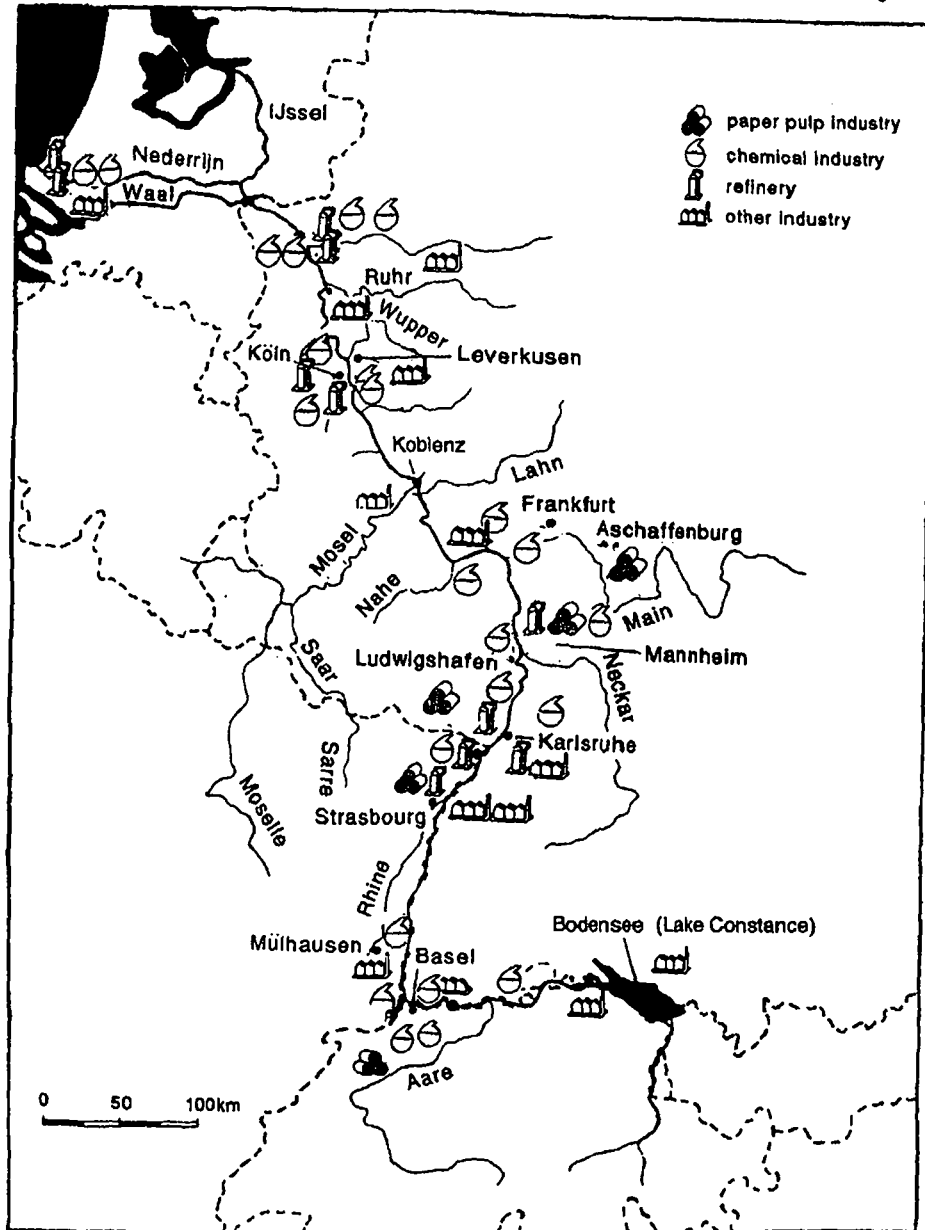


Figure 1 Industrial centres in the Rhine catchment area.

alterations, meanders and alluvial areas were cut off, which meant that the river's ecosystem was drastically altered. Among the many unforeseen, and undesirable, side-effects of the re-routing of the river were increased flow velocity, leading to increased erosion, and a drop in the groundwater levels in the surrounding regions, and as well as an increased risk of floods in the middle Rhine area (ICPR, 1994a).

Further ecological changes were brought about by the numerous dams and weirs that were constructed on the Rhine and its tributaries for the purpose of electric power generation. These physical barriers made it almost impossible for the atlantic salmon, the most important fish species in the Rhine, to reach its spawning grounds in the upper reaches of the river. As

a consequence, the number of Rhine salmon caught decreased steadily from more than 280 000 around 1870 to zero in 1950 (Figure 3). The disappearance of the salmon is the most striking example of the negative impacts on the Rhine ecosystem brought about by man-induced changes to the river's natural flow (ICPR, 1994b).

Although problems with the quality of water in the Rhine were already recognized in the 15th Century, it was not until the 20th Century that the advanced stage of water pollution in the river became clearly apparent, towards the end of the 1960s. By that time, the pollution of the Rhine by organic substances had lowered dissolved oxygen levels to below 2 mg l^{-1} . Due to insufficient oxygen, almost all aquatic life

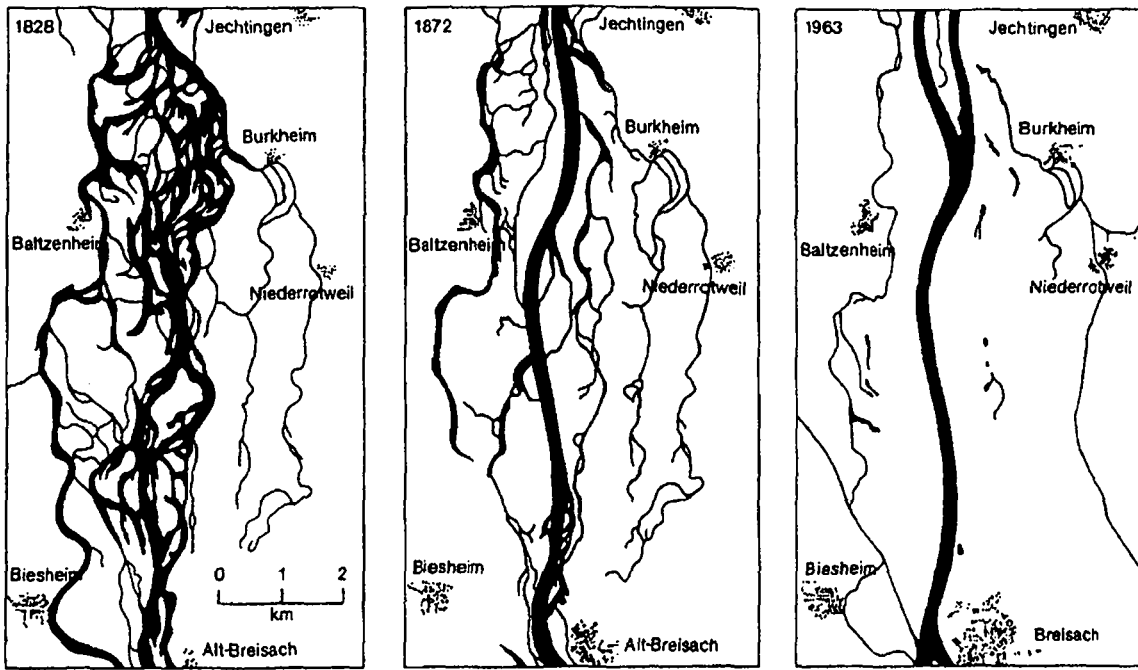


Figure 2 The Upper Rhine at Breisach: (a) In 1828, before the river development; (b) in 1872, after the Tulla realignment; and (c) in 1963, after further canalization.

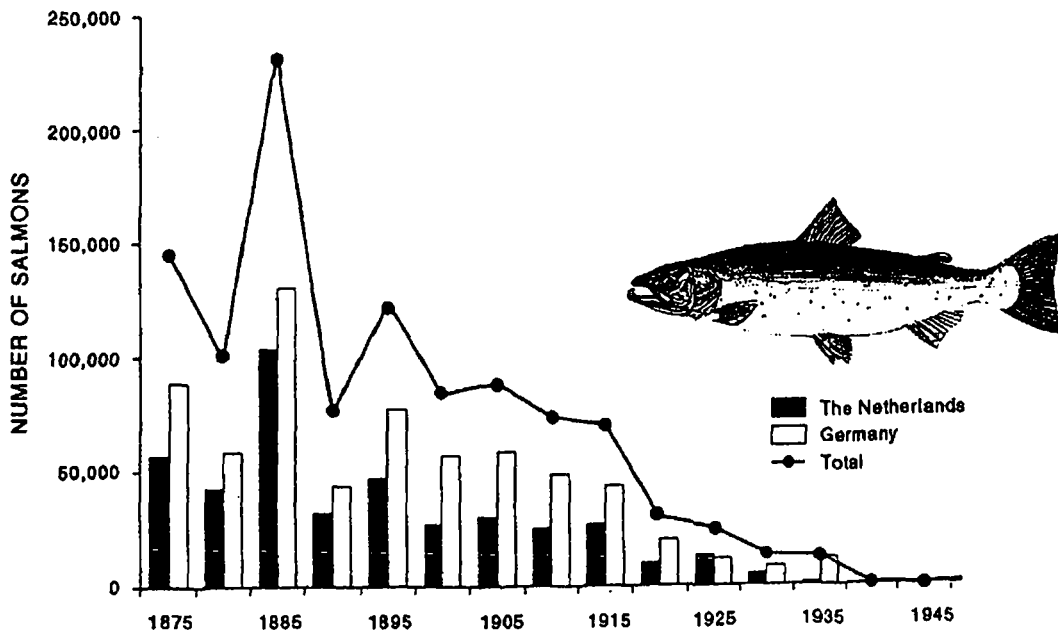


Figure 3 Number of salmon caught in Germany and the Netherlands between 1875 and 1950.

had disappeared from the river. Other threats to the Rhine ecosystem included effluents from chemical industries located on the river banks. Large amounts of heavy metal compounds, pesticides, hydrocarbons and organic chlorine compounds were being discharged into the river. This caused further ecological problems, notably the disappearance of indigenous fish species, the continued deterioration of the water quality and the pollution of sediments. The

provision of good quality drinking water required ever greater efforts. By the end of the 1960s, the Rhine had the unflattering reputation of being the sewer of Europe.

International cooperation

It was becoming obvious that the problems afflicting the river Rhine could only be tackled effectively through

international cooperation. In 1950, the riparian states of the Rhine, namely Switzerland, France, Germany, Luxembourg and the Netherlands jointly established the International Commission for the Protection of the Rhine (ICPR), in response to the serious situation. However, it took some twenty years before this cooperation resulted in actual measures to reduce or prevent pollution. In 1963, the Berne Convention on the Protection of the Rhine, was signed. In 1976, the European Commission joined the ICPR, which greatly strengthened it. However, it was not until around 1970 that the first internationally agreed measures to protect the river against the effects of organic pollution were taken.

One might ask why the ICPR took almost two decades to decide on and implement measures that would require changes to ongoing practices regarding wastewater discharges into the river. There were two main reasons for this delay. First, states working together in the context of an international organization need a certain amount of lead time to develop a positive atmosphere and a spirit of co-operation. Mutual confidence is the most important prerequisite for international co-operation. Even for the Rhine states, with very similar socio-economic backgrounds, time was needed for the parties to get accustomed to each other, to learn about the specific problems, goals and approaches of the other states and to identify common grounds for co-operation.

A second important factor was the overall political attitude towards environmental problems before 1970. In the absence of widespread support and commitment at the political level, stringent measures to reduce effluents could not be enacted. Towards the end of the 1960s, after the Torrey Canyon disaster,¹ environmental problems became a serious issue on the political agenda. Especially the problems of water pollution received much attention and a series of international conventions were established to protect the aquatic environment. The new political acknowledgement of environmental problems is demonstrated by the holding of a number of international conferences and the emergence of international conventions to protect the environment, such as the United Nations Conference for the Environment, held in 1972 in Stockholm; the 1973 Marpol Convention to reduce pollution from ships; the 1972 Oslo and London Conventions to reduce dumping of wastes into the seas; and the 1974 Paris Convention to reduce the pollution of the seas by land based sources. At the national level, similar activities took place, resulting in the passing of legislation and development of various plans to protect surface waters. The very favourable political climate in conjunction with the staggering degree of pollution of the river, paved the way for environmental decisions and measures to reduce the discharge of effluents into the river Rhine.

Between 1970 and 1985 successful programmes were developed to reduce discharges into the river of polluted municipal and industrial waste water. Between

1970 and 1990 more than 80 billion DM were invested in the construction of community and industrial waste water treatment plants. The quality of the Rhine waters slowly improved under the influence of the work of the ICPR. Oxygen levels improved steadily, and a certain improvement could also be observed with regard to inorganic pollutants. During this time, efforts were mainly focused on 'end-of-the-pipeline' techniques, i.e. treatment of wastewater, rather than preventive measures.

In 1976, the Rhine Commission agreed on the International Convention on the Prevention of Chemical Pollution of the Rhine. This Convention marked a further step towards increased environmental protection of the Rhine.

A very important aspect of the Chemical Pollution Convention is the introduction of a 'black' and 'grey' listing system, intended to limit the discharge of dangerous substances.

One of the tasks of the ICPR under the Convention was the development of internationally binding ceiling values for extremely hazardous substances. Such ceilings were set for mercury, cadmium and a number of organic substances. Action was also taken at the national level to implement the new standards. However, it soon became evident that the difficulties related to ceilings for dangerous effluents had economic implications that went beyond the Rhine catchment area. The Commission of the European Community was therefore called upon to look into the situation with regard to fair international competition. Unfortunately, the work of the European Community proved very time consuming, and time was precious. The slowness of the progress also had an effect on the ICPR. For a considerable period of time, the EC-Commission focused the discussion of ceiling values only on selected hazardous substances. However, in Germany, a sectoral approach had already proved successful earlier. In this approach, specific minimum requirements had been determined for all relevant pollution parameters (BOD, COD, heavy metals, organic micro-pollutants, etc.) for discharges from selected industrial sectors. Under specific circumstances, standards may be even more stringent, but they can never be relaxed. Various approaches were discussed by the ICPR, but no decisions could be made.

This proved to be a period of great stress for the International Rhine Commission.

On the one hand, considerable international progress was made in reducing the discharge of organic pollutants into the Rhine. As a result, biodiversity increased substantially for the first time in the post-war period. This progress is recorded in the monitoring programme, now considerably improved, which is being applied in the ICPR countries.

On the other hand, inorganic pollution by dangerous chemical substances could not be tackled adequately, despite the existence of an internationally agreed Convention. The prescriptive and detailed approach of the Chemical Pollution Convention was often an impediment to the realization of its objectives.

Due to the ambiguity of the situation, discussions in

¹The crude oil carrier Torrey Canyon stranded off the coast of England in 1967, causing an oil spill of 121 000 tonnes, the largest ever registered at the time.

the ICPR were considerably complicated and slow. The situation remained unchanged until 1986, when, as so often in environmental decision-making, a serious accident provided the necessary impetus for action on the pollution issues (Nollkaemper, 1990).

The Sandoz accident and the Rhine action programme

An accident in a chemical plant at the end of 1986 demonstrated how vulnerable the Rhine ecosystem was and how many potential dangers still threatened it. A fire broke out at a warehouse of Sandoz Chemical Industries near Basel, Switzerland, which resulted in the discharge of fire extinguisher fluids and water, polluted with a variety of toxic chemicals, into the Rhine. These flowed down river and caused the death of almost all aquatic life as far downstream as the Loreley Cliff, near Koblenz. The fragile Rhine ecosystem was still easily endangered.

The Sandoz incident triggered a wave of publicity in all the countries bordering the Rhine. Political attention was alerted and within a very short time not less than three ministerial conferences were addressing the issue of Rhine pollution. Out of this, the Rhine Action Programme (RAP) finally emerged in 1987.

It is often argued that the ICPR had the 'luck' of having the Sandoz accident at exactly the right moment. It is certainly true that in the mid-1980s environmental issues were high on the political agenda in many countries, as they had been in the early 1970s. Given the political interest in the environment at the time, the Sandoz accident provided the perfect occasion for environmental ministers of the countries bordering the Rhine to show their willingness to act. The timing of this event was, of course, not foreseen and from that point of view the expression 'luck' is appropriate. But the quality of the decisions taken by the ICPR Ministers was certainly not merely a lucky coincidence. At this moment, the existing institutional framework of the ICPR proved its value. The combination of political preparedness, the Sandoz accident and the existence of an institutional framework and extensive preparatory work carried out by the ICPR formed the perfect basis for the Rhine Action Programme.

The Rhine Action Programme (RAP) set out clearly defined goals to be reached by the year 2000:

- the Rhine ecosystem should be improved to such an extent that higher species, such as salmon and sea trout, again became indigenous;
- the production of drinking water from the Rhine must be guaranteed for the future; and
- the pollution of river sediments must be reduced to such an extent that at any time sludge may be used for land fill or be dumped at sea.

With the Rhine Action Programme, the Ministers agreed on some very challenging and ambitious targets, such as the 50% reduction of the discharge of dangerous substances between 1985 and 1995 and the return of the salmon by the year 2000.

In 1988, enormous algae blooms appeared in the North Sea. This showed the close interrelation between discharges into the river Rhine and effects on the marine environment outside its estuary. A fourth target was subsequently added to the RAP:

- the improvement of the ecology of the North Sea.

The Rhine Action Programme marks a very important step in international water management. For the first time, an explicit commitment was made to broaden the scope of cooperation beyond water quality aspects. The formulation of clear ecosystem goals laid the foundation for the integrated water management for the river Rhine. Thus, it was envisaged not only to control and prevent pollution but also to restore the entire Rhine ecosystem as a whole (Ruchay, 1994).

The Programme was divided into three phases. In a first phase, the ICPR established a list of hazardous substances to be dealt with on a priority basis. These were analysed, as were their sources and amounts discharged. Furthermore, the ICPR pressed for a working methodology based on an industrial approach. In order to reduce pollution, both of water and suspended matter, the state-of-the-art techniques and procedures had to be determined both for industrial production and urban wastewater treatment.

In addition, the Commission developed well defined measures to reduce the risk of pollution of the Rhine in case of accidents like the Sandoz fire.

Based on the work accomplished in the first phase, the second phase, up to 1995, aimed at the actual implementation of the measures agreed. The third phase (1995-2000) should make possible further implementation, 'fine-tuning' and finally the establishment of additional measures to reach the agreed goals.

In 1987, as a direct consequence of the Sandoz spill, the Rhine Ministers asked the ICPR to develop a model that allows the estimated reach of an accidental spill to be quickly and reliably predicted. Such a prediction model has been developed and tested by the ICPR in co-operation with the International Commission for the Hydrology of the Rhine catchment area, specific agencies of Rhine riparian countries, and with the Universities of Delft, Freiburg and Bern. With the help of this model, the concentration of a wave of pollutant, as well as the time when the highest concentration may be expected at a certain point along the river, can be predicted for the entire length of the Rhine. The model is available as a computer programme and works as an easy-to-use decision support system. Thanks to short computing times, the warning and alarm centres along the Rhine are able to predict downstream effects immediately after the occurrence of a major accident. Measures to forestall or mitigate pollution damage can therefore be initiated without delay. The model can be used for accidents happening along the entire course of the Rhine, from Lake Constance to the Netherlands. Even the three estuarine rivers IJssel, Nederrijn and Waal, are included, although not their tidal areas. Accidents along the tributaries Aare, Neckar, Main and Moselle are also monitored by the alarm system. Even the influence of still water zones on the spreading of toxic substances is

calculable by the model, which has been calibrated with the help of extensive tracer tests.

The ICPR has also made an inventory of all industrial plants in the Rhine catchment area which could potentially cause considerable water pollution in case of an accident. Responsible national authorities regularly check these plants for safety standards and installations.

Essential industrial safety aspects are outlined in the comprehensive ICPR report, 'Prevention of accidental pollution and safety of industrial plants' (ICPR, 1991). Since 1992, the ICPR has formulated recommendations concerning crucial aspects of prevention of accidental pollution and the safety of industrial plants. These recommendations address issues such as overflow safety locks, concepts of fire protection, turnover of dangerous substances, safety of pipelines etc.

Although an accident triggered the RAP agreement, the programme mainly concerns reductions in the regular daily discharge of dangerous substances. The implementation of this part of the Rhine Action Programme must be termed very successful. All along the river, measures have been taken to prevent pollution. Already in 1994, the ICPR could report that most of the reduction goals had been reached. In the area of industrial sources of pollution, the 50% target was almost completely met and, for many substances, reductions up to 90% were realized (ICPR, 1994a).

Difficulties in implementation are still being reported in the area of diffuse sources of pollution, especially with respect to agricultural effluents of pesticides and nutrients. These sources of pollution will receive further attention during the third phase of the Action Programme. Nevertheless, it can be stated that an enormous improvement in the water quality of the Rhine has been achieved in a very short time. For many substances, the quality of Rhine water nowadays fully meets the standards for drinking water. From being termed the 'sewer of Europe' in the 1970s, the Rhine has now become one of the cleanest transboundary rivers in the region.

To facilitate the open and effective assessment and evaluation of the quality of the waters of the Rhine, the ICPR has developed a system of quality objectives. These 'target objectives' (*Zielvorgaben*) do not constitute absolute effluent levels. Their main purpose is to facilitate the easy quantitative assessment of the quality of the Rhine and to create a tool for the setting of priorities when measures for different substances are developed. The target objectives relate to the most important environmental assets to be protected in the Rhine: aquatic life (NOEC values) and drinking water (EC Directives). Furthermore, the quality standards for fisheries and the necessary quality of suspended matter and sediments are included. For some 45 substances, the most stringent quality objective is used.

The reaction of various assets meriting protection to each of the 45 substances, or groups of substances, is of course different. The example of chloroform is given below.

Chloroform does not tend to bioaccumulate, and can therefore not accumulate in fish. As a consequence, levels of chloroform are irrelevant as far as protecting

assets in the category of 'fisheries' is concerned. Neither does chloroform have any influence on the quality of suspended matter and sediment. It is, however, relevant for the protection of drinking water. Normally, directives for drinking water fix a threshold value of $1.0 \mu\text{g l}^{-1}$. However, this value is too high in view of the protection of aquatic communities. Estimations on the ecotoxicological effects of chloroform on bacteria, algae, crustaceans and fish seem to indicate that a lower value of $0.6 \mu\text{g l}^{-1}$ would be justified. That is why, for the ICPR, this lowest value is relevant in order to equally protect the most sensitive of these four assets.

By the end of 1994, it was found that the measures taken within the framework of the Rhine Action Programme had achieved the goal objectives for most of the test substances. Substances for which the desired concentrations had not been reached included the heavy metals lead, mercury, cadmium, copper and zinc; for lindane (gamma-hexachlorocyclohexane, a pesticide), HCB (hexachlorobenzene) and several PCBs (polychlorinated biphenyls) and for the nutrient ammonium-nitrogen (Table 1).

In order to reach target concentrations for these substances, additional efforts will be needed to reduce discharges. In most cases, the origin of these pollutants are diffuse sources or contaminated sediments.

The ecological dimension. The Salmon 2000 project

The political will to improve the Rhine ecosystem expressed by the responsible ministers directly after the Sandoz accident, was translated into very ambitious goals. The most challenging goal, perhaps, involves improving the Rhine ecosystem to such an extent that migratory fish species can return to their spawning grounds and become indigenous again. Thus, the meaning behind the slogan is that the Salmon should return to the Rhine by the year 2000 (ICPR, 1994b).

The return of the salmon is of course not a single goal limited to a single species, but should be considered as a symbol and measure of the ecological restoration of the Rhine as a whole.

The ICPR realized that, in order to reach this goal, a range of measures had to be taken within a very short time span. The improvement of the water quality of the river through the programme discussed above to reduce effluents was, of course, the first prerequisite for a successful reintroduction of previously indigenous fish species. Moreover, extensive programmes had to be developed and implemented to enable the salmon to return to its spawning grounds. One such measure was to build costly fish passages at the many physical barriers in the Rhine and its tributaries. Measures to improve habitats also had to be taken in many tributaries in order to restore spawning grounds. Finally, Salmon eggs from which to recreate a new stock of Rhine salmon were purchased in Scotland and in the southwest of France. The fish eggs were hatched in special hatcheries. Thousands of fry were released into the river and a programme was developed to monitor the behaviour of the salmon. Many of these projects were realized thanks to the financial support of the European Commission.

Table 1 Reductions of point source inputs per substance in percent between 1985 or 1990 and 1992

No detectable point source inputs in 1990 or 1992	Reductions		
	80-100%	50-79%	30-49%
Atrazine	Cadmium	70-79%	Ammonium endosulfan ^b
Azinphosethyle	Chromium		4-Chlorotoluene ^a
Dichlorvos	1,2-Dichloroethane	Nickel bentazone ^a	
Fenitrothion	Tetrachloroethene	60-69%	
Malathion	Trichloromethane		
Parathionmethyle	Trichloroethane	Copper	
Simazine	Tetrachloromethane	Zinc	
Trifluraline	Benzene	Lead	
DDT	Hexachlorobenzene	2-Chlorotoluene ^a	
Dioxins	Hexachlorobutadiene	50-59%	
	Chloroanilines	Mercury	
	Chloronitrobenzenes	1,1,1-Trichloroethane	
	PCB	Trichlorobenzenes	
	AOX	Total phosphorous	
	Pentachlorophenol		
	Azinphosmethyle ^a		
	Fenthion ^a		
	Drins		
	Parathionethyle		
	Organic tin compounds		

^aReference year 1990.

^bMinor inputs of 3 kg.

The so-called 'Salmon 2000' Programme of the International Rhine Commission marks the successful development of integrated water management in north western Europe. The integration of ecological and water quality aspects in policy formulation and implementation is a prerequisite for successful river management.

As a result of this programme, substantial progress has been made in the improvement of the ecological condition of the river. In fact, the results of the 'Salmon 2000' programme exceed expectations. Since 1990, salmon and sea trout are known to have returned from the Atlantic to the Rhine and its system of tributaries, and since 1992 natural reproduction has been recorded. In 1995, nine salmon were caught under the Iffezheim barrier, near Strasbourg, France, demonstrating that salmon, returning from the ocean, can actually swim more than 700 km up river. What in 1987 appeared an almost utopian goal, seems to have become a reality in a very short time.

The success of the 'Salmon 2000' project once more underlines the effectiveness of the international cooperation between the Rhine's riparian states. Ambitious political goals at the international level have been successfully translated into concrete measures and activities at the local level. All along the river, people are working to reach common goals and are achieving positive results (Ruchay, 1994).

The 1993 and 1995 floods

In 1994, the ministers responsible for water management in the states bordering the Rhine opted for the further broadening of the scope of cooperation through ICPR to include in their policies the quantitative aspects of the management of the river Rhine. This decision paved the way for the further

integration of qualitative, quantitative and ecological aspects of river management.

The occurrence, in 1993 and 1995, of catastrophic floods in the middle and lower Rhine regions gave added impetus to the idea of further integration of the Rhine river management, as well as additional political commitment. On the basis of the very positive results of the Rhine Action Programme, the concerned ministers charged ICPR with the development of an international action programme for the prevention of floods. It was felt that the proven spirit of cooperation between the riparians of the Rhine and the efficient holistic and pragmatic approach of the ICPR should be able to yield equally positive results with international flood problems.

Without further hesitation, the ICPR proceeded to integrate this new area of concern into its mandate. Already by the end of 1995, the first international strategy for the management of Rhine river floods was agreed upon. The most important conclusion of this strategic document is that naturally occurring floods cannot be stopped and that international action should be focused on floodplain management rather than flood management. Ten guiding principles were formulated as the basis for a multitrack structural approach (Internationale Kommission zum Schutze des Rheins, 1995).

The ICPR also started work on an inventory of all historically known areas of naturally occurring floods that are active at present. This inventory, which was finalized by the end of 1996, will be an important background document to serve as a basis for decisions concerning the actual international Action Programme and related measures. A second inventory addresses the existing international alarm and warning system along the Rhine in combination with the international net of weather forecast stations.

The formulation of the international Action

Programme on protection against floods is a direct plea for transboundary solidarity. A narrow approach based on only local, regional or national priorities will not be sufficient. Technical solutions may give some relief, but in the end downstream problems can only be solved by structural measures upstream. It will be a major task for the ICPR to initiate this process and to convince the many stakeholders involved—authorities, organizations and local people—of the necessity for a common approach.

Another challenging focus for the ICPR is the close interrelationship between the action programme on protection against floods and the current and future activities of the Commission with respect to the ecological restoration of the Rhine. The objectives of flood plain management and ecological restoration of the alluvial areas can very well be combined. However, the practical implementation on a project level may be more complicated.

Just as transboundary river pollution is not exclusive to the Rhine, so also floods likewise occur in other international rivers. Similar problems are experienced for example along the Meuse and the Scheldt rivers. Consequently, similar strategies and solutions are being developed for these rivers. The European Community has taken the initiative to develop a programme for the protection against floods within the framework of the European land use planning programmes.

This very valuable Community initiative offers the opportunity to take measures quite different from the 'classical measures' related to water management. Land use planning instruments will help to keep endangered areas free of construction activities, to design specific areas for retention or overflow purposes and to improve the storage capacity of the whole river basin.

It is obvious that so many initiatives, in so many different fora, require a well balanced coordination between the different groups and organizations involved.

The above example illustrates the complexity of international co-operation in solving water problems, and demonstrates the need for high level coordination between different river basins.

The experiences of the ICPR emphatically plead for a management approach designed at the river basin scale. It may be observed that such an approach is actually being applied to almost all important European rivers and seas. Moreover, the European Community is in the process of preparing an overall European water policy in the form of a new Framework Directive. In view of the enormous differences that exist between the various international water bodies, it would be futile to attempt to develop one general prescriptive policy for all European waters. On the other hand, there is a need for a structure of co-operation between the different rivers and seas, aiming at an exchange of information and experience, as well as a certain level of harmonization between the different areas. With respect to such harmonization, it will, of course, be necessary to take complete and accurate account of the specific geographical, natural and socio-economic conditions of the different basins.

Present organization of the Rhine Commission

The organization of the Rhine Commission has been adjusted more than once to accommodate changes in policy. The ICPR was structurally reorganized in 1995, in view of integrating flood control into the Commission's work, and to optimize and streamline its activities.

Ministerial conferences are held every two to three years to formulate the political goals of the Commission and at the same time serve as a platform for the assessment and evaluation of ongoing and completed activities. The Commission itself, consisting of the highest officials from the member states, meets annually and decides on work programmes, finances and formal procedures. A coordination group, meeting four times a year, is responsible for the actual planning and coordination of the work of the ICPR.

Three permanent working groups cover the areas of water quality, ecology and effluents. Two non-permanent project groups, with a mandate limited in time, prepare the work on the new Rhine Convention and on the Action Programme on protection against floods.

A number of expert groups deal with specific problem areas related to the work of the working and project groups. Each group consists of a number of national governmental experts. A small international secretariat, with a permanent office in Koblenz, Germany, provides administrative support to the work of the Commission.

A relatively new development within the framework of the ICPR is its initiative towards co-operation with non-governmental organizations, NGOs. The ICPR has decided to promote the exchange of information with international NGOs in order to create a better common understanding of problems and solutions. As a first initiative, the ICPR organized an international conference 'Living with the Rhine'. This conference addressed all current Rhine issues, with a view to developing future policies. All relevant international non-governmental organizations took part in this conference and expressed their views on the future of the Rhine and the future tasks of the ICPR.

This conference was very successful, and was followed by an official hearing of NGOs, which was organized by the Commission. The latest development is the introduction of special meetings between NGOs and ICPR working groups. These meetings address specific issues such as the formulation of quality objectives, the development of monitoring programmes etc.

The exchange of information with NGO's is expected to be institutionalized as a regular part of the ICPR tasks.

River basin management now and in the future: conclusions, lessons learned

The recent floods once more emphasize the importance of an integrated approach at the level of the whole river basin. Founded on international solidarity, measures have to be taken in the whole catchment area of the Rhine.

The International Commission for the Protection of the Rhine has gained much experience in the development of such a river basin management approach. Between 1950 and 1970, the main activities of the Commission consisted of the development of a legal basis for cooperation and of joint monitoring programmes. From 1970 onwards, many measures were developed to reduce discharge of pollutants into the river. The basic instrument was the construction of industrial and municipal wastewater treatment plants. While this 'end-of-the-pipeline' approach improved the water quality in the river, real progress was not made until the Rhine Action Programme was agreed upon in 1987. The RAP tackled the water quality problems through an integrated approach. Precaution and prevention became the basic principles and, for the first time, an actual reduction in effluents was realized. With the introduction of ecological goals for the river, the Rhine Action Programme broadened the scope of river management from water quality management to water management. The integration of quantitative aspects into the work of the Commission after the 1993 and 1995 floods further expanded the scope of ICPR to integrated water management.

As a consequence of these developments, the ICPR needs to expand its institutional base in order to be able to realize its goals. The prevention of discharges of dangerous substances requires much more than a mere licensing system. Process integrated measures have to be developed for different branches of industry, product policies will have to be changed to an integrated European context and even changes in consumption patterns may become necessary. With respect to the flood problems, it is obvious that close cooperation with land use planning organizations is a prerequisite.

The International Commission for the Protection of the Rhine is in the process of preparing a new Rhine Convention, which will form a legal basis for the integrated approach. This new convention will address and integrate all the elements that are necessary for the future sustainable development of the river Rhine. An important element of the new convention will be the information exchange or cooperation with non-governmental organizations. Successful implementation of future Rhine policies will only be possible on the basis of a general consensus about objectives and means. River management is not only a government responsibility but also the responsibility of every citizen, farmer, community or industry in the Rhine catchment area. The new Rhine Convention and the ICPR will have to provide the infrastructure for discussions, agreement and implementation of Rhine policies.

On the basis of the experience gained in forty-six years of cooperation, it is noted that future Rhine management, based on the concept of integrated water management on a river basin scale, should leave room for a certain flexibility in its implementation. Based on the aforementioned general agreement and the framework policies developed in the ICPR, states should have the possibility to choose their own means for implementation. Overly detailed, prescriptive policies take considerably more time to develop and also may hinder rather than stimulate implementation

in different countries or areas. The same approach should be applied in relation to the formulation of concrete measures to be taken by industries or other polluters. Decisions on technical measures, investments in new production processes etc. can most effectively be taken by these very target groups and not at a central intergovernmental level.

Openness is another important element when developing future policies. Political and public support are prerequisites for a successful formulation and implementation of Rhine policies. This can only be realized when innovative, transparent and goal oriented policies are formulated and forwarded to a broader public. Recent developments in computer and communication techniques offer new possibilities for the ICPR information strategy.

The successful cooperation between the Rhine riparians within the framework of the ICPR has been an example for many other river basin organizations. Of course, it is not possible to project the Rhine approach on any other river in the world. Therefore, it is very important to take careful note of the process of steps taken in the Rhine Commission and to learn from both positive and negative experiences of the ICPR. Conversely, the ICPR can learn from the experience on other international rivers.

Although much has been achieved, much also remains to be done for the Rhine. Sustainable development of the Rhine requires additional programmes and measures in the years to come. The ICPR has the challenging task of demonstrating its capacity to fulfil this task as well.

International cooperation, solidarity, flexibility and practical implementation were and will be the basis for the success of the Rhine Commission. The ongoing process of integration of all relevant aspects of water management for the whole Rhine catchment area and the future strategies aimed at a sustainable development of the river will further improve the Rhine and will offer a new example for water management, at the river basin scale, for other regions of the world.

Conclusions

- International water problems can only be effectively resolved and prevented at the river basin scale. There is, however, a clear need for an exchange of information and experiences between the different basins. The European Community may play an important role in creating a basis for such an exchange.
- River basin management requires an overall integrated approach including water quality, ecological and water quantity issues. An approach addressing only one aspect can only solve problems partially and will cause new problems in the long run.
- Sustainable development of the entire river should be the basis for future policies for international rivers. That means the promotion of a balanced use of the river, respecting all interests and interest groups, now and in the future

- Precaution and prevention are the most important basic principles for river basin management. Taking measures after the fact is always more expensive than preventing problems before they occur. Decision-makers should have learned their lessons from the Sandoz disaster and the recent floods.
- International strategies and policies should leave room for flexible national implementation. Working towards the same objective does not necessarily involve taking the same measures. Detailed, prescriptive policies take considerably more time to prepare and agree on, and are often less effective in their implementation.
- Important decisions concerning the solution of environmental problems cannot be taken without having heard the opinions of all the stakeholders involved. Non-governmental organizations can contribute positively to the quality of the decisions taken and form a very important factor in the successful implementation of these decisions.
- Public and political support are also prerequisites for the successful formulation and implementation of environmental policies. Open planning processes, access to data and transparent and goal oriented policies serve this goal.
- Co-operation in river basin management has to be based on mutual confidence between all the parties involved. The co-operation achieved within the International Commission for the Protection of the Rhine may serve as a good example for other international water management authorities in other regions of the world.

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