

## Integrated water resources management in the Ruhr River Basin, Germany

H. Bode\*, P. Evers\*\* and D.R. Albrecht\*\*\*

\* Executive Technical Director, Ruhrverband, Kronprinzenstr. 37, D-45128 Essen, Germany  
(E-mail: [bode@ruhrverband.de](mailto:bode@ruhrverband.de))

\*\* Head of the Division Wastewater Treatment, Construction and Operation, Ruhrverband, Kronprinzenstr. 37, D-45128 Essen, Germany (E-mail: [pev@ruhrverband.de](mailto:pev@ruhrverband.de))

\*\*\* Head of the Department of Public Relations, Ruhrverband, Kronprinzenstr. 37, D-45128 Essen, Germany  
(E-mail: [dal@ruhrverband.de](mailto:dal@ruhrverband.de))

**Abstract** The Ruhr, with an average flow of 80.5 m<sup>3</sup>/s at its mouth, is a comparatively small tributary to the Rhine River that has to perform an important task: to secure the water supply of more than 5 million people and of the industry in the densely populated region north of the river. The complex water management system and network applied by the Ruhrverband in the natural Ruhr River Basin has been developed step by step, over decades since 1913. And from the beginning, its major goal has been to achieve optimal conditions for the people living in the region. For this purpose, a functional water supply and wastewater disposal infrastructure has been built up. The development of these structures required and still requires multi-dimensional planning and performance.

Since the river serves as receiving water and at the same time as a source of drinking water, the above-standard efforts of Ruhrverband for cleaner water also help to conserve nature and wildlife. Ruhrverband has summed up its environmental awareness in the slogan: "For the people and for the environment". This basic water philosophy, successfully applied to the Ruhr for more than 80 years, will be continued in accordance with the new European Water Framework Directive, enacted in 2000, which demands integrated water resources management in natural river basins, by including the good ecological status of surface waterbodies as an additional goal.

**Keywords** Ecological forestry and fish stock management; effective strategies; European Water Framework Directive; monitoring systems; river water quality and quantity management; user related policies

### History

A hundred years ago, in the aftermath of the industrial revolution, severe problems occurred in the municipal water supply due to the rapid expansion of the industrial region. Responsible for this development was the booming coal mining and steel making industry. The then existing water facilities could neither cope with the rising water demand, nor with the wastewater discharge of the extremely rapidly growing communities. In consequence, epidemics of infectious diseases occurred in the region. These circumstances led to the establishment of two water management associations for the Ruhr basin (Figure 1). In 1913, by special act of the Prussian State, the Ruhrverband (Ruhr River Association for water quality management) and the Ruhrtalsperrenverein (Ruhr Reservoirs Association for water quantity management) were set up as independent organizations. They became responsible for integrated water resources management in the entire natural river basin. In 1990, both associations were merged into a single unit by a new Ruhrverband act. The association is a self-governing, but state-controlled public body. The Ministry of the Environment of the State of North Rhine-Westphalia controls the association. Unhampered by political borders, the Ruhrverband designs, constructs and operates the required facilities. Thus, system-wide management has been put into effect, which has the potential of balancing and minimizing costs.



spring, sufficient water from uncontrolled areas is available to meet the demand. During summer and autumn, the reservoirs discharge into the river system to augment low flow by application of a sophisticated, computer-model controlled system. It should be noted that a combined system has been used instead of a direct reservoir supply by means of connecting pipelines. Direct reservoir supply would not only require long water conduits, but also additional reservoir capacity of the order of 200 million m<sup>3</sup>. To improve the river water quality in low flow periods, discharges from the reservoirs are voluntarily increased by the Ruhrverband beyond the legally demanded level (Bode, Morgenschweis, Willems, 2001).

Upland reservoirs and impounded lakes on the Ruhr River are very attractive and have a high recreational value. At weekends, more than 100,000 people will come to visit them. All recreational facilities, built under ecological aspects, are being properly maintained and operated so that their footprint on the environment is as gentle as possible. Further side benefits are hydropower generation and flood control. Conflicts that normally result from competing uses of a river and its water can be minimised by an association like the Ruhrverband, performing integrated water resources management. Whereby potable water supply from the Ruhr has top priority over all other uses like those in recreation, hydropower generation, fishery and navigation.

In total, the wastewater load of 3,6 million population equivalents (p.e.) being contained in a volume of 400 million m<sup>3</sup>/a wastewater is treated in Ruhrverband's 84 treatment plants located in the river basin. Tertiary treatment for nutrient removal is compulsory (Bode, Klopp, 2001). There is no export of wastewater into adjacent river basins. Tasks are divided between the communities, on the one hand, and the Ruhrverband, on the other hand. The communities are responsible for the construction and operation of the sewerage systems up to a location where a wastewater treatment plant could theoretically be constructed. At this point, the Ruhrverband takes over responsibility for wastewater treatment.

The Ruhrverband can thus provide the most efficient and cost-effective solutions. Feasibility studies are used in each particular case to decide whether pumping stations and connecting trunk sewers to central treatment plants or local purification units would be more suitable. Within the last decades, the number of Ruhrverband's wastewater treatment facilities was at first increased from 82, in 1958, to 120, in 1977 (when additional regions were connected to sewers and, primarily, to decentral treatment facilities) and then decreased again to 84 in 2001, as a result of treatment centralization. Pretreatment of toxic industrial wastewater is required by law and controlled to ensure that the biological processes in Ruhrverband's facilities do not deteriorate (Bode, 1998).

The water demand of the industrial Ruhr District has decreased during the last decade due to the increasing tendency of industry and trade to minimize water consumption and to promote water recirculation. With the present zero-growth rate in population development in the region, water export from the Ruhr has stabilized. The available capacity of the Ruhr reservoirs is sufficient to meet even the prognosticated future demand. Therefore, Ruhrverband's current activities in the field of water quantity management mainly focus on the maintenance and upgrading of the existing reservoir structures. In particular, the foundations of the dams and the bottom outlets, which are up to 100 years old, have to be replaced or improved according to most recent technical requirements and standards.

In contrast to the relatively stable situation for water quantity, the Ruhrverband has to implement a very ambitious programme for water quality management with large financial implications. By the end of the year 2005, € 100 million are to be invested annually for the upgrading of the existing wastewater treatment facilities in the Ruhr river basin. Major tasks and objectives are the following:

- Further improvement of purification performance of wastewater treatment facilities beyond current legal requirements with respect to the key issue: potable water produc-

tion from Ruhr water. For this purpose, the Ruhrverband operates all activated sludge stages in such a way that even in winter nitrification is achieved. This causes – compared to the normal German requirements – higher operational costs.

- Further improvement of phosphorus removal from municipal wastewater by phosphorus precipitation stages to minimize mass algal growth in the receiving waters.
- Extension of sludge incineration and disposal facilities.
- Improved stormwater treatment, in particular for the prevailing combined sewerage systems.
- Prevention of hazardous wastes from entering the water cycle, or at least minimization at their source. Industries are required by law to apply the best available technology for pretreatment of their wastewaters before discharging them into the municipal sewerage system. With regard to the potable water supply from the Ruhr, direct discharge of treated industrial wastewater into the Ruhr is avoided to the greatest possible extent.

The principal objective of the European Water Framework Directive is to achieve not only a good chemical, but also a good ecological status within each river basin of the European Union until 2015. Thus, the status of rivers will in future not only be assessed by parameters relating to water uses, but instead by characteristics relating to aquatic ecosystems. Since both the European and the German water legislation define the role of water bodies within the context of the entire balance of nature, a great number of rivers in the industrialized and densely populated countries will have to be rebuilt into near-natural aquatic systems of high biological diversity and stability. This includes to achieve a certain degree of continuity for the migration of fish and macroinvertebrates and structural measures in the river bed, on river banks and riparian plains. A cost estimation established for the entire Ruhr River Basin, with a total of about 5,000 km of rivers and brooks, showed that to achieve the good ecological status investments of between € 200 million and € 1 billion would be required. Based on the population in the river basin, the probable per capita costs will be in the range of € 100 to € 500.

Independently of the new European directive, Ruhrverband has already performed forestry under ecological aspects, in its woodlands around the reservoirs, for more than 15 years. Focal points of an ecological forestry policy are: avoidance of pesticide application, avoidance of complete deforestation, and cultivation of a variety of appropriate, location-adapted bushes and trees instead of monocultures of spruce-wood. Properly applied forestry is an important instrument that helps enhance the quality of ground and surface water. Moreover, the Ruhrverband takes care of an ecological fishery management in its artificial ecosystems: the reservoirs. This helps to maintain a sustainable fish stock and a sound macroinvertebrate society.

The water quality management of the Ruhrverband is affected by the dual use pattern, that means withdrawal of potable water, on the one hand, and discharge of extensively treated wastewater, on the other hand, from and into the same river system. Rivers are endangered by accidental or illegal pollution. And an identification of water pollutants and polluters is often difficult, if not impossible because water samples for analysis cannot be secured in time. Five water quality monitoring stations are being operated by the Ruhrverband along the river's course. Two of them are equipped with sophisticated online analysers, automatic sampling units and biomonitoring systems using water fleas and muscels as detectors (Bode and Nusch, 1999). The statistics of incidents caused by unidentified polluting agents in the entire Ruhr basin, with its 5,000 km of rivers and brooks, indicate a significant reduction from thirteen in the year 1990 to only one in the year 1999. This is one remarkable result of the intensified and improved river quality monitoring (Ruhrverband, 2000).

River quality management is a never ending story. The success achieved in improving

the water quality of the Ruhr is documented in the annual reports published by the Ruhrverband. It is also visible in the improved quality and quantity of fish stock in the rivers and lakes of the Ruhr basin. Figure 2 illustrates the improvements in water quality achieved over the last 25 years. The reduction of organic pollution is clearly evident, but the elimination of nutrients and heavy metals is even more impressive with rates of up to 96% (Ruhrverband, 1977, 2002).

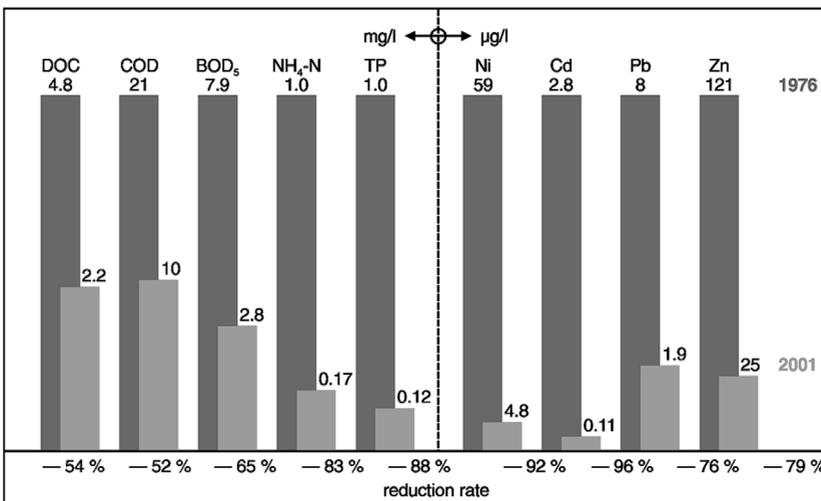
### Advantages of integrated river basin management and conclusions

The advantages of the described form of integrated river basin management and water governance can be summarized as follows (Albrecht, 1995).

- As rivers do not know any political borders, it is most effective, economical, and therefore reasonable to perform water resources management within natural river basins. The new European Water Directive acknowledges this principle, which has been performed professionally by the Ruhrverband since 1913.
- All water-related measures can be performed by supra-municipal master plans instead of local decisions.
- Planning of facilities can be centralized to minimize costs.
- Operation of plants can be regionalized according to the topographical situation and the given traffic connections in the basin.
- The self-government of a river association ensures the participation of all compulsory members in the decision-making process.
- Many synergy effects can be unlocked and utilized in the planning, construction and operation of water facilities.

A recent document titled “The German Water Sector – Policies and Experiences” published by the German Federal Ministry for the Environment in October 2001 concludes: “The Ruhr is a shining example of German environmental policy: While its name, on the one hand, is associated with an extensive industrial area, it was Germany’s first river catchment area with an integrated management on the other hand.” (Federal Ministry for the environment, 2001).

Though the Ruhrverband was established more than 80 years ago, the above mentioned advantages have lost nothing of their relevance and can still be used today – for the benefit of the people and the environment.



**Figure 2** Improvement of Ruhr water quality at Essen (1976–2001)

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