THE GERMAN WATER SECTOR
- POLICIES AND EXPERIENCES -

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The German Water Sector

Policies and Experiences

0. PREFACE

The excessive use and pollution of freshwater resources has become a grave problem in many regions of the world. Looking at Germany, one may conclude that the protection of water bodies is an example of the successful implementation of environmental policy. The economic development that took place after World War II quickly exceeded the capacity of water bodies. Mountains of foam and large numbers of dead fish indicated that the economy was growing at the expense of the environment. Environmental policy reacted to this situation - and has since accomplished a great deal: Economic growth in Germany has become uncoupled from the pollution of aquatic resources. The increase of the gross national product is accompanied by a decreasing water consumption. The pollution of water bodies has been significantly reduced. These achievements are the results of the cooperation of many different public players: the federal government, states, municipalities, businesses, professional associations, and last but not least, involved local citizens.

The present documentation offers the reader a perception of the development of water body management in Germany and shows the conditions under which this management is economically and ecologically successful today. This publication is intended primarily for international readers; however, it can also deliver further information to German readers. This documentation can also serve to stimulate ideas for other countries that are currently experiencing a rapid economic growth and are possibly confronted with problems similar to those of Germany.

Therefore, in the foreground of this documentation are examples which illustrate that the high standard of living in a modern industrial nation need not be accompanied by water pollution and a high level of water consumption. Since 1990, water consumption in Germany has been reduced by almost 20%.

The Ruhr River 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. The Rhine River is a model of successful international cooperation. Once known as "Europe's Sewer", it has become a river into which salmon have returned.

A particular challenge for the development of water management was the repair and construction of a modern water supply and wastewater disposal in former East Germany after the German reunification.

Despite all these achievements, however, one should not forget that the water management problems in Germany are not yet resolved. Of greatest importance is the necessary reorientation of agriculture toward ecological cultivation methods. This will also further reduce water pollution. I also expect positive effects from the European Water Framework Directive. This will present water management agencies with the task of managing water bodies in the future on the same level as river catchment areas - extending beyond national and state boundaries. Moreover, this directive will require further measures in order to restore water body structure to a more natural condition.

Jürgen Trittin
German Federal Minister for the Environment,
Nature Conservation, and Nuclear Safety

1. SYNOPSIS

The management of natural resources is a fundamental responsibility of mankind. In urban areas, bodies of water must be effectively protected as natural habitats and water resources. The sustained management of water in a highly - developed and densely-populated industrial nation requires an especially high level of technology and organization.

The supplying of water and disposing of wastewater in Germany are duties of the municipalities. They are free to individually choose the organizational and technological concepts that will adequately serve their needs.

In an industrial nation like Germany, the need for the security of water supply and the protection of the environment is inevitably great. For this purpose, there exist numerous *laws and ordinances*. Water laws are a matter of the individual German states, whereas the framework legislation corresponding to the federal structure and division of duties is handled at the federal level. Over and above all this, the requirements of the European Union must be met.

The 182 billion m³ of naturally *available water* [16] is entirely sufficient in Germany, even though there are regional and seasonal shortages and not all occurrences are adequately suited for supplying water. The technological standard of the present systems is by international comparison very high; the rate of leakage is only 9% on average. Due to an ever more conscientious use of water, the volumes of water used in industry and in households have continually decreased. In domestic use, the average inhabitant today uses just short of 130 l per day.

Even the percentage of wastewater connected to sewer systems and treated in wastewater treatment plants (WWTP's) is by international as well as European comparison very high. There are still deficiencies in, among other places, the region that was previously the GDR, where the protection of water bodies within the scope of a unique national construction program needed to be realized within a very short period of time. Today there exist approx. 450,000 km of public sewer pipes and almost 10,500 WWTP's. Ninety-three point two percent of the population is connected to a central sewer system, and 86% of inhabitants' wastewater is disposed of in conformity with EU standards - that is, using fully biological treatment and, in some cases, still further treatment.

Citizens' action committees played an important role in solidifying the concern for environmental protection in the population's consciousness and in carrying out environmental protection goals in the face of short-sighted individual interests.

Today, water demand is no longer seen as a prerequisite; rather, it is viewed as a quantity that can be influenced by the careful use of water, the utilization of rainwater, and water recycling.

Descriptions of central problems in the following areas will serve as concrete examples: public water supply, municipal wastewater disposal, the discharge of industrial wastewater, the reduction of nutrients in water, and the realization of a large-scale water management project. In each case, the specific measures with which a successful solution was found and executed will be brought to light.

Using the Ruhr River as an example, the integrated management of a river catchment area, as it has been required since the EC Water Framework Directive took effect (December 2000), will be described in its historical context and with the technological and institutional structures that were consequently developed. The Rhine, the largest river in Germany and once known as "Europe's Sewer", was developed into a model for a successful cleanup of a river - the result of good international cooperation.

Despite all its successes, there is still much to be done in the German water sector. One focal point for future tasks will be the further reduction of the operational and maintenance costs of facilities for water supply and wastewater disposal. The agricultural sector needs to be led to the same results for reducing emissions that are self-evident for municipalities and industry today. There are still many problematic pollutants (e.g. heavy metals, chlorinated organic compounds, pesticides, and pollutants with hormone-like effects) and epidemic hygiene problems (such as chlorine-resistant parasites) that need to be researched. New protective measures must be developed and applied. This will also take place in conjunction with the implementation of the European Water Framework Directive.

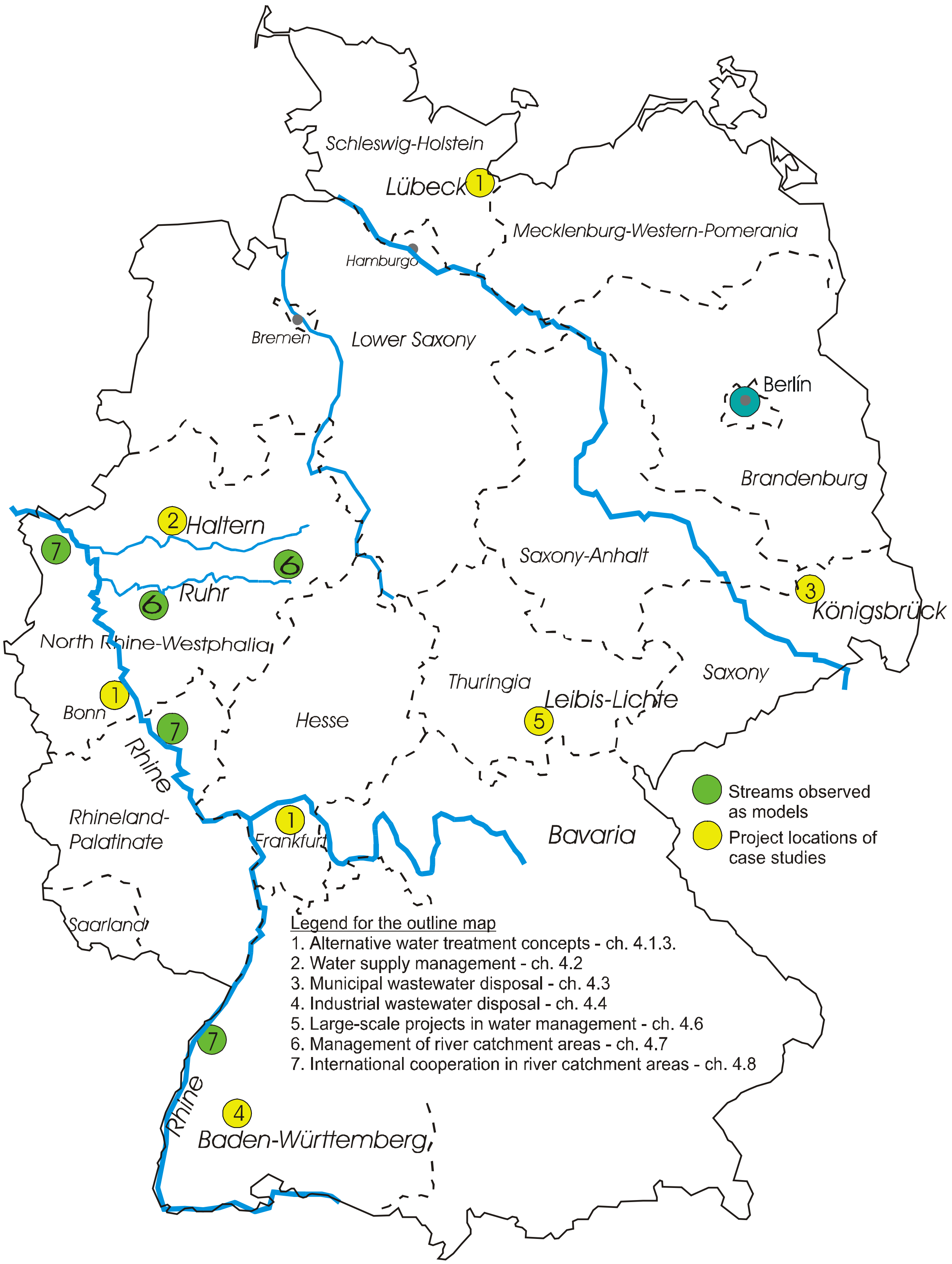


Figure 1: Regional allocation of case studies

2. INTRODUCTION

Germany was industrialized early on and is a densely-populated country. Unlike in England or Japan, it was not possible to pipe wastewater out of congested urban areas into the ocean by short routes.

At the end of the 1960's / beginning of the 1970's, the water pollution in the Federal Republic of Germany reached a level that caused grave concern. During the years of rapid economic growth, water protection measures could not keep up with the expansion of industrial activities.

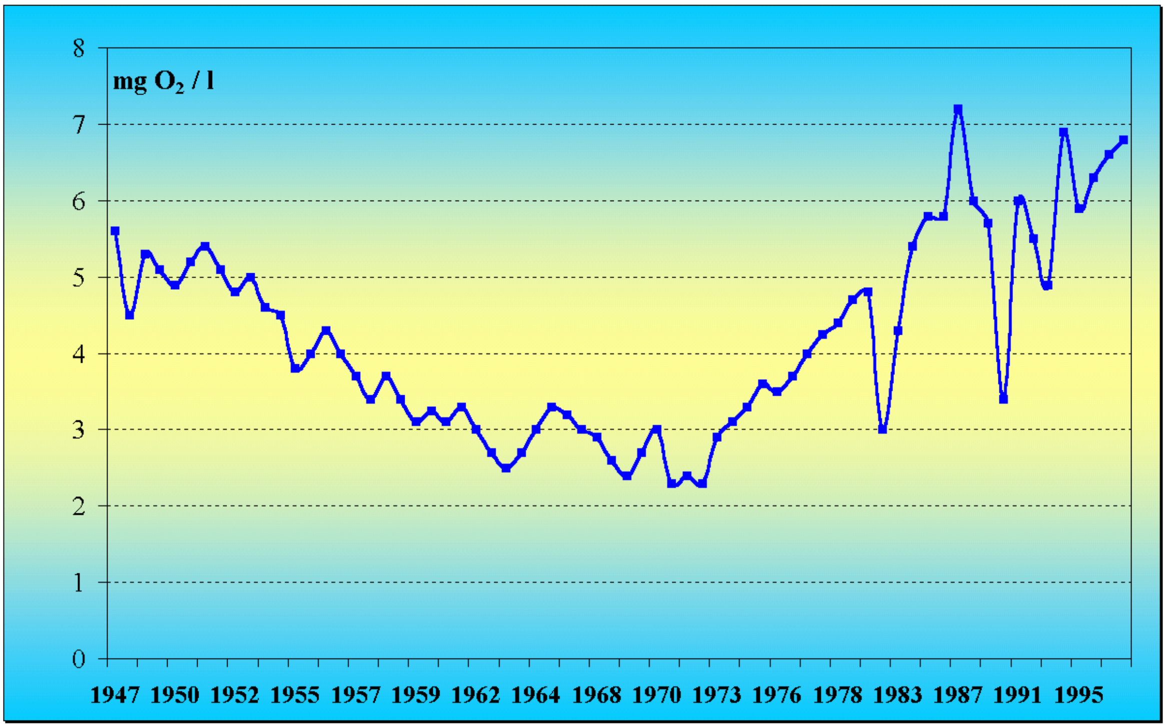


Figure 2: Development of the oxygen concentration of the Rhine [24]

With the construction of over 8,000 biological WWTP's in the municipal sector, as well as intensive wastewater treatment and supplementary internal measures in industrial enterprises, the emission of contaminants and oxygen-consuming, organic wastewater components into bodies of water has been significantly reduced. Decisive improvements in the quality of surface waters have thereby been reached.

At the time of the reunification of Germany in 1989, the water bodies in the eastern part of Berlin and in the newly-formed German states - Brandenburg, Mecklenburg-Western Pommerania, Saxony, Saxony-Anhalt, and Thuringia - were, in part, dramatically contaminated. They needed to be quickly and effectively cleaned up. This required the joint efforts of the nation, the municipalities, the states, and the economy in a national solidarity action with substantial financial means. More than 2,000 WWTP's were erected, hundreds of kilometers of sewer pipes were laid, and entire branches of industry were cleaned up.

The German Reunification

After WW II, Germany was divided into two countries. The German Democratic Republic (GDR) existed in the East, which had a planned economy and was ruled by a communistic, single-party government. In the West existed the Federal Republic of Germany with a democratic multi-party system and a social market-based economy. The border separating the two German nations, the so-called "Wall", was secured by the GDR with barbed-wire fence and gun towers. Hardly any regular GDR citizens were allowed to leave the country for the "free West".

The collapse of the GDR and the reunification of the two German nations in 1989/1990 came about by changes in the Soviet Union that started in the mid 1980's. In May 1989, Hungary started to cut a hole in the Iron Curtain. The complete opening of the Hungarian border to the West followed on September 11, 1989. In the summer of 1989, thousands of GDR citizens fled into West Germany through Hungary.

At the time of this mass flight, the opposition movement inside the GDR grew. The activists ventured out into the streets and made their demands public. The resignation of the secretary general of the SED* and state council chairman of the GDR on October 18, 1989, heralded in the collapse of the SED regime.

The opening of the Berlin Wall on the evening of November 9, 1989, was the most important step towards the reunification of both German countries. On May 18, 1990, the agreement concerning economic, monetary, and social union was signed. The GDR adopted the economic system of the Federal Republic of Germany on July 1, 1990. Shortly thereafter, discussions began in Berlin concerning the reunification agreement. On August 23, 1990, the GDR acceded to the federal territory established by the German Federal constitutional law of October 3, 1990.

In the night on October 3, 1990, in front of the Reichstag building, thousands of people celebrated the accession of the GDR to the territory of the new Federal Republic of Germany. The new elections for the Bundestag on December 2, 1990, were the first free parliament elections for all of Germany since 1933.

*(SED = Sozialistische Einheitspartei Deutschland – *United Socialist Party* – the communist ruling party in the GDR)

Today, Germany is one of the most advanced countries, within Europe and worldwide, in the area of water technology and water management. This is not only true with respect to end-of-pipe water protection (e.g. well-constructed WWTP's with a high percentage of hook-ups), but also with respect to a prudent use of drinking water.

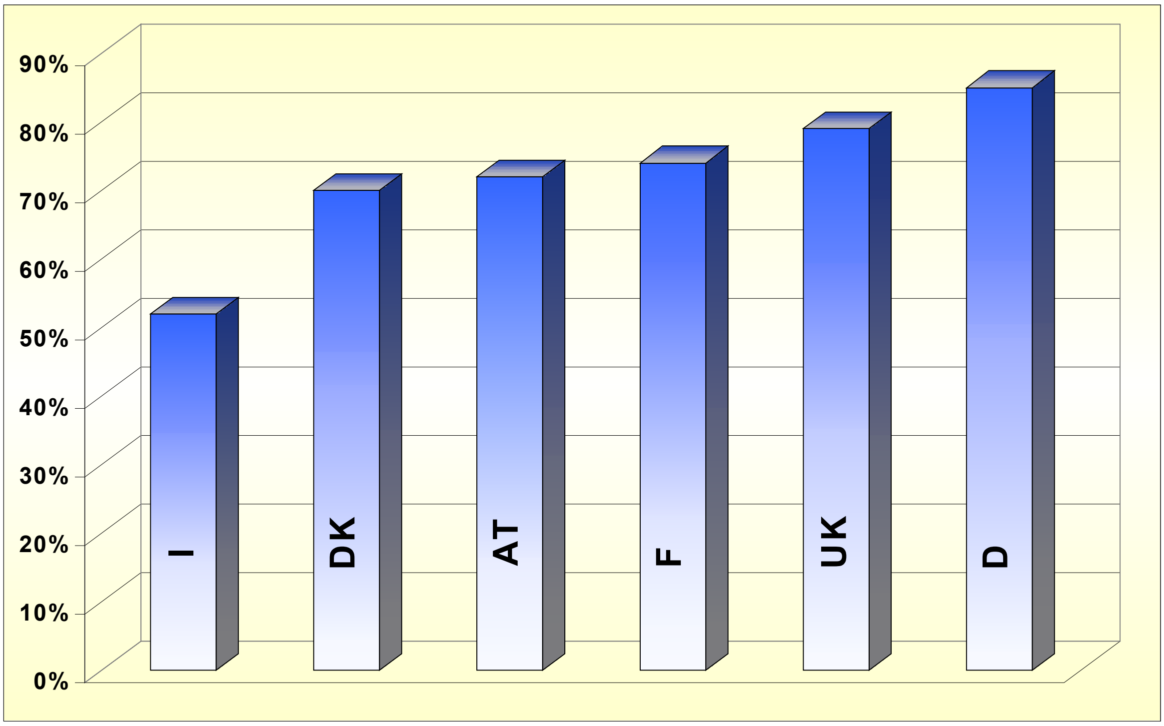
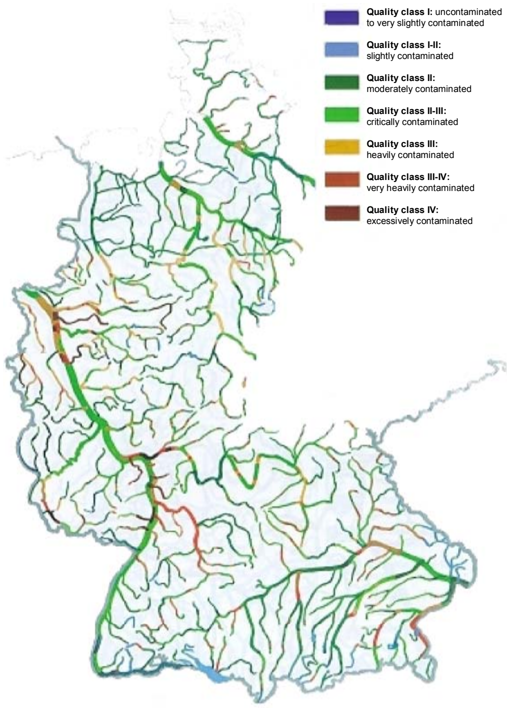


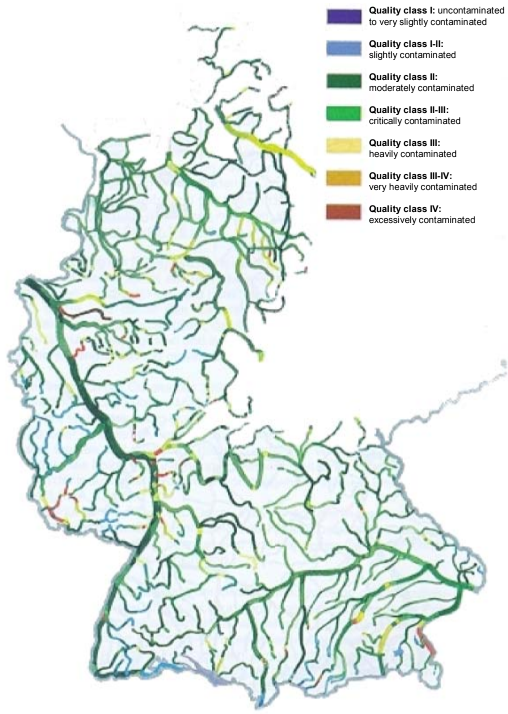
Figure 3: EU-comparison – percentage of wastewater treated in fully biological WWTP`s [47]

The responsibility for water bodies does not stop at national borders. The federal government has accordingly made international cooperation for the protection of seas and inland waters a special emphasis of its environmental policies. In the European Union, the German government is working towards common requirements for water protection on a high level.

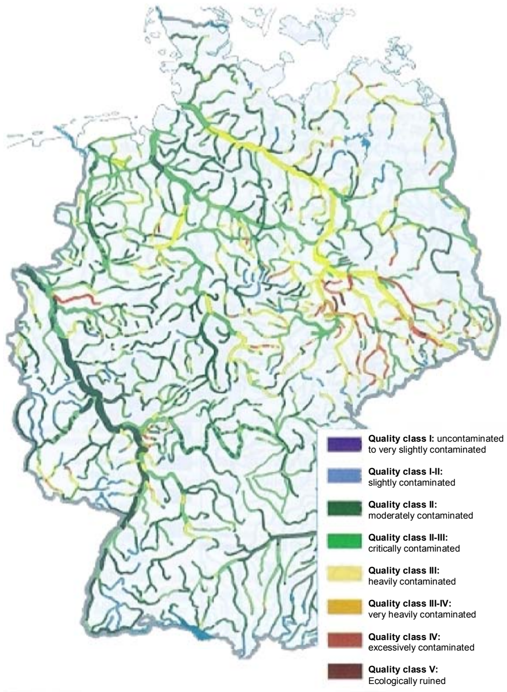
The results of the implementation of this water protection policy can be seen in the development of the water quality in Germany. On the following page are maps depicting Germany's water quality in the years 1975, 1985, 1989, and 1995. The colored sections indicate the quality class of the water bodies in each respective year. Due to the change in the past few years, a positive development in the quality of water in Germany has emerged.



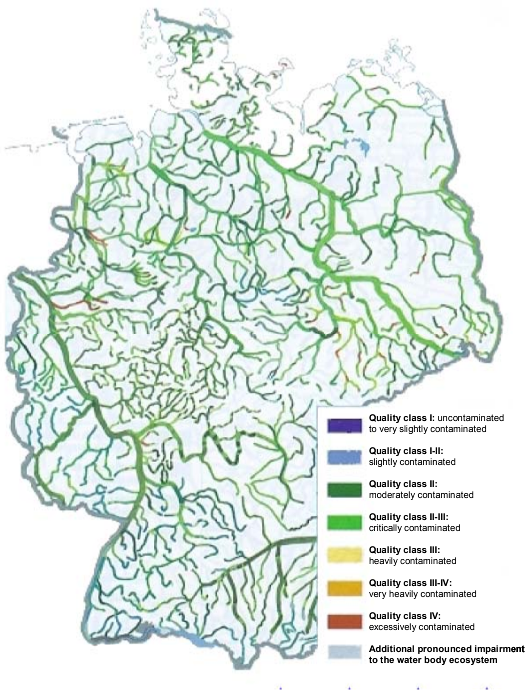
Water quality – status in 1975



Water quality – status in 1985



Water quality – status in 1989



Water quality – status in 1995

Figure 4: Maps depicting the water quality in Germany in various years [22]

3. OPERATION AND INSTRUMENTS OF GERMAN WATER MANAGEMENT – GENERAL FRAMEWORK

3.1 INSTITUTIONAL FRAMEWORK

Germany has a federal structure: the responsibilities of government are divided among the national, state, and municipal levels. The *federal government*, with its headquarters in Berlin since reunification, is responsible for promulgating a national legislative and defining national tasks of water management. There are several federal ministries for various specialized fields: the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (*Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit* - http://www.bmu.de) is responsible for the protection of water bodies; the Federal Ministry of Economics and Technology (*Bundesministerium für Wirtschaft* – http://www.bmwi.de) oversees water supply systems and the water industry; the Federal Ministry of Education and Research (*Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie* – http://www.bmbf.de) is in charge of developing new technologies; and the Federal Ministry for Health (*Bundesministerium für Gesundheit* – http://www.bmgesundheit.de) ensures the quality of drinking water. International cooperation is overseen by the Federal Ministry for Economic Cooperation and Development (*Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung* – http://www.bmz.de). The ministries have at their disposal advisory authorities, such as the Federal Environmental Agency (*Umweltbundesamt* – http://www.umweltbundesamt.de) and the Federal Institute of Hydrology (*Bundesanstalt für Gewässerkunde* – http://www.bafg.de), as well as private, commissioned agencies, such as the Project Agency for Water Technology (*Projektträger Wassertechnologie* – http://www.fzk.de) or the Organization for Technical Cooperation (*Gesellschaft für technische Zusammenarbeit* – http://www.gtz.de).

The *state governments* of the 16 federal states are responsible for the regulation of water supply and wastewater disposal in their territories, within the framework of the federal laws.

The organization and implementation of the water supply and wastewater disposal belong to the traditional duties of the *municipalities*, in accordance with state water laws. In order to cover incurred expenses, the municipalities charge consumers with tariffs and fees. The municipalities must also maintain smaller water bodies in their jurisdiction.

How do the involved members at the various levels and in the various institutions cooperate in German water management?

First of all, whoever wishes to utilize natural the water resources or water bodies must apply for a permit. Applicants are mostly municipalities, water utilities, or industry that desire to construct a groundwater abstraction facility or waterworks, for example, making use of groundwater. Even when a development area or industrial park is to be built and a regular wastewater disposal system (WWTP and sewer system discharging into a river) is planned, an application for authorization is still necessary. With the application for authorization, not only the technical designs need to be submitted, but also (depending on the scope and significance of the project) emission reports, environmental compatibility studies, etc. (See box in sect. 4.6 concerning EIA laws, EIA bound facilities, etc.)

The application for authorization is submitted to the responsible authorizing agency. These are (in most states) the so-called lower water authorities (located in county government offices) for "smaller" projects and the upper water authorities (located in district government offices) for "larger" projects. These water authorities use their advisory authorities at the respective levels - that is, the water management or environmental bureaus [11]. A fundamental, democratic element is the hearing of third parties - for example, nature protection organizations, citizens' action committees, or concerned individuals - which takes place for important decisions through strictly regulated procedures. (See sect. 4.6 for an example.)

If authorization is granted after examination of legal and technical conditions, the proposed project may be carried out, with the observance of the applicable environmental standards and, if the case may be, special requirements for construction and operation.

The definition of standards takes place at various levels. The overlying framework is anchored in the European Union legislation, including especially the following:

- Directive 2000/60/EC Water Framework Directive (http://europa.eu.int/eur-lex)
- Directive 91/271/EEC, concerning the handling of municipal wastewater
- Directive 96/61/EC, concerning the integrated pollution (IPPC Directive)
- Groundwater Directive (80/86/EEC)
- Drinking Water Directive (98/83/EC)
- Nitrate Directive (Directive 91/676/EEC)
- Pesticide Directive (91/414/EEC)
- Water Protection Directive, concerning the emission of hazardous substances into water bodies (76/464/EEC)
- Bathing Water Bodies Directive (76/160/EEC).

German federal law has been and continues to be conformed to this European law and further developed in consideration of the specific, high demands of an environmentally compatible, organized industrial status. At the federal level, the most important regulations within this framework are:

- The Water Management Act
- The Drinking Water Ordinance
- The Groundwater Ordinance
- The Wastewater Ordinance
- The Effluent charge Act
- The Act on the Impact Assessment of Washing and Cleaning Agents
- The Fertilizer Agents Ordinance.

These federal regulations are further substantiated at the level of the 16 German federal states. Corresponding to the individual circumstances and political objectives of each respective state, a state water law, state effluent charge act, etc. has been empowered.

The requirements and standards are formulated most concretely at the lowest level, where framework requirements of the respective superordinate level must be observed. For example, the final decision with regard to treatment standards for a WWTP is made by the municipality. Nevertheless, the municipality must still heed the conditions set by the district government; the district government, on the other hand, must observe the minimum requirements set by the state and federal governments, which must conform to the EU directive (for municipal wastewater). There are more than a few cases in Germany whereby a municipality has voluntarily installed excessively high-performance wastewater treatment technology (with especially good phosphate elimination or additional wastewater disinfection). In very "sensitive" river catchment areas, the district government (or as the case may be, the state government) determines legal limits which are significantly stricter that the minimum requirements in the state (or federal) laws (as is the case in the catchment area of Lake Constance, in Bavarian bathing lakes, or at the Baltic See coast).

In the political process, starting from the first discussion through to the final decision, a close network formed between the various decision-making bodies and the municipal council, the county parliament, the Bundestag, etc. Into this network are integrated also all the scientific associations and interest groups, which exert influence - at so-called hearings, for example - on important new legislation (cf. sect. 3.2.5).

The advantage of such a federal, several-layered structure is that one is able to include all interested parties and experts. For the local parties responsible for water management issues (that is, especially municipal and private enterprises and the water-consuming industry), it is necessary to heed the multitude of laws and regulations with their organizational and technical specifications.

In view of the decentralized decision-making structure, however, it is difficult in Germany to implement all of the central specifications of the European legislation in proper form and in due time. Therefore, complaints have been raised by the EU not only against nations with a less-developed protection of water bodies, but also against the Federal Republic of Germany - despite its undisputedly high standard of execution in comparison with the rest of Europe (Figure 3). The following figure shows the percentage of private households in Germany connected to wastewater disposal. This is representative of Germany's end-of-pipe protection of water bodies.

The supply of water, and even more so the disposal of wastewater, has traditionally been a responsibility of the municipalities. With the increase of technology, the corresponding, gradually rising costs, and, in part, financial bottlenecks, numerous other organizational forms besides the traditional municipal department have been developed and realized (corresponding to the respective requirements of the specific location and political environment) in the last twenty years (see box).

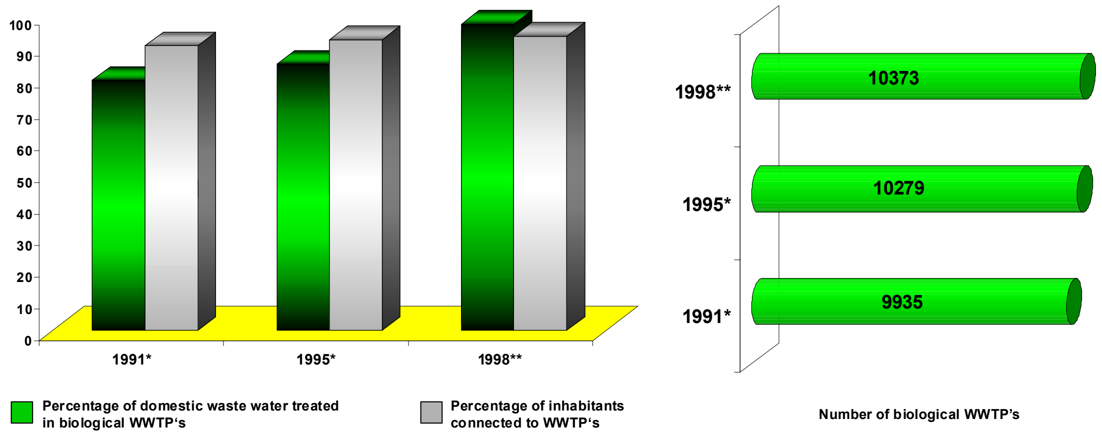


Figure 5: Percentage of households connected to wastewater disposal and number of biological WWTP`s [48, 52]

Due to its federal structure and decentralized decision making process, Germany is most certainly the nation with the greatest diversity of organizational forms, whereas the majority of the ca. 450 cases with private involvement consist of a combination of various models for private involvement [46]. The municipalities have a prominent position in Germany because of the legal situation. The national water market is not dominated by international corporations, as is the case in some other European countries, but rather by a multitude of chiefly medium-sized enterprises and municipal companies [44].

The cooperation between municipalities in water and wastewater associations plays a special role in Germany. This cooperation emerges mostly voluntarily, but it is sometimes also initiated by the state. The associations work to make the organization of water supply and wastewater treatment, the maintenance of water bodies, and water protection more technically and economically efficient. They differ from one another according to tasks, regional size and form of organization.

Organizational forms of water supply and wastewater disposal systems

By virtue of the federal and state laws, municipalities are free in choosing the organizational form of "their" wastewater disposal. The municipalities may decide for themselves (according to their political and economical preferences), if and to what to degree they want to privatize or not. There are no central specifications for the so-called "delegation of duties to a third party". Complete privatization, however, is only permitted in a few states, and then only under considerable stipulations [cf. 10, 44]. The most common organizational forms are as follows:

Municipal department (Regiebetrieb):

Operated by the municipality within the scope of the regular municipal administration.

Municipal utility (Eigenbetrieb):

Operated by the municipality in a separate capacity with independant bookkeeping.

Municipal company (Eigengesellschaft):

Private entity company in the hands of the municipality.

Joint venture (Kooperationsmodell):

Municipal utility with the involvement of a private firm.

Operator model – BOO, BOOT, BOT, etc. (Betreibermodell):

Delegation of the plant operations to a private firm, whereas the responsibility for the fulfillment of tasks remains with the municipality.

Management and service contract (Betriebsführungsmodell):

The plant property belongs to the municipality, but the operations and any further management tasks are delegated to a private firm.

Depending on jurisdiction, it is possible that boundaries for associations, water utilities, and municipalities overlap, so that outsiders have difficulty recognizing the organizational structure. Therefore, there are water supply associations or private long-range water utilities whose boundaries of operation do not coincide with the boundaries of the local water utilities, which are supplied by the former. Similarly, there are large-scale wastewater associations which are responsible solely for long-distance transportation and for wastewater treatment and whose boundaries do not match up with the municipalities or disposal companies. These municipalities and disposal companies, on the other hand, handle wastewater collection through local sewer systems.

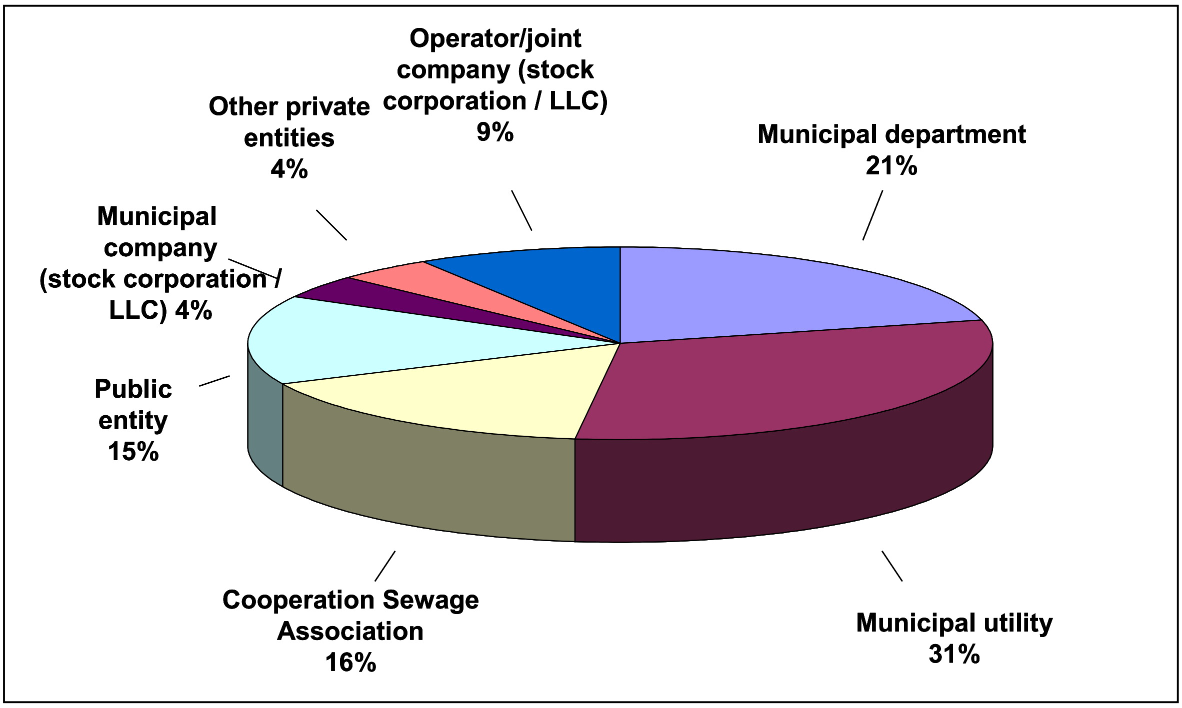


Figure 6: Implementation of wastewater handling in Germany (in % of total population) [own assessments, based on data from the water industry (BDE) and ATV as of 2001]

There is also variation in the composition of the decision-making bodies of regional associations, municipal parliaments, municipal committees, member assemblies of associations, and supervising councils and advisory boards of private water utilities.

It becomes apparent that the strength of Germany's water management lies by no means in a central and tightly-organized arbitration or in the controllability of the system "from above". Its strength is found rather in the obligatory and widespread hearing of experts and interested parties of all relevant groups and in the *democratic and constitutional consideration of various interests and viewpoints*. This all leads in the end to a consensus, or as the case may be, to a compromise. The more drawn-out and difficult the way to a consensus or compromise is, the more pertinent and successful the implementation of the solution will be.

3.2 IMPORTANT, SPECIFIC REGULATORY INSTRUMENTS

The technical and economical regulation of water management takes place in Germany on the basis of the above-mentioned laws (sect. 3.1) according to various operative principles that supplement one another. The following regulatory instruments will be addressed in greater detail:

- Price control (sect. 3.2.1)
  With various regulations for the supply of water and disposal of wastewater.

- Financial incentives (sect. 3.2.2)
  By which the participants' interest in a sustainable use of water bodies is to be strengthened. For example, the abstraction of groundwater or the discharge of wastewater is controlled by charges (Water Abstraction Fee – *Gundwasserentnahmeentgelt*; Effluent Charge – *Abwasserabgabe*).

- Minimum requirement standards (sect. 3.2.3)
  With quality requirements for drinking water or, as shown below, for effluent from WWTP's, corresponding to the Ordinance on Wastewater—as well as standards for the technology and operation of plants.

- Prohibitions and obligations (sect. 3.2.4)
  Mostly for the limiting of substances hazardous to water bodies, as is then shown in the example of the Act on Washing and Cleaning Agents.

Beyond these, there are several environmentally relevant principles in the area of water management (Figure 7). They concern the fundamentals of a sustainable water management policy which, in practice, cannot be perfectly implemented at all times and in all places. Nevertheless, these principles offer the decisive orientation for politics and the economy in view of a sustainable use of resources.

3.2.1 MUNICIPAL CHARGES ACT AND ANTITRUST LAW

Price mechanisms for water supply are based on principles and regulations which differ from those of wastewater disposal. *Wastewater disposal* is subject to the cost recovery principle; that is, the municipalities responsible for wastewater disposal allocate the costs to the consumers, but they may not include a profit margin.

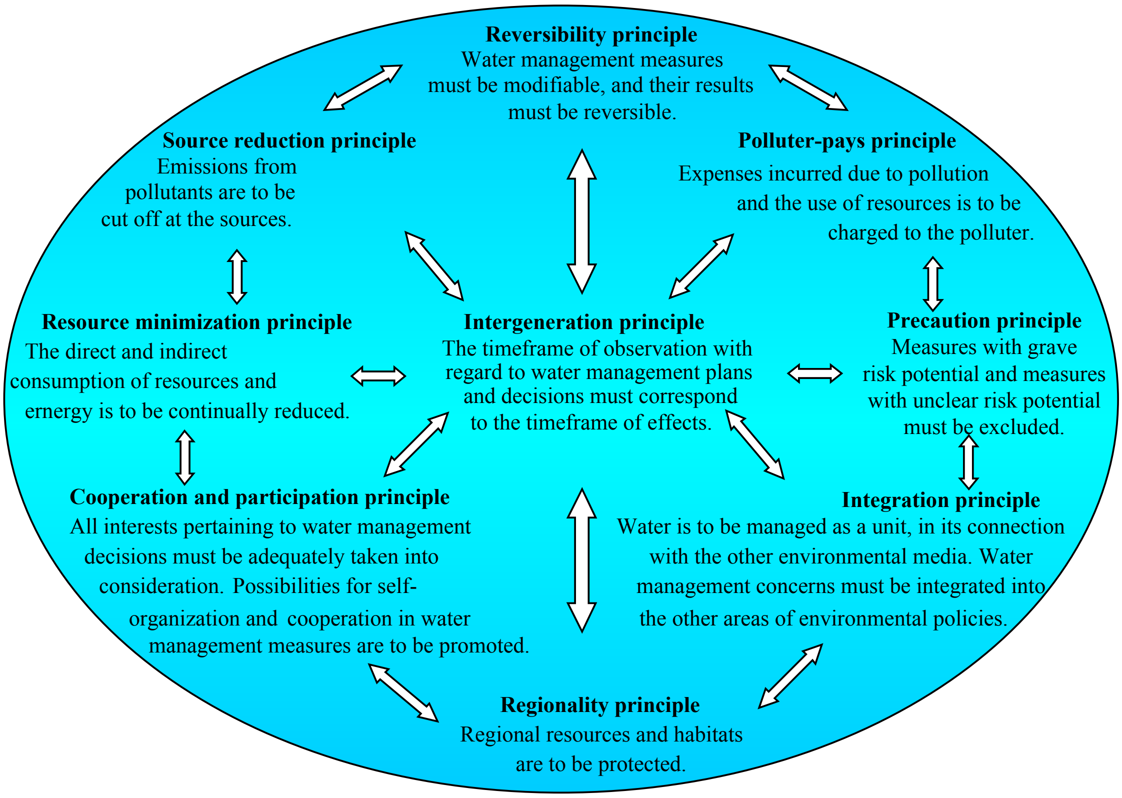


Figure 7: Interaction of principles relevant to water management [26]

In practice, there is an abundance of precepts and relevant court decisions dealing with approaches in the individual cost positions. Figure 8 presents an overview of types of costs and their part in the calculation of wastewater fees.

Water supply systems organized as private entities are regulated in a different manner. The municipality is not responsible for their supervision, but rather the antitrust agency (which, incidentally, also regulates the supply of gas and electricity). Upon inquiry, water utilities must be able to verify, and if need be, demonstrate, that their water prices are not higher than those of comparable companies and suppliers.

If the antitrust agency conducts an investigation due to suspicion of “misuse of pricing”, the technical standard and cost structures are closely examined and then compared to those of similar companies (which corresponds, in part, to Cost Benchmarking – *Kosten- Kennzahlenvergleich*).

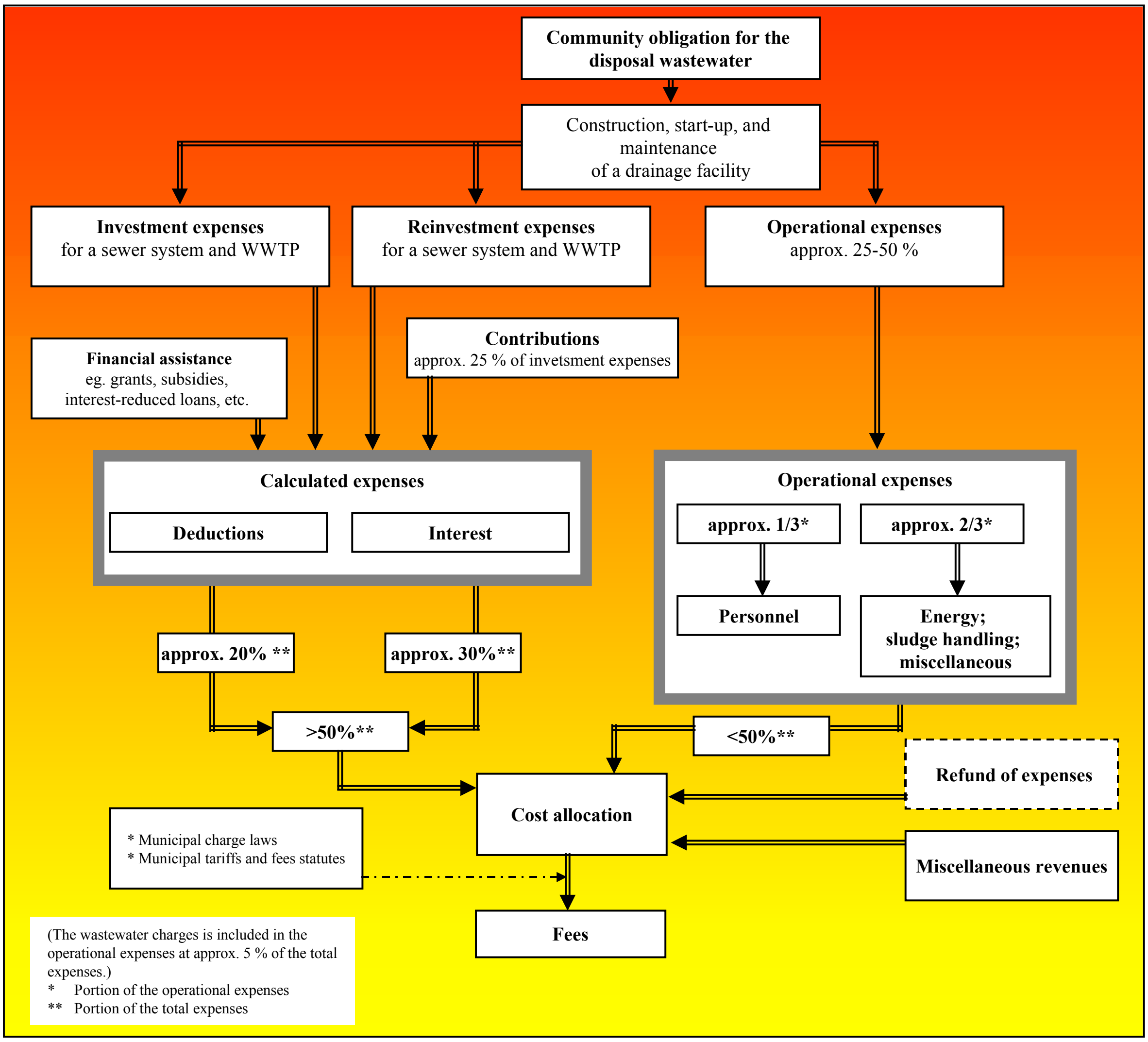


Figure 8: Breakdown of the most important types of expenses in wastewater disposal [48]

This approach is essentially not any different than in countries with central price regulation*. Germany's approach differs from these others, however, in that it uses no uniform formulas applied from a central agency, but instead considers each situation individually, which corresponds to Germany's federal, decentralized structure [41, 48].

3.2.2 EFFLUENT CHARGES ACT (*Abwasserabgabengesetz, AbwAG*)

The Effluent Charges Act of 1976 (last amended in 1994) makes the provision that a charge must be paid for the point source discharge of treated wastewater into a water body. Generally, the payment of effluent charges in no way exempts one from the responsibility of treating wastewater. *This charge is the only nation-wide environmental charge in the area of water that functions as a deterrent.* The polluter-pays principle is brought to bear with this charge, for point source dischargers must be held liable for at least a portion of

* as, for example, in English water management with the Office of Water, OFWAT

the costs of the utilization of the environmental resource of water. The charge is calculated according to the amount and harmfulness of the respective substances discharged.

The charge per pollutant has been raised, in several steps, from DM 12 (ca. € 6) in 1981 to DM 70 (ca. € 35) since January 1, 1997. Economic incentives are to be created with this charge for reducing as many point sources as possible. For that reason, the AbwAG (Effluent Charges Act) also provides discounts for cases in which the payer meets certain minimum requirements. In addition, certain investments for the improvement of wastewater handling can be offset against the charge.

The effluent charge is paid to the states. It is to be used strictly for the conservation of water bodies. On average, the effluent charge comprises about 5% of total costs. In Germany, this corresponds to approx. € 5 per inhabitant per year. The economic deterrent function is greater in individual cases, however, since fines need to be calculated into the total if a plant exceeds the so-called monitoring standards. Such fines apply most of all to point source dischargers with deficient WWTP's, but also to operators of modern plants who, because of their poor operation, do not attain to a satisfactory level of treatment.

Table 1: Contaminants and pollution units (*Schadeinheit*, SE)* according to the Effluent Charges Act (AbWAG)

Rated contaminants and contaminant groups	Measurements constituting one pollution unit
Oxidizable substances in chemical oxygen demand (COD)	50 Kilograms Oxygen
Phosphorus	3 Kilograms
Nitrogen	25 Kilograms
Halogen compounds as adsorbable organic halogen compounds (AOX)	2 Kilograms Halogen as organic chlorine
Metals and their compounds: Mercury Cadmium Chromium Nickel Lead Copper	 20 grams 100 grams 500 grams 500 grams 500 grams 1000 grams metal
Toxicity to fish	3000 cubic meters of wastewater divided by the dilution factor G_F, by which wastewater is no longer toxic to fish

* "One SE corresponds roughly to the harm caused by the raw waste water produced by one inhabitant in one year (inhabitant equivalence)." - http://www.umweltbundesamt.de/uba-info-daten-e/daten-e/waste-water-charges-act.htm

3.2.3 WASTEWATER ORDINANCE (*Abwasserverordnung*, AbwV)

The Wastewater Ordinance sets technical standards, such as legally binding pollutant limits, which are for various kinds of wastewater. The ordinance was one of the first measures for the implementation of the sixth amendment to the Water Management Act, which took effect in November 1996. It regulates, among other things, the requirements for the discharge of wastewater within the scope of municipal handling of wastewater and implements European requirements for the protection of water bodies. Altogether, there are 54 appendices with specific regulations for domestic wastewater and for various industries. Table 2 lists some of the appendices for selected industries.

Table 2: Appendices to the Wastewater Ordinance (*Abwasserverordnung*, AbwV)

Area / branch of industry	Example
Municipal disposal	Appendix 1 Municipalities / domestic wastewater
Foodstuffs industry	Appendix 3 Milk processing Appendix 7 Fish processing Appendix 10 Meat processing
Animal feed industry	Appendix 14 Drying of plant products for the production of Animal feed
Chemical industry	Appendix 9 Manufacturing of coating materials and varnish Resins Appendix 22 Chemical industry Appendix 45 Petroleum processing
Metalworking industry	Appendix 24 Part A Iron and steel production Appendix 24 Part B Iron, steel, and malleable iron foundries Appendix 40 Metalworking, metal processing
Waste management industry	Appendix 51 Aboveground landfills
Electrical industry	Appendix 54 Manufacturing of semiconductor components

These discharge requirements are *minimum requirements* within the scope of a federal law. It is left to the states and their water authorities to define and enforce higher standards on an individual basis, where this is necessary due to an especially sensitive water body ecology and other reasons for the protection of the common good (cf. sect. 3.1). Therefore, there are many municipal WWTP's that have a higher discharge standard than the minimum requirements listed in Table 3.

These standards are to be observed for continuous operation, even in unfavorable pollutant conditions. With regard to the minimum requirements for the parameter $P \leq 1$ mg/l, for example, an even better operational standard (e.g. $P \leq 0.7$ mg/l) is set, in order to maintain a sufficient margin of safety above the minimum requirement. In Germany, if these prescribed standards are not observed, an administrative offense is to be assumed. Under certain circumstances, the violation of the prescribed minimum standards is a punishable act that is prosecuted by the authorities.

Table 3: Minimum requirements concerning the discharge of municipal wastewater according to the AbwV

Size classes of WWTP's	Chemical oxygen demand (COD)	Biological oxygen demand in 5 days (BOD_5)	Ammonium nitrogen	Total nitrogen as total of ammonium-, nitrite-, and nitrate nitrogen	Phosphorus total (P total)
Population units	mg/l*	mg/l*	mg/l*	mg/l*	mg/l*
less than 1,000	150	40	---	---	
between 1,000 and 5,000	110	25	---	---	---
between 5,000 and 10,000	90	20	10	---	---
between 10,000 and 100,000	90	20	10	18	2
larger than 100,000	75	15	10	18	1

1 population unit = 60 g BOD_5/d in untreated wastewater *Qualified sample or 2 hr mixed sample

3.2.4 WASHING AND CLEANING AGENTS LAW

The Washing and Cleaning Agents Law of 1975 (amended in 1994) sets requirements for the environmental compatibility of washing and cleaning agents. The use of water-polluting substances can be forbidden or limited. The law obligates makers of washing and cleaning agents to inform the Federal Environmental Agency (UBA) of the basic contents of their products. Furthermore, the law requires that the consumer be informed by the packaging of the respective product about the most important components and the quantity to be used.

On the basis of the Washing and Cleaning Agents Law, the Ordinance on Surfactants and the Ordinance on Maximum Permissible Amounts of Phosphate were enacted. The Ordinance on Surfactants stipulates that surfactants contained in washing agents must be at least 90% primary biodegradable.

Phosphate-free washing agents have become widely available on the market. Due to this change in cleaning agents, the emission of phosphate into water bodies through washing agents in domestic wastewater had decreased from 42,000 tons of phosphate in *1975* to approx. 2,000 metric tons in *1993* (in the former West Germany).

In addition, in 1993, after foundations were laid with strict criteria concerning the complete biological degradability and the toxicity to water organisms, the “Blue Eco Angel” (a voluntary product symbol) was first awarded to a cleaning agent in the modular construction system, in order to support product users in making their households environmentally friendly. In 1995, criteria that had been worked out under German leadership were passed for a European Environmental Label for cleaning agents.

3.2.5 THE TECHNOLOGICAL REGULATORY FRAMEWORK OF GERMAN WATER MANAGEMENT

The implementation of water management tasks does not just take place on the basis of regulations from governmental agencies. Scientists and representatives of water management work closely together with governmental agencies in the conceptualizing of uniform technological specifications. With this approach, the cooperation and participation principles are allowed for in German water management.

The implementation of uniform technological regulations makes a significant contribution to the effective and economical protection of the environment and of real assets. Through the continual process of revising and updating, based on the current state of science and technology, the regulatory framework supports policy issues, administration, and industry. The specifications are important for the designing, constructing, and operating of water supply systems and WWTP's. Even statements concerning the maintenance and monitoring of plants are taken into consideration by experts in the drafting of the regulatory framework. A selection of topics in the technological regulatory framework and its contents are summarized in the following table.

Table 4: Examples of topics in the technological regulatory framework

Area	Contents
Water supply	Protected water areas Mechanical equipment in waterworks Optimization and cost reduction in waterworks
Drainage systems	Planning / calculating Construction / repair Operation
Municipal wastewater treatment	Assessment Treatment processes Small WWTP's
Industrial wastewater	Technology-related water protection
General water management	Hydrology Groundwater Water quality Ground protection Nature protection and ecology

The following regulatory frameworks, among others, used in German water management are also available in foreign languages:

Table 5: German regulatory frameworks in foreign languages

Regulatory framework	Language
ATV standards (Abwassertechnische Vereinigung e.V. www.atv-dvwk.de)	German; partly in English, French, Spanish, Polish
DIN standards (Deutsches Institut für Normung e.V. www.din.de)	German; partly (depending on demand) in English, French, Chinese
DVGW regulatory framework (Deutsche Vereinigung des Gas- und Wasser www.dvgw.de)	German; some excerpts in English, French, Russian, Polish

German regulatory frameworks and technological standards (DIN: http://www.din.de) are being increasingly adapted into the European standards, the so-called CEN Standards. As a result, legislatures as well as licensing and supervisory authorities revert to such regulatory frameworks in defining standards and in evaluating individual cases.

It is remarkable that such regulatory frameworks arise out of the independent responsibility of experts, organized by professional associations of water management. To such an extent, even regulations and standards are the result of a consensus or compromise-finding process into which various viewpoints have entered. The current trend "away from detailed standard specifications for measures in the sense of input definitions – toward a result-oriented regulation of operational performance in the sense of an output-oriented definition" will help expedite matters so that the dynamic of technological innovations is not slowed down through far-too-sluggish standardization processes and obsolete regulatory frameworks.

3.3 WATER SUPPLY

The natural *availability of water* in Germany is approx. 182 billion m³ [16]. The largest portion, namely 26.4 billion m³ (1991: 28.7 billion m³), was used in 1998 as cooling water in thermal power plants for public power supply. Industry was supplied with 8.9 billion m³ and agriculture 0.2 billion m³. Public water supply requires 5.5 billion m³ (1991: 6.5 billion m³).

Water potential [m³/pers./a]
(= rainfall + inflow +runoff - evaporation)

Kuwait	10
Saudi Arabia	111
Israel	346
Egypt	851
South Africa	1,238
Peru	1,559
India	1,882
Germany	2,080
Austria	10,998

On the 5.8 billion m³ water supply, approx. 4 billion m³ were distributed to households and small trade. The pie chart shows the types of untreated water used (1995).

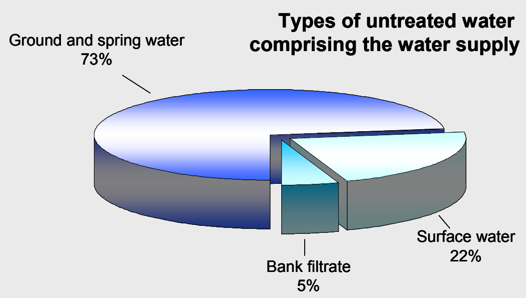


Figure 9: International water potential [19] and types of untreated water that comprise Germany`s water supply [16, 45]

In the long-term average, the water balance displays a surplus of water. Currently, nearly 2% of the natural water resource, in reference to precipitation, is used for public water supply. A quantitative shortage of this resource does not need to be feared under current climatic conditions. However, in regions where there is a large demand for drinking water, yet at the same time a poor quality of raw water, it is quite possible for a temporary, regional shortage situation to develop. Regions of water shortage are offset by regions of water surplus by means of long-distance water supply lines. Long-distance water supply lines are located, above all, in Bavaria, Baden-Württemberg, Lower Saxony, Saxony, Saxony-Anhalt, Thuringia, in the Ruhr area, and in the area surrounding Frankfurt/Main.

For the public *drinking water supply*, groundwater and spring water were predominantly used in 1998 (72.7%), followed by surface water (22%), and bank filtrate (5.3%) [54]. Of the 5.5 billion m³ of water intake for the public water supply in 1998 (1991: 6.5 billion m³), 23% (1991: 23.5%) could be supplied directly to consumers as “clear water” without any previous treatment, and 77% (1991: 76.5%) were supplied as raw water into drinking water treatment plants.

Since the mid 1970's, a decoupling of water consumption from the general economic development has taken place. When comparing the added value generated by industry to the total drinking water supply (water from private wells + water from utilities) of industry, then the decrease of the industrial drinking water consumption per € 1 billion added value and thereby the increase of water productivity in the German national economy becomes clear.

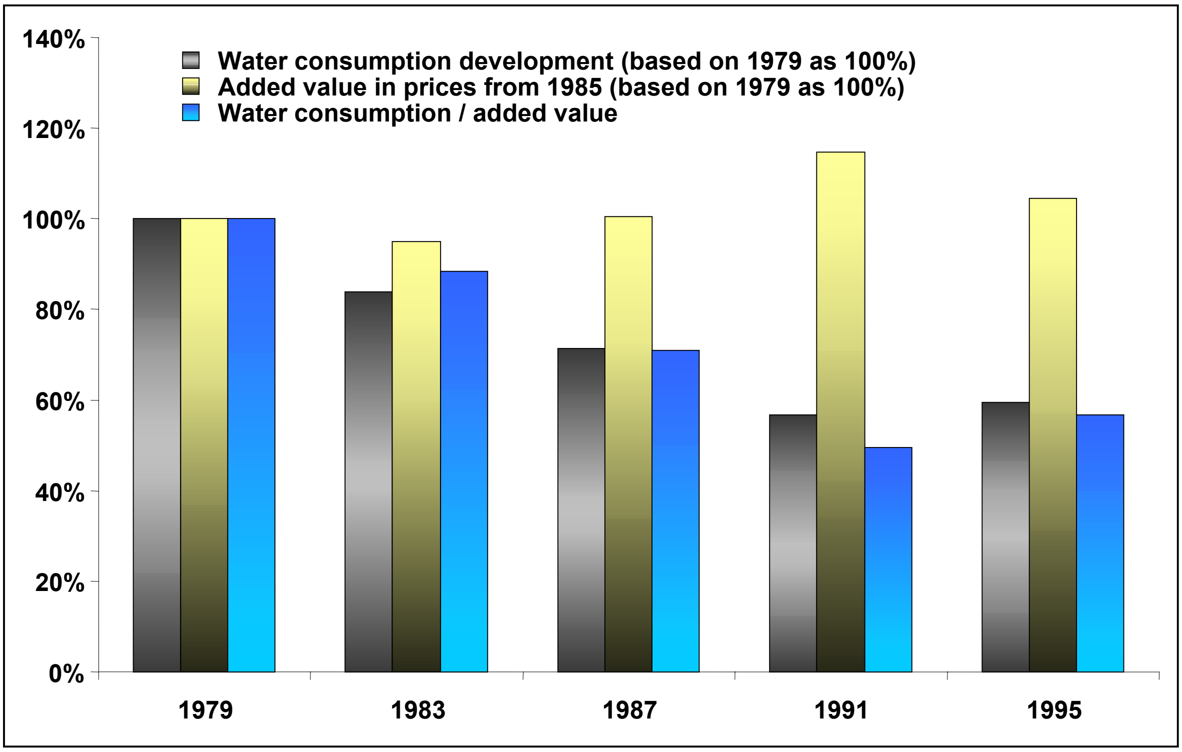


Figure 10: **Added value and specific water consumption of the German economy (mining and manufacturing trades)**

Similarly, this is also true for the per-capita consumption (specific water consumption of private households and small businesses) (see Figure 12). Of total water consumption, personal hygiene (36%) and toilet flushing (27%) account for the greatest portions. Just short of 4% is required for drinking and cooking.

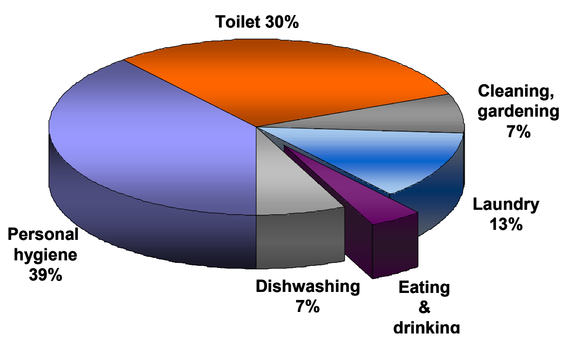


Figure 11: Water consumption in an average German household [24]

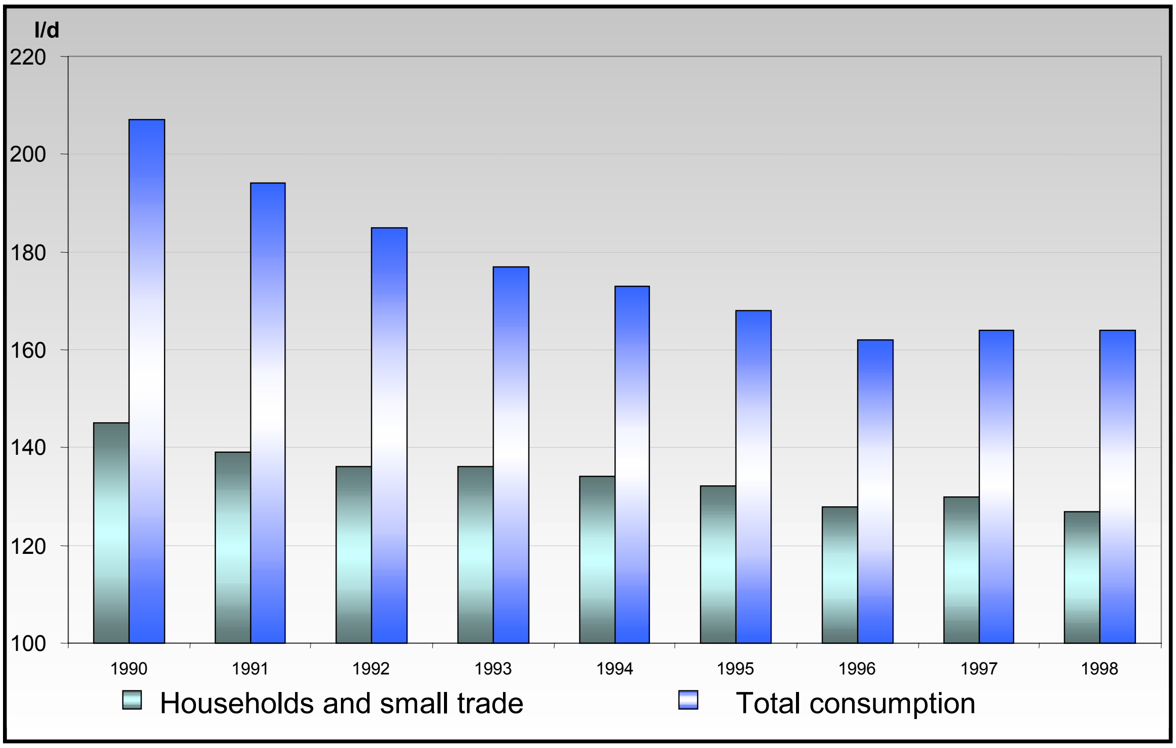


Figure 12: Development of the specific water consumption of selected consumers [52]

Regardless of the organizational form of water supply systems in Germany, as a basic principle, all costs of drinking water supply are covered by the *price of water*. This leads to regional price variations. The average price for drinking water in the household sector in 1992 was € 1.35 / m³. According to BGW (Federal Association of German Gas and Water Management – *Bundesverband der deutschen Gas- und Wasserwirtschaft*) surveys, the average price of water for private households in former West Germany in 1995 was € 1.50 / m³, while the price increased in the newly-formed German states (formerly GDR) from € 1.56 / m³ (01/01/95) to € 1.65 / m³ (01/01/96). Including miscellaneous charges (metering and base fees), the price of water in Germany today (2000) is approx. € 1.73 / m³; and unlike most other nations, it covers the full cost of supplying water (see also sect. 4.3.6.2).

Germany has a very good *drinking water quality*. The government monitors the observance of the strict legal specifications through the local health authorities within their jurisdiction. Hygienic risks - such as bacterial contamination, for example - are lowered by means of the ongoing maintenance of plants and distribution systems. The constant monitoring of drinking water quality makes it possible to quickly analyze shortages and introduce countermeasures [16]. Therefore, even in Germany, additional chlorine, for example, is used in some regions for disinfection when problems arise; or immediate and detailed information is sent out to the consumers in the potentially affected regions. Emergency procedures, especially, prevent negative long-term consequences.

Leakage

The percentage of leakage in a distribution system is no doubt the most important quality parameter for the state of repair of pipelines and pipe fittings, including operation and the condition of maintenance. If the pipe system is out-of-date, in a bad condition of maintenance, or poorly operated and monitored (so that, for example, water is illegally abstracted), a correspondingly high rate of leakage results. Even though Germany is a country that is abundant in water, the water utilities have been required for decades to minimize leakage - whereby hygienic and ecological aspects also play a role, next to economic considerations. (Every cu. meter of transported and treated water that is lost also means a wasted use of energy, chemicals, etc. Not only treated drinking water is lost through leakage; under certain circumstances, pollutants may also enter into the water system, which results in a contamination of the drinking water.)

A high leakage rate in a water distribution system signals deficiencies in the condition of the pipes and fittings, old age and pending need for renewal, and / or deficiencies in the ongoing maintenance and leakage-monitoring. The following graph shows the relation of water utilization to leakage in several countries.

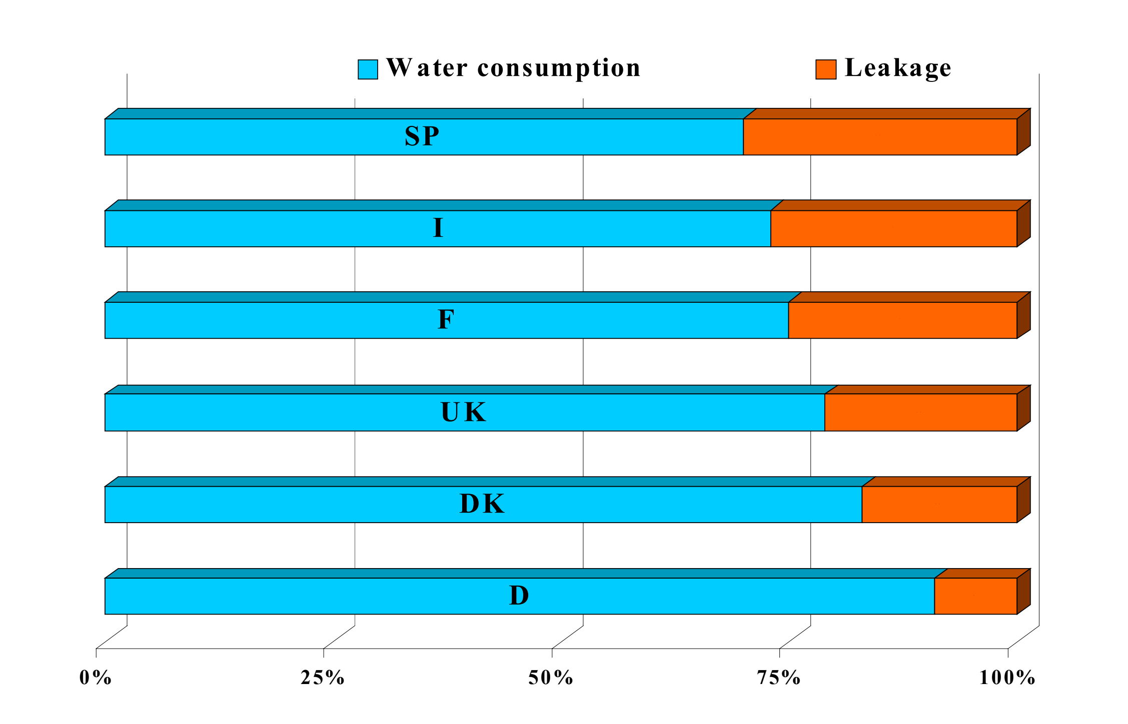


Figure 13: Leakage according to UN data [50 updated in part]

3.4 WASTEWATER DISPOSAL

Every densely-populated area of Germany, without exception, possesses a central wastewater disposal system. According to information from the Federal Statistical Office, the total volume of wastewater in 1998 was approx. 9.6 billion m^3, including about 4.9 billion m^3 of domestic and commercial wastewater. The predominant amount of wastewater (99.5%) was treated in public WWTP's. Only 0.5% of the wastewater was handled in industrial plants. The portion of external water that entered into the sewer systems in 1998 was estimated at about 2 billion m^3. Point source discharges without any treatment were reduced from about 115 million m^3 in 1995 to about 65.3 million m^3 in 1998.

Figure 14: Joint WWTP Bitterfeld (above-ground bioreactor – population equivalent =453,000) (pilot project of the BMU for the joint handling of domestic wastewater and industrial chemistry wastewater)[5]

From 1970 to 1994, over € 78 billion were invested by the municipalities in former West Germany for the construction, expansion, and renovation of sewer systems and WWTP's. Twenty-three billion Euros went for the expansion of WWTP's, and approx. € 55 billion were appropriated for *investments* in the area of sewer systems. From 1991 to 1996, approx. € 22 billion were invested in the overall area of WWTP's in Germany. The annual expense of municipalities and wastewater associations for public wastewater disposal amounts to over € 6 billion.

The term "wastewater"

The term "wastewater" defines water that ends up in the sewer system and has come from one of these sources: water that has been altered, in particular contaminated, through domestic or commercial use, surface run-off, or rainfall (cf. WHG, AbwAG, DIN 1045). There are thus two kinds of wastewater: contaminated water and meteoric precipitation.

Contaminated water originates, for example, from clean water that has been altered in its chemical or physical properties through use as wash or rinse water. In the Wastewater Charges Act, the distinction is often made whether the alteration of the water is ecologically detrimental, inconsequential, or even advantageous.

Regarding the term "contaminated water", it is irrelevant where the water originates - that is, whether it was taken from groundwater before alteration through use, from surface waters, or from a water supply line.

If the water, however, is extracted only for storage purposes and is discharged again (e.g. at excavation sites), it does not fall under the term "contaminated water", unless it was used for another purpose (e.g. as wash water or for flotation purposes) before it was discharged.

According to 1998 statistics, only 6.8 % of Germany's population was not hooked-up to a public sewer system in that year. With a 93.2% connecion, one can speak of a practically complete sewer system in Germany. There are still gaps in the newly-formed German states, where, according to individual states, between 12% (Thuringia) and 31.4% (Brandenburg) of the population is not hooked-up to public sewers. There are connection gaps in other areas of Germany as well, particularly in several rural areas. But even there, wastewater is practically completely disposed of through private septic tanks with periodic fecal sludge removal and treatment.

Altogether, there are approx. 445,700 km of usable public sewers in Germany, about 51% of which are mixed-water sewers, in which contaminated water and rainwater are transported together. There are about 134,000 km of sewers in the public sewer system that only transport contaminated water. In these sewers, feces are carried off for treatment along with greywater from domestic and commercial use. Rainwater is drained in about 85,000 km of separate rainwater sewers. Alternatively, rainwater seeps away on-site. Besides the public sewer system, there are privately owned sewer systems, as is the case with large industrial enterprises. Accurate figures for the length of these sewers are currently not available.

According to a survey taken by the Association for Wastewater Technology (*Abwassertechnische Vereinigung e.V.* – ATV – http://www.atv.de), 33% of all *sewers* were less than 25 years old or less in 1997. More than one third of all public sewers were between 25 and 50 years old. Eleven percent were in the 50 to 75 year-old age group, and 16% were between 75 and 100 years old. Only 4 % of all public sewers in Germany were more than 100 years old. Somewhere between 40,000 and 80,000 km of public sewers were in need of repair. The repair and modernization of present systems is a future task in Germany, after all necessary sewers and treatment plants have essentially already been built.

About 60% of the approx. 2.5 million Mg (1998) of *wastewater sludge*-dry matter that accumulates during wastewater treatment is reused. Wastewater sludge is used as fertilizer in the preparation of nutrient-rich soil for agriculture and gardening. However, the high level of recycling in agriculture is to be greatly reduced. According to resolutions by the responsible authorities in the summer of 2001, it is intended that, in the future, sludges be predominantly burned. Responsible for these decisions to "exit" out of recycling wastewater sludge by agricultural means were incalculable microbial and chemical risks with regard to the depositing of wastewater sludge onto agricultural areas. Starting in 2005, no more organic wastewater sludge is to be deposited in landfills. Therefore, thermal resource recovery (e.g. in thermal power plants) will gain in importance.

Mandatory connection and use

In the statutes for wastewater disposal in the municipalities, mandatory connection to and use of wastewater disposal facilities has been made binding for the land within the municipality. Therefore, every property owner in the area of jurisdiction is obligated by these statutes to connect the property to the local wastewater disposal system as soon as wastewater accumulates on the property (mandatory connection). The landowner is then further obligated to discharge the total amount of wastewater generated on the property into the wastewater disposal system (mandatory use). There are also exceptions, however, which the statutes regulate for selected cases, such as agricultural production.

Mandatory connection and use in Germany traditionally belongs to duties delegated to the municipalities and is part of the public health protection policy.

The intended purpose of public wastewater disposal is the continual guarantee of the cleanliness of groundwater, in the interest of the common good. Regulations for exceptions apply to individual solutions; however, they must not be beneficial just for industrial firms or private households, but must be technologically and economically purposeful also for the entire disposal area.

continuation of Mandatory connection and use

It is obvious that mandatory connection and use involves many conflicts. When centralized water supply system was introduced in rural areas after WWII, in the 1950's and the beginning of the 1960's, there were time and again individual citizens who were satisfied with their own private wells and - despite the many hygienic risks involved in a private water supply - categorically refused to connect to the municipal facility. With regard to wastewater disposal, there are cases still today in Germany in which the connection to central wastewater collection and treatment is fought against with sever means, in one case even with a long-lasting hunger strike. Reasons for such opposition are most often the costs of wastewater disposal, but sometimes also ecological arguments and a grassroots-democratic striving for autonomy.

Indeed, no nonsensical centralized system may be implemented beyond the mandatory connection and use system. Technological advances today allow for the secure operation of even very small WWTP's. For that reason, decentralized and semi-decentralized concepts have gained increasingly in importance in designs for wastewater disposal.

The *costs of wastewater* disposal basically need to be covered by the fees and tariffs paid by private and commercial connected parties. Therefore, mandatory connection to and use of the public water supply and wastewater disposal is generally necessary.

According to surveys by the Association for Wastewater Technology and the Federal Association of German Gas and Water Management, the average total cost for wastewater disposal in 1996 amounted to € 108 per inhabitant per year. In the newly-formed German states, in comparison to the old German states, there was an € 18 lower charge per inhabitant per year. The reason for this is that, despite higher average wastewater fees, water consumption in the newly-formed German states is lower than in former West Germany. For initial investments in WWTP's, states offer much support to municipalities by means of subsidies in varying amounts.

The distribution of cost types (see Figure 8) for wastewater disposal, as the basis for calculating disposal fees, varies with the regional peculiarities in the respective municipal disposal areas. In 1998, on average, amortization accounted for 27% of costs, interest payments for 24%, personnel for 15%, the cost of electricity and materials accounted for 14%, waste disposal took up 4%, and the rest went to "miscellaneous expenses".

Water tariffs and wastewater fees

In a densely-populated industrial nation like Germany, the reliability and quality of a water supply system and of water protection is extremely important. Germany's level of technology and logistics is comparatively high; however, so are the costs, which are largely paid by the consumers by means of water tariffs and wastewater fees (full cost recovery).

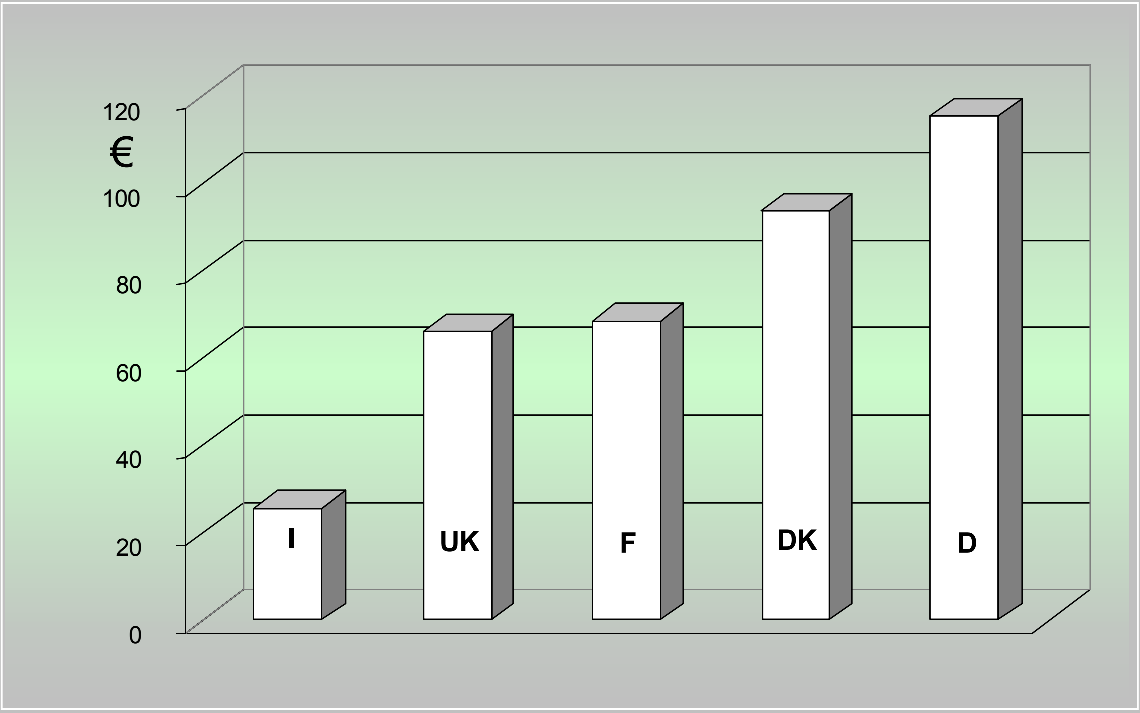


Figure 15: International comparison of wastewater treatment fees 1998 (per inhabitant per year) [28] [52]

In the former GDR, the wastewater treatment facilities were in a deplorable condition; in many places, WWTP's were nonexistent. The water prices in the socialist planned economy didn't even come close to covering the costs of water treatment.

After German reunification, the systems needed to be repaired and newly built in as short of a time as possible. While the costs could be somewhat cushioned by state subsidies, etc., primarily industry and the population connected to the systems had to bear the drastically increased water prices, including capital and operational expenses. This led to protest and political problems in many places.

There were similar problems also in several municipalities in western and northern Germany. Brought on by a few undesirable developments or extremely high costs, due to the rural structure and unfavorable conditions (construction grounds, topography, small receiving waters), doubts arose concerning the fairness of prices.

continuation of Water tariffs and wastewater fees

The solution to such problems and the transformation that was achieved in the ecological remediation of the former GDR can serve as a model for many nations world-wide which are currently struggling with the same basic problems in the water sector.

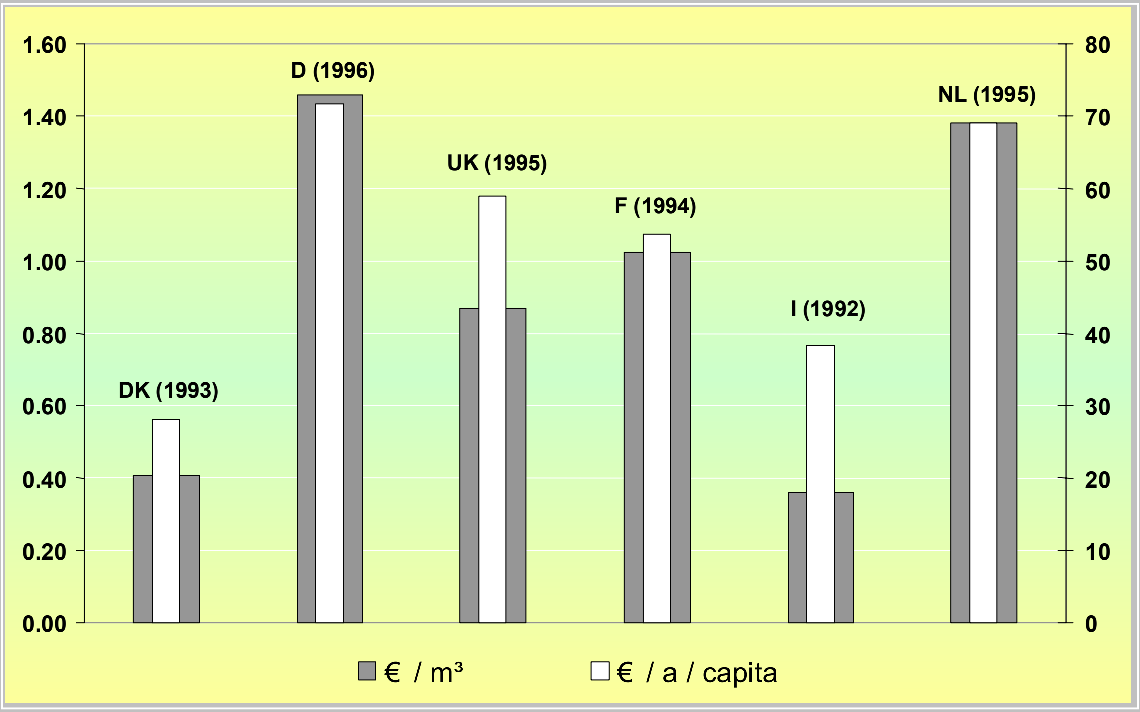


Figure 16: International comparison of the water prices 1998 [58]

3.5 THE ROLE OF THE CITIZENS' ACTION COMMITTEES IN WATER PROTECTION POLICIES*

The level of water body remediation that has been achieved in Germany is not only the credit of federal and state water authorities. The widespread commitment of citizens' action committees and environmental organizations in particular contributed to the political implementation of water protection measures. Grave incidents and catastrophes caused water laws to be gradually tightened. Looking back upon thirty years of water protection policy in Germany, it is evident that the successes that have been achieved so far could not have taken place without the participation of engaged citizens. Governmental water protection was dependent upon cooperation - a cooperation which was thoroughly conflict-bound - with environmental action groups. These groups function as a pacesetter in water protection policies still today.

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The BBU is an umbrella organization of citizens' action committees that are committed to environmental protection. Further information concerning the work and project areas of the Ak Wasser im BBU can be found on the internet at: www.akwasser.de

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3.5.1 INCIDENTS AND CATASTROPHIES AS CATALYSTS FOR AWARENESS

During the night of November 1, 1986, the Upper Rhine River near Basel in Switzerland turned blood-red. There was a large fire in the storehouse of the Basel chemical company *Sandoz*. Along with 20,000 m³ of water used to fight the fire, approx. 30 metric tons of pesticides and dyes entered the Rhine. As a consequence, in the southern Upper Rhine, 150,000 eels and countless other types of fish and small animals were estimated to have died. This "pesticide death" in the Upper Rhine developed into an immense media and political event. Only one year later, poisonous "killer algae" proliferated in the North and Baltic Seas, killing thousands of seals. The resonance in the media - and following in politics - of the disaster in the North and Baltic Seas was even greater than that of the "Sandoz poison wave". In the face of public outrage, quick political action was essential; and legislation concerning water protection was significantly heightened.

Already in the autumn of 1969, an enormous amount of fish died in the entire section of the Rhine below the Main River Delta. It was even much larger than the death of fish after the Sandoz accident of 1986. Photographs taken from a helicopter after the incident in 1969 show a 400 km-long silver glistening on the Rhine River; millions of fish were floating down the river belly-up. The death of the fish presumably had two causes. Due to a high amount of organic contamination, the river had a considerable lack of oxygen. The additional discharge of an insecticide into the already heavily polluted river then poisoned the fish. The catastrophe of 1969 symbolized the climax of the pollution of the Rhine. Water pollution - and not only in the Rhine River, but elsewhere as well - had continually Increased after WW II until the late 1960`s.

Flood catastrophes are cause for more flood control

The ecological catastrophes in the Rhine River gave water protection policies the necessary political power for the implementation of protective measures. In a similar way, this was also true for flood control.

Flood control measures are now anchored in the Water Management Act (WHG). It contains the underlying principles to keep flooding under control. Within the scope of a debate over amending the act that lasted several years, the "Flood Prevention Clauses" were subjected to various alterations. However, the two century-high floods of 1993 and 1995 then expedited the amendment debate. At that time, many villages and cities along the Middle and Lower Rhine were inundated twice in quick succession. The Netherlands barely escaped an enormous flooding. In Bonn, the former national capital of Germany, the construction of the new parliamentary buildings was deeply affected by penetrating flood waters.

Figure 17: Sandbags to protect against floodwater/ flooding of the Rhine River

During the time of the debate of the sixth amendment to the Water Management Act in 1996, this flooding made such a great impression upon the members of parliament that the ecologically-oriented prevention of floods was given much greater significance in the WHG.

(continuation of Flood catastrophes are cause for more flood control)

Whether the new regulations will be helpful in the identification of flood retention areas is still to be determined. Uncertainty continues to dominate in the dispute over the identification of flooding regions.

For the administration of water management, the identification of flooding areas is still coupled with lengthy disputes. Wherever flooding areas are to be identified, subjective interests are vehemently made known – *“Flood control should be everywhere, but not here with us!”* At every respective location, there are always *“very special and unique reasons”* seen subjectively from the point of view of those affected for forbidding the definition of a flood plain. This goes to show that the administration of water management must follow a policy that favors protecting national over individual interests. Managing conflicts so that solutions can be found which are even halfway agreed upon is very difficult and not always successful.

In many places, skeptical citizens complain of a lack of information from the administration. Not enough transparency in the decision-making processes leads to a growing mistrust by affected citizens. Awkward maneuvering on the part of agencies strengthens the opposition. Ultimately, the necessary flood control measures, such as retention polders and the repositioning of dams, are often not able to be politically executed.

After the death of fish which had until then been unprecedented, the Rhine waterworks formed the first pressure groups for effective water protection in the Rhine catchment area. The Rhine waterworks were faced with the difficulty of preparing drinking water for millions of people on the Middle and Lower Rhine out of the increasingly dirty Rhine water and at an ever increasing technological expense.

3.5.2 ENVIRONMENTAL ORGANIZATIONS AND CITIZENS’ ACTION COMMITTEES PUSH WATER PROTECTION POLICIES FORWARD

The Rhine catastrophe in the fall of 1969, the persistent lobbying of German and Dutch Rhine waterworks, and the suddenly increasing interest in environmental issues in the 1970’s all led to the investing of billions of Deutschmarks in the construction of WWTP’s in municipalities and in industry. Environmental action groups denounced the discharge of pollutants along the Rhine in various campaigns. Wastewater pipes were walled up and polluting factories were demonstrated against. The discharge of pollutants from the chemical industry in particular stood at the center of interest.

The spectacular actions of the environmentalists were brought to a large public through the press, as well as through radio and television. In the ecologically sensitized public, the activities of environmental organizations and citizens' action committees were overwhelmingly viewed with sympathy. The activities of environmental organizations were brought together Europe-wide in 1983 in the "International Water Tribunal": In Rotterdam, particularly spectacular cases of water pollution in Europe were handled by an international jury.

The interaction of environmental activists and the press increasingly forced politics to act. Beginning in 1976, following the fourth amendment to the Water Management Act, legal limits ("monitoring standards" – *"Überwachungswerte"*) were agreed upon for the first time for the discharge of pollutants by countless branches of industry. In 1986, within the scope of the fifth amendment to the Water Management Act, industry-specific monitoring standards for *"hazardous substances"* were considerably tightened. The framework wastewater administration regulations defined in particular heavy metals and organic chlorinated compounds as *"hazardous substances"* at that time (cf. sect. 4.4).

3.5.3 THE STRUGGLE FOR THE "TRANSPARENT WASTEWATER PIPE"

Citizens' action committees and environmental organizations also sought a better insight into the water permits of large-scale dischargers of contaminants. The set monitoring standards for the dischargers of contaminants were recorded in the *"water books"* of the upper water authorities. These *"water books"* were at first not accessible to the public. Authorities and emitters insisted on the protection of "*corporate secrets"*. It took campaigns and court cases to abolish the secrecy provisions for the *"water books"* in the Water Management Act and in state water laws. Even though there are still restrictions in part, the activities from the 1970's until today have brought Germany quite far down the path to the *"transparent wastewater pipe"*.

The reassignment of permits for point sources today is negotiated at public debates. Other water body users as well as environmental organizations are able to view, comment on, and criticize the application documents.

3.5.4 WATER POLLUTION BECAME COUNTERPRODUCTIVE FOR SEVERAL INDUSTRIES

The “International Water Tribunal” of European environmental organizations was sponsored by the Rotterdam Harbor, among others. Contaminated sediments from the Rhine catchment area are continuously deposited in the harbor basin at Rotterdam. The disposal of the toxic harbor deposits cost the Rotterdam Harbor hundreds of millions of Dutch guilders.

This example illustrates that the increasing level of water pollution found opposition not only among citizens’ action committees and waterworks; other water consumers as well became opposed to the harming of their commercial interests. The Rotterdam Harbor, together with Dutch environmental organizations, organized a laboratory ship to sail the Rhine River. Samples were taken and analyzed in the plumes of the respective Rhine polluters. Based on the results, the Rotterdam Harbor threatened the polluters - especially the chemical industry - to sue for indemnity. Consequently, the Association of the Chemical Industry in Germany (*Verband der Chemischen Industrie – VCI*) and the chemical industry in Basel, Switzerland made a pact with the Rotterdam Harbor companies for a “voluntary obligation.” The chemical industries thereby obligated themselves to a further reduction of their pollutant emissions.

It was not just the activities of environmental organizations but the interests of authoritative industrial enterprises as well that expedited the clean-up of the Rhine River.

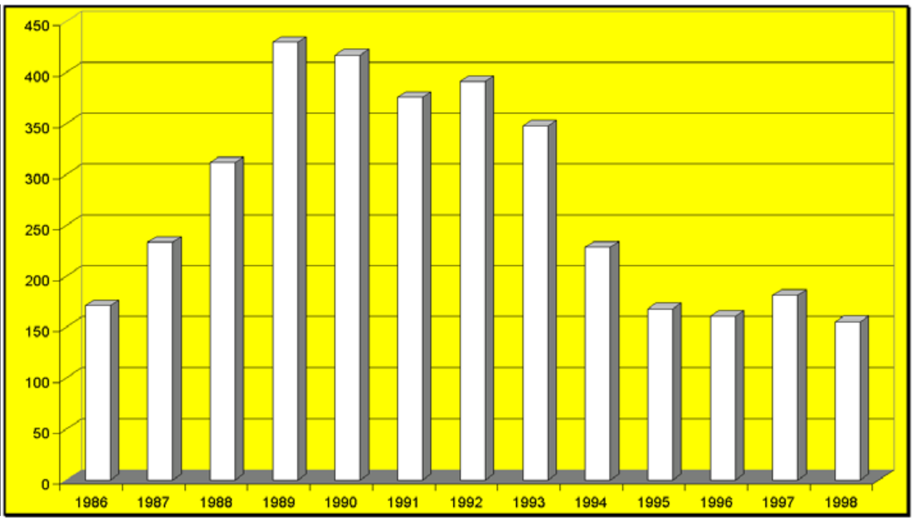

Figure 18: Investments of the chemical industry in additional protection of water bodies (in € millions) [59]

Furthermore, the high level of the organic and inorganic contamination of the Rhine was also detrimental to the interests of industrial water consumers. Countless industrial firms along the Rhine and its tributaries used the river water for cooling and production purposes. Moreover, the contamination of the Rhine with waste heat from countless thermal power plants together with the high level of organic contamination would have led to an oxygen deficiency that would no longer have been acceptable. First of all, the industry implemented additional water protection measures. This involved investments for end-of-pipe measures, such as WWTP's. These plants were all completely built by the middle of the 1990's. Reinvestments for the renewal of these facilities are now necessary. In the future, so-called integrated measures will be increasingly realized, such as the reconfiguration of production processes or the use of other raw materials in such a way that pollution is significantly reduced.

3.5.5 THE DOWNSTREAM PARTIES ARE TRACKING DOWN THE POLLUTANT DISCHARGES

Large regions of the Netherlands and major cities, such as Amsterdam, use water from the Rhine for their water supply. Therefore, the people living along the Rhine who are impacted by the contamination of the river have always kept a watchful eye on the chemical pollution of the Rhine water. For that reason, high-tech monitoring stations were installed in Dutch waterworks for the continual analysis of the Rhine water. Dutch waterworks routinely measure dozens of waterworks-related pollutants. In certain measurement programs, hundreds of various pollutants can be analyzed.

In the 1970's and 1980's, there were many illegal and unintentional discharges of pollutants from German production sites that at first were not detected in German measuring stations, but rather in the Netherlands. Over the years, the water management authorities in the German federal states have built up a large capacity for water analysis. Not only chemical parameters are analyzed; by means of various bioassays, the entire effect of Rhine water contaminants are able to be recorded.

The analytics of the German and Dutch Rhine waterworks as well as of German agencies have become so widespread in the course of the last few years that practically every abnormal pollutant can be discovered at the moment of discharge into the river. Since emitters are additionally obligated to take routine samples, accidents affecting the Rhine hardly have a chance to remain secret. *The diversified and close-meshed analytical monitoring of the Rhine and its tributaries has contributed to the fact that in the last three years emitters have developed a strong feeling of responsibility for water protection.*

The analytical surveillance of receiving waters is supplemented by a further control system directly at the point of discharge. The employees of the industrial wastewater division of the upper water authorities examine during on-site meetings in the industry those production procedures which generate wastewater and the condition of the company's water protection measures (see also sects. 4.4 and 4.9).

Environment-oriented procedures for wastewater treatment were implemented by committed citizens' action groups

In many villages in Germany, one can no longer tell the difference between wastewater treatment facilities and wet biotopes. Wastewater is treated in *"root system WWTP's"* (wastewater treatment by applying the cleaning power of plant roots) in an economical and energy-efficient manner (see Fig. 25 on p. 55). However, "root system WWTP's" were able to march in triumphal procession only against extensive opposition of agencies and engineering offices. Citizens' action committees and involved individuals in many places had to fight for many years for the implementation of such environment-oriented versions of wastewater treatment. Conservative civil engineers who dominated the construction of WWTP's nation-wide often could not imagine that high-quality wastewater treatment could take place also in *"overgrown ground filters"*, and not just in technological concrete constructions. This skepticism on the part of the engineers was at first confirmed by operational shortages in such procedures in the beginning. The decade-long dispute over "root system WWTP's" and other environment-oriented wastewater treatment procedures was nevertheless crowned with victory in the end. Since then, wastewater treatment in *"overgrown ground filters"* has become accepted as a state-of-the-art procedure.

Combined with the struggle for the acceptance of " root system WWTP's" were disputes concerning decentralized versions of wastewater treatment. Beginning in the 1970's, environmental organizations and citizens' action committees no longer accepted large, central treatment systems as "wisdom's last decision". Action groups pushed for decentralized solutions with much engagement. They no longer wanted 10 villages to be connected to one central WWTP by means of kilometer-long trunk sewers. Each village should have its own local treatment facility - preferably a " root system WWTP". The inhabitants of villages occasionally even founded wastewater associations. They took up the shovel themselves, and construction crews set up their equipment: The inhabitants built sewers and root system WWTP's themselves, saving a good deal of money.

The battle for decentralized wastewater treatment systems that was bitterly waged in many places was finally put to an end by the Water Management Act. In the sixth amendment to the Water Management Act in 1996, decentralized models of wastewater treatments were approved. Decentralized as well as energy- and resource-efficient versions of sanitary wastewater management could be an alternative also for rural areas of emergent, transformation, and third-world regions. Thus "root system WWTP's" are of particular interest for areas with sufficient cheap land available. Wastewater associations and a large degree of work done by the inhabitants themselves can contribute to economical solutions for wastewater treatment in such areas [23].

The recently widely discussed versions of an alternative and ecologically-oriented future sanitary wastewater management policy were first brought into debate by interested scientists and environmental organizations. In the beginning, the established sanitary wastewater management industry expressed only ridicule and scorn for the idea of a circulation process of wastewater-bound nutrient and energy flux. In the meantime, the topic of "alternative water systems" can be considered as one of the technologically most innovative fields of work.

The external monitoring system is interlocked with an internal monitoring system. The latter is administered by the industrial emitters in the form of employees commissioned with the task of water protection (the so-called “water protection managers”). These independent employees are the “personified self-regulators” for water protection in industrial firms. The institution of water protection managers according to §21 ff. of the Water Management Act helped to implement the legal regulations for the prevention and treatment of wastewater in a quick and binding fashion.

3.5.6 THE INSTITUTIONALIZATION OF CIVIL ENGAGEMENT

Within the scope of the implementation of the AGENDA 21, the institutionalization of the cooperation of interested citizens as well as of associations and NGO’s in municipal and regional water management has been attempted in countless German municipalities. There are even several activities independent of AGENDA 21 that focus on *the greater-than-ever inclusion of the expertise and commitment of public initiatives in planning and decision-making processes for water management.*

What is AGENDA 21?

In 1992, 178 nations signed the AGENDA 21 document in Rio de Janeiro as a global action program for a sustained environmentally sound development. By this agreement, the countries declared their intent to strive for more equity between nations and for the protection of the fundamental natural basis for this generation and for generations to come.

AGENDA 21 is an action program for a sustainable, future-securing development in society, economics, and environment. All governments of the world, from the national to the local level, are called upon to develop plans and measures for the goals of sustainability and equity.

One such activity to be mentioned in this context is *“regioWASSER 2005”* in Freiburg, a southwestern German city on the Upper Rhine with approx. 200,000 inhabitants. The goal of *“regioWASSER 2005”* is to bring together all of the water experts in the region of Freiburg. The interdisciplinary work group *“regioWASSER 2005”* was founded in February of 1999 at the suggestion of an NGO active in the field of water, together with the “Freiburger Energie- und Wasserversorgungs AG“ (FEW – Freiburg Energy and Water Utility). Aside from FEW and the NGO, all agencies that are concerned with water management (from the public health office to the upper and lower water authorities to the environmental organizations of cities and counties) as well as the authoritative chairs of the

University of Freiburg (hydrology and landscape protection) all cooperate in the work group. FEW, as a regional water utility, finances the activities of “regioWASSER 2005”.

The goal is to bring together in the work group, in which several sub-groups have formed in the meantime, a gathering of all the water management expertise in the region. In the sub-groups, the history of drinking water supply and wastewater disposal in the region is to be compiled, and a model for future sanitary wastewater management (including aquatic nature protection) is also to be developed for the greater region of Freiburg.

4. THE STATE AND EXPERIENCES OF GERMAN WATER MANAGEMENT -CASE STUDIES IN PRACTICAL CONTEXT-

The following will attempt to provide an overview of the instruments and techniques of German water management through the description of case studies which could serve as models for other countries.

The careful reader will recognize that Germany - today a “matured” industrial nation - had to struggle in the beginning with the same problems of water management that are only too well known today in developing and emergent economies: Wastewater disposal must be improved for the protection of natural water bodies, not least to secure the water supply, which can no longer cover the increased demand. The financing and in particular the refinancing of necessary investments by means of cost-covering water tariffs is socio-politically very difficult to realize, and chronic deficits in the water sector lead to disrepair of sewer systems and treatment plants. In contrast to earlier times, high-performance and comparatively cost-efficient water technologies are available today. The limiting success factor lies more in the organizational and institutional areas.

To start, the newest developments for the determination of water demand with active demand management will be presented (sect. 4.1). Section 4.2 contains a case study of the water supply system “Haltern Lakes”, with cooperative protection of resources. Municipal wastewater disposal, including the cost problems related to it, will be handled in section 4.3 with the example of Königsbrück, while section 4.4 will deal with complex solutions for industry. Section 4.5 will present master plan measures and successes for the reduction of nutrients. Section 4.6 will also describe how large-scale projects are prepared and executed in a democratic, federal state through the example of the Leibis-Lichte Dam. Section 4.7 presents the historical development and the current situation of the integrated management of the Ruhr River catchment area. International relations and programs for large river catchment areas will be illustrated through the example of the Rhine River (sect. 4.8).

4.1 WATER DEMAND –A CHANGING CONCEPT*

The analysis and prognosis of water demand is the fundamental determining factor for the planning, building, and operating of water systems. Water systems must be laid out in such a way that they cover the calculated demand. Through improved technologies in water utilization, from pipe fittings and individual installations to entire recycling systems, water consumption can be significantly decreased without an unreasonable loss of comfort. Therefore, the up-to-now purely supply-oriented planning strategy needs to be supplemented with a demand-oriented component. By means of such a diversified and transformed plan, economic advantages benefiting water customers, with corporate business opportunities on the part of water utilities, are able to be attained. Ultimately, this leads to environmental relief through a diminished generation of wastewater.

*by: **Dr.-Ing. Harald Hiessel**

(supplemented by the editors)

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4.1.1 INTRODUCTION

Water plays a central role in countless industrial processes, as well as in the public and private sectors. The centralized water supply and wastewater disposal systems that have arisen in water-rich industrialized nations have a long-standing tradition and therefore often rest upon basic concepts which have remained unchanged over a long period of time, although the needs and technological possibilities have been further developed.

According to the German Water Management Act (WHG), water bodies are to be managed in such a way that they serve the common good and, in accordance with it, serve individual needs without impinging on its quality (§1a (1) WHG). For that reason, everyone is obligated to use the necessary precaution to avoid the contamination of water and to use water conservatively (§1a (2) WHG).

The explicit exhortation from the legislature not only to conserve water, but also to avoid generating wastewater means that water, as a resource for countless processes in industry, business, agriculture, in the public sector, and in private households, must be used efficiently. In that way costs can be reduced, and the environment can at the same time be spared. This approach, "creating more value with less impact", was developed in the so-called Eco-Efficiency-Plan of the World Business Council for Sustainable Development (WBCSD)* and combines economic with ecological efficiency.

Even though there is an overabundance of water in Germany and there is no pressing need for a frugal use of water, driven by a general striving after an ever-improved efficiency and by a deeply-ingrained attitude in this country of using resources conservatively, new, innovative ideas and technologies have been developed and successfully implemented. Germany's experiences could serve as models precisely in those areas of the world where water and finances are not available, such as arid regions and developing and emerging economies.

4.1.2 THE CONCEPT OF "WATER DEMAND"

According to the German Industry Norm (Deutsche Industrienorm – DIN) 4046, water demand is a *planning factor* which serves as a basis for water utilities in the assessment of water supply plants. It indicates the expected water volumes that are needed in any given area to be supplied in a given time span. It can be differentiated according to the demand for potable, process, and irrigation water.

In the determination of water demand, local conditions must be taken into account. Due to the variation, which is in part rather great, in supply and demand structures, as well as the varying requirements of individual users, water demand is determined separately for individual user groups. The distinction is most often made between domestic demand, public and business demand, industrial demand, and agricultural demand. In addition, leakage and the expected demand for water used in fire-fighting need to be included in the demand analysis.

* The WBCSD is an international alliance of over 120 globally active enterprises from 20 different industries in 34 countries. The member companies have obligated themselves to implementing a sustainable development along the lines of the environment summit in Rio de Janeiro in 1992.

A realistic assessment of the total water demand and its components includes an analysis of consumption characteristics of the individual groups to be supplied as well as the assessment of future developments. Some of these are, for example:

- The number of inhabitants to be supplied with water and their demographics
- The consumption habits and standard of living of the population - especially how well buildings, apartments, and houses are furnished with showers, baths, toilets, urinals, and other consumption determining equipment
- The number of occupants per housing unit and the amount of time they are present or absent (e.g. in hotels, health resorts, barracks, other types of housing, and workplaces)
- The range of present individual or private systems for water supply
- Climatic and meteorological factors, such as the amount, duration, and distribution of precipitation; average temperatures as well as summer temperature highs; humidity; and evaporation
- The type of development, property size (single family or multiple family houses), and size of gardens and other green spaces
- The condition and capacity of sewer systems
- The water demand of public establishments
- The type, number and water demand of business and industry
- The water demand of intensive garden cultures
- The livestock of agricultural farms and the need for irrigation of agricultural areas
- The tariff system of water distribution
- The level of wastewater fees
- The demand for fire-fighting water, dependent upon the risk to persons and property and upon the danger of the spreading of a fire

Because of the numerous uncertainties concerning the future development of influencing factors, a reliable assessment of water demand is difficult to obtain, especially if one bases the average duration of use of a distribution system at about 40 to 80 years. False estimates concerning necessary capacities are often able to be corrected after the fact only at an enormous expense. What complicates a reliable assessment even more is that some factors influence consumption with short notice (e.g. meteorological factors, the constructing of new development areas), while others influence consumption over a long period of time (e.g. climatic factors, population development), so that these influences are able to either intensify each other or balance each other out.

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One central consequence of this is that the application of the assessment procedures is theoretically no longer as secure as it once was and that the information derived from the assessments is tainted with greater uncertainties.

Change of paradigms I

The current foundations of water supply, wastewater disposal, and drainage from human settlements in industrial nations are over 100 years old and are very successful in view of their original economic and hygienic goals.

In the debate over a sustainable water management and an ecologically efficient use of the resource of water, a change of paradigms emerges which at the same time facilitates both the constructive use of this option and of other future options for a sustainable water supply and wastewater disposal. This change of paradigms can be describes as follows:

- In the old paradigm, *water demand* was a “supply-sided” concept (i.e. it represented the viewpoint of water utilities) which primarily placed the questions concerning a demand-covering layout and concerning the operation of water supply systems into the foreground. Today, “demand-sided” aspects (i.e. from the viewpoint of water consumers), and with them aspects of demand management, are becoming more important. This also corresponds to the fact that water demand in the old paradigm primarily was a question concerning the quantity of water of a certain quality, while water demand increasingly represents a complex concept which integrates quantity and quality aspects with its uses.

- All *uses* of water were construed along the lines of a one-time use of water, draining then into the sewer. This system was conceptualized as a flow-through system. This is still the system used in the municipal sector. By means of decentralized technologies, multiple uses of water and re-circulation systems are increasingly being conceptualized and realized, being systematically implemented first of all in the industrial sector.

continuation of Change of paradigm

- *Rainwater* and *wastewater* used to be viewed as "burdens" which needed to be disposed of into receiving waters as soon as possible after more or less intensive treatment. The realization is now gaining ground that rainwater and even wastewater (particularly in industry at present) present a valuable resource.

- In the old paradigm, it was important to achieve economics of scale by means of large, centralized infrastructures of water supply and wastewater disposal. It is being increasingly recognized that with many centralized systems, the optimal amount of space has been exceeded and that in certain cases, decentralized and smaller designs can be more economical and more environmentally friendly.

- While the institutional division between water supply and wastewater disposal predominated in the old paradigm, possible synergy effects in an institutionally integrated solution are being recognized and developed according to the new paradigm. In the future, resource management sectors other than water-related can be integrated, in order to develop further synergy potentials.

- The old paradigm focused upon reducing the wide diversity of technological systems through standard solutions. By contrast, the new paradigm places significantly more emphasis upon problem-specific solutions, specifically including those from outside of the classical innovation systems of sanitary wastewater management. This is done in order to obtain solutions that are as resource-efficient and flexible as possible, able to be easily applied to a changing framework, and able to integrate future technological advances as easily as possible.

- The innovativeness of the *framework* was not an urgent topic in the old paradigm, since water supply and wastewater disposal widely functioned as area monopolies. Because of reasons of cost and improved sustainability, the creation of a framework that supports innovation and competition receives a predominant role in the new paradigm.

- The *public* - which, with regard to public water supply and wastewater disposal is primarily private households - played a passive-receiving role in the old paradigm. This was evidenced, for example, in that customer contact in the majority of water operations was handled by a "public relations" department, which was strongly focused on politics and the media. In the new paradigm, private households play an increasingly active role and are recognized as "customers". This is expressed, for example, in that utilities have an increasing interest in dialogue and in the inclusion of their customers in questions concerning areas of improvement and supply services.

The significance of a demand assessment that is as precise as possible is also underlined by the amount of investments the public water supply in Germany. On average for the last ten years, approx. € 2.5 billion were invested yearly in the expansion and renovation of public water supply network. According to an estimate by the BGW (www.bgw.de), in 1999, 61% of investments were apportioned for the pipeline network, 18% went to purification plants, and storage facilities for drinking water accounted for 6%. Therefore, false estimates regarding water demand are very costly.

The current water distribution networks were planned on the basis of demand prognoses which assumed a continual increase in water demand. This increase did not take place. The reasons for that were *technological developments*, among others. Examples are appliances (such as water-saving dishwashers, washing machines, toilets with a saving button, urinals, shower heads and washstand appliances in private households), but also the increased use of rainwater and greywater. In industry and business, the implementation of water-efficient technologies, the construction of water circulation systems, or even the substitution of water in production processes were promoted.

Even the measures put into place by water utilities for the reduction of leakage - currently at about 9% (see Fig. 13) - strengthen this effect.

The general overcapacity that arises in the public water supply network results in part in drinking water remaining in the distribution network for long periods of time. In order to avoid adverse chemical, physical, and microbial effects to the water, measures are necessary for assuring the quality and partly for the disinfection of potable water.

4.1.3 PRACTICAL EXAMPLES OF INNOVATIVE SOLUTIONS

The intense innovative activity in all areas of the economy lead to a constant improvement of conventional technologies as well as to a rapidly growing number of new technologies. Although the great majority of these innovations were not developed for uses in water management, many of these technologies have a considerable potential for being applied to water management.

One example worth mentioning is the membrane technology, which was developed initially for uses in pharmaceutics and chemistry. One possible use of this technology is in reverse osmosis (nano- or microfiltration). Other examples are innovations in sensor technology, information and communication technology, or in biotechnology and genetic technology. Thus, a great number of new options have come about for fulfilling functions of water management in a way that is more cost-efficient, environmentally friendly, and sustainable. They start with modern fittings and lead to complex systems, as the following examples show.

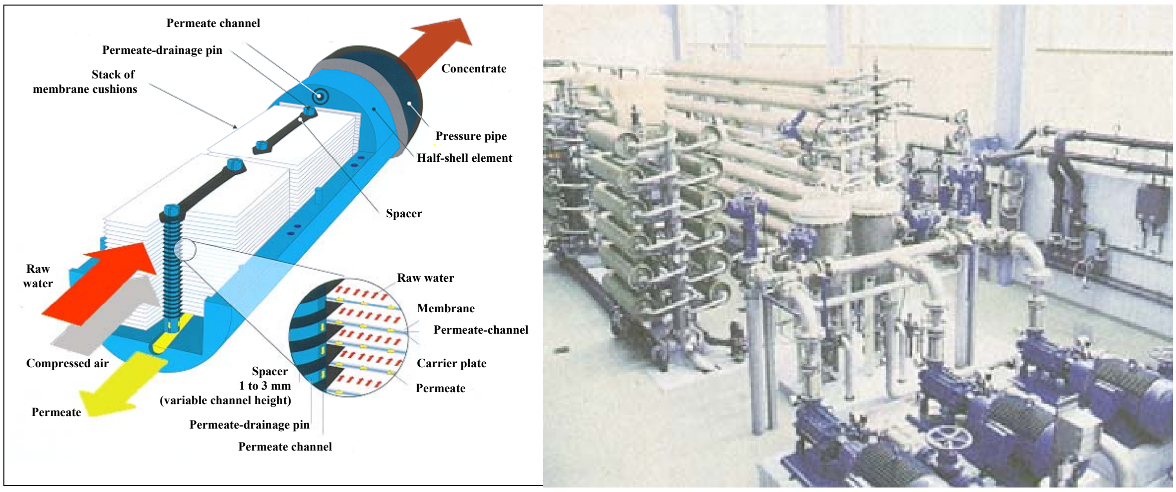


Figure 19: Left – flat membrane modular system; right – membrane plant [15, 40]

Depending upon the construction and configuration of sanitary fixtures for the sink and shower, water consumption levels can greatly vary. Two-lever fixtures for the separate adjustment of warm and cold water in particular are out-dated because of the long period of time it takes for adjusting the right temperature and because readjustment of the combined hot/cold water is often needed. Hardly anyone makes the effort with such systems, for example, to turn off such a fixture while soaping down or shampooing. These fixtures should be replaced as quickly as possible with modern *single-lever water fixtures*. Single-lever water fixtures have the advantage of a faster adjustment and readjustment time. Also, water can be turned on and off with one knob without changing the selected temperature.

Many quality fixtures already have integrated limits for volumes of water by which the flow rate per minute is reduced without noticeable loss of comfort (e.g. a sink in which the volume of water can be reduced to six liters per minute). Conservation of up to 50% can be achieved by showers that have thermostats. They take only the absolutely necessary volume of cold water out of the water pipes, in order to bring the hot water to the preselected temperature. Variations in pressure and temperature in the water pipes are thereby equalized without the user noticing it. With high-quality thermostats, even with little preheating, temperature can be regulated to the exact degree. Independent of that, water flows at the exact set temperature no matter how often the shower is turned off.

The newest generation of *thermostats* is set at a maximum flow rate of approx. 50% of the flow rate of traditional fixtures. Similar to temperature regulators, there is a lock on the volume-adjustment lever that prevents the further opening of the faucet. By the push of a button, this lock can be released so that the full volume of water can flow out. (Zentralverband der Sanitär-, Heizungs-, Klima-, Kälte- und Klempnertechnik SHK; http://www.zvshk.de).

Remote sensing sanitary fixtures, particularly in administration buildings and public institutions, significantly reduce water consumption and have a high payback rate. The same goes for self-stopping fixtures at public swimming pools or at other sport facilities, as well as for water-conserving urinals in public institutions, restaurants, and administration buildings.

Even the water consumption of washing machines and dishwashers has been dramatically reduced in the past few years. While the water consumption of washing machines in the mid 1980’s was still between 100 to 120 liters per wash cycle, consumption of current models for a 40° C or 60° C bright-colors cycle is between 39 and 72 liters per cycle. Accordingly, the water consumption of dishwashers was able to be reduced to 17 liters per cycle - in the most conserving appliances it was even reduced to 15 liters per cycle. The reduction of water consumption also has the direct consequence of reducing energy costs, since less water needs to be heated.

Although the idea of gathering rainwater in reservoirs for use in dry times is as old as the human civilization, and although cisterns are used world-wide for balancing out rainy and dry periods, the utilization of rainwater was not a topic in Germany for a long time. In the course of growing environmental awareness and as an effort to conserve resources, the desire began to grow in many people to increase the use of rainwater and greywater. Since Germany is a country with a large degree of precipitation (cf. box on the next page) that in general has a sufficient supply of water at its disposal, this development was considered to be very controversial, in view of the hygienic and ecological risks. Therefore, the portrayal of the experiences in Germany and of the technologies developed here does not mean that their application is warranted. Rather, they are meant to demonstrate how Germany’s instruments and technologies can stimulate ideas for problems in other countries.

The substitution of rainwater for potable water, for example, as process water for toilet flushing, did not gain in importance until about 15 years ago. In the past few years, the necessary technology, particularly for toilet flushing using stored-up rainwater, reached a high technical standard as well as a good reliability of operation. The installation of rain water utilization systems is being supported by a growing number of municipalities as a measure for the management of rainwater.

<u>Utilization of rainwater</u>

As the map shows, Germany is a water-rich country. There is no shortage of water. Potable water is sufficiently available practically everywhere. Despite this fact, rainwater utilization systems are being continually technologically further developed and ever increasingly installed (www.fbr.de). The reason for this is the desire of many people - even out of ethical considerations - to use natural resources conservatively and with a sense of responsibility, even though there is sufficient water in almost all regions of Germany throughout the year.

From the viewpoint of water utilities with their given capacity and contingency reserves, the utilization of rainwater is problematic because the high fixed costs of water supply have to be prorated to an ever smaller number of cubic meters of water sold. The result is that water tariffs then rise for all consumers (even for those consumers who do not utilize rainwater). Since wastewater fees are mostly calculated according to the volume of potable water consumed, wastewater fees per cubic meter also rise when the consumption of potable water decreases; the volume of wastewater remains the same (because rainwater that is used also ends up in the sewers as wastewater) [1].

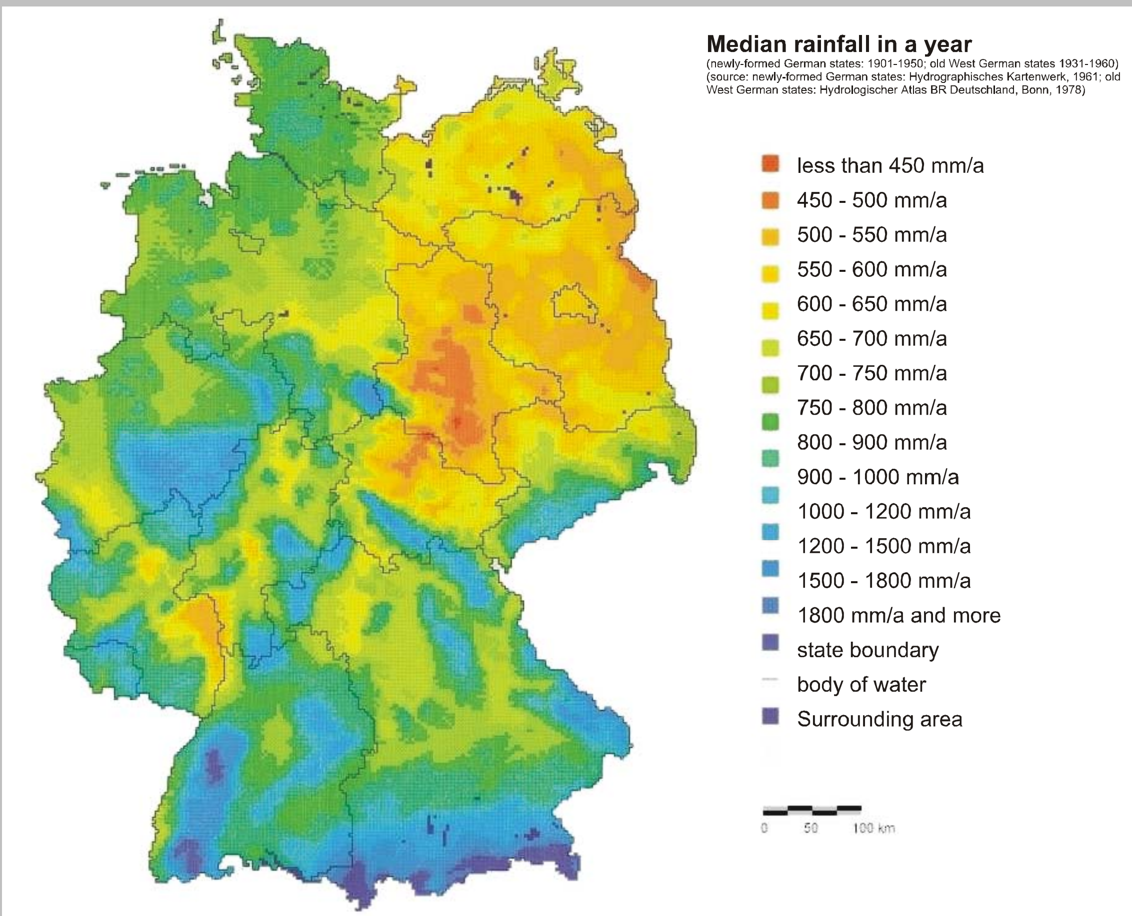


Figure 20: Rainfall map of Germany [51]

The situation is different in places where groundwater and surface water alone do not suffice or where the technological capacities of facilities are tight, especially in densely-populated areas or in developing countries and emerging economies. In such places, the utilization of rainwater can bring relief to the environment and can also make sense from a macroeconomic point of view.

The diagram below illustrates the essential components of a rainwater utilization system. It is very important to make sure than no rainwater, which could possibly be contaminated, enters the potable water network, which may only supply high quality drinking water.

A balancing of the individual circumstances determines the ecological benefits of each instance of rainwater use. When potable water is conserved, energy, chemicals, and resources are also conserved. On the other hand, materials and energy are even required by rainwater utilization systems [6].

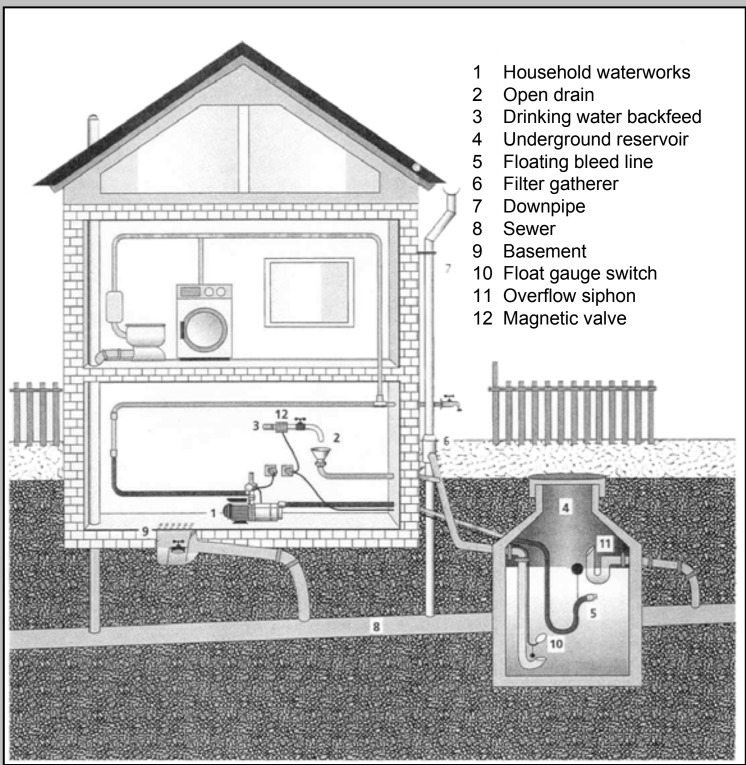


Figure 21: Functional principle of a rainwater system with an underground reservoir [2]

The utilization of rainwater, for instance, has been successful in ten public institutions in Hamburg, in the Frankfurt airport, at the Hessischer Rundfunk broadcasting company, at the UFA Film & TV Production Institute in Berlin, in the Weil municipal garden center, and in a car wash in Überlingen. Typical basic requirements for such systems are a large roof surface and, as much as possible, a regular consumption of water throughout the whole year. Such conditions allow for a large number of applications with economical potential, especially in the area of commerce (e.g. shopping centers, sports facilities, transportation centers).

The *city of Bonn* (310,000 inhabitants) changed its fee schedule for the usage of public wastewater systems (sewer regulation) at the beginning of 1996 in order to promote rainwater utilization, rainwater seepage, the opening of scaled surfaces, and the introduction of “green roofs” (roofs covered with vegetation). In Bonn, wastewater fees are made up of a fee for rainwater and a fee for contaminated water (a split fee standard). Homeowners can now save up to 50% of their rainwater fees if they pave their driveways and sidewalks with water permeable surfaces, reduce the volume of rainwater runoff by installing “green roofs”, dig seepage areas (depressions, ditches, ponds), or install rainwater utilization systems. Similar programs have been applied to numerous other municipalities, for example, within the scope of a joint research project by the Federal Ministry of Education and Research (Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie)[36].

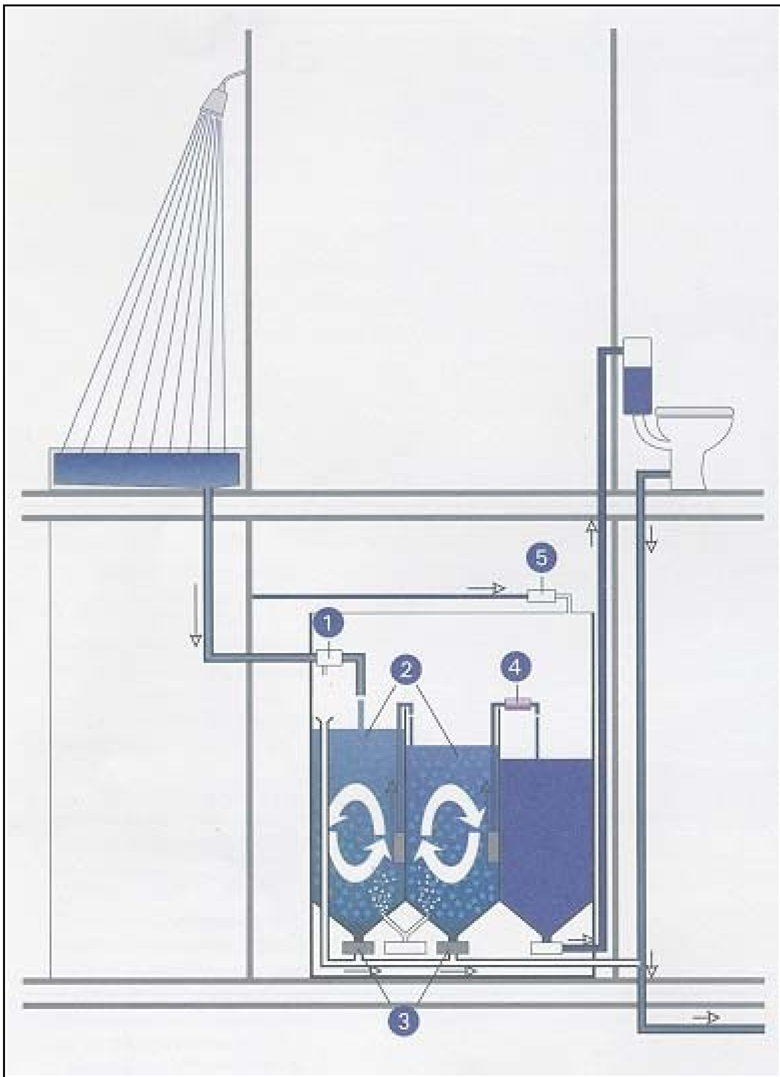
The city of *Frankfurt a. M.* (654,000 inhabitants) in 1992 set for itself the goal of reducing the current dependence upon long-range water supply through the efficient use of water in private households, public institutions, and businesses. Through a widespread campaign, water consumption in the year 2000 should be reduced by 20% in comparison to 1991/1992 (by changes in consumer behavior, upgrading of water-saving installations and fixtures, water-saving contracting, etc.). The use of rainwater in households (both in single-family homes and in multiple-family homes) for flushing the toilet, washing laundry, and watering the garden was promoted through a public subsidy program.

Besides the substitution of rainwater for potable water, process water generated from domestic *greywater* is gaining in significance.

Greywater is the runoff from the bathtub, shower, washbasin, or washing machine. In a water-conserving household, approx. 60 liters of greywater are generated per person daily. Since greywater is generated directly in every household in just about equal volumes every day independent of the weather, compared to runoff from roofs, it presents a constant resource. It is only slightly polluted; to a large extent free from feces, oily substances, and solid matter; only slightly bacterially contaminated; and furthermore has a usable temperature. First greywater processors are being used in both private households and in hotels. A hygienic risk can be excluded to a high degree.

Treated greywater can be used as process water for flushing the toilet, for watering the garden, and for cleaning. Laundry washing with greywater is currently being tested.

A further possibility is the combination of the use of greywater with “green roofs” in single- or double-family houses. Through the retention of rainwater and the large degree of evaporation on the planted roof, rainwater is kept out of the sewer system. At the same time, the household’s use of potable water is reduced by one third of the daily per capita consumption by using greywater as process water for flushing the toilet.



❶ Filtering:
Coarser pieces of waste, such as hairs and pieces of thread, are first caught. The filter is backwashed automatically by means of a jet pump. Residues drain off into the sewer line.

❷ Biological cleansing:
Waste particles are broken down in the primary and secondary cleansing chambers by means of biocultures. The water is pumped from here on in four-hour intervals.

❸ Sludge extraction:
Organic wastes, which accumulate during the cleansing process, are sucked off and fed into the sewer line.

❹ Disinfection:
On the way to the third chamber, the non-drinkable water reservoir, the water flows through a UV lamp, which disinfects the water up to 99 percent. The quality of the cleansed water meets the EU guidelines for bathing water.

❺ Drinking water backfeed
If the supply in the non-drinkable water reservoir sinks to a certain level, drinking water is automatically fed in, so that the toilet is always operable.

Figure 22: Functional sketch of a greywater processor [25]

In hotels and public establishments (sports facilities, swimming pools, residential and retirement homes), relatively large volumes of greywater accumulate with great regularity. There are practical examples of utilizing greywater in hotels, administration buildings, university campuses, etc. The payback period of the greywater reutilization system installed in 1996 in the four-star hotel Arabella-Sheraton (400 beds) in Offenbach, for example, is expected to be seven years.

An innovative settlement plan was implemented with the ecological housing development *Flintenbreite* in Lübeck (World EXPO housing development). The 5.6 hectare-large residential area with 12 duplexes, 45 townhouses, condominiums, and apartments is a trendsetter not only because it uses ecological construction materials, but primarily due to its integrated energy, wastewater, and refuse system. This system is structured around closed material cycles.

The advanced treatment of wastewater includes, besides the saving of water, the use of nutrients and energy content. The project is oriented toward the objectives of a modern recycling economy: to complete material cycles as close to the original location as possible, thus reducing the use of resources and avoiding environmental contamination at the very outset. Within this integrated design for energy and wastewater, the separate gathering and handling of rainwater, greywater (wastewater without feces from the shower, kitchen, etc.), blackwater (toilet wastewater), and organic refuse is envisioned. Rainwater seeps directly into the ground of the residential area. Greywater is treated in root system WWTP's with very little odor and is led back into the natural water cycle.

Figure 23: Root system treatment plant [22]

Blackwater that has been gathered by means of a water-saving vacuum system is used together with organic refuse for biogas recovery. The biogas is used to run the housing development's own combined heat and power station. In that way, up to 60% of the yearly electricity demand is generated at "Flintenbreite" itself. Through the use of modern technology, CO_2 emissions are reduced by 90%, and operational costs in comparison to conventional housing developments are reduced by approx. 30% (www.flintenbreite.de).

Decentralized technologies that are being increasingly used in households and businesses for the efficient use of water are often complex and require competent maintenance. Together with other equipment used in buildings for the generation of heat (heaters, warm water heaters, solar-powered systems, heat pumps), the generation of electricity (photovoltaic systems, in the future also fuel cells), lighting systems, and ventilation systems, water technologies are also a component of an increasingly complex housing technology.

There are many possibilities in this area for water utilities to work together with other industries, such as power or gas utilities. They can, for example, build joint communication networks for the long-distance reading of consumption data, long-distance monitoring, and remote problem identification, thereby creating more customer-oriented services. Such a communication infrastructure is a prerequisite for the creation of new offers of service for the provision and reliable operation of decentralized (on-site) water technologies - a strategy that power utilities have already begun to implement in a similar way in their deregulated markets. These housing technologies use modern installation and building monitor technologies. The internet guarantees the functioning of decentralized facilities and permits remote monitoring, load management, and quick consumption monitoring and billing. Information and communication technologies enable an integrated management of the building with all its technical processes.

Thus, water utilities could expand their fields of business, within the scope of contracting offers, by offering private households decentralized technologies, such as rainwater utilization and greywater processing, but also other water-conserving fixtures and sanitary systems (together with the corresponding services, including maintenance). The energy sector demonstrates that this is indeed possible. The United Power Plants of Westphalia (*Vereinigte Elektrizitätswerke Westfalen* – VEW*) make innovative, decentralized technologies in the areas of solar-thermal energy, home ventilation, heat pumps, and fuel value technology available to building contractors and customers by means of a rent/purchase system. They also offer their customers system solutions for new construction, renovation of older constructions, or housing repair, in order to implement the ordinances on heat and energy conservation.

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* In 2000, VEW was merged together with RWE AG (Rhine Water and Electricity Company – *Rheinische Wasser- und Elektrizitätsgesellschaft*). Since then, Thames Water, London has also joined this group of companies.

Through such demand-sided measures, significantly more flexibility can be brought into the rigid, centralized design of water supply and wastewater disposal with respect to both changing customer needs and the integration of innovative technologies. This development would entail a new approach that could overcome the historic separation that has developed in Germany between the water supply and wastewater disposal sectors - a separation which so far has hindered a holistic management of the resource of water in human settlement areas. Such new measures could also contribute to the development of synergies between both supply sectors (e.g. in the area of network management, the conceptualization of a comprehensive water management service sector) and thus increase the ecological efficiency of water consumption in human settlement areas.

4.2 ECONOMICALLY AND ECOLOGICALLY SUSTAINABLE WATER SUPPLY - ILLUSTRATED BY THE EXAMPLE OF THE HALTERN LAKES*

Eighty-three percent of nitrogen pollution of Germany's environment comes from agriculture. The following article describes water protection in the catchment area of a dam. In order to ensure the quality of raw water, the water suppliers closely cooperate with agriculture. This is achieved by the water utilities supporting farmers in restricting their use of fertilizers and pesticides.
In this way, the contamination of surface water and groundwater can be greatly reduced. In addition, the water utility has activated carbon filtration at its disposal in order to guarantee the highest quality of potable water even when accidents occur.
Through the cost-optimized combination of pollutant avoidance (in agriculture) and pollutant compensation (activated carbon technology) a significant reduction of costs and risk in the water supply was achieved.

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4.2.1 PRELIMINARY REMARKS

The Haltern Waterworks - built in 1908, one of the largest of its kind in Europe today - is the foundation for the drinking water supply for about one million people, businesses, and industry in 20 cities in the northern Ruhr area, in the Münsterland, and in the city of Duisburg. The "Haltern Sands" groundwater supply, which is up to 200 meters deep in some places, offers good conditions, from a geological and hydrological viewpoint for this purpose.

The security of the water supply is primarily warranted by the artificial recharge of groundwater. Surface water is taken from the reservoir, pretreated, and injected into the ground, from where it is pumped together with the groundwater. In addition, two pure groundwater pumping stations are operated in the adjacent forests.

The volume of water supplied per year is today approx. 105 million m³, about a quarter of which comes from the groundwater supply of the "Haltern Sands".

Figure 24: Haltern Waterworks

Manifold uses of water in the neighboring cities, municipalities, and agricultural areas compete with the demands of water management and can impair both the quality of the water in the dam and the quality of the groundwater. Agriculture plays a significant role in this, using about three-fourths of the approx. 880 km²-large catchment area of the Haltern Dam. About 3000 farmers engage in an intensive crop and animal production. The result is impairment of the quality of raw water, especially due to certain pesticides.

In other areas, there are potentials for hazard due to the storage of refuse and residual wastes and due to the treatment plant-related handling of water-hazardous substances. Furthermore, there were problems with coal mining in the 1980’s.

4.2.2 COOPERATION BETWEEN AGRICULTURE AND WATER MANAGEMENT - DEVELOPMENT OF A DEFENSE STRATEGY

Contamination from pesticides and fertilizers [57] led first of all to a phase of confrontation between agriculture and water management in North Rhine-Westphalia in the second half of the 1980’s, due to rigid requirements of the Drinking Water Ordinance. However, a cooperation grew out of this confrontation with the realization that only a partnership that equally takes both the interests of agriculture and of the water sector into consideration could lead to permanent solutions. The basis for this cooperation is financial compensation which the water sector pays to the affected farmers.

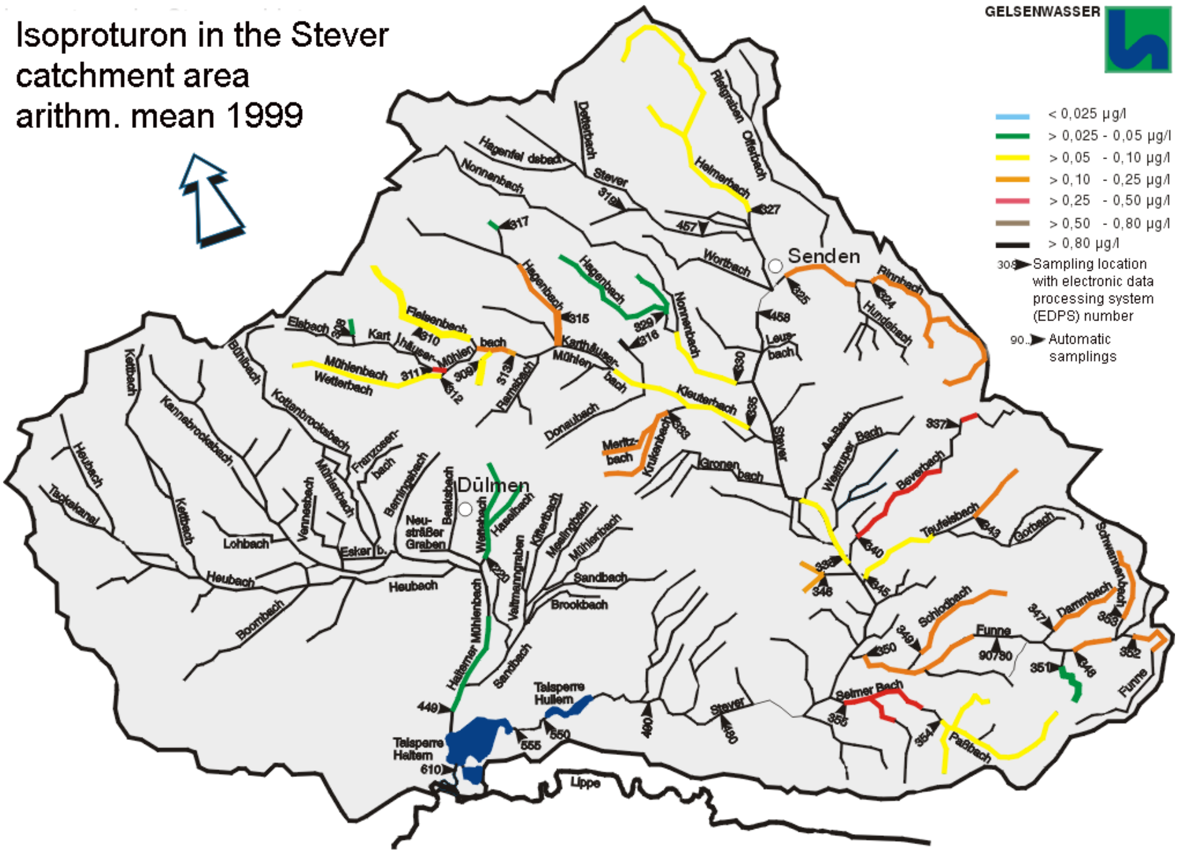

Figure 25: Haltern Dam catchment area

A two-path strategy was chosen for handling the problems:

- The first path was and still is the *avoidance principle*, which is applied at the source of pollution. At the beginning of 1989, the North Rhine-Westphalia Ministry for Environment, Regional Planning, and Agriculture (*Ministerium für Umwelt, Raumordnung, und Landwirtschaft*) set up a five-point program that envisioned a cooperative procedure and in which the responsible authorities, numerous farmers, and Gelsenwasser, as the regional water supplier, all participated. Part of the program was a directive in the spring of 1989 forbidding the use of atrazine and simazine in the catchment area of the Haltern Dam. The work group "Stever Catchment Area Joint Venture (*Kooperationsmodell Stevergebiet*)" was founded as a local board, and it met for the first time in the fall of 1989. Agencies and farmers, by means of water-conservational farming methods, worked together in trying to reduce the use of pesticides to the amount absolutely necessary, to eliminate misapplications, to optimize production methods, and to utilize environmentally compatible substitutes. The goal was to clean up the catchment area and to avoid further contamination.

- The second path is the *compensation principle*. With the construction and operation of a high-performance activated carbon filter, the highest quality of pesticide-free drinking water can be guaranteed at all times. By apportioning the activated carbon powder according to need, selecting a suitable sort of activated carbon, and regulating the amount of activated carbon, one can directly react to the time of pesticide application and the type and level of pesticide loads in the untreated water.

One can sometimes forego any use of activated carbon for extended periods, such as low precipitation periods or when pesticides are not applied, which only lead to temporary peak concentrations in surface water.

While it sufficed to fulfill the *immediate* requirements of the Drinking Water Ordinance with activated carbon filters, a *long-term* reduction of water pollution in terms of preventative water protection was sought through the cooperation between agriculture and water management.

Since 1990, the so-called “Five Point Work Group (*5-Punkte-Arbeitsgemeinschaft*)” in the Stever River catchment area has been determining projects and topics which should lead to a coexistence of agriculture and water management, without unreasonably restricting either of the partners. The goal is to maintain a viable agriculture while minimizing water pollution from agricultural practices. The work group is made up of representatives from the chamber of agriculture of the Westphalian-Lippe region in Münster, from the District of Coesfeld and adjacent districts, from the association of agriculture, from state and municipal agencies (e.g. the District of Coesfeld, the Münster State Environmental Office), from the Ministry of the Environment, and from water utilities from the region (Gelsenwasser AG, Stadtwerk Coesfeld, Stadtwerk Dülmen). The work group meets twice a year for reporting on cooperative work, discussing and agreeing to subjects of cooperation, and adopting programs.

The water sector pays for three additional coworkers to augment the consultant potential in the chamber of agriculture in the area of cultivation (crop protection and fertilization). The water sector is also in charge of the execution and financing of the entire untreated water analysis. Projects are additionally financed by the Gelsenwasser utility.

The District of Coesfeld integrates the cooperation goals into advisory goals of the official consultation for cultivation. Therefore, official consultation and cooperative consultation are uniform.

The cooperation focuses particularly on consultation and information in matters of crop protection and fertilization. Consultation matters have to do with the implementation of "good agricultural practices" and the minimizing and substitution of water-relevant herbicides.

Figure 26: Cooperation between agriculture and water management

From the viewpoint of water management, trend-setting cooperation projects were the substitution of urea derivatives in pesticides (isoproturone and chlortolurone) in the lower catchment area of the Stever River and the banning of bentazone in the growing of corn in the Stever catchment area, in collaboration with the manufacturer BASF and the agricultural business.

The results of the cooperation are described as follows:

- Through the ban on atrazine as part of the "Five Point Program", the atrazine contamination of raw water is no longer a problem.

- As a result of the cooperation with the chemical company BASF, the level of benzatone contamination in the spring / summer of 2000 was significantly lower than the previous year.

- The water quality improved significantly through the substitution of urea derivatives in project areas. For the past year, activated carbon treatment has no longer been needed.

- The quantitative, qualitative, and free-of-charge increase in consulting services for agriculture has led to same or even better returns in crops while minimizing operational costs, resulting in the more efficient use of resources.

- Despite high concentrations of animals, nitrate capacities did not rise due to the targeted, pesticide-oriented use of commercial fertilizers, based on soil tests supported by the cooperation.

- Both the agricultural trade and water utilities gained from an improved image.

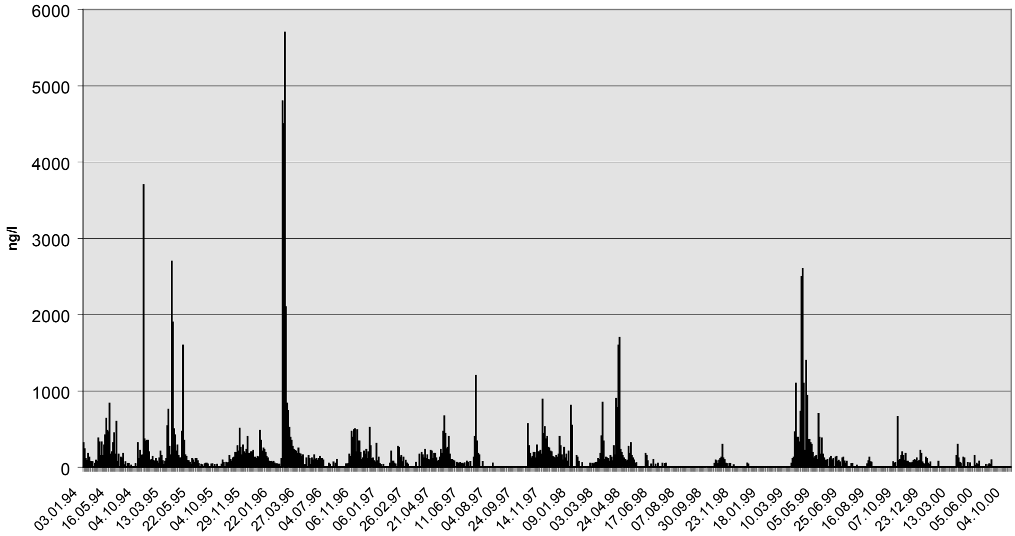

Figure 27: Isoproturon concentrations in the Stever River – test point „Füchtelner Mühle“

4.2.3 MONITORING OF WATER PROTECTION ZONES

According to specifications in the Water Management Act, water bodies are to be managed in such a way that every preventable impairment is avoided. Where necessary, water bodies can be further protected in the interest of the public water supply by being included into water protection zones. Special requirements and prohibitions apply to legally-declared water protection zones. The distinction is made between narrower zones of protection, in which neither the construction for housing nor for industry is permitted, and broader zones of protection, in which certain provisions apply to commerce, WWTP’s, and traffic routes. Also in broader zones of protection, neither gas stations nor chemical warehouses with water-hazardous substances are permitted to be built or operated.

By establishing water protection zones around Haltern, it is hoped that water pollution and water quality impairment can be prevented. The applicable ordinances contain listings of permit and prohibition rules, by which the special hydrological conditions in the catchment area are taken into consideration. With this, the foundations for a comprehensive ground water protection system are laid. To what extent these measures have an effect depends on how well the stipulations are observed in practice.

Effective monitoring contributes to the success of the protection of water bodies. Dangers can be recognized already at the onset and can be intercepted by means of preventive water protection. Monitoring is principally a subtask of water body control and is, according to state water laws, the responsibility of water authorities. In practice - this is also what the guidelines of the German Association of Gas and Water (*Deutscher Verein des Gas- und Wasserfaches e.V.* - DVGW) recommend -, it is useful to carry out these tasks in collaboration and agreement with waterworks operators. Water protection in Haltern proceeds according to this model.

In order to detect hazards to water early on, Gelsenwasser AG in Haltern operates approx. 50 of its own groundwater-quality measuring points upstream of the dam and in groundwater wells, at which samples are taken either regularly or as needed in individual cases. In addition, measuring points of the state environment authority are also used. The analysis results enter into a laboratory information system and can be displayed with the help of a geographic information system (GIS; Fig. 28).

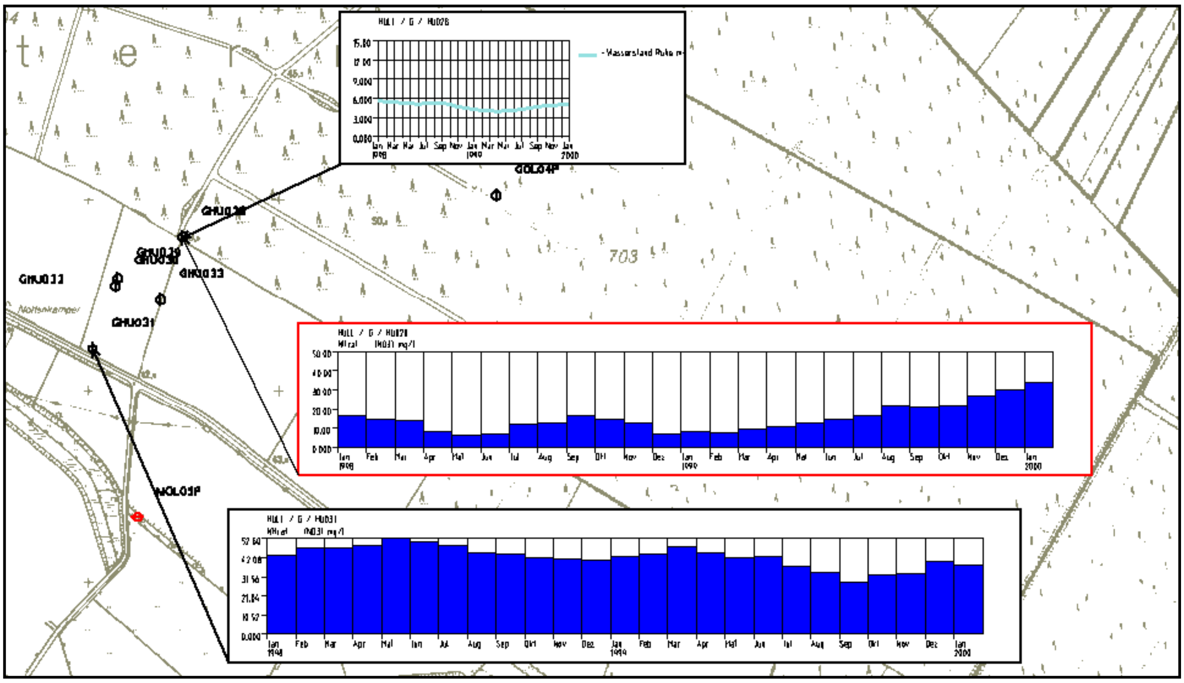

Figure 28: GIS-Plot groundwater quality monitoring

The regular groundwater-quality measurements can be drawn upon in order to determine how a hazard that may possibly have entered the groundwater is spreading. In Haltern in particular, more than 2000 readings are performed per year, which can be administered with the help of a water management databank. If required, a further processing of data ensues in the form of groundwater plans, out of which information can be derived concerning the direction of flow and speed of groundwater.

In wooded areas, monitoring of water protection zones is done by flyovers [cf. 20]. Flyovers in such areas are advantageous since forests are often difficult to travel or see through, or because the entering of some areas is prohibited by law. The narrower and wider protection zones are monitored on a quarterly basis. According to a preset grid, the grid squares are overflown one after the other on a north-south axis. The flight paths proceed through the middle of the grid squares at intervals of approx. 250 meters. Objectionable activity, such as illegal construction sites or the depositing of residual wastes, is marked on a map from the plane and later entered into a report form, together with a more exact specification of the location. Photographs are taken as evidence and can be drawn upon if further procedures are necessary. After the evaluation, any further steps are taken by the waterworks personnel or the oversight authorities.

Figure 29: Aerial view of the monitoring of a protected water area

Furthermore, in accordance with the Ordinance on Water Protection Zones, Gelsenwasser AG participates in principle in all authorization procedures, such as planned housing development projects, on the part of the lower water authority. In such procedures, it can be reviewed, for example, to what extent construction regulations, such as concerning the storage of water-hazardous substances, have been observed; or suggestions can be introduced that are the result of someone's experience - for example, concerning the use of environmentally friendly fuels in one's own company.

Old contaminated sites are investigated by the water authorities and are evaluated in collaboration with the local water supplier with relevance for the supply of drinking water. If necessary, a remedial program will be implemented to clean up the site.

4.2.4 PROTECTION AGAINST EFFECTS FROM UNDERGROUND MINES

With the startup of mining activities in the beginning of the 1980's, hazards arose for the Haltern Waterworks due to mines collapsing. Besides possible damage to structural equipment, it was feared that salty water might flow into the well.

Consequently, comprehensive examinations were performed. After a detailed analysis of the structural condition of the water plants, expert opinions pointed out which areas could be susceptible to mine collapses and which measures for structural reinforcement would be necessary to secure the condition of the waterworks. In addition, the possible effects on the conditions of groundwater flow were evaluated with the help of a mathematical groundwater model. This led to an agreement between the mining industry and the local water supplier, and a continuous, geodesic measuring program for the monitoring of ground movements was decided upon.

Since then, measurement results have been discussed and any possible structural reinforcement measures voted upon in a regularly-meeting work group, which is made up of representatives from the mining industry and from the waterworks. Regularly executed measurements of the water level at the wells along with the monitoring of the water distribution network help with data gathering and early detection of damages. Possible reinforcement of pipes and the planning and constructing of backup wells can in this way be tackled in good time and without a serious loss of the water supply.

4.2.5 RESULTS AND PERSPECTIVES

The selected monitoring method of the water protection zone has proven to be practicable and effective in the past. A new and sustained source of damage to the groundwater supply in the “Haltern Sands” was able to avoided so far.

The agreement reached with the mining industry led to the securing of the existence of the waterworks. No mining takes place beneath the waterworks. The groundwater conditions in the central area of the waterworks are stable. The present mining procedures present no threat to the quality of water.

Next to the continuation of the Stever cooperation between water management and agriculture, the main goal of the next few years will be the management of problematic pesticide agents (currently isoproturone, chloroturone, bentazone, and in some cases terbutylazine) in the whole Stever River catchment area, in order to further keep the expense of water purification at a low level. Every metric ton of activated carbon saved also means a considerable reduction of costs for the disposal of treatment residues.

The report of the Institute for Water-, Ground-, and Air Hygiene at the Federal Environmental Agency (*Umweltbundesamt*) in Berlin already hinted at this strategy as a component of the Five Point Program. The reduction of isoproturone usage to 10% was not able to be implemented at the time because there were not enough alternatives. In the meantime, sufficient approved alternatives that are more compatible with water have become available on the market.

First consultations with other important actors (agrochemical industry and trade, manufacturers) have taken place. The practicability has been evaluated. In order to determine the effectiveness of the measures, one needs to record not only the output of active substances into the Stever River (concentration and load), but also the input (amounts of pesticides sold and used).

The necessity of substitution is supported by the new authorization stipulations of 1999 for urea herbicides (like isoproturone and chlortolurone), which forbid the output of urea derivatives in the Stever River catchment area up to 90%. With regard to this, the cooperation in the Stever area has led to the necessary measures to comply with the new legal situation. In order to ensure an even better protection of surface water against pesticides in the future, an adaptation of the current licensing procedures (catchword: post permit monitoring) is desirable, as it is also envisioned in the Five Point Program.

After the experiences of the last 10 years, there are warranted hopes that in the next decade the pesticide problems in the Stever River catchment area will be able to be resolved by following agricultural practices involving chemical pesticides while keeping the nutrient situation in the manufacturing-intensive region under control.

Agricultural influences on the environment viewed from an international perspective

Environmental experts in the international community and a multitude of politicians all agree that agriculture will be a major cause for environmental degradation over the next 50 years (cf. sect. 4.5). Besides the reduction of the greenhouse effect, one task for the future is the prevention of diffuse emissions in agriculture. The global expansion of agricultural fields for the supplying of foodstuffs for the ever-growing world population and the type of field use (extensive, intensive) are two substantial influencing factors for environmental degradation, and therefore also for water resources. An increasing cultivation of crops implies still today the increased use of nitrogen, phosphorus, and pesticides, which end up in surface waters.

An example of such negative effects is the “dead zone” in the Gulf of Mexico in the area of the Mississippi Delta. The river transports a multitude of pollutants from American agriculture into the ocean. The biological diversity and ecological cycles of the ocean are in danger of experiencing irreversible harm. Global prevention strategies that have lasting effects and are able to be practically implemented are only possible through an international consensus [43]. Successful national approaches for solving these problems are an important step in this direction. However, it must not be forgotten that agriculture only produces what the nation subsidizes or what the consumer requests. A reorientation of national subsidy programs and a rethinking on the part of the consumer, especially in economically highly-developed nations, are further steps toward a solution of the problem.

4.3 COST-EFFICIENT ORGANIZATION OF MUNICIPAL WASTEWATER DISPOSAL, ILLUSTRATED BY THE EXAMPLE OF KÖNIGSBRÜCK*

After the German reunification in 1990, many East German municipalities found themselves in the situation that they needed to make great investments in WWTP's in a short period of time while making sure that their own administration apparatuses did not expand and effluent charges did not rise more than absolutely necessary. The involvement of a private wastewater disposal company under conditions of uniform competition can contribute to reaching a maximum of cost-efficiency. The following article, using the example of the Wastewater Association of Königsbrück (Abwasserverband Königsbrück), illustrates how, despite unfavorable starting conditions, a wastewater-related infrastructure combined with a private BOOT model was developed and has already been successfully operating for over five years.

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4.3.1 SITUATION DESCRIPTION

Königsbrück is a small town with about 5,000 inhabitants and is located in the state of Saxony, approx. 25 km north of Dresden. Historically, the town developed as a farming community until the end of the 19th century, when it became a garrison town. During the more-than 100 years that Königsbrück served as a garrison town, it housed troops of the "Red Army" for over 45 years. When the GDR collapsed and Königsbrück regained autonomy at the beginning of the 1990's, the municipality was confronted with a difficult situation.

As the heritage of the garrison, about 350 hectares of empty barracks, a military training area of 7,000 hectares, and diverse military waste (ammunition, waste oil, scrap metal, garbage, ruins) were left behind. The buildings in the city were is a desolate state and the housing quality low. Its infrastructure was worn-out. Businesses and industries were in bad condition. The region lost over 1,000 jobs. Ownership issues were unclear. The fulfillment of municipal tasks was made difficult by the old structures that still existed. For example, the WWTP's did not belong to the municipalities, but rather to the former VEB* water supply and wastewater disposal operators or to their successor companies. Therefore, the municipalities could not obtain any revenues from the plants until 1994.

Figure 30 : Remains and residual waste on the site of the subsequent WWTP

In addition, municipal administration needed to be restructured, and new laws needed to be abided by (e.g. the Law Concerning Municipal Cooperation, the Water Management Act, the Effluent Charges Act).

At the same time, since there had inevitably been no head start in planning, design concepts needed to be developed for all levels and areas, such as the following:

- Urban development (urban renewal, urban land-use planning)
- Infrastructure (power and water supply, wastewater, school development)
- Traffic concept (ring roads, street repair, inactive traffic)
- Nature and environmental protection
- Development of business structure (business area) use of former military real estate.

* VEB – Volkseigener Betrieb (*state-owned enterprise*), the organisational form of companies in the socialistic system of the German Democratic Republic (GDR)

The entire situation was mainly defined by high legal and technical requirements for the infrastructure that needed to be reconstructed, by a great need for repair, and by the related costs. In contrast, there were sinking tax revenues, rising municipal charges, an increasing public debt, and increasing unemployment.

Since all these measures needed to be realized at the same time, an expected potential for conflict between technical necessity and financial feasibility was obvious.

4.3.2 FOUNDING OF THE WASTEWATER ASSOCIATION

In order to fulfill compulsory municipal duties, the Wastewater Association of Königsbrück was founded on January 14, 1991. The association comprises the city of Königsbrück, the municipalities of Laußnitz and Höckendorf, and the former municipalities of Schmorkau and Weißbach. The founding of the wastewater association was preceded by the realization that one of the essential foundations for the further development of the region was the solving of the wastewater problem.

Besides fulfilling legal requirements, the goals of the association were the revitalization of water bodies; the improvement of the aesthetic nature of the area to attract new settlers, businesses, and industries; and last but not least, investments as an economic factor as such for civil engineering, road construction, the refurbishment of buildings, and thereby also for maintaining and creating new jobs.

The administrative territory of the association includes a population equivalent of about 9,000 inhabitants, 8,000 of which actually live in the territory and 1,000 of which are business-related. Therefore, the Wastewater Association of Königsbrück can be classified as a small special interest association in the state of Saxony. Nevertheless, due to the large number of problems needed to be resolved through the founding of the association, the complexity of the situations, and the approaches which it has chosen, Königsbrück can serve as a good and clear example of the successful realization of a private BOOT* model.

At the outset of the founding of the wastewater association, the following situation existed:

- A several-decades-long back-up of investments (example: the cessation of work in the construction of a municipal WWTP in 1914)
- No central WWTP – Accumulating wastewater was only poorly treated in sediment and multi-chamber pits in decentralized form and then fed into receiving waters.

* BOOT – Build, Own, Operate, Transfer

- Only partial sewer sections existed in Königsbrück and Laußnitz, and there were no connecting trunk sewers.
- No qualified specialists for the administration and operation of wastewater-related facilities
- Far-reaching structural change through demilitarization (withdrawal of the CIS troops, conversion of the military property, end of the 100-year garrison period)
- Unknown demand development by the business and housing sectors, as a result of far-reaching social changes
- Lack of empirical data concerning consumption patterns amid rising charges for potable water and wastewater
- Uncertain planning figures as a result of population migration and structural changes in the economy and commerce
- No legally valid regulations for the collection of fees and tariffs
- High investment needs
- Limited financial means of the municipality
- High water treatment standards on the part of the responsible water authorities
- Limited availability of subsidies
- Lack of understanding and rejection of increases in fees in large circles of the population

An efficient solution for the planning, construction, financing, and operation of a WWTP was needed. At the same time, the partial catchment areas of the sewers that were already present needed to be connected to the trunk sewers that were to be newly built, leading to the location of the WWTP. The following *chief objectives* were to be considered in investment planning:

- The economic viability of the entire measure
- Minimizing of investment and operational costs
- Gradual (i.e. in accordance to the needs) expansion of wastewater-related facilities
- Temporal staggering of investments in consideration of refinancing
- Interdependence of investments, percentage of connections to wastewater treatment, and charge revenues

4.3.3 DECISION FOR A PRIVATE BOOT MODEL

In assuming the task of wastewater disposal, the wastewater association had to decide between a public and a private organizational model. Already in 1992, the association favored a private BOOT model for the realization and operation of a WWTP. There were diverse *criteria* to be evaluated in the preliminary stages. Among them were the following:

- Legal basis
- Ownership issues of present facilities
- Does the wastewater association have a sufficient technical understanding to fulfill the tasks?
- Are public tasks compatible with the private sector?
- What influences from public administration will there be on the operation of the WWTP?
- Is there a political will for privatization in all of the municipalities?
- May private BOOT models be subsidized?
- Development of sustainable fee structures
- Should WWTP’s and sewers be privatized?
- Coordination between operator and wastewater association
- What criteria does a serious private operator need to fulfill?
- Can service be offered at a better price through private operation?

With the support of the Federal Ministry for the Environment (*Bundesministerium für Umwelt – BMU*), the above-mentioned criteria were able to be evaluated professionally and cost-efficiently [13].

One can imagine that the political *discussion* of the privatization question was accompanied by great controversy. There were misgivings about the future operating firm. What if it were untrustworthy? It could lead the municipality into difficulties. In any case, the expense of supervision would be considerable. In this respect, it would be generally wrong to place wastewater disposal into private hands and thereby lose municipal responsibilities and influence. Above all, though, there arose doubt over how a private company would be able to operate more cost-efficiently than a public entity, since it would be subject to considerable additional taxes and would have to still make a profit. Nevertheless, in contrast to neighboring associations (which are not doing as well as Königsbrück at the present time with respect to wastewater fees and water protection), the final decision was made in favor of inviting bids for a private BOOT model.

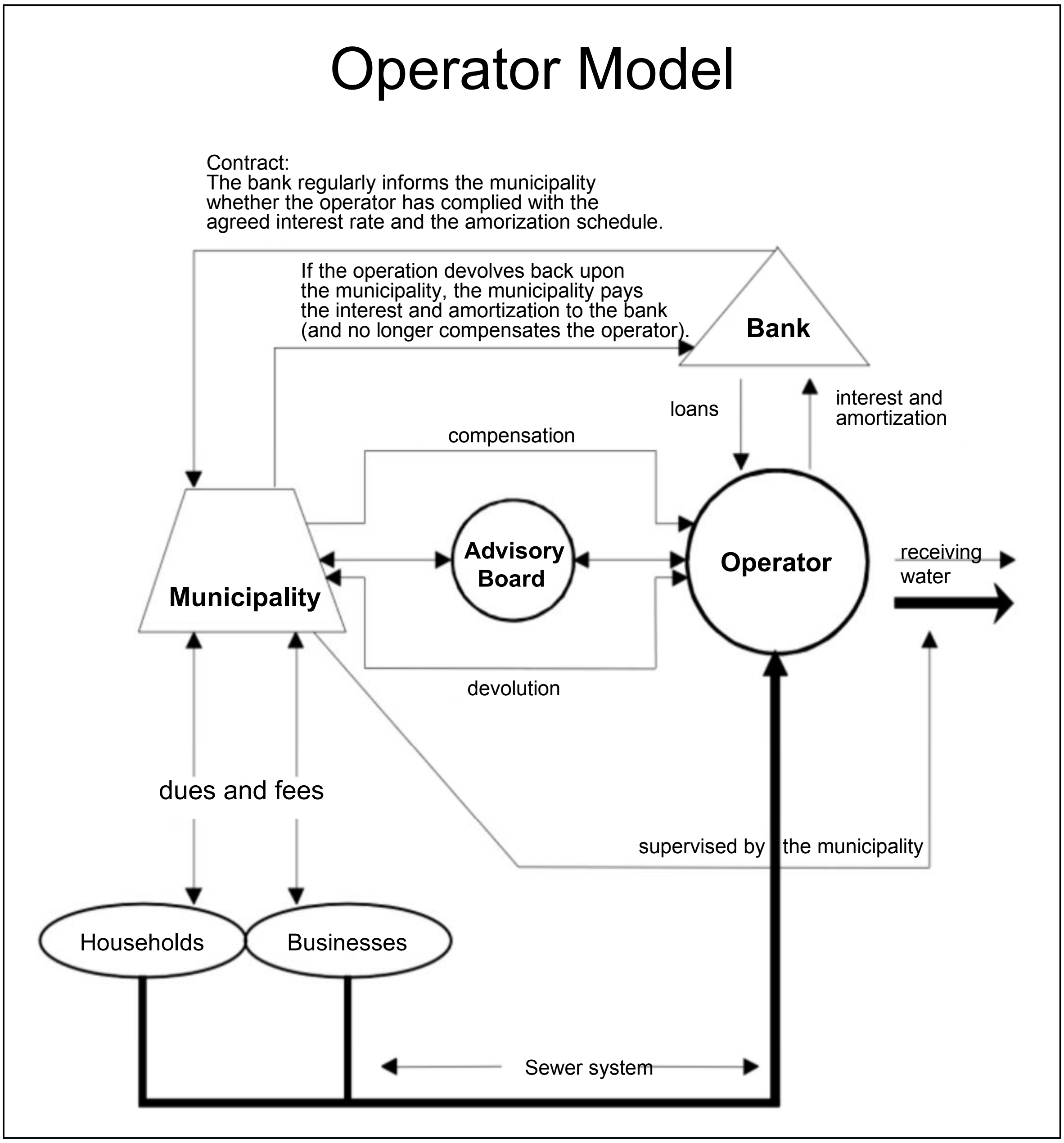

Figure 31: Example of an operator model (BOOT) [38]

The *reasons* for this decision by the wastewater association were the following:

Starting conditions:

- No developed infrastructures in existence (civil engineering office, etc.)
- No technically trained personnel to operate the WWTP

Results / expectations:

- The saving of future administration costs by minimizing the number of necessary wastewater association personnel
- The acquisition of short-term external experts is less costly than hiring in-house experts.

- The benefit of private know-how - above all, technical and business knowledge - in order to implement the wastewater plan quickly and cost-efficiently
- Expectation of a positive operational cost development, since the planning and operation of the plant are performed by one party, and the municipality shifts the cost risk factor onto the operator
- High quality equipment and a guaranteed functioning of the plant as a result of a long-lasting operator contract (25 years)
- A pledge from the state of Saxony for financial subsidies, applying also to a private BOOT model
- Public bid tendering corresponding to legal requirements for public tenders
- Assumption of the preliminary expenses for an operator model by the future operator

The latter-named expectations were confirmed by the results of the public bidding process and were the main reasons for the choice of an operator model.

The investments in a sewer system were and are still carried out independently by the wastewater association. The coordination of the interface between the sewer system and the treatment plant was ensured by means of external project management during the planning and implementation phases.

4.3.4 PROJECT MANAGEMENT

The *project management* includes the following tasks:

- Progress control for the planning and construction of a sewer system (municipal) and the WWTP (private)
- Evaluation and optimization of the association's sewer plans (coordination of three different engineering offices, investment focuses, holding off on plans that are not need-based (e.g. rain overflow basins), priorities: drainage of contaminated water > treatment of mixed water > drainage of rainwater)
- Supporting and advising the association in its dealings with water authorities
- Advising the association in the compiling of investment plans
- Advising the association in the drafting of statutes, in particular statutes for tariffs and fees, as a prerequisite for the refinancing of investments (goal: enactment at the time of the startup of the WWTP)
- Cost calculations for the ascertainment of cost-covering fees on the basis of planned and fixed investment expenses (i.e. calculation of overhead expenses as a way to evaluate how well the planned investments will be able to be financed)
- Supporting the wastewater association in public discussion

4.3.5 PUBLIC TENDERING FOR THE OPERATOR MODEL

It should be pointed out that the use of an operator model does nothing to change the municipality's responsibility of fulfilling its public legal duty of wastewater disposal. The municipality delegates only the execution of wastewater disposal to the private company, not the responsibility itself. Legal relationships exist between the municipality and the citizens (tariffs and fees) on the one hand, and on the other hand between the municipality and the operating company, which receives compensation for its services from the municipality. In accordance with the legislation in force in Germany, operator models are subject to public tendering.

In *preparation* of the tender documents for the operator model of the Königsbrück WWTP, an independent engineering and business consultant was first of all assigned with the drafting of the legal permit documents of the WWTP. After the draft was completed, it was submitted to the water authority for authorization and examined. At the same time that the permit documents were prepared, a construction expert opinion for the site of the WWTP and a survey were compiled.

After the permit planning was concluded, the *documents for the tender* were compiled. These included:

- Work program with permit planning
- Construction expert opinion
- Documentation of the preliminary expenses for engineering services (permit planning), etc. to be assumed by the bidde
- Draft of the service contract with price scaling clauses and devolution terms
- Draft of the real estate lease agreement
- Draft of the arbitration agreement

Besides investment costs, the bidders had to state in their offers a binding *base charge and a unit charge* for the duration of 25 years of operation, on the basis of given water volumes. Both rates needed to be calculated and stated without public subsidies of the measure and under consideration of a given public subsidy rate. The rates were to be calculated including the replacement investments necessary for 25 years of operation. The base charge accounts for the yearly fixed costs; the unit charge includes all variable costs (electricity, chemicals, sludge treatment, etc.), given in DM/m³. *Supplementary technical bids to the permit draft were expressly permitted.*

Water services for a municipality – procedures for bid tendering of a private wastewater model

- According to European law, German federal, state, and municipal law, public contracts have to be publicly tendered.
- According to the Municipal Budgeting Ordinance (*Gemeindehaushaltverordnung – GemHVO*), specific definitions apply in the federal states concerning the allocation of services within the scope of PSP models (*Private Sector Participation* – an umbrella term for privatization models and partial privatization models, such as operator models, joint ventures, partial public models, etc.).
- Equally, the EU Service Directive 92/50/EEC of June 18, 1992, concerning the coordination of procedures for delegating public service contracts must be observed.
- Before a public tendering takes place, a so-called calculation of overhead expenses with the prognosis for wastewater fees should generally be compiled. By means of this, it can be determined prior to the bid invitation at what cost the performance of the task would be possible as a public utility (municipal utility or municipal department). Realistic timetables and additional building costs should be applied in the calculation of overhead costs, plus a supplement proportionate to cost risks.
- Operational costs should be as comprehensive as possible and should include an administration supplement and a supplement for unforeseeable cost increases.
- The tendering procedures that may be followed include the public tendering, the limited bid (On the basis of a public competition, a list of three to eight pre-qualified companies is posted. These companies are then asked to make a concrete bid.), and the so-called negotiation procedure (a public pre-qualification bid followed by organized negotiations with equal treatment of pre-qualified bidders).
- If the PSP bid tendering produces no economic offers (the criterion is the expense threshold of the public form of organization, according to the above-mentioned calculation of overhead expenses), the bid invitation can be annulled by the supervisory authority after another close examination of the circumstances.
- Whether a PSP model can be considered economic, and to what extent possible costs can be avoided under specific conditions, can only be determined by public tendering and admission of conceptual auxiliary bids.

According to the Federal Ministry of Economics (*Bundeswirtschaftsministerium*), the VOL regulations (*Verdingungsordnung für Leistungen* – general contractual terms and conditions) are to be applied to such matters. Likewise, the EU Service Directive 92/50/EEC concerning the coordination of procedures for delegating public service contracts must be observed.

4.3.6 CONSTRUCTION AND OPERATION OF THE WWTP / EXPANSION PLAN

After the conclusion of the necessary agreements, the WWTP was erected within 10 months. The official dedication took place on September 1, 1995, after a successful test operation that lasted several months.

As a result of the good coordination between the construction of the sewers (trunk sewers) by the municipality and the construction of the WWTP, approx. 50 % of the population in the association territory was able to be immediately connected directly to the treatment plant. Today, about 75 % is connected to the sewer system; the other 25 % has individual wastewater disposal.

The WWTP was built as an activation plant with aerobic sludge stabilization, intermittent nitrification / denitrification, and chemical phosphate elimination. State monitoring standards have been observed continuously since the startup of the plant; there has been no cause for complaints or sanctions.

A three-stage expansion plan was chosen:

First expansion stage – disposal capacity for 6,000 inhabitant equivalents, using aerobic sludge stabilization (or disposal capacity for 9,000 inhabitants with a separate, additional sludge stabilization necessary)

Second expansion stage – disposal capacity for 12,000 inhabitant equivalents, using aerobic sludge stabilization

Third expansion stage – disposal capacity for 18,000 inhabitant equivalents, using aerobic sludge stabilization.

The purpose of the service agreement was the construction and operation of the first expansion stage. The wastewater association was not bound to a timeframe for the implementation of the second expansion stage. The fee increase associated with the second expansion stage is stipulated with the option of expansion. The third expansion stage was taken into consideration in the operator’s plans according to the contractual terms by providing respective construction sites and interfaces.

The variable expansion plan of the WWTP avoids unnecessary burdens for the municipality due to financial requirements by the operator for oversized treatment capacities (because they were based on unrealizable prognoses). The plan thereby stabilizes the contractual relationship between both partners. At the same time, citizens only bear the minimum fees necessary.

Figure 32: Königsbrück WWTP – expansion stage 1.

4.3.7 REFINANCING

After five years of operation, the private BOOT model in Königsbrück has gained a very high public acceptance. One beneficial factor in this was that the wastewater association had a strong sense for what to expect as far as the development of charges, based on management costs determined in 1992, and laid these open from the very beginning.

Today, the wastewater association operates on a full-cost-covering basis. This means that no additional allocations from the budgets of municipalities involved are necessary.

The investments are refinanced by means of fees and tariffs. The tariffs are levied on the basis of the Saxon Municipal Charge Act (*Sächsisches Kommunalabgabegesetz – SächsKAG*). The average connection charge per real estate lot is approx. € 3,250. As a result of intensive public relations work engaged in over several years by the responsible local legislators and legislature, public opposition with regard to the assessment of charges was less than 5%.

The current cost-covering wastewater fee (for the sewer system and for the WWTP) is € 2.90 / m³. Specific water consumption in Königsbrück is very low and amounts to only about 33 m³ / inhabitant / year. That means that the annual cost of wastewater treatment is approx. € 97.86 / inhabitant / year and is below the national average (cf. Fig. 15).

The current fee confirms the prediction made in 1994, in which management costs of € 3.04 / m³ (at 33 m³ / inhabitant / year) for 1995-1999 were calculated.

It should also be mentioned that an advisory board was set up on the basis of the service agreement for the operator model of the WWTP, which meets regularly to ensure the adherence to the stipulations of the service agreement. The board is comprised of two representatives from the wastewater association and two from the operating company, with an independent arbitrator.

4.3.8 SUMMARY

The example of Königsbrück shows that private models can be successfully implemented even in small and medium-sized municipalities and public entities. Especially advantageous is the total optimization of the tendered services under competitive conditions. The potential for innovation, which can be activated, on the part of expert service providers can lead to significant cost savings in a municipal budget, provided there is competent supervision of the privatization process.

The Königsbrück private BOOT model was the first operator model to be publicly tendered in the state of Saxony and one of the first in the former GDR. The tender procedures were supported by the Federal Ministry for the Environment as a pilot project. Credit for the successful realization of the project can be contributed not least to the close cooperation of all involved parties from the municipality, from agencies, and the business sector.

4.4 REGULATION AND MONITORING OF INDUSTRIAL WASTEWATER ILLUSTRATED BY THE EXAMPLES OF A LARGE CHEMICAL CORPORATION AND A METAL MANUFACTURING COMPANY*

Until the end of the 1960's, industrial wastewater was to a large extent discharged into water bodies untreated. Only after legal limits for emissions were introduced did it become possible to construct WWTP's in municipalities and in industry and thereby improve water quality all over the country. The detailed procedures of the water authorities and of industry will be illustrated through the example of a large chemical corporation and of a medium-sized metal manufacturer. After the minimum standards were met, further state-of-the-art standards for pertinent industries and substances were implemented which apply already at the production stage, where wastewater is first generated. Therefore, it was necessary to expand water regulations and permits, to compile wastewater registers, and to implement constant monitoring.

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Obmann Bund-Länder-Arbeitsgruppe
"Chemieabwasser"

4.4.1 SITUATION DESCRIPTION

Until the end of the 1960's, most industries, including a large chemical complex on the Upper Rhine and a medium-sized metal manufacturer, discharged untreated wastewater into rivers. The respective agency limited itself to monitor a significant deterioration of the quality of the Rhine at the point source of the chemical corporation. In addition, it was verified that shipping was not impaired in any way, for example, due to the discharge of acids or waste material. The municipality responsible for the wastewater disposal of the metal manufacturer had no objections at that time to the company discharging heavy metals into its public sewer system.

The Water Management Act took effect already in 1960. At that time, it was not an environmental protection law, but rather a law governing the management of water resources. It gave responsible authorities a wide range of possibilities for prohibiting discharges if they were detrimental to the common good. Yet it was unclear why rivers, particularly the Rhine, were excessively polluted. A special export report (1976) on this topic by the Advisory Council for Environmental Issues (*Sachverständigenrat für Umweltfragen*) provided this answer [cf. 17]: "The vague legal term 'the common good' had a detrimental effect." One reason for this was that the water authorities were pitted against experts with political support at the local level because they represented the establishment of industry and the creation of jobs. The water authorities were overstrained with the implementation of the law because of the large number of individual cases.

4.4.2 THE NEW WATER MANAGEMENT ACT (1976) AND ITS IMPACTS

With the fourth amendment to the WHG (1976), the *emission principle* was implemented. This means that minimum requirements defined by the government need to be met by the dischargers irrespective of the water body. After thorough discussion in the political expert groups of the Bundestag and Bundesrat, there was a consensus that every discharger of wastewater should be obligated to immediately begin constructing fully biological WWTP's for domestic wastewater and at least equivalent WWTP's for industrial wastewater. This was paraphrased with the term "generally accepted technology". This technology can be implemented by every water user without particular technical difficulty [18].

The final breakthrough came with the drafting of industry-specific legal emission limits in the so-called wastewater administrative regulations for the individual branches of industry. For the *large chemical corporation* under consideration, the result was that a fully biological WWTP needed to be built and operated. The treatment plant was built in 1984 in order to be able to meet the requirements set for the chemical industry (COD reduction by at least 75%). In addition, treatment plants were built for the pretreatment of two difficult-to-degrade partial streams. These partial streams contained high pollutant loads. The loads were not able to be broken down in the biological WWTP's; they even inhibited biological degradation in part.

The *metal manufacturing company* had to implement the following wastewater treatment measures in order to observe the industry-specific legal emission limits:

- Removal of cyanide, nitrite, and chromate (chromic acid), combined with the separation of the corresponding wastewater partial streams, in order to avoid in particular the accumulation of hydrocyanic acid
- Neutralization of acids and bases, joint precipitation of heavy metals as hydroxides, removal of metal hydroxide sludge
- Separation of oils and fats from contaminated immersion baths
- Hook-up to a municipal WWTP, where the wastewater undergoes full organic treatment

4.4.3 STANDARDS BEYOND THE MINIMUM REQUIREMENTS

Based on the political will and the new WHG, the water authorities then required companies, on an individual basis, to implement measures that went beyond the legal emission limits specified in the wastewater administrative regulations. These applied to especially critical substances which, from the point of view of an immission analysis, needed to be limited.

Stricter standards

The following are typical examples of stricter standards which have been implemented in *chemical corporations*:

- Listing in a "wastewater register" all significant wastewater partial streams and wastewater components which emerge in the individual syntheses or synthesis stages, in order to find out where critical (difficult to degrade) substances occur and to be able to treat them specifically
- Limitation and significant reduction of the discharge of hexachlorobenzene, which accumulates in fish by a factor of 1:1,000,000 – This also involved the closing of a manufacturing plant.
- Limitation of the emissions of vinyl chloride from the production of vinyl chloride / PVC
- Construction of plants for the pretreatment of heavy-metal-laden wastewater partial streams originating from the production of organic dyes containing copper and chromium; construction of a plant for removing nickel from a wastewater partial stream of the vitamin C synthesis

In the *metal manufacturer*, the standards that went beyond the corresponding wastewater administrative ordinance were implemented for the protection of the municipal WWTP's. These standards pertained to the following water pollutants:

- Ammonia: 50 mg/l, since ammonia was not sufficiently eliminated from WWTP's, and ammonia gases interfere with sewer operation
- Aluminum: 10 mg/l, since aluminum, when it mixes with domestic wastewater, leads to excessive sludge deposits in sewers
- Sulfides: 10 mg/l, due to the danger of the formation of hydrogen sulfide gas and sulfuric acids which damage concrete

This applied especially to the protection of water bodies against substances hazardous to water. The legal basis for this was already contained in the WHG since 1960. The clear political intention to confront dischargers more intensively with the legal specifications led to the heightened implementation and enforcement of laws that were already in existence.

4.4.4 INTRODUCTION OF STATE-OF-THE-ART TECHNOLOGY

In the following years, the definition and implementation of industry-specific legal emission limits irrespective of water quality brought about an across-the-board improvement of the water quality through the construction of WWTP's in municipalities and industry.

A limitation of certain "hazardous" substances even beyond those limits was essentially possible (cf. example in section 4.4.3) - as long as the state government and its agencies were equipped for it. Nevertheless, such standards were legally and technically difficult to justify and to implement in individual cases. In addition, there were problems in implementing the necessary measures across-the-board at nonpoint sources. For that reason, a renewed amendment to the WHG was necessary in order to raise standards up to the state of the art. The industry-specific wastewater administrative regulations were subsequently revised and converted into appendices to the Wastewater Ordinance (see section 3.2.3) [30, 31].

The following were the most important new components in the introduction of the state-of-the-art technology:

- Tightening standards and introducing new standards for "hazardous substances" such as heavy metals and organic halogen compounds (AOX)
- Implementing standards for these substances not only at the point of discharge, but also for all relevant wastewater partial streams
- Defining "general standards" (e.g. for rinsing techniques in metal manufacturing companies) with the goal of withholding wastewater constituents already at the production stage
- Exploring possibilities for avoiding wastewater contamination and documenting the results in a "wastewater register"

4.4.5 IMPLEMENTATION OF NEW STATE-OF-THE-ART TECHNOLOGY

Since the mid-1980's, enterprises implemented measures which were expected to be state-of-the-art technology already in anticipation of and at the same time as the revision of the industry-specific wastewater ordinances. The water authorities profited from the fact that politics and the public were interested in effective water protection measures in the mid-to-late 1980's, due to the Sandoz accident and the death of seals in the North Sea (cf. section 3.5.1).

The following are some of the measures that were implemented by the chemical corporation under consideration:

- The wastewater register was expanded into a central wastewater management system. It was important to allocate the pollutant streams to the individual syntheses or synthesis stages and to accurately describe the wastewater-relevant production procedures (process engineering). In this way, one could recognize where the prevention or pretreatment of wastewater partial streams was still possible or necessary.
- All pollutant partial streams were recorded and pretreated which are only able to be poorly eliminated (< 70%) in biological WWTP's and cause significant loads (> 1 Mg/yr total organic carbon (TOC)) at the point of discharge.
- Separate sewers, enrichment plants, and high-pressure wet-oxidation plants were constructed in order to eliminate difficult-to-degrade wastewater constituents in the production of organic dyes and aromatic intermediate products. Wastewater partial streams from vitamin syntheses which are hard to break down were dried and burned or treated by low pressure wet oxidation.
- Measures were implemented for reducing AOX (adsorbable organic halogens): special pretreatment of vitamin-synthesis partial streams containing AOX; the rest of the treatment of heavily contaminated partial streams is done in the above-mentioned wet oxidation plants.
- Wastewater partial streams were pretreated that were highly contaminated with ammonia from alkaline stripping. The recovered ammonia was recycled.

Based on the new state-of-the-art standards, the following measures were implemented in the metal manufacturing company:

- Concentrations of heavy metal were significantly reduced, for example, by means of a fine filter or end ion exchanger.
- The WWTP's were converted to batch operation.
- The rinsing techniques were further developed in order to multiply rinsing water usage by about a factor of 10 by means of reducing water volumes.

- The spilling of wastes was significantly reduced (50%) by increasing drip times, etc.
- The process-bath lifespan was extended by means of activated carbon treatment and electrolytic treatment.
- Active chemical components from rinsing were recycled to process baths.

The multiple use of rinse water led to a significant reduction of pollutant loads in the water body (due to lower wastewater volumes); the other measures led to a considerable reduction of waste volumes ("galvanic sludges") and to a conservation of raw materials and energy, due to the closing of material cycles.

New treatment technologies needed to be developed first of all for problematic industrial wastewaters, in order to advance the state-of-the-art technology to the degree that environmental problems could actually be resolved in practice [34].

For organically contaminated wastewaters, anaerobic reactors were developed with which energy in the form of biogas is able to be generated, which can make such procedures very financially attractive. So-called cross-sectional technologies, such as ozone treatment of water, are able to be successfully applied today in various areas, beginning with the elimination of nitrogen in polluted groundwaters to the oxidation of difficult-to-degrade substances in wastewater (e.g. the treatment of landfill leachate) or wastewater sanitation.

The use of such "end-of-pipe" technologies, however, is only useful if pollution cannot be more economically prevented in the industrial production process itself or at the location of the wastewater partial stream. For this reason, numerous technological developments in Germany have addressed wastewater prevention and production optimization near to the source, by which, for example, the load of organic pollutants (AOX) could be drastically reduced in cellulose bleach (substitution of chlorine bleach through ozonization).

Figure 33: Above-ground bioreactor [15]

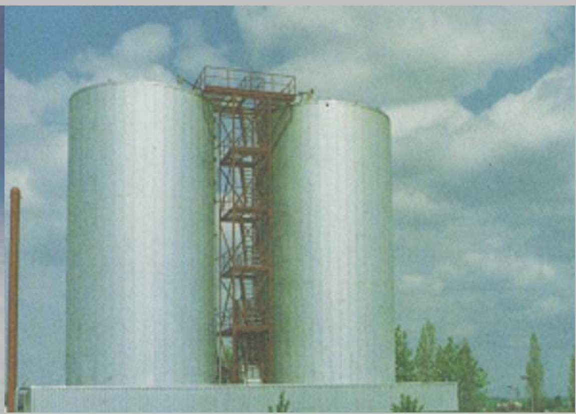

Figure 34: Bioreactor for the fermentation organically contaminated wastewater [15]

4.4.6 DEFINITION AND MONITORING OF LEGAL LIMITS AND OTHER STANDARDS

In most cases, the implementation of the necessary measures for wastewater treatment and prevention could be ascribed to the fact that specifications of the industry-specific wastewater administrative regulations by the responsible water authorities were successively assumed into water discharge permits. Most enterprises did not make any large objections to this since their industrial associations participated in the drafting of the standards from the very beginning. Particularly the companies that treated and discharged their own wastewater were aware that, after the expiration of their permit (e.g. after 10 years), they would only be re-permitted if they observed the existing legal limits [30]. This was also applied to water permits for enterprises that disposed of wastewater into municipal WWTP's. In some cases, the water authorities also made use of the option to require additional water protection measures in order to reach the state of the art. Even in these cases, the dischargers declared their willingness to cooperate, in order to be able to contribute in the making of more appropriate standards.

Modern water permits contain the following main components [31], as is demonstrated by the case study of the large chemical corporation:

- Limits on concentrations and loads for the following main parameters:
  (1) BOD_5: 30 mg/l, in order to ensure fully biological treatment
  (2) COD: standards for concentrations and loads, which correspond to a COD reduction by 90 % in the production of organic dyes and by 95 % in the production of vitamins and pharmaceuticals
  (3) AOX: dependent upon the percentage of AOX-relevant products, legal limits within 1 mg/l
  (4) Heavy metals, relevant to the degree used; concentration and load standards for copper and chromium in the production of organic dyes, which correspond to a reduction of heavy metals in wastewater by 90%
  (5) Total NH_4-, NO_3- and NO_2-N: 50 mg/l
  (6) P total: 2 mg/l
  (7) Salts (chloride and sulfate)
- Determinations for the compiling and annual updating of the wastewater register
- Standards for the further improvement of wastewater condition (consequent measures), including specifications for the use of environmentally compatible chemicals
- Definitions of wastewater load charges
- Self-monitoring as well as monitoring by state agencies

In order for standards to be met, the corresponding legal limits need to be monitored regularly. For that reason, comprehensive self-monitoring obligations are imposed on the enterprises. In addition, the water authorities make unannounced inspections at irregular intervals. At the same time, random tests are performed to see whether the results of self-monitoring are reliable. If a company does not observe the legal limits, it faces fines and penal consequences [33]. Furthermore, it is in the dischargers' own interest to meet the nationwide uniform, state-of-the-art standards, since the wastewater charge increases by a multiple if the standards are not met.

The following example illustrates the steering effect of the wastewater charge:

After the wastewater register and partial stream pretreatment of the industrial chemical company were so far advanced that there were hardly any nitrification-inhibiting substances left, it became evident that the mixed chemical wastewater availed itself to a biological N-elimination in the WWTP. Although the legal standards ($N \leq 50$ mg/l) had already been met due to internal pretreatment measures, the existing treatment plant was converted into a two-stage activation with pre-denitrification plant, without it being required by the authorities. The investment costs of almost € 1.5 million were able to be calculated against the effluent charges of the prior three years. In this way, the large chemical corporation was able to recover almost the entire investment expenses after the costs had been verified by an independent accountant and a 20% reduction of the pollutant load (N) was proven.

Below is the calculation of the wastewater charge (W) for a discharge source, calculated as pollutant units (SE - *Schadeinheiten*), in Euros for one year:

$$W = \frac{1{,}500{,}000 \text{ kg COD}}{50 \text{ kg COD/SE}} + \frac{250{,}000 \text{ kg N}}{25 \text{ kg N/SE}} + \frac{5{,}000 \text{ kg P}}{3 \text{ kg P/SE}} + \frac{1{,}000 \text{ kg Cu}}{1 \text{ kg Cu/SE}} + \frac{1{,}000 \text{ kg Cr}}{0.5 \text{ kg Cr/SE}} + \frac{20{,}000 \text{ kg AOX}}{2 \text{ kg AOX/SE}}$$

W = 30,000 SE + 10,000 SE + 1,666 SE + 1,000 SE + 2,000 SE + 10,000 SE

W = 44,666 SE x € 7.50/SE + 10,000 SE x € 30.00/SE

W = € 384,000.00.

The standards of the respective wastewater treatment regulation were able to be met for the parameters COD, AOX, N, P, Cr, and Cu. The wastewater charge was therefore reduced by 75%. For the parameter AOX, the legal limit of the wastewater treatment regulation could not be reached, so the full charge amount (€ 30) had to be paid. No wastewater charge had to be paid for the parameters Hg, Cd, Pb, Ni, and G_f because the respective threshold values were not reached.

Water protection –
cost factor and development factor for industry and environmental protection

The implementation of increasingly more stringent regulations for wastewater treatment has brought substantial costs. Significant competitive disadvantages arose for wastewater-intensive industries in comparison to their foreign rival enterprises, which, without costly WWTP's, produced more inexpensively. Conversely, under the pressure of cost, new economization potentials for industry and water management were constantly being discovered, and more efficient technologies and logistics concepts were contstantly being developed. As a result, the costs for water as well as of electricity, chemicals, and personnel were able to be reduced. This in turn strengthened the industry's ability to export.

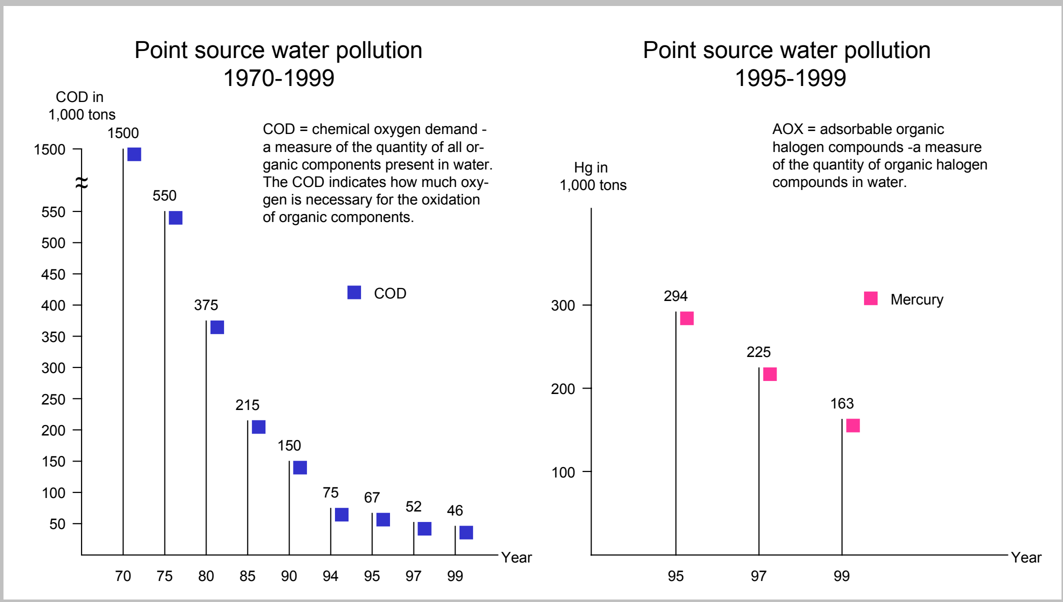

Figure 35: Reduction of selected contaminant loads, chemical industry [60]

Furthermore, a powerful environmental protection industry has emerged. With over 5,000 enterprises, a turnover of approx. € 25 billion, and estimated 500,000 employees, this industry has made an important contribution to the German national economy. The largest trade fair in the world for water and waste technology, IFAT (www.ifat.de), takes place in Munich every three years; over 2,000 companies from all over the world present their technologies, products, and services to more than 100,000 trade visitors.

4.5 POLLUTANT - GROUP ORIENTED ACTION CONCEPTS - ILLUSTRATED BY THE EXAMPLE OF NUTRIENT REDUCTION*

Water protection in Germany in the first development phase applied primarily to the reduction of carbon (COD, BOD) to safeguard the dissolved oxygen content in rivers. Later, one also had to focus on the reduction of nutrients (nitrogen and phosphorus), most importantly for the protection of lakes and seacoasts. The most important step was first of all the reduction of phosphate emissions through the legally required use of phosphate-free washing agents and through the degradation of nutrients in larger WWTP's. The residual pollution today comes essentially from so-called nonpoint sources, such as fertilizer from agriculture, rainwater avulsions, and cross-boundary air pollution. Therefore, pollutant-group oriented action concepts are required which include a coordinated package of various instruments and technological measures.

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based on materials by
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4.5.1 NUTRIENT EMISSIONS

The emission of the nutrients phosphorus and nitrate into water bodies can extremely contaminate the water resources. The term *eutrophication* (eutrophic = “nutrient-rich”) describes the condition of water bodies that have a high nutrient content. An excessive content of nutrients promotes a proliferation of algae. They produce large amounts of oxygen at first, but then use up great quantities of oxygen as they decompose. The water body is endangered if decaying processes develop due to the consequent lack of oxygen. Negative resulting effects are the death of fish and an impairment to the usage of the water body (e.g. for potable water supply).

With regard to sources of nutrient pollution into the water resource, the distinction is made between natural (geogene), point, and nonpoint sources.

Reducing the emissions of water-polluting substances through legal regulations – using the example of washing and cleaning agents (cf. sect. 3.2.4)

In the 1950's, the increasing proliferation of household washing machines, the rising usage of textiles, and a heightened hygienic awareness all led to a greatly increasing usage of washing agents. Due to reasons of cost, a synthetic surfactant was used in the production of washing agents, which, however, was not easily biodegradable. This led to an enormous rise in the concentration of surfactants in water bodies in the 1960's. Mountains of foam on the rivers and lakes made it clear that washing agents had a large impact on the environment.

As a reaction to the growing environmental problems, the *Washing Agents Law* was passed in 1975. It regulates the authorization for the sale of washing and cleaning agents so that, after use, every preventable impairment to the quality of water bodies, especially with regard to the ecosystem and drinking water supply, and to the operation of WWTP's is avoided. The *Ordinance on Surfactants* took effect in 1977 to complement the Washing Agent Law. According to this ordinance, at least 80% of the surfactants of a washing agent had to be biodegradable. Manufacturers then synthesized surfactants with a molecular structure that was considerably more biodegradable. The mountains of foam on the water bodies disappeared.

In addition, it was discovered in the 1970's that the phosphates present in washing agents have a substantial influence on the eutrophication of water bodies. Phosphates are used in the washing agent industry primarily as so-called structural substances in order to react with the salts responsible for the hardness of water and to prevent calcium deposits. In 1980, the *Ordinance on Maximum Permissible Amounts of Phosphate* was passed in Germany. Manufacturers of washing agents were thereby obligated to reduce the maximum permissible amounts of phosphate in washing and cleaning agents by 25% in 1981 and by a total of 50% in 1984, in comparison to 1980. In 1986, half of all washing agents were phosphate-free; in 1987, already two-thirds. Today, there are practically only phosphate-free washing agents on the market.

The revised *Washing and Cleaning Agents Law* (WRMG, 1987) was an attempt to adapt the old Washing Agent Law to the raised standards of present water protection policies. One essential change was that manufacturers became obligated to indicate the concentration of washing agents, in order to counteract overdoses.

Newer approaches of an ecological assessment of washing agents take the overall view into consideration - starting with the production of washing agents to the washing process, all the way to disposal. Included in this overall view, from material and energetic aspects, are the availability of raw materials, manufacturing, application, use, wastes that are generated, and the interaction with the environment. The goal of such an eco-balancing is to indicate further approaches for an environmentally friendly use of washing agents.

While point source nutrient pollution is emitted directly into rivers from municipal WWTP's and industrial discharge sources, nonpoint source (diffuse) nutrient pollution is the sum of emissions from many different sources. Included among these various sources are avulsions, washouts into ditches and groundwater, evaporation resulting in precipitation, and runoff from farms [39].

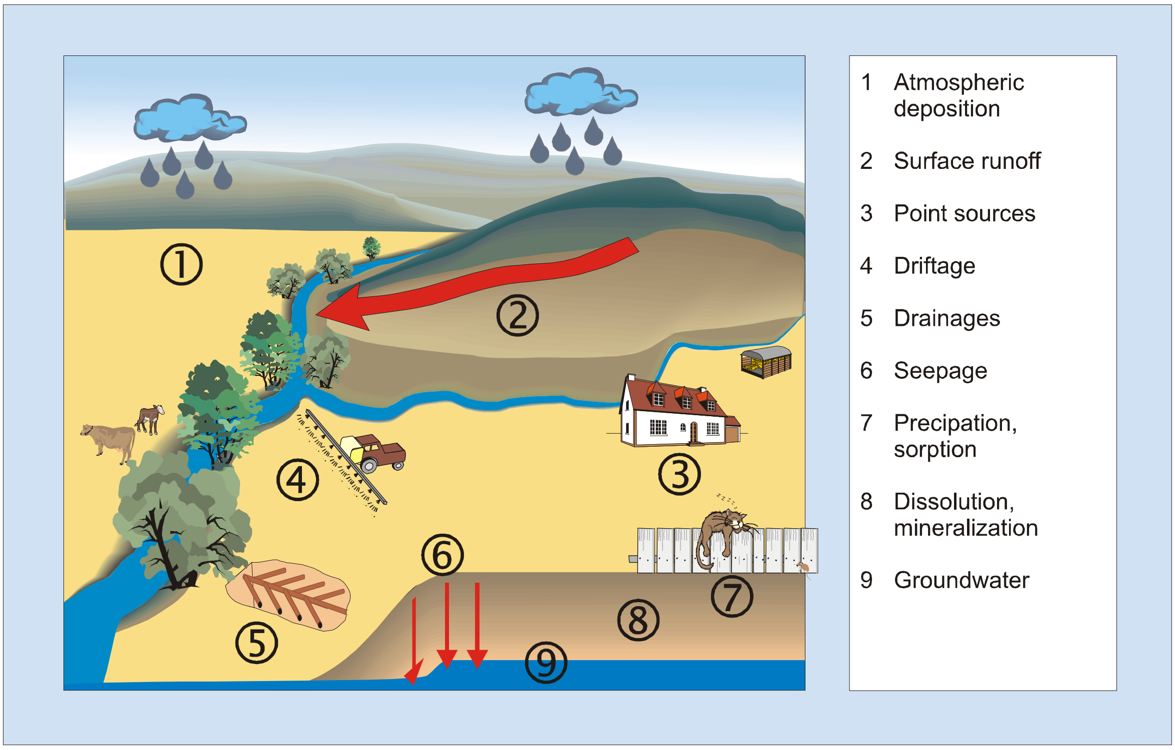

Figure 36: Sources of nutrient pollution into streams

In order to assess the proportions of nutrient pollution from diverse sources, various models are used [27], and the results are compared to the substance loads in the rivers.

4.5.2 EMISSIONS OF PHOSPHORUS AND NITROGEN

The total amount of phosphorus emitted into the river catchment areas of Germany was approx. 37 Mg P/yr from 1993 to 1997. Phosphorus emissions were reduced by 60% in comparison to the period of time from 1983 to 1987, by 70% compared to 1975. As was agreed upon at the second North See Protection Conference in London in 1987, the goal of reducing emissions by one-half from 1985 to 1995 was reached in Germany, as well as in most of the neighboring countries [3].

The Washing and Cleaning Agents Law which took effect in 1987 effected a significant reduction of phosphorus pollution from soaps and detergents. Due to the use of phosphate-free washing agents and to phosphate removal in WWTP's, only 20% of the emission loads observed from 1983 to 1987 enter into water bodies today.

The phosphate emission at municipal WWTP's was reduced by 80% through the upgrade of *WWTP's* (third treatment stage), combined with the introduction of phosphate-free washing agents. This source of phosphorus pollution has thereby had the greatest proportion of reduction; currently, it accounts for only 31% of total phosphorus pollution.

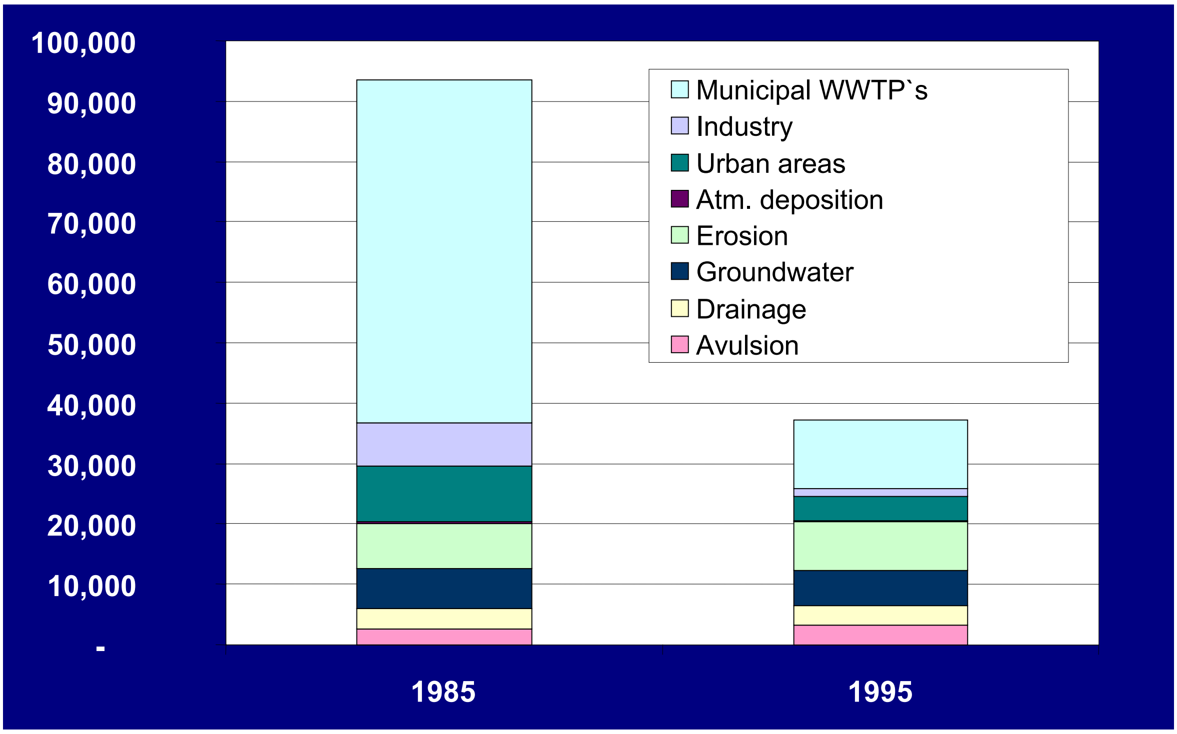

Figure 37: Phosphorus pollution into the surface water [tons/yr]

The comprehensive ongoing development of wastewater treatment in Germany has led to an improvement in water quality. However, the emission of nutrients from nonpoint sources in *agriculture* is still a problem. Large amounts of phosphorus have accumulated in agricultural fields in the last several decades through mineral fertilization. Over 60% of the fields are sufficiently or even excessively supplied with phosphorus today. Since 1980, German agriculture has reacted to this by reducing the use of mineral fertilizers (1980: 29.9 kg P/ha; 1995: 14.4 kg P/ha). Nutrient emissions from agriculture have decreased due in part to the following factors: the realization that a reduced usage of chemicals is economically advantageous, that the phosphate content of agricultural fields is sufficient or too high, and an increasing environmental awareness on the part of farmers, as a result of public debate and ultimately the EU agricultural reform. However, emissions of phosphorus from agriculture continue to increase due to the excess of phosphorus that still exists.

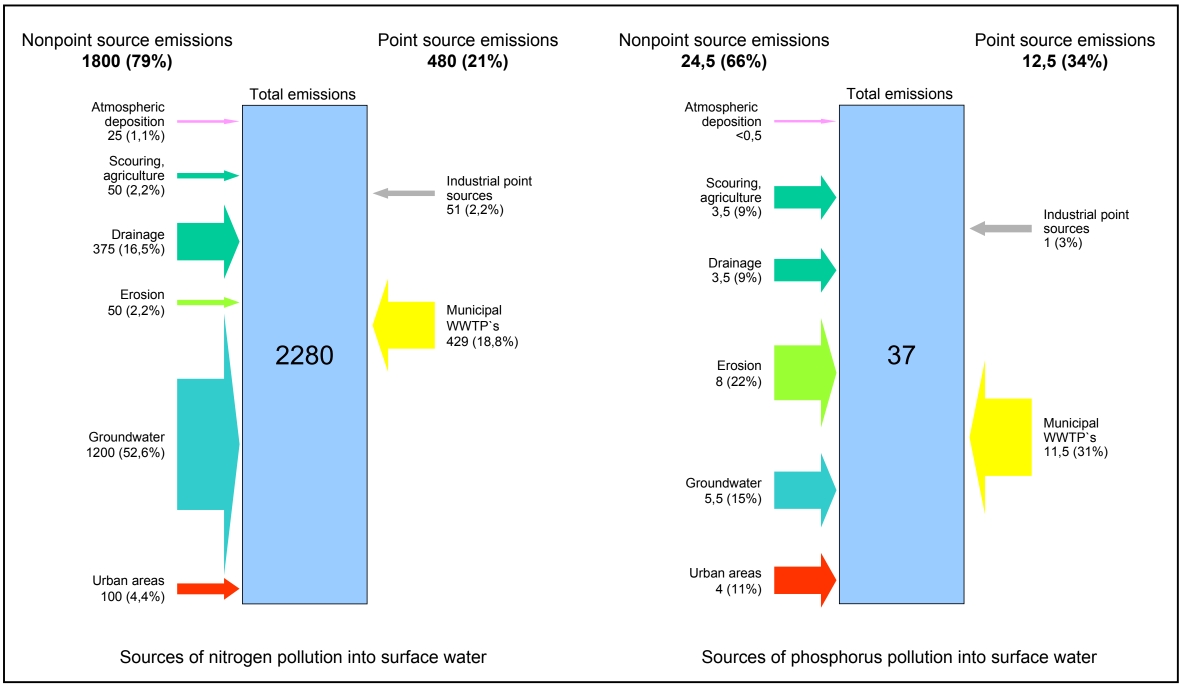

Figure 38: Sources of nitrogen and phosphorus pollution into surface water 1998 [tons 10^3/yr] [37]

The amount of total nitrogen emitted into the river catchment areas of Germany was approx. 820 kt N/yr from 1993 to 1997, which was 25% less (266 kt N/yr) than a decade earlier. Nevertheless, the international goal of reducing nutrient emissions into the oceans by half from 1985 to 1995 could not be reached. All states bordering Germany also missed this goal. As was the case with phosphorus, the greatest reduction of nitrogen emissions was from point sources (reduced by about 45%). Point sources currently account for only 28% of all emissions of nitrogen. By contrast, only about a 10% reduction of nonpoint source nitrogen emissions was able to be recorded.

4.5.3 STATUS OF POLLUTION PREVENTION

Preventable nutrient pollution from agriculture is to a large extent the result of the separation of livestock-poor regions (such as industrial fruit farms) from regions with large quantities of livestock (such as feed production enterprises) and industrial livestock farms. Due to this separation, fertilizers containing nitrogen (solid and liquid manure) need to be disposed of in regions rich in livestock, leading to excessive nutrient emissions in water bodies. In livestock-poor regions, large amounts of inexpensive mineral fertilizers are used to supply fields with nitrogen, with the same negative results for water bodies. Very few farms have an ecologically balanced system by which the excess of nitrogen from livestock farming is applied on-site to supply nitrogen in the cultivation of fields.

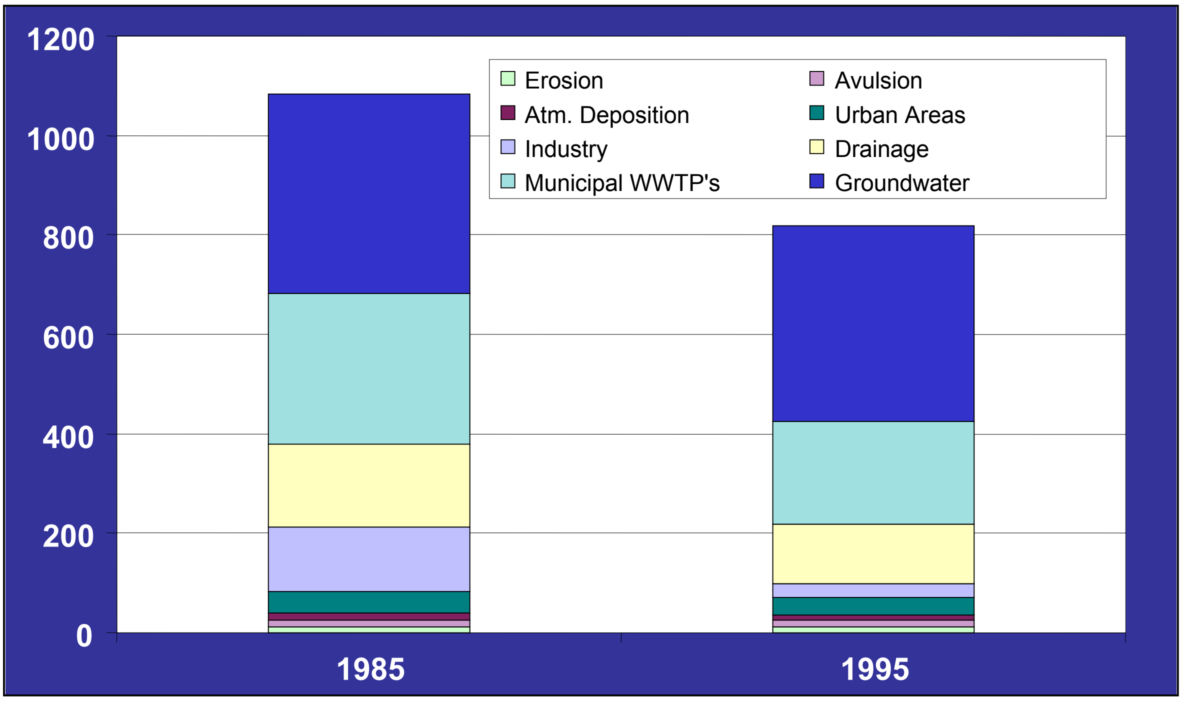

Figure 39: Nitrogen entries into surface water [tons 10^3 N/yr]

Agricultural development has had an influence on the national nutrient balance. The excess of nitrogen in German agricultural areas has decreased by 27% since its peak in 1987; the excess of phosphorus has decreased by almost 80% since 1980.

The mean residence time of nitrogen in groundwater results from excesses in agriculture and concentrations of nitrogen in rivers. It is between 10 and 20 years in the groundwater inflow to the Rhine, 20 years in the Danube River, and 30 years in the Elbe River Valley. The results were similar in a groundwater flow model in the plains in the Elbe River: Flow times ranged from 1.5 to about 500 years, with a median of 25 years.

Because of these long residence times, after the inflow of nitrogen into the groundwater has been reduced from its peak in 1987, it will still last decades until the large rivers supplied by groundwater are relieved [7, 8].

In order to achieve a desirable reduction of nitrogen loads by half, a further reduction of the nitrogen excess to approx. 50 kg N/ha/yr and a considerable improvement of the denitrification capacity of the land (e.g. by backing-up or closing ditches, re-saturating wetlands, and improving the morphological structure of water bodies) would be necessary.

Nutrient balances

Regarding nutrient emissions from agriculture, there are neither nationally nor internationally uniform valuation bases for estimating the effects and progress of reduction measures. Furthermore, there is often a time delay between the implementation of measures and the effects on the emissions into water bodies. Therefore, the member nations of the Paris Commission (North Sea) annually draw up a mineral balance for the agricultural sector.

The nutrient balances involve the essential nitrogen- and phosphorus-related cycles in agriculture. The excesses calculated correspond to the quantities of nutrients that end up in the environment (air, soil, water). Changes in the excess allow for an assessment of the effectiveness of the measures that were implemented.

In comparison to other countries adjoining the North Sea, Germany takes on a middle position with regard to excess nitrogen, despite its intensive agriculture, and even a relatively low position with respect to phosphates.

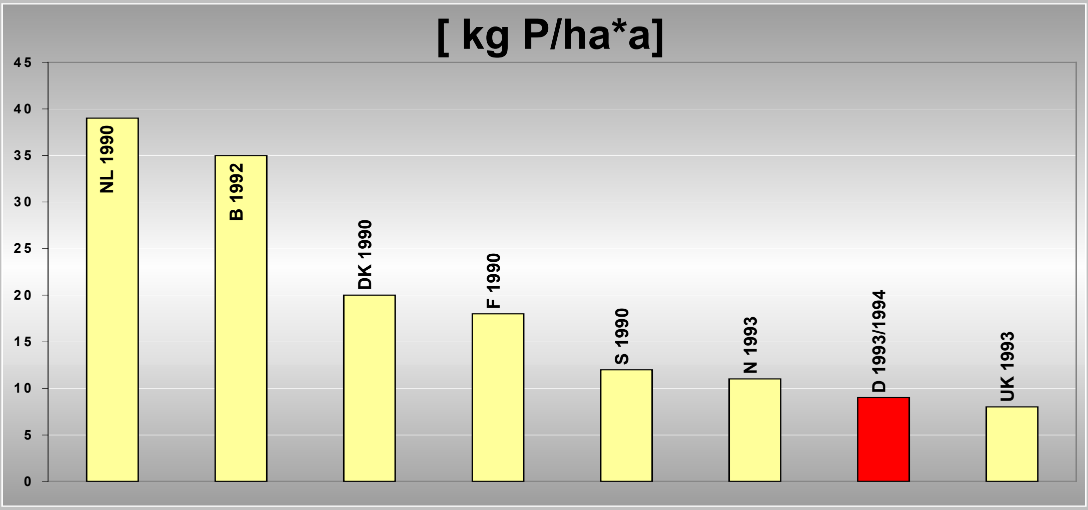

Figure 40: International comparison of nitrogen surplus

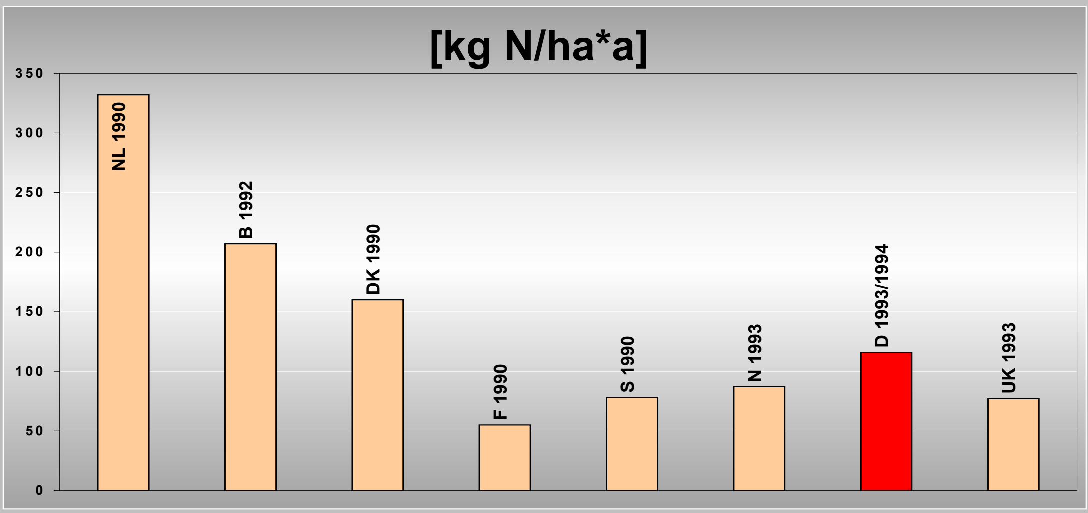

Figure 41: International comparison of phosphorus surplus

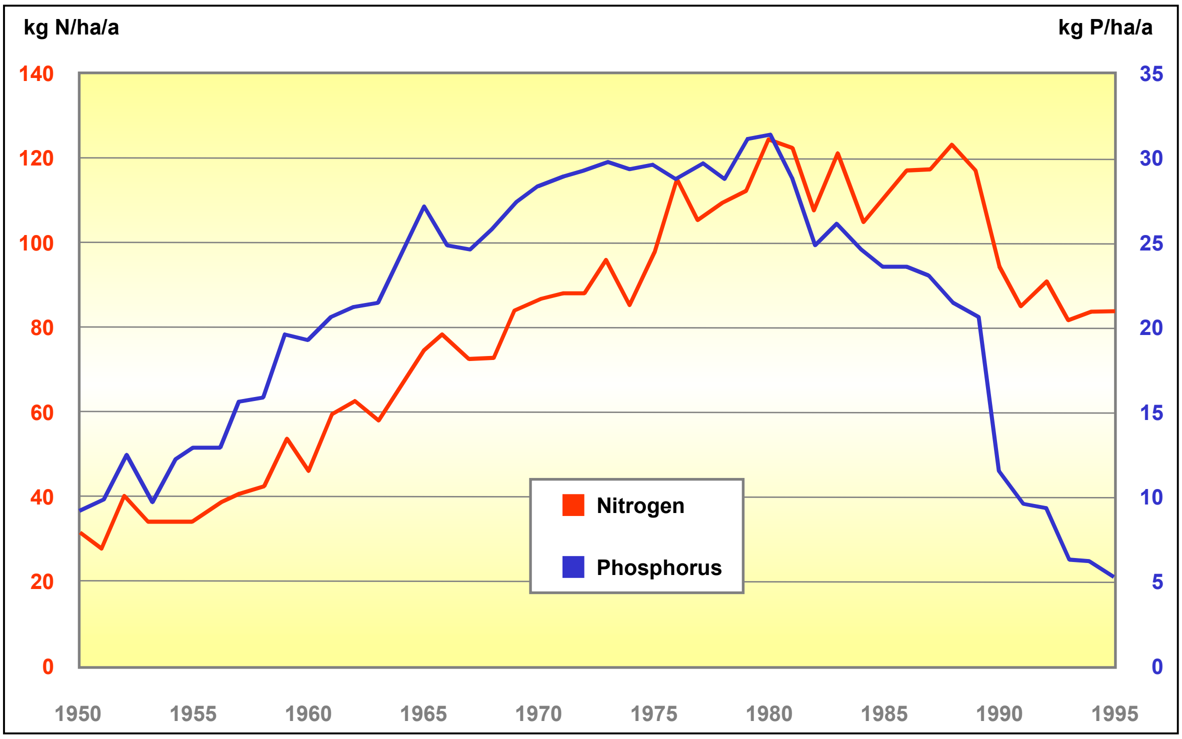

Figure 42: Nitrogen and Phosphorus balance surpluses in German agricultural areas 1950 – 1995

The Fertilizer Ordinance (EU directive adopted into German law) requires farms to perform fertilizer balances. Nevertheless, the maximum permissible amounts of organic fertilizers - 210 kg/ha/yr nitrogen since 1996, 170 kg/ha/yr since 2000 - are still too high from the viewpoint of water protection. There are also no limits for the total amount of fertilizer used. Furthermore, this can be increased by 30% to compensate for nitrogen losses through organic fertilization. Deposits of nitrogen from the air are not required to be taken into account. With such high application of nitrogen, further noticeable nitrogen pollution can be expected, especially from areas with water permeable surfaces, locations vulnerable to erosion, and fertilized shorelines.

According to the Fertilizer Ordinance, the overapplication of phosphorus must be reduced wherever "*hazardous effects to water bodies...can be expected*." This is the case with marshes, for example. The high degree of ground moisture combined with a lack of oxygen in the trenches leads to the washout of excess phosphate into the bordering mud flats, which suffer from a nutrient oversupply. For that reason, the livestock population and phosphorus fertilization in marsh regions would have to be significantly reduced in order to achieve negative balances.

Nitrate content in groundwater

Regional observations of the nitrate content in groundwater have concluded that the percentage of higher concentrations of nitrate increases from north to south. One main reason for this must be viewed in the geological context, particularly in the distribution of loose and solid rock.

In a loose rock area, the deeper aquifers are normally only slightly polluted even though the aquifers near to the surface are often highly polluted with nitrate. Nitrate is practically nonexistent in the deeper aquifers, since it is in part completely reduced to ammonia and elemental nitrogen.

On the whole, the results of a study by LAWA (The Working Group of the Federal States on Water Problems – *Länderarbeitsgemeinschaft Wasser*) prove that nitrate pollution of the groundwater is quite frequent nationwide. Taking potable water from deeper aquifers is not a permanent solution to the problem. A comprehensive, nationwide water protection policy is necessary which reduces the emission of nitrogen into water bodies, particulary from agriculture (allocation of spaces to animal keeping, Fertilizer Ordinance).

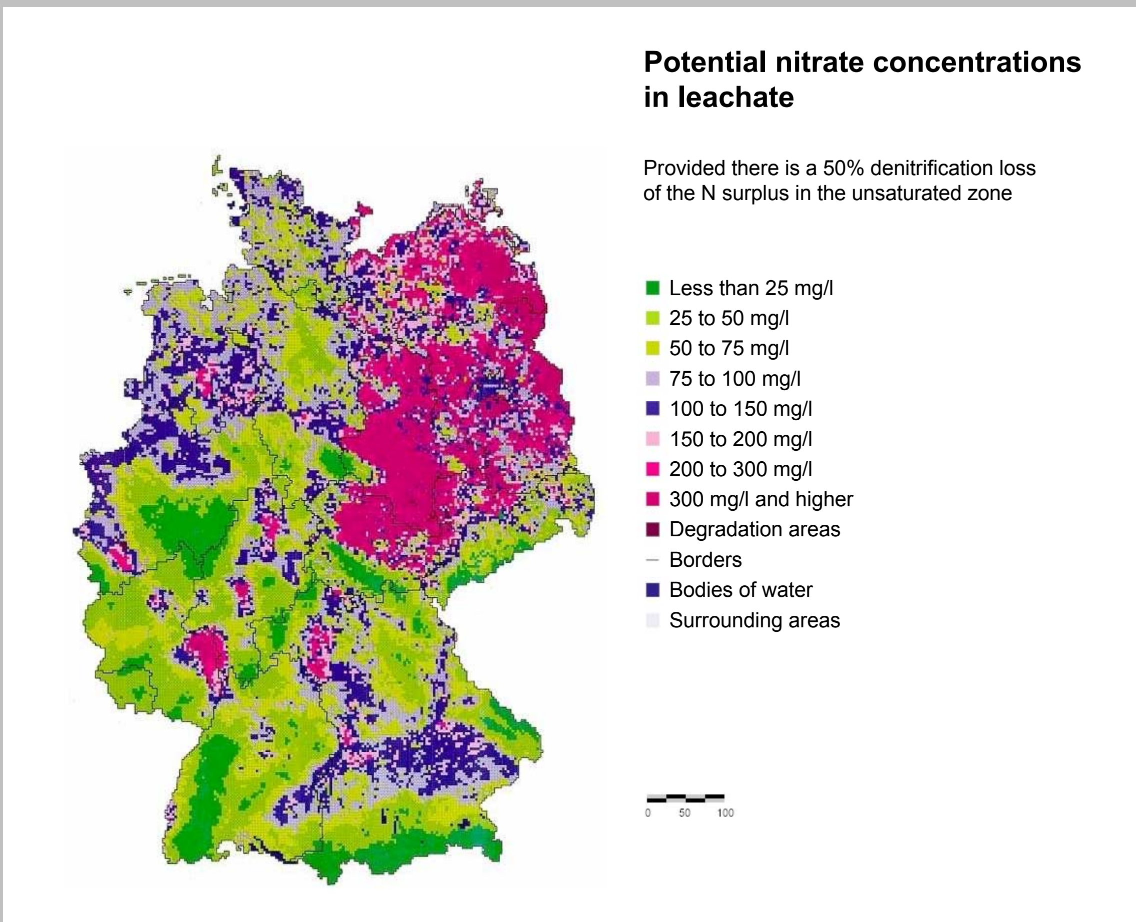

Figure 43: Nitrate concentrations in leachate in Germany [61]

Call for action for agriculture

At a technical seminar [INA 2001: Nature Protection and Ecological Agriculture – Call for action for the AGENDA 2000 and joint preparation for the AGENDA 2007, Symposium of the Federal Agency for Nature Conservation (*Bundesamt für Naturschutz*) and the International Academy for Nature Conservation, Vilm Island (INA – *Internationale Naturschutzakedemie Insel Vilm*) – April 10, 2001], the following measures were recommended under the working title "Ecological agriculture is no cure-all for environmental policy – requirements for the predominantly conventional agriculture from the viewpoint of environmental protection", in order to reduce the pollution of soil and water bodies from emissions in agriculture:

1) Further development of the requirements for agricultural fertilization:

- Ban on fertilizer application when soil is frozen or snow-covered
- No multinutrient fertilization of soil that has already been heavily supplied with potash and phosphate
- Nitrogen limits for commercial fertilizers from animal sources (liquid manure) and secondary fertilizers (wastewater sludge)
- General upper limit for nitrogen for pasture – 170 kg/ha/yr
- Introduction of a mandatory differentiated recording and documentation requirement
- Low emission manure application technique with introduction into the land within one hour
- Liquid manure storage capacity for at least six months, in order to guarantee the season- and need-related use of liquid manure
- Reduction of the cadmium content in phosphate fertilizer
- Regulation and monitoring of potential heavy metal emissions from commercial fertilizers

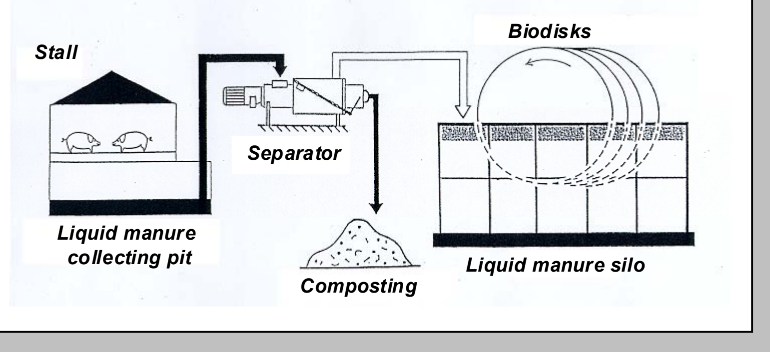

Figure 44: [12] Pilot installation for eliminating nitrogen in agriculture with the use of biodisks

2) Tightening of the requirements for plant protection practices:

- Plant protection equipment and application technology (equipment causing little drifting, federally uniform proof of expertise, efficient monitoring systems)
- Obligation to document every field section
- Constant updating and case-specific, concrete specifications for an integrated plant protection policy (pollution threshold principle)
- Examination of pesticide permits (environmental agencies at the federal level in charge of authorization decisions)

3) Quality goals for surface waters (according to ecotoxicological effect thresholds from 0.1 µg/l and below for all water body-relevant pesticides)

4.6 REALIZATION OF LARGE-SCALE PROJECTS IN THE WATER SECTOR ILLUSTRATED BY THE EXAMPLE OF THE LEIBIS-LICHTE DAM *

Large-scale projects in the water sector [cf. 62] are not easy to realize in a democracy like Germany because the various interests of the water supply sector, nature protection, inhabitants, and economy need to be balanced in a fair and transparent process. Besides qualified technical planning, it requires a comprehensive environmental impact assessment with an auxiliary landscape conservation plan and a solid permit plan. Through the example of the water dam project Leibis-Lichte, it will be demonstrated how the decision-making process was able to be managed and how the construction plan was structured and financed.

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4.6.1 INTRODUCTION

With the Leibis-Lichte Dam, a long-distance water supply system, an additional water utility, and an 80 km long-distance pipe network were to be built in order to stabilize the regional long-distance water supply, to supply additional areas that have shortages of water, and to improve the flood protection in the catchment area of a small river [55].

The planning of this system was begun already in the 1970's. Originally, this system was also supposed to supply a large, adjoining industrial zone with water. Therefore, besides the Leibis-Lichte Dam, the plans envisioned four crossover ducts from adjacent catchment areas into the Leibis-Lichte Dam and two supplementary water intakes from the flowing wave. This system would have had a total capacity of approx. 240,000 m³/d.

The realization of the system began in 1981. Besides the pumping station and the long-distance pipe network, a pre-dam barrier, the drainage tunnel from the Leibis-Lichte Dam to the pumping station, and a crossover tunnel into the dam were constructed.

Due to considerable supply problems, this new long-distance water supply system came into provisional operation (water intake at the pre-dam barrier) in 1992. This provisional operation is afflicted with substantial problems, especially regarding the water quality, and therefore needs to be discontinued as soon as possible.

The Leibis-Lichte Dam is to be built now to complete the new long-range water supply system. The old long-distance water supply system already in existence and the new, additional long-distance water supply system are to then be operated as a combined system. This combined water system will supply approx. 400,000 inhabitants in an area of 3000 km² with 80% of the potable water needed in constantly sufficient volume and perfect quality. After the completion of the Leibis-Lichte Dam, the provisional water supply from the pre-dam barrier of the new system can be discontinued and the old long-distance water supply system can be stabilized.

4.6.2 PREPARATION FOR THE PROJECT

4.6.2.1 Technical Planning

First of all, the technical plans for the construction of the new dam were drafted from 1993 to 1995, building upon the considerations of earlier planning stages. These plans had to comply with the new framework that had changed through the reunification of Germany [56].

The *location* of the planned Leibis-Lichte Dam could be retained. On the one hand, the location alternatives had been very carefully evaluated already in the first planning stages in the 1970's; on the other hand, the answer to the location question had already been predetermined by the construction of the pre-dam barrier, the crossover tunnel, and the drainage tunnel to the pumping station.

The *dimensions* planned for the dam were based on a raw water capacity of approx. 65,000 m³/d. In order to provide for this volume of raw water, water was to be transferred from an adjoining catchment area by means of a transfer channel, to supplement the water supply of the dam. The Leibis-Lichte Dam features a catchment area of 72 km²; the size of the neighboring catchment area is 36 km².

The median drainage rate is 0.81 m^3/s at the dam and 0.28 m^3/s at the crossover duct, so that a total median flow rate of 1.09 m^3/s is available. A reservoir capacity of 39.2 million m^3 is planned for the Leibis-Lichte Dam, with a depth of 91 m and a dammed surface area of 120 ha. Five point six million m^3 of the total dam capacity is constantly kept available for flood prevention purposes. The barrier structure will be a gravity dam made out of hydrotechnical cement. The structural volume of the dam wall will be 620,000 m^3, with a height of 93.5 m above ground level. The length of the crest will be 370 m, its width 9 m, and the width of the flange 81 m.

Figure 45: Computer simulation of the future dam

During *flood relief*, water spills over the back of the dam wall overflow with a subsequent ramp. Three bottom outlets are envisioned, each with a capacity of 10 m^3/s. The flood overflow and bottom outlets meet in a joint turbulence basin. Raw water may be extracted through five outlets which are built into the dam wall at various heights. The extracted raw water flows into a tunnel intake tower. From there, the water can be pumped through the drainage tunnel to the pumping station. Electricity can be generated from the raw water intake as well as the bottom outlets by means of two turbines.

EIA-Law, Plants requiring an EIA

A special environmental impact assessment (EIA) is required according to the Environmental Impact Assessment Law of 12.02.1990 (UVPG) for any investment involving a major transformation of a water body and the construction or removal of a dam or dam structures (Appendix to § 3 UVPG, No. 6)

EIS / EII - Environmental Impact Study / Environmental Impact Inquiry

Documents which bear a decisive influencing factor of the environment are to be introduced prior to the startup of a major investment project through an independent environmental impact study according to § 6 of the Environmental Impact Assessment Law (UVPG). The extent of the study is to be prior determined between the authorizing authority and the investor in a scoping procedure (§ 5UVPG). In this EIS / EII, the effects of the project on the environment is to be recorded, analyzed, and to be evaluated as a contribution of the project investor to the ensuing environmental impact assessment by the respective environmental authority.

EIA – Environmental Impact Assessment

The environmental impact assessment is the investigation, description, and evaluation of the environmental effects of a planned investment project on the protected subjects "human, animal, plant and soil, water, air, climate, and landscape, as well as cultural and other goods by the responsible administrative authority" (§ 21 UVPG). The purpose of an environmental impact assessment is to record the environmental effects of a planned investment at an early stage and to take into consideration the results already at the permitting decision (§ 1 UVPG). The EIA is an independent part of the permitting process (preliminary authorization or permit) and includes a factual part (description of the environmental effects, § 11 UVPG) and the evaluation of the environmental effects (§12 UVPG). The legal effect consists in the inclusion of the evaluation of the environmental effects by the authorizing authority in the decision of the permissibility of the planned investment.

Auxiliary Landscape Protection Plan
(LBP- Landschaftsspflegerischer Begleitplan)

The project investor has to produce an independent auxiliary land protection plan (LBP) with text and map with the required natural and landscape protection measures to compensate for any unavoidable encroachment into nature and landscape by the planned investment. The described measures compensating for the encroachments will be evaluated by the respective permitting authority and the authorized LBP becomes part of the respective permitting documents for the planned investment. The measures determined by the LBP to compensate and replace the encroachment are legally binding.

4.6.2.2 Environmental Impact Assessment and Auxiliary Landscape Protection Plan

According to federal and state law, a water permit for an investment project of this magnitude is dependent upon the performance of an environmental impact assessment (EIA). In preparation for the EIA, an environmental impact study (EIS) was compiled from 1994 to 1996 as a supplement to the technical planning.

In the EIS, the impacts of the planned investment on environment-related protected goods (flora/fauna, soil, water, climate / air, landscape, people, cultural / material goods) were determined. The following were considered especially grave *impacts*:

- Devastation of valuable terrestrial ecosystems, such as marshlands, grassy highlands, meadows, bush, and natural forests due to overdamming
- Devastation of pristine rivers and streams and the habitats connected with them due to overdamming
- Breakup of the water body network due to the construction of the dam
- Noise pollution for habitats, in particular for the wood grouse (*Auerwild*) habitat, due to constructional noise.

The compiling of the EIS in a form acceptable to the licensing authority was a lengthy process. The difficulties that arose were especially attributed to the fact that the spatial investigation area and the content depth of the investigation had not been coordinated intensively enough between the project investor and those involved in the later licensing procedures. While such so-called scoping is provided for in the UVPG, it is not mandatory.

Based on the EIA, an auxiliary landscape conservation plan (LBP) was drafted in 1996/1997. Besides design measures, an LBP comprises above all minimization, balancing, and substitution measures which shall minimize or compensate for the impairments determined in the EIS. The LBP for the construction of the Leibis-Lichte Dam contains primarily the following *measures*:

- Restoration of the continuity of rivers and streams through the reconstruction of weirs
- Renaturalization of rivers and the adjacent floodplains, in order to recreate natural conditions
- Expansion of meadowlands, renaturalization of areas stressed from periods of construction, and toleration of succession areas for the upgrading of terrestrial open-land ecosystems

- Reforestation or conversion of existent forest areas, in order to enlarge / upgrade forest lands and wood grouse habitats
- Stabilization of the wood grouse population by reintroducing wood grouse populations from captivity into wilderness.

Figure 46: Wood grouse in an FFH area **Figure 47: Site of the future Leibis-Lichte Dam**

In the drafting of an LBP, the problem generally exists that, on the one hand, it is based upon available technical planning, but on the other hand, it may also contain specifications and changes in the results (minimization measures). This fact must be taken into consideration in the time-management of the various planning activities.

4.6.2.3 The Permitting Procedure

In August of 1996, the Thuringian Dam Administration submitted an application for project approval to the responsible permitting authority, the Thuringian State Administration Office in Weimar. The completeness and summary content of the application documents were first examined through the permitting authority and its expert, the Thuringian State Agency for the Environment. After the necessary corrections, supplements, and changes were made, the public was able to participate in the project approval procedure, based on the revised application documents.

For such participation, representatives of public interest, including recognized nature protection organizations, received a compilation of the application documents. On this basis, they could submit written opinions concerning the proposed project. In order to enable public access to the content of the application documents, the documents were made available at appropriate public locations in the area affected by the proposed project. All who felt affected by the proposal could submit their objections in writing to the permitting authority.

After evaluation of the opinions and objections, the date for public hearing was set. The hearing took place in the affected region on a total of eight days between February 18 and March 5, 1997. Representatives of public interest and objecting parties were invited to the hearing. Furthermore, the interested public was allowed to participate. The intense discussions during these eight days, which were mostly lead in an objective and calm manner, centered particularly on the following points:

- The nature protection organizations discussed in particular the necessity of the project, the suitability of the location and catchment area for the project, the impacts of the project on the environment, and the range of the envisioned LBP measures. Dissenters and representatives of public interest from the agricultural sector had objections especially to the implementation of a whole series of LBP measures that involved the revocation of agricultural areas.

- The focus of the comments by the representatives of public interest (mayors) as well as the objecting parties from the region immediately affected by the project was not so much the necessity of the procedure, because it was already highly accepted due to the long history of the project, the work of convincing the people done throughout that period of time, and the resettlement of the village of Leibis that had already been complete for quite some time. The focus was rather impairments to certain settlement areas due to the construction and operation of the project and the possible related financial damages. The other representatives of public interest expressed their opinions concerning specific details of the technical plans and of the LBP. Otherwise, the planned technical implementation of the project was hardly discussed.

Due to the massive criticism on the part of both nature protection organizations and the agricultural sector concerning the nature and extent of individual LBP measures, the LBP was revised after the hearing. This revised LBP was then the topic of a new hearing, which took place on December 15, 1997.

The opinions, objections, and suggestions from the public participation were afterwards evaluated and taken into consideration later on in the permitting process. Furthermore, the application documents were subjected to an intense expert examination. The results were presented by the Thuringian State Institute for the Environment on April, 30, 1998, as a conclusive technical expert opinion. After weighing all the facts, in particular after the performance of the EIA, the project approval resolution for the construction of the Leibis-Lichte Dam was issued on July 1, 1998. In the project approval resolution, the submitted technical plans as well as the modified LBP were to a large extent confirmed. However, the proposed withdrawal water volume was reduced to 52,100 m^3/d because of a new water management goal, and the transfer of water from neighboring water supply tunnel was not approved.

Various objections were raised against this project approval resolution, which, however, were defeated by the project approval authority. In the course of this objection process, the withdrawal volume was again reduced - to 43,700 m^3/d - due to new prognoses of the foreseeable population development. A nature protection organization thereupon filed a suit against the project approval resolution at the responsible administrative court. This suit is currently still pending.

Since the realization of the project did not tolerate any postponement, due to reasons mentioned in the introduction, the applicant submitted a request for immediate execution of the project approval resolution for certain pre-construction measures. The request was granted by the permitting authority. The appeal filed by a nature protection organization against this immediate execution was denied by permitting authority, or the responsible administrative court, as applicable.

A legal peculiarity of the process with far-reaching significance resulted from the environmental legislation of the European Union in the form of the FFH Directive (Flora-Fauna-Habitat) of May 21, 1992, which serves the preservation of natural habitats and of wild animals and plants. This should be reached through a cohesive European ecological network made up of individual (FFH) protected areas. Since this directive was not adapted into national law by the legislature within the prescribed two year time limit, it was to be regarded in this project approval procedure as an immediately binding law. According to it, direct and indirect encroachments into such areas are only permitted if they are compatible with the preservation goals of these protected areas. Exceptions are only permitted if especially pressing reasons for the project exist. Therefore, the criterion for exceptions is significantly more stringent than that of ‘classical’ federal nature protection law. These aspects are to be examined within the course of an independent impact inquiry in addition to an environmental impact assessment.

Two protected areas are potentially affected by the project, which, as declared EU bird sanctuaries, come under the protection of the FFH Directive. Since no conclusive notification was present at the time of the project approval procedure as to which areas in the state of Thuringia should come under the protection of this directive, these protected areas were also to be regarded as potential FFH areas. Therefore, in addition to the EII, impact expert opinions were compiled for these protected areas. These expert opinions come to the conclusion that the project could be incompatible - with regard to the preservation goals of the affected EU bird sanctuary, because of constructional noise pollution in particular, and with regard to the FFH protected area located downstream, because of impairment to the river caused by water withdrawal.

Based on the environmental impact inquiry, minimization and compensation measures were developed analogous to the LBP. Regarding the bird sanctuary, the already planned LBP measures could be reverted to, which had been considerably expanded in range. Concerning the FFH protected area, additional and very costly measures had to be planned. Examples are the modification of the storage management for the consideration of ecological concerns of the FFH area and an ecological monitoring in the FFH area.

The conclusive environmental impact assessment resulted in that, on the one hand, under the observance of these compensation measures, the coherence of the ecological network remains preserved, and on the other hand, with regard to the specific project, the requirements for an exception are given.

4.6.2.4 Result of Public Participation

The experiences gathered during the public participation process may be summarized as follows:
Public participation requires the project investor to clearly describe the necessity of the project and to carefully plan the project so as to consider all environmentally-relevant aspects.

Public involvement is primarily not meant to impede the project but to encourage its optimal implementation with regard to the technical aspects and its environmental impact including effects on humans (while minimizing the effects and providing adequate compensation of any remaining effects).

The example given clearly demonstrates that with a responsible investor and an alert public the minimization and compensation of any environmental effects will be pursued with equal priority and consequence as the actual investment project.

Public participation involves considerable financial and time resources. In the case in point, the duration of the authorization procedure has required four years and generated costs of approx. € 7.5 million.

As a disadvantage, one has to mention that public participation in the described procedure takes on mostly a confrontational nature (hearings, lawsuits). A wider and more constructive pursuit based on mutual interest representation of an investment project in particular in the project preparation and following the completion of hearings would be useful.

During the discussion of the effects of the planned investment, not always the most important factual issues are at the center of public discussion. Often, not so much the factual meaning of an investment-related consequence is at the center of discussion, but rather its legal consequences. In the case in point, one should mention that easily communicable results (extinction of the rare wood grouse population in the State of Thuringia) are discussed to such an extent that cannot be explained purely subjectively.

4.6.3 PROJECT PERFORMANCE

4.6.3.1 Tendering Process

Any public tender in which the proposed construction project to be bid on exceeds the amount of € 5 million has to be tendered Europe-wide. The construction tender for the Leibis-Lichte Dam project exceeds this threshold amount several times, thus requiring a Europe-wide tendering process pursuant to regulations of the tendering law as of January 1, 1999.

The awarding of the construction bid for the Leibis-Lichte Dam involved a closed selection process. The pre-qualification of the bidders took place pursuant to a point-scoring model by announcing the points needed to be pre-qualified. This model has the advantage that the bidders are required to extensively study the complexity of the construction project and to evaluate themselves as to whether they possess the necessary know-how in order to comply with the project.

Award Procedure for a Europe-wide Tender

A Europe-wide tender may be performed according to three possible tendering procedures:

In the *open bidding process,* an unlimited number of companies have the opportunity to submit a bid after a public call for bids has been posted. The open bidding process is therefore essentially identical to a public tender. In the case of technically complex projects, it may, however, lead to the submission of bids of companies which do not possess sufficient qualifications for the construction of such a structure.

The second possibility is given by the *non-open bidding process*. In this process, an initial publication calls for the call for tenders. Interested companies receive the required documents which specify which qualifications these companies have to prove and how these shall be evaluated. Only those companies meeting the necessary qualifications will be invited to submit a tender.

The third process is the *negotiation process* with and without bid tendering. This procedure is permissible only in exceptional circumstances.

Of over 30 companies, eight submitted tenders which fulfilled the requirements of the prequalification. These companies received the terms of reference for the submission of a bid. The offers received were examined with regard to form, calculation, technical content and economic feasibility. In the process of examining the economic feasibility, the adequacy of the total price offer will be considered. Open questions, such as regarding the technical details, were discussed during individual meetings with the bidders in which price negotiations are not permissible. In the end the most economically feasible offer was determined and the contract awarded to the respective bidder.

Following the new European public tender law, bidders which did not get a contract awarded have the possibility to ask for a review of the award of a contract and, where applicable, to seek a revision. For this reason, bidders that were not awarded a contract were informed 10 days (since 2001: 14 days) prior to the award of a contract about the failure, giving the reasons for their failed bid. Additionally, the failed bidder was informed about the name of the party which is to be awarded the contract. Within this 10.day period, the bidder had the opportunity to review the awarding of the contract and to cite any errors in the awarding of the bid. If this complaint is to no avail, the bidder may initiate a two-pronged review. Typically, the contract award is suspended during this period of time, meaning that the contract is not awarded.

This mechanism was created in order to provide the bidders a right of due process to uphold the contract awarding regulations and in case of noncompliance to ensure that their vested interests are complied with. This is also achieved by suspending the award of the tender during the review stage and by awarding it with respect to the results of the review. In the case of the Leibis-Lichte Dam tender, one bidder made use of this review process, which delayed the contract awarding by approx. half a year.

4.6.3.2 Organizational structure of the project

In view of the high level of competition in the construction sector, projects such as the construction of the Leibis-Lichte Dam are calculated with a very narrow margin of profit. The construction companies therefore attempt to renegotiate the terms after an award of the contract and to claim objections for hold-ups or to minimize potential follow-up costs, such as warrantee. The investor has maintain a strong organizational structure to answer project management issues of the contractor and to be able to lead a professional, business and legal discussion on par with the contractor. For this reason, the dam administration in Thuringia decided on the following organizational structure for the project “Construction of the Leibis-Lichte Dam”:

Starting out, a project team consisting of two *engineering firms* was formed which is responsible for the planning and construction supervision. This project team is therefore the immediate party responsible for all contractors involved in the project. As an intermediary between the project team and the investor, the dam administration in Thuringia introduced a *project manager*. The project manager not only examines the quality of the project team, but also represents the interests of the investor vis-a-vis the engineering firms.

Parallel to the project manager, the legal issues are followed by legal counsel who already has permanently been involved in the public tendering process. The legal counsel reviews all meeting protocols and also takes part during the meetings, were necessary. The role of the legal counsel is to find equitable legal solutions between the parties and not to unilaterally enforce the legal rights of the investor. In this sense, legal counsel acts like a mediator between the parties.

Integrated in the construction process is the realization of the auxiliary land protection plan. For this purpose, an ecological consulting engineers office was hired. This office is also working under the supervision of the project manager so that the total project costs may be controlled at any time.

Insurance of the large-scale project

In the case of large-scale projects, such as the construction of a dam, a so-called combined insurance policy is to be preferred as an alternative to the classic insurance policy. This includes provisions which are project-specific and which cannot be found in standard insurance policies, such as the exact definition and monitoring of a flood during the construction phase.

In the case of the combined insurance policy, the investor insures all parties involved in the construction project. The insurance covers the investor liability but also the corporate and environmental liability of the contractors and sub-contractors and the various planners. In addition to this, the construction liability insurance, typically provided by the investor, is part of the combined insurance policy.

Various advantages can be derived by combining all insurance needs through the investor in one insurance company. The first advantage is that the investor is a contractual party to the insurer, thereby making the insurance premium transparent and easier to calculate and that the investor may individually define the insurance coverage desired. In case of an insurance claim, the insured amount falls directly to the investor.

Since always the same insurer has to pay out potential claims, the issue of liability between the various contractual parties involved in the project can be simplified. Any damages can therefore be resolved in an expedited manner.

Since the project as a whole, and not the individual involved parties are insured, this also serves as a protective measure against insufficient or missing insurance protection of the individual involved parties. Moreover, the cancellation of a combined insurance policy can be excluded following the payment of an insurance claim.

The insurance cost is divided amongst all involved parties of the project. Already in the tendering documents it is pointed out that the investor will provide the combined insurance policy and a certain fraction of a percentage shall be withheld by the investor. The construction company will then deduct this amount from the calculation basis for his insurance policy. The combined insurance policy remains a cost-neutral factor for the investor. The administrative expense is typically only justified for projects above approx. 50 million DM.

4.6.4 PROJECT ECONOMY

The total costs for the Leibis-Lichte Dam project will amount to € 433,6 million. Of these, € 103 million were included in the project calculation for work already performed during the GDR. After German reunification until the current date, further € 177,2 million have been invested in the completion of the project. Until 2005 further € 153,4 million will be invested in the project.

Already in use are the pre-dam barrier and the drainage tunnel. These are currently used on a provisional basis for the supply of drinking water to a population of 100.000 people.

In order to finance the completion of the new long-distance water supply system, in large part subsidies from the state of Thuringia are received. The remaining expenses are covered by proceeds according to the planned use of the dam. A further grant is paid by the state of Thuringia for investments against flood control in proportion to the dam volume to be kept available for flood waters. This grant does not represent a unilateral subsidy but represents the assumption of the respective costs for flood control, since this task is performed in the interest of the state. The remaining part is financed by own capital and credits. The cost of the credit, i.e. the interest due, becomes part of the raw water price calculation. state of Thuringia for investments against flood control in proportion to the dam volume to be kept available for flood waters. This grant does not represent a unilateral subsidy but represents the assumption of the respective costs for flood control, since this task is performed in the interest of the state. The remaining part is financed by own capital and credits. The cost of the credit, i.e. the interest due, becomes part of the raw water price calculation.

Full cost recovery water tariffs

As already mentioned above (section 3.3) full cost recovery water tariffs are calculated in Germany. The water customer ensures through the payments that not only the operational costs but also the capital costs (amortization and interest of the investments) are completely covered.

This does not mean that public *subsidies* are not paid. In particular for the reconstruction of infrastructure in the new states in former GDR substantial special funding by the federal government and the EU was made available. In addition to this, there are varying funds available according to the individual states and regions to overcome “disparities” – in order to minimize the difference in the price for water even in areas with low population density in comparison to cities .

The water supply utilities are subject to taxation, in particular corporate tax and VAT and therefore contribute to the federal and state budgets. In addition, some states levy further *taxes and fees*, such as the groundwater extraction fee in particular (in Berlin, this amounted to € 0.30 / m^3 groundwater extracted in 2000).

In the *waste water management sector*, the situation is even more complex. Municipal waste water utilities are tax-exempt, in comparison to private waste water utilities, even if these perform identical tasks (for the future, an equal treatment with regard to taxation is expected, not least because of the harmonization of the Europe-wide competition requirements). Additionally, waste water investments may be subsidized on an individual basis. On the other hand, waste water charges have an influence on waste water fees. On a practical level, there are various subsidies and steering instruments which may in part have a counterproductive effect.

In this context it is difficult to determine exactly whether the full cost recovery of the water supply and waste water management sectors in Germany are only present in a business perspective or also on a macro-economical level. Calculations which are available in current literature estimate that the current water and waste water fees cover approx. 80% of the total costs (slightly higher than in England, higher that in France and very much higher than in Italy).

The so called “external effects” which are difficult to calculate in part (such as the user value of a renaturalized water body [cf. 43]) have not been considered in this calculation.

4.7 INTEGRATED MANAGEMENT OF A RIVER CATCHMENT AREA ILLUSTRATED BY THE EXAMPLE OF THE RUHR RIVER*

With the founding of the Ruhr Dam Association (Ruhrtalsperrenverein) for the expanding industrial region on the Ruhr River at the end of the 19th century, the cornerstone for an organizational and technological concept was laid which is still followed today in its fundamentals: the integrated management of the Ruhr River catchment area - initially with regard to water quantity and later also with regard to water quality management. Out of a crisis situation - the overuse of the resource of water - that arose at the beginning of the 20th century as a result of increasing industrialization and a growing population density in the Ruhr catchment area, the Ruhr Dam Association created a system of river catchment area management which has been systematically further developed and adapted to the needs of the time. The decisive factor is to improve and ensure the availability and quality of the Ruhr River water for the drinking water supply as economically as possible.

*by: **Diplom - Biologin Ulrike Staffel-Schierhoff** (see ch. 4.5)

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The Ruhr Association (*Ruhrverband*) operates a network of dams. Furthermore, the association secures the wastewater disposal by means of a great number of WWTP's in the catchment area of the association. International activities take place through the subsidiary company, RWG – the Ruhr Water Management Company (*Ruhr-Wasserwirtschafts-Gesellschaft mbH*) and through shareholdings.

4.7.1 HISTORICAL RETROSPECT OF THE SITUATION ON THE RUHR AT THE END OF THE 19TH CENTURY

In the second half of the 19th century, due to conveniently situated coal deposits, the region between the Ruhr and Emscher Rivers began to be industrialized. Within a few decades, a predominantly agricultural area with a relatively low population density developed into the center of German heavy industry. The expanding industry as well as the growing population were cause for an extremely high water demand of the Ruhr River and in the adjoining catchment areas that were supplied with drinking water from the Ruhr.

As a result of this development, several water utilities were established along the Ruhr whose intake volumes soon increased to such a level that in critical dry periods, water shortages occurred in the sections of the river that were further downstream. This situation not only affected the Ruhr water utilities, but also the power plants below the mouth of the Lenne River, which required a constantly high water channel for the continual generation of electricity.

Out of this situation, the Ruhr Dam Association was founded in 1899 as a voluntary merger of water and hydroelectric utilities on a private basis. Already five years after the founding of the association, four dams with a total reservoir capacity of 16.1 million m³ became operative, in order to augment low water in the Ruhr in dry seasons.

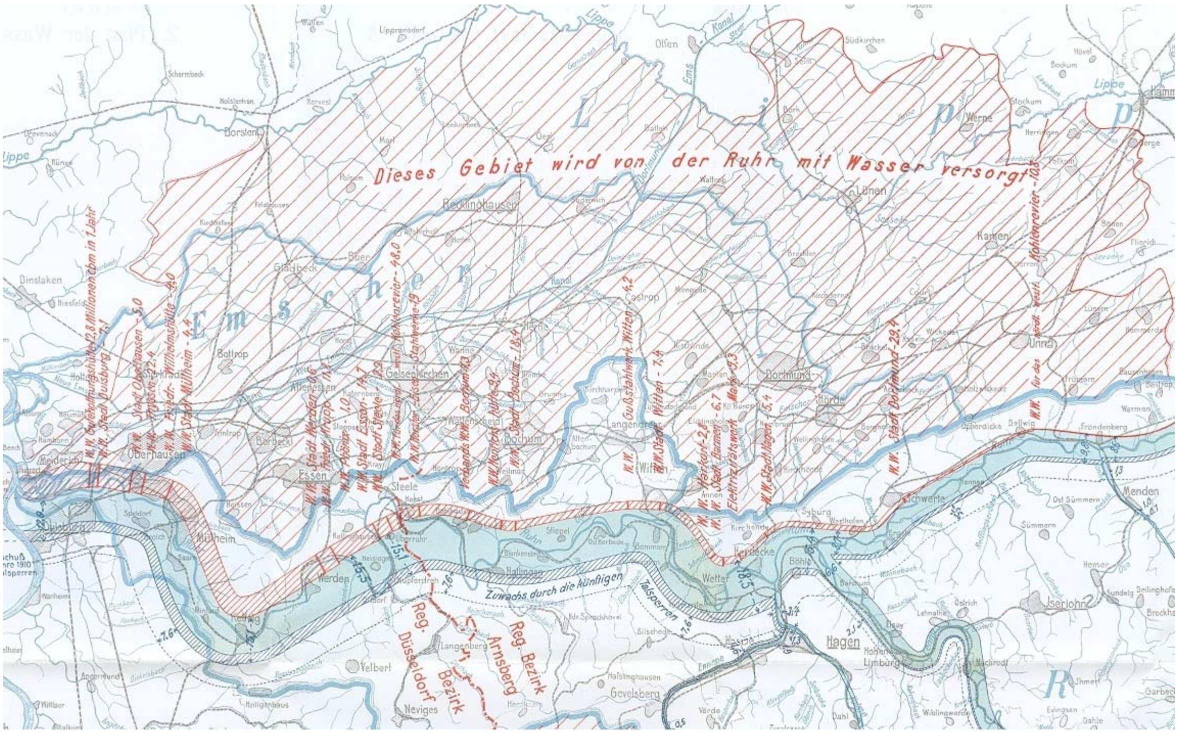

Figure 48: Layout of water volumes (extract) [49]

Inevitably coupled with the rising domestic and industrial consumption of water was a greater accumulation of wastewater, which was discharged into the rivers untreated. These large amounts of wastewater, especially in times of low water, led to substantial adversities at the turn of the century. Diseases such as malaria, typhoid fever, and dysentery could be traced back to these bad hygienic conditions.

Because of the pressing water management problems in the Ruhr area, special laws were enacted in the following years by which four independent cooperatives were established. Similarly to the municipalities, these water associations, founded as public entities, were granted self-administration rights. The water associations' areas of operation were the respective river catchment areas.

The associations may fully develop their activities in the catchment areas almost independent of political boundaries. The state limits its control strictly to legal aspects of association activities. The members of the respective cooperatives are all the municipalities and enterprises in the association area that either have direct water intakes or substantially contribute to pollution with wastewater. In the Ruhr Association, the water utilities are also members. The cooperative members pay proportionate dues to cover the costs needed to fulfill the legal tasks.

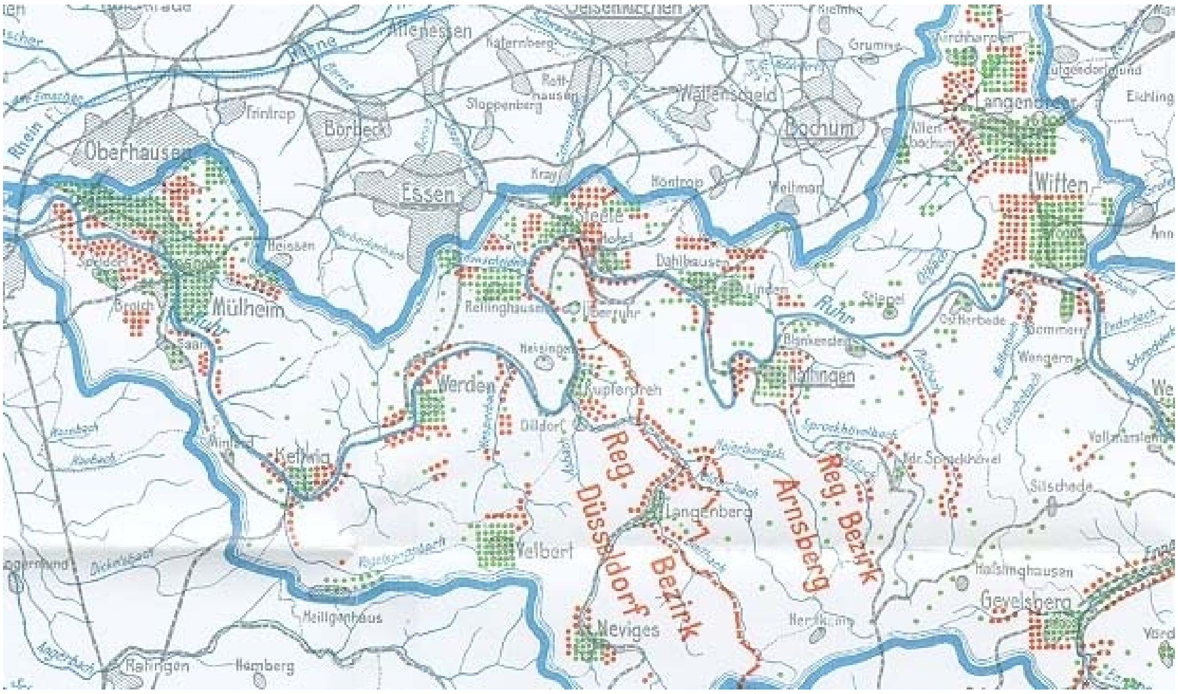

Figure 49: Layout of pollution sources in the Ruhr catchment area (extract) [49]

4.7.2 TOWARDS THE IMPLEMENTATION OF A TARGETED RIVER BASIN MANAGEMENT ON THE RUHR

The necessity for implementing the targeted river basin management of the Ruhr was caused by – as was already mentioned – the rapid economic growth at the beginning of the 20th century and the accompanying unjustifiable overstraining and exploiting of the water resources.

Contemporary history of the Ruhr River basin

1899	Founding of the Ruhr Dam Association as a voluntary merger of Ruhr water utilities
1901	Typhoid fever epidemic in Gelsenkirchen - Prof. Robert Koch initiated the idea of the establishment of a hygiene institute, which was subsequently founded.
1904	Startup of four dams
1910	Dr. K. Imhoff writes “An Expert Opinion on Pollution Control of the Ruhr”.
1913	Founding of the Ruhr Association, the Prussian Water Law of April 7, Ruhr Dam Law of June

Up until the industrialization, there was only a small need for water management measures and an even smaller need for investment in technical plants. This need mainly concerned the regulation of drainage, flood protection, and the supplying and draining of water for the protection of the inhabitants and for increasing the productivity of agricultural fields. In the course of industrialization, the demands on the Ruhr River changed due to new uses of the water resources [47].

It is recognized today, as it was back then, that various water users, such as industry, agriculture, mining, water supply, wastewater drainage, etc., each have specific and competing needs. The mutual influence, and in some cases detriment, of these needs becomes evident especially in areas with jointly used water bodies (i.e. receiving waters). The same is true for river catchment areas.

The meaning of the term “river basin”

The term ***“river basin”*** designates the catchment area of a river, the boundaries of which are determined by the hydrology of the river system. As such, a river basin is a natural unit for the integration in water management; it constitutes an ecological unit.

Only in the rarest cases does such a river basin coincide with the local, regional, or international boundaries of administration, so that a comprehensive observation and management of a river basin is already confronted with difficulties in organization and competence.

Furthermore, the competencies and authorizations necessary for the management of a river basin are often distributed among numerous “actors”. Therefore, a river basin can never be successfully managed by governmental authorities alone; rather, it requires the inclusion of the public as potential users of the river basin.

At the time of the "crisis" in the Ruhr area, the opinion was held that it was neither reasonable nor possible to assign a single function to the Ruhr within the catchment area. Because of the urgent problems, it was decided to place the quantity and quality of the water supply into the forefront of one's objectives.

4.7.3 WATER QUANTITY

Although the Ruhr River, only 271 km long, originates in a region with a high rainfall, it is subject to great fluctuations in its in- and outflow in the approx. 4,500 km^2-large* precipitation catchment area. The average flow rate of the Ruhr at the point of inflow into the Rhine is approx. 80 m^3/s. However, in dry periods, the Ruhr's flow rate can sink to 3.5 m^3/s. By contrast, the Ruhr can increase its flow to a rate of 2,000 m^3/s during a flood.

Figure 50: Lower Ruhr River in the drought of 1911; the riverbed could be crossed by foot [9]

At the turn of the century, the problem of securing a sufficient flow rate was aggravated by the fact that a significant portion of the water that water utilities withdrew did not flow back into the Ruhr. Instead, it was transferred into other river areas (so-called "extraction"). At the time of the formation of the Ruhr Association (1913), 87 water utilities withdrew a total of approx. 275 million m^3 of water annually from the river. Only about 56 million m^3 of that were discharged back into the river as wastewater.

* By comparison, the Rhine flows at about 2,160 m^3/s at the Dutch border.

Since then, the greatly fluctuating flow rate of the river and the resulting disproportion between water availability and demand contributed to the need for management of this river basin (and laid the foundation for the founding of the Ruhr Dam Association).

Despite the substantial fluctuations in outflow, the Ruhr River has been and is still used for the drinking water supply. It has become the chief water supplier for the Ruhr area. Today, more than five million people receive their drinking water from the Ruhr. In addition, there is multitude of small, medium-sized, and large enterprises and plants that are dependent on water from the Ruhr.

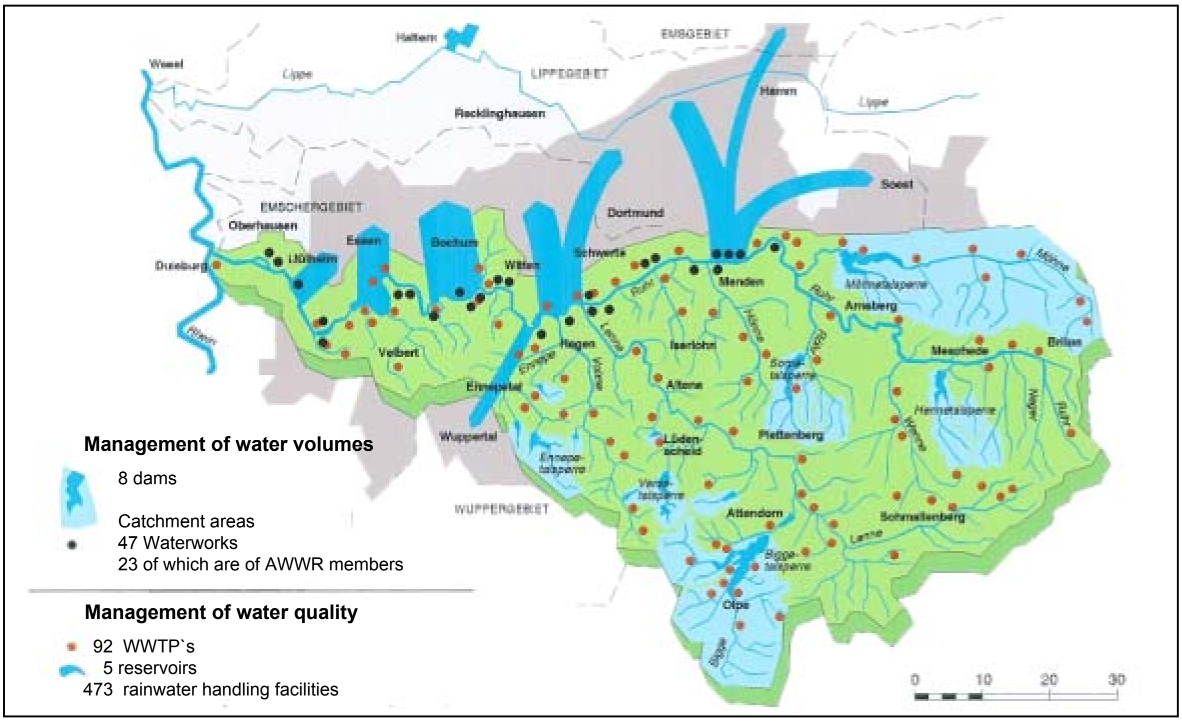

Figure 51: Management of water volumes and water quality in the Ruhr River area [9]

4.7.4 WATER QUALITY

More problematic than a secure quantity of Ruhr water available was the quality of the water, with advancing industrialization at the beginning of the 20th century. The enormous sludge content of the Ruhr especially detracted from the water quality. Coal sludge from mines, iron sludge from factories, and wastewater sludge from the municipalities were deposited at the bottom of the slowly flowing river (obstructed by several weirs) at low and mean water levels and clogged the riverbed. The Ruhr water was thereby prevented from entering the gravel river bed, so that the water utilities no longer received sufficient water.

Other pollution of the Ruhr water from dissolved substances and bacteria, which entered into the river through the discharge of untreated wastewater, played a less significant role than the “sludge problem”.

Today, the classification of water quality is mainly based on hydrobiological assessments of the water body biocenosis, which is supplemented by the chemical analysis of the water quality. Altogether, one may conclude that the water quality of the Ruhr and its tributaries has reached a comparatively high level at the present time, in spite of the high potential for contamination and hazard from settlements, industry, and business.

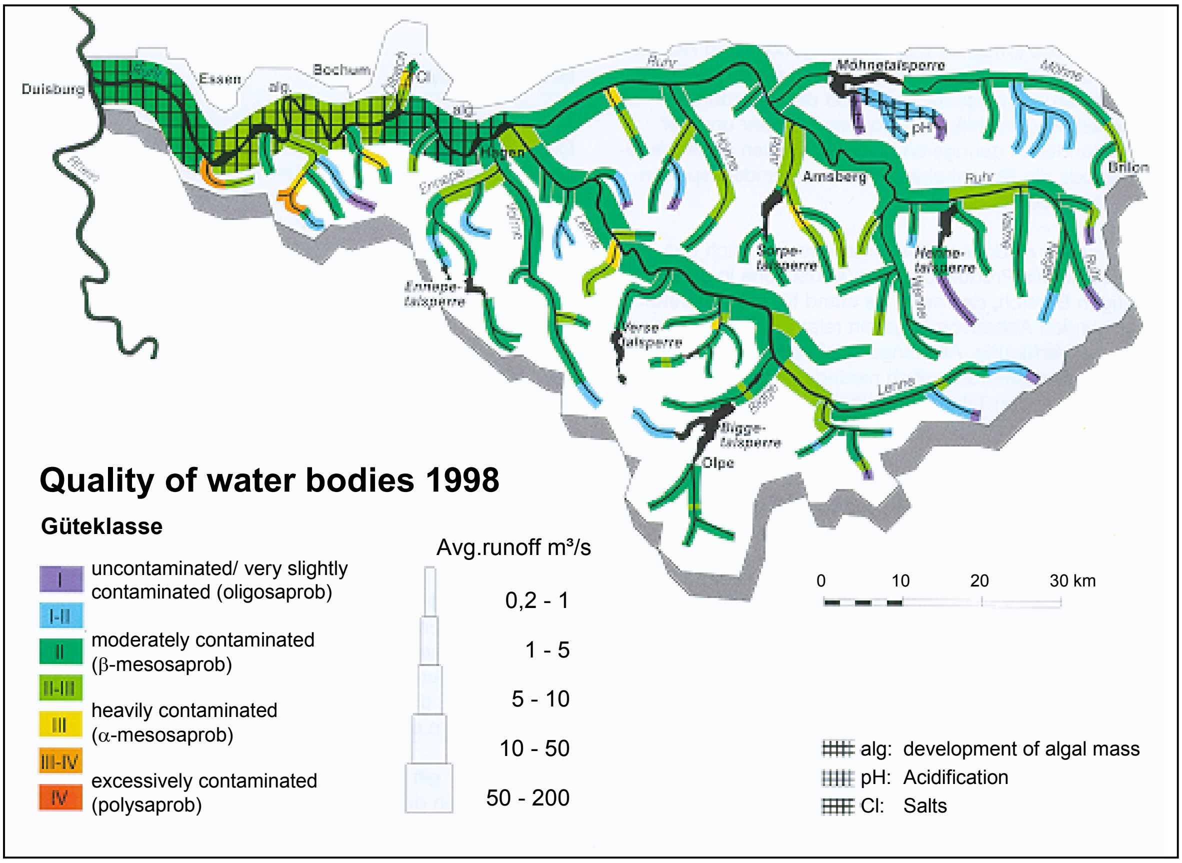

Figure 52: Quality of water bodies in the catchment area of the Ruhr River 1998

4.7.5 CHANGES IN THE AREA OF CONFLICT OF WATER MANAGEMENT IN THE COURSE OF TIME

A “genuine state of emergency” existed at the beginning of the direct and organized river basin management measures implemented by the Ruhr Association. Today, the issue of costs is the most common topic of discussion among the public and the media. The sufficient availability, safe quality, and trouble-free supply of potable water are taken for granted.

Currently, approx. 20 m³/s of water are withdrawn from the Ruhr, 10 m³/s of which are permanently extracted. The situation has still not changed that the natural flow of the Ruhr would drop to about 4 m³/s in dry periods if it were not for the controlled inflow from the dams. At present, only the integral management of the river catchment area, with its dams, reservoirs, WWTP's, and rainfall water treatment plants, is able to maintain the desired volume of Ruhr water in a suitable quality at the critical sections of the river.

4.7.6 CURRENT STATUS OF EFFORTS IN POLLUTION CONTROL

In 1999, about 96% of the wastewater in the area of the Ruhr Association was treated in biological WWTP's. The improvement of the water quality, in particular the reduction of the heavy metal content since the peak of contamination in the mid-1970's, was chiefly a result of the reduction of the pollutant concentrations in the discharge from WWTP's.

Table 6: Change in the water quality at the Ruhr – 1976 to 1997

	1976	*1997*	*Change (76-97)*
DOC [mg/l]	4,8	2,8	(-40 %)
NH_4-N [mg/l]	1,0	0,5	(-50 %)
P_{ges} [mg/l]	1,0	0,15	(-85 %)
Nickel [µg/l]	59	6	(-90 %)
Cadmium [µg/l]	2,8	0,2	(-95 %)

In the majority of its national territory, Germany applies the specifications for "sensitive areas" (according to the EU directive (91/271/EEC) of 1991). The reason for this is that Germany is densely populated and has relatively little water available for the removal of polluted water, compared to less-populated areas with analogous rainfall volumes. Thus, the need for wastewater collection and treatment based on the definition of the area is very high.

Despite the decrease in water withdrawal, with an intake of about 20 m³/s, the river is subject to extremely heavy use of water. Future measures and tasks, therefore, aim at continuing to manage the river basin as efficiently as possible.

4.7.7 THE ORGANIZATION OF WATER MANAGEMENT ASSOCIATIONS ILLUSTRATED THROUGH THE EXAMPLE OF THE RUHR ASSOCIATION

The Ruhr Association is a public entity. This organizational model lends itself to situations in which one desires to involve all politically directly affected and interested parties in the fulfillment of duties. The Ruhr Association is self-administered, yet is under the legal supervision of the state of North Rhine-Westphalia through the State Ministry for the Protection of the Environment, Nature, Agriculture, and Consumer Interests (*Ministerium für Umwelt und Naturschutz, Landwirtschaft und Verbraucherschutz*).

One essential characteristic of a public association is the legal justification for membership, i.e. compulsory membership. The members of such an organization are in principle all those who benefit from the work of the organization or who have given objective reason for being included.

Quotation from the Ruhr Association Law (§ 25 sect. 1 RuhrVG):

The members are obligated to pay dues necessary for the fulfillment of the association’s tasks and duties, for its financial obligations, and for an orderly housekeeping and management whenever other income does not cover the association’s expenses.

The members of a water association, such as the Ruhr Association, are municipalities and counties which lie partially or completely within its boundaries, industrial and business enterprises that discharge wastewater, owners of power plants, other entities which withdraw water, and other utilities of the public water supply. The principles for the calculation of dues are stipulated in the Ruhr Association Law.

In the calculation of dues for the management of water quality, the dischargers of wastewater are assessed according to the quantity and quality of the discharged wastewater, the cost of the removal of the contamination, and the advantages of such removal. Members dues for the management of water quantity and quality are defined according to the quantity of water withdrawn.

4.7.8 ADAPTATION OF THE RUHR ASSOCIATION STRUCTURES EXPANSION OF OPERATIONAL REALM

Organizational structures are always task-oriented. Even in the Ruhr Association*, new tasks require new organizational structures. In its internal structure and allocation of tasks, the Ruhr Association today strongly resembles a stockholding corporation. The association membership assembly resembles a stockholders' assembly, the association board assumes tasks similar to those of the board of directors of a stock corporation, and the executive board is similar to that of a stock corporation in its function.

Organizational structure and decision-making processes of the Ruhr Association

The Ruhr Association is under the supervision of the state of North Rhine-Westphalia, is self-administered, and has an internal structure similar to that of a stock corporation. The organs of the association are the association membership assembly, the association board, and the executive board.

The association membership assembly, as the highest decision-making body, comprises up to 150 delegates from contributing members and two delegates from the chamber of agriculture. The duties of the association membership assembly are the determination of the business plan, setting the budget, assumption of tasks, and the selection of the members of the association board. The origin of the 148 delegates to the association assembly of 2000 and the members of the association board is illustrated below. The association board monitors the conduct of business through the executive board. The duties of the association board are the resolution of the business agenda and the selection of the executive board. The association board is bound to the resolutions of the association membership assembly.

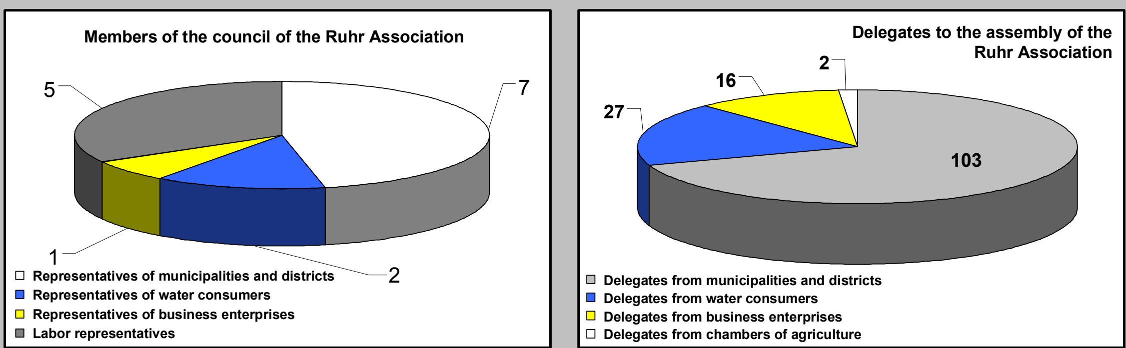

Figure 53: Composition of organizational bodies

The executive board of the Ruhr Association has three members. It handles the current transactions of the association and represents the association legally. The three members of the executive board head the departments of finance, technology, and river catchment area management as well as personnel and administration.

* Combination of the water management organizations of the Ruhr Association (responsible for the Ruhr pollution control) and the Ruhr Dam Association (responsible for water quantity management) into the

Besides the traditional tasks of wastewater disposal and the procurement and treatment of water for the potable and non-potable water supply, the following fields of activity are open to the Ruhr Association:

- Regulation of drainage, including the equalization of water levels and the stabilization of the flood runoff of surface water bodies and water body sections in their catchment areas
- Maintenance of surface water bodies and the facilities that are functionally interconnected to them
- Reintroduction surface water bodies into their natural state
- Prevention, reduction, disposal, and compensation of detrimental alterations (to the environment or water management) which result from influences to the condition of the groundwater

By creating private subsidiaries, the Ruhr Association expanded its business opportunities in that it is now able to make its know-how available to third parties - for a charge. Through its subsidiaries, the Ruhr Association engages both in national and increasingly in international projects.

Through its subsidiary RWG Ruhr-Wasserwirtschafts-Gesellschaft mbH (e-mail address: ruhrwasser@t-online.de), the Ruhr Association is a shareholder of the internationally active company RuhrWasser AG International Water Management. Other shareholdings include RWE Umwelt Aqua GmbH, Essen and RWW Rheinisch-Westfälische Wasserwerksgesellschaft mbH, Mülheim on the Ruhr.

The company offers a comprehensive water management program on the international market which includes the various project areas of energy, water, and wastewater, beginning with the first gathering of data to financing, all the way to the construction and operation of water supply and wastewater disposal systems, under the application of economic and ecological criteria [53]. Reference projects include the organizational structuring and operation of the WWTP "Ankara", Turkey and the operation of the WWTP "Is Arenas" in Cagliari in Sardinia, Italy.

Ruhr Association (1990) through a North Rhine-Westphalian special law

4.8 THE RHINE 2000 – A PROGRAM FOR EUROPE*

The international cooperation between the member nations of the International Commission for the Protection of the Rhine against Pollution ((ICPR) – Internationale Kommission zum Schutz des Rheins – IKSR) is exemplary and has proven itself even in difficult situations, such as the Sandoz fire in 1986. Through the implementation of accident-prevention measures, accidents in the Rhine River catchment area have been significantly reduced. Future activities will focus particularly on the improvement of flood protection and prevention as well as the implementation of an overall ecological concept. The goal is to merge all measures and activities into one uniform and integral water protection policy, so that the "sustainability" of the Rhine, in the sense of the Rio Conference of 1992, will be a living example of resource conservation, successful management, and quality of life. Important impulses of the past years and challenges for future work shall be described in the following examples and results.

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State Office for the Environment
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The Rhine, one of the most important rivers of Europe, has developed in the past few decades from "Europe's Sewer" into a model for a successful remediation. Step by step, the wastewater treatment measures in all the neighboring countries improved, so that the water quality of the Rhine today corresponds to that of the beginning of the previous century, in number and range of species living in the river. Several chemical pollutants and trace elements which have not met the target standards are still cause for concern.

4.8.1 THE QUALITY OF THE RHINE IN THE 20TH CENTURY

Since the beginning of the century, water quality has increasingly deteriorated, parallel to industrial development. The populations of salmon and shad decreased. The last sturgeon was caught in 1931. After 1933, the water quality continued to deteriorate in the course of the advancing industrialization, due to missing wastewater treatment measures. A slight recuperation at the end of the war was frustrated by the reconstruction of Germany, in which ecological aspects were initially of no consideration. The first serious environmental protection measures were implemented in the 1950’s with the construction of WWTP’s and the collection and disposal of waste oil from ships. However, these measures could not keep up with the rapid growth of industry and economic activity.

The extension of the WWTP network first showed noticeably positive effects after 1970, when the Rhine water quality had dropped to an all-time low. The Rhine began to recover, accompanied by a corresponding environmental legislation at the national and European levels.

After the accident at the Sandoz corporation in 1986 in Schweizerhalle, the responsible parties of the countries on the Rhine reacted very quickly by setting up the “Program for Action – Rhine”. Under the symbolic name “Salmon 2000”, the measures for the time period up to the end of the millenium were determined. The century-high flooding incidents on the Rhine in the years 1993/1994 and 1995 quickly lead to the “Plan of Action – Flood”. The underlying concepts and strategies were made public already at the end of 1995. In the meantime, they have been implemented step by step. Since the end of the 1990’s, work has been in progress for the “Rhine Program 2020”, which will succeed the “Program for Action – Rhine” in place until 2000.

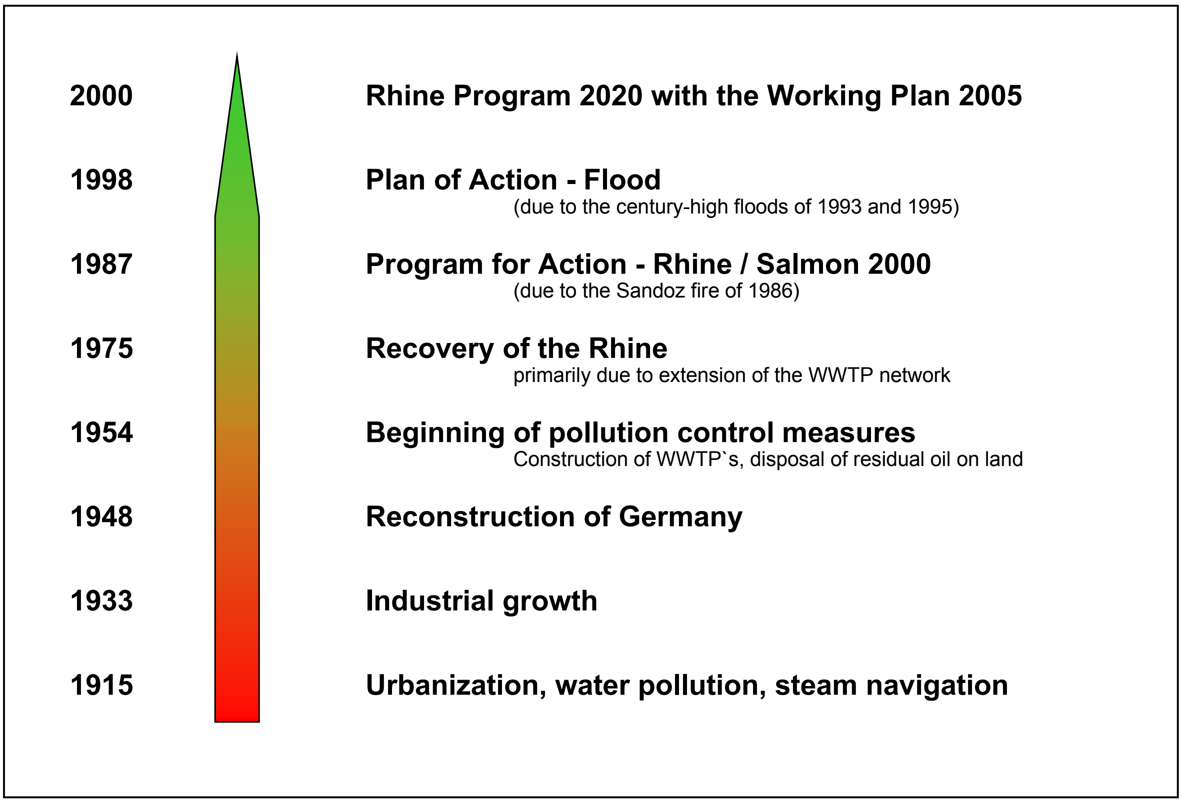

Figure 54: Historical phases of the Rhine River in the 20th century

4.8.2 INTERNATIONAL COOPERATION IN THE RHINE CATCHMENT AREA

Since the 1970's, there has been a heightened implementation of internationally concerted measures for water protection. These measures are initiated, coordinated, and realized by a multitude of governmental agencies and other institutions. In the area of governmental environmental administration, the International Commission for the Protection of the Rhine against Pollution (ICPR) should be given mention [28]. In order to attune the opinions and votes of the German delegation to the ICPR to the various state and federal interests, the German Commission for the Protection of the Rhine (*Deutsche Rheinschutzkommission* – DK) was founded. In this commission, the standards and measures specific to Germany are also initiated, coordinated, and drafted in specialist mirror-bodies.

Table 7: Important governmental players for the protection of the Rhine

ICPR members	*DK members*	*Specialist agencies*
European Union	Federal government	Environmental Agency – Berlin / BfG Koblenz
Switzerland	Bavaria	State Bureau for Water Management – Munich
France	Baden-Württemberg	State Bureau for Environmental Protection – Karlsruhe
Luxembourg	Rhineland-Palatinate	State Bureau for Environmental Protection – Mainz
Germany	Hesse	Hessian State Bureau for the Environment and Geology – Wiesbaden
Netherlands	North Rhine-Westphalia	State Environmental Agency NRW – Essen

Besides the governmental-political authorities (normally the environmental ministries as the highest water authorities), the subordinate specialist agencies of the federal government and of the five states of the Rhine catchment area are involved in the planning and executing of the specialized measures in Germany.

The ICPR has now been in existence for 50 years (as of 2000). The organizational structure and the determination of focal tasks has been regularly aligned with the changing demands. While the improvement of water quality was in the forefront in the 1970's, the remediation of the ecosystem was viewed as the most important task after the Sandoz fire. In the mid-1990's, the topic of flooding received increasing attention.

In 1999, the international agreement of 1963 was replaced by the new Rhine agreement. The ICPR was then assigned the additional task area of groundwater protection in the Rhine catchment area. Formal regulations for cooperation are defined in the agenda and financial regulations of the ICPR. The expenses for the annual budget (business year 1997: € 0.63 million) are shared between the contractual parties, for example, according to these regulations.

The EC bears at least 2.5% of the costs, Switzerland 12%. The rest is assumed, proportionately, by Germany (32.5%), France (32.5%), Luxembourg (2.5%), and the Netherlands (32.5%). Figure 55 shows the organizational chart of the ICPR (as of July 1998).

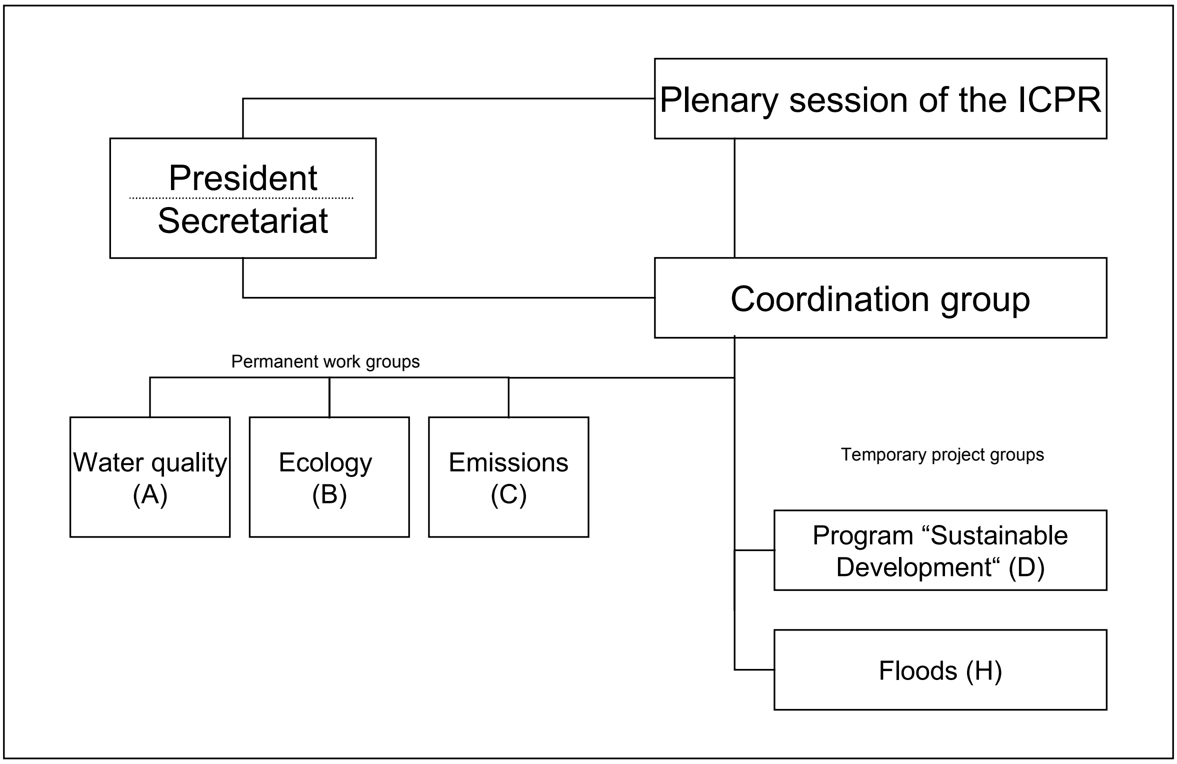

Figure 55: Organization chart of the IKSR

Comprehensive environmental problems can only be successfully resolved through international cooperation. The greenhouse-effect with its impacts on the world climate, and thus also the water cycle, and hazards to oceans and seas are environmental problems that require global solutions. Even many local environmental problems, such as groundwater protection, can very quickly have international impacts, since they affect competitiveness. Therefore, the harmonizing of environmental protection policies in and beyond the European Union becomes exceptionally important. The nations of this earth are growing ever closer to a union of fate in environmental protection.

The integrated management of river systems takes place on a large scale at transboundary water bodies within the scope of international commissions for entire river basins or bilaterally for boundary water bodies.

The international agreement for the protection and use of transboundary waters and international seas, promoted by Germany within the scope of the UN regional organization ECE (Economic Commission for Europe), was ratified by Germany in 1995. With this agreement, a joint foundation has been laid for the ECE Region and for the countries of Central and Eastern Europe in particular for the protection of transboundary rivers and seas.

Germany is a member of

- The International Commission for the Protection of the Rhine against Pollution (ICPR – *IKSR*)
- The International Commission for the Protection of the Elbe (IKSE)
- The International Commission for the Protection of the Danube (IKSD)
- The International Commission for the Protection of the Oder against Pollution (IKSO)
- The International Commission for the Protection of the Mosel and the Saar against Pollution (IKSMS)
- The International Commission for the Protection of Lake Constance

Germany also maintains close ties with the neighboring countries in regard to boundary waters.

4.8.3 SIGNALS OF INTERNATIONAL COOPERATION ON THE RHINE FOR EUROPE

The most important signal for Europe is the striking impression that was made on all member countries on the far-reaching organizational, professional, and political impact resulting from the comprehensive cooperation on the Rhine. The water management problems of this multilaterally- and intensely-used river were resolved with sustainability and increasing efficiency. These positive experiences on the Rhine have therefore exerted and still exert far-reaching influence on the formation of other international river basin commissions in Central Europe. These experiences assisted in the drafting of the European Water Framework Directive.

The international cooperation was not successful from the start. First of all, in the beginning phase of the ICPR after 1950, distrust toward the respective upstream users needed to be abated. At the 1995 ICPR Symposium, the Dutch ambassador quoted the prevalent opinion in the Netherlands in 1950 concerning the cause of the bad water quality of the Rhine: *"Everything evil comes from upflow!"* This initial situation was able to be increasingly dismantled and overcome in the years and decades that followed by means of the transparent and successful cooperation.

Today, the trustful understanding among one another is shaped by the spirit that all residents on the river are upstream or downstream water users and that there is no other alternative for cooperation. As an example, the North Rhine-Westphalia Office of the Environment and the respective Dutch organization RIZA are currently planning the consolidation of their monitoring activities on the Lower Rhine.

Remarkable about the international cooperation on the Rhine and proof of the good, common understanding is that the results of the ICPR have mostly been able to be immediately and continuously implemented even *without being bound by international law*. The agreements and recommendations drafted and voted on in the ICPR are submitted to the environmental ministers of the nations adjoining the Rhine, who discuss and agree on these recommendations in annual Rhine Minister Conferences.

As expected, the organizational, subject-related tasks of the international Rhine protection measures have dynamically changed over the course of the cooperation: At the beginning the of the cooperation, *chemical water pollution* (through municipal and industrial wastewater, oxygen deficiency, oil, and chloride) and elimination of its causes were clearly in the forefront. After the introduction of an internationally concerted monitoring program, the first results in the improvement of the water quality of the Rhine were able to be achieved, with the help of contractual and political agreements. Step by step, the *biological quality indicators* were increasingly drawn upon as a criterion for quality assessment.

The introduction of target standards for a manageable number of hazardous substances represented an important step for material assessment in Rhine protection measures. Concentration limits were determined for selected *priority substances*. From the present point of view, the adherence to such limits in water bodies enables both the comprehensive protection of aquatic symbioses as well as a risk-free usage of the water bodies.

The introduction of legally-binding immission limits for the Rhine was consciously avoided. It was deemed important to define exacting and professionally-comprehensible *quality targets*, which should be reached on a pragmatic basis of an extended, realistic time period. Of the 47 specifically determined priority substances or substance groups in the Rhine, the target standards of only eight substances / substance groups are currently still exceeded (Table 8).

In the 1980's and 1990's, at the same time as the systematic linking of the monitoring network on the Rhine, the harmonizing of methods and technologies was promoted in the important areas of wastewater treatment and accident-prevention.

Table 8: quality targets for priority substances in the Rhine (ICPR, 1997)

quality targets, that were not met at at least one measuring point:				
mercury	0.5	mg/kg	γ-HCH (lindane) 0.002 µg/l	
cadmium	1.0	mg/kg	hexachlorbenzene 0.00 1µg/l	
copper	50.0	mg/kg	Ammonium-N 0.2 mg/l	
zinc	200.0	mg/kg	6 PCB each 0.1 ng/l	
Target standards met or almost met				
Heavy metals and arsenic (mg/kg)			**Organo-tin compounds (µg/l)**	
chromium	100.0		dibutyl tin compound	0.8
nickel	50.0		*tributyl tin compound*	0.001
lead	100.0		triphenyl tin compound	0.005
arsenic	40.0		tetrabutyl tin compound	0.001
Organic micropollutants (µg/l)				
atrazine	0.1		1,2-dichloroethane	1.0
azinphos-ethyl	0.1		1,1,1-trichloroethane	1.0
azinphos-methyl	0.001		trichloroethene	1.0
Bentazon	0.1		tetrachloroethene	1.0
DDT each 0.001			*trichloromethane*	0.6
DDE each 0,001			etrachloromethane	1.0
DDD each 0,001			benzene	2.0
dichlorovos	0.007		2-chloroaniline	0.1
aldrin	0.001		3-chloroaniline	0.1
dieldrin	0.001		4-chloroaniline	0.05
endrin	0.001		3,4-dichloroaniline	0.1
isodrin	0.001		1-chlorine-2-nitrobenzene	1.0
endosulfane	0.001		1-chlorine-3-nitrobenzene	1.0
fenitrothion	0.001		1-chlorine-4-nitrobenzene	1.0
fenthion	0.007		trichlorobenzines each	0.1
α-HCH	0.1		2-chlorotoluene	1.0
β-HCH	0.1		4-chlorotoluene	1.0
γ-HCH	0.1		hexachlorobutadiene	0.5
malathion	0.02			
parathion-ethyl	0.0002			
parathion-methyl	0.01		**Further measured variables**	
pentachlorophenol	0.1		*AOX*	50 µg/l
simazine	0.06		*total phosphorus*	0.15mg/l
trifluralin	0.002		*4 PAH* each	0.1 µg/l

With this combination of wastewater norms and target standards (developed according to the pattern of the German Wastewater Law), the combined approach in water protection was successfully implemented for the first time in an international river catchment area. The EU adopted this concept into the Water Framework Directive.

In the area of *accident-prevention* for industrial plants, organizational recommendations have been drafted and passed through the Rhine Minister Conference which are valid internationally in the Rhine catchment area since 1995. The visual model for all of the documents of this line of work is a transparent spill tray which lies below the respective affected industrial area. Altogether, it can be substantiated that the number of industrial accidents in the Rhine catchment area has considerably decreased.

The successes in the prevention of hazardous *wastewater discharges* and the consequent improvement of the water quality has led to a significant shift in the main focuses of water management on the Rhine, as well as in other river catchment areas. Chemical *pollutants* relevant to the Rhine and the increasing significance of nonpoint source discharges continue to be determined with flexible methods and the consequences are followed according to demand for treatment [cf. 24].

Parallel to the decrease of deficiencies in the present Rhine water quality, the *biological-ecological status assessment* has gained in importance. The samplings performed in five-year rotation record biological quality components, such as fish, invertebrates, phytoplankton, and waterfowl. These quality components are substantially drawn upon in the status assessment. The results of the sampling performed in 1995 substantiate that 45 species of fish again exist in the Rhine. This includes even sensitive migrating fish such as salmon and ocean trout. The status of invertebrates has increasingly recovered since 1970. The number of different species is approaching 200. Of the almost one million total waterfowl counted, more than 38 species were able to be recorded. The species composition of plankton was also determined, which mirrors a situation of increase in the longitudinal profile of the Rhine and eutrophic situation in the Lower Rhine.

In the evaluation of chemical-physical and in particular biological-ecological quality characteristics, it becomes evident that the significance of point and nonpoint source pollution is constantly decreasing in comparison to the effects of deficient morphologic water quality. Intensive tests and mappings indicate considerable deficiencies for the Rhine regarding the diversity of its habitats. The expansion of the Rhine has led to a monotonous river appearance. Dams are still insurmountable barriers for salmon. The “cropping” of the surrounding area effects a grave loss of habitats.

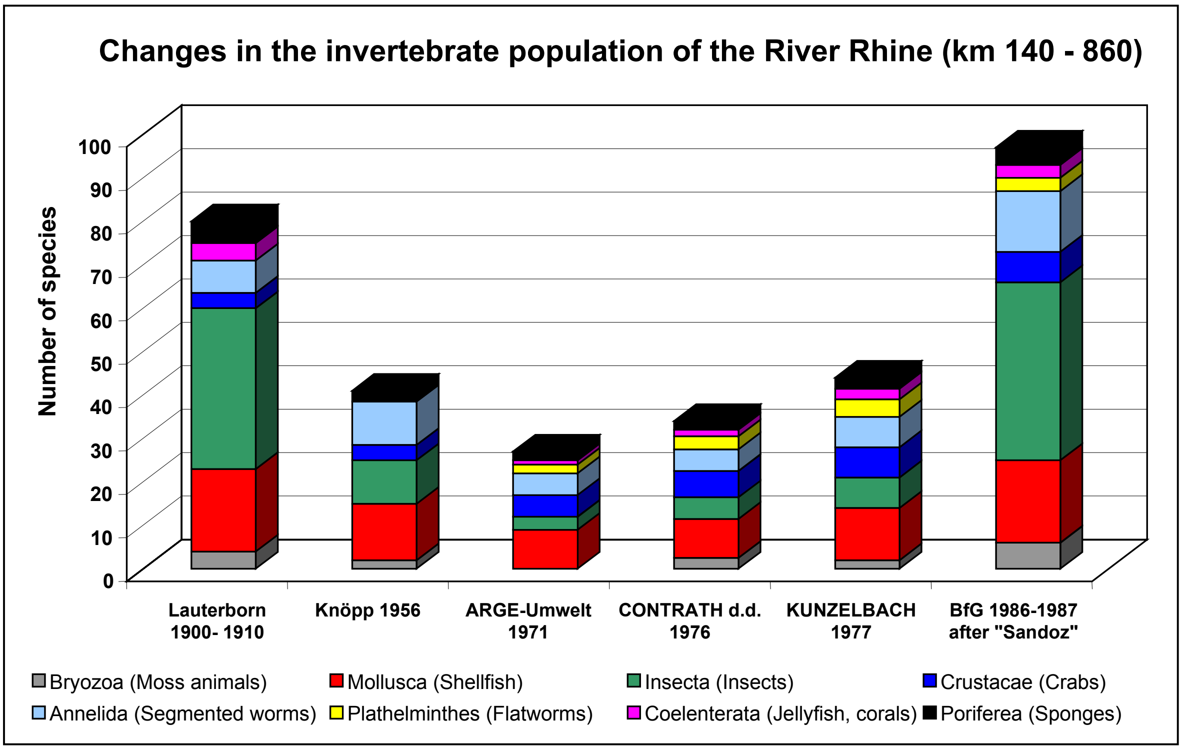

Figure 56: Changes in the invertebrate population of the Rhine River [15]

These deficiencies need to be reduced long-term, and the individual biotopes association on the Rhine must be interconnected as widely as possible. The first steps towards these goals are specified in the Rhine Atlas with the ecologically most important areas and the present / future flood zones.

A further emphasis of Rhine protection activities is the protection of residents and property against flooding. Stimulated by the aforementioned flood incidents in the 1990's, the ICPR assessed and summarized the *flood-protection activities* on the Rhine. The "Plan of Action – Flood" was set up in 1995, which, besides the previous priority technical flood-protection measures, describes important steüs for an ecologically-oriented flood-protection policy. This plan centers especially on water retention in the river plains and the expansion of retention basins on the Rhine. The "Plan of Action – Flood", which is to be implemented in phases until 2020, is estimated to cost € 12 billion. Its successful implementation presupposes interdisciplinary thinking and measures from the local to the international level.

4.8.4 THE RHINE AT THE BEGINNING OF THE 21ST CENTURY

Despite all successes, there will be no standstill in environmental protection. In the ambitious "Program for Action – Rhine", it was decided that in the third phase, from 1995 to 2000, the results of the program up to that point would be examined and any further measures necessary for the protection of the Rhine would be determined. This task will be fulfilled through the implementation of the subsequent program "*Rhine 2020 – A Program for the Sustainable Development of the Rhine – Working Program until 2005*". The main focuses of this program will be the further implementation of the ecological comprehensive plan and the improvement of flood-prevention measures. A new task in the plan is groundwater protection. The constant monitoring of the quality of the Rhine and the continuation of measures for the further improvement of the water quality will be pursued as an indispensable component of the program.

The chief points of the 2020 program contain details and instructions for the procedure, individual measures, for the instruments, success monitoring, and public relations. A detailed "Working Program until 2005" is set up in order to apply activities and means to the cleanup of the Rhine without delay. The specific measures in the four central areas of the ecosystem of the Rhine, improvement of water quality, execution of the "Plan of Action – Flood", and groundwater protection are listed in this program of individual segments of the Rhine.

In the review the work schedule until 2005, it becomes clear that a complete remediation of the Rhine is not possible in just a few years, nor that it can be measured in legislative periods. Even in the present view of the requirements, the cleanup of the Rhine remains a generational task. This is not astonishing in view of the previous history, in which the Rhine was expanded solely for improved industrial use, which had an ecologically detrimental impact on the river.

Additional requirements and emphases will be determined by the European Water Framework Directive, particularly in the areas of biological monitoring and assessment and integration of groundwater protection measures.

Also included in the 2020 Rhine program are further endeavors and activities in the area of public relations, which should increasingly develop from a pure information brokering towards public participation. Important experiences even in this area were already able to be gathered in the international cooperation on the Rhine. Since 1998, a regular information exchange with non-governmental organizations has been cultivated in the ICPR.

5. PERSPECTIVES OF THE GERMAN WATER SECTOR IN EUROPE

The future development of the water sector in Germany has a very European touch. The European Water Framework Directive (http://www.europa.eu.int/eur-lex) requires the integrated management of water bodies in the boundaries of the large river basins, based on the immissions and efficiency principles [41]. This necessitates a corresponding adaptation of the administrative structures and a modified division of labor between the states and municipalities or water / wastewater associations, as applicable.

In this context, the tasks at hand need to be solved according to German laws and environmental policy directives, namely:

- The integration of indoor plumbing into the quality assurance of the water supply (Lead pipes still exist in many eastern German cities from previous times.)

- The completion of the organized wastewater disposal (even with decentralized concepts) in the outlying territories and rural regions not yet organized, above all in the state of Saarland and in eastern Germany – Newly-developed alternative water systems, amongst others, should be considered in such areas [50b]

- The further assessment and safeguarding of ways to manage and dispose of wastewater sludge

- The expansion of rainwater management systems (decentralized utilization or seepage of non-polluted rainwater and treatment of polluted rainwater)

- The reduction of water pollution from nonpoint sources, particularly in agriculture, through a proper combination of preventive measures (e.g. optimization of fertilization application to fields) and end-of-pipe measures (e.g. in the treatment of liquid manure - see box *"Call for action for agriculture"* in sect. 4.5.3)

- Observation and reduction of emissions of environment-relevant substances (especially heavy metals, pesticides, chlorinated organic compounds, and substances with hormone-like effects as well as hygienic contamination) [42],

- The systematic further development of the ecological water body structure, in reference to the entire water landscape, from river bed to catchment area.

An "agricultural turnaround" for a groundwater-conserving agriculture

As a consequence of the livestock epidemics BSE and foot and mouth disease (FMD), there has been increased consideration of an "agricultural turnaround" since the turn of the century 2000/2001 in the EU and in Germany in particular.

Environmental- and nature-protection organizations, among others, have prepared arguments for an agricultural policy based on ecological criteria for over two decades. The "organic agriculture" demanded by environmental organizations would also have advantages for water protection measures. Through the widespread reduction of the use of agrochemicals, such as mineral fertilizers and pesticides, and of the excessive use of liquid manure, the widespread pollution of the groundwater in Germany by nitrogen compounds and pesticides would clearly be further reduced (see sect. 4.5). A rethinking in agricultural policy was first initiated by the appearance of the livestock epidemics. As in the water sector, "catastrophes", in the form of BSE and FMD, opened up the possibility for reorientation also in the agricultural sector.

In collaboration with environmental organizations and open-minded farmers, various water utilities (such as for a long time Gelsenwasser AG - see sect. 4.2.2) have already begun to promote a groundwater-conserving land management in their water collection areas. A groundwater- and resource-conserving organic agriculture could also offer an orientation for many small farmers in threshold economies, transformation economies, and third-world countries, in which costly land management practices with expensive mineral fertilizers and synthetic pesticides cannot be financed by a majority of the farmers.

Despite all of these unfinished tasks, the German water sector is certainly no longer a growth market. The expansion phase of the water sector in other European and extra-European countries has to a large extent already been concluded in Germany. The main task involves the consolidation and constant renovation of the systems by means of sufficient reinvestments and modernization measures. These must warrant that the water and wastewater treatment plants do not become obsolete and that the technologies and concepts are constantly adapted to the latest developments, legal requirements, and desires of the water customers.

The introduction of a European currency, the Euro, which will replace the internationally highly-valued and stable Deutschmark on January 1, 2002, will lead to an increase in competition in the water sector. Hydrology not only requires a comfortable, sustainable, and secure water supply and wastewater disposal, but also a maximum possible cost-transparency and –efficiency. Because of their size and municipal form of organization, only very few water utilities in Germany are capable of international competition and will in most cases not be able to elude a grave structural change [14].

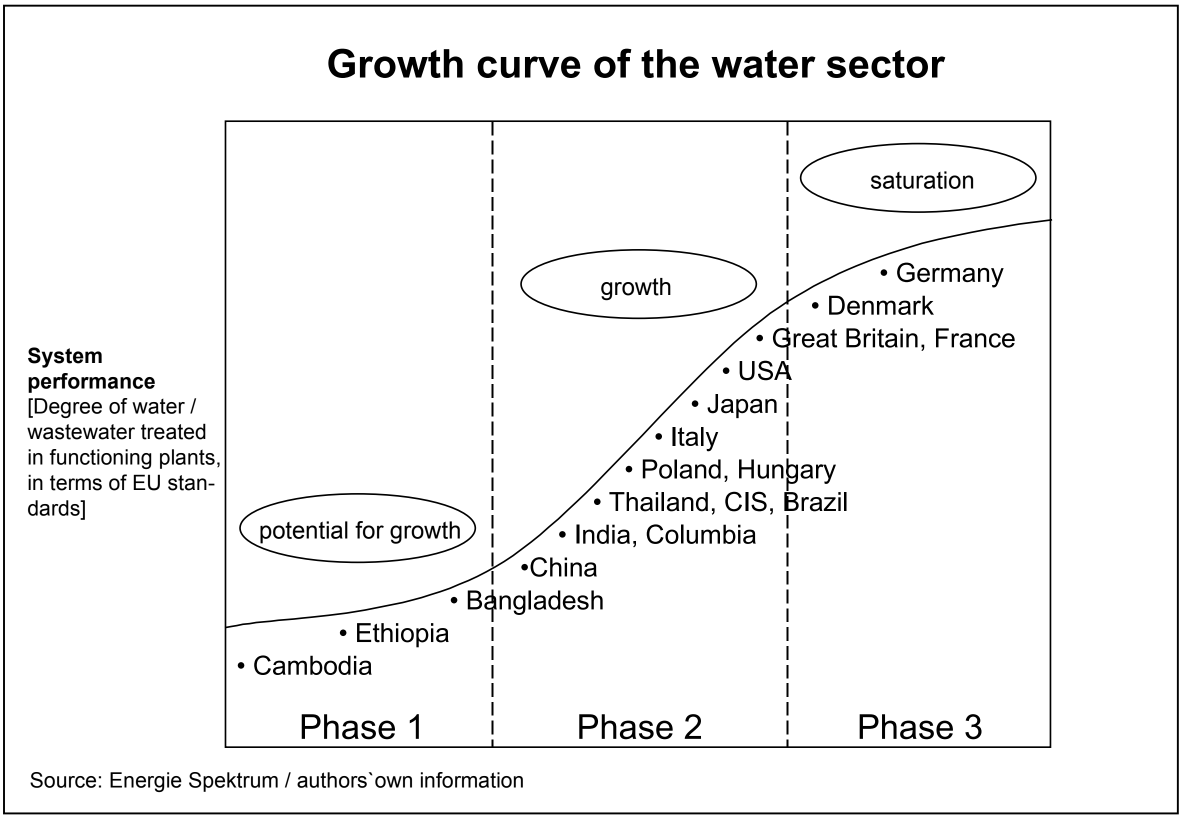

Figure 57: Growth curve of the water sector

Analogous to the deregulation of telecommunication and the power sector, strategic measures for the water sector are being discussed under the catchwords "competition-oriented privatization" (= involvement of private service enterprises [38] - see box *"organizational forms"* at page 14) and "differentiated liberalization" (= limitation of the distribution and collection network monopoly and of mandatory connection - see box *"Mandatory connection and use"* in sect. 3.4). It is clear that such measures must not be allowed to burden the security of the water supply and put into question preventive water protection measures [10].

On the other hand, it is not just the high technical standard that makes the know-how and experiences of the German water sector appear attractive to many countries. Interest is expressed precisely in *the great variety of case-specific solution concepts* with the most diverse forms of organization and municipal involvement (maintained even in most privatization projects) [46].

An example of international cooperation and support

More than one-fifth of the population in Peru does not have access to a drinking water supply system. So far, only 27% of the population is connected to a wastewater disposal system. There is great need in Peru for the securing of a sustainable water supply and wastewater disposal.

PROAGUA is a program for water supply and wastewater disposal by the Organization for Technical Cooperation (*Gesellschaft für technische Zusammenarbeit* – GTZ) in Peru. It is funded by the Federal Ministry for Economic Cooperation and Development (*Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung*). PROAGUA cooperates closely with the Credit Institute for Reconstruction (*Kreditanstalt für Wiederaufbau* – KfW), which, together with the DEG (German Investment and Development Corporation – *Deutsche Investitions- und Entwicklungsgesellschaft* – http://www.deginvest.de) provides financial and consultative support to private investors in the construction and development of infrastructure in selected Peruvian water and wastewater utilities.

Eight public Peruvian enterprises with between 100,000 and 750,00 inhabitants to be supplied per service area are supported by PROAGUA in the sustainable development of water supply and wastewater disposal services. Already since 1996, PROAGUA has been able to report positive developments in the service areas of the enterprises and in the bordering cities and villages.

Figure 58: Drinking water filling station in Peru

Continuation of international cooperation and support

In some of the towns, the majority of the population lives in areas with very low income. It is therefore important not to apply German standards in supply and disposal practices. With support from PROAGUA, customized forms in the implementation and management of services are applied.

One important task in the program is "private sector participation" (PSP) as an instrument in the struggle against poverty. Without professional management and private financial means, the difficult social, economic, and ecological problems of water supply

Figure 59: Waterworks at Peru

and wastewater management will not be able to be resolved. PROAGUA helps in the development of attractive, private investment concepts and customized PSP models.
The experiences with cooperative privatization projects from Germany, in particular from the reconstruction of the infrastructure in the former GDR, have become of large interest in Peru.

Under the condition of constant coordination with the government and high-ranking regional politicians, PROAGUA is involved in the establishment of normative and institutional general framework for the water sector in Peru. In this process, experiences from the German water sector can be incorporated to reach the desired success.

6. COOPERATIONS / ORGANISATIONS

6.1 Federal Ministries

Auswärtiges Amt
Werderscher Markt 1
10117 Berlin
Telefon: +49 1888 / 17-0
Telefax: +49 1888 / 17 - 3402
Internet: http://www.auswaertiges-amt.de

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
Kennedyallee 5
53175 Bonn
Telefon: +49 1888 / 305-0
Telefax: +49 1888 / 305-32 25
Internet: http://www.bmu.de

Bundesministerium für Wirtschaft und Technologie
Scharnhorststraße 36
10115 Berlin
Telefon: +49 30 / 20 14-9
E-Mail: info@bmwi.bund.de

Bundesministerium für Bildung und Forschung
Heinemannstraße 2
53175 Bonn
Telefon: +49 1888 / 57-0
Telefax: +49 1888 / 8-36 01
E-Mail: bmbf@bmbf.bund400.de
Internet: http://www.bmbf.de

Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
Friedrich-Ebert-Allee 40
53113 Bonn
Telefon: +49 228 / 535-0
Telefax: +49 228 / 535-34 51
Internet: http://www.bmz.de

6.2 Federal Agencies and the LAWA

Umweltbundesamt
Bismarckplatz 1
14193 Berlin
Telefon: +49 30 / 89 03-0
Telefax: +49 30 / 89 03-22 85
Internet: http://www.umweltbundesamt.de

Bundesamt für Naturschutz (BfN)
Konstantinstraße 110
53179 Bonn-Bad Godesberg
Telefon: +49 228 / 84 91-0
Telefax: +49 228 / 84 91-200
E-Mail: PBOX-BFN@BFN.de
Internet: http://www.BFN.de

Bundesanstalt für Gewässerkunde (BfG)
Kaiserin-Augusta-Anlagen 15-17
56068 Koblenz
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Telefax: +49 261 / 13 06-53 02
E-Mail: posteingang@bafg.de
Internet: http://www.bafg.de

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Telefax: +49 385 / 588-83 56
E-Mail: lawa@um.mv-regierung.de
Internet: http://www.lawa.de
from 01.01.2002
Umweltministerium Niedersachsen
30169 Hannover
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E-Mail: poststelle@min.niedersachsen.de
Internet: http://www.min.niedersachsen.de

6.3 Professional Associations / Foundations

ATT Arbeitsgemeinschaft Trinkwassertalsperren e.V.
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Telefax: +49 2241 / 128-430
E-Mail: such@wahnbach.de

Arbeitsgemeinschaft für Umweltfragen e.V. (AGU)
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