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The Chemical
and Biological
Laboratory



Water for millions

More than 5 million people obtain their drinking water from the Ruhr River. The Ruhrverband provides the prerequisites for this permanent and ample supply.

Water quantity management

A system of large reservoirs balances the variation in the natural flow of the Ruhr. Floods are reduced, electrical energy is generated and the water supply is guaranteed even during dry periods.

Water pollution control

About 100 wastewater treatment plants in the Ruhr River Basin purify the wastewater from communities and industrial plants. Water pollution control is the prerequisite for providing a supply of water for private households and for a variety of recreational activities in and along the Ruhr and its impounding lakes and reservoirs.

The Chemical and Biological Laboratory

The laboratory plays a key role in helping the association to meet its obligations concerning the water management in the Ruhr. Its tasks include the monitoring

- of the association's wastewater treatment plants
- of the composition of the municipal wastewater as well as sewage sludge
- and of the composition of its members' industrial wastewater.

The effects of wastewater discharges from nonpoint sources are monitored by intensive chemical and biological analyses of the Ruhr, its tributaries and of the reservoirs. The laboratory's monitoring activities help to in time recognise failures of wastewater treatment and the short-term pollution of water as well as to diagnose long-term trends. Thus, the need for sanitation can be explained and its success can be documented. Also a standard of water quality can be guaranteed which covers the population's needs and at the same time takes into account that water as part of the eco-system must be protected.

As a result of this range of tasks the laboratory has three divisions:

- Monitoring of wastewater treatment plants
- Monitoring of surface waters
- Instrumental analysis

Monitoring of wastewater treatment plants

The division "Monitoring of wastewater treatment plants" of the chemical and biological laboratory has the following range of tasks:

- analysis of the composition of the discharges of the association's wastewater treatment plants under the stipulations of the ordinance concerning type and frequency of self-monitoring of wastewater treatment plants and wastewater discharges and under § 60 North-Rhine-Westphalian Water Act.
- analysis of the efficiency of wastewater treatment plants and of selected stages of purification respectively.
- analysis of sewage sludge under the sewage sludge ordinance.
- determination of pollution data for wastewater treatment plants as a basis for expansion measures or new developments.
- tests to establish the reasons for disturbances of processes in and the operation of wastewater treatment plants.

- analysis of Ruhrverband members' wastewater discharges to establish the level of their financial contribution and to establish whether they comply with the stipulations concerning self-monitoring as laid down in the certificate of approval under the current wastewater legislation.
- analysis of indirect discharges concerning hazardous substances and checks in the drain and sewage systems to detect illegal wastewater discharges containing toxic substances.
- guidance and support of the staff of the association's wastewater treatment plants and of the operators of commercial and industrial wastewater treatment plants in the event of problems and disruptions.
- investigations of the scientific basis of advanced wastewater treatment (e.g. nutrient elimination) and of specific problems of wastewater technology (e.g. the treatment of seepage water).

This also includes dealing with micro-biological and bio-chemical questions resulting from planning and operating municipal wastewater treatment plants. One focus of research activities is therefore the exploration of the aerobic and anaerobic stages of a wastewater treatment plant.

Using the methods of metabolism physiology as well as biochemical, bacteriological and microscopic methods, digested sludge and bio-sludge are characterised and their metabolism activities are quantified. Also taking into account the physico-chemical analysis of wastewater, this facilitates a comprehensive evaluation of the biological stages of purification.

Laboratory scale wastewater treatment plants for basic research and for the evaluation of selected questions in the context of wastewater technology are available, as are equipment and devices for the determination of microbial metabolism performance, the degradability of certain components of wastewater or for the cultivation of micro-organisms under specific environmental conditions (respirometer, laboratory fermenters, digestion chambers). Toxic substances can both impair the biological degradation and thus the functioning of a wastewater treatment plant and also – as residual pollutants – jeopardise the aquatic biocoenosis of surface water.

Various bio-tests involving bacterially mixed and pure cultures are carried out in order to detect toxic properties of municipal as well as industrial water and of leachate.



In order to fulfil these tasks, laboratory staff in the entire river basin take wastewater samples from the inlets and outlets of the association's wastewater treatment plants, of the wastewater treatment facilities of industrial indirect dischargers and samples of digested and raw sludge. These samples are then examined for various relevant parameters either on site or subsequently in the laboratory. Moreover, the samples are preserved respectively reprocessed for further examination on specific substances in the division "Instrumental analysis".

Monitoring of surface waters

The specific situation of water quality management on the Ruhr results from its traditional dual function as a source of drinking water supply and as a recipient of treated wastewater, i.e. from the requirements of both drinking water supply and wastewater disposal.

The monitoring of rivers, lakes and reservoirs is particularly important because the polluters themselves control the efficiency of their water management measures. In this process, the chemical tests of the water quality and the biological evaluation supplement each other.

Since the twenties, the water quality of the Ruhr has been analysed by samples taken at the reference sampling stations in Essen-Rellinghausen ("Zornige Ameise"). Moreover, several times annually samples are taken along the Ruhr at up to 35 sampling locations. The hydro-biological survey of the Ruhr's aquatic ecosystem and its tributaries are the basis for the drawing up of the water quality map of the catchment area.

In order to protect the drinking water supply from the Ruhr, it is necessary to determine water pollution (e.g. by transport accidents, illegal pollution) as soon as possible, i.e. not only post festum. This is done with the help of several monitoring stations. These contain continuously working measuring systems and bio-monitors which trigger an alarm and the taking of a sample if pre-determined threshold levels are exceeded. Thus, waterworks can be warned in time of the contamination of river water. The analysis of collected samples can also help determine the reasons for and the originators of water contamination.

The limnological investigations of the reservoirs provide an insight into the spatial and chronological dynamics (e.g. the various layers of the body of the water as a result of changes in temperature) and the ecological relationships which influence oxygen content and fish stocks.



In order to determine and evaluate the reasons for and the consequences of eutrophication (i.e. the intensification of algae growth in water as a result of an abundance of nutrients), both the nutrient additions via the inlets and also the phosphorus and nitrogen compounds (as nutrients), BOD, COD, TOC (as depletion substances) and the chlorophyll concentrations (as a measure of the algae biomass) and finally 20 further parameters are analysed in the reservoir water.

The groundwater analysis near sewage sludge deposits and of leachates are supposed to ensure that these facilities are not dangerous.

Eco-toxicological investigations (bio-tests) are used in order to determine and quantify the effects of pollutants on water organisms. As representatives of organisms executing major functions in aquatic eco-systems, bacteria, algae, water plants, daphnias and fish are used in laboratory tests. In this way, the biocoenoses of both sewage treatment plants and surface waters are to be protected from toxic pollutants, and the compliance with discharge regulations prescribed by the authorities can be proved. The results of water quality investigations are published in the annual Ruhr-water-quality-report.



Instrumental analysis

In the division "Instrumental analysis" the major analysis procedures requiring equipment are concentrated. For reasons of systematic arrangement the division has three departments with the following fields of activity:

- Inorganic Trace Analysis,
- Organic Trace Analysis,
- Special Analysis.

The division "Instrumental analysis"

- offers wide ranging analytic services within the laboratory,
- has qualified personnel and modern instruments to efficiently analyse environmental samples from a wide range of differing matrixes,
- varies its range of analyses in accordance with the legal and specific requirements,
- develops and improves new analytic procedures with a view to problems occurring
- gives priority to the examination of anthropogeneous substances in municipal and industrial wastewater as well as the Ruhr and further surface waters of the catchment area.



For the analytical tasks highly sensitive, computer-aided appliances are available. The methods used are those either developed by the laboratory staff themselves and/or in compliance with the German standard methods for analysing water, sewage and sludge including the relevant DIN-, EN and ISO norms. Inorganic trace analysis applies the most important procedures of absorption and emission spectroscopy including various fusion devices. In addition to AAS with the major atomisation techniques like flame, graphite tube furnace, hydride system and cold vapour amalgamising system with different subsurface compensations, these also include the stimulation with inductively coupled plasma (ICP-OES) as a procedure involving many elements, and an optical spectrometer. In addition to these optical procedures, there is also ICP-mass spectrometry for the ultra-trace determination of a variety of elements. The determination of anions is achieved by ion-chromatographic separation as well as by UV- and conductivity detection.

For the analysis of individual organic substances gas chromatographs (GC) with various detectors, like e.g. FID, ECD and mass selective detectors are used. All GCs are equipped with an auto-sampler and data processing systems. In order to increase selectivity and sensitivity, special techniques are available, as e.g. MS/MS.

Moreover, polar and various other types of micro-pollutants like pesticides and PAH are separated by HPLC-facilities and characterised by their UV- and fluorescence spectrums respectively. Unknown organic substances are identified by using a mass spectrometer linked to a spectrum library with 140,000 entries. The laboratory for preparing the samples is equipped with modern, partly automatic facilities for extraction and enrichment.

The determination of the sum parameters TOC, DOC and TIC is based on catalytic combustion processes and IR-detection, which is also used for analysing mineral-oil hydrocarbons.

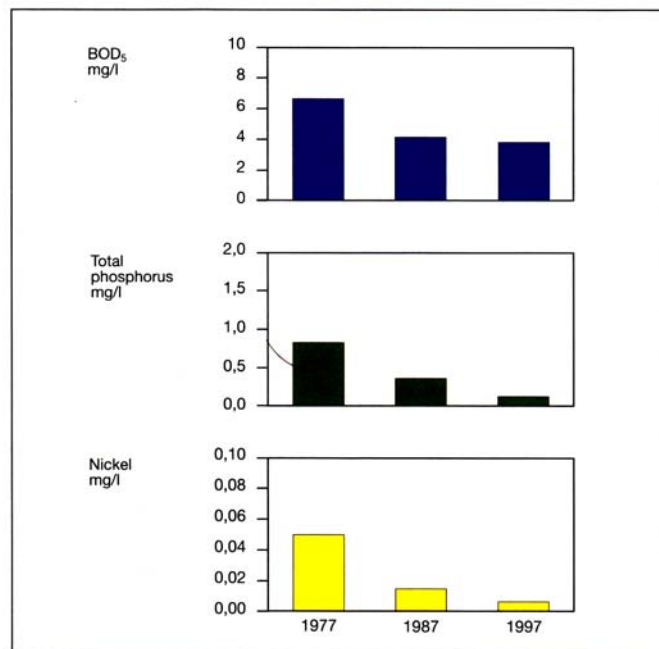
AOX analysis is carried out by means of coulometric detection. Both the shaking and the column methods are applied. The devices are all equipped with auto-samplers and are computer-controlled.

The supervision and guarantee of the quality of the analyses is a central task. On the one hand it is ensured by internal measures, on the other hand by external activities like the participation in interlaboratory trials.

Summary

The rapid industrial development of the Ruhr district and the resulting growth of cities at the turn of the nineteenth century had disastrous consequences for the water quality in the Ruhr basin. Further deterioration was the result of the war and post-war years. Since a consistent and performance-orientated water

quality management was introduced in the Ruhr in the early seventies, a continuous improvement of the water quality has been achieved primarily by the development of municipal wastewater treatment. The result is that today many rare species of animals and plants can be found in and near our rivers, lakes and reservoirs. Nevertheless, water protection and water analysis, carried out by the laboratory of the Ruhr River Association, continue to be task in the interest of the region and its population.



Development of the pollution of the Ruhr at Essen

The laboratory – some statistics (1997)

completion of the new laboratory	1996
usable space	3,300 m ²
staff	appr. 80
including	7 scientists 10 chemical engineers
sample-taking vehicles with laboratory equipment	3
analysis parameters (physical, chemical, biological)	appr. 500
number of samples analysed	appr. 13,000 per year
number of individual determinations	appr. 200,000 per year

Sample-taking locations for surveillance of surface waters (as 1998)

