

02.01 Water Quality (Chemistry) (Edition 2004)

Overview / Statistical Base

Berlin is located between the two major river basins of the Elbe and the Oder. The **Spree** and the **Havel** are the most important natural watercourses in the Berlin area. Additional natural watercourses include the Dahme, Fredersdorf Creek, the Straussberg Mill Stream, the Neuenhagen Mill Stream, the Wuhle, the Panke and Tegel Creek. Besides these natural bodies of water, there are a number of artificial bodies of water within the municipal area of Berlin, the **canals**. These include prominently the Teltow Canal, the Landwehr Canal and the Berlin Shipping Canal, with the Hohenzollern Canal.

The Spree is of special significance for the **quality condition** of Berlin streams. The canals in Berlin are predominantly fed by Spree water, so that their quality is influenced by the quality of that water. Since its effluent quantities are considerably higher than those in the upper Havel, the condition of the Spree water also decisively affects the quality of the Havel below the mouth of the Spree. In turn, the water condition of the Spree in the city is determined by numerous smaller tributaries within the municipal area.

Among Germany's rivers, the Spree ranks only in the **lower medium range**. In comparison with the Oder (long-term mean flow at Hohensaaten-Finow: 543 cu.m./sec.) or the Elbe (long-term mean flow at Barby: 558 cu.m./sec.), the Spree and Havel, even when combined in the lower Havel, have only about one tenth the flow.

A [quality measurement network](#) is operated to monitor the quality of Berlin's surface bodies of water; it concentrates as a matter of priority on ascertaining the impact of the numerous point-sources and diffuse water pollution sources along the course of the river. The measurement network includes a total of 63 measurement points, with 39 on the Dahme, Spree, Havel and the canals, and 24 on the smaller streams and lakes. As a rule, **physical chemical, bacteriological and biological parameters** are ascertained from **monthly sampling tests**.

For the continuous monitoring of oxygen conditions, the water temperature, the pH value and the conductivity, nine **water quality measurement stations** are also operated on the major streams.

As a rule, an average of 11 to 17 measurements are carried out per year at the **sample measurement points**. As a rule the 90th percentile (minimum sample size: n = 11) range is used to determine the quality classes. For the assessment of the temperature, the maximum value is used, and for the oxygen assessment, the minimum value.

At the continuously operating measurement stations, fifteen-minute values are ascertained and compiled to statistical key values. For the assessment of the temperature, the 95th percentile, and for the oxygen content the 10th percentile of day values are used. These values are of course more significant than the sample test results.

Methodology







For the evaluation of the data from the monitoring of the general chemical-physical condition of the water, the target stipulations based on the **LAWA procedure for the chemical classification of bodies of water** (LAWA 1998) are used. This classification is used for the parameters oxygen, chloride, sulfate, ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, AOX and TOC, shown on the strip maps. In the developed classification scheme (see Tab. 1), **Quality Class I** corresponds to the geogenic background value for the substances occurring in nature, such as nutrients and salts, while **Quality Class II (target)** covers the protection of the biotic aquatic association as well as other criteria for the prevention of water pollution. The other classes have been established by multiplication by a factor of 2.

The actual ecological significance of the parameters varies, sometimes considerably. Oxygen, ammonium and nitrite are important eco-toxicological parameters.

On the other hand, **nitrates** in the concentrations which occur have no toxic relevance, even for sensitive water organisms. The significance of nitrates lies rather in their function as a nutrient in nitrogen-limited bodies of water. Paradoxically, higher nitrate contents can in fact have an ecologically stabilizing effect. In particular, nitrates as an alternative oxygen supplier can also check the processes of phosphorus re-dissolution at the interface between the sediment and the open water, and hence also check eutrophication.

The classification of **chloride, AOX and TOC** has more of an indicator role. For instance, chloride concentrations of around 100 mg/l are indeed an expression of anthropogenic influences, but they are ecological quite safe. **Sulfates** can reach values considerably greater than 100 mg/l, due to either geogenic or anthropogenic causes. In ecological regard, eutrophication-promoting processes are being discussed in connection with higher sulfate values. Sulfates certainly have an additional significance for the drinking water supply in the Berlin area as of Quality Class II-III. For **phosphorus**, a classification adapted to natural areas has been developed with reference to the eutrophication effect, in comparison with the classification "plankton-dominated streams (LAWA 1996)."

The **temperature values** were classified according to a Berlin-specific approach for summertime-lowland bodies of water.

Quality Class			Oxygen content mg/l	Temperature °C	NH ₄ , N mg/l	NO ₂ , N mg/l	NO ₃ N mg/l	Chlorides mg/l	Sulfates mg/l	TOC mg/l	AOX µg/l	Phosphorus mg/l
	I	Geogenic background value or "0"	> 12	≤23	≤0.04	≤0.01	≤1	≤25	≤25	≤2	≤0	≤0.03
	I, II	Very low burden	> 8	≤24	≤0.1	≤0.05	≤1.5	≤50	≤50	≤3	≤10	≤0.06
	II	Moderate burden (target)	> 6	≤25	≤0.3	≤0.1	≤2.5	≤100	≤100	≤5	≤25	≤0.08
	II - III	Significant burden	> 5	≤26	≤0.6	≤0.2	≤5	≤200	≤200	≤10	≤50	≤0.16
	III	Enhanced burden	> 4	≤27	≤1.2	≤0.4	≤10	≤400	≤400	≤20	≤100	≤0.20
	III - IV	Great burden	> 2	≤28	≤2.4	≤0.8	≤20	≤800	≤800	≤40	≤200	≤0.30
	IV	Very great burden	≤2	> 28	> 2.4	> 0.8	> 20	> 800	> 800	> 40	> 200	> 0.30

Tab. 1: Quality classification of bodies of water, according to LAWA (1998) and SenStadt (2003)

The water-quality mapping shows the development of the key quanta of the **water composition** of the Berlin bodies of water during the period from **1991 to 2001** (key values for odd-numbered years), which are shown in the strip maps.

The strip map consists of **six separate strips** which as a rule show the period from 1991 to 2001 in **two-year stages**. The direction of flow is determinant. The strip for 1991 is marked by a thick black border. Depending on the respective parameter, the area boundaries have been drawn such that significant immission points of sewage plants or power stations which can bring about changes of the values are included. The spatial representation is based on the fact that each **measurement point** represents the evaluation for a **relatively homogeneous section**. This convention has to be taken into account for the interpretation of the map. The location of the test points is shown as a red dot with a test point number. The location of the measurement stations for continuous measurement is shown by green points. The individual strips of the bodies of water are colored according to their class assignment.

The **measured values** for the parameters for each year can be viewed in a separate window by clicking on the colored segments (mark the function "**display data**" in the menu below the map and click in the map). Strip sections not shown in color indicate that no data were found there for the time

period in question. No data can be revealed by clicking the quality measurement points and measurement stations.

Map Description

Temperature (02.01.2)

The temperature is an important quantum affecting all natural events in bodies of water. **Biological, chemical and physical events in the water** are temperature-dependent e.g. reduction and production processes, likewise adsorption and solubility for gaseous, liquid and solid substances. This also applies to interactions between water and underground or floating substances and sediments, as well as between the water and the atmosphere. The viability and life activity of water organisms are tied to certain temperature limits or optimums, as are the occurrences of species or organisms and various adapted fish populations in Central European river regions.

The representation of the **thermal power stations** in the map as well as its influence on the temperatures of bodies of water must be taken into account in the assessment.

The temperature distribution map shows clearly that there has been a **decline in the immission of heat** into the Berlin bodies of water within the last few years, primarily in the area of the mouth of the Spree and in the Havel. The critical threshold of 28°C was not exceeded, and the maximums, or 95th percentiles, lie in the area of 25°C. Temperatures above 28°C were still being measured sporadically at the end of the '90s.

The reduction in **heat pollution** from Berlin power stations into bodies of water since 1993 has amounted to approx. 13 million GJ, and is due primarily to the connection of the Berlin power supply system to the Western European integrated grid system. Sinking power procurement costs caused by the liberalization of the electric-power market and the resulting **reduced production of the Berlin power stations** has led to the closure or partial closure of power stations. This has to some extent also occurred in connection with modernization for increased efficiency.

Present heat pollution amount to approx. 10 million GJ.

Oxygen Content (02.01.1)

The oxygen content of the water is the result of **oxygen-infusion and consumption processes**. Oxygen enters the water from the atmosphere, with oxygen intake depending primarily on the size of the water surface, the water temperature, the saturation deficit, the water turbulence and the movement of the air. Oxygen is also released by the photosynthesis of aquatic plants, which may result in oxygen super-saturation.

Oxygen is **used up** by the **natural decomposition of organic material** in the water by microorganisms as well as by the **breathing of animals and plants**. This can lead to **oxygen deficiency** in the bodies of water. The critical value below which sensitive species of fish can be damaged is 4 mg/l.

The readings from both the values from the measurement stations and from sampling indicate **only a partial improvement** in the oxygen content of the Berlin bodies of water. The bodies of water into which **mixed-water overflows** take place are still critical. In the mixed-water sewage system, rain water and polluted water are collected in a sewage pipe and moved by pumping stations to the sewage-treatment plants. This sewage system exists throughout inner-city Berlin (cf. Map 02.09).

At heavy rainfalls, the intake capacity of the mixed-sewage system is insufficient, and a **mixture of rainwater and untreated waste water** spills over into the Spree and Havel. This can lead to **oxygen deficits** because of oxygen-consumption processes. Particularly extreme events may even trigger **fish kills** in some watercourse segments (especially in the Landwehr Canal and the Neukölln Shipping Canal).

To considerably reduce the amounts of overflow in the future, additional underground storage spaces are to be activated or newly created in the context of a comprehensive **redevelopment program**.

The critical situations in the Tegel Creek is due to the aftereffects of sewage farms, or to agriculture.

TOC (02.01.10) and AOX (02.01.7)

The total organic load in surface bodies of water was investigated with the aid of the conduction parameter **TOC (total organic carbon)**. The total of "**adsorbable organically-bound halogens**" is represented by the **AOX** determination.

For the determination of the combined AOX parameter, the halogens (AOI, AOCl, AOBr) in a variety of substances with quite different qualities are ascertained. Thus, the parameter serves less for the ecotoxicological assessment of bodies of water than for the **monitoring of the success** of measures for the reduction of the entry of "adsorbable organically-bound halogens".

Fundamentally, **neither** measurement quantum allows **any conclusion** to be drawn on the composition and **origin of the organic load**. However, in major urban areas like Berlin, increased AOX values can principally be ascribed to anthropogenic immissions from **municipal sewage plants**. TOC entries can be of either **anthropogenic** or **natural origin**, e.g. due to the entry of humic substances from the catchment area, which to some extent limits the ability of the parameter to provide significant ecological statements. The assessment scale for the two measurement quanta is the 90th percentile.

With the application of this strict standard, the target quantum of Quality Class II for **TOC** is already **exceeded** for all main and subsidiary streams, both in the **tributaries** flowing into Berlin and in their stream courses flowing through the city.

Measurements for **AOX** are not available for all stream-course segments of the surface bodies of water in Berlin. Nevertheless it can be deduced that **slightly increased AOX values** occur only in segments immediately exposed to sewage-treatment plant immissions (Neuenhagen Mill Stream, Wuhle, Teltow Canal, Nordgraben), where target values are only slightly exceeded (Quality Classes II to III).

Ammonium Nitrogen (02.01.3), Nitrite Nitrogen (02.01.5), Nitrate Nitrogen (02.01.4)

Nitrogen appears in the water both in molecular form as nitrogen (N_2) and in inorganic and organic compounds. When organically bound, it is primarily fixed in vegetable and animal material (biomass). Inorganically bound nitrogen occurs primarily as **ammonium (NH_4)** and **nitrites (NO_2)**. In the water, soil and air as well as in technical facilities (e.g. sewage-treatment plants), bio-chemical (microbial) and physio-chemical **transformation of nitrogen compounds** take place (oxidation and reduction reactions). A unique feature of nitrogen infusion is nitrogen-fixing, a bio-chemical metabolic activity of bacteria and blue-green algae (cyanobacteria), which can introduce molecular gaseous nitrogen from the atmosphere into the metabolic process.

In Berlin, immission via **sewage-treatment plants is the main source of this pollution**. The **rain drainage systems** sporadically cause critical ammonium immissions.

In higher concentrations, **ammonium** can be a considerable burden on the oxygen balance, since the microbial oxidation (nitrification) of 1 mg of ammonium nitrogen to nitrate consumes approx. 4.5 mg of oxygen. However, this process is strongly temperature-dependent. Considerable transformation levels occur only during the **warm season**. At times, **oxygen consumption** due to nitrification processes considerably exceeds that caused by the decomposition of carbon compounds. Ammonium may become toxicologically significant if the pH value is moved into the alkaline range, and **ammonia, which is toxic to fish**, is released in waters with high ammonium contents.

Nitrite nitrogen occurs as an intermediate stage in the microbial oxidation of ammonium to nitrate (**nitrification**). Nitrite is of relatively minor eco-toxicological significance. At increased chloride concentrations and at the same pH value, nitrite toxicity is reduced.

While the LAWA quality targets (Quality Class II) are met for NH_4 -N in the **Spree, Dahme and Havel upstream from Berlin**, the targets are exceeded wherever bodies of water are exposed to the immission of municipal sewage-treatment plants and mixed-water or rainwater immissions.

The **upgrading of the nitrification capacity of the sewage-treatment plants** of the Berlin waterworks since reunification has led to a significant **relief** of the bodies of water in the city, with quality leaps of **three or four classes**. Many stream-course segments have even jumped into Quality Class II.

The values for the **Wuhle** and parts for the **suburban Spree** no longer reflect the current situation, since the **closure of the Falkenberg sewage-treatment plant** in the spring of 2003 has removed a significant pollution source.

The major pollution of the Teltow Canal could also be **reduced considerably** with the closure of the **Mariefelde sewage-treatment plant** (Teltow Canal, 1998) and the **upgrading of the Wassmansdorf plant**.

The **Neuenhagen Mill Stream** is still very highly polluted. There is need for action here at the **Münchehofe sewage-treatment plant**.

The **City Spree** (from Köpenick up its mouth into the Havel) consistently maintains Quality Classes II or III, and thus fails to achieve the LAWA target, as do the **Lower Havel**, the **Teltow Canal** and the **inner-city canals**, which are affected by mixed-water immission.

In 2001, sewage-treatment plant influenced segments of **Neuenhagen Creek**, the **Wuhle** and of three sections of the Teltow Canal exceeded the LAWA targets for nitrite nitrogen (90th percentile) (see above remark).

The nitrate values of the Berlin bodies of water are non-critical throughout.

Chloride (02.01.8)

In the Berlin bodies of water the natural chloride content is less than 60 mg/l. Anthropogenic increases in chloride concentrations are due to **domestic and industrial waste water** as well as **road salt** from winter road clearance. The chloride concentration typically undergoes a fluctuation over the course of a year due to the summertime drop in Spree water flow and the resulting higher concentration in the city. At chloride values above 200 mg/l, problems for the **drinking water supply** may occur.

The chloride values of the Berlin bodies of water **do not constitute any problem for the ecology of the bodies of water**.

Sulfates (02.01.9)

Anthropogenic impairment in the Berlin area is considered to begin at about 120 mg/l. Thus, **Quality Class II** (< 100 mg/l) **cannot** be the **target quantum** for our region. The significance of the sulfate parameter in the Spree-Havel area involves not so much its eco-toxicological relevance as its significance for the drinking water supply. The **drinking water limit value** is 240 mg/l (especially for the protection of the kidneys of babies from an excessive salt intake). The **streams** flowing into Berlin show concentrations of between 150 and 180 mg/l. In the future, an increase in **the sulfate inflow** from the Lusatian mining regions is to be expected.

The following immissions into the bodies of water are of relevance in the Spree area:

- Immission of drainage water from strip-mines;
- Direct immission from post-strip-mining lakes used for water storage;
- Indirect immission via the ground water from strip-mined areas;
- Immission from active mining;
- Atmospheric sulfur immission (burning of fossil fuels);
- Diffuse and direct entries (sewage-treatment plant discharge, wash-outs, agriculture).

From the point of view of the ecology of bodies of water, increased sulfate concentrations may have a **eutrophication-promoting** effect. Sulfates may lead to the **mobilization of phosphorus** trapped in the sediment.

Overall Phosphorus (02.01.6)

Phosphorus is a nutrient element which can cause **mass algae development** in surface bodies of water under certain conditions (for a more detailed explanation, see Map 02.03). Pollution-free spring creeks show overall phosphorus concentrations of <1 to 10 µg/l P; the upper reaches of stream courses with no anthropogenic immissions in catchment areas with deciduous forest lands have 20-50 µg/l P. The geogenic background concentrations for the lower Spree and the Havel are in the area of 60 to 90 µg/l P.

Due to the extensive use of phosphate-free detergents and especially, too, the progressive phosphate elimination in **sewage treatment**, phosphate immissions via **municipal sewage-treatment plants** dropped considerably especially during the period between 1990 and 1995. Immissions via **farmland** has also has declined.

Phosphorus pollution of Berlin's bodies of water for the time period 1995-1997 was as follows:

Inflow to Berlin	188 t/a
Total, sewage plants	109 t/a
Mixed-water and sewage systems	38 t/a
Total inflow and immissions	336 t/a
Total, outflow	283 t/a

For **inflows** to Berlin, diffuse entries predominate, with approx. 60%. The **groundwater** provides the predominant inflow **path**, accounting for 50% (diffuse entry: 100%).

For overall phosphorus, the mean value for the corresponding years is used as the basis. This shows **increased P pollution** of Berlin bodies of water of approximately at a factor of 2 or 3 above the background values.

Tegel Lake constitutes an exception. The inflow to the main basin of the Tegel Lake passes through a P-elimination facility, which reduces nutrient entry into the lake by approx. 20 t/a.

Literature

- [1] **LAWA 1996:**
Klassifikation "Planktondominierter Fließgewässer" (Phosphor) [Classification of plankton-dominated streams (phosphorus)], 1996
- [2] **LAWA 1998:**
LAWA-Verfahren zur "Chemischen Gewässerklassifikation" [LAWA procedure for "chemical classification of bodies of water"], 1998

Laws

- [3] **Laws of Water:**
[Downloads and publications of the theme Water and Geology](#)