7.9 Biological Water Quality Classification (2000)

The water courses in the mostly densely populated landscapes of Germany are subject to more or less intensive human use. This includes water abstraction for industries, small businesses, agriculture and public water supply and also the discharge of treated waste water. Waste water discharge is generally a point source of pollution and may have different impacts according to the discharge volume in relation to the river's runoff and the effectiveness of sewage treatment. Other impacts are from diffuse sources such as drainage from agricultural land or from livestock.

The biological water quality chart of the LAWA ("saprobe chart") describes the pollution affecting the oxygen balance of the water courses. It is essentially caused by carbon and nitrogen oxidation of easily bio-degradable sewage constituents.

Methodology

The basis of the method is the biological water analysis based on the saprobe system (DIN 38410). The method of the LAWA for the indication and assessment of biological water quality is only applicable in flowing water courses, streams and rivers of Central Europe, and not in still waters. It is easily applicable, on the basis of uniform guidelines, for most water courses. There may be problems in the assessment of water courses which do not continuously flow, in very slow-flowing and barrier-regulated waters, in acidified waters or waters devastated by toxic substances, and in canals without adequate bank structure. Stretches of this kind are assigned a special symbol in the quality chart. If, in such cases, biological analysis is not possible, or only with restrictions, chemical measurements may also be applied as aids to the indication and assessment of biological water quality.

Biological analysis of water bodies based on the saprobe system basically indicates the pollution impact on the water courses from bio-degradable organic substances. The impact of persistent substances, of salts, heavy metals and organic pollutants, as well as radioactive materials, is not recorded by this method. The impact of nutrients (eutrophying substances such as phosphor and nitrogen compounds) is likewise not directly reflected in the quality chart, but only to the extent that the organic impact of the nutrients influences the saprobial classification as a secondary pollution impact.

The biological water quality of the rivers in the Federal Republic of Germany has hitherto been classified using a multipoint scale. The classification and characterisation of water quality is based on registering organisms or combinations of organisms that are especially characteristic of the degree of pollution, and whose occurrence and frequency are used to calculate the saprobic index as a basis for assessment (primarily macrozoobenthos = invertebrates dwelling on the river bed).

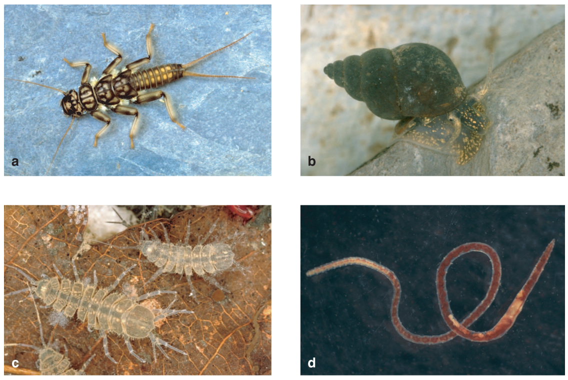

Fig. 1 Examples for biological indicators of water quality
(a) larva of stonefly (perla marginata), quality class I
(b) gastropod (bithynia tentaculata), quality class II
(c) fresh water isopod (proasellus coxalis), quality class III
(d) tubifex (tubifex sp.), quality class IV

In the first water quality chart for the whole of unified Germany, published in 1990, it proved necessary to introduce an additional 8th class, water quality class IV (ecologically destroyed) to describe the quality of the water of the *Elbe* and to take account of the sometimes alarmingly poor water quality in the Elbe catchment area. As a result of changes in production profiles, the closure of major industrial facilities and the construction of new sewage treatment plants, water quality improved over the period to 1995 in the most heavily polluted sections of the river above and below Dresden and below Pirna from quality class IV (excessively contaminated) and quality class IV (ecologically destroyed) by 3 and 4 classes respectively to water quality class II-III (critically polluted). Further improvements can also be discerned in 2000. From the German/Czech border to the mouth of the Havel, the Elbe now possesses water quality class II, apart from a short stretch below Riesa (II-III). Below the mouth of the Havel down to the outlet into the North Sea the Elbe is classified as quality class II-III like in 1995. Two important tributaries of the Elbe, the Mulde and the Schwarze Elster, also showed an improvement in their lower reaches from quality class IV to quality class II. The Mulde shows this quality class from the confluence of the headwaters down to the outlet into the Elbe, the Schwarze Elster shows also quality class II apart from the middle reach (quality class II-III).

Table 1 The classes of the saprobic system and biological quality classification 1995 and 2000 (approx. 30 000 km total river kilometres; LAWA/Federal Environmental Agency)

Quality class	Saprobic stage	Degree of organic pollution	Saprobic index	Brief definition of water quality classes	Percentage 1995	Percentage 2000	Change 1995/2000
I	oligosaprobe	unpolluted to very lightly polluted	1.0 to < 1.5	Water sections with pure water that is always more or less saturated with oxygen and low in nutrients; low bacteria content; moderately densely colonised, mainly by algae, mosses, flatworms and insect larvae; if cool in summer, spawning grounds for salmonids.	0.7 %	0.8 %	+ 0.1 %
I-II	oligosaprobe to betamesosaprobe	lightly polluted	1.5 to < 1.8	Water sections with low inorganic or organic nutrient supply without any appreciable oxygen depletion; densely populated, usually with wide variety of species; if cool in summer, spawning grounds for salmonids.	3.8 %	6.5 %	+ 2.7 %
II	betamesosaprobe	moderately polluted	1.8 to < 2.3	Water sections with moderate pollution and good oxygen supply; very wide variety of species and high individual density of algae, snails, small crustaceans, insect larvae; water plant populations may cover large areas; wide variety of fish species.	42.7 %	57.8 %	+ 15.1 %
II-III	betamesosaprobe to alphamesosaprobe	critically polluted	2.3 to < 2.7	Water sections with critical loads of oxygen-depleting organic substances; fish mortality due to oxygen deficiency; decline in number of species of macroorganisms; tendency to mass development of certain species; filamentous algae often form populations covering large areas. Usually still rich fishing waters.	43.6 %	31.4 %	− 12.2 %
III	alphamesosaprobe	heavily contaminated	2.7 to < 3.2	Water sections with heavy oxygen-depleting organic pollution and mostly low oxygen content; local sapropel deposits; large-area colonies of filiform wastewater bacteria and sessile ciliates exceed the occurrences of algae and higher plants; only a few macroorganisms resistant to oxygen deficit conditions, such as sponges, leeches, aquatic isopods occasionally occur in large quantities; low fish catches; periodic fish death is to be expected.	7.4 %	2.8 %	− 4.6 %
III-IV	alphamesosaprobe to polysaprobe	very heavily contaminated	3.2 to < 3.5	Water sections with considerably restricted living conditions as a result of very heavy pollution with oxygen-depleting organic substances, often exacerbated by toxic effects; sometimes total lack of oxygen; turbidity due to suspended solids from wastewater; extensive sapropel deposits, densely colonised by red midge larvae or tube worms; decline in filiform wastewater bacteria; fishes are found only intermittently and, if at all, in locally limited areas.	1.1 %	0.3 %	− 0.8 %
IV	polysaprobe	excessively contaminated	3.5 to 4.0	Water sections with excessive pollution as a result of oxygen-depleting organic waste waters; putrefaction processes predominate; for long periods of time oxygen is only available in very low concentrations or is lacking completely; colonised largely by bacteria, flagellates and free-living ciliates; no fish; biological devastation in cases of high toxic stress.	0.7 %	0.4 %	− 0.3 %
IV	azoic community	ecologically destroyed	> 4.0	Water sections with destroyed ecological balance as a result of excessive pollution with organic or toxic waste water, water stretches are characterised by anaerobic decomposition (putrefaction processes) with sulphate reduction and accumulation of hydrogen sulphide in the water phase and by severe toxic pollution so that animal populations can not survive.	only in 1990		

Development of biological water quality

As a comparison of the biological water quality maps for 1975, 1990 and 1995 shows, the increased wastewater treatment measures since the 1970s are now being reflected in a marked improvement in biological water quality. The number of flowing waters possessing the targeted water quality class II and better increased from 47 % in 1995 to 65 % in 2000 (Table 1).

Today the *Danube* largely belongs to biological quality class II due to sewage measures taken. As in 1995 some sections below the confluence of the headwaters, the sinking creeks in the Tuttlingen area and river sections between Sigmaringen and Zwiefaltendorf, a number of impounded sections between the mouths of the Riss and Iller and sections below Neu-Ulm and Geisling sewage works are still in class II-III, while the section of the Danube within the ambit of the Tuttlingen sewage works is in class III. In the area from the mouth of the Schmiecha down to the mouth of the Ostrach and in the region of the barrage weir at Straubing the Danube has fallen to quality class II-III from the former quality class II. Similar to the barrage weir at Geisling reaching the full reservoir level at the barrage weir at Straubing changed the living conditions for species and led to a deterioration of biological water quality thereby.

The *Rhine*, after exhibiting biological quality class IV in some stretches in the 1970s, has made a marked recovery. The High Rhine has quality class I-II, or below the mouth of the Wutach class II. Along the Upper Rhine between Basel and Mannheim the river has quality class II now. Apart from the noticeable influence of the outlets of a large industrial company below Ludwigshafen (II-III), the Rhine maintains quality class II right down to the Dutch border.

In its upper reaches the *Ems* is classified as quality class II-III, or in places class III, due to chemical pollution and significant physical alterations. In the area from Greffen down to the mouth of the Große Aa the Ems is of quality class II apart from a short stretch in Rheine, and of quality class II-III down to Meppen. A short moderately polluted stretch is followed by a stretch classified as quality class III-IV, characterised by decomposition processes and by the additional influence of the brackish water area. The increased influence of the brackish water in the outlet area of the Ems is due to major river construction operations and dredging which can resolve in a shift of the brackish water limit to upper stretches and in a higher flow velocity.

The *Weser* is of quality class II-III from the confluence of the Fulda and Werra down to the outlet into the North Sea apart from the stretch between Höxter and Holzminden (quality class III). In spite of the reduction in the salt pollution during the last years the high chloride concentrations still disturb the saprobe system-based assessment in the stretches down to the mouth of the Aller and in the tide-dependent Lower Weser. Mass algae growth in the barrier-regulated stretches is an additional significant pressure.

Like in 1995 the *Odra* was classified along the entire length of the German section as biological quality class II-III. Compared with 1990 there were improvements below Eisenhüttenstadt and Frankfurt (quality class III) even then.

Although a large number of flowing waters today possess the targeted water quality class II (moderately polluted), there are only a few river stretches which can be described as unpolluted to very lightly polluted (quality class I) or lightly polluted (quality class I-II) (Table 1).

Practical Information

The LAWA working group "Biological Water Quality Chart 2000" in cooperation with the Federal Environmental Agency published the third water quality map referring to Germany as a whole. The 1975, 1980 and 1985 editions provided an overview of the quality of running waters in the former West Germany. The biological assessment of waters will be developed further within the next years. With the Water Framework Directive (EC 2000/60) coming into force in 2000 biological assessment will be established on a broader spectrum of biological elements in future and will enable a more comprehensive classification. In addition to the assessment of invertebrates dwelling on the river bed (macrozoobenthos), algae, macrophytes as well as fish fauna will be included in the ecological characterisation of waters. Future presentation of ecological quality will therefore assess and describe more aspects including structural quality (degree of physical alteration).