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INDICATORS OF OXYGEN DEMAND IN THE ECOSYSTEM OF THE DANUBE IN SERBIA

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Abstract. *Actual problems of pollution of aquatic systems require the determination of the ecological status of the Danube, stressing the importance to the realization of the principles of sustainable water management, Directive 2000/60EC, as well as the preservation of the environment. The aim of this paper is to monitor oxygen concentration demand by measuring stations along the river, and use these data to determine the ecological status of the Danube in Serbia. Indicator of the oxygen regime in the watercourse involves monitoring the concentration of biological oxygen demand (BOD-5) and ammonium ions (NH4-N), by monitoring state of the environment based on the load of surface water with organic matter and ammonium, respectively (Regulation on the national list of environmental indicators, "Official Gazette of the RS", no. 37/2011). The paper used the Ministry of Agriculture and Environmental Protection, Agency for Environmental Protection of the Republic of Serbia water quality data for the year 2012, obtained from ten hydrological measuring stations on the Danube. Mean annual concentrations values of two indicators of oxygen demand, calculated for the year 2012, are BOD-5 = 1.93 mg/L and the NH4-N = 0.08 mg/L, respectively. Comparative analysis, based on the values of these environmental indicators, showed that the water quality of the Danube in Serbia fits high ecological status or class I surface waters. Generally, it is necessary to perform monitoring and analysis of other environmental indicators in order to assess conditions of the functioning of the Danube ecosystem in Serbia.*

Key words: *the Danube, aquatic ecosystem, indicators of oxygen demand*

1. INTRODUCTION

The European Union gives great significance to the protection and preservation of water resources and environment, treating them as the base of sustainable development in the 21st century. Water resources are considered the most important segment of the

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environment; therefore, protection of natural environment is unthinkable without adequate protection of water that includes water monitoring, water classification, and regulation of water quality standards [1]. Regulations on the national list of environmental indicators prescribes indicators by thematic areas significant at national and international level, relevant for reporting, measurable and statistically correct, easy to understand and economically justifiable. The indicator represents the best measure of the causes, conditions, consequences and effects of the programme of environmental management. Changes in value indicators show improvement or deterioration of the observed phenomena in the environment [2].

The quality of environment depends on the quality of river water, so the pollution of surface water is important environmental issue and an important indicator of the state of the environment. The degree of water pollution by organic compounds is defined by the amount of oxygen required for the oxidation of present biodegradable ingredients performed by water aerobic microorganisms. As an indicator of the environment in the area of water, indicator of oxygen consumption of surface water (BOD-5) has been defined. BOD-5 shows the amount of oxygen that is consumed by decomposition of organic matter under the influence of aerobic bacteria in surface water [3]. The waters have high level of organic pollution, consumption of oxygen is accelerated, and there is a high rate of metabolic processes, with consequent reduction for oxygen in the water and the occurrence of anaerobic conditions. Under anaerobic conditions, nitrogen from the water is being translated into reduced form, where there is a higher concentration of ammonium ions (NH4-N). Ammonium is above the corresponding boundaries toxic to organisms living in water [2].

2. EXPERIMENTAL

Assessment of the state of the environment is based on the indicator view, which allows a simplified monitoring of the status and changes in the quality of certain segments of the environment over time. All surface water bodies are classified into six types according to which the Danube belongs to the type of large lowland rivers dominated by fine sediment, i.e. to the Type 1 [4]. The Danube is one of the type of large rivers dominated by fine sediment, Type 1, for which the actual Regulations define concentrations of BOD-5 = 2 mg/l and NH4-N = 0.1 mg/l of high ecological status, and class I surface waters [5,6]. The paper used the Ministry of Agriculture and Environmental Protection, Agency for Environmental Protection of the Republic of Serbia water quality data for the year 2012, obtained from ten hydrological measuring stations on the Danube [7].

3. RESULTS AND DISCUSSION

Table 1 and Table 2 show the concentrations of the selected parameters BOD-5 and NH4-N, which are used to assesses the state of water quality along the Danube through Serbia. Based on the monthly values of the parameters BOD-5 and NH4-N at the observed measurement locations, the average value in 2012 has been calculated.

Table 1 The average values of BOD-5 at the measuring stations on the Danube - 2012.

Measuring station	BPK-5 (mg/l)
1 Bezdan	1.91
2 Bogojevo	2.13
3 Novi Sad	2.37
4 Slankamen	2.22
5 Zemun	2.04
6 Smederevo	1.78
7 B. Palanka	1.86
8 Tekija	1.76
9 Brza Palanka	1.66
10 Radujevac	1.58
The average annual value	1,93

Concentration of the parameter BOD-5 at measuring stations of Bezdan, Smederevo, B. Palanka, Tekija, Brza Palanka and Radujevac are lower than the limits defined in the Regulations (2 mg/l). For this reason, the water quality in the Danube reaches an excellent ecological status. At the measuring stations of Bogojevo, Novi Sad, Slankamen and Zemun concentration values of the parameter BOD-5 range from 2 mg/l to 5 mg/l maintaining good ecological status, i.e. Class II of the Danube water in 2012 .

Table 2 The average values of NH4-N at the measuring stations on the Danube - 2012

Measuring stations	NH_4-N, (mg/l)
1 Bezdan	0.05
2 Bogojevo	0.04
3 Novi Sad	0.05
4 Slankamen	0.06
5 Zemun	0.09
6 Smederevo	0.11
7 Banatska Palanka	0.13
8 Tekija	0.07
9 Brza Palanka	0.10
10 Radujevac	0.09
The average annual value	0,08

Concentration of the parameter NH4-N at measuring stations of Bezdan, Bogojevo, Novi Sad, Slankamen, Zemun, Tekija and Radujevac are lower than the limits defined in the Regulations (0.1 mg/l), so the water quality on the Danube are brought to an excellent ecological status. At the measuring stations of Brza Palanka, Smederevo and Banatska Palanka concentration values of the parameter NH4-N range from 0.1 mg/l to 0.13 mg/l maintaining good ecological status, i.e. Class II of the Danube water in 2012.

Finally, the results show that the mean monthly values of concentration of the biological oxygen demand range from BOD-5 = 1.58 mg/l to BOD-5 = 2.37 mg/l, whereas the ammonium ion ranges from NH4-N = 0.05 mg/l to NH4-N = 1.13 mg/l at the observed measurement locations. Mean annual concentration values of two indicators of oxygen demand, calculated for the year 2012, are BOD-5 = 1.93 mg/l and the NH4-N = 0.08 mg/l, respectively. Comparative analysis, based on the values of these environmental indicators, showed that the water quality of the Danube in Serbia achieves high ecological status or

class I surface waters. Surface water belonging to this class provides, based on the limit values of the elements of quality, requirements for the functioning of ecosystems and protecting fish. Therefore, they can be used for the following purposes: drinking water supplies after appropriate treatment, bathing and recreation, irrigation, industrial use, etc.

4. CONCLUSION

Environmental protection and sustainable use of water resources is a priority task that involves continuous quality monitoring and assessment of the ecological status of water. The concentrations of biological oxygen demand (BOD-5) and ammonium ions (NH_4-N) represent the need for oxygen of organisms that consume it during oxidation of organic matte, and for this reason they can be used as environmental indicators and the main indicators of surface water pollution by organic substances.

The level of change in the natural state does not show serious irreversible impact of human activities of aquatic ecosystem because the mean annual values of the parameters observed are within the limit values of high ecological classification. Indicators of oxygen consumption for the year 2012 show that the water quality in the Danube in Serbia corresponds to high ecological status of surface water quality as an integral part of the environment. Generally, monitoring and analysis of other environmental indicators are necessary in order to assess conditions of ecosystem functioning of the Danube in Serbia.

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INDIKATORI POTROŠNJE KISEONIKA U EKOSISTEMU DUNAVA U SRBIJI

Aktuelni problemi zagađenja akvatičnog sistema zahtevaju utvrđivanje ekološkog statusa Dunava, naglašavajući značaj kako u ostvarivanju principa održivog upravljanja vodama Direktive 2000/60EC, tako i u očuvanju kvaliteta životne sredine. Cilj rada je da se praćenjem vrednosti koncentracije indikatora potrošnje kiseonika, kao pokazatelja stanja životne sredine na mernim stanicama duž toka reke, proceni kvalitet akvatičnog ekosistema Dunava u Srbiji. Indikator kiseoničnog režima u vodotoku podrazumeva monitoring koncentracije biološke potrošnje kiseonika (BPK-5) i amonijum jona (NH_4–N), praćenjem stanja životne sredine na osnovu opterećenja površinske vode organskim materijama i amonijumom, respektivno (Pravilnik o nacionalnoj listi indikatora životne sredine, Sl. glasnik RS,, br.37/2011). U radu su korišćeni podaci o kvalitetu voda Agencije za zaštitu životne sredine Republike Srbije za deset mernih lokacija Dunava u Srbiji za 2012. godinu. Srednje godišnje koncentracije vrednosti dva pokazatelja potrošnje kiseonika, izračunate za 2012. godinu, su BPK - 5 = 1.93 mg/L i NH4 - N = 0,08 mg/L, respektivno. Uporedna analiza, zasnovana na vrednostima ovih ekoloških pokazatelja, pokazala je da je kvalitet vode u Dunavu u Srbiji odgovara visokom ekološkom statusu ili I klasi površinskih voda. Generalno, neophodan je monitoring svih indikatora stanja životne sredine kako bi se ocenili sveobuhvatni uslovi funkcionisanja ekosistema Dunava u Srbiji.

Ključne reči: *Dunav, akvatični ekosistem, indikatori potrošnje kiseonika*