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# ECOLOGICAL AND CHEMICAL – PHYSICAL INDICATORS OF LAND WATER QUALITY WITH SUSTAUINABLE PROTECTION MEASURES

**Rajfa Musemić**
**Faculty of Mechanical Engineering, University of Sarajevo**
**71000 Sarajevo, Vilsonovo šetalište 9, Bosnia and Herzegovina**

**Azra Bašić**
**Federal Ministry of Environment and Tourism**
**71000 Sarajevo, Titova 9a, Bosnia and Herzegovina**

## ABSTRACT
*Everything that happens in a watershed affects the water quality to some degree. Many watersheds have been altered as a result of human being activities. These activities led to pollution of rivers and degrade water quality. The measurement method of water quality using different Water Quality Indicators is investigated. The results of physical-chemical characteristics and load of pollution for river Miljacka and its tributaries and collectors of waste water are given. The method and results are strictly based on legislative obligatory methods and EU/EC water directives and parameters for land water. The biological characteristics macro invertebrates zoo-benthos for the Miljacka river before it inflows in Sarajevo city are investigated and calculated by using Saprobe Index (SI) and Extended Biotic Index (EBI). On the base of valid experimental data the calculations of biological characteristics are performed by Extended Biotic Index (EBI) and Diversity Index (Shanon -Weaver Index) for Miljacka's river delta. The sanitary micro-biological characteristics by the measurement of sanitary micro-biological parameters for three target locations are analised. Analyzing reliable results of research we made some proposals of sustainable protection measures for the chosen cases.*
**Keywords**: *water quality, chemical-physical and biological indicators, sustainable protection measures.*

## 1. INTRODUCTION
The river Miljacka belongs to the flood water current with average year's flux of 5,7 $m^3/s$. The relative low specific outflows of minimal water currents in the Miljacka basin are the consequence of geology structure and climate, or specific precipitation regime. Its minimal fluxes have increased by dirty waste water which directly inflow into it's current upstream at spring and successively grow up due to many drainpipes in Sarajevo city. The Miljacka bed is properly regulated in the city of Sarajevo and across all the flow length takes several tributaries which are polluted by municipality and industrial waste water.

## 2. THE PHYSICAL-CHEMICAL INDICATORS AND LOAD OF POLLUTION – RESEARCH AND RESULTS
The physical-chemical properties of water current are very important for the development and existence of the population of plants and animals, disregarding the subject of interest, land or water eco-systems. The analysis of the state and usage of water performed by a number of procedures: physical, chemical and biological. **The physical indicators** involve: temperature, smell and taste,

colour, transparency, water conductivity, suspended solids and dry residua. **The chemical indicators** are: acidity, alkalinity, hardness, redox-potential, dissolved or saturated oxygen, chemical oxygen demand-COD; biochemical oxygen demand-BOD; nutrients (nitrate and phosphorus compounds); metals (copper, zinc, cadmium, lead, mercury, etc), etc. The methods used are: electro-chemical, jodometria, colorimetria, volumetria, nefelometria, fotometria, Graphite furnace atomic absorption spectrometry (GFAAS), Electic aneealing furnace, etc. **Biological indicators** include animals and microbial indicators to monitor the health of an aquatic system: Saprobic Index, Extended Biotic Index, Shannon-Weaver's diversity index and bacteriological analysis.

As the representative indicators of water quality for Miljacka river, we have taken the samplings at four profiles (cross sections): 1. Kozija ćuprija; 2. Skenderija; 3. Main collector for the city of Sarajevo and 4. The mouth of Miljacka to the Bosnia river, [1]. There are four classes of Water Quality (WQ), from I to IV, by the regulations, [5]. The investigations of all indicators of water pollution with added elements necessarily for definition of quality and load pollution were made. The Miljacka river has pH parameter of 7,28–7,52 at all observed locations, what shows approximately neutral medium. These values are in properly range. At the profile No.1, the suspended solid sediment has value of 22,6 mg/l, what belongs to the second –WQ Class II. At the other three profiles the values lie in the range of limits for WQ Class III. The dissolved oxygen has the value of 7,83 mg $O_2$/l, at the profile No.1., what is in the range of prescribed WQ Class I; the value of 1,5 mg $O_2$/l at the profile No.3; or at the mouth of river it has the value of 1,95 mg $O_2$/l, what belongs to the WQ Class IV. The saturation with oxygen ranges from 80% at the profile No.1, what is in the range prescribed for WQ Class II, to 17% at the profile No.3, or at the mouth of 21%, what the river Miljacka classifies out of the WQ Class IV. The BOD 5 is equal 3 mg $O_2$/l at the profile No.1, belongs to WQ Class II, up to 31 mg $O_2$/l at the profile No.3, and up to 35 mg $O_2$/l at the mouth, what the river Miljacka classifies into the WQ Class IV. The COD is equal 11 mg $O_2$/l at the profile No.1, belongs to WQ Class II, up to 62 mg $O_2$/l at the profile No.3, what is out of WQ Class IV, and up to 40 mg $O_2$/l at the mouth, what the river Miljacka classifies into the WQ Class IV. On the base of cited indicators, it can be state that the Miljacka river at Kozija ćuprija location mostly belongs to the prescribed WQ Class II of the water currents, but at the others three locations it mainly belongs to the WQ Class IV, [5], or out of it. The **Load of pollution** was expressed by population equivalent (PE). The setting of the population equivalent (PE) on the base of the data reached by the investigation of the waste water samplings and by measurement of the flux, [1,5], is made using the expression:

$$\mathbf{PE} = \{Ess; Eor; En; Ep\}+Etoc+R_T \qquad (1)$$

where: PE-population equivalent; E – equivalent of harmfulness (by suspended substances like: organic, nitrogen, phosphorus compounds, chemicals); $R_T$ – thermal pollution indicator.

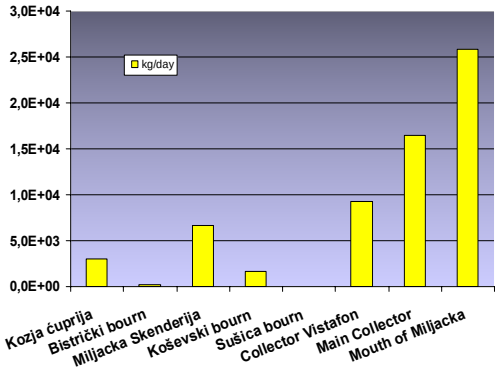


*Figure1: Load of pollution in kg/day*

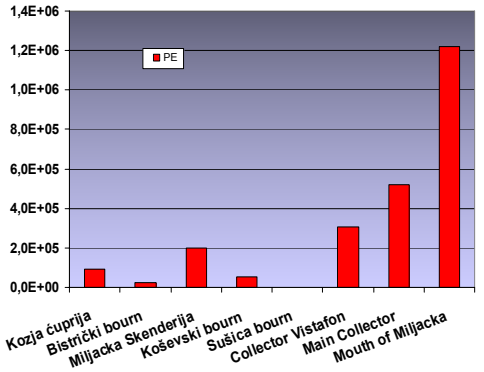


*Figure 2 : Load of pollution as PE*

The results show that the load of pollution of waste water in drainpipes of collectors and tributaries is extremely high (Figure 1). We found that one collector and three brooks release the city waste water into the Miljacka river in amount of $Q_{tot}$ = 660 liter/s, what means that the level of pollution, expressed by PE, is equal 390.079. Finally it effects on the total level of Miljacka river pollution, which PE is equal 1.220.458 at the mouth into the Bosnia river (Figure 2). The regular minimal flux for the calculation of the impact of the pollution water to the water quality of a water current upon the critical conditions (average monthly small water level of 95% reservation), for Miljacka river amounts only $Q_{MP}$= 489 l/s. So small flux 'doesn't allow' the inflow of the quoted waste water into Miljacka, if we want to protect its regulated quality.

## 3. BIOLOGICAL INDICATORS AT TARGET LOCATIONS

The sampling methodology is adapted in order to investigate some parts of the Miljacka river flow. We applied so called „kick sampling" method. The „kick sampling" methodology served as a very acceptable for the biomonitoring of running water in Bosnia and Herzegovina, [2]. The results of the analysis of the qualitative-quantitative structure of benthos macroinvertebrates are applied to the WQ in the part of water current from the Kozija ćuprija to the Bentbaša, [4], (Table 1). The estimation of the WQ was made by the Extended Biotic Index – EBI. It is actually extended EBI calculated on the family's level. We also used the Saprobic Index (S) – a measure of the level of organic pollution. It was calculated by next relation:

$$S = \frac{\sum hsG}{\sum hG} \tag{2}$$

where are: S- saprobic index; s - saprobic value by Wegl, [2].; h - relative abundance taxon, G-indicator's value of taxa. The modified extended biotic index represents the modification of the Trent biotic index. Its values are in the range of 0 to 14, [3]. First of all, this index pointed out the macroinvertebrat's bioindicators on the higher taxa level, what is based on the two facts: organic pollution reduces the species diversity and increase of the pollution leads to the dying out of macroinvertebrates. It is useful to mention that used saprobic index point out the saprobic values of the macroinvertebrates taxa.

*Table 1: Measured saprobic index (SI) and Extended Biotic Index (EBI) for three locations at Miljacka before its inflow to the city of Sarajevo (Measured on July-September, 2004).*

| Location | Saprobic index-S | | | | Extended Biotic Index-EBI | | | |
|---|---|---|---|---|---|---|---|---|
| | 08.07.2004. | | 06.09.2004. | | 08.07.2004. | | 06.09.2004. | |
| Kozja ćuprija | 1,78 | I/II | 2,06 | II | 9 | II | 9 | II |
| Dariva | 1,71 | I/II | 1,77 | I/II | 9 | II | 8 | II |
| Bentbaša | 2,29 | II | 2,05 | II | 9 | II | 9 | II |

The saprobic rate is the intensity of bio-degradation of organic substance. The saprobic rates were determinate with empirical studies. On the base of one-year research of the structure of benthos macroinvertebrates, [4], the results of the quantitative benthos macroinvertebrates structure show great poverty at the mouth of Miljacka. We found the individual representatives of the Class *Oligochaeta* and *Insecta.* The total taxa population in the benthos of the Miljacka mouth was 5,0, but total number of individuals was 3601. The taxa population density is uniform during one year, [4]. The samplings from the mouth of Miljacka, according to the minimum value 1,0 and maximum values 2,0 of Extended biotic index (EBI), point out the critical state with great level of contamination. The average value during a year 1,62 confirms the emphasized state. Using the calculations the Shannon-Weaver index, [3] we determinate the diversity of the macroinvertebrates structure as:

$$H' = -\sum \frac{n_i}{N} log_2 \frac{n_i}{N} \tag{3}$$

where are: H'- diversity index; $n_i$ – number of individuals *i*-taxon in a sample; N-total number of individuals in sampling. The Shannon-Weaver's diversity index for the mouth Miljacka in the period,

[3,4] is in the range from 0 to 0,98 and points out the great level of contamination. Aquatic invertebrates live in the bottom parts of our waters. They make good indicators of watershed health because they: a) live in the water for all or most of their life, b) stay in areas suitable for their survival, c) are easy to collect, d) differ in their tolerance to amount and types of pollution, e) are easy to identify in a laboratory, f) often live for more than one year, g) have limited mobility, h) are integrators of environmental condition.

## 4. SANITARY MYCRO-BIOLOGICAL PARAMETERS

The bacteriological analysis of the taken sampling of water, [1] gives the enormous huge lump number of 30 000 Coliform bacteria (in 100 ml water) at location Kozija Cuprija, 30 000 at Bentbaša, and 30 000 at Skenderija. Streptococcus faecalis was found (in sampling of 100 ml water), at Kozija Ćuprija with value of 750, at Bentbaša 7 500 and at Skenderija 15 000. This results of measurement point out extremely high values of micro-biological parameters which are out of legislation standards. Streptococcus faecalis is a Gram-positive commensal bacterium inhabiting the gastrointestinal tracts of humans and other mammals. It is among the main constituents of some probiotic food supplements. A commensal organism can cause life-threatening infections in humans.

## 5. THE MEASURES FOR SUSTAINABLE PROTECTION

It is necessary to establish more automatic stations for control of qualitatively parameters and observation levels. During the year it is obligated to make the physical-chemical and hydro-biological examinations in four characteristic situations and the water flux measurement. All industrial operators which contribute the contamination should build waste water treatment plant, in refer to legislations. Some added sub-collectors have to be installed at tributaries and existing collectors. It is high time to rebuilt and put on work the ‘’Butile’’ municipal waste water treatment system. The using of pesticides and artificer fertilizers has to be strictly controlled in according to the current regulation. The transformation of forest to agro-soil and building should be also strictly controlled. The important is public awareness rising for saving use water in houses and stop to disposal waste on „wild dump“ places around the river.

## 6. CONCLUSION

Regarding the physical-chemical parameters, the river Miljacka at Kozija ćuprija belongs to the WQ Class II of water current, but at the other locations it belongs to WQ Class IV and out of it. Therefore, it can be concluded that Miljacka is much polluted, loaded by the waste water of commune and industry. The load of pollution analysis shows that there are great drainpipes of sewage waste water. The main problem is small water flux, especially during the summer and drought. The obtained saprobic index values are at I/II quality level at the upstream flow before the entering to Sarajevo city (oligo/betamesosaprobic), but downstream receiving the larger part of allochtoon’s organic substances it transfers to the II level (betamesosaprobic). EBI values show that the water has II level of quality with rich fauna and present dirty. At the mouth Miljacka has critical pollution regarding the calculated values of EBI of 1,62 during a year. The diversity index values from 0 to 0,98 for mouth of Miljacka also point out the great level of pollution. By the standards given in legislation, [5], it is not possible to make classification concerning the sanitary - microbiological parameters because of very high level of pollution which is out of standards. The sustainable protection measures should be established in order to improve the water current state.

## 7. REFERENCES


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