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ENVIRONMENTAL IMPACT OF THE POGRADEC WASTEWATER, ESTIMATED THROUGH THE GLOBAL POLLUTION INDEX METHOD

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Abstract

Discharge of untreated urban waters on surface waters is one of the main sources of natural water pollution in our country. During many years in the Ohrid Lake is discharged the wastewater from city of Pogradec and the surrounding villages, which certainly had environmental impact on the lake. Last year, the drainage channel of Drilon, built to remove the excess waters from the surrounding peaty soil area, now is serving to remove the wastewater of the city Pogradec after being treatment. The usage of this drainage channel for this purpose, also helped to assess environmental impact of used water in the area, which is estimated by using the global pollution index method, proposed by Rojanski and enhanced by Popa et al. This method is not used so far in our country. The value of global pollution index shows that the quality of the environment is modified by discharge of wastewater in the lake. Comparing the value of the global pollution index of not treated water with those treated by the Waste Water Treatment Plant, gives a clear picture of the extent of modification of water quality of the environment.

Keywords: global pollution index, environment impact assessment, waste water treatment plant.

1. INTRODUCTION

Lake Ohrid is an ancient lake, created by tectonic forces 2-3 million years ago, in the Tertiary period. Because the lake is so old and is isolated by surrounding hills and mountains, a unique collection of plants and animals have evolved. These include a number of relict species, or "living fossils," and many endemic species, found only in Lake Ohrid (Stankovic, 1960). Because of their high biodiversity and unique cultural heritage, Lake Ohrid is a lake of tremendous local, regional, and international significance. Its unique biodiversity and the crystal clear water that is Lake Ohrid's major tourist attraction (Avramoski et al. 2003). Population growth and development have impacted the lake. These include natural habitat destruction in the littoral zone, the introduction of pollutants, especially phosphorus, into lake waters etc. One of the most serious threats to the sustainable use of Lake Ohrid comes from nutrient loading. Lake Ohrid is being fertilized by nutrients in found in detergents and human and animal waste, and also by nutrients in runoff from the land. As a result, the lake is becoming more eutrophic. According Avramoski et al (2003) historically, Lake Ohrid was known as an "oligotrophic" or clear water lake. It is likely that Lake Ohrid may have "aged" by thousands of years in just the last few decades because the actions of people have greatly accelerated eutrophication. The concentration now may be 3 or 4 times the concentration measured before World War II. Eutrophication is one of the major hazards of the Lake Ohrid. Among the nutrients, the phosphorus is the prohibitory factor of the algae development and as result for the eutrofication. The dissolved phosphorus load in the year 1995 is calculated to be 150 ton per year, and it must be reduced to 50 ton year in order to preserve the average phosphorus concentration less than 7 mg m^{-3} (Avramoski 2002).

The urban waste water is one of the major pollutants of the superficial waters. The discharge of the pollutant load is already a necessity, especially to the sensitive zones, like the lake Ohrid; in whose waters are discharged sine the beginning the non treated water from the Pogradec town and the surrounding villages. Their volume, the pollution load they contain, and their potential to impact the quality of the waters lead to a very important environmental problem.

In Pogradec, the wastewater generated by about 30% of the town is collected but it is simply discharged into Lake Ohrid near Tushemisht (Avramoski etj. 2003). In 2001, the Project "Environmental Protection of Lake Ohrid, Water Supply, Sewerage Disposal Pogradec" was implemented to design and construct a water supply and also completed sewerage system for the city. The new sewerage system being developed for the Pogradec area on April 2009 will treat the wastewater of about 60% of the homes and businesses in the region including the small existing industries. A possible extension after 2010 would extend the Waste Water Treatment Plant and would allow the treatment of all the wastewater produced

in the Pogradec area. The total phosphorus load delivered to the Waste Water Treatment Plant from all sources is estimated to be 166 kg P/day, or about 60.6 tons/year. The treatment plant has been designed to remove about 80% of the phosphorus that is delivered to it (about 48.5 tons), therefore, the annual load to Lake Ohrid after treatment would be reduced to 12.1 tons (Avramoski etj. 2003). The discharge of treated water shall comply with European Community discharge requirements for the treated wastewater in sensitive water bodies (EU 91/271/EWG). These requirements specify a discharge concentration <2 mg/l, which is the current design specification (WSSP, 2006). All national standard and regulations have to be respected by the operation of the Waste Water Treatment Plant.

The site for the new Waste Water Treatment Plant (with anaerobic ponds, trickling filters, maturation ponds, sludge tanks and maturation ponds), is located about 1,500 m south of Lake Ohrid between the villages Buçimas and Zagorçan. The total area of the treatment site amounts to approx. 13 ha. The treatment site includes an area of about 8.5 ha with fish ponds which have been used before for carp hatching and is included in the treatment concept. The Driloni hydrovoir, which had been constructed to remove the excess waters from the torphic zone of the surrounding fields, actually serves to discharge the waste water after being treated to the Waste Water Treatment Plant.To evaluate the quality of superficial water are taken into consideration the most often pollution factors (nitrogen, phosphorus and the BOD_5, COD) as a result of the factors of antrophic pressure. These qualitative indicators of the waste water from the Pogradec City have been taken into consideration to show the impact of the waste water discharge ante and after the treatment process to the Lake Ohrid. The evaluation of the environmental impact has been through the Global Index of Pollution improved by Popa (2005). Also through the calculation of the treatment efficiency of the waste water to the observed indicators we have evaluated the treatment quality, compared to the Directive 91/271/EEC concerning urban waste water treatment.

2. MATERIAL AND METHOD

Environmental impact assessment is done by the Method of Global Pollution Index. The Global Pollution Index Method allows the evaluation of the degree of environmental pollution induced to the environment by certain activities, and its quantification using an index, which considers the ideal and the real values of the quality indicators representative for the evaluated environmental components. This method known also as Rojanschi's method (Rojanschi, 1991) is a synthetic estimation, based on the quality indicators for each environmental component, and a further correlation using a graphical representation. Therefore, for each environmental component different evaluation grades are established on a scale from 1 to 10, considering the levels of quality indicators as imposed by the standards. On the scale, the evaluation grade 1 describes a very severe situation concerning environmental pollution, while the grade 10 describes the ideal situation that is the quality of evaluated environmental component is not affected by human or industrial activities (Macoveanu, 2005; Rojanschi et al., 1997). The global pollution index method has some advantages are offers a global overview of environmental state, and its quality; allows the comparison of some regions, with requirement that these regions have to be analyzed based on the same quality indicators; allows the comparison of environmental states of one area, at different moments, offering the possibility to overview the evolution of environmental components quality and global quality of environment. The disadvantage of this method consists in a high degree of subjective approach, generated during the calculation of evaluation grades, which highly depends on evaluator's experience. The evaluation of grades are calculated for each environmental component, as an arithmetic mean of the grades received for quality indicators that are affected by industrial activities, production processes. These values are used for a graphical representation that depicts the synergic effect produced by all types of pollution. The index of global pollution (I_{GP}) is defined by Rojanshi (1991), as in equation:

$$I_{GP} = \frac{S_i}{S_r}$$

where: *Si* area of the ideal state of the environment, *Sr* area that represents real state (evaluated situation).

Popa et al. (2005), similarly to Rojanschi's method, improved a new method also considers the index of global pollution (I_{GP}) as the ratio between the surfaces of the concentric circles that corresponds to the ideal (*Si*) and the real state (*Sr*) of the ecosystem, respectively leading to the final equation that allows the calculation of global pollution index. That is one of the advantages of

this improved method. Thus, the final information about the global state of the ecosystem is easier to be found than in the Rojanschi's method. Another advantage of this new method is that the global state of the ecosystem can be assessed using only one environmental components (e.g. water), while the Rojanschi's method can be applied considering at least three environmental components (e.g. water, soil, air). Thus, a concentric circles graphical methodology proposes that the index of global pollution index can be calculated using only the arithmetic mean of the evaluation grades ($\overline{b}^2$):

$$I_{GP} = \frac{b_{\max}^2}{\overline{b}^2} = \frac{100}{\overline{b}^2}$$

The authors (Popa et al., 2005, Petruc et al., 2006) proposed a scale of the arithmetic mean values for the evaluation grades, correlated with the global state of the ecosystem (Tab. 1).The waste water was analyzed taking into consideration the basic indicators, BOD_5 (Biological Oxygen Demand), COD(Chemical Oxygen Demand), ammonium nitrogen and total phosphorus, based on the data taken from the laboratory of the Waste Water Treatment Plant of the Pogradec City. The data are compound during the first year since the start of the operation of the Waste Water Treatment Plant from April 2009 since March 2010. The treatment efficiency (β) has been calculated by the equation:

$$\%\beta = \frac{C_i - C_e}{C_e} \cdot 100$$

where: *Ci* - concentration of pollutant at the inlet of the treatment plant (mg/l), *Ce* -concentration of pollutant at the outlet of the treatment plant (mg/l).The calculated ratio COD/BOD and BOD/COD serves to evaluate the degradation degree of the pollutants part of the waste water.

Table 1. Correlation between the arithmetic mean of the evaluation grades and the global state of the ecosystem

Values of $\overline{b}$	Value of I_{GP}	Class	Effects/real situation
10	$I_{GP} = 1$	A	Natural environment, not affected by industrial/human activities
9.999 – 7.072	$1 < I_{GP} < 2$	B	Environment modified by industrial activities within admissible limits
7.071 – 5.774	$2 < I_{GP} < 3$	C	Environment modified by industrial activities causing discomfort conditions
5.773 – 5.001	$3 < I_{GP} < 4$	D	Environment modified by industrial activities causing distress to life forms
5 – 4.083	$4 < I_{GP} < 6$	E	Environment modified by industrial activities, dangerous for life forms
< 4.082	$I_{GP} \geq 6$	F	Degraded environment, not proper for life forms

3. RESULTS AND DISCUSSIONS

The average results of the chemical analyses of the waste water before and after the treatment are shown to the Table 2.

Table 2. The main quality indicators of treated wastewaters samples

Month	Inflow concentration				Outflow concentration			
	COD mg/l	BOD mg/l	NH_4-N mg/l	P total mg/l	COD mg/l	BOD mg/l	NH_4-N mg/l	P total mg/l
April	226.00	124.30	-	-	49.87	11.20	-	-
May	233.83	128.00	-	-	42.80	14.20	-	-
June	199.33	126.20	-	-	46.82	11.00	1.10	2.31
July	248.22	174.50	28.65	5.32	39.29	11.35	1.55	3.37
August	313.43	175.00	19.90	4.96	44.99	9.23	2.61	3.64
September	209.25	154.80	14.79	4.17	35.49	12.05	1.82	2.93
October	174.42	56.33	14.10	3.42	58.18	28.43	2.83	2.74
November	305.00	183.00	17.15	6.69	26.20	9.00	3.41	2.39
December	253.29	165.00	19.60	4.17	24.46	10.00	3.21	2.54
January	243.75	123.00	9.16	5.52	27.81	8.46	2.79	2.71
February	286.88	130.50	16.60	5.39	22.74	7.72	2.09	2.33
March	311.75	188.75	19.10	4.65	36.86	8.40	1.91	2.67
Average values	**250.43**	**144.11**	**17.67**	**4.92**	**37.96**	**11.75**	**2.33**	**2.76**

The norms of the urban waters defined to the Albanian legislation, that also correspond to the norms set by the Directive of the European Union 91/271/CEE related to the treatment of the urban waste water is shown to the Table 3. These norms served to compare the purification efficiency of the Waste Water Treatment Plant.

Table 3. Emission limits for the Urban Waste Water Treatment Plants (Dir. 91/271/CEE)

Parameters	Concentration	Minimal reduction percentage
Biological Oxygen Demand (BOD_5 in 20°C), mg/l O_2	≤ 25	70-90
Chemical Oxygen Demand (COD), mg/l O_2	≤ 125	75
Total Phosphorus (P mg/l)	≤ 2	80
Total Nitrogen (N mg/l)	≤ 15	70-80

The ratio COD with BOD is linked to the biodegradation of the load. The urban waste water generally has a ratio of COD/BOD_5 of the sequence 1.8-2.2. The general ratio for the waste water for biodegradable COD and BOD_5 is 1.6 (Boni 2007). The values of ratio BOD5/COD < 0.4 indicate that wastewater has a high content of hard biodegradable compounds (Capatina and Lazar, 2005). The data in the Table 4, show that the ratio COD/BOD of the Pogradec City waste water is 1.59 – 2.07, with an average ratio of 1.87. The values of the ratio BOD/COD for the period taken in the study are higher than 0.4, with an average of 0.55. These data show that the biodegradation scale is in general higher. The load of the Pogradec City waste water is mainly compound of easily biodegradable matters, and the load of the biodegradable matters is hardly lower.

Table 4. Values of the ratio COD/BOD and BOD/COD

Month	COD/BOD	BOD/COD
April	1.90	0.55
May	1.90	0.54
June	1.60	0.63
July	1.77	0.58
August	1.90	0.56
September	1.59	0.63
October	1.82	0.55
November	2.07	0.50
December	1.93	0.52
January	2.05	0.50
February	2.02	0.47
March	1.95	0.53
Average values	1.87	0.55

The evaluation of the non treated waste water to the Lake Ohrid is done taking into consideration the qualitative indicators BOD, COD, Total Phosphorus and ammonium nitrogen. The evaluation degree for the environmental component superficial water is given to the Table 5. The data for the scales, water categories and COD and BOD are referred to Zaharia etc. (2006) and Petruc etc. (2006). Based on the data from different Directives of the European Union for the water (Dir. 76/160/EEC, Dir. 91/271/CEE, Dir. 98/83/CE, Dir. 2006/7/EC, Dir. 2006/44/CE), and also on the data used by the Agency of Environment and Forestry (AMP) about the evaluation of the pollutants of the superficial waters by the urban discharges and also for the evaluation of the water quality of rivers and lakes(MMPAU, 2008) we have compiled the values of the total P and NH_4 for each scale.

Taking into consideration the annual average values, the evaluation scale for each qualitative indicator is: COD - grade 4; BOD – grade 2; P total- grade 3 and NH_4 – grade 3. The evaluation degree for water is 3. It can be observed that the main pollutants for water are emissions of P-total and ammonium, which seriously affect the water quality.

Table 5. The evaluation scale for superficial water

Grades	Water category	COD (mg/l)	BOD (mg/l)	P total (P mg/l)	NH_4 (N mg/l)
10	Drinking water	< 10	< 3	< fond*	< 0.5
9	Category I	10	3	0.2	0.5 - 1.0
8	Category II	10-25	3-5	0.2 - 0.4	1.0 - 2.0
7	Category III	25-50	5-10	0.4-1.0	2.0 - 4.0
6	Category IV	50-125	10-25	1.0 – 2.0	4.0-7.0
5	Category V	125-175	25-30	2.0-3.0	7.0-10
4	Degraded stage 1	175-300	30-50	3.0-4.5	10-15
3	Degraded stage 2	300-500	50-100	4.5-6.5	15-20
2	Waste water stage 1	500-700	100-500	6.5-9.0	20-30
1	Waste water stage 2	> 700	> 500	> 9.0	> 30

* Concentration in natural condition, no emissions

The next step in environmental impact assessment is the quantification of impact by calculating the value of the global pollution index. For the assessed situation it was applied the improved method for calculation of global pollution index. Thus, the mean of evaluation grades has the value 3, the parameter (b^2) is 9, and the I_{GP} = 11.11. The waste water of Pogradec City before the treatment to the Waste Water Treatment Plant creates a degraded environment, not adequate to the living creatures. For this reason the activity of the non treated waste water directly to the Lake Ohrid up to the moment of the operation of the Waste Water Treatment Plant has seriously modified the quality of the Lake environment.

The evaluation scales for each qualitative indicator of the treated water are: COD - grade 7; BOD – grade 6; P total- grade 5 and NH_4 – grade 7. The average of the evaluation scales is 6.25, parameter (b^2) is 39.06, and I_{GP} = 2.56. The waste water of the Pogradec City after the treatment process creates a modified environment that causes uncomfortable conditions. The highest impact to the water pollution comes from the total phosphorus

component which still high also above the foreseen operation standards of the Waste Water Treatment Plant and also above the standards of the Dir. 91/271/CEE. This is a direct indicator that brings the necessity to improve to the near future the operation and the efficiency of the Waste Water Treatment Plant by reducing the total phosphorus load to the permitted limits 2 mg/l. The removal of the chemical pollutants as Phosphorus and Nitrogen will be possible after the implementation of another phase of the project "Environmental Protection of Lake Ohrid, Water Supply, Sewerage Disposal Pogradec" which is actually to the project proposal phase and the investor is the German Bank for Development KfW.

The treatment efficiency (β) to the Table 6, for each qualitative indicator taken to the study show that for the COD the treatment efficiency during the operation months varies from 53.91 % in October 2009 to 91.79 % in February 2010, in annual average value of 81.87 %. For the BOD the lowest treatment efficiency is in October 2009 with value 50.24 %, and the highest in March 2010 with value 94.77 %, the annual average value is 88.56 %.

These indicators show that for the studied period the treatment efficiency in average yearly figure is within the standards except of the month of October 2009 where the efficiency was lower than the standard of 75 % for the COD and 70-90 % for the BOD.

The further improvement of the treatment efficiency, especially for the COD, will reduce the value of I_{GP} and improve the quality of the environment.

Table 6. Treatment efficiency (β) for the qualitative indicators

month	COD %	BOD %	NH_4 %	P total %
April	77.93	90.30	-	-
May	80.61	86.82	-	-
June	73. 15	90.28	-	-
July	83.02	92.47	94.59	36.65
August	84.96	94.55	86.88	19.36
September	75.14	88.62	87.69	29.74
October	53.91	50.24	79.69	19.88
November	88.00	93.25	80.12	64.27
December	90.09	94.18	83.82	39.01
January	87.75	93.43	69.54	50.90
February	91.79	93.77	87.41	56.77
March	87.36	94.77	90.00	42.58
Average values	**81.87**	**88.56**	**86.81**	**43.90**

The treatment efficiency of the total phosphorus is low compared to the allowed standards in a minimum of 80 %.

The improvement of the treatment efficiency for the total phosphorus up to the lower limited value will reduce the concentration of this compound under 1 mg/l and the evaluation scale (b) from the current scale 5 to the scale 7.

This improvement is accompanied by the increase of the efficiency of COD will be reflected also to the value of the Global Pollution Index, and the actual situation of the treated waste water of Pogradec City will be improved by the modified environment that causes uncomfortable conditions (class C) to the comfortable environment within the allowed limits (class B).

4. CONCLUSIONS

The improved global pollution index method has the advantage that the global state of the environment can be evaluated using only the arithmetic mean of evaluation degrees, and can be applied for a lower number of environmental components (e.g. one or two environmental components).

The average ratio COD/BOD of the waste water of Pogradec City is 1.87, the average value of the ratio BOD/COD is 0.55. Both ratios show that the waste water load is compound mainly by easily biodegradable matters, while the load of the biodegradable matters is hardly lower.

The calculated value of the Global Pollution Index, (I_{GP} = 11.11), shows that the untreated waste water belong to the class "F", that corresponds to the Degraded Environment, not proper for life forms. The direct discharge of the waste water for years to the lake Ohrid has seriously impacted the water and environment quality in a dangerous way for life forms, inducing a great impact in environment.

The value of the Global Pollution Index, for the treated waste water is 2.56 and shows that they compound a modified environment with uncomfortable conditions. The highest impact to the waste water pollution comes from the total phosphorus load in value of 2.76 mg/l, which is above the operation standard of the Waste Water Treatment Plant and also above the allowed standard. This requires the reduction of the total phosphorus concentration to the treated waste water.

The treatment efficiency for the COD, BOD and the ammonium is within the standards, while the total phosphorus is almost to the half of the value and of the allowed standards.

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