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Wastewater treatment impact on water quality - a case study

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ABSTRACT

The untreated wastewater implies a tough challenge nowadays due to sewage disposal and consequently to environmental considerations. Depending on the types of waste and amount of waste generated, industrial wastewater treatment plants are designed to tackle huge amounts of wastewater using innovative technology and to meet environmental requirements after treatment.
The purpose of this paper is to evaluate the environmental impact of wastewater treatment plants in Pogradec using the alternative method of global pollution index. Therefore, during a two-year monitoring period, chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammonia nitrogen ($N\text{-}NH_4$) and total phosphorus (TP) have been measured in water samples taken before and after wastewater treatment. The results are then compared with the standard values for the urban waters defined by the European Directive 91/271/EEC on urban wastewater treatment, and based on them the treatment efficiency of wastewater treatment plant is calculated. Global pollution index is an indicator used to estimate the efficiency of the wastewater treatment plant taken in consideration.
The data show that the enhanced wastewater treatment efficiency has an immediate positive impact not only on the environmental protection of Ohrid Lake, but also on the improved life quality of the residents and thus enhancing tourism attraction in the area.

Keywords: Wastewater Treatment Plant (WWTP); treatment efficiency; biodegradation; global pollution index; environment impact.

INTRODUCTION

Wastewater can be defined as the flow of used water discharged from different activities and directed to treatment plants by a carefully designed and engineered network of pipes (WEF, 2009). Wastewater treatment became a necessity in big cities in order to reduce the number of pollutants in the used water discharged in the environment (Lofrano and Brown, 2010). Untreated waste water disposed near population centres have created serious issues for public health, resulting in epidemic events (Lucking, 1984; Aiello et al., 2008). However, according to the Human Development Report (2006), the progress in wastewater management and sanitation was driven above all by political coalitions uniting industrialists, municipalities, and social reformers. Untreated or party-treated urban wastewater consists of a high concentration of nutrients as well as organic matter (Qayoom et al., 2020), which upon decomposition releases additional nutrients. Increased levels of nutrients especially nitrogen and phosphorus in aquatic ecosystems are associated with eutrophication. Several toxins are liberated from sewage into the water, which is consumed by fishes and other forms of aquatic life and thereby increasing their possibility of entering the food chain.

The environmental impact assessment is a multivariate, multidisciplinary decision-making tool where the knowledge of experts in various fields is integrated into the evaluation of environmental impacts before, during, and after a proposed developmental activity organized into an existing functional unit or a contaminated site, and thus allowing measures that ensure environmental compatibility (Goyal and Deshpande, 2001). This method takes into consideration the proposed method of global pollution index introduced by Rojanschi (1991), and improved by Popa et al. (2005) (as an alternative method of global pollution index). 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).

In Albania, the construction of sewage treatment plants began after 2000. Before their construction, sewers (untreated water) discharged into a water body such as a river, lake, or sea, which has resulted in their degradation as well as loss of biodiversity. Inappropriate domestic wastewater management (wastewater discharge) of Pogradec city and the villages is certainly one of the most important sources of pollution in Ohrid Lake (Damo et al., 2010).

This paper describes and evaluates the positive effects of wastewater treatment plants in Pogradec on water quality using the alternative method of the global pollution index. This case study considers and analyses the available monitoring data, during 2017 and 2018, for chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammonia nitrogen ($N\text{-}NH_4$), and total phosphorus (TP), in untreated and treated wastewater discharge flow. The results are then compared with the standard values for the urban waters defined in the Albanian legislation and the European Directive 91/271/EEC on urban wastewater treatment, and based on them the treatment efficiency of wastewater treatment plant is calculated. Global pollution index is an indicator used to estimate the efficiency of the wastewater treatment plant taken in consideration.

MATERIAL AND METHODS

Study area

Pogradec is located in the southeast of Albania and it is part of the Korça district. The city has a surface of 13 km^2 and it is located on a narrow plain between two mountain chains along the southwestern banks of Ohrid Lake. Ohrid Lake is well known for its unique aquatic ecosystem of worldwide importance, with more than 200 endemic species. Formed in the tertiary period between 3.5 and 4 million years ago, Ohrid Lake is considered one of the oldest lakes in the world (Popovska and Bonacci, 2007), with numerous freshwater organisms whose close relatives can be found only as fossil remains (Spirkovski et al., 2001). Because of its unique hydrological system and ecological value, UNESCO (1979) declared the Macedonian side of Ohrid Lake as a “site of cultural and natural values of the global patrimony”. The property was extended to include the rest of Ohrid Lake, located in Albania, in 2019.

Previously, the wastewater generated by the town had been discharged directly into the Ohrid Lake. Therefore, it was the main contributor to lake water quality, and to excessive plant growth that disrupts its unique ecosystem and threatens the human health.

In 2001, the Project “Environmental Protection of Ohrid Lake, Water Supply, Sewerage Disposal Pogradec” was implemented to design and construct a water supply and also completed a sewerage system for the city (WSSP, 2006). The project goal was to reduce the discharge of sewage into the lake, making a substantial contribution to reducing environmental pollution and maintaining the water quality. The WWTP includes anaerobic ponds, tricking filters, maturation ponds, sludge tanks and maturation ponds. This site is located about 1500 m south of Lake Ohrid with a total area of treatment approximately 13 ha (Damo et al., 2010) (Figure 1). After its treatment, the water is discharged in Ohrid Lake.

Figure 1. Wastewater Treatment Plant in Pogradec (AlbStar, 2005).

Wastewater parameters

In order to evaluate the surface water quality, some chemical parameters influenced by anthropogenic activities are considered. These include chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammonia nitrogen ($N\text{-}NH_4$), and total phosphorus (TP). The water samples are taken and then analysed according the appropriate methods from the laboratory of the Waste Water Treatment Plant of the Pogradec City. The water samples are taken from two monitoring sites containing untreated and treated wastewater, meaning before and after entering the treatment plant.

The differences between COD and BOD_5 in water samples might originate from two major sources: some inert, non-degradable soluble organic materials (SI) from the influent (Henze et al., 1999); some refractory soluble microbial products (SMP) forms enduring wastewater treatment (Xie et al., 2016).

The treatment efficiency

In a biological wastewater treatment plant, organic matter (BOD_5 or COD) is transformed into water, gases, and new cell material (biological cells). However, the new biological cells that are produced in the reactor are themselves, organic matter. In order to analyse this balance between consumption and production, it is necessary to resort to mathematical models of the treatment process. Usually, the major episodes of deterioration of effluent quality in a treatment plant are associated with suspended solids loss, which can mask the possible good conversion that may have taken place in the biological reactor. In other words, organic matter conversion may have been very high, but the introduction of particulate matter in the effluent from the secondary sedimentation tank will decrease the calculated value of removal efficiency. Because of this, for this particular case, it is useful to calculate what is known as the biological removal efficiency in addition to calculating the removal efficiency in the traditional way. This calculation of biological removal efficiency applies to the actual conversion that takes place in the biological reactor (Sperling et al., 2020):

$$\%\beta = \frac{(C\,in - C\,out)}{C\,in} * 100$$

where: C_{in} - concentration of pollutant at the inlet of the treatment plant (mg l^-), C_{out} -concentration of pollutant at the outlet of the treatment plant (mg l^-).

The norms of the urban waters according to the European Union 91/271/EEC related to the treatment of urban wastewater, to compare the purification efficiency of the WWTP are shown in Table 1.

Table 1. Emission limits for the Urban Waste Water Treatment Plants (Dir. 91/271/EEC).

Parameters	Concentration mg l^-	Minimal reduction percentage
Chemical oxygen demand (COD in 20 ^oC), mg l^- O_2	≤ 25	70-90
Biochemical oxygen demand (BOD_5)	≤ 125	75
Ammonia nitrogen ($N\text{-}NH_4$)	≤ 15	70-80
Total phosphorus (TP)	≤ 2	80

The environmental impact assessment

The assessment of environmental quality is done by the Alternative Method of the Global Pollution Index. For each environment component, an evaluation score that quantifies the pollution of the component expressed by an evaluation scale is proposed. The evaluation scale consists of different variation intervals for the evaluation score which correspond to the specific pollution situation. The minimum and maximum values for the evaluation score are respectively 1 and 10, where 10 represents the nonaffected natural state of the environment and 1 represents an irreversible and major degradation of the studied environment components (Zaharia and Murăraşu, 2009).

The authors of the alternative method of global pollution index (Popa et al., 2005) follow the concentric circles graphical methodology proposing a scale of the arithmetic mean values for the evaluation scores, correlated with the global state of the environment. The calculation of the alternative global pollution index (I^*_{PG}) is done with relation (2), where (2b) is the arithmetic mean of the square of the evaluation scores for each investigated quality indicator of the environment component (b), where "I" can be the groundwater, air or soil component (Zaharia and Murăraşu, 2009):

$$I^*_{PG} = \frac{100}{\overline{b^2}}$$

The correlation between the arithmetic mean of evaluation scores, the global pollution index, and the global state of the environment is presented in Table 2 (Popa et al., 2005; Zaharia and Murăraşu, 2009). The well-known method of the global pollution index can be applied to assess the environmental impact of economic activity from an industrial site when information for more than three environmental components is available.

The evaluation degree for the environmental component of superficial water is given in Table 3. The data for the scales, water categories, and COD and BOD_5 are referred to Zaharia and Murăraşu (2009). Based on the data from different Directives of the European Union for the water (Dir. 91/271/CEE, Dir. 98/83/CE, Dir. 2006/44/CE), and also on the data used by the MMPAU (2008) about the evaluation of the pollutants of the superficial waters by the urban discharges and also for the evaluation of the

Table 2. Correlation into alternative global pollution index methodology.

Class	Value of I^*_{PG}	Effects/real situation
A	$I^*_{PG}=1$	Natural environment, not affected by industrial/human activities
B	$1< I^*_{PG} <2$	Environment modified by industrial/economic activities within admissible limits
C	$2< I^*_{PG} <3$	Environment modified by industrial/economic activities generating discomfort effects
D	$3< I^*_{PG} <4$	Environment modified by industrial/economic activities generating distress to life forms
E	$4< I^*_{PG} <6$	Environment modified by industrial/economic activities, dangerous for life forms
F	$I^*_{PG} \geq 6$	Degraded environment, not proper for life forms

water quality of rivers and lakes, the values of measured chemical parameters for each scale are compiled.

RESULTS AND DISCUSSIONS

Water quality parameters before and after treatment during 2017-2018

The average results of the wastewater analyses before and after the treatment are shown in the Table 4 below.

During 2017, as shown in Table 4, the COD inlet concentrations varied from 227 to 480 mg l- and in 2018 from 256 to 442 mg l-. Meanwhile BOD_5 inlet concentrations in 2017 varied from 174 to 262 mg l-, and during the 2018 the data show the variation from 165 to 236 mg l-. $N\text{-}NH_4$ inlet concentrations in 2017 varied from 14.7 to 20.8 mg l- and in 2018 from 14.7 to 28.1 mg l-. During the 2017 the inlet total phosphorous varied from 3 to 4 mg l- and in 2018 from 3 to 5 mg l-. Figure 2 represents the variation of COD, BOD_5 and $N\text{-}NH_4$ inlet concentrations in WWTP in Pogradec during 2017 and 2018.

When considering the outlet concentrations, it can be noticed that COD values in 2017 vary from 40 to 84 mg l-, and during 2018 from 33 to 57 mg l-. BOD_5 concentrations during 2017 range from 9.6 to 15.6 mg l-, and $N\text{-}NH_4$ values range from 3 to 7 mg l-. During 2018, COD outlet values show the variation from 33 to 57 mg l-, BOD_5 from 9.1 to 13.8 mg l-, and $N\text{-}NH_4$ from 2 to 5 mg l-. Total phosphorous outlet concentrations during 2017-2018 show values less than 2 mg l-. The Figure 3 represents the variation of outlet concentrations of chemical parameters that determine the water quality.

According to Dir. 91/271/EEC (Table 1) the limit for COD is ≤125 mg l-. The Figure 4 shows the COD inlet and outlet concentrations during 2017-2018. The outlet average value during 2017-2018 is 53 and 42 mg l-, respectively. In 2018 the COD concentration is decreased. However, its values are lower than the limit. Anaerobic digestion can remove the pollutants in high-strength wastewater while producing valuable biogas as a by-product. However, high organic loading rates often lead to a decrease in biogas production and/or lower removal of COD (Musa and Idrus, 2020).

Figure 5 represents the variation of BOD_5. Its average values during 2017-2018 was 12 and 11 mg l-, respectively, so it is lower than the standard ≤25 mg l- (Dir. 91/271/EEC). Moreover, the $N\text{-}NH_4$ and TP average

Table 3. The evaluation scale for water component (mg l-).

Grades	Water category	COD	BOD	$N\text{-}NH_4$	TP
10	Drinking water	< 10	< 3	< 0.5	< fond*
9	Category I	10	3	0.5 - 1.0	0.2
8	Category II	10-25	3-5	1.0 - 2.0	0.2 - 0.4
7	Category III	25-50	5-10	2.0 - 4.0	0.4-1.0
6	Category IV	50-125	10-25	4.0- 7.0	1.0 – 2.0
5	Category V	125- 175	25-30	7.0-10	2.0-3.0
4	Degraded stage 1	175- 300	30-50	10-15	3.0-4.5
3	Degraded stage 2	300- 500	50-100	15-20	4.5-6.5
2	Wastewater stage 1	500- 700	100- 500	20-30	6.5-9.0
1	Wastewater stage 2	> 700	> 500	> 30	> 9.0

* Concentration in natural condition, no emissions.

Table 4. Average concentrations of quality indicators of water samples in WWTP in Pogradec.

Inlet					Outlet				
	COD	BOD_5	$N\text{-}NH_4$	TP		COD	BOD_5	$N\text{-}NH_4$	TP
Jan-17	277	189	19.7	3	Jan-17	84	13.3	7	2
Feb-17	306	193	19.7	4	Feb-17	53	12.4	6	2
Mar-17	421	217	17.7	4	Mar-17	57	10.7	5	2
Apr-17	357	174	20.8	4	Apr-17	45	10.4	4	2
May-17	390	192	19.6	4	May-17	40	9.6	5	2
Jun-17	398	209	17.1	3	Jun-17	56	11.1	4	2
Jul-17	400	195	20.2	4	Jul-17	63	15.6	4	2
Aug-17	379	196	14.7	3	Aug-17	50	13.1	3	2
Sep-17	393	207	14.7	3	Sep-17	52	12.7	4	2
Oct-17	423	215	20.1	4	Oct-17	46	13.8	4	2
Nov-17	480	262	19.8	4	Nov-17	43	11.7	4	2
Dec-17	397	248	17.5	4	Dec-17	53	13.3	3	2
Jan-18	442	219	18.1	4	Jan-18	55	13.8	5	2
Feb-18	344	193	19.5	4	Feb-18	49	12.4	5	2
Mar-18	421	217	17.7	3	Mar-18	57	10.7	5	2
Apr-18	315	165	16.3	3	Apr-18	33	10.2	4	2
May-18	340	236	16.0	3	May-18	38	9.1	2	2
Jun-18	346	188	28.1	4	Jun-18	36	10.5	4	2
Jul-18	338	175	33.2	4	Jul-18	35	9.6	3	2
Aug-18	343	221	35.1	5	Aug-18	39	10.7	2	2
Sep-18	393	207	14.7	3	Sep-18	52	12.7	4	2
Oct-18	341	193	20.2	3	Oct-18	40	9.9	3	2
Nov-18	414	205	18.3	4	Nov-18	40	11.7	4	2
Dec-18	256	191	23.7	5	Dec-18	41	10.7	5	2

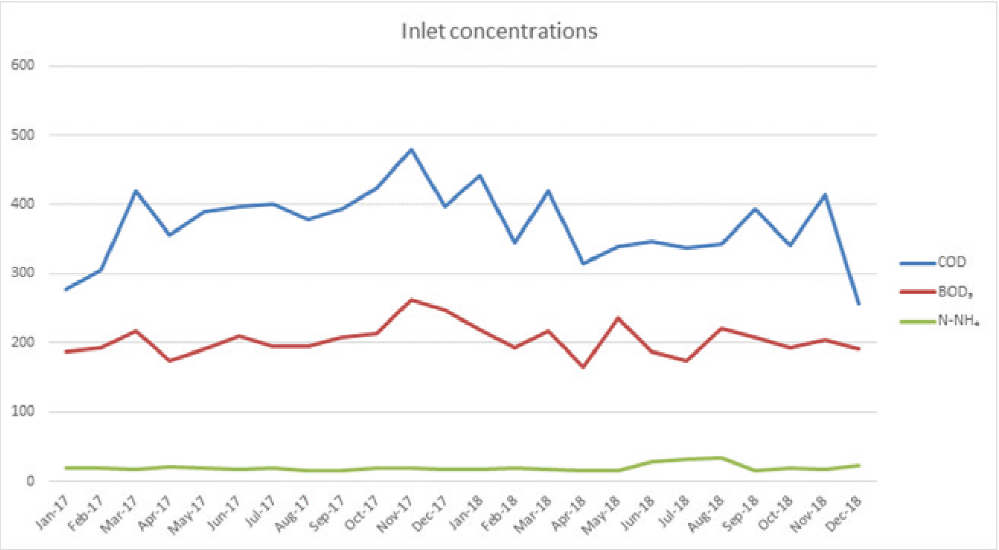

Figure 2. Inlet Concentrations during 2017 and 2018.

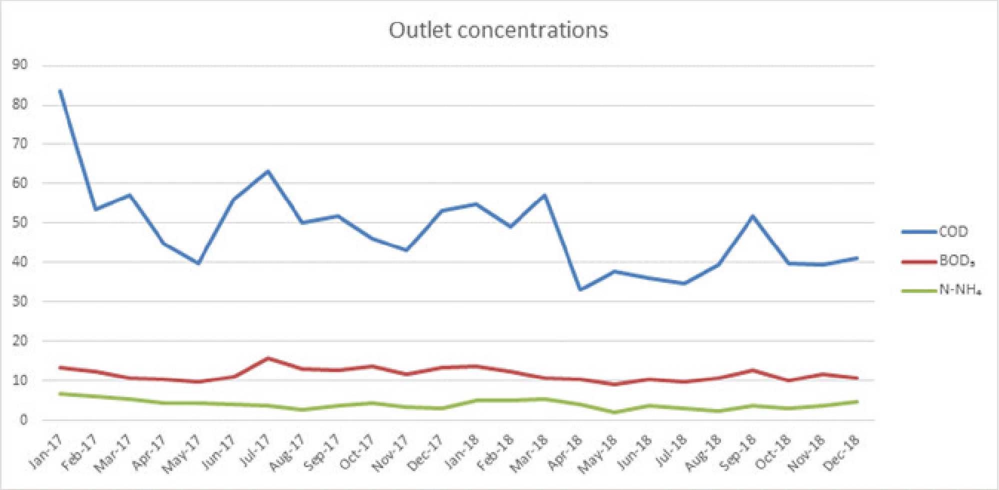

Figure 3. Outlet Concentrations during 2017 and 2018.

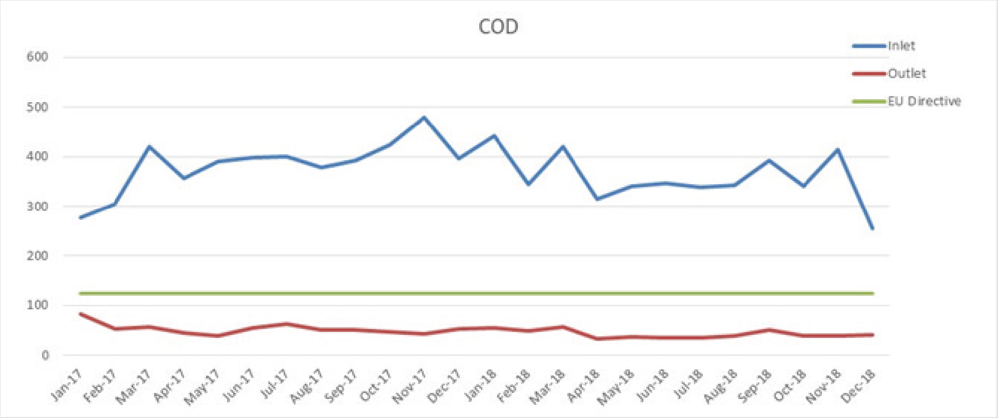

Figure 4. COD inlet and outlet variation.

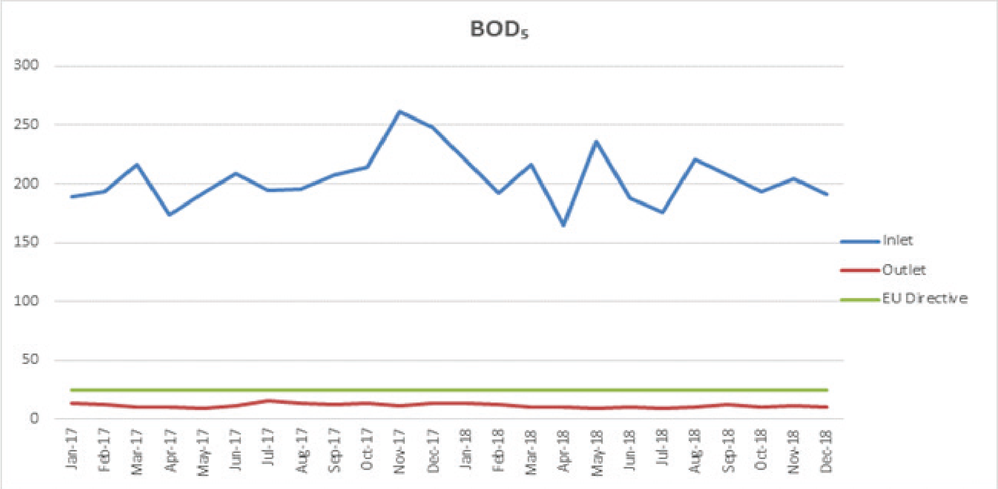

Figure 5. BOD_5 inlet and outlet variations.

values during 2017-2018 were lower than the standard, ≤ 15 and ≤ 2 mg l⁻¸ respectively (Dir. 91/271/EEC).

As it is shown from the above results, the concentration of contaminants decreased after the treatment. Considering the average values for each component, COD decreased in 2017 from 385 to 53 mg/l, BOD_5 from 208 to 12 mg/l, $N\text{-}NH_4$ from 18 to 4, and total phosphorous halved. Similar situation can be observed during 2018. COD decreased from 352 to 42 mg/l, BOD_5 from 198 to 11 mg/l, $N\text{-}NH_4$ from 22 to 4 mg/l and total phosphorous decreased from 4 to less than 2 mg/l. This suggests that the treated water quality parameter standards are met satisfactorily.

COD/BOD_5 and BOD_5/COD ratios

The ratios between BOD_5 and COD are used to evaluate the biodegradation of the wastewater. The COD/BOD_5 ratio for the urban wastewater generally ranges from 1.8 to 2.2. This ratio for biodegradable wastewater is 1.6 (Boni, 2007). Meanwhile, the BOD_5/COD ratio has been commonly used as an indicator of biodegradation capacity. It is called "Biodegradability index" (B.I.). It is generally considered the cut-off point between biodegradable and non-biodegradable waste (Metcalf and Eddy, 2003). The values of the ratio BOD_5/COD less than 0.4 is an indicator that the wastewater has a high content of hard biodegradable compounds (Capatina and Lazar 2005). However, reported values for the biodegradability index vary from 0.4 to 0.8, for municipal raw wastewater. The ratio can exceed 10 for industrial wastewater (Markantonatos, 1990).

The data in Table 5 show that the COD/BOD_5 ratio varies from 1.47 to 2.05, with an average of 1.86 during 2017 and from 1.34 to 2.03 with an average of 1.79 during 2018. Meanwhile the ratio between BOD_5 and COD varies from 0.49 to 0.68 during 2017 and from 0.50 to 0.70 during 2018, with the average values respectively of 0.55 and 0.57. Since the main origin of wastewater are the urban waters of Pogradec city and its surrounding areas, the data show that biodegradable components are the main component.

The BOD_5/COD ratio, as Table 6 shows, remains almost constant, after anaerobic treatment of the wastewater. This type of treatment plays a significant role in the performance of the whole treatment system since it efficiently removes chemical and biological material maintenance.

According to Metcalf and Eddy (2003), typical values for the BOD_5/COD ratios for untreated municipal wastewater are in the approximate range of 0.3 to 0.8 and decrease to 0.11-0.31 for the treated sewage. If the ratio is equal to or greater than 0.5 the wastewater is considered to be easily treatable by biological treatment. If the ratio is below 0.3, the wastewater may have some toxic components or acclimated microorganisms may be required for degradation (Metcalf and Eddy, 2003).

According to the data on Table 5, Table 6 and Figure 6, during 2017-2018, the BOD_5/COD ratio in the inlet varies from 0.5 to 0.7, and in the outlet varies from 0.16 to 0.3. These values are within the limits (Metcalf and Eddy, 2003), and it implies that the wastewater is composed mainly of easily biodegradable matters.

The treatment efficiency of wastewater treatment plant

Table 7 shows the treatment efficiency of the WWTP in Pogradec.

Table 5. Values for COD/BOD_5 and BOD_5/COD inlet ratios during 2017 and 2018.

	COD/BOD_5	BOD_5/COD		COD/BOD_5	BOD_5/COD
17-Jan	1.47	0.68	18-Jan	2.01	0.50
17-Feb	1.58	0.63	18-Feb	1.79	0.56
17-Mar	1.94	0.52	18-Mar	1.94	0.52
17-Apr	2.05	0.49	18-Apr	1.91	0.52
17-May	2.03	0.49	18-May	1.44	0.70
17-Jun	1.90	0.53	18-Jun	1.84	0.54
17-Jul	2.05	0.49	18-Jul	1.93	0.52
17-Aug	1.94	0.52	18-Aug	1.55	0.64
17-Sep	1.89	0.53	18-Sep	1.89	0.53
17-Oct	1.97	0.51	18-Oct	1.76	0.57
17-Nov	1.83	0.55	18-Nov	2.03	0.49
17-Dec	1.60	0.62	18-Dec	1.34	0.75
Average	1.86	0.55	Average	1.79	0.57

Table 6. Values for COD/BOD_5 and BOD_5/COD outlet ratios during 2017 and 2018.

	COD/BOD_5	BOD_5/COD		COD/BOD_5	BOD_5/COD
17-Jan	6.29	0.16	18-Jan	3.99	0.25
17-Feb	4.31	0.23	18-Feb	3.94	0.25
17-Mar	5.38	0.19	18-Mar	5.38	0.19
17-Apr	4.31	0.23	18-Apr	3.24	0.31
17-May	4.13	0.24	18-May	4.14	0.24
17-Jun	5.05	0.2	18-Jun	3.45	0.29
17-Jul	4.03	0.25	18-Jul	3.63	0.28
17-Aug	3.83	0.26	18-Aug	3.69	0.27
17-Sep	4.08	0.25	18-Sep	4.08	0.25
17-Oct	3.35	0.30	18-Oct	3.99	0.25
17-Nov	3.68	0.27	18-Nov	3.38	0.30
17-Dec	3.98	0.25	18-Dec	3.83	0.26
Average	4.37	0.24	Average	3.89	0.26

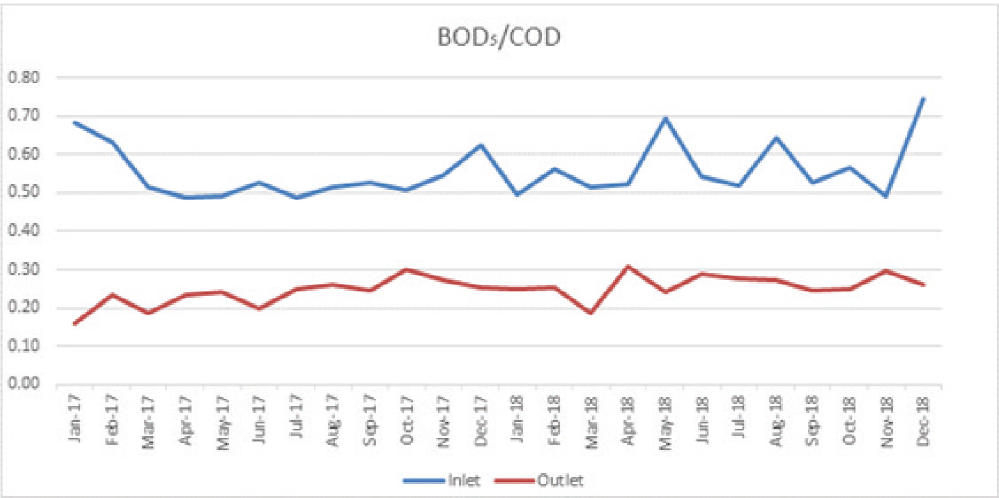

Figure 6. The BOD_5/COD ratio during the study period.

Table 7. Treatment efficiency of WWTP in Pogradec during 2017-2018.

	COD	BOD_5	$N\text{-}NH_4$	TP		COD	BOD_5	$N\text{-}NH_4$	TP
17-Jan	69.80	92.96	65.9	33.33	18-Jan	87.56	93.73	71.47	50.00
17-Feb	82.52	93.58	69.21	50.00	18-Feb	85.75	93.55	74.81	50.00
17-Mar	86.39	95.09	69.17	50.00	18-Mar	86.39	95.09	69.16	33.33
17-Apr	87.45	94.03	79.09	50.00	18-Apr	89.50	93.80	76.08	30.01
17-May	89.81	94.99	76.89	50.00	18-May	88.93	96.15	87.00	34.75
17-Jun	85.92	94.7	76.26	33.33	18-Jun	89.56	94.42	86.23	43.60
17-Jul	84.25	91.98	82.38	50.00	18-Jul	89.74	94.54	91.19	44.75
17-Aug	86.78	93.31	82.66	33.33	18-Aug	88.53	95.17	93.68	56.82
17-Sep	86.82	93.87	74.40	33.33	18-Sep	86.82	93.87	74.40	33.33
17-Oct	89.08	93.57	78.56	50.00	18-Oct	88.37	94.86	84.90	41.35
17-Nov	91.00	95.52	82.27	50.00	18-Nov	90.47	94.28	79.70	52.72
17-Dec	86.65	94.62	83.20	50.00	18-Dec	83.96	94.39	80.08	59.60
Average	85.54	94.02	76.67	44.44	Average	87.97	94.49	80.72	44.19

The removal efficiency of COD, as shown in table 7, in 2017 and 2018 varied from 69.8% in January to 91% in November 2017, with an annual average of 85.54%, and from 85.75 in February to 90.47% in November 2018, with an annual average of 87.97%. The removal efficiency of BOD_5 during 2017 and 2018 varied from 92.96 in January to 95.52% in November 2017, with an annual average of 94.02%, and from 93.55 in February to 96.15% in May 2018, with the average of 94.49%. The removal efficiency of $N\text{-}NH_4$ during 2017-2018 varied from 65.9 in January to 83.2% in December 2017, with an annual efficiency of 76.67%, and from 69.16% in March to 93.68% in August 2018 with an annual efficiency of 80.72%. The removal efficiency of TP during 2017-2018 varied from 33.33% to 50%, with an annual average efficiency of 44.44%, and from 30.01% to 59.6%, with an annual efficiency of 44.19%.

During 2018, the efficiency of water treatment was improved for the COD, BOD_5, $N\text{-}NH_4$, and TP compared to 2017, as shown in Figure 7. The removal efficiency of the COD, BOD_5, and $N\text{-}NH_4$ during 2017-2018 is within the standards (Table 1), except for COD during January 2017 where the efficiency was lower than 75%, and $N\text{-}NH_4$ during January, February, and March 2017 and March 2018, which are lower than the standard 70-80%. Total phosphorous removal efficiency is lower than the standard of 80% during all the study period.

Compared with the study of Damo et al. (2010), there is an improvement in the treatment efficiency of the WWTP in Pogradec for all the parameters during 2017 and 2018, except for the total phosphorous.

The improvement of the treatment efficiency for the total phosphorus up to the lower limited value would reduce the concentration of this compound. Figure 7 shows the improvement of removal efficiency of WWTP in Pogradec.

The environmental impact assessment

The evaluation of the non-treated wastewater to Lake Ohrid is done by taking into consideration the qualitative indicators of chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammonia nitrogen ($N\text{-}NH_4$), and total phosphorus (TP). Considering the evaluation scale for the water component (Table 3), the evaluation scores for each indicator of water quality of Ohrid Lake, according to the average value during 2017 are COD - 3, BOD_5 - 2, $N\text{-}NH_4$ - 3, and TP - 4. In this context, the average evaluation score is 3. Accordingly, the average values during 2018 are COD - 3, BOD_5 - 2, $N\text{-}NH_4$ - 2, and TP - 4, and the average evaluation score is 2.75. It can be observed that the main pollutants for water are emissions of ammonium and total P, which seriously affect water quality.

The environmental impact assessment is the quantification of impact by calculating the value of the global pollution index and it's calculated by the alternative method of a global pollution index. So, the evaluation score has the value of 3 (2017), the parameter (b^2) is 9, and the I^*_{GP}=11.11, and for 2018 the evaluation score is 2.75 so the I^*_{GP}=13.22. The wastewater without treatment creates a degraded environment, not proper for life forms. The discharge of untreated urban wastewater on Ohrid Lake is one of the main sources of its pollution.

For the treated water, the evaluation scales during 2017 are COD - 6; BOD_5 - 6; $N\text{-}NH_4$ - 7, and TP - 6. The average of the evaluation scales is 6.25, parameter (b^2) is 39.06, and I^*_{GP}=2.56. The evaluation scales during 2018 are COD - 7; BOD_5 - 6; $N\text{-}NH_4$ - 7 and TP - 6. The average of the evaluation scales is 6.25, parameter (b^2) is 39.06, and I^*_{GP}=2.56.

Based on the results, the wastewater after the treatment process creates a modified environment that causes uncomfortable conditions. The highest impact on water pollution comes from total phosphorus.

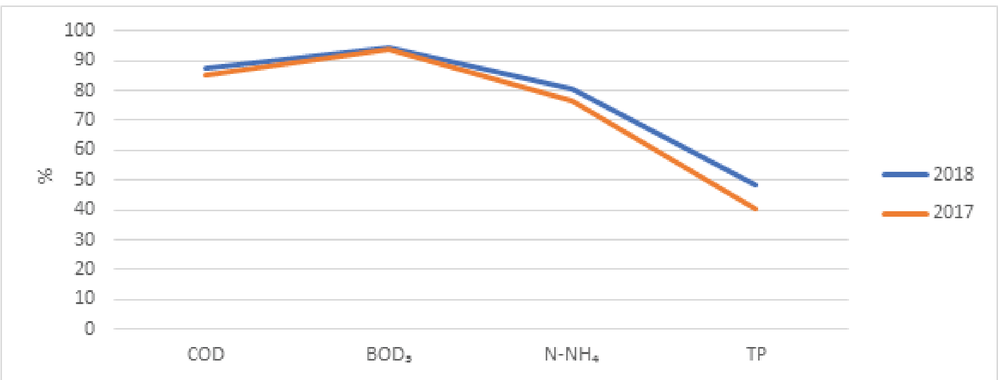

Figure 7. Removal efficiency of COD, BOD_5, $N\text{-}NH_4$ and TP 2017 vs 2018.

CONCLUSION

Ohrid Lake, one of the most ancient lakes in the region and in the world with a wide range of endemic species, has taken considerable attention regarding its environmental state through the years. The results of this study showed that the concentration of contaminants decreased after the treatment. The BOD_5/COD ratio shows that the wastewater is composed mainly of easily biodegradable matter. During the years, the removal efficiency of BOD_5, COD, $N\text{-}NH_{4,}$ and TP was improved. However, the TP treatment efficiency needs improvement to reduce his concentration to the lower limit. The Global Pollution Index for untreated wastewater belongs to the class “F” which corresponds to “the Degraded Environment, not proper for life forms”. The Global Pollution Index for treated wastewater belongs to the class “C” which corresponds to ‘the Environment modified by industrial/economic activities generating discomfort effects”. According to the evaluation degree for the environmental component of superficial water, Ohrid Lake water when discharged untreated wastewater belongs to the Water category ‘Degraded stage 1 and stage 2’, and treated water belongs to the Water category ‘Category III and IV’. The discharge of untreated urban wastewater on Ohrid Lake is one of the main sources of its pollution and has a negative impact on water quality and lake ecosystem. The decrease in contaminants concentration after the treatment suggests that the treatment of wastewater effluents is satisfactory, but it needs some improvement. Therefore, the wastewater treatment plant has a positive impact on the environmental protection of Ohrid Lake

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