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# Performance Evaluation of Skenderaj Wastewater Treatment Plant, Kosova

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**Abstract:** Wastewater treatment is fundamental to preserve the environment and to protect public health, both in urban and rural areas. Poorly treated wastewater with high levels of pollutants creates major environmental problems when discharged to surface water or land. The present study aimed to evaluate performance efficiency of Wastewater Treatment Plant (WWTP) in Skenderaj, Kosova, to assess the effluent and its suitability for discharge into river. Influent and effluent wastewater samples were collected during April 2016 to June 2016. Physico-chemical parameters analysed for evaluation of performance of WWTP were temperature, pH, dissolved oxygen, conductivity, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), PO4-P and N-total. The BOD5, TSS and COD removal efficiency of WWTP in Skenderaj were 98.47%, 78.66% and 32.64 % respectively. The values of temperature, pH, dissolved oxygen, conductivity, TDS, TSS, BOD5, COD, PO4/P and N-total for the final effluent produced from Skenderaj WWTP meet the values determined by the European Union (EU), World Health Organization (WHO) Standards.

***Keywords:*** *Skenderaj WWTP, evaluation, BOD, COD, TSS, TDS, removal efficiency*

## Introduction

Currently, wastewater treatment coverage is low globally and varies among countries depending on technology availability and funding. It is higher in developed countries and low in developing ones. The overall global situation as depicted by United Nations Environmental Program (UNEP) shows that about 90% of the wastewater flow untreated into rivers, lakes and highly reproductive coastal zones (Corcoran *et al*., 2010). The wastewater from domestic and residential premises, industrial wastewater discharges to sewers, the rainwater and from urban area draining to sewers would have significant adverse impact on the water environment. Without treatment the wastewater produced every day would cause significant damage to the environment and create a potential health risks. It may cause the chronic ecosystem damage due to oxygen depletion of receiving water from the biodegradation of organic matter, ecosystem damage of eutrophication of water resulting from excessive input of nutrients present in waste water, potential health risk from water borne pathogens (Templeton & Botler, 2011).

Wastewater treatments are designed to remove the various contaminants of sewage such as solids, pathogens, nutrients, toxic chemicals and all other compounds dangerous to wildlife and humans. A typical WWTP consists of a series of unit processes including primary treatment, biological secondary treatment, occasional tertiary treatment and sludge treatment. The removal of impurities present in wastewater in the form of suspended solids, organic substances, and nutrients and removal of pathogens are some of the basic purposes of wastewater treatment. In case an effective treatment is performed, treated wastewater can be returned to the environment or, after a further treatment, can be reused for agricultural uses (Qadir *at al*., 2009). The treatment of wastewater is important to prevent pollution of the environment and water bodies. The amount of collected and treated wastewater is likely to increase considerably with population growth, rapid urbanization, and improvement of sanitation service coverage (Tchobanologous *et al*., 2003).

One of the commonly environmental problems in Kosova is direct discharge of untreated wastewater into rivers and represents one of the main polluters of surface waters. The wastewater Treatment Plant in Skenderaj is the only one wastewater treatment Plant in Kosova. The WWTP

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receives domestic and industrial wastewater. It is a mechanic/biologic WWTP for removal of the organic matters BOD5 and COD by IMMHOFF-Tank and trickling filter with simultaneous aerobic sludge stabilization. The objective of this research was to evaluate wastewater characteristics in order to evaluate performance efficiency of wastewater treatment plant (WWTP) in Skenderaj, to assess the effluent (treated) wastewater produced from WWTP and to evaluate its suitability for discharging into river.

## Material and Methods

### *Plant description*

In Kosova a large proportion of wastewater is discharged into rivers with little or no treatment and represents one of the main polluters of surface waters. The only plant to treat wastewater is treatment plant for wastewater in Skenderaj (figure 1). The Skenderaj Wastewater Treatment Plant under study is located in village Llaushe, the Skenderaj municipality, and situated at the geographical coordinates of 42.7296° N, 20.7710° E. It has started the work on August 2011. This plant treats wastewater for 10,000 inhabitants, entire Skenderaj municipality.

**Figure 1**. Wastewater treatment plant in Llaushe, Skenderaj, Kosova

The wastewater treatment plant comprises: intake pump station, compact unit with screens, an aerated grit and grease chamber, Immhoff-Tank, trickling filter, secondary settling tank. Sludge treatment comprises: sludge treatment by cold digestion in Imhoff-Tank, gravity thickening and sludge drying beds. The final effluent is discharged into the Klina River.

### *Physico-chemical analysis*

Influent and treated wastewater samples from Skenderaj Wastewater Treatment Plant were collected during April 2016 to July 2016. Influent wastewater samples were collected using clean polyethylene containers. Whereas treated wastewater samples were collected from the treatment plants just before discharged into river. Before sampling, the bottles were rinsed three times with sample water before being filled with the sample. The wastewater characteristics included the determination of temperature, pH, dissolved oxygen, conductivity, total dissolved solids, total suspended solids, biochemical oxygen demand, chemical oxygen demand, PO4-P and N-total following APHA (2005) procedures. The temperature, pH, electrical conductivity (EC), dissolve oxygen (DO) and total dissolved solid (TDS) were determined at the time of sampling in the field using field water analysis apparatus. Samples were analysed immediately after collection at the Skenderaj WWTP Laboratory. Total Suspended Solid (TSS) was determined by gravimetric method (dried at $103^0$C). BOD5 was measured using OxiTop Systems based on the measurement of pressure (ISO 6060). Chemical oxygen demand (COD), PO4/P, and N-total were measured by spectrophotometer AQUANAL-professional SPECTRO 1000.

Efficiency of municipal wastewater treatment plant was evaluated by removal of nutrients and organic load measured as biological oxygen demand (BOD). Treatment efficiency was calculated as the percentage of removal for each parameter as follows:

$$\text{Removal efficiency} = \frac{C_{in} - C_{ef}}{C_{in}} \text{ x } 100$$

where $C_{in}$ and $C_{ef}$ are the influent and effluent concentrations.

## Results and Discussion

The minimal, maximal and mean values as well as the removal efficiency of each water quality parameter considered for both influent and effluent wastewater samples collected from Skenderaj WWTP are presented in table 1. The obtained results have been compared with European Commission (EC, 1991) and World Health Organization, WHO (2006) standards.

**Table 1**. Wastewater characteristics and removal efficiency of Skenderaj Wastewater Treatment Plant

| Parameters | Influent | | Effluent | | % Removal |
|---|---|---|---|---|---|
| | Range | Mean | Range | Mean | |
| Temperature, °C | 15.15-17.83 | 17.03 | 15.55-18.45 | 17.44 | |
| pH | 7.65-7.84 | 7.72 | 7.99-8.18 | 8.08 | |
| DO, mg/l | 0.98-2.77 | 1.59 | 3.93-6.05 | 4.87 | |
| Conductivity, μS/cm | 180.4-208.6 | 199.03 | 175.82-198.57 | 190.7 | 4.19 |
| TDS, mg/l | 88.99-106.4 | 99.84 | 87.67-99.96 | 95.29 | 4.55 |
| TSS, mg/l | 32.15-43.47 | 37.8 | 7.71-8.73 | 8.06 | 78.66 |
| BOD5, mg/l | 37.40-42.20 | 39.8 | 0.58-0.64 | 0.61 | 98.47 |
| COD, mg/l | 88.05-89.7 | 88.82 | 54.50-67.30 | 59.83 | 32.64 |
| PO4/P, mg/l | 3.28-4.81 | 4.23 | 2.16-2.83 | 2.59 | 38.70 |
| N-total, mg/l | 14.00-16.22 | 15.48 | 8.2-10.92 | 9.68 | 37.45 |

The temperature of the wastewater is a very important parameter as it affects the rate of both the chemical and biological treatment. Wastewater temperature is one of the most important physical factors which influence the growth, reproduction and other biological activities of all aquatic organisms (Metcalf & Eddy, 2004). Temperature affects the solubility of oxygen in water. Warm water holds less oxygen that cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic invertebrates or certain fish. Some compounds are also more toxic to aquatic life at higher temperatures.

The temperature of the influent wastewater ranged from 15.15 to 17.83 °C with a mean temperature of 17.03 $^0$C. The effluent temperature ranged from 15.55 to 18.45 °C with a mean value of 17.44 °C, which are within the recommended standard limits. There was no significant change in temperature from the influent to the final effluent. Water temperatures in this study were found to be lower compared to EU (1991), permissible limit. Based on these guidelines, the temperature of the effluent does not appear to pose any threat to the homeostatic balance of the receiving water bodies; neither will it adversely affect the use of the receiving watershed for irrigation purposes.

The pH of wastewater samples is a measure of the concentration of hydrogen ions. All micro-organisms have an optimum pH at which they grow best. Since most microbial life occur within a narrow pH range (typically 6-9), the hydrogen-ion concentration is of great concern in relation to biological treatment. The pH directly affects the performance of a secondary treatment process (Metcalf & Eddy, 2004) because the existence of most biological life is dependent upon narrow and critical range of pH. Influent water with exceptional high or low pH-values can be hard to treat by biological means. Effluent water may also affect the pH of the natural waters in the recipient. The influent samples analysed were slightly alkaline and ranged from 7.65 to 7.84 with a mean value of 7.72. The effluent wastewater was also alkaline and ranged from 7.99 to 8.18 with a mean value of 8.08. The EU sets pH protection limits of 6.0 to 9.0 for fisheries and aquatic life. This suggests that the effluent may not negatively impact on the usefulness of the receiving watershed for domestic, fishery, and recreational purposes with reference to pH standards.

For water quality variable such as dissolved oxygen (DO), water quality criteria are set at the minimum acceptable concentration to ensure the maintenance of biological function. The analysis of

DO is a key test in water pollution control activities and wastewater treatment process control. Dissolved oxygen concentrations in unpolluted water normally range between 8 and 10 mg/l and concentrations below 5 mg/l adversely affect aquatic life (Rao, 2005). DO standard for drinking purpose is 6 mg/L whereas for sustaining fish and aquatic life is 4-5 mg/L (Rao, 2005). Dissolved oxygen is essential for all kinds of aerobic life forms. In aerobic biological wastewater treatment, dissolved oxygen in the water is required for bacterial respiration. The comparison of DO concentration before and after biological treatment steps are thus of great interest, since it indicates the rate of biological activity within the treatment unit. The DO of the influent ranged from 0.98 to 2.77 mg/l with a mean of 1.59 mg/l while the DO of the effluent ranged from 3.93 to 6.05 mg/l with a mean of 4.87 mg/l. The mean DO values of the influent did not meet the WHO limits of 5-14 mg/l, while the mean DO values of the effluent was slightly lower that the acceptable limit (≥5 mg/L).

Electrical Conductivity (EC) is the ability of water to conduct electrical current. This depends on the ionic strength of the water sample. Conductivity increases as the concentration of ions increases, since electrical current is transported by ions in solution. The EC is a valuable measure of the amount of metal ions dissolved in wastewater and water. Conductivity is also a good measure of salinity in water. EC is an important parameter in assessing water quality for drinking and irrigation purposes. The conductivity of the influent ranged from 180.40 to 208.6 μS/cm with a mean value of 199.03 μS/cm. The conductivities of the effluent ranged from 175.82-198.57 μS/cm with a mean value of 190.7 μS/cm. The mean overall removal efficiency was 4.19 %. The mean conductivity values for both the influent and the effluent satisfied the WHO (2006) guideline of 1500 μS/cm. The low conductivity levels may be attributed to low concentrations of dissolved ions present in the raw wastewater.

Total Dissolved Solids (TDS) are a measurement of inorganic salts, organic matter and other dissolved materials in water. TDS includes positive and negative ions, such as dissolved chloride, sulphate, phosphate, carbonate, bicarbonate, sodium, calcium, magnesium, potassium and other inorganic and organic matter. They can be naturally present in water or the result of mining or some industrial or municipal treatment of water. TDS are critical contaminants commonly used as general indicators of salinity. TDS cause toxicity through increases in salinity, changes in the ionic composition of the water, and toxicity of individual ions. Salinity affects the beneficial reuse of effluent for irrigation and can also impact the quality of fresh water streams. A high salt content in water can increase the salinity of the soil and hence affect the growth and productivity of plants and/or crops (Tjandraatmadja & Pollard, 2006). The TDS concentration of the influent wastewater ranged from 88.99 to 106.40 mg/l with a mean value of 99.84 mg/l. The TDS levels of the effluent ranged from 87.67 to 99.96 mg/l with a mean of 95.29 mg/l. The mean overall TDS removal efficiency was calculated to be 4.55%. The TDS results from this study were all below the EU (1991) and WHO (2006) standards. The percentage reduction in total dissolved solids of 4.55%, is much below the expected removal of 70-80% indicating poor efficiency in terms of total dissolved solids removal. Figure 2a shows the variation of suspended solids from the inlet and outlet of Wastewater treatment plant.

Total Suspended Solid (TSS) is a very important quality parameter in wastewater treatment. High concentrations of suspended solids can cause many problems for stream health and aquatic life. The discharging of effluents with high levels of suspended solids can cause sludge deposition and create anaerobic conditions in the receiving water body (Metcalf & Eddy 2004). High TSS can also cause an increase in surface water temperature and cause dissolved oxygen levels to fall, which can harm aquatic life in many other ways. TSS values are widely used to determine treatment efficiency for conventional treatment processes and to assess the need for effluent filtration in the case of reuse applications (Tchobanoglous *et al*., 2003). Total Suspended Solid of influent samples ranged from 32.15 to 43.47 mg/l with a mean value of 37.80 mg/l. The effluent TSS ranged from 7.71 to 8.73 mg/l with a mean value of 8.06 mg/l (figure 2b). The TSS results from this study were all below the EU (1991) and WHO (2006) standards. The mean overall removal efficiency of the plant was 78.66% which is relatively high but is below the expected value of 85-90 % (EU, 1991).

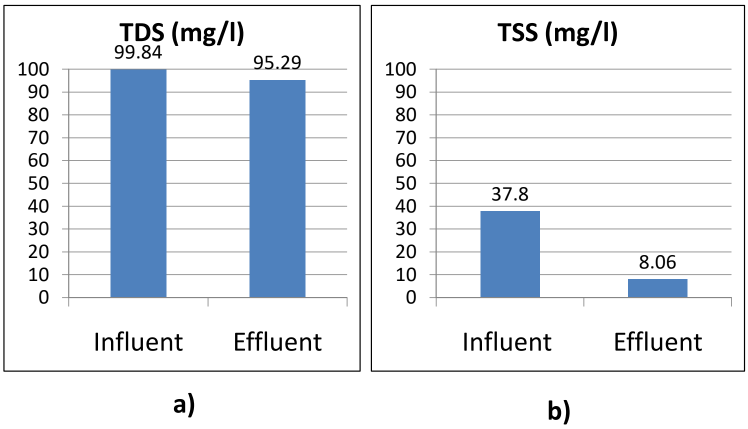



**Figure 2.** The mean values of influent and effluent wastewater TDS (a) and TSS (b) concentrations

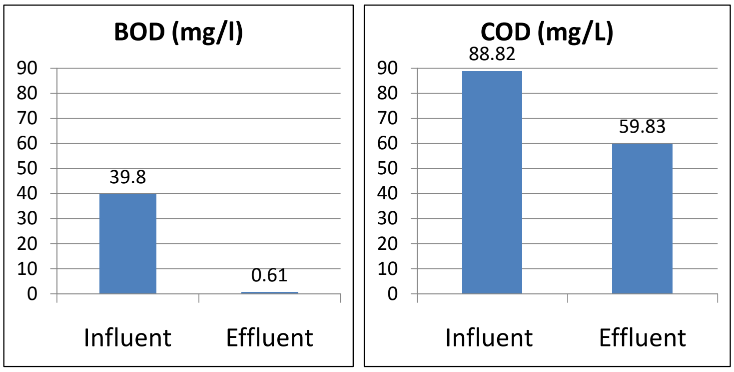
Biochemical Oxygen Demand (BOD) is the rate at which microorganisms use the oxygen in wastewater while stabilizing decomposable organic matter under aerobic conditions. In decomposition, organic matter serves as food for the bacteria and energy results from this oxidation. Biochemical oxygen demand does not actually indicate water quality but potential for removing oxygen from water. High BOD means that there is less of oxygen to support life and indicates organic pollution. BOD5 is the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter. During the five-day period of a BOD test, the bacteria oxidize mainly the soluble organic matter present in the water. Very little oxidation of the solid (insoluble) matter occurs in that short time (Delzer & McKenzi, 2003). The higher values of BOD5 means present of more biodegradable organic matter. Effluents high in BOD can deplete oxygen in receiving waters, causing fish kills and ecosystem changes (Hach *at al*., 1997).

The BOD test is used to measure waste loads to treatment plants, determine plant efficiency (in terms of BOD removal), and control plant processes. It is also used to determine the effects of discharges on receiving waters. The influent BOD concentration ranged from 37.40 to 42.20 mg/l with a mean load of 39.80 mg/l whereas the effluent BOD concentration ranged from 0.58 to 0.64 mg/l with a mean load of 0.61 mg/l. The results obtained in the study are in agreement with the Council Directive 91/271 ECC guideline of 25 mg/l. The mean influent wastewater BOD5 concentration and mean effluent (treated) wastewater BOD5 concentration are shown in figure 3a. However, the mean BOD removal efficiency was found to be very satisfactory 98.47%, against the expected value of 85-90 % by Council Directive 91/271 ECC concerning urban wastewater treatment.

The Chemical Oxygen Demand (COD) is the amount of oxygen required to oxidize both organic and oxidisable inorganic compounds. It is a measure of the concentration of the contaminants in the water that can be oxidised by a strong chemical oxidizing agent (dichromate) in the presence of a catalyst and strong acid. Some organic substances can be oxidized chemically, but are harder to oxidise biologically. COD test is used to measure the total organic content in water. It is normally measured in both municipal and industrial wastewater treatment plants and gives an indication of the efficiency of the treatment process. COD is commonly used to indirectly measure the amount of organic compounds in wastewater by measuring the mass of oxygen needed for their total oxidation to carbon dioxide. COD measures biodegradable and non-biodegradable organic matter of wastewaters. As a result, COD values are greater than BOD values and may be much greater when significant amounts of biologically resistant organic matter are present (Sawyer & McCarty, 1978). The COD levels of the influent wastewater samples ranged from 88.05 to 89.70 mg/l with a mean value of 88.82 mg/l, while the effluent COD levels ranged from 54.55 to 67.30 mg/l with a mean value of 59.3 mg/l (figure 3b). COD concentrations fell within acceptable limits of EU (1991) and WHO (2006) standards therefore it presents no risk for effluents to be discharged into surface waters. However the mean overall removal efficiency was 32.64%, which is below the expected value of 75% (EU, 1991).

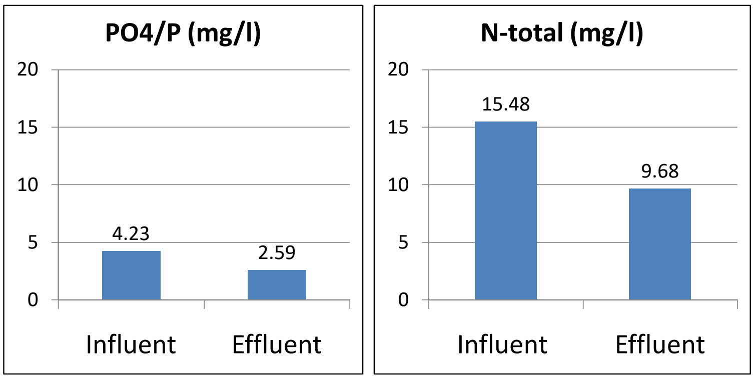
Phosphate-Phosphorus (PO4-P), Phosphorus is found in wastewater in three principal forms: orthophosphate ion, polyphosphates or condensed phosphates and organic phosphorus compounds. Organically bound phosphorus originates from body and food waste and, upon biological decomposition of these solids, is converted to orthophosphates. Polyphosphates are used in synthetic detergents, and used to contribute as much as one-half of the total phosphates in wastewater. Polyphosphates can be hydrolysed to orthophosphates. The principal form of phosphorus in wastewater is assumed to be orthophosphates, although the other forms may exist. Orthophosphates consist of the negative ions $PO_4^{3-}$, $HPO_4^{2-}$, and $H_2PO_4^-$. Other sources of phosphorus aside human waste include animal wastes, industrial waste, soil erosion and fertilizers. Controlling phosphorous discharged from municipal and industrial wastewater treatment plants is a key factor in preventing eutrophication of surface waters. The microorganisms can accumulate large quantities of up to 20% their mass of phosphorus in their cells. They utilise phosphorus during cell synthesis and energy transport. As a result, 10 to 30 percent of the influent phosphorus is removed during traditional mechanical/biological treatment (Metcalf & Eddy, 2004).

The phosphate-phosphorus ($PO_4$-P) concentration of the influent samples ranged from 3.28 to 4.81 mg/l with a mean concentration of 4.23 mg/l while effluent concentrations ranged from 2.16 to 2.83 mg/l with a mean value of 2.59 mg/l. The mean phosphate concentration of the final effluent was less compared to the EU (1991) and WHO (2006) guidelines. The mean overall phosphate removal efficiency of the WWTP was 38.70%. The average values of the influent to effluent PO4-P concentration are presented in the figure 4.a.




a) b)

**Figure 3.** The mean values of influent and effluent wastewater BOD5 (a) and COD (b) concentrations




a) b)

**Figure 4.** The mean values of influent and effluent wastewater PO4-P (a) and N-total (b) concentrations

Raw domestic wastewater normally holds a large fraction of nitrogen, either as organically bonded nitrogen or in inorganic forms such as ammonium ($NH_4^+$), nitrite ($NO_2^-$) or nitrate ($NO_3^-$). The term total nitrogen refers to the sum of the organic and inorganic compounds of nitrogen. Urea and proteins are normally the main contributors to the nitrogen content in raw wastewater. Nitrogen is an essential nutrient for the growth of microorganisms, plants and animals. Since it is an essential building block in the synthesis of protein, it is a necessity in biological treatment processes. The content of nitrogen in the effluent of wastewater cause an environmental concern, as it contributes to eutrophication (Tchobanoglous *et al*., 2003). On the other hand, if reuse of the wastewater effluent for irrigation is desirable, the nitrogen content should be conserved as it makes an important nutrient for this purpose. The N-total concentrations of influent ranged from 14.00 to 16.22 mg/l and that of the effluent ranged from 8.2 to 10.92 mg/l. The mean influent N-total concentration was 15.48 mg/l, whilst the mean effluent was 9.68 mg/l. The average values of the influent to effluent N-total concentration are presented in figure 4.b. The mean N-total concentration of the final effluent was found to be less than the EU (1991) and WHO (2006) guidelines therefore it presents no risk for effluents to be discharged into surface waters. However the mean overall removal efficiency was 37.45% which is below the expected value of 70-80% (EU, 1991).

***Determination of contaminant biodegradability BOD5/COD***

The ratio BOD5/COD in the raw effluent cannot be used as an operative parameter for the wastewater treatment, but gives a rough indication of biodegradability (Mantzavinos *et al*., 1996). BOD5/COD ratios before treatment of <0.2 indicate relatively un-degradable organic substances, ratios between 0.2 and 0.4 indicate moderately to highly degradable organic substances, and ratios of >0.4 indicate highly degradable organic substances. Wastewater treatment plants treat wastewaters with BOD5/COD ratios in influent >0.4 indicate wastewaters with highly degradable organic substances. Low BOD/COD values (usually less than 0.1) indicate their resistance to conventional biological treatment (Koch *et al*., 2002).

The mean ratio of BOD5/COD in the influent samples was 0.448, which indicates highly degradable organic substances. While mean ratio BOD5/COD in the effluents was found to be 0.012, which means relatively un-degradable organic substances and indicate their resistance to conventional biological treatment. This is owing to the fact that biodegradable fraction of the waste decreases through the biological treatment whereas the non-biodegradable fraction remains unchanged (Horan, 1990). In view of its simplicity and rapidity, the COD test is the most suitable assay for the determination of the strength of both raw and treated wastewater. The COD test is rarely used in effluent discharge control, but primarily in assessing the strength industrial effluents (Tchobanoglous & Schroeder, 1999). It is worth mentioning here that the numeric value of the COD removal efficiency is less than the BOD because of the non removal of the non-degradable fraction of the COD.

**Conclusion**

From the obtained results of physicochemical analysis of Skenderaj Wastewater Treatment Plants, it was concluded that temperature, pH, DO, EC, TDS, TSS, BOD5, COD, PO4/P, and N-total were within the permissible limit standards values prescribed by EU and WHO. The effluent fell within the recommended quality standards therefore it presents no risk and can be discharged in to the nearby water body or soil without further treatment. The mean ratio of BOD5/COD in the raw influent was 0.448, which indicates highly degradable organic substances. While mean ratio BOD5/COD in the effluents was found to be 0.012, which means relatively un-degradable organic substances and indicate their resistance to conventional biological treatment. The value of the COD removal efficiency is less than the BOD because of the non-removal of the non-degradable fraction of the COD. The overall efficiency of the WWTP was in the order TDS < COD < N-total < PO4/P < TSS < BOD5. The performance studies on the Skenderaj Wastewater Treatment Plants indicated a positive efficiency of the system only for BOD5, while the other parameters were lower that the permissible standards of EU, Urban Wastewater Treatment Directive. In order to achieve better performance, the trickling filter operation should maintenance of a good growth of microorganisms on the filter media.

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