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Evaluation of Drinking Water Quality in Al Wahda Treatment Plant in Baghdad City- Iraq

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ABSTRACT

This study aims to evaluate drinking water quality at the Al Wahda plant (WTP) in Baghdad city. A conventional water treatment plant with an average flow rate of 72.82 MLD. Water samples were taken from the influent and effluent of the treatment plant and analyzed for some physicochemical and biological parameters during the period from June to November 2020. The results of the evaluation indicate that treated water has almost the same characteristics as raw water; in other terms, the plant units do not remove pollutants as efficiently as intended. Based on this, the station appears to be nothing more than a series of water passage units. However, apart from Total dissolved solids, the mean values of all parameters in the study were of acceptable quality in accordance with World Health Organization (WHO) guidelines.

Keywords: Drinking water, Treatment plant, Tigris river.

تقييم جودة مياه الشرب في محطة معالجة الوحدة في بغداد–العراق

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الخلاصة

تهدف هذه الدراسة إلى تقييم جودة مياه الشرب في محطة الوحدة (WTP) في مدينة بغداد. محطة معالجة مياه تقليدية بمتوسط معدل تدفق يبلغ 72.82 مليون لتر/ يوم. تم أخذ عينات من المياه المتدفقة من محطة المعالجة وتم تحليلها لبعض العوامل الفيزيائية والكيميائية والبيولوجية خلال الفترة من يونيو إلى نوفمبر 2020. تشير نتائج التقييم إلى أن المياه المعالجة لها نفس خصائص المياه الخام تقريبًا؛ من ناحية أخرى، فإن وحدات المحطة لا تقوم بإزالة الملوثات بكفاءة على النحو المنشود. بناءً على ذلك، يبدو أن المحطة ليست أكثر من سلسلة من وحدات مرور المياه. ومع ذلك، كانت القيم المتوسطة لجميع المعلمات في الدراسة ذات جودة مقبولة وفقًا لإرشادات منظمة الصحة العالمية (WHO)

الكلمات الرئيسية: مياه الشرب، معالجة المياه، نهر دجلة.

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1. INTRODUCTION

Against the global water crisis, the pressure to produce drinking water is more than ever. There is a great requirement for high water quality because it influences public health, microbial components, and also the effects on aquatic life **(Alver, 2019)**. According to WHO statistics, water pollution is responsible for 80% of human diseases. **(Zhang et al., 2018)**

The main purpose of water treatment plants (WTPs) is to supply the customers with clean and safe water free of microorganisms. As there is no single water treatment plant expected to remove the contamination in water under all conditions, monitoring and to evaluate water treatment plant performance is required. There is a need to investigate the operational status of WTPs to find the best possible mechanism for ensuring proper drinking water production and its management. Evaluation of the performance gives a better understanding of the difficulties in the design and operation of WTPs. Also, the conclusions withdrawn from these evaluations highlight the modifications that may determine the required recommendation for continuous operation and design schemes. **(Burile** and **Nagarnaik, 2010)**

The disposal of hazardous waste into rivers may have an adverse effect on the environment. The Tigris river serves as excellent disposal for some riverbank communities and farmers.

The design and operation of the water treatment plant are based on, among other factors, the chemical, physical and microbiological characteristics of its source water. Drinking water treatment plants respond to water quality declines within design limits by altering treatment methods (for example, chemical dosing, etc.) to meet potable water standards and performance targets. Abrupt declines in water quality caused by algae blooms or the presence of cyanobacteria can sometimes result in temporary plant shutdowns, increasing drinking water capital assets, which, in turn, can lead to a decrease in consumer welfare. It is essential to examine the variation of raw water quality because such variation affects the water treatment's efficiency and, thus, the health risk associated with the finished water. **(Henry, 2013, KDHE, 2011**)

In this study, the physicochemical and biological parameters have been examined in raw water and drinking water samples taken for six months with the objective of comparing the parameters analyzed to the WHO requirements to determine their contribution in affecting the quality of the river.

2. Material and Methods

2.1 Processes description

Al-Wehda is a conventional water treatment plant located in Al-Karrada, in the southern part of Baghdad, between 33°17'35.4 "N latitude and 44°26'42.7" E longitude. It is located on the Tigris River's eastern bank near the General Company for Vegetable Oils at Almusbah Street's entrance. It comprises two integrated treatment systems of a conventional type: the first line and the second line placed in service between 1951 and 1958. In keeping an eye on the region's growth and serving the customers more effectively and efficiently, the entire project was rehabilitated and expanded in 2006. The rated capacity of WTP grew from 50 MLD to 72.82 MLD. Such expansion had offered the city greater operational flexibility to supplement reduced production from other water treatment facilities to service requirements with increased output from the WTP. Also, the expansion improved the capability of the City and the WTP to sustain peak production flows.

2.2 Collection of Water Samples:

The samples were taken from the plant intake on the river to determine the concentrations of temperature (Temp) pH, turbidity, alkalinity, total hardness (TH), calcium (Ca^{+2}), magnesium

(Mg^{+2}), total dissolves solids (TDS), electric conductivity (EC), chloride (Cl^{-}), sulfate (SO_4^{+2}) dissolved oxygen (DO), and biological oxygen demand (BOD)

The second sample point was from the treated water line, as shown in **Fig. 1**.

The samples were collected every week from June to November. The samples were taken five centimeters below the water surface (to minimize the contamination of the water sample by surface films). As soon as the samples were collected, they were transported immediately to the laboratory for testing. The sampling and analysis were conducted according to the standard methods **(APHA, 2012).**

Figure 1. Samples location at Al-Wehda water treatment plant. **(Google Earth, 2021).**

3. RESULTS and DISCUSSION

All studied variables mean and standard deviation values are presented in **Table 1**.

Table 1. Descriptive statistics of raw water and treated water.

Descriptive Statistics		(Mean±S.D)		WHO, 2011
	Unit	Raw water	Treated water	
Temperature (Temp)	**C°**	28.39± 0.42	28.89± 0.39	20
PH	-	7.90± 0.02	7.23± 0.02	6.5-8.5
Turbidity	**(NTU)**	41.73±2.57	3.72± 0.16	5

Alkalinity	**(mg/l)**	152.46± 3.54	144± 0.64	150
Total Hardness	**(mg/l)**	337.81± 20.92	314.19± 18.67	500
Calcium	**(mg/l)**	94.15± 8.51	81.69± 1.7	200
Magnesium	**(mg/l)**	25.15± 0.54	23.15± 1.08	150
Total Dissolves solids	**(mg/l)**	572.35± 14.76	541.62± 14.9	500
Electric conductivity	**(µs/cm)**	722± 79.23	707.46± 79.84	1000
Chloride	**(mg/l)**	54.92± 10.34	50.57± 10.61	250
Sulfate	**(mg/l)**	239.31± 38.71	231.74± 38.71	250
Dissolved oxygen	**(mg/l)**	6.51± 0.59	5.78± 0.86	4
Biological oxygen demand	**(mg/l)**	4.64± 0.76	3.88± 0.69	5

3.1 Water Temperature and pH

At the time of evaluation, the temperature of raw water observed varied from 16 to 37ºC. **Fig. 2** indicated that nearly all water samples had temperature values, not within the standard limitation recommended by the WHO. Temperature is a significant parameter because it has an impact on the chemistry of water. At higher temperatures, the rate of chemical reactions tends to increase **(Eugster, 1986)** The pH values were within the permissible level set by WHO, varying between 7.81 to 7.93 for raw water and between 7.2 to 7.27 for drinking water, as in **Fig. 3**.

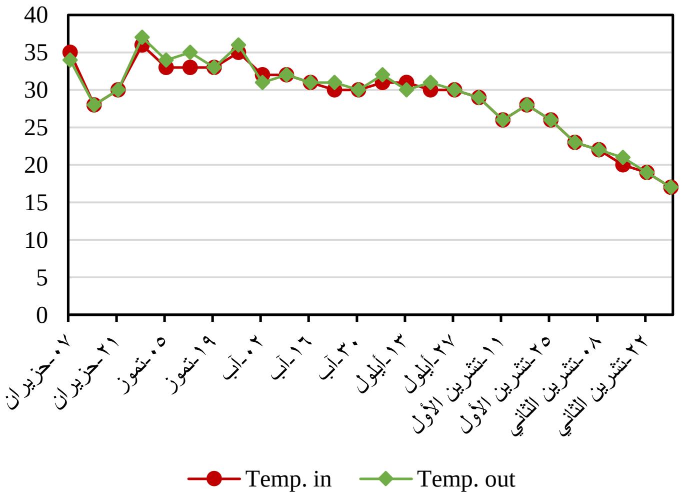

Figure 2. Temperature variation of raw water and treated water.

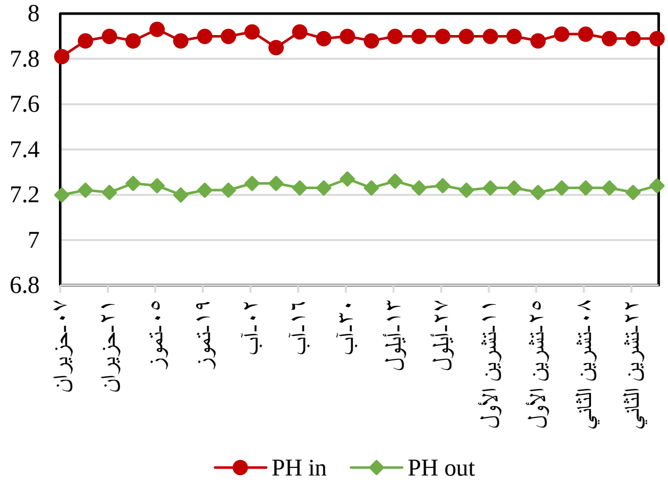

Figure 3. pH variation of raw water and treated water.

3.2 Turbidity

Turbidity showed a wide range of fluctuations along the studied period, as in **Fig. 4**. Turbidity is a measurement that reflects the transparency of water. Sediment, mostly clay and silt, lies on the top of the substances causing turbidity in the Tigris river. Also, it is caused by organic matter from sewage discharges during vegetable oil plant bypasses and algae that grow with nourishment from nutrients entering the stream through leaf decomposition or other naturally occurring decomposition processes. The passage of turbidity spikes from the raw through the finished water appears related to changes in raw water quality, which indicate a lack of process control skills and exposes the plant to a risk of pathogens passing through the treatment barriers.

The increase and decrease in turbidity levels in drinking water depend on the contents of the river water in terms of the material causing turbidity, the age of the project, the efficiency of operation and maintenance of the project, as well as the water consumption by citizens in quantities more than the productive capacity of the project as the water does not have sufficient time to stagnate in the sedimentation basins or use low-quality Alum **(Hassan** and **Mahmood, 2018)**. This all agreed with a study conducted by **(Al-Fatlawy, 2007)** who indicated that the Al-Wehda project has the least filtration efficiency than the rest of Baghdad's WTPs.

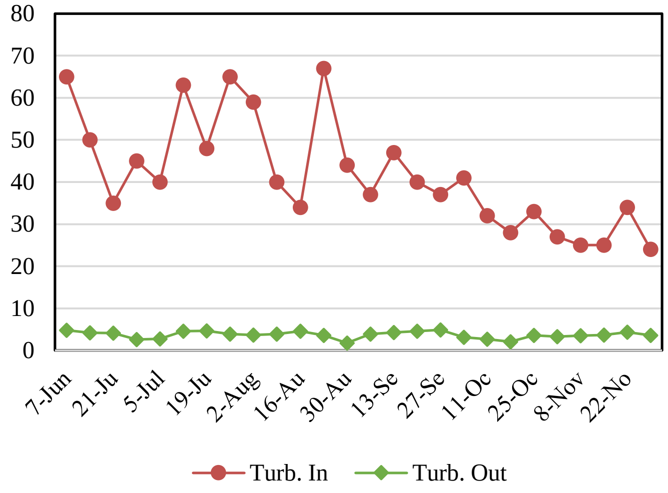

Figure 4 . Turbidity variation in raw water and drinking water**.**

3.3 Alkalinity

The alkalinity value ranged between 144-156 and 136-150 mg/l for raw and treated water, respectively. The average alkalinity of treated water was within the WHO recommended limitations. **Fig. 5** below shows a decrease in treated water alkalinity caused by the consumption of the treatment chemicals that are utilized. The operators at the water treatment plant used Aluminum Sulfate as a coagulant, which consumes 0.51 mg/L of $CaCO_3$ of alkalinity per mg/L of chemical. **(Hart, 2007)**

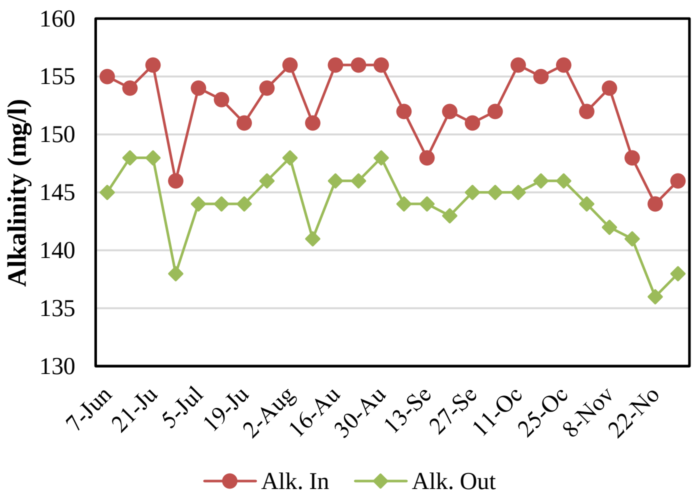

Figure 5. Alkalinity variation of raw water and treated water.

3.4 Total hardness

The average total hardness of the raw and treated water was 337.81 and 314.19 mg/l, respectively. The outcomes are consistent with WHO standards. Although hard water does not pose a health risk, dealing with it can be quite a nuisance. The hardness of drinking water is important for consumer aesthetics, as well as economic and operational considerations. Hard water requires more soap and synthetic detergents for home laundry and washing and contributes to scaling in boilers and industrial equipment **(ASAE and WQA, 2016)**. Hard water is softened for those reasons using several applicable technologies, such as water softeners or a mechanical ion exchange softening unit. **(WHO, 2010)** The absence of these technologies at Al-Wehda WTP makes treated water have close value to raw water, as stated in **Fig. 6**.

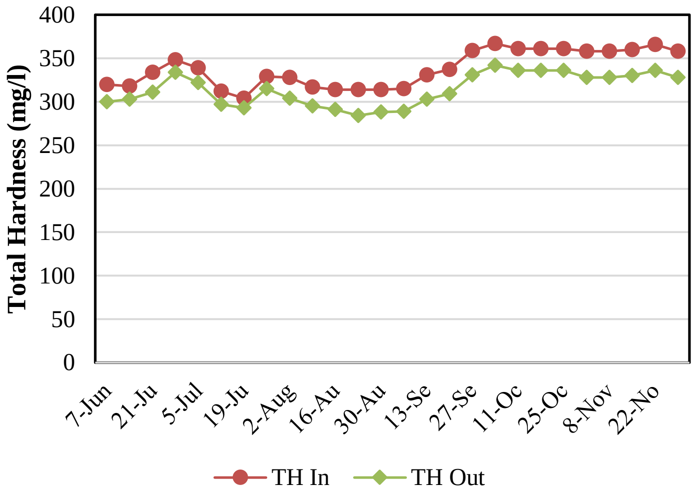

Figure 6. Total hardness variation in raw water and treated water.

3.5 Calcium and Magnesium

The calcium concentration in the inlet water ranges between 82-110 mg/l, as shown in **Fig. 7**, while the calcium concentration in the outlet water ranges between approximately 78-97 mg / l. The decrease in temperature enhanced the solubility of CO_2 in water and forms carbonic acid, which helps dissolve calcium salts **(Skipton et al., 2004)**. For magnesium, the average recorded was 23.15 and 25.15 mg/l, for both raw water and treated water, respectively, as shown in **Fig. 8**. Magnesium and calcium from raw to treated water had almost the same values, and the reason refers to the absence of chemical treatment that removes dissolved pollutants from raw water.

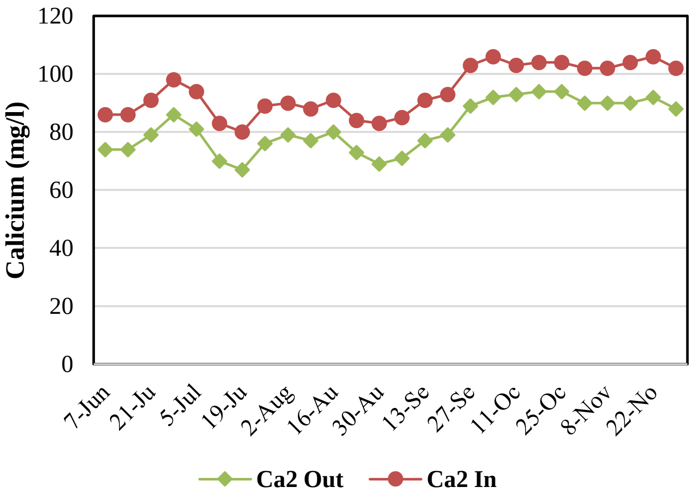

Figure 7 .Ca^{+2} of raw water and treated water.

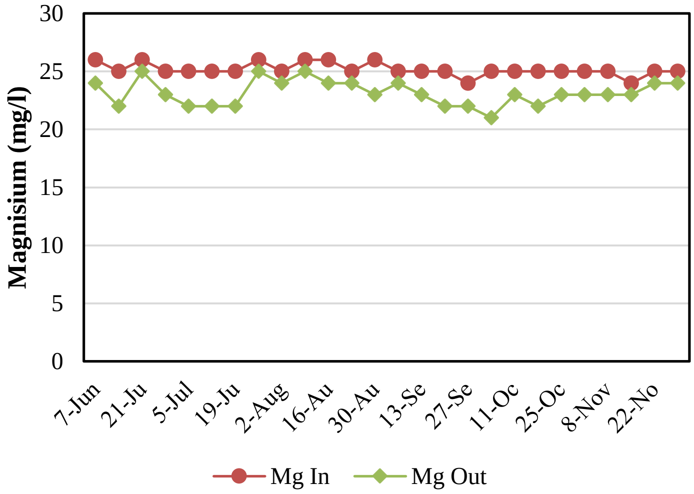

Figure 8. Mg^{+2} of raw water and treated water.

3.6 Total dissolved solids

The average value of total dissolved solids ranged from 572.35 mg/l to 541.62 mg/L after treatment. The average value of the total dissolved solids results has exceeded the WHO permissible limits. TDS (total dissolved solids) are salts and minerals that are dissolved in water (mg/l) and can not be removed by conventional filtration **(Fernández et al. 2004).** Water with a high dissolved solids content can be laxative or constipating. **Fig. 9** depicts an increase in TDS as the temperature rises. The chemistry of water is influenced by temperature. At higher temperatures, the rate of chemical reactions tends to increase. More minerals from the surrounding rock can be dissolved by water at higher temperatures. **(Pei-Yue et al., 2010)**

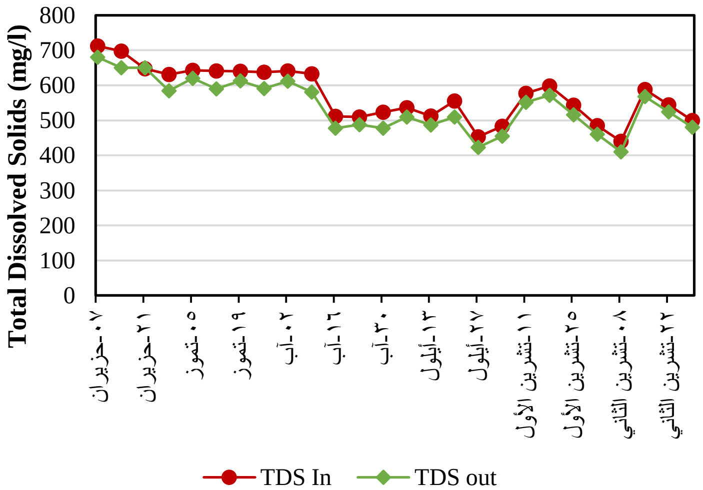

Figure 9. Total dissolved solids variation in raw water and drinking water.

3.7 Electrical conductivity

For raw water, the maximum value of EC was 886 μs/cm, while the minimum recorded value was 590 μs/cm. For drinking water, the highest value for electric conductivity was 874 μs/cm, while the minimum value was 579 μs/cm. **Fig. 10** shows an increase in the EC with increasing temperature. An increase in a water's temperature will cause a decrease in viscosity and increase the ions' mobility in the water. An increase in temperature may also cause an increase in the number of ions in the water due to the molecules' dissociation. As a result, there will be an increase in the conductivity of the water **(Soni, 2017)**. The electrical conductivity of raw water was not reduced through the sequence treatment processes. There was very little change in electrical conductivity values between raw and treated water.

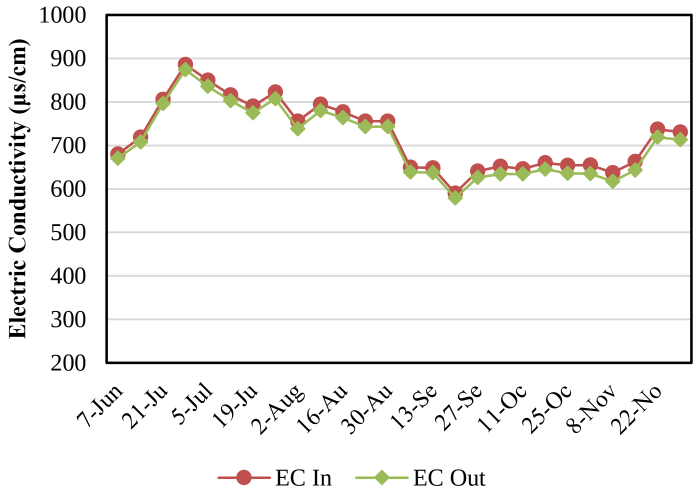

Figure 10. Electric conductivity variation in raw and treated water.

3.8 Chloride and sulfate

Both Cl and SO_4 exhibit a wide variation as presented in **Fig. 11** and **12**, which is likely due to the river discharge variation. In drinking water, the average concentration of Cl and SO_4 was 50.57 and 231.74 mg/l. It is evident from these findings that the concentration of Cl and SO_4 in drinking is more significant than in raw water. This increase is caused by the adding of Alum and chlorine to the water. Despite this increase in SO_4 and Cl^- in water concentration, it remains with the WHO limitations.

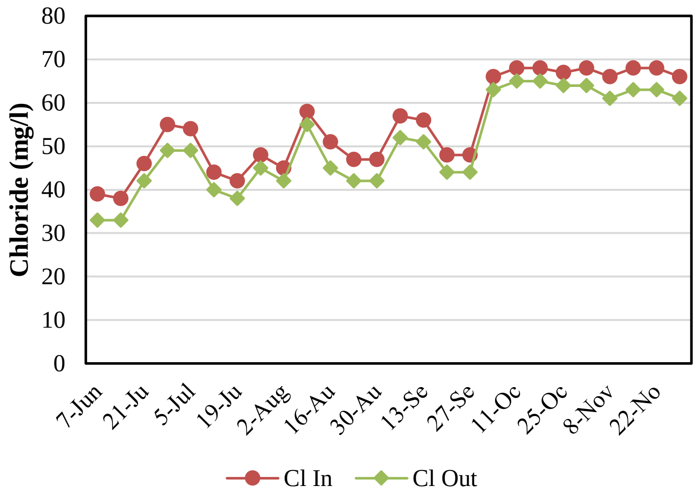

Figure 11. Chloride variation in raw and treated water.

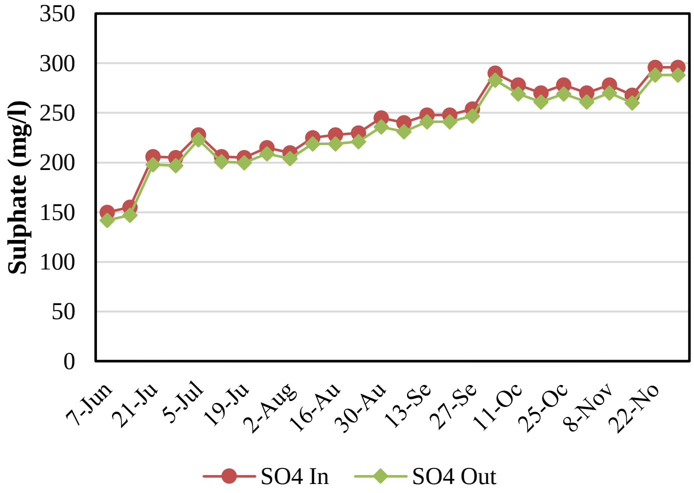

Figure 12. Sulfate variation in raw and treated water.

3.9 DO and BOD_5

DO is a critical parameter in evaluating water quality because it influences the organisms living within a water body. The lowest values recorded were 5.31 and 4.75 mg/l for raw and treated water, respectively. While high levels recorded were 7.68 and 6.88 mg/l for raw and treated water. Dissolved oxygen enters the water through the air or as a plant byproduct, mixing atmospheric oxygen with water through wind and stream current action. **Fig. 13** below shows the concentration of dissolved oxygen (DO) in water is influenced by temperature. As the temperature rises, the solubility of oxygen decreases. This means that deeper, cooler water requires less dissolved oxygen to achieve 100% air saturation than warmer surface water. **(Ioryue et al., 2015)**

Regarding water BOD_5 level, the mean value of BOD_5 was recorded to be varying from 4.64 and 3.88 mg/l for raw and treated water, respectively. Over explication of BOD_5 produces suffocation and kills aquatic organisms, just as reduced dissolved oxygen levels. The higher BOD_5 value may be attributed to higher organic load with higher microbial activity that increased the BOD_5 and resulted in DO depletion. High levels of nitrate from leaves and woody debris, dead plants and animals, domestic wastewater, and agricultural runoff containing pesticides and fertilizers have resulted in higher BOD_5 water. **Fig. 14** depicts a decrease in BOD_5 levels as temperature increases, temperature resulting in decay of organic substances and consequently raised BOD_5 levels. **(Fokmare etal., 2000)**

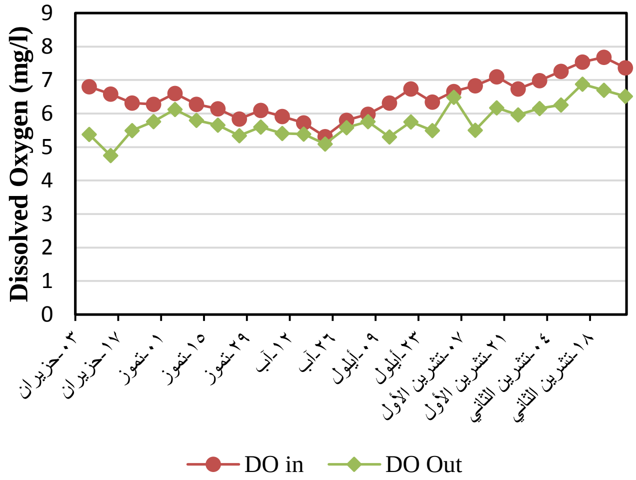

Figure 13. Dissolved Oxygen variation in raw and treated water.

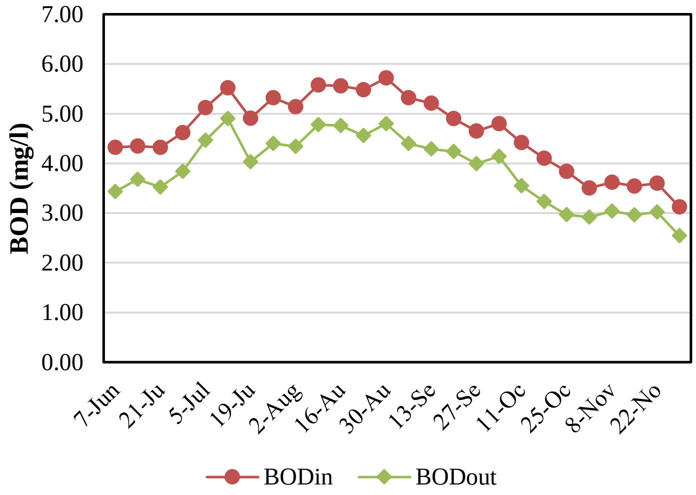

Figure 14. BOD_5 variation in raw and treated water.

4. CONCLUSIONS

The results showed that while the plant showed promise in some aspects of its treatment, it had several problems that hindered its potential. The study's findings revealed a slight improvement in the influent quality, but it remained unsuitable from an operational standpoint. Regardless, the plant's performance could be improved by regularly improving process control and maintenance.

5. Recommendations

This work was conducted with limited time and resources. Further studies should be conducted and enhanced and improved water treatment management. Based on the finding, the following points would recommend:

1. Management should ensure that operators have comprehensive training in maintenance and operation and management of flow rates for the successful operation of Al-Wehda WTP.

2. Operators should be required to establish procedures for monitoring raw water changes, evaluate alternative chemicals, conduct jar tests to determine the optimal dosage, and calibrate chemical feed pumps.
3. Providing a slow mixing basin to improve the work of the sedimentation tank.
4. Using information provided by the current water quality studies, Al- Wehda utilities WTP can explore all future options, including rehabilitation of the existing plant, while considering potential water quality changes.

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