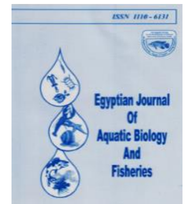
Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 –6131
Vol. 28(5): 997– 1008 (2024)
www.ejabf.journals.ekb.eg



Evaluation of the Discharged Water from the Boyer Drainage Station Before Homogenization with the Wastewater Discharged into the River in Nineveh Governorate/Iraq

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ARTICLE INFO

Article History:
Received: Sept. 8, 2024
Accepted: Sept. 19, 2024
Online: Sep. 27, 2024

Keywords:
Physicochemical,
Biological,
Wastewater,
Iraq

ABSTRACT

The current study included the Al-Buwair drinking water station located northwest of Mosul City in Nineveh Governorate/Iraq with the aim of evaluating the station's performance efficiency compared to the Iraqi standard specifications. Samples were collected starting from October 2023 until July 2024. Some physicochemical and biological properties were measured, including acidity (pH), electrical conductivity (EC), turbidity concentration (Turb.), total hardness (T.H), total basicity (Alk), total dissolved solids (TDS), sulfate ions ($SO4^{-2}$), chloride (Cl^{-}), and nitrate (NO_3) in addition to the total bacterial count (T.P.C). The results of the current study showed that all the studied properties conformed to the Iraqi standard specifications.

INTRODUCTION

Water pollution, according to the **WHO(1964)**, is the qualitative changes in the physical, chemical and biological properties that harm the public health of living organisms using this water for drinking purposes. Polluted water is one of the most prominent problems facing humanity today. Concern has increased in recent years about water in the world. Population growth in large cities and industrial development are among the most prominent causes of environmental imbalance. Water pollution is one of the most dangerous types of pollution because water occupies vast areas of the globe. The final fate of soil and air pollutants is water bodies, whether directly or indirectly. The largest part of the composition of different cells is water, and for the survival of living organisms, no vital process can take place except in the presence of an aqueous medium **(Hamuda & Patko, 2012)**. The World Health Organization has proven that 80% of bacterial, viral and parasitic diseases are transmitted through contaminated water in addition to the fact that 5% of child deaths around the world are due to poor water quality, and that diarrhea, which is one of the most common and dangerous diseases, is transmitted through intestinal viruses found in drinking water **(Kilic, 2021)**.

The Al-Buwair water treatment plant is located northwest of Nineveh Governorate, 35km from the center of Mosul. It includes an intake basin, rapid mixing basins for thorough water mixing, eight shared sedimentation and flocculation basins, and 40 rapid sand filters. The sterilization unit, which is the final stage of water purification, adds alum in solution during the rapid mixing phase. After passing through the sedimentation and flocculation basins, the water flows through the gravity-operated rapid sand filters, before entering the sterilization unit, where chlorine is used for disinfection. Finally, the treated drinking water is pumped for distribution.

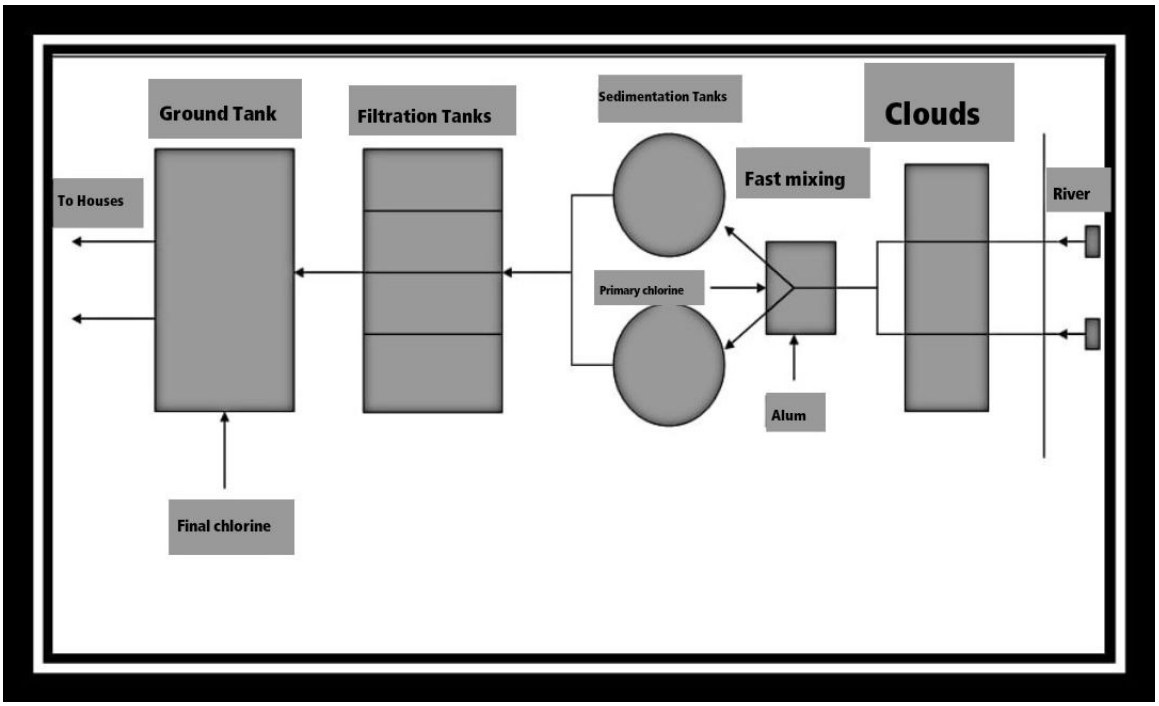

Fig. 1. Schematic diagram of the treatment stages at the Boer liquefaction plant

MATERIALS AND METHODS

Samples were collected from the current study area starting from October 2023 until July 2024, at a seasonal sample rate, and included measuring water parameters before and after leaving the station according to **APHA and WCPE)2017)**.

Environmental tests

The acidity function and electrical conductivity were measured, in addition to measuring the concentration of total dissolved solids in reality, while the basicity, turbidity, concentration of sulfate, chloride and nitrate ions, as well as the total number of bacteria were measured in the laboratory.

Table 1. Iraqi standard specifications for drinking water **(Abawi & Hassan, 1990)**

Properties	pH	EC (µs\cm)	Turb. (mg\l)	T.H (mg\l)	TDS (mg\l)	SO_4^{-2} (mg\l)	Cl^- (mg\l)	NO_3^- (mg\l)	T.P.C (Call\ml)
Maximum	6.5-8.5	1500	50	500	500	200	200	50	0

RESULTS ANDDISCUSSION

Table (2) shows the quarterly results of the physicochemical and biological properties during the current study period.

Table 2. Values and concentrations of physicochemical and biological properties during the current study period

Seasons / Indicator		Autumn	Winter	Spring	Summer	Min	Max	Mean
pH	Raw Water	7.2	7.62	7.58	6.5	6.5	7.62	7.22
	Treated Water	7.1	7.61	7.57	6.6	6.6	7.61	7.22
EC	Raw Water	460	401	411	478	401	478	437.5
	Treated Water	458	399	410	477	399	477	436
Turb.	Raw Water	5.7	10.5	13	6.17	5.7	13	8.8
	Treated Water	3.8	5	4.9	4.8	3.8	5	4.6
T.H	Raw Water	209	215	219	210	209	219	213.25
	Treated Water	208	214	217	209	208	217	212

Alk	Raw Water	138	144	148	143	138	148	143.25
	Treated Water	137	143	146	141	137	146	141.75
TDS	Raw Water	252	236	292	266	236	292	261.5
	Treated Water	250	232	290	264	232	290	259
SO_4^{-2}	Raw Water	67	69	65	66	65	69	66.75
	Treated Water	65	67	63	64	63	67	64.75
Cl^-	Raw Water	17	18	17	16	16	18	17
	Treated Water	19	20	19	18	18	20	19
NO_3	Raw Water	2.6	3.21	3.11	1.84	1.84	3.21	2.69
	Treated Water	1.3	1.5	1.5	0.95	0.95	1.5	1.31
T.P.C	Raw Water	290	211	214	380	211	380	273.75
	Treated Water	0	0	0	0	0	0	0

The pH values

The pH value varied as shown in Fig. (2), with the highest value recorded in January at 7.62 in raw water, coinciding with the onset of rainfall and soil erosion in the river basin. The lowest value, measured at 6.5, occurred in early July due to the relative retention of rainwater. These results are consistent with the findings of **Al-Sarraj*et al.* (2014)** on the Tigris River within the city of Mosul, which reported pH values ranging from 8.4 to 7.7 and 6.8 to 8.0, respectively. This indicates that Tigris River water is a suitable source of raw water for filtration stations, as it falls within the permissible pH range of 6.5 to 8.5 for drinking water.

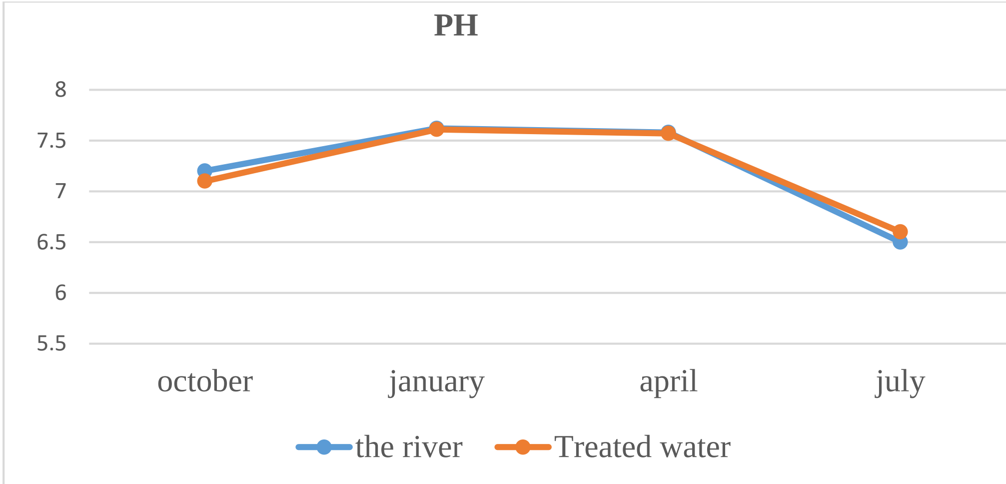

Fig. 2. The pH values during the current study period

Electrical conductivity (EC)

Electrical conductivity values ranged between 478 and 399 µS/cm, as shown in Fig. (3). The highest electrical conductivity was recorded at 478 µS/cm in July, while the lowest value was 399 µS/cm in January. No significant differences were observed between the electrical conductivity of raw water and the treated water, as there were no procedures in place at the treatment station to reduce its value. These findings are consistent with the results reported by **Mustafa (2011)**.

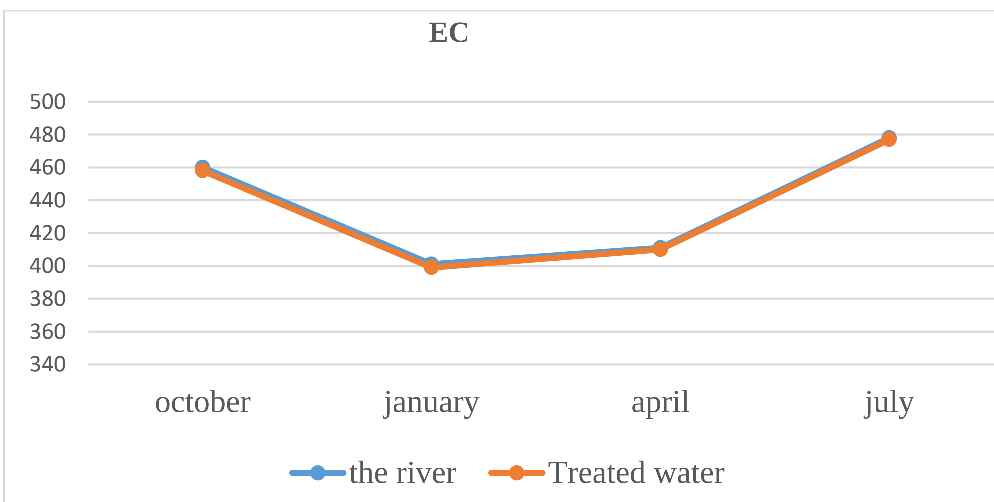

Fig. 3. The EC values during the current study period

Turbidity

The results of the current study, shown in Fig. (4), indicate that the highest turbidity value in raw water was 13 mg/l in April, while the lowest value in treated water from the station was 3.8mg/l in October. The high turbidity rates observed in river water during the winter months are attributed to the rainfall, which increases turbidity due to surface runoff of soil into the river. Turbidity levels are directly proportional to the amount of rainfall and the resulting floods and are also influenced by river discharge and current speed **(Wolde *et al.*, 2020)**.

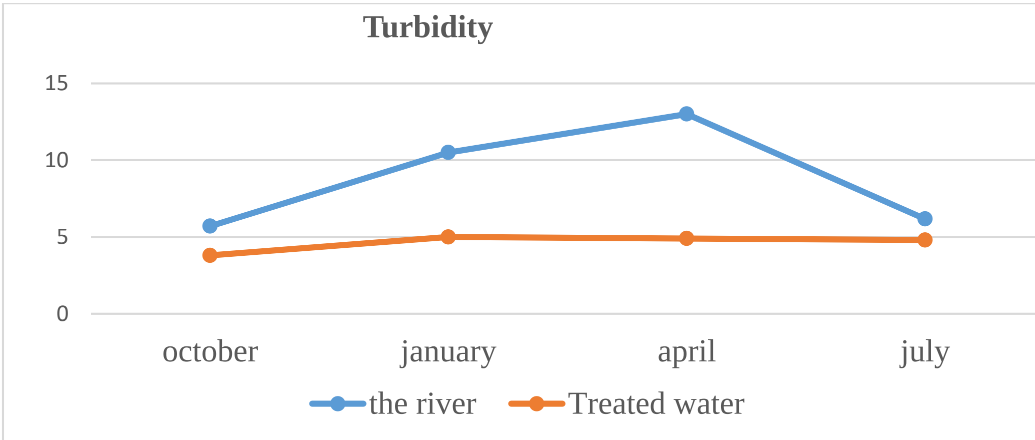

Fig. 4. The concentration of turbidity during the current study period

Total hardness (TH)

The results of the study in Fig. (5) recorded that the highest value of total hardness in raw water was 219mg/l during the month of April, while the lowest value was 208mg/l in produced water during the month of October. No significant changes were observed in its value due to the abundance of rain during this year. The current findings agree with those of **Al-Sarraj (2013)** with values ranging between 194 & 292.

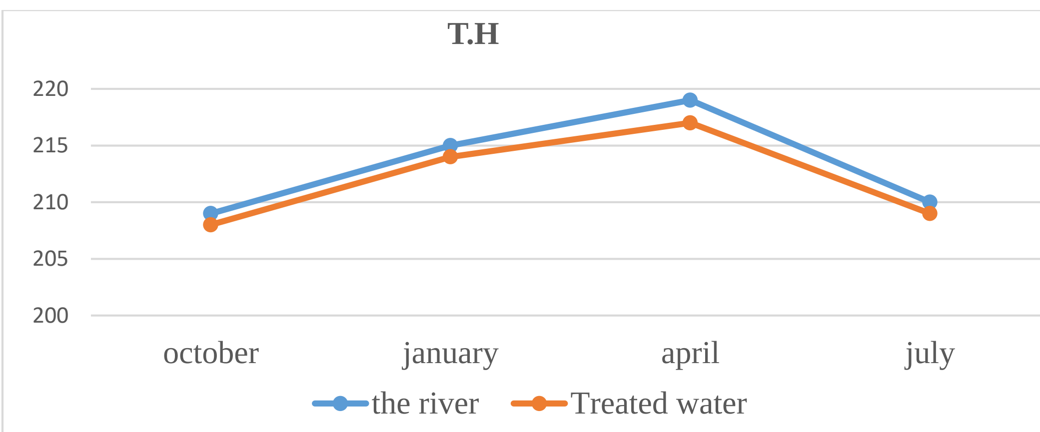

Fig. 5. The concentration of TH during the current study period

Total alkalinity (AlK)

The results of the study in Fig. (6) show that the highest recorded value of alkalinity in raw water was 148g/ l in April, and the lowest value of alkalinity was 137mg/l in October. This is due to the increase in rainfall in this month or due to the effect of alkalinity on the filtration process due to the addition of alum and chlorine, which leads to the decomposition of bicarbonates and the release of carbon dioxide gas **(Gebbie, 2000)**.

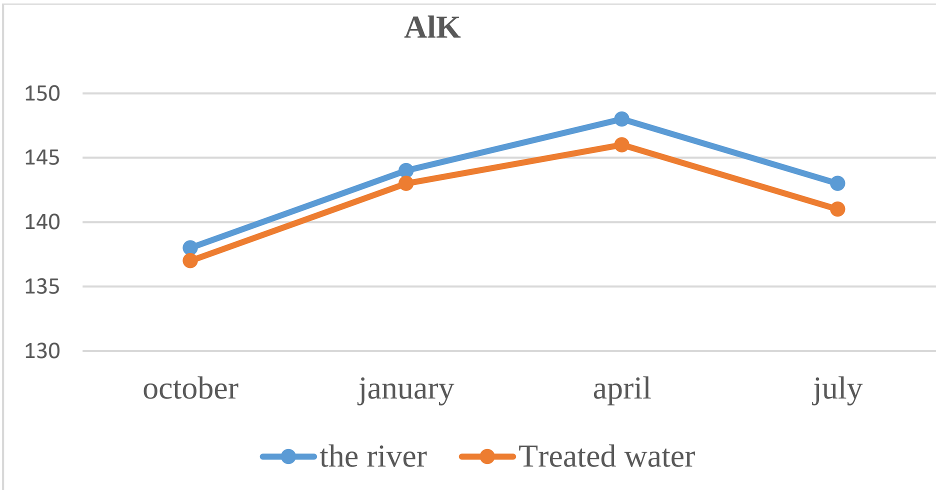

Fig. 6. The concentration of Alkalinity during the current study period

Total dissolved solids (TDS)

The concentration of total dissolved solids in the Tigris River water within the study area varies spatially and temporally, and the decrease and increase of TDS concentrations depend on the concentrations of ions present in the water, and the reason for the increase is due to the decrease in discharge rates or due to the discharge of waste into the river water or as a result of washing the soil with rainwater, or due to the direct addition of organic waste to the river **(Razuki & AL-Rawi, 2010)**. The results in Fig. (7) showed that the highest value of total dissolved solids in the water was 292mg/ l, in the raw water in April, while the lowest value was 232mg/l in the produced water in January. These results agree with what was recorded by **AL-Hamdany and Mazin (2015)**, where it was found that the values of TDS were between 236 & 294.

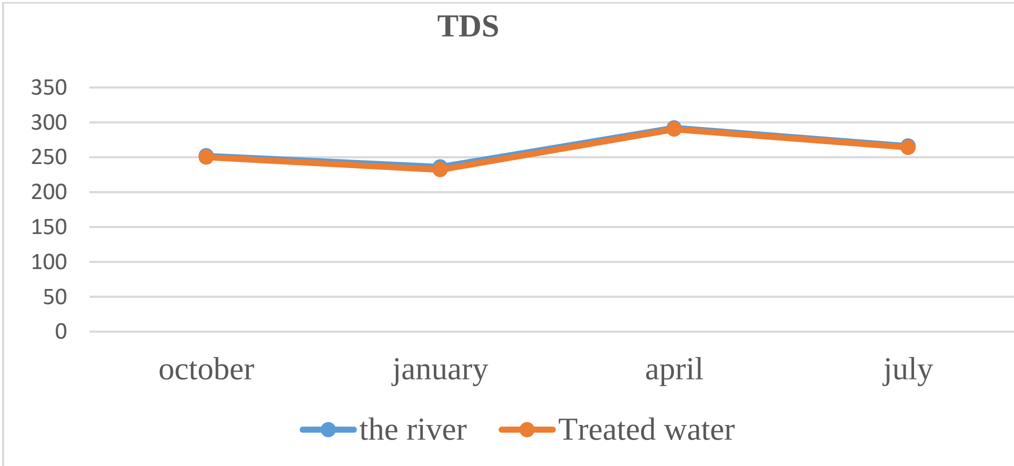

Fig. 7. The TDS concentration during the current study period

Sulphatessulphates ($SO4^{-2}$)

The sulfate ion has the potential to reach water sources containing it due to the use of fertilizers in agriculture, and also when disposing the domestic wastewater that often contains this ion **(Varol *et al*., 2018)**. The results of this study in Fig. (8) showed that the highest value of sulfate in raw water was 69mg/l, in January, and the lowest value of sulfate was 63mg/l, in the water produced from the station in April.

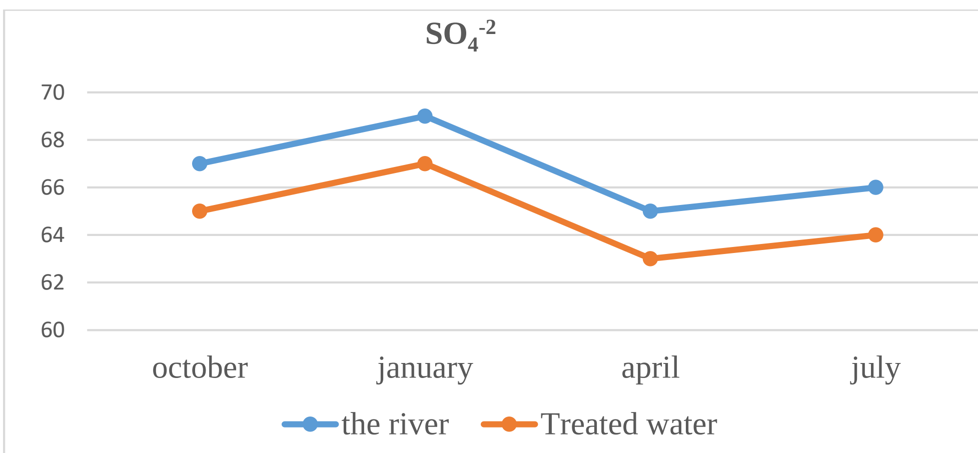

Fig. 8. The concentration of $SO4^{-2}$during the current study period

Chloride (Cl^{-})

The results in Fig. (9) show that the lowest value of chloride ion in raw water was 16mg/L in July, and the highest value was also in raw water with a value of 20mg/L in January. These results are consistent with those of **Al-Sarraj(2020)**, and less than the results of **Al-Khayat and Qasim(2024)**, as chloride values decreased slightly during winter. This is attributed to the dilution of river water due to rainfall in the winter and the resulting rise in water levels. The source of chloride ions is often related to the presence of potassium, magnesium, and calcium salts, which dissolve completely in water **(Razuki & Al-Rawi, 2010)**.

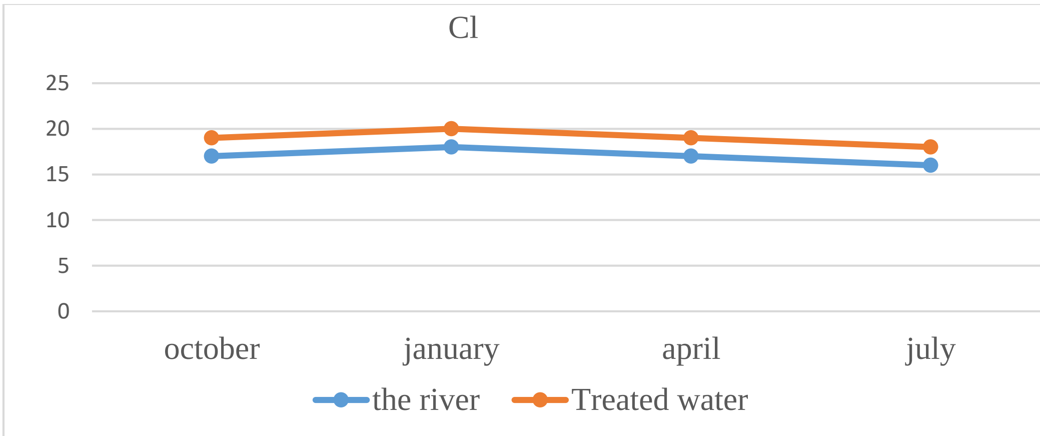

Fig. 9. Cl^- concentration during the study period

Nitrate (NO_3^-)

The results of the study in Fig. (10) reveal that the lowest value of nitrates was 0.95mg/l in the water produced from the station for the month of July, while the highest value was 3.21mg/l in the raw water during the month of January. The values of the current study are close to those of **Al-Hussieny *et al*. (2015)**, with values of 3.01-0.736mg/l. The high values of nitrates is ascribed to the nature of household waste and sewage water discharged into the rivers. While, high values in raw water (river water) are traced back to agricultural lands supplied with nitrogenous fertilizers since these fertilizers enter the river due to their drift, and may be due to the increased concentration of nitrates in river water **(Wolde *et al*., 2020)**.

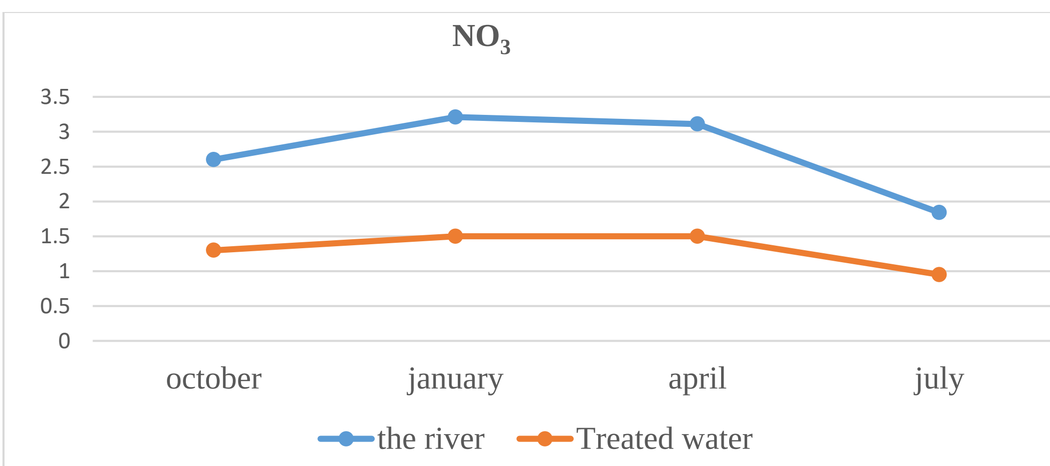

Fig. 10. The concentration of NO_3^- during the current study period

Total plate count (TPC)

It is known that surface water is a suitable place for the growth of microorganisms because it contains high concentrations of organic matter, and its temperature is more suitable for the growth of these organisms **(Krupa & Parikh, 2018)**. The results of the bacterial examination shown in Fig. (11) indicate that the highest total number of bacteria in raw water reached 380 cells per cm^3 in July due to the high temperatures in summer and the presence of dissolved nutrients in the water, while the lowest total number of bacteria in the produced water was 0 cells per cm^3 in January, which may be attributed to the efficiency of the sterilization processes in the liquefaction plant.

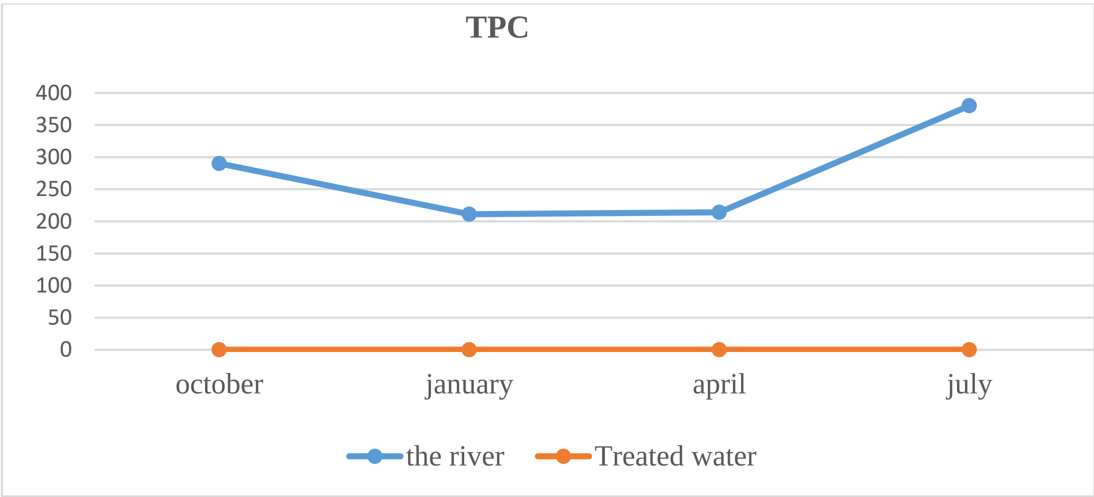

Fig. 11. The values of total bacterial counts (TPC) during the study period

CONCLUSION

Based on the results obtained from testing the water coming out of the station, it can be concluded that the station operates efficiently to treat the water before it is pumped out, in accordance with Iraqi drinking water standards. This indicates that the treated water is suitable for both drinking and agricultural purposes. Additionally, the pipes used to transport the water to the station are of good quality, with no leakage of pollutants into the water.

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