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The Evolution of the Al-Qayyarah Refinery's Treatment Plant's Effectiveness and the Impact of its Discharges on the Tigris River's Quality

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ABSTRACT

This study was conducted to evaluate the efficiency of the Excretion Management Station in the Al-Qayyarah refinery in Nineveh Governorate, as well as addressing the impact resulting from the industrial discards on the characteristics of the water of Tigris River and its validity for domestic, industrial, and agricultural uses. Numerous environmental factors were evaluated, viz. pH, total hardness, calcium hardness, magnesium hardness, sulfate, phosphate, chloride, total solid, total dissolved solid and suspended solid. A remarkable variation in concentrations was recorded during the study period. The highest value of pH was 7.7, while the lowest was 6.6. The electrical conductivity (EC) ranged between 902 [1] & 674µmhos/ cm before treatment, while after treatment, chloride ion recorded values between 16 & 44mg/ L; before treatment, the highest value of sulphate (SO_4)[2] was 218mg/ L and the lowest was 40mg/L. In addition, orthophosphate (PO_4^{-3}) recorded a high value of [3] 6.1mg/ L & a low value of 0.1mg/ L.

INTRODUCTION

Industry is the most important source of water pollution & it has a negative impact on living organisms, especially humans. Industrial companies receive water from rivers & lakes, then discharge industrial water to the rivers with polluted materials (organic and inorganic) e.g., pb, Hg and Cd. When these toxic materials accumulate in the rivers, a decrease is monitored in fish wealth & other organisms in the food chain, causing centered diseases to human associated with *E. coli*, *Cholera*, *Salmonella*, etc. **(Al-Saadi, 2006)**.

It is worthy to mention that, the second longest river in southwest Asia is the Tigris River. About 30km north of the Euphrates watershed, there is an island called Jazar Golu, which represents the headwater of the Tigris River **(Issa *et al.*, 2014)**. The village of Fish Khabur represents the first area to which the Tigris River enters within the Iraqi borders **(World Bank, 2006)**. The total drainage area of the river is 235,000km^2 distributed over four countries, namely Iraq (52%), Iran (29%),Turkey (17%) and Syria (2%) **(Al-Ansari, 2021)**, and the total length of the Tigris River is 1900km; the distribution of which is as follows: 400km inside Turkey, and 32 km along the borders of Syria and Turkey. While, most of its flow is within Iraqi territory, with a length of more than 1430km. By the confluence of the Tigris and Euphrates Rivers in the far South of Iraq; the Shatt al-Arab is formed and flows for a 190km in the South before entering the Arabian Gulf **(Rahi & Halihan, 2018)**. There are five major rivers feeding the Tigris River in Iraq, including Khabur, GreateZab, Lower Zab, Al-Adhiam and Diyala **(Abbas *et al*., 2018)**.

The Tigris River in the city of Mosul is the only source of surface water; its waters are used for various human services and industrial purposes in addition to playing a fundamental role in the sustainability and diversification of aquatic life. This river passes through the city of Mosul from its northwest side, and divides it into the right and left sides, where all kinds of wastes are disposed of, such as sewage from residential homes, industrial water and hospitals, as well as service waste. Furthermore, agricultural institutions are constructed on both sides of the river owing to the city's lack of a sewage network and treatment plants. Unfortunately, the river is the main reservoir of these pollutants **(Mahmood *et al*., 2021)**.

Recently, an increasing concern has emerged about water in numerous countries around the world. Water pollution is a world challenge that has accelerated in all developed and developing countries. It hinders the economic growth as well as the environmental and physical health of billions of people **(Mateo-Sagasta *et al*., 2017)**.

Additionally, population explosion in large cities & industrial development was the first reason causing the ecological imbalance. At the present time, the most dangerous types of pollution (water pollution) cover a large, wide area on the Earth. Final fate of all air & soil pollution put water bodies directly or indirectly at risk **(Al-Hayani, 2018 ; Al-Sultan, 2019)**.

Water is a radical component in different living cells & no vital process can be performed without an aqueous medium for the survival of all organisms **(Al-Waeli, 2008)**.

The decrease of the level of Tigris River during the last years through increasing the amount of pollutants dumped (350,000 m^3/day) through twenty-four big estuaries and many other small estuaries down the stream without any treatment has deteriorated the situation in the Mosul City, causing a real problem by increasing the pollution in the waters of the Tigris River and minimizing the areas that utilize water for a variety of purposes (**Al-Rawi, 2005)**.

Pollution of water sources cause health risks threatening human life and the aquatic ecosystem. It is worth noting that, the Tigris River suffers from a huge amount of civil and industrial pollutants. Studies indicate that the wastewater flowing into the Tigris River in the city of Mosul has surpassed 158000m^3/ day, which contributes to the deterioration of the river water quality (**Al-Safawi 2007; Najeeb & Saeed, 2022)** and that this risk extends to cities such as Salah al-Din and Baghdad, down to Basra in southern Iraq, as well as the districts and sub-districts south the city of Mosul including Al-Qayyarah city which is situated south the Mosul city, about 80km far, and near to one of the oil refineries and on the banks of the Tigris River. Moreover, it contains a huge number of oil wells. That is why the topic of current study was chosen in Qayyarah City, south of Mosul.

MATERIALS AND METHODS

1. Location of the study area

Iraq is one of the largest oil-producing countries in the Middle East. It is located on latitude 33° 00′ N (between 29° 02′ N and 37° 23′N) and longitude 44° 00′ E (between 38° 47′ E and 48° 35′ E). It owns several water resources including the Tigris River **(Chabuk *et al*., 2020)**.

The total length of the Tigris River is 1,900km; 1415km of which is located on Iraqi territory and flows from the North to the South. The watershed area includes Turkey, Iraq, Syria, and Iran and is approximately 235,000km^2 (**Abd-El-Mooty *et al*., 2016)**.

On the world map, Iraq is surrounded by Syria and Jordan to the West, Turkey to the North, the Gulf to the Southeast, Iran to the East, Saudi Arabia and Kuwait to the South **(Al-Hasani, 2019)**.

Qayyarah refinery is considered one of the most famous & oldest north oil refineries in Nineveh, where the work was inaugurated during 1950 by England's oil company; it located in the South of Qayyarah, near Tigris River, as the only refinery in the South of Mosul City (Fig. 1).

2. Samples' collection

For the purpose of determining the extent of pollution in the industrial water from the Qayyarah oil refinery, one sample (each month from December 2018-October 2019) was collected from the 1st location, which represented the "before treatment process", while second location represented the "after treatment process".

Prior to collecting the industrial water samples, the sample bottles were acid-washed and re-washed with industrial water, and returned to the laboratory for analysis. Then, the average value was determined after each analysis.

All parameters were determined in the laboratory following standard protocols of the **American Public Health Association (APHA, 1998)**. The samples were analyzed for 11 parameters; namely, electrical conductivity (EC), dissolved oxygen (DO), turbidity, pH, chloride (Cl-), sulphate (SO4-2), total solids (TS), total dissolved solid (TDS), total suspended solids (TSS), chemical oxygen demand (COD), orthophosphate (PO_4^{-3}), total hardnees(TH), calcium hardness(Ca H.), and magnesium hardness (Mg H.).

Fig. 1. A map of Iraq showing the Qayyarah refinery in Mosul City;(from Google earth).

3. Bacteriological tests

a. **Total Plate Count**

Pour plate **American Public Health Association. (APHA, 1998)**. Number of CFU/ml = number of colonies × 1/dilution factor

b. **Total Coliform bacteria**

Most probable number (MPN), Colonies were stain by Gram stain (**Collee *et al.*, 1996)**. Identifying by certain biochemical test.

RESULTS AND DISCUSSION

The environmental factors

pH

The results as show in Tables (1, 2), values of pH ranged between 6.6 & 7.7 before treatment, while after treatment, a value range (7.1-7.7) was assessed by physical treatment. These recorded values may be traced back to the decomposition of organic matter by microorganisms and the release of CO_2 in addition to the balance of pH (acidic function), or may be due to the density toward alkalinity form bicarbonate **(Abawi & Hassan, 1990)**.

EC and total dissolved salts

Results of the thermal relationship between EC & the concentration of TDS during treatment (before and after) throughout the study period are displayed in Fig. (2). A high value of EC902 (µmhos/cm) and a high TDS value of 508mg/ l were recorded before treatment; while after treatment, the highest EC and TDS values (1082µmhos/ cm, 591mg/ l) were administered, respectively. These values may be ascribed to the acid or base which can increase EC **(Mustafa *et al*, 2014)**.

Total Ca, Mg hardness

The values of all types of hardness were (190-342) (148-282) (40-110) mg/l, respectively, before treatment, as shown in Table (2), while values after treatment (74-118) (40-170) (158-244) mg/l were recorded, respectively. On the other hand, for the total solid & total suspended solid, the results presented in Table (1) show that the suspended solid values were 98, 111, 19mg/ l, respectively, before treatment, and 2, 26, 4mg/ l after treatment. It is worthy to relate the high values of the suspended solid before treatment to the subtraction of solid & liquid wastes, while low values can be traced back to the precipitate of some materials in the settling basin of the treatment plant **(Abawi & Hassan, 1990)**.

Chloride ion Cl^{-1}

Chloride concentration was 2mg/ l (Fig. 9), and the highest concentration during January before treatment reached a value of 44mg/ l, while the lowest was recorded during October (16mg/l). Whereas, after treatment and during the study period, values of 16, 34, 14 were recorded, respectively. These results are due to the acidic function equation of adding hydrochloric acid or sodium hydroxide in treatment plant to neutralize acidic ion or to attain alkalinity, and this in turn increases chloride ion concentration **(AL-Shaker & Mohammed, 2019; Mahmood & Saeed, 2021)**.

Table 1. Characteristics of industrial water for Qayyarah refinery before being subjected to the treatment process

Factor / Months of sampling	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Mean
Turb. N.T.U.	35	73	292	210	143	104	142.83
ECµmhos/cm	902	668	605	585	565	640	660.83
pH	7.7	7.05	6.6	8.2	8.05	8.06	7.61
D.O. (mg/L)	1.2	1.9	2.4	2.7	1.7	2.3	2
C.O.D.(mg/L)	157	395	433	223	140	166	252
T.S. (mg/L)	606	549	400	190	224	202	361.83
T.D.S. (mg/L)	508	438	381	90	160	110	281.16
T.S.S. (mg/L)	98	111	19	100	64	92	80.66
T.H. (mg/L as $CaCO_3$)	342	190	258	472	410	429	350.16
Ca.H. (mg/L as $CaCO_3$)	282	150	148	323	313	295	251.83
Mg.H. (mg/L as $CaCO_3$)	42	40	110	149	97	134	95.33
Cl^{-1} (mg/L)	18	44	16	16	19	22	22.5
SO_4^{-2} (mg/L)	218	40	91	58.5	70	63	90.08
PO_4^{-3}(mg/L)	1.7	1.3	0.1	3.3	4.7	0.8	3.18

Table 2. Characteristics of industrial water for Qayyarah refinery after being subjected to the treatment process

Factor / Months of sampling	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Mean
Turb. (N.T.U.)	**15**	**22**	**108**	**103**	**45**	**63**	**59.33**
EC (µmhos/cm)	**460**	**674**	**584**	**575**	**611**	**533**	**572.83**
pH	**7.7**	**7.1**	**7.1**	**8.13**	**7.6**	**7.8**	**7.57**
D.O. (mg/L)	**3.8**	**3.5**	**3.6**	**5.2**	**3.1**	**3.7**	**3.81**
C.O.D. (mg/L)	**118**	**125**	**171**	**124**	**87**	**123**	**124.66**
T.S. (mg/L)	**593**	**471**	**297**	**232**	**252**	**196**	**340.16**
T.D.S. (mg/L)	**230**	**445**	**293**	**128**	**166**	**80**	**223.66**
T.S.S. (mg/L)	**2**	**26**	**4**	**104**	**86**	**116**	**56.33**
T.H. (mg/L as $CaCO_3$)	**310**	**204**	**244**	**433**	**373**	**476**	**340**
Ca.H. (mg/L as $CaCO_3$)	**276**	**150**	**170**	**317**	**345**	**327**	**264.16**
Mg.H. (mg/L as $CaCO_3$)	**34**	**54**	**74**	**116**	**28**	**149**	**75.83**
Cl^{-1} (mg/L)	**14**	**34**	**16**	**18**	**15**	**20**	**19.5**
So_4^{-2} (mg/L)	**184**	**50**	**99**	**73**	**65.5**	**59**	**88.41**
Po_4^{-3} (mg/L)	**6.4**	**1.8**	**0.1**	**6.7**	**7.7**	**1.6**	**4.05**

Phosphate Po_4^{-3}

Phosphate concentration before treatment exceeded the standard values, especially during December & January (1.7 & 1.3mg/ l) (Table 1). While, after treatment, 6.4 and 1.8mg/ l were recorded. The high values recorded are due to using various detergent materials of production lines.

Sulfate So_4^{-2}

It was noticed that, the values of sulfate concentration didn't exceed the permissible upper limits, as shown in Fig. (3). The values recorded before treatment were 91, 40 & 218 mg/l. While after treatment, values were 0.1, 1.8 & 6.4mg/ l. This variation may be due to sulphate dumps, which result from sulphate as a part of industry **(World Health Organization, 2002)**.

Coliform bacteria

The findings revealed that coliform bacteria levels in the Tigris River were significantly higher than the allowed limits for water at the study sites, indicating that the water in the study area is unhealthy for human use **(Mahmuad, 1988; Al-Aazaawiu, 1997)**.

This finding is due to the fact that the bacterial contamination exceeded the acceptable level according to the Iraqi drinking water standards and the World Health Organization, which should be (0cells/ ml) **(Dawood, 2017; World Health Organization, 2011)**.

In both sewage and freshwater, total coliform bacteria (excluding *E. coli*) are present. Many coliforms are heterotrophic and can grow in water and soil settings, yet some of these bacteria are expelled in the feces of humans and animals. In water distribution systems, total coliforms can also persist and develop, particularly when biofilms are present. Total coliforms may signify regrowth, possible biofilm formation, or contamination brought on by the introduction of exogenous substances like soil or plants **(World Health Organization, 2011)**. Based on the aforementioned data, the presence of a source of organic pollution may be the reason of the high number of bacteria in the water.

CONCLUSION

Based on the current results, it can be concluded that, some measured traits exceeded the global determinants of global and Iraqi WHO. In addition, the electric conductivity values exceeded global determinants, and phosphate concentration values were high before & after treatment.

RECOMMENDATIONS

1. Speed up the completion of work in new treatment plant since work has been stopped for a period of time.
2. Preparing a specialized environmental cadre in order to know the extent of plant's ability to eliminate or reduce the problems of industrial wastewater.
3. Reduce as possible the disposal of pollutants resulting from the use in various production stages of this refinery.

REFERENCES

Abawi, S.A. and Hassan, M.S. (1990).Practical Engineering of the Environment Water Testing, Dar Al- Hikma for Publishing and Printing, Iraq: 275 pp.

Abbas, N.; Wasimi, S.; Al-Ansari, N. and Sultana, N. (2018). Water resources problems of Iraq: Climate change adaptation and mitigation. Journal of Environmental Hydrology, 26: 1-11.

Abd-El-Mooty, M.; Kansoh, R. and Abdulhadi, A. (2016).Challenges of water resources in Iraq. Hydrology Current Research, 7(4): 1-8.

Al- Sultan, F.M. (2019). Evaluation of Old East Coast Water Treatment Plant and Pipelines Performance in Some Areas in Mosul City.M.Sc thesis, Collage of Environmental Sciences And Technology. 118 pp.

Al-Aazaawiu, A.H. (1997). Study of bacterial contamination in drinking water in Babil Governorate. Master Thesis, Faculty of Science, University of Babylon.

Al-Ansari, N. (2021). Water Resources of Iraq. Journal of Earth Sciences and Geotechnical Engineering, 11(2): 15-34.

Al-Hasani, A.A. (2019). Sensitivity assessment of the impacts of climate change on streamflow using climate elasticity in Tigris River Basin, Iraq. International Journal of Environmental Studies, 76(1): 7-28. DOI: 10.1080 / 00207233 . 1494924. https://doi.org/10.1080/00207233.2018.1494924

Al-Hayani, A.S.J.Z. (2018). The case of some heavy elements in Wadi Al-Danfli (Mosul city) and its impact on soil, plant and water pollution, Doctoral thesis, College of Agriculture and Forestry / Mosul University

Al-Rawi, S.M. (2005). Contribution of Man–Made Activities to the Pollution of the Tigris within Mosul Area/IRAQ. International journal of environmental research and public health, 2(2): 245-250.

Al-Saadi, H.A. (2006). Principles of ecology and pollution. Al. Al-Yazori Publishers, Amman, Jordan: 405 pp.(In Arabic).

Al-Safawi, A.Y. (2007). Quantitative And Qualitative Study of Discharged Wastewater from Mosul City and their Effect on the Quality of Tigris River. Proceeding of 1st E.P.C.R.C. Scientific conference 5-6 June.Mosul University.

AL-Shaker, Y.M. and Mohammed, A.B. (2019).Assessing the Environmental Situation for Excretion Management Stations in Al–Qayyarah Refinery.Rafidain Journal of Science, 28(2): 8-22.

Al-Waeli, H.S.A. (2008).Biosorption of nickel from industrial wastewater by two bacterial species.MSc, Biology / College of Science /University of Baghdad Iraq.

American Public Health Association, (1998).Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works association, Water Environment Federation, Washington.

Chabuk, A.; Al-Madhlom, Q.; Al-Maliki, A.; Al-Ansari, N.; Hussain, H. M.and Laue, J. (2020).Water quality assessment along Tigris River (Iraq) using water quality index (WQI) and GIS software. Arabian Journal of Geosciences, 13:1-23.

Collee, J.G.; Miles, R. S. and Watt, B. (1996).Tests for identification of bacteria. Mackie and McCartney practical medical microbiology, 14: 131-49.

Dawood, A.S. (2017). Using of Nemerow's Pollution Index (NPI) for water quality assessment of some Basrah Marshes, South of Iraq. Journal of Babylon University/Engineering Sciences, 25(5) : 1708-1720.

Issa, I. E.; Al-Ansari, N.; Sherwany, G. and Knutsson, S. (2014). Expected future of water resources within Tigris–Euphrates rivers basin, Iraq. Journal of Water Resource and Protection, 6(5): 421-432. http://dx.doi.org/10.4236/jwarp.2014.65042

Mahmmood, N.G.;Saeed, I.O. and Al-Mandeel, F.A. (2021).An Ecological Study of Phytoplankton in Selected Location of the Tigris River in Nineveh Governorate.M.Sc., Thesis, Biology, College of Sciences, Tikrit University.150 pp.

Mahmuad, T.A. (1988). Environmental Technology Science.Directorate of the House of Books for Printing and Publishing, Ministry of Higher Education and Scientific Research, University of Mosul, Iraq.

Mateo-Sagasta, J.; Zadeh, S. M.; Turral, H. and Burke, J. (2017). Water pollution from agriculture: a global review. Executive summary.

Mahmood, N. G.;Mandil, F.A. andSaeed,I.O. (2021). Temporal And Spatial Changes of Some Indicators of The Water Quality of The Tigris Within Nineveh Governorate/Iraq.Review of International Geographical Education Online,11:5.

Mustafa, M.H.;Alaa, R.T. and Al-Jubouri, M.I. (2014). Some characteristics of the Industrial Effluents of the Al-Qayyarah Refinery in Northern Iraq. International Journal For Environment and Global Climate Change, 2(2).

Najeeb, R.R. and Saeed, lO. (2022). Evaluating Groundwater Quality in Al-Hamdaniya District For Drinking Purpose Using the Canadian Water Quality lndex Model (CCME WQl). Egyptian Journal of Aquatic Biology and Fisheries,26(6):243-255.

Rahi, K.A. and Halihan, T. (2018).Salinity evolution of the Tigris River. Regional Environmental Change, 18(7): 2117-2127.

World Health Organization, (2011)."Guidelines for drinking-water quality". 4th edition

World Bank, (2006). Iraq: Country Water Resources, Assistance Strategy, Addressing Major Threats to People's Live- lihoods. Report No. 36297-IQ: 1-97

World Health Organization, (2002).Guidelines for drinking-water quality.World Health Organization.