University of Baghdad
College of Engineering
JOURNAL OF ENGINEERING

Journal of Engineering

journal homepage: www.jcoeng.edu.iq

Volume 31 Number 2 February 2025

Estimate the Concentrations of Some Heavy Metals in Industrial Wastewater in Al-Dora Oil Refinery

Hawraa G. Auied [1,*], **Saadiyah A. Dhahir** [1], **Maitham A. Sultan** [2]

[1]Department of Chemistry, College of Science for Women, University of Baghdad, Baghdad, Iraq
[2]Department of Environment and Water Research, The Ministry of Science and Technology, Baghdad, Iraq

ABSTRACT

Industrial wastewater is discharged in large quantities into water bodies, and different treatment processes are employed to reduce pollutant levels. This study quantifies copper, iron, cadmium, cobalt, lead, and nickel levels in industrial wastewater samples at Al-Dora refinery. Results showed variations before and after treatment, with physical and chemical tests conducted in summer and winter. The measured values were (pH, T, Turbidity, EC, TSS, TDS), respectively (8.23, 34.8 °C, 60.88 NTU, 2883 ms/cm, 575 mg/L, 1441 mg/L) in summer, while in the winter it was (7.516, 28.6 °C, 100.6 NTU, 1147 ms/cm, 780 mg/L, 569.8 mg/L), respectively. Heavy metals were measured and showed a slight decrease during the treatment units, nevertheless, they continue to be among the environmental determinants of the Iraqi river maintenance system (1967). The measured elements were (Cu, Fe, Cd, Co, Pb, and Ni), and their concentrations in the treated water and discharged to the river were (0.064, 0.020, 0.109, 0.031, 0.029, 0.092) mg/L, respectively, in the winter. While in summer, their concentrations were (0.017, 0.018, 0.0105, 0.017, 0.138, 0.078) mg/L, respectively. The values of pollutant concentrations were a key environmental factor in the maintenance of Iraqi rivers, as the treatment plant effectively reduced or removed these pollutants from the water before discharging it into the river, without impacting water quality.

Keywords: Al-Dora oil refinery, Heavy metals, Industrial wastewater, Performance evaluation, Treatment.

1. INTRODUCTION

The quality of Iraq's surface water has deteriorated due to sewage drainage into rivers without proper treatment. Improper use and failure to treat water discharge into sources have worsened the Iraqi water scarcity issue for years due to inadequate management. Water loss and microbiological contamination may occur as it enters the distribution system

*Corresponding author
Peer review under the responsibility of University of Baghdad.
https://doi.org/10.31026/j.eng.2025.02.03

Article received: 02/06/2024
Article revised: 23/09/2024
Article accepted: 24/09/2024
Article published: 01/02/2025

(Mahmood et al., 2019; Al-hadithy, 2022). The introduction of chemicals and other compounds into the environment has led to an imbalance in the components' balance—both biotic and abiotic—when compared to natural conditions, which has resulted in an increase in pollution issues with the water in recent years. Human activity may be the cause for this, as it alters important environmental components including soil, water, and air on a biological, physical, and chemical level. An increase in pollutants, especially heavy metals, has negatively impacted the aquatic environment **(Al-Taher et al., 2020)**. As a result of industrial development, heavy metals spread widely and are thought to be the most dangerous kind of pollution as they cannot naturally degrade, instead building up in organisms and being passed on to humans through the food chain **(Kaur and Mehra, 2012; Hassan et al., 2016)**.

Heavy metals are extremely harmful compounds that have a big impact on the environment and people's health **(Araghi et al., 2014; Majeed and Ibraheem, 2024)**. The term "Heavy Metals" (HMs) refers to elements such as cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), and platinum (Pt) that have a higher density and atomic mass and can have an impact on both people and the environment. One of the most significant environmental issues affecting people, animals, and plants, is the poisoning of water with heavy metals. Because heavy metals are not biodegradable, they could be dangerous even in low amounts **(Wang et al., 2021; Zaynab et al., 2022; Azar and Vajargah, 2023)**.

The primary cause of pollution from these elements is industrial processes like mining and manufacturing that discharge heavy metals into the air and water **(Zhang et al., 2022)**. They eventually find their way into food systems and contaminate soil and rivers after being released **(Al-Khuzaie et al., 2024)**. The danger of heavy metals stems from their bio-accumulative characteristic in the bodies of living organisms that feed on plants grown in polluted soils due to factors related to geological weathering of soil caused by excessive use of chemical fertilizers and agricultural pesticides; most often, this is the result of irrigation with water contaminated with sewage and factory waste. Heavy metals are classified as dangerous environmental pollutants **(Sultan and Khalid, 2023)**. Heavy metals are the most common pollutants that affect the growth of different aquatic organisms and accumulatein their muscles and tissues, reducing the activities of many metabolites and leading to death **(Nasir and Al-Najare, 2015)**. Whereas, some of these metals are considered micronutrients and are important for organisms **(Dhahir, 2015; Hassan et al., 2016)**. Copper, iron, chromium, and nickel are necessary metals since they are vital to biological systems. They are essential nutrients, but excessive amounts can be harmful, and sensitive methods are needed to detect these metals in the environment and wastewater samples cadmium and lead are non-essential metals because they are poisonous even in minimum levels **(Dhahir et al., 2015; Joda et al., 2019)**.

In recent years, there has been a growing concern about the discharge of heavy metals into the biosphere, as they have cumulative toxic effects on plants, animals, and humans. Most of these concentrations are not measured, and heavy metals in wastewater can re-enter the biosphere through treatment processes, leading to contamination of the food chain. Heavy untreated metals found in wastewater have harmful effects, including interference with biological processes used in wastewater treatment, causing a decrease in treatment efficiency as they accumulate in sludge many times, thereby increasing their concentration in sludge, and therefore sludge' uses as fertilizers will harm the food chain **(Issa and Thuwaini, 2012; Mohammed et al., 2019)**. To achieve a technology-based treatment criterion, innovative methods for treating industrial wastewater containing heavy metals frequently use toxicity reduction technologies **(Barakat, 2011)**.

A previous study **(Abdulkareem et al., 2021)** demonstrated the efficient performance of the wastewater treatment plant at Al-Dora refinery in removing various contaminants from the effluent. The plant achieved the following removal efficiencies: 70% for Total Dissolved Solids (TDS), 99.98% to 100% for Oil and Grease, 85.9% to 98.21% for Total Suspended Solids (TSS), and 61.73% to 64.1% and 98.43% to 99.48% for both Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD). The highest turbidity removal was recorded with an influent turbidity of 105 NTU.

In another study conducted by researchers **(Al-Suhaili, 2008)**, they evaluated the performance of the industrial wastewater treatment plant in Al-Dora Refinery compared to the treatment performance designed for it, and through the tests and results obtained, the industrial wastewater treatment plant in Al-Dora Refinery demonstrated high efficiency in removing pollutants such as TSS, COD, BOD, sulfide, phenol. As for other pollutants, such as ammonia, sulfates, and phosphates, they showed less efficiency in removing them. **(AbdulRazzak, 2023)** evaluated the performance of the Rustamiya wastewater treatment plant in Baghdad, focusing on its efficiency in treating wastewater to meet Iraqi liquid waste standards. The results indicated that although the liquid waste discharged into the Diyala River did not fully comply with Iraqi standards, the biological processes at the station showed chronic biological disturbance. Data from the plant's operation in 2011 showed that the effluent concentrations of BOD5, COD, TSS, and chloride were within Iraqi effluent standards. The plant demonstrated efficient removal of pollutants, with BOD5 removal efficiencies ranging from 90.31% to 92.96%, COD removal efficiencies from 87.9% to 88.23%, TSS removal efficiencies from 80.72% to 89%, and chloride removal efficiencies from 14.79% to 15.37%. The study highlighted the importance of understanding wastewater characteristics for designing and sizing treatment facilities. It emphasized the need to monitor and optimize treatment processes to ensure compliance with effluent standards and protect the environment. The evaluation of the plant's performance indicated its capability to treat wastewater effectively, although challenges such as biological upsets were identified. Analyzing selected metal elements and phenols in industrial wastewater from Al-Dora refinery and Al-Najaf refinery before and after treatment by **(Risan and Al-hamdani, 2020)**. The researchers used flame absorption spectroscopy, graphite furnace spectroscopy, and ultraviolet spectroscopy to analyze the samples. The results showed a significant difference in the treatment rate for contaminated water, with a 63% improvement in area after treatment. Statistical tests, including the T-test, were conducted to compare treated and untreated samples. The study also compared the efficiency of the Al-Dora refinery and Najaf refinery in treating different elements, with varying results for different metals. The findings suggested the need for effective treatment methods to reduce the levels of heavy metals in industrial wastewater.

In another study conducted by **(AL-Kordy and Khudair, 2021)** on the wastewater treatment plant in the city of Hilla, they evaluated the quality of liquid waste in the wastewater treatment plant in the city of Hilla using principal components analysis and cluster analysis. The plant, which serves 500,000 people, used an activated sludge process with a daily flow of 107,000 cubic meters. Data collected from November 2019 to June 2020 indicated the removal efficiencies of 88%, 75%, 94%, 57%, and 77% for various contaminants. The quality of the effluent has met Iraqi quality requirements, demonstrating

the effective treatment of wastewater at the plant and compliance with environmental standards for environmentally friendly waste production.
The aim of this study is to measure, study and evaluate the levels of heavy metals and some indicators that indicate water pollution in industrial wastewater that is released into the water of the Tigris River by Al-Dora Refinery after being treated in the industrial water treatment unit inside the refinery.

2. THE STUDY AREA

Al-Dora Refinery is located at the western bank of the Tigris River, south-west of Baghdad, Iraq. Its coordinates are latitudes 33°15'38"N and longitudes 44°25'28"E. The refinery was established in 1953 and began production in 1955 refining large quantities of crude oil into oil products.. After that, the processing unit was built in the refinery in 1980, with a design capacity of 750 m3/hr and a production capacity of 210,000 barrels per day.**Fig.1** represents the location of the Al-Dora refinery in Baghdad.

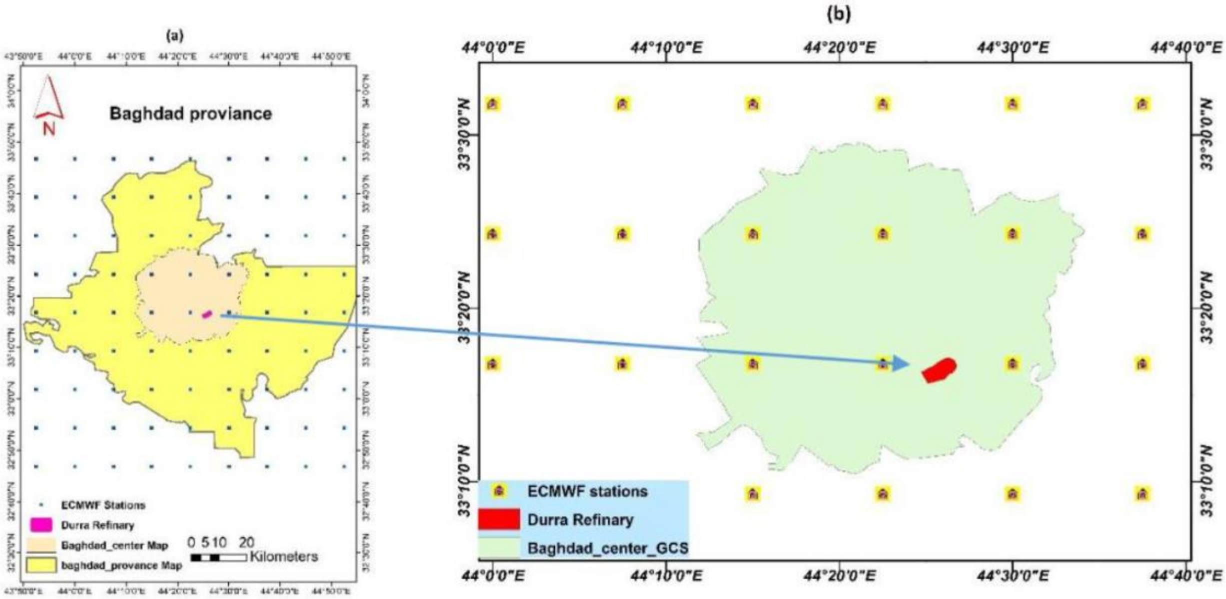

Figure 1. Location study, (a) the map of Baghdad province and its center (b) the location of Al-Dora refinery in Baghdad **(Hassoon and Al-Dabbagh, 2023)**.

2.1 Treatment of Wastewater from Oil Industries

Oil refinery wastewaters are toxic and pose significant environmental health hazards due to high concentrations of contaminants such as emulsified oil, phenols, sulfides, mercaptans, cyanides, ammoniacal nitrogen, hydrogen sulfide, and micropollutants **(Santos et al., 2015)**. As a result, these industrial wastewaters require adequate treatment before being released into water bodies **(Corona et al., 2013)**. Al-Dora refinery wastewater plant treatment began operating in 1980, connecting the two old API giving the full name then abbreviation for (API)separators built in 1955 with the new treatment facilities. The refinery wastewater enters several stages and treatment basins before their release into the river, as shown in **Fig. 2.**

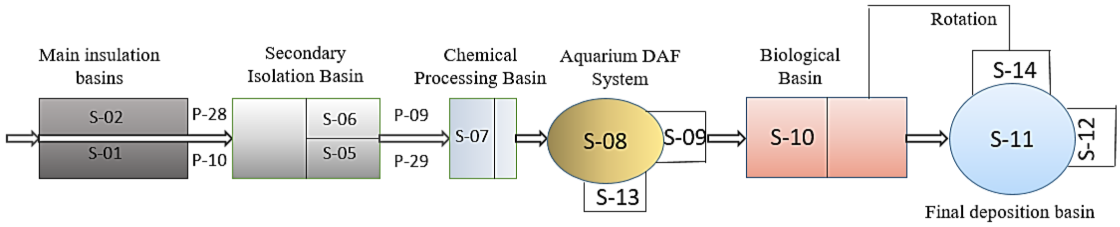

Figure 2. An illustrative diagram of the industrial water treatment plant in Al-Dora Refinery **(Risan and Al-hamdani, 2020)**.

In each treatment tank some contaminants are removed using concrete buffers and dis-coil devices inside main isolation ponds. Afterwards, residual pollutants are eliminated using concrete barriers and skimmers in the secondary isolation basin. Alum and polyelectrolytes are added to the chemical treatment tank. Subsequently, the suspended particles that have become flocculated in the chemical treatment tank are removed inside the flotation tank that represents the physical part of the treatment, float to the surface and are skimmed off by skimmers. The next step include the addition of Urea and phosphoric acid as nutrients within the biological treatment basin. Recycling is adopted within the biological treatment basins. The sludge fromvarious parts of the treatment units is finally filtered off to be treated and incinerated later.

Finally, workers remove and dispose the sedimented materials in the sedimentation basin into a secondary basin, and discharge the pure water into the Tigris River through special pipes.

3. MATERIAL AND METHODS

Water samples were collected from five sites, five replicates for each site, to ensure the validity of the results. They were collected in a cleanpolyethylene containers (1 Liters) after being homogenized with sample water several times. Electrical conductivity (EC), Total dissolved solids (TDS), and temperature (T) were measured using one device (Mi 170 Bench Meter). Total suspended solids (TSS) were determined by filtration and afterward dried at (103–105) ◦ C. The pH was measured using a CRISON (GLP22) pH meter. The mesaurements of turbidity were conducted using an AL250T-IR device,no need . The sample was filtered and nitric acid was added to it. A series of standard solutions were prepared for each metal ion, by diluting the stock solution of the measured metal. Standard calibration curves were constructed for these metal ions and measured using a AA-6200 (Shimadzu Company) flame atomic absorption device at Ministry of Science and Technology.

Sample collection locations, Pictures of samples during processing stages are demonstrated in **Fig. 3**.

- S1: Water entering the treatment plan.
- S2: Water after the mechanical treatment stage.
- S3: Water after the physicochemical treatment stage.
- S4: Water after the biological treatment stage.
- S5: water after the final sedimentation stage.

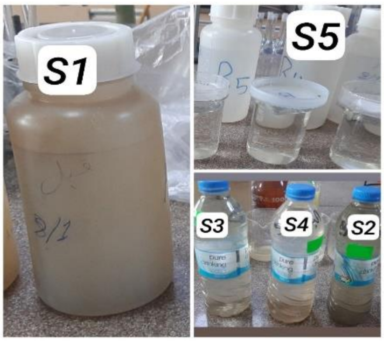

Figure 3. Pictures of samples during processing stages.

4. RESULTS AND DISCUSSION

The physical and chemical parameters that are used to evaluate the quality of treated water discharged into the Tigris River resulting from the industrial wastewater treatment plant at Al-Dora Refinery include temperature, pH, electrical conductivity, total suspended solids (TSS), total dissolved solids (TDS), As well as heavy metals (Copper, Iron, Cadmium, Cobalt, Lead, and Nickel). In **Table 1** the results for industrial wastewater in the summer and in **Table 2** in the winter.

Table 1. The mean and standard deviation of physio-chemical parameters for the Summer season.

physio-chemical parameters	Unit	S1	S2	S3	S4	S5
		mean± S.D	mean± S.D	mean± S.D	mean± S.D	mean± S.D
PH	-	8.23±0.09	7.23±0.08	7.02±0.01	7.07±0.01	7.03±0.01
Temperature	°C	34.80±0.40	25.80±1.17	25.20±0.40	25±0.63	24.8±0.40
Turbidity	NTU	60.88±0.62	32.96±0.59	15.60±0.52	11.45±1.72	3.12±0.81
EC	ms/cm	2883±28.02	2408±16.49	2265±26.73	2187±6.23	2253±21.59
TSS	mg/l	575±8.20	525.40±5.31	396±47.93	379±6.01	136±18.95
TDS	mg/l	1441±14.01	1210±5.635	1130±7.144	1095±7.222	1125±10.37

Table 2. The mean and standard deviation of physio-chemical parameters for the winter season.

physio-chemical parameters	Unit	S1	S2	S3	S4	S5
		mean± S.D	mean± S.D	mean± S.D	mean± S.D	mean± S.D
PH	-	7.52±0.03	7.49±0.06	7.16±0.05	7.21±0.05	7.07±0.04
Temperature	°C	28.60±0.49	27.80±0.75	24.80±0.40	23.80±0.40	22.60±0.49
Turbidity	NTU	100.60±1.85	82.80±2.79	25±2.28	14.80±0.75	8.04±0.40
EC	ms/cm	1147±4.45	1027±5.49	963±3.87	1369±3.54	1711±2.79
TSS	mg/l	780±4.69	397.20±7.57	347.80±4.87	319.20±2.48	101.60±2.15
TDS	mg/l	569.80±5.19	512.60+3.01	480.60+3.01	688+2.83	852+3.85

4.1 Chemical and Physical Parameters

The results of the measurements that were conducted showed a slight increase in its concentrations in the summer compared to the winter in some analyses, and vice versa in other analyses. There was a noticeable increase in the samples before and after treatment,

as the pH in the summer before treatment was 8.23, and the acidity percentage gradually decreased during the treatment stages to reach 7.03 in the water discharged into the river. In contrast, in winter it was slightly lower, reaching 7.516 in the water entering the treatment plant and 7.072 in the water discharging, which is within the environmental limits. The pH of water is affected by temperature as the change in temperature leads to a change in the amount of ions in the water **(Castells et al., 2003)**.
As for the temperature, as expected, it was higher in the summer(34.8 °C in the incoming water and 24.8°C in the outgoing water), while in the winter it was 27.6 °C in the incoming water and 22.6 °C in the outgoing water. These values were acceptable within the Iraqi and global environmental specifications. Temperature has an important effect on the levels of other pollutants in the water, as well as positive and negative effects on the growth of plants and organisms that live in the water**(Kara et al., 2004)**. As for the Turbidity rate, it was higher in the winter than in the summer, reaching 100.6 NTU in the incoming water, but it decreased significantly during the treatment stages reaching 8.04 NTU in the outgoing water excreted into the river, while in the summer it was 60.88 NTU in the incoming water and 3.12 NTU in the outgoing water.
The level of EC in the summer was 2883 (ms/cm) in the incoming water and 2253 (ms/cm) in the outgoing water, while in the winter it was 1147 (ms/cm) in the incoming water and 1711 (ms/cm) in the outgoing water after treatment. There was a 2 to 3% increase in the electrical conductivity of water for every 1 °C rise in temperature. The conductivity of the water increases with increasing ion concentration **(Lawson, 2014; Alharbawee and Mohammed, 2024)**.
Higher concentrations of TSS were observed in the winter samples entering the treatment plant at 780 mg/L and outgoing water at 101.6 mg/L compared to 575 mg/L in incoming water and 135.6 mg/L in outgoing water in summerThe concentration of TSS treated and discharged to the river in the winter is lower than in the summer, from here the sentence is not clear even though it was higher in concentration before treatment. High levels of TSS in the effluent can be caused by inadequate TSS removal during primary treatment, such as in grit chambers and primary sedimentation tanks. The size and specific gravity of the settling particles determine the TSS level removed **(Alsaqqar et al., 2023)**. The presence of high levels of suspended solids can diminish water quality as they absorb light. Not clear from here As the water warms up, it loses its capacity to hold onto the oxygen needed by aquatic organisms **(Lawson, 2011)**.
Finally, the materials' TDS concentration in the summer was twice its concentration in the winter samples, reaching 1441 mg/L in the incoming water and 1125 mg/L in the outgoing water in the summer, while in the winter its concentration was 569.8 mg/L in the incoming water and 852 mg/L in the outgoing water. The more suspended solids in the water, the higher the materials' TDS concentration. In addition, the higher dissolved salts percentage in the water gives a, higher EC. Also, the evaporation factor affects the increase in TDS in the summer. Highly pure water that does not contain salts or minerals has a very low EC **(Lawson, 2011)**.

4.2 Heavy Metals

The results obtained showed the presence of different concentrations of Cu, Fe, Cd, Co, Pb, and Ni that were detected in the industrial wastewater released from the treatment stages of the treatment station, as shown in **Tables 3** and **4**.

Table 3. The mean and standard deviation of heavy metals for the Summer season.

Heavy metals	Unit	S1	S2	S3	S4	S5
		mean± S.D	mean± S.D	mean± S.D	mean± S.D	mean± S.D
Cu	mg/l	0.15±0.009	0.13±0.006	0.09±0.002	0.02±0.007	0.02±0.004
Fe	mg/l	0.09±0.003	0.06±0.001	0.03±0.002	0.02±0.005	0.02±0.004
Cd	mg/l	0.27±0.03	0.21±0.02	0.13±0.01	0.11±0.006	0.10±0.003
Co	mg/l	0.07±0.003	0.061±0.003	0.04±0.002	0.03±0.002	0.02±0.002
Pb	mg/l	0.45±0.04	0.41±0.03	0.33±0.01	0.16±0.02	0.14±0.02
Ni	mg/l	0.22±0.04	0.12±0.009	0.11±0.006	0.09±0.005	0.08±0.006

Table 4. The mean and standard deviation of heavy metals for winter season.

Heavy metals	Unit	S1	S2	S3	S4	S5
		mean± S.D	mean± S.D	mean± S.D	mean± S.D	mean± S.D
Cu	mg/l	0.16±0.004	0.12±0.009	0.09±0.006	0.09±0.001	0.06±0.004
Fe	mg/l	0.06±0.002	0.05±0.003	0.03±0.002	0.03±0.001	0.02±0.001
Cd	mg/l	0.18±0.004	0.17±0.001	0.14±0.005	0.13±0.01	0.11±0.003
Co	mg/l	0.09±0.004	0.089±0.001	0.07±0.004	0.05±0.003	0.03±0.003
Pb	mg/l	0.15±0.012	0.088±0.003	0.07±0.006	0.04±0.002	0.03±0.004
Ni	mg/l	0.23±0.011	0.21±0.005	0.19±0.006	0.12±0.003	0.09±0.007

The tabulated results concluded that the heavy metals exists in water samples during summer season **Table 3** regarding the copper elements were lower compared to the winter season, where its concentration before treatment was 0.148 mg/L write after. A decrease to 0.017 mg/L was found for the outgoing water drained into the river, while the highest percentage of copper element removal was during the biological stage with the percentage of removal estimated at 0.061mg/L. Iron showed a slight decrease during the treatment stages, and its highest removal rate was during the physicochemical stage at 0.036 mg/L. A slight decrease for Cadmium concentration from 0.268 mg/L before treatment to 0.105 mg/L during the treatment process, which is higher than the permissible environmental limits for water discharged into the river.

The concentration of cobalt decreased from 0.073 mg/L before treatment was 0.073 mg/L to 0.017 mg/L after the treatment processes, which consider less than the permissible environmental limits. The highest removal rate during the biological treatment process was 0.022 mg/L. Regarding lead element , the concentration before treatement was 0.449 mg/L, afterwards, it decreas to 0.138 mg/L, which is approximately within the permissible environmental limits. The highest removal amount of during the biological stage was 0.165 mg/L. The nickel concentration before treatment was 0.221mg/L and its concentration decreased to 0.078mg/L after treatment, which within the permissible environmental limits. The results showed that there is an inverse relationship between the two variables, with the percentage elimination decreasing steadily as the initial concentration value for all heavy metal ions in general increases **(Shadhan and Abbas, 2021)**.

The results during the winter **Table 4** entering to the station were for copper at a concentration of 0.158 mg/L, while after treatment the concentration reached to 0.064 mg/L in the discharge water from the station. due to a decrease in its concentration by a significant proportion during the treatment stages, as the highest copper removal percentage in the mechanical stage was 0.042 mg/L. Iron element concentration in the inlet water the station

was 0.064 mg/L, while its concentration after treatment in wastewater which discharge to where was 0.02 mg/L, and the removal rates were close during all treatment stages.
For the cadmium element, it showed a very slight decrease, its concentration was 0.177 mg/L in the water sample before treatment, while after treatment it was 0.109 mg/L. The highest removal rate of cadmium during the physicochemical stage was 0.034mg/L. It turns out that the concentration of cadmium is more than the permissible environmental limit of 0.01 mg/L. The increase in the concentration of cadmium causes health problems for humans such as kidney damage and disorders. It is a carcinogenic substance **(Gunatilake, 2015)**. Regarding for the element cobalt, its concentration in the water before treatment was 0.091 mg/L and after treatment was 0.031mg/L, and the highest removal rate was in the biological stage by 0.022mg/L. The concentration of lead in the water before treatment was 0.146 mg/L and gradually decreased during the treatment stages to 0.029 mg/L, where the highest removal percentage was reached during the mechanical treatment stage with a removal rate of 0.058 mg/L. The highest concentration of lead in the water discharged into the river was in the summer, at high temperatures and low acidity, which is consistent with **(Uysal and Taner, 2009)**. The nickel element showed a significant decrease, as its concentration in the water before treatment was 0.228 mg/L, and it decreased to 0.092 mg/L in the water after treatment, where the highest percentage of nickel removal during the biological treatment stage was 0.069 mg/L. The high concentrations of elements in the water before starting the treatment process are due to the fact that the temperature was 22°C, and the lower it is, the lower the solubility of the metal ions, i.e. the lower the concentration **(Risan, 2020)**. By comparing the results obtained for the selected parameters in the treated industrial wastewater discharged into the river with the standard Iraqi parameters for the river maintenance system and with the parameters of the World Health Organization **Table 5**, it was found that they are within the permissible limits in the results of both chapters regarding pH, temperature, and total dissolved solids.

Table 5. The results of the parameters measured in this study compared with the limits of permissible concentrations from the World Health Organization and the Iraqi specifications for the system of protecting rivers from pollution, 1967.

parameters	Results of the current study during the		Unit	Iraqi Determinants of River Pollution Conservation System (Richter et al., 1967)	Determining Wastewater Treatment Standards (Edwards, 2019)
	summer	winter			
PH	7.03	7.072		6-9.5	6-9
Temperature	24.8	22.6	°C	>35	Temperatures higher than the receiving medium
Turbidity	3.12	8.04	NTU		5
EC	2253	1711	ms/cm		1000
TSS	135.6	101.6	mg/l	60	50
TDS	1125	852	mg/l	1500	
Cu	0.017	0.064	mg/l	0.2	0.5
Fe	0.0186	0.020	mg/l	2.0	1
Cd	0.105	0.109	mg/l	0.01	0.1
Co	0.017	0.031	mg/l	0.5	
Pb	0.138	0.029	mg/l	0.1	0.5
Ni	0.078	0.092	mg/l	0.2	0.25

The turbidity concentration in winter was higher than the permissible limits, and the electrical conductivity was also higher than the limits in both seasons. Total suspended solids also exceeded the specified concentration. The heavy metals measured in this study were all within the permissible environmental limits. There was no discernible difference in the concentrations of Cu, Fe, Ni, Cd, Pb, and Co in the summer and winter, but the seasonal trend for all the heavy metals was the same high concentrations in the summer and low concentrations in the winter **(Kaur and Mehra, 2012)**

5. CONCLUSIONS

The physical, chemical, and heavy metal measurements showed a substantial variation in pollutant levels between the industrial wastewater entering and exiting or discharging the water treatment facility at Al-Dora Refinery. This is due to the ability and efficiency of the plant in treating this water and reducing the concentrations of pollutants before their discharge into the river, and the presence of a slight or relative discrepancy between its results in the summer and the winter. The temperature in summer is higher than in the winter. This is due to the significantly high temperatures in the summer in general of Iraq, where it sometimes reaches 50 °C. This has a negative effect, as it increases the interactions between the polluting compounds that are present in the inlet and discharge wastewater from the treatment plant. However, the levels of these measured pollutants in the current study remain within the Iraqi environmental determinants levels of the river maintenance system and industrial water discharged into the river.

NOMENCLATURE

Symbol	Description	Symbol	Description
EC	Electrical conductivity ms/cm	TSS	Total suspended solids mg/l
T	ambient temperature, °C	NTU	Nephelometric Turbidity Unit
TDS	Total dissolved solids mg/l	pH	Potential of Hydrogen

Acknowledgments

The authors would like to thank the Department of Chemistry, College of Science for Women, University of Baghdad, the Ministry of Science and Technology, the Department of Environmental and Water Research, and the College of Engineering, Department of Environmental Engineering, University of Baghdad. Also they would like to thank the Dora Refinery and the Industrial Water Treatment Department for their valuable support and assistance in conducting the necessary measurements for this research.

Credit Authorship Contribution Statement

Hawraa G. Auied carried out the experimental work, collected and analyzed the data, and wrote the manuscript, while Maitham A. Sultan and Saadiyah A. Dhahir contributed to the design and concept of the study, participated in discussing the results, drafting and editing the research paper, and reviewed and approved the final version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Abdulkareem, F.A., Hussain, T.A. and Najaf, A.A., 2021. The treatment of wastewater produced from Al-Doura refinery to increase production and minimize pollutant materials. *Iraqi Journal of Science*, 62(11), pp. 3984–3996. https://doi.org/10.24996/ijs.2021.62.11.19.

AbdulRazzak, A.M., 2023. Performance evaluation of al-Rustamiya wastewater treatment plant. *Journal of Engineering*, 19(4), pp. 429–438. https://doi.org/10.31026/j.eng.2013.04.01.

Al-Suhaili, R.H., Abed, M. A., 2008. Evaluation of the performance of the Dora refinery wastewater treatment plant. *Journal of Engineering*, 14(4), pp. 3020–3036. https://doi.org/10.31026/j.eng.2008.04.12.

Al-hadithy, A., 2022. The direct effect of water pollution in iraq on public health and safety. *Journal of Urban Planning and Development*, 148(1), p. 23. https://doi.org/10.5281/zenodo.5732842.

Al-Khuzaie, M. M., Maulud, K. N. A., Mohtar, W. H. M. W., Yaseen, Z. M., 2024. Assessment of untreated wastewater pollution and heavy metal contamination in the Euphrates river. *Environmental Pollutants and Bioavailability*, 36(1), p. 2292110.

AL-Kordy, S.U. and Khudair, D.B.H., 2021. Effluent quality assessment of sewage treatment plant using principal component analysis and cluster analysis. *Journal of Engineering*, 27(4), pp. 79–95. https://doi.org/10.31026/j.eng.2021.04.07.

Al-Taher, Q.M., Akbar, M.M. and Al-Qarooni, I.H., 2020. Estimation of heavy metals in water, sediments and bioaccumulation in pseudodontopsis Euphraticus and bellamya bengalensis in Euphrates river in al-Nassiriyah city/south of Iraq. *Plant Archives*, 20(2), pp. 1454–1460.

Alsaqqar, A.S., Khudair, B.H. and Mekki, A., 2023. Assessment efficiency evaluation of Al-Diwaniya sewage treatment plant in Iraq. *Journal of Engineering*, 20(2), pp. 20–32. https://doi.org/10.31026/j.eng.2014.02.02.

Araghi, P.E., Bastami, K.D. and Rahmanpoor, S., 2014. Distribution and sources of polycyclic aromatic hydrocarbons in the surface sediments of Gorgan Bay, Caspian Sea, *Marine Pollution Bulletin*, 89(1–2), pp. 494–498.

Barakat, M.A., 2011. New trends in removing heavy metals from industrial wastewater. *Arabian Journal of Chemistry*, 4(4), pp. 361–377. https://doi.org/10.1016/j.arabjc.2010.07.019.

Castells, C. B., Ràfols, C., Rosés, M., Bosch, E., 2003. Effect of temperature on pH measurements and acid-base equilibria in methanol-water mixtures. *Journal of chromatography. A*, 1002, pp. 41–53. https://doi.org/10.1016/S0021-9673(03)00644-7.

Corona, F., Mulas, M., Haimi, H., Sundel, L., Heinonen, M., Vahala, R., 2013. Monitoring nitrate concentrations in the denitrifying post-filtration unit of a municipal wastewater treatment plant. *Journal of Process Control*, 23(2), pp. 158–170.

Dhahir, S. A. RhajabBakir, S., 2015. Cloud point extraction spectrophotometric determination of nickel, copper, cobalt and chromium by 4- HBDA1, 5DPHP as reagent in wastewater of Iraq. *Environmental Science and Pollution Research An Indian Journal*, 10(4).

Edwards, J. D. 2019. *Industrial wastewater treatment*. CRC press.

Gunatilake, S.K., 2015. Methods of removing heavy metals from industrial wastewater. *Journal of Multidisciplinary Engineering Science Studies (JMESS)*, 1(1), pp. 12–18.

Hassan, F.M., AL-Baidhani, A.N.A.R. and Al-Khalidi, S.H.H., 2016. Bioadsorption of heavy metals from industrial wastewater using some species of bacteria. *Baghdad Science Journal*, 13(3), p. 0435. https://doi.org/10.21123/bsj.2016.13.3.0435.

Hassoon, A.F. and Al-Dabbagh, S.K., 2023. Effect dynamic stability of atmospheric boundary layer on plume downward flux emitted from Daura refinery stacks. *Iraqi Geological Journal*, 56(1), pp. 161–171. https://doi.org/10.46717/igj.56.1A.12ms-2023-1-24.

Issa, I.K., Daoud, T.N. and Thuwaini, M.N., 2012. Estimate the level of some heavy elements in treated wastewater returned to the Diyala river from the Rastamiya station in Baghdad. *journal of the college of basic education*, 18(75), pp. 221–235.

Joda, B.A., Alheloo, H. S., Al-Mankosh, H. J., & Maitham, S. A., 2019. Determination of heavy metals arsenic, cadmium and lead in water, sediments and fish from al delmaj marshes-Iraq. *AIP Conference Proceedings*, 2144. https://doi.org/10.1063/1.5123069.

Kara, Y., Kara, I. and Basaran, D., 2004. Investigation of some physical and chemical parameters of water in the Lake Isykli in Denizli, Turkey. *International J. Agriculture and Biol*, 6(2), pp. 275–277.

Kaur, S. and Mehra, P., 2012. Assessment of heavy metals in summer & winter seasons in River Yamuna segment flowing through Delhi, India. *Journal of Environment and Ecology*, 3(1), pp. 149–165.

Lawson, E.O., 2014. Physico-chemical parameters and heavy metal contents of water from the mangrove swamps of lagos lagoon , lagos , nigeria physico-chemical parameters and heavy metal contents of water from the mangrove swamps of lagos lagoon , lagos , nigeria. (January 2011).

Mahmood, W., Ismail, A.H. and Shareef, M.A., 2019. Assessment of potable water quality in Balad city, Iraq. in *IOP conference series: materials science and engineering*. IOP Publishing, p. 22002.

Sultan, M. A., Khalid, F., & Al-Hayanni, H. S., 2023. Use Cu and Fe metals as a pollution index for status estimation of some agricultural soil in Baghdad city/ Iraq. *Journal of Population Therapeutics and Clinical Pharmacology*, 30(13), pp. 334–345. https://doi.org/10.47750/jptcp.2023.30.13.034.

Majeed, O.S. and Ibraheem, A.K., 2024. Using heavy metals pollution indices for assessment of tigris river water within al-Tarmiya city , northern Baghdad , Iraq. (January). https://doi.org/10.12912/27197050/178457.

Mohammed, S.A., Dhahir, S.A. and Hmmod, A., 2019. Estimation of water pollution and cultivated plants on the Diyala River with heavy elements during the summer by flame atomic absorption. *Iraqi Journal of Market Research and Consumer Protection*, 2(3), pp. 32–45.

Nasir, N.A.-N. and Al-Najare, G.A., 2015. Bioaccumulation of heavy metals concentration in mullet fish (Palaniza abu), waters and sediments from Al-Hammar marsh, Iraq. *Mesopotamia Environmental Journal*, 2(1), pp. 24–32.

Richter, L.E., Carlos, A. and Beber, D.M., 1967. Regulation no. 25 of 1967 maintenance of rivers and public water from pollution. Food and Agriculture Organization of United Nations

Risan, S. and Al-hamdani, A.A.S., 2020. Determination of metal ions , phenols , and No3- , No2- in industrial wastewater of al-Dura and al-Najaf refinery. 24(05), pp. 5132–5141. https://doi.org/10.37200/IJPR/V24I5/PR2020220.

Santos CarlosE, André Fonseca, Eva Kumar, Amit Bhatnagar, Vítor J.P. Vilar, Cidália M.S. Botelho, Rui A.R. Boaventura., 2015. Performance evaluation of the main units of a refinery wastewater treatment plant - A case study. *Journal of Environmental Chemical Engineering*, 3(3), pp. 2095–2103. https://doi.org/10.1016/j.jece.2015.07.011.

Shadhan, J. and Abbas, M.N., 2021. Removal of heavy metals from refineries wastewater. *Journal of Engineering and Sustainable Development*, pp. 97–107.

Uysal, Y. and Taner, F., 2009. Effect of pH, temperature, and lead concentration on the bioremoval of lead from water using Lemna minor. *International journal of phytoremediation*, 11(7), pp. 591–608.

Wang,N., Qiu, Y., Kaimei, H., Huang, C., Xiang, J., Li, H., Tang, J., Wang, J., Xiao, T., 2021. One-step synthesis of cake-like biosorbents from plant biomass for the effective removal and recovery heavy metals: Effect of plant species and roles of xanthation. *Chemosphere*, 266, p. 129129.

Zaynab,M., Al-Yahyai, R., Ameen, A., Sharif, Y., Ali, L., Fatima, M., Khan, K. A., Li, S., 2022. Health and environmental effects of heavy metals. *Journal of King Saud University - Science*, 34(1), p. 101653. https://doi.org/10.1016/j.jksus.2021.101653.

Zhang, L., Tan, X., Chen, H., Liu, Y., Cui, Z., 2022. Effects of agriculture and animal husbandry on heavy metal contamination in the aquatic environment and human health in huangshui river basin. *Water*, 14(4), p. 549.

تقدير تركيزات بعض المعادن الثقيلة في مياه الصرف الصناعي في مصفى الدورة النفطي

حوراء جويمير عويد[1]، سعدية احمد ظاهر[1]، ميثم عبدالله سلطان[2]

[1] قسم الكيمياء، كلية العلوم للبنات، جامعة بغداد، بغداد، العراق

[2] دائرة البيئة والمياه، وزارة العلوم والتكنلوجيا، بغداد، العراق

الخلاصة

يتم تصريف مياه الصرف الصناعي بكميات كبيرة إلى المسطحات المائية، ويتم استخدام عمليات معالجة مختلفة لتقليل مستويات الملوثات. تهدف هذه الدراسة إلى تحديد مستويات النحاس والحديد والكادميوم والكوبالت والرصاص والنيكل في عينات مياه الصرف الصناعي في مصفاة الدورة. أظهرت النتائج اختلافات قبل وبعد المعالجة، مع إجراء الاختبارات الفيزيائية والكيميائية في الصيف والشتاء. كانت القيم المقاسة (pH، TOC، Turbidity، EC، TSS،TDS) على التوالي (8.23، 34.8 °C ، 60.88 NTU، 2883 ms/cm، 575 mg/L، 1441 mg/L) في الصيف، بينما كانت في الشتاء (7.516، 28.6 °C ، 100.6 NTU، 1147 ms/cm، 780 mg/L، 569.8 mg/L) على التوالي. تم قياس العناصر الثقيلة وأظهرت انخفاضاً طفيفاً خلال وحدات المعالجة، ومع ذلك لا تزال من بين المحددات البيئية لنظام صيانة الأنهار العراقية (1967). وكانت العناصر المقاسة هي (Cu، Fe، Cd، Co، Pb، Ni)، وكانت تركيزاتها في المياه المعالجة والمصرفة إلى النهر (0.064، 0.020، 0.109، 0.031، 0.029، 0.092) mg/L ، على التوالي، في فصل الشتاء. بينما كانت تركيزاتها في الصيف (0.017، 0.018، 0.0105، 0.017، 0.138، 0.078) mg/L ، على التوالي. وكانت قيم تركيزات الملوثات عاملاً بيئياً رئيسياً في صيانة الأنهار العراقية، حيث قامت محطة المعالجة بشكل فعال بتقليل أو إزالة هذه الملوثات من المياه قبل تصريفها إلى النهر، دون التأثير على جودة المياه.

الكلمات المفتاحية: مصفى الدورة النفطي، المعادن الثقيلة، مياه الصرف الصناعي، تقييم الأداء، المعالجة