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Evaluating The Efficiency of Industrial Water Treatment Unit at Baiji Refinery According to International Environmental Standards

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ABSTRACT

This study was conducted to evaluate the treatment unit for industrial water from Baiji refinery located in Salahuddin Governorate for three months (2023), and it was found that the temperature ranged between (15-27), while turbidity reached (2.9-14.9) NTU, while electrical conductivity values were (569-801) µS/ cm.

While the upper limit of total hardness, calcium and magnesium hardness reached about (140.67, 117.00 and 41.00) Milligrams per liter as Ca CO_3, respectively, as well as the upper limit of chloride ion reached about (53.0) milligrams per liter, nitrate (1.560) micrograms per liter and nitrite (0.250) micrograms per liter. 250 micrograms / liter, sulfate (265.33) milligrams / liter, phosphate (0.510) micrograms / liter, as for dissolved oxygen and chemical oxygen demand, their values reached (3.67) milligrams / liter and (0.889), respectively

The concentration of heavy metals such as lead, nickel, cadmium, zinc, cobalt and chromium reached the upper limit of (0.16287, 0.1651, 0.12992, 1.3487, 0.05178, 0.01919) ppm, respectively, while the water was free of mercury and arsenic elements. The study showed that the water specifications were within the limits allowed by the World Health Organization and the US Environmental Protection Agency.

Keywords: Water treatment, water quality, heavy metals, pollution.

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تقييم كفاءة وحدة معالجة المياه الصناعية في مصفاة بيجي وفق المعايير البيئية العالمية

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الملخص

أجريت هذه الدراسة لتقييم وحدة المعالجة للمياه الصناعية المطروحة من مصفى بيجي الواقعة في محافظة صلاح الدين ولمدة ثلاث أشهر (2023) وقد تبين أن درجة الحرارة تراوحت بين (15−27) أما العكورة فقد بلغت (NTU 14.9−2.9)بينما قيم التوصيلية الكهربائية كانت بين (µS/ cm 801.00−569.00)كما أن نسبة المواد الصلبة الذائبة الكلية تراوحت بين (411.00−291.67) مليغرام/لتر وكانت قيم الرقم الهيدروجيني بين (8.3−7.1) والقاعدية الكلية بين (153.00−143.33) مليغرام/لتر. بينما بلغ الحد الأعلى للعسرة الكلية وعسرة الكالسيوم والمغنيسيوم حوالي (140.67 و117.00و41.00) مليغرام/لتر على التوالي وكذلك بلغ الحد الأعلى لأيون الكلوريد حوالي (53.0) مليغرام/لتر وللنترات (1.560) مايكرو غرام/لتر والنتريت (0.250) مايكرو غرام/لتر والكبريتات (265.33) مليغرام/لتر والفوسفات (0.510) مايكرو غرام/لتر أما قيم الأوكسجين الذائب والمتطلب الكيميائي للأوكسجين فقد وصلت قيمها إلى (3.67) مليغرام/لتر و(0.889) على التوالي.

أما تركيز المعادن الثقيلة مثل الرصاص والنيكل والكادميوم والزنك والكوبالت والكروم فقد وصل الحد الأعلى لها إلى (0.16287, 0.1651, 0.01919, 0.05178, 1.3487, 0.12992ppm)على التوالي بينما كانت المياه خالية من عنصري الزئبق والزرنيخ وقد تبين من خلال الدراسة أن مواصفات المياه كانت ضمن الحدود المسموح بها لمنظمة الصحة العالمية ووكالة حماية البيئة الأمريكية.

INTRODUCTION

Water is a unique chemical compound, one of the main solvents for many substances, characterized by its ability to form hydrogen bonds and its high specific heat. Water is one of the few substances that can exist in three physical states—solid, liquid, and gas—at normal temperatures and pressures, is the basis of life and its demand is continuously increasing due to population growth, leading to increased consumption of freshwater (1).

The Pollution of aquatic and terrestrial ecosystems by wastewater resulting from crude oil extraction and refining has become a significant global environmental challenge (2)

Iraq faces significant pollution risks from oil derivatives due to its status as one of the largest oil producers, coupled with the presence of numerous refineries, transportation lines, fuel stations, and power plants across its territory (3)

Wastewater from these activities is a major source of environmental pollution, causing degradation and altering the physical and chemical properties of ecosystems compared to pristine environments (4-6) These waters often contain a variety of pollutants that pose a serious threat to the environment, such as hydrocarbons, grease, oils, sulfates, ammonia, organic compounds, suspended and dissolved solids, and heavy metals (7). High concentrations of these pollutants negatively affect plants and animals, and lead to many human diseases such as cancer, lung diseases, skin diseases (8)

Wastewater from oil refineries is typically treated before discharge using three main stages: primary treatment (removal of suspended solids via sedimentation, coagulants, sieves, or filters), secondary treatment (biological processes to degrade organic matter), and advanced treatment (e.g., adsorption, ion exchange, reverse osmosis, or chemical oxidation with chlorine or ozone) [9] Industrial wastewater discharged contains various hazardous and foreign pollutants that deteriorate the quality of water for various purposes and affect aquatic life, economy and human health[10]

This study aims to assess the efficiency of the wastewater treatment unit at Baiji Refinery by analyzing selected physical and chemical properties and measuring the concentrations of heavy metals in the treated water.

Description of the study area

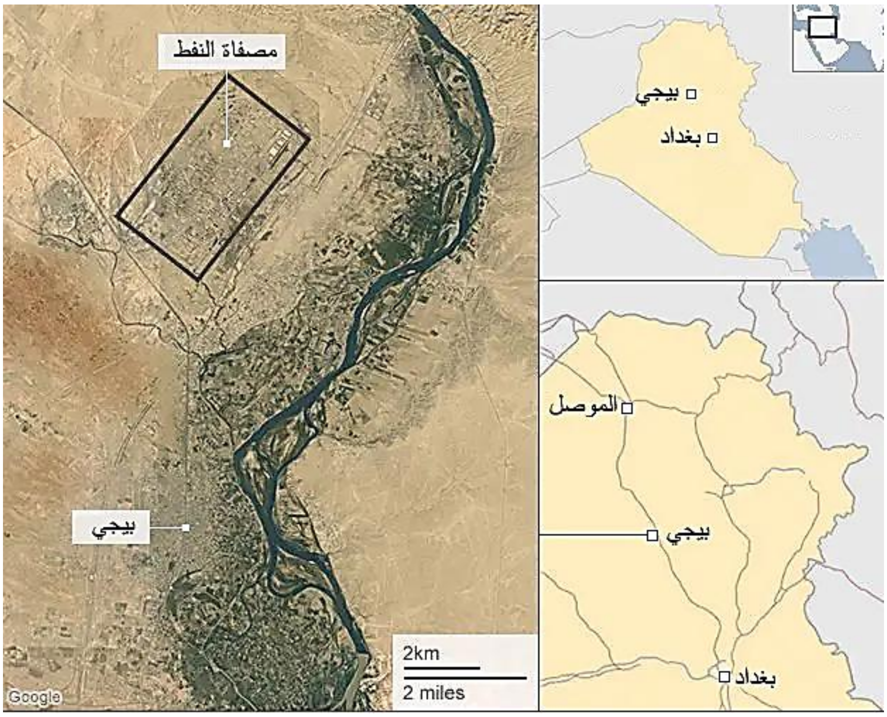
Located in northern Salahuddin Governorate, Baiji Refinery is one of the largest oil refineries in Iraq, established in 1978. As of 2024, the refinery's production capacity was approximately 250,000 barrels per day.

This high production generates substantial amounts of industrial wastewater, which are directed to the refinery's water treatment units. Occasionally, the volume of industrial wastewater from refining operations exceeds the capacity of the treatment units, leading to a decline in treatment efficiency and higher levels of contaminants in the water discharged into the environment.

MATERIALS AND METHODS

Location of the study

Samples were taken from pipes directly from the treatment units after treatment and compared with the natural standards for chemical and physical properties of water shown in Table (1), which flows into the Nuri canal inside the company Map 1, with three samples per month for three months from October to December (2023) for the purpose of determining the qualitative characteristics of the wastewater and the efficiency of the treatment units in purifying the water.



Map 1: Study site

Table 1: Normal values of some physical and chemical properties of water

Parameter	Unit	Standard	Reference
pH	mg·l–1	6.5-8.5	-
Dissolved oxygen (DO)		4.0-6.5	-
Biochemical oxygen demand (BOD5)		3	WHO, 2017
Phosphates (PO4) concentration		0.4	IQS 417, 2009
Nitrate (NO3) concentration		1	-
Calcium (Ca) concentration		25	-
Magnesium (Mg) concentration		50	-
Total hardness (TH)		250	-
Potassium (K) concentration		8	-
Sodium (Na) concentration		20	-
Sulfates (SO4) concentration		250	IQS 417, 2009
Chlorides (Cl) concentration		250	-
Total dissolved solids (TDS)		450	-
Electrical conductivity (EC)	µS·cm–1	1600	-
Alkalinity (ALK)	mg·l–1	250	WHO, 2017
Turbidity (TRUB)	NTU	5	-
Copper (Cu)	µg / L	100	IQS 417, 2009
lead (Pb)		10	-
Zinc (Zn)		3000	-
Cadmium (Cd)		3	WHO, 2017
Iron (Fe)		300	-

Physical Analysis of water

The method [10] was followed to measure the physical properties

Water & Air Temperature The air temperature was measured by a graduated mercury thermometer (1°-50°), where the thermometer was placed at a height of one meter above the ground and the readings were taken, which express the air temperature surrounding the site, while the water temperature was measured by the same thermometer after immersing its mercury-containing tip in water for two minutes, then the readings were recorded after the thermometer was stabilized.

Turbidity of the water was measured in the laboratory with a Turbidity meter after calibrating the device with standard solutions, and the device used to measure the amount of turbidity in units of (NTU). The sample was shaken before use to ensure that its components were well mixed, and the sample was poured into the measuring cell to the indicated limit, taking care not to form bubbles and maintain the stability of the device, as well as the cleanliness of the measuring cell by wiping it with a clean cloth to get rid of fingerprints on it, and the readings were recorded in three repetitions for each sample.

Electrical Conductivity The electrical conductivity of water was measured by an Oyster type Conductivity Meter. The device was calibrated and the electrode was washed before use with distilled water, after which the electrical conductivity of the samples was measured with three repetitions of each sample in the unit of micromoles/cm.

Total Dissolved Salts: Total Dissolved Salts TDS

The total dissolved salts were measured by taking a volume of (100) ml of the water sample after filtering it with a filter paper and pouring it into a pre-weighed handful (W1) and the handful was placed in an electric oven at a temperature of (105 °) until it was completely dry and then the handful was weighed again (W2) and the following equation was applied to know the amount of total dissolved salts as in the following equation T.D.S and the results are expressed in units (mg / liter)

Chemical Analysis for water

The method [11] was followed to measure the chemical properties and heavy elements in water, and the chemical oxygen demand was measured according to [12]

pH

The pH was measured by a pH meter type HANNA after it was calibrated before use with standard solutions of pH [9,7,4] where the sample was placed in a glass beaker, then the end of the glass electrode of the device was washed well and placed in the water sample and the readings were recorded after the device's reading stabilized with an average of three readings

Total Alkalinity

The concentration of total alkalinity in water samples was estimated by taking 50 ml of water and placing it in a 250 ml glass beaker with the addition of approximately two drops of methyl orange reagent until the color turned yellow, then the sample was corrected with dilute sulfuric acid solution at a concentration of 0.02N until the sample color turned from yellow to pink or reddish orange indicating the end point of the reaction and expressed in terms of calcium carbonate mg/L according to the following equation

Total Alkalinity=V H2SO4×N H2SO4×1000×Eq.wt. Eq.wt. of $CaCO_3$
CaCO3
V sample

Total Hardness

Hardness was measured by taking 50 ml of the sample and placing it in a 250 ml glass beaker, then adding 1 ml of Ammonia Buffer Solution to regulate the pH of the solution, then adding a little Erichrom Black as a solid until the sample became purple in color, then the sample was washed with 0.01N Na2EDTA solution until the sample disappeared. 01N until the purple color disappeared and the blue color appeared, then the hardness was calculated in units of mg calcium carbonate/liter according to the following equation

Total Hardness = V Na2EDTA × N Na2EDTA × 1000 × Eq.wt. as CaCO3
/V sample

Calcium Hardness

Calcium hardness was measured by taking 50 ml of the water sample and placed in a 250 ml glass flask, then 2 ml of NaOH solution was added to it with continuous stirring, then 0.2 g of calcium muroxide guide was also added, then the sample was crushed with standard Na2EDTA 0.01N with continuous stirring until the color turned from pink to purple, then calcium hardness was calculated in terms of units of mg calcium carbonate / liter and according to the following equation

Ca Hardness = V Na2EDTA × N Na2EDTA × 1000 × Eq.wt.as CaCO3/
V sample

Mg Hardness

Magnesium hardness is measured by the following equation and expressed in units of mg calcium carbonate/liter

Mg Hardness as CaCO3 = Total Hardness - Ca Hardness

Chloride Ions Concentration

The percentage of chloride in water was measured by taking 50 ml of water and placing it in a 250 ml glass beaker and adding 2-3 drops of potassium dichromate guide K2CrO4 to the sample with stirring the mixture well, then the sample was rectified with 0.02N silver nitrate solution AgNO3 until the color of the sample turned from yellow to meaty red and expressed in mg/L by applying the following equation

Chloride = V AgNO3 ×N AgNO3 ×1000 ×Mo. wt
V sample

Nitrite

To measure nitrite, 50 ml of the sample was taken and 1 ml of Sulphonil Amid was added and left for 8 minutes, then Ethylenediamine N(1-Naphthl

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dihydro) was added. Naphthl dihydrochloride) and the mixture was mixed well and after 10 minutes the absorbance was measured at a wavelength of 543nm and nitrite concentrations are expressed in units of micrograms of nitrogen-nitrite atom / liter and according to the following equation reading the absorbance of the sample F $No_2(\mu g/l)=ABS_3$

Nitrate The concentration of nitrate in the sample was measured by the cadmium column method, where the sample is passed through a cadmium column to measure its nitrate concentration, Where 50 ml of the sample passing through the cadmium column is taken and 1 ml of Sulphonil Amid is added to it and left for 8 minutes, then a solution of N(1- Naphthl dihydrochloride Ethylenediamine), mix well and leave for two hours, then the sample is measured by spectrophotometer at a wavelength of 543nm and nitrate concentrations are expressed in micrograms per liter and calculated according to the following formula $No_3(\mu g/l)=(ABS-B)_3F-0.95_2No_2C$

ASB=sample absorbance

B=Blank

F=Fixed

C=Concentration of nitrate in the sample in micrograms per liter

Sulphate Ione Concentration

The sulfate ion concentration was determined by the turbidmatric method cc by taking 100 ml of the sample and adding 5 ml of the conditioning reagent solution to it and mixing well with a magnetic sterral device, then adding 0. 15g of barium chloride BaCk2 was added to the sample and mixed again by the magnetic rotor at a constant speed for one minute in order to precipitate the sulfate ion SO4 by combining with the conditioner, then the absorbance of the sample is measured by a spectrophotometer at a wavelength of 420 nm. The sulfate ion concentration is calculated after comparing it with the graphical curve obtained from standard solutions treated in the same way and expressed in mg / liter

Reactive phosphate

The percentage of phosphate in the water sample was estimated by taking 100 ml of the sample and adding 10 ml of the prepared mixed reagents solution to it, provided that the preservation time of the mixed solution does not exceed 6 hours, then we wait from 2-3 hours, then we measure the absorbance of the sample by a spectrophotometer at a wavelength of 880nm and the phosphate percentage is calculated according to the equation[11].

ABS×F=PO4

Measurement of Dissolved Oxygen Concentration

The concentration of dissolved oxygen in water was measured using the Winkler method, using 250 ml bottles that were filled with sample water and sealed tightly, then after removing the cap from the bottle, 2 ml of manganese sulfate solution MnSO4 was added. H2O and then added 2 ml of basic potassium iodide KI+KOH and sealed tightly, then shake the contents of the sample well, taking care not to form air bubbles, leave the sample for 10 minutes, then remove the cap and add 2 ml of concentrated sulfuric acid H2SO4 and sealed tightly. In the laboratory, 50 ml of the sample water was taken in a glass beaker and then heated with 0.025N sodium thiosulfate Na2S2O3 solution until the color changes to yellow, then drops of starch guide are added as a reagent where the color turns blue, then the rectification process is completed until the blue color disappears and the solution turns colorless and the results are expressed in mg / L

Chemical Oxygen Demand

Chemical Oxygen Demand was measured by the USEPA Reactor Digestion, Method: 8000 using a spectrometer (HACH DR3900). This method is based on heating the sample with the reagent consisting of sulfuric acid and potassium dichromate as oxidizing agents. The organic matter is oxidized and the dichromate is reduced to a green solution whose intensity is proportional to COD concentrations.

Heavy metals in water

The percentage of heavy elements in water was estimated by taking 100 ml of the water sample and drying it at a temperature of 80 °C. Then the remaining solution of the sample was taken after the evaporation process and placed in a container and added 6 ml of a mixture consisting of hydrochloric acid HCL and nitric acidHNO3 in a ratio of 1: 1:1, then the mixture was heated to dryness at 80°C, then 4 ml of a mixture of HF and HCLO4 in a 1:1 ratio was added and the mixture was heated to dryness again, then the precipitate was dissolved by adding 20 ml of dilute HCl0. 5N and the mixture was left for 10 minutes, then it was separated by centrifugation for 20 minutes at 3000 rpm The solution that was separated by centrifugation was transferred to a 25 ml volumetric bottle, while the precipitate was washed with distilled water, then added to the volumetric bottle as well and the volume was completed to 25 ml with deionized distilled water Afterwards, the sample was examined by a SHIMADZU AA-6200 atomic absorption spectrometer and the results were expressed in ppm.

RESULTS AND DISCUSSION

Temperature of air and water

The results shown in Table 2 showed a significant variation in air and water temperatures during the study period. The highest temperatures were recorded at the beginning of October, with water temperature (27°C) and air temperature (31°C). In contrast, the lowest temperatures were recorded at the end of December, where the water temperature reached (15°C) and the air temperature reached (10°C). The average water temperature during the study period was (20.4°C). This discrepancy is attributed to the different nature of industrial water and its varying operational conditions ([13]).

Electrical conductivity and total dissolved salts

The data shown in Tables (2) and (3) indicate that the electrical conductivity and TDS values increased during the fall, reaching (801.00 µS/cm) and (411.00 mg/L) respectively in mid-October. This increase can be attributed to the presence of organic and inorganic salts associated with crude oil, which may undergo chemical weathering reactions, resulting in mineral dissolution and ion release. Higher temperatures also contribute to increasing the solubility of salts and thus increase the percentage of dissolved solids, which is reflected in higher electrical conductivity [(14)] In contrast, the values decreased during winter, reaching (569.00 µS/cm) and (291.67 mg/L) in January, which is attributed to the lower water temperatures during this period [(15)].

Table 2: Some physical properties of industrial water

	Day 10	Day 20	Day 30	Day 40	Day 50	Day 60	Day 70	Day 80	Day 90	Mean of Water
Water Temp	27a	25Ab	25Ab	24B	19cd	17De	16ef	15efg	16ef	20.4a
Air Temp	31a	29ab	28b	29ab	24c	22c	13d	11 de	10e	22.0a
Turbidity	12.37 c	14.9 ab	12.43b c	10.31 cd	9.02de	7.43ef	5.30fg	4.23gh	2.90h	8.7656 b
E C	789.33 a	801.00 A	750.33 B	709.00 B	675.67 b	618.00 C	584.33 D	620.33 C	569.00 d	675.99 a
T D S	403.00 a	411.00 A	380.67 B	349.67 C	328.67c d	302.33 D	291.67 E	301.33 de	300.00 de	340.93 a

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Table 3: Some chemical properties of industrial water

	Day 10	Day 20	Day 30	Day 40	Day 50	Day 60	Day 70	Day 80	Day 90	Mean of Water
p H	7.7 b	7.1 c	7.2 c	7.9 ab	7.9 ab	7.8 ab	8.0 ab	8.0 ab	8.3 a	7.77 a
Total Alkaline	143.33 b	143.67 B	145.67 b	146.00 b	144.33 b	146.67 b	149.33 B	150.33 b	153.00 B	146.93 b
Total Hardness	129.00 c	127.67 C	134.33c	140.67c	134.00c	125.67c	123.00C	126.33 c	124.67C	129.48 b
Ca Hardness	113.67 b	117.00Ab	112.67 bc	99.67 de	93.33 e	98.33 de	111.33 Bc	112.67 bc	103.67D	106.927 a
Mg Hardness	15.33 bc	10.67 C	21.67 bc	41.00 a	40.67 A	27.33 b	11.67 C	13.67 c	21.00b c	22.557 b
C l	43.0 b	45.0 b	47.0 b	47.3 b	50.3 b	51.3 b	51.0 b	51.7 b	53.0 b	48.851 b
NO3	1.376 d	1.36 d	1.410 d	1.510 cd	1.500 cd	1.560 cd	1.560 cd	1.520 cd	1.433 d	1.469 b
NO2	0.230 A	0.233 A	0.243 a	0.250 a	0.230 A	0.250 a	0.213 a	0.220 a	0.240 a	0.23433 a
S O 4	248.00B	242.00 B	242.33 b	251.33 b	253.67 b	257.00 b	257.00 b	263.67b	265.33 b	253.370 b
P O 4	0.455	0.442 a	0.446 a	0.430 a	0.510 A	0.493	0.508 a	0.463 a	0.501 a	0.472 a
D O	3.33 a	2.67 a	3.33 a	3.00 a	3.00 a	3.00 a	3.00 a	3.00 a	3.67 a	2.96 a
C O D	0.889 a	0.883 a	0.849 a	0.814 a	0.810 a	0.836 a	0.877 a	0.802 a	0.875 a	0.812 a

pH and turbidity

The data in Tables 2 and 3 indicate that the pH values of the water leaned toward slight basicity, accompanied by variations in turbidity levels. The lowest pH value was recorded in mid-October (7.1), accompanied by high turbidity (14.9 NTU). In contrast, the highest pH value of 8.3 was associated with a reduction in turbidity to 2.9 NTU. These results reflect an inverse relationship between pH and turbidity [(16)].

Alkalinity, total hardness, calcium and magnesium hardness

Table 3 shows that alkalinity and total hardness values remained relatively stable throughout the study period. The upper limits of total base and total hardness were (153.00 mg/L) and (140.67 mg/L), respectively, while the lower limits were (143.33 mg/L) and (123.00 mg/L). Calcium hardness ranged from (93.33-117.00 mg/L), while magnesium hardness ranged from (10.67-41.00 mg/L). These results reflect the carbonate hardness of the water, as indicated by alkalinity values exceeding total hardness. The slight basicity of the water reduces the reactivity of carbon compounds, limiting their conversion to bicarbonates, which in turn contributes to maintaining higher alkalinity and hardness levels [(17)].

Chloride, Nitrate and Nitrite

Table 3 indicates that chloride, nitrate, and nitrite concentrations were low in October, measuring 43.0 mg/L, 1.36 µg/L, and 0.213µg/L, respectively. A slight increase was observed in December, with concentrations of (53.0 mg/L), (1.560 µg/L), and (0.250 µg/L). Overall, there were no significant variations in these values during the study period, likely due to the absence of industrial wastewater and pollution from agricultural fertilizers or sewage, which are rich in nitrogen and chlorine compounds [(18)].

Sulfate and phosphate

Table 3 demonstrates that sulfate and phosphate concentrations remained relatively consistent throughout the study period, with no significant variations observed. The minimum values of sulfate and phosphate ranged between (242.00 mg/L) and (0.430 µg/L) in mid-October, while the maximum values reached (265.33 mg/L) and (0.510 µg/L), respectively. These values are likely due to the oxidation of sulfur and organic compounds, along with the bacterial degradation of phosphorus-containing organics, processes that enhance the efficiency of the refinery's treatment unit [19, 20].

Dissolved Oxygen and Chemical Oxygen Demand

The results shown in Table 3 indicated a relative stability in dissolved oxygen values, which ranged between (2.67-3.67 mg/L), and chemical oxygen demand values, which ranged between (0.802-0.889 mg/L) during the study period. The reduction in dissolved oxygen and chemical oxygen demand levels can be attributed to the decrease in organic pollutants in the treated water [21].

Heavy metals

The data presented in Table 4 showed that the industrial water contained varying concentrations of heavy elements, such as lead, nickel, cadmium, zinc, cobalt, and chromium. The concentrations ranged from (0.14912-0.16287 ppm) for lead, (0.1209-0.1651 ppm) for nickel, (0.11022-0.12992 ppm) for cadmium, (1.2299-1.3487 ppm) for zinc, (0.04945-0.05178 ppm) for cobalt, and (0.01824-0.01919 ppm) for chromium. In contrast, the results showed that the water was free of mercury and arsenic. The low concentrations of heavy elements can be attributed to the slightly basic pH, which reduces their solubility and limits their transition into the liquid phase [22, 23].

Table 4: for some heavy elements in industrial water

	Day 10	Day 20	Day 30	Day 40	Day 50	Day 60	Day 70	Day 80	Day 90	Mean of Water
P b	0.14991 b	0.15062 b	0.15003 b	0.14912 b	0.16287 A	0.15094 b	0.15166 b	0.15108 b	0.15058 B	0.15187 a
N i	0.1212 B	0.1227 b	0.1215 b	0.1232 b	0.1238 B	0.1209 b	0.1539 a	0.1651 a	0.1305 B	0.1314 a
C d	0.11022 c	0.11391 c	0.11829 b	0.12053 ab	0.12219 Ab	0.12992 a	0.12187 ab	0.12019 b	0.11892 B	0.11956 a
Z n	1.2299 b	1.2385 b	1.2984 ab	1.3467 a	1.3487 A	1.3349 a	1.3281 a	1.3239 a	1.3306 A	1.3089 a
C o	0.05178A	0.05106 a	0.05146 a	0.05097 a	0.05127 A	0.05118a	0.05027 a	0.04945 a	0.05111A	0.05095 a
C r	0.01836 a	0.01824 a	0.01844 a	0.01874 a	0.01919 A	0.01899 a	0.01898 a	0.01902 a	0.01881 A	0.01872 a
H g	0.001 a	0.001 a	0.001 a	0.001 a	0.001 a	0.001 a	0.001 a	0.001 a	0.001 a	0.001 a
AS	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a

CONCLUSIONS

1. **Variation in temperature and conductivity:** The study revealed fluctuations in temperature, electrical conductivity, and dissolved salts, with higher values observed in the fall, influenced by treated water discharges and seasonal temperature changes.
2. **Stabilization of basicity and hardness:** The water exhibited carbonate hardness, with consistent alkalinity and total hardness values, and a pH leaning slightly toward alkalinity.
3. **Low contaminants:** The water contained low levels of chloride, nitrate, nitrite, mercury, and arsenic, highlighting the effectiveness of the

treatment units in minimizing pollutant concentrations.

4. **Heavy elements within limits:** The water contained low concentrations of heavy elements, all within acceptable limits, which can be attributed to the pH's slight alkalinity, reducing their solubility and mobility.

REFERENCES

1. Chakraborty SK. Riverine Ecology Volume 1: Eco-functionality of the Physical Environment of Rivers: Springer Nature; 2021. http://dx.doi.org/10.1007/978-3-030-53897-2

2. Al-Hamdani NAS. Application of water quality indicators to assess the water quality of a number of wells on the left coast of the city of Mosul, Iraq. Mosul, Iraq: University of Mosul, College of Environmental Sciences and Technologies; 2020.

3. Mojiri A, Zhou JL, Ohashi A, Ozaki N, Kindaichi T. Comprehensive review of polycyclic aromatic hydrocarbons in water sources, their effects and treatments. Science of the total environment. 2019;696:133971. https://doi.org/10.1016/j.scitotenv.2019.133971

4. Abbas AJ, Gzar HA, Rahi MN, editors. Oilfield-produced water characteristics and treatment technologies: a mini review. IOP Conference Series: Materials Science and Engineering; 2021: IOP Publishing. http://dx.doi.org/10.1088/1757-899X/1058/1/012063

5. Hussein A, Saeed IO, Mahal JD. Wastewater Treatment a way sedimentation and filtration and study its impact on the accumulation of trace elements in plant celery Apium graveolens L. Kirkuk Journal of Science. 2015;10(2).

6. Salem FA, Thiemann T, Kawamura K, Nakamura A, Poulose V, Saibi H, editors. Purification of produced water from Kuwaiti oil fields using ceramic membranes. International Petroleum Technology Conference; 2024: IPTC. https://doi.org/10.2523/IPTC-24571-MS

7. Elmobarak WF, Hameed BH, Almomani F, Abdullah AZ. A review on the treatment of petroleum refinery wastewater using advanced oxidation processes. Catalysts. 2021;11(7):782. https://doi.org/10.3390/catal11070782

8. Al-Hussein AI, Al-Shaker YM, Al-Saffawi AY. Health safety of drinking water: A study of the groundwater case of Wana district, northern Iraq. BioGecko A Journal for New Zealand Herpetology. 2023;12(03):4429-38.

9. Yacoup RJ. Baji Refinery Water Treatment to Reuse for Agricultural Purposes. Journal of Engineering. 2014;20(7):1-12.

10. Taher AM, Saeed IO. Bioremediation of contaminated soil with crude oil using new genus and species of bacteria. Journal of King Abdulaziz University, Marine Science. 2022;32(2):13-35.

11. Association APH. Standard methods for the examination of water and wastewater: American public health association.; 1926.

12. Jirka AM, Carter MJ. Micro semiautomated analysis of surface and waste waters for chemical oxygen demand. Analytical chemistry. 1975;47(8):1397-402.

13. Kader AY, Abdoon FM, Ahmed AMK. EVALUATION OF INDUSTRIAL WATER QUALITY AND THE EFFICIENCY OF THE DESALINATION UNIT IN REMOVING SOME HEAVY MINERALS IN EFFLUENTS OF IRAQI NORTH OIL COMPANY. Journal of Pharmaceutical Negative Results. 2022;13. https://doi.org/10.47750/pnr.2022.13.S08.110

14. Mohammed WJ, Salih MI. Studying the Physical and Chemical Properties of the Industrial Wastewater of the North Refineries Company-Beiji. Journal for Research in Applied Sciences and Biotechnology. 2023;2(3):274-83. https://doi.org/10.55544/jrasb.2.3.35

15. Ahmed YS, Al-Shandah BT. Evaluating the efficiency of oil waste treatment plant in AL-Qayyarah Refinery-Iraq. Tikrit Journal of Pure Science. 2024;29(5):19-29.

16. Dewangan SK, Toppo DN, Kujur A. Investigating the impact of pH levels on water quality: An experimental approach. International Journal for Research in Applied Science and Engineering Technology. 2023;11(9):756-9. https://doi.org/10.22214/ijraset.2023.55733
17. Jory OT, Erdeni AA. Assessment of Physical and Chemical Properties in Northern Refineries' Water. Central Asian Journal of Medical and Natural Science. 2024;5(3):264-71.
18. Numaan MM, Kadhem AJ, Moyel MS, Bayati MB, Sabeeh NN, Alabdraba WMS, et al. Study the Possibility of Using the Treated Industrial Wastewater of North Refineries Company, Baiji-Iraq, for Irrigation Purposes. Tikrit Journal of Engineering Sciences. 2024;31(4):183-90. https://doi.org/10.25130/tjes.31.4.18
19. Al-Hamdany N, Al-Saffawi A, Al-Shaker Y. Applying the sub-index model to evaluate the quality of water for irrigation purposes, a case study: wells water of left side from Mosul city, Iraq. Nippon J Environ Sci. 2020;1:1-8. https://doi.org/10.46266/njes.1015
20. Alwan IA, Saeed IO. Monitoring Pollution Indicators of the Water of the Tigris River in Tikrit and its Suburbs. Egyptian Journal of Aquatic Biology & Fisheries. 2024;28(2). https://dx.doi.org/10.21608/ejabf.2024.346018
21. Auied HG, Dhahir SA, Sultan MA. Industrial Wastewater Efficiency Assessment of Al-Dora Refinery Plant in Baghdad by Decreasing BOD5 and COD Concentrations. The Iraqi Geological Journal. 2024:95-106. https://doi.org/10.46717/igj.57.2A.7ms-2024-7-17
22. Al-Hamdani EAS, Saeed IO. Bioaccumulation of some heavy elements in Osage shawii Lycium and Tamarix arabica collected from the Lower Zab Tributary - Karkuk Governorate/Iraq. Zagazig Journal of Agricultural Research. 2016;43(4):1137-52.
23. Azizi A, Krika A, Krika F. Heavy metal bioaccumulation and distribution in Typha latifolia and Arundo donax: implication for phytoremediation. Caspian Journal of Environmental Sciences. 2020;18(1):21-9. https://doi.org/10.22124/cjes.2020.3975