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Studying the Physical and Chemical Properties of the Industrial Wastewater of the North Refineries Company-Beiji

Wissam Jassim Mohammed[1] and Mwafaq Inhab Salih[2]
[1]Department of Biology, College of Education for Pure Sciences, University of Tikrit, IRAQ.
[2]Department of Biology, College of Education for Pure Sciences, University of Tikrit, IRAQ.

Corresponding Author: Wissam Jassim Mohammed

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ABSTRACT

Water is regarded as one of the most important natural resources on the surface of the globe, and its wrong use can turn it into a source of environmental pollution. So, it must be given attention. Thus, attention must be given to it. One of the most important ways to preserve the water environment and protect it from pollution is to treat polluted water in all its forms. Industrial wastewater is considered as one of the types of polluted water resulting from various human activities. Due to the significance of the water environment in the human health aspect, and the special attention given by the ministries and departments concerned in this regard, therefore, the current study was conducted on some physical and chemical properties of industrial wastewater of the North Refineries Company for a year and a seasonal system (January 1 to November 1, 2022). The results showed that the water temperatures ranged between (9.7-33.4 °C). As for the turbidity, it ranged between (14.4-40.5 NTU), while the electrical conductivity ranged between (287.1 - 1644.6 μS/cm). It was found that most of the water in the studied stations was high in terms of suspended solids, which ranged between (1063 - 2588 mg/L) while the pH values ranged between (6.7 - 8.54). It was also observed that the dissolved oxygen values increased in most of the study stations, ranging between (1.31 - 23.4 mg/L). As for the values of the biological requirement for oxygen, it ranged between (9.3 – 9.4 mg/L). Depending on the values of the vital requirement for oxygen, the value was between (0.46 - 9.32 mg/L). Moreover, it was found that the total hardness was high in most of the study stations, with values ranging between (28.46 - 754.12 mg/L). The chloride ions in most of the studied stations were not within the permissible limits with values ranging between (63.77 - 1140.5 mg/L), while the phosphate values were between (0.23 - 1.62 mg/L). The organic carbon concentration TOC was recorded with values that ranged between (1.14 -62.7 mg/L), while the values of oil residues ranged between (0.84 -14.35 mg/L) during the study period.

Keywords- chemical properties, Physical properties.

I. INTRODUCTION

Humanity is living today in a difficult stage of its life, as the negative human impact on the environment is increasing due to technological progress and the accompanying industrial development, with the changes it has brought about in the environment [1]. As a result of the irregular exploitation of the basic components of the environment (water, air and soil) by the action of many physical, chemical and biological factors, the environment, especially the water environment, is made as large bodies of many pollutants in their various forms, solid and liquid, most of which are derived from industrial, agricultural and domestic activities. These in turn contribute to the deterioration of natural resources and aquatic organisms which are present in a balanced manner in nature [2,3]. The pollution of aquatic and terrestrial ecosystems with wastewater resulting from crude oil refining is a serious environmental problem that affects its physical, chemical and biological properties compared to unpolluted environmental systems [4]. Industrial waste resulting from the chemical, mining, agricultural, and oil industries, which drain into rivers, pollutes them with

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acids, alkalis, dyes, hydrocarbon compounds, toxic salts, and fats [5]. The residues and pollutants resulting from this water are the cause of the spread of many environmental and health problems by affecting plants and animals, as well as their impact on humans through many waterborne diseases such as cancer, lung diseases, skin diseases, allergies and other diseases [6].

II. AIMS OF THE STUDY

The current study aims at:

- Studying the physical and chemical properties of the industrial wastewater in the North Refineries Company.
- Determining the suitability of this water for human use and consumption.

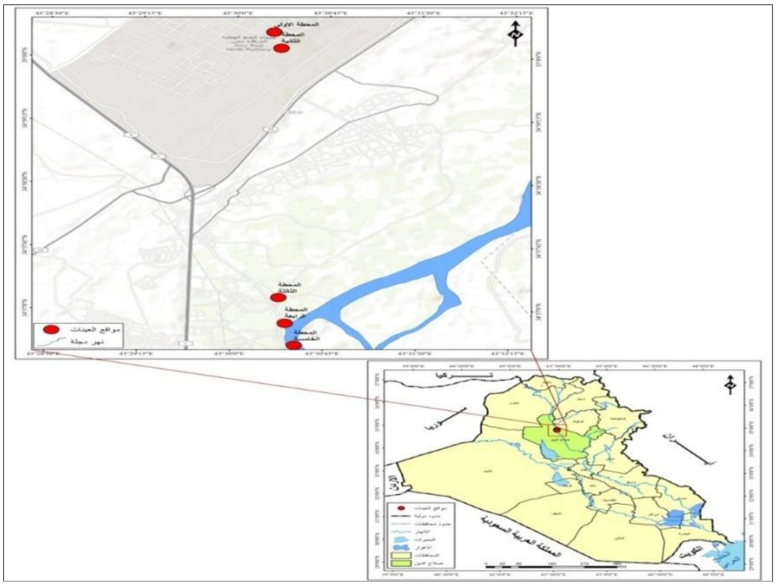
III. MATERIALS AND METHODS OF WORK

3.1. Sample Collection Sites

Water samples are collected from five study sites during the study period from January to November of 2022. Sterile polythene containers with the capacity of (5) liters and the BOD samples in opaque glass containers with a capacity of (250) milliliters are used and marked for each station with one sample and three replicates after they were washed twice with the sample water at each station and filled from the surface layer (0-30) cm. Then, it is closed well and kept in a cork container designated to be transported to the laboratory to conduct physical and chemical analyzes directly. Samples of the vital oxygen requirement are kept in a water bath at (25°C) in the dark.

Table 1: GPS Coordinates of Water Sample Collection Sites

No.	Station	GPS Coordinates	The Site
1.	Station one	43.5054260.35.0049240E	Main tank
2.	Station two	43.5060900.35.0017580E	Nouri Channel
3.	Station three	43.5073210.34.9488290E	500m before the downstream point
4.	Station four	43.5074680.34.9472340E	Estuary point in the Tigris River
5.	Station five	43.5076920.34.9451300E	1000 m after the downstream point



A map showing the location of the study stations

3.2. Physical and Chemical Properties

A. Water Temperature

The water temperature in the study stations is measured locally using a mercury thermometer with a range (0-50°C) and a gradient (0.1°C).

B. Turbidity

Water hardness was measured by a HACH device (model HI 2100). The device expresses standard solutions in FTU=*Formazine Turbidity Unit*.

C. Electrical Conductivity

An Inolab device of the type (Cond 7110-WTW) is used. The results are expressed in microsiemens/cm (µS/cm) units.

D. Total Dissolved Solids (TDS)

The suspended solids are measured by the colorimetric method (Photometric Method: 8006) [7] using a spectrometer (HACHDR3900). The concentration is read according to (mg/L) units.

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E. pH Measurement

The pH of the samples is measured using the (WTW Inolab/pH 7110) device.

F. Dissolved Oxygen Measurement

Dissolved oxygen is measured using (Ultra High Range, Method: 8333) [8] with a spectrometer (HACH DR3900). The device is expressed in (mg/L) units.

G. Biological Oxygen Demand

The biological oxygen demand is measured by the *Respirometric Method* using the *Lovibondox iDirect* device which is expressed in units of (mg/L).

H. Total Hardness

The total hardness is measured using (Calcium and Magnesium; Chlorophosphonazo Rapid Liquid, Method: 8374) [9]. The total hardness concentration is read in units of (mg/L).

I. Chlorides

Chloride ions are determined by [Mercuric Thiocyanate, Method: 8113] [10] using a spectrometer (HACH DR3900). Chloride concentrations are read in(mg/L) units.

J. Phosphate

Phosphate levels in water are estimated spectrophotometrically based on the US Environmental Protection Approach [11] (USEPA: Method 365.2) (ascorbic acid method) using a spectrometer (HACH / DR3900), and phosphate concentrations are recorded in(mg/L) units.

K. Organic Material

The total organic carbon is estimated using the direct method (10129) [12] with a spectrometer (HACHDR3900). The total organic matter concentrations are read according to (mg/L) units.

L. Oil Residue

Oil residues are estimated with a UV-Vis spectrometer (HATCH DR3900) using the (Total Petroleum Hydrocarbons TPH: Method 10050) [13], described by HATCH and attached with the spectrometer. Its absorbance is read at the above wavelength, as the spectrometer gives results of concentrations in(mg/L) units.

M. Statistical Analysis

The data are analyzed statistically using the analysis of variance (ANOVA=Analysis of Variance) and the least significant difference (LSD=Least Significant Difference) using the (SPSS-V26) program in order to compare the means for the different variables. This is conducted in order to compare the means of the different variables, find the relationship between them, and to find the values of the range, the standard deviation and the Pearson correlation coefficient between these variables.

IV. RESULTS AND DISCUSSION

4. 1. Physical Properties

A. Water Temperature

The nature of the industrial water and its composition differ according to the conditions of the different operational units in the refinery. The water temperature ranged between (9.7ºC) during the winter season in the fourth station and (33.4ºC) during the summer season in the first study station (Fig. 1.4), with a total mean of (21.2ºC) and a standard deviation (7.3). It is observed through the results of the variance analysis that there are significant mean differences in the water temperature between the seasons of the year by (0.57), and there are no significant differences between the locations of the study stations. The results of the statistical analysis also show that there is a medium positive correlation of water temperatures with TOC of (0.68) and with BOD (0.66), and negative with chlorides (-0.56) at a significant level ($P<0.01$), and medium with a COD of (0.55) at the level of significance ($P<0.05$).

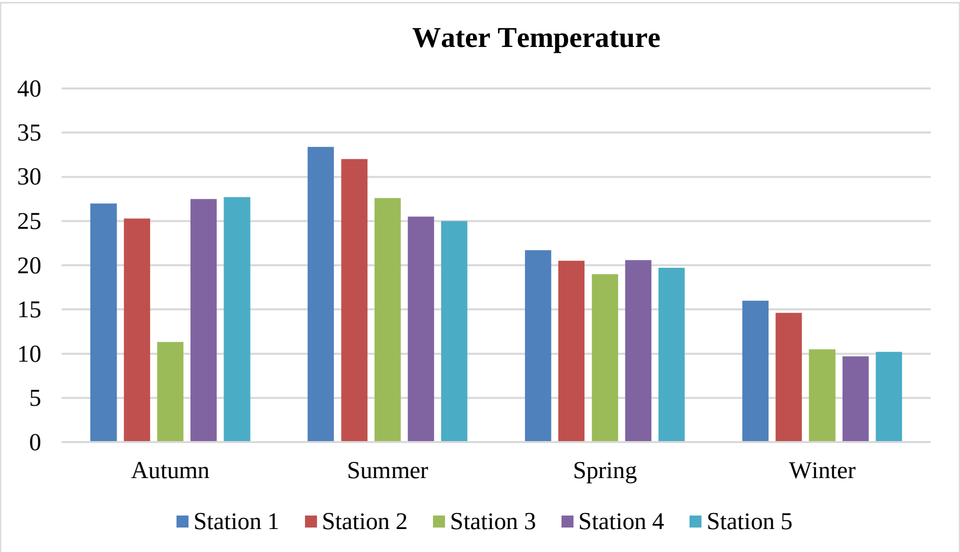

Figure.1: Seasonal changes in water temperature in the study sites

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B. Turbidity

Turbidity values range between (14.4 NTU) during the summer at the third study station and (40.5 NTU) during the winter at the fifth study station, as shown in Figure (2.4) with an average of (27.2NTU) and a standard deviation (8.4). The results of the analysis of variance show that there are no significant differences in turbidity with neither the seasons of the year nor the study sites. A strong significant correlation is observed for turbidity with suspended solids (TSS) by (0.94) at the level of significance (P<0.01). The waters of the Tigris River have recorded the highest values of turbidity in the fifth study site during the winter, and the lowest (14.4 NTU) in the third study site during the summer, and the results in most of the study stations were higher than the standard value (5NTU) according to what is stated by the American Environmental Protection Agency [14].

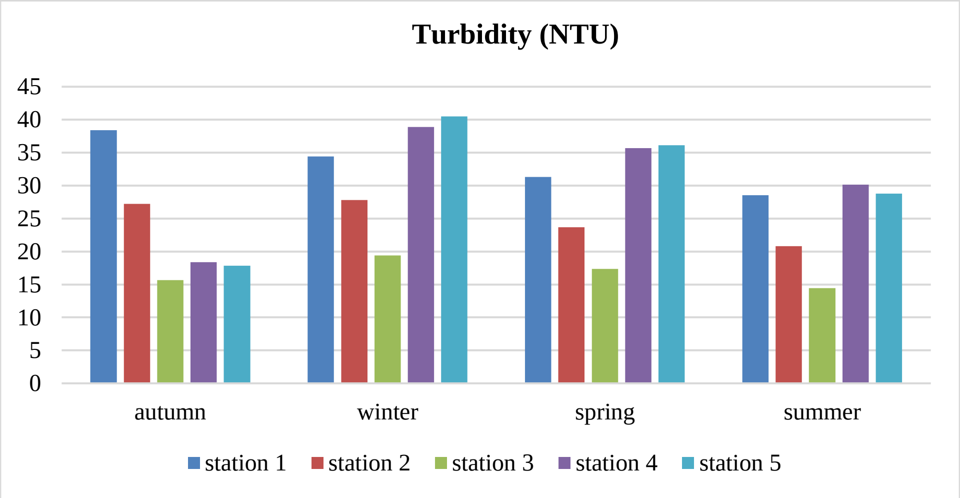

Figure 2: Seasonal changes in water turbidity in the study sites

C. Electrical Conductivity

The electrical conductivity values range between (287.1µS/cm) during the autumn season in the fifth station and (1644.6 µS/cm) during the winter season in the first station (Fig. 4.3) with an average of (770.8µS/cm) and a relatively large standard deviation of (413). The results of the analysis of variance show that there are significant differences in the electrical conductivity between the study stations, and there are no significant differences between the seasons of the year. Moreover, a positive correlation is observed with total hardness (0.92), phosphates (0.91), and oil residues (0.86) at the level of significance (P<0.01). A weak negative relationship with air temperature is shown by (0.45) at a significance level of (0.05). The results of the current study show that the recorded values of electrical conductivity in the waters of the Tigris River are less than the values recorded in the wastewater of Noori Canal, where the results of electrical conductivity are compared with the standard value and is higher than that with (1000 µS/cm) in most of the study stations according to what is stated by the American Environmental Protection Agency [14].

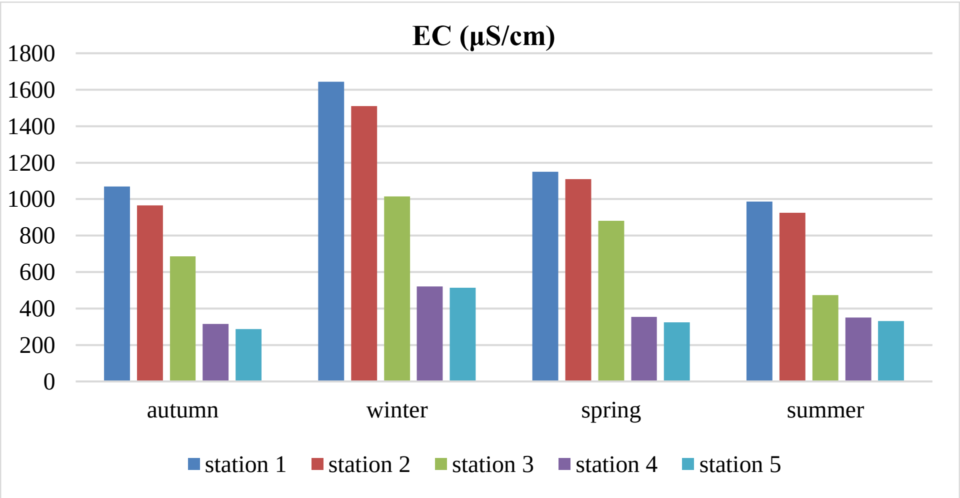

Figure 3: Seasonal changes in electrical conductivity in the study sites

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D. Suspended Solids

The TSS values range between (1063mg/L) during the summer in the third study station and (2588mg/L) during the winter in the fifth station (Figure 4.4), with an average of (1712mg/L) and a standard deviation of (457). The results of the analysis of variance show that there are no significant differences in the TSS concentrations between the seasons of the year or the study stations. As for the results of the correlation analysis, it shows only one strong correlation with turbidity by (0.94) at a significant level (P<0.01). The first, second and third wastewater stations are characterized by high concentrations of suspended matter throughout the study period and are lower than the values of suspended matter (31.15mg/L) for the biologically treated water of the Basra refinery complex [15]. Also, the concentrations of suspended matter in the fourth and fifth stations for the winter and spring seasons are higher than the values of suspended matter recorded (179.191mg/L)) in the upper Tigris River in the Turkish territory [16]. The reason for the rise in suspended solids is due to the presence of large sizes of suspended particles in the water with complex composition and living and dead organisms and waste with a mixture of organic and mineral substances [17].

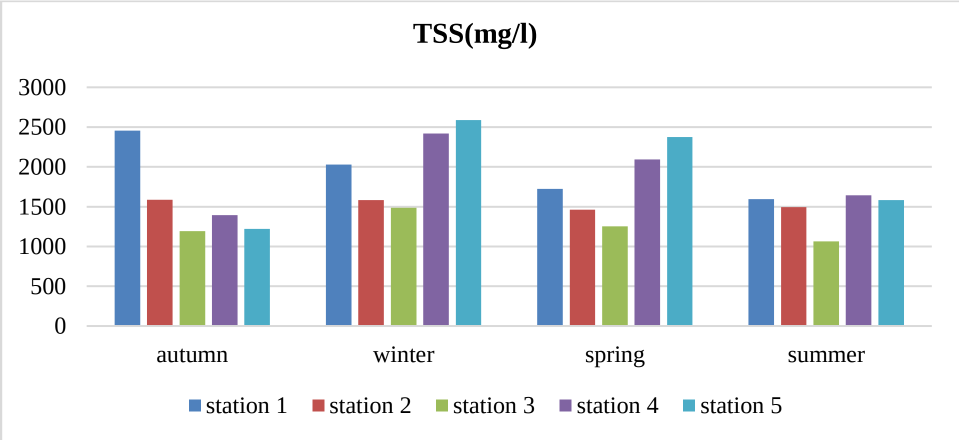

Figure 4: Seasonal changes in the concentrations of total suspended solids in the study sites

4.2. Chemical Agents

A. pH Function

The pH values range between (6.7) during the autumn season in the third station and (8.54) during the summer season in the fifth station (Fig. 5.4), with a total average of (7.67) and a standard deviation (0.5). The significant differences of the pH values between the seasons of the year are weak (0.45) and non-existent between the stations as shown by the analysis of variance. As for the correlation analysis, it shows a weak negative correlation with the OD by (-0.52) at the significance level (P<0.05). The results of the current study show that the pH tends to weak alkalinity in most of the study stations, where the high pH is due to the dominance of alkaline ions [18]. The pH values do not decrease in most of the five study stations in the acidic side, i.e. they are of a weak basic nature. The extent of the variation in the pH values to the alkaline side is due to the water containing carbonate and bicarbonate compounds, in addition to what enters the water body of these compounds from the soil surrounding the water surface, given that the Iraqi soil is rich in these compounds [19, 20].

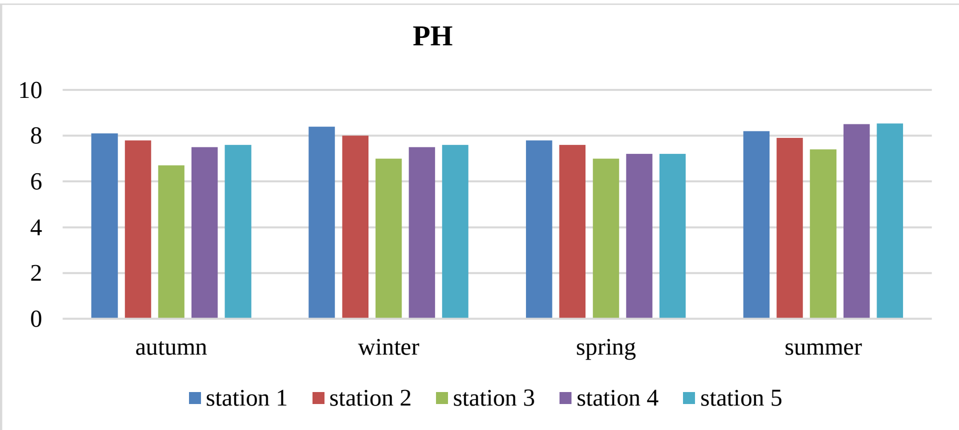

Figure 5: Seasonal changes of pH in the study sites

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B. Dissolved Oxygen in Water

The lowest level of dissolved oxygen is recorded in the first station during the summer at a concentration of (1.31mg/L), and the highest level is at (23.4mg/L) during the summer in the third station (Fig. 6.4). The total average is (6.56mg/L) with a standard deviation (4.98). The results of the analysis of variance show that there are no statistically significant differences during the seasons of the year or between the study stations. The correlation analysis shows that there are statistical correlations of dissolved oxygen with some of the studied variables discussed previously. Dissolved oxygen concentrations are low in the waste channel (Noori channel) compared to the water of the Tigris River, as recorded in the fourth and fifth stations of the Tigris River water for all seasons of the year compared to the waste water (Noori channel) represented by the first, second and third stations. The reason for the decrease in the percentage of oxygen saturation may be attributed to the high percentage of salinity or the increase of the activity of microorganisms on the decomposition of the organic materials present in these waters due to the high temperature of the water leading to the depletion of the amounts of dissolved oxygen [20, 21]. As for the increase, it is due to a decrease of pollutants and the solubility of dissolved oxygen in cold water to a greater degree than in warm water. In addition, there is the rise in atmospheric pressure, which leads to an increase in the solubility of oxygen in water [22]. The results of most of the study stations show that they do not match the results of dissolved oxygen standards according to what is stated by the American Environmental Protection agency [14].

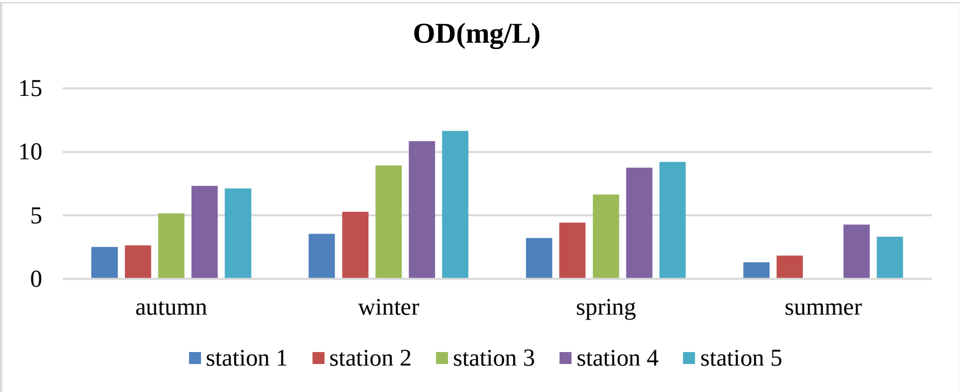

Figure 6: Seasonal changes in dissolved oxygen concentrations in the study sites

C. Requirement of Oxygen

The lowest level of BOD is recorded at (0.46 mg/L) during the winter season in the fifth study station, and the highest level is at (9.32mg/L) during the summer season in the first station (Fig. 7.4). The total average concentrations are (3.15mg/L) with a standard deviation (2.7). The significant differences are weak between the study stations, and non-existent between the seasons of the year as shown by the results of variance analysis. The correlation analysis shows a strong significant correlation with COD of (0.81) and with TOC (0.79) at the significance level ($P<0.01$). The values of the vital oxygen requirement are characterized by their convergence in all stations as shown by the results of the statistical analysis and an indicator of weak significant differences between the study stations based on the analysis of variance tests. The results of the current study show that the highest value (9.32mg/L) of the biological oxygen requirement is recorded in the first study site during the summer, which is an undesirable condition in the water according to what is stated by the American Environmental Protection Agency [14].

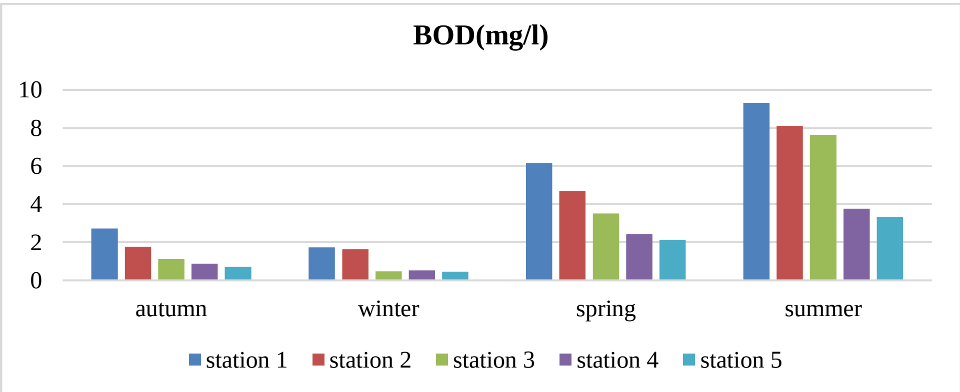

Figure 7: Seasonal changes in BOD concentrations in the study sites

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D. Total Hardness

The total hardness values range between (28.46mg/L) during the summer in the fifth study site and (754.12mg/L) during the winter in the first site, with a total average of (283mg/L) and a large standard deviation (255.75) (Fig. 8.4). It indicates the dispersion and heterogeneity of the values between the stations as shown by the analysis of variance. The analysis of variance shows that there are significant differences between the study stations and that there are no significant differences between the seasons of the year. The results of the correlation analysis show a strong positive correlation with phosphate (0.88), magnesium (0.97), calcium (0.98), and oil residues (0.81), and a weak positive correlation with COD (0.56) and TOC (0.58) at the level of significance ($P < 0.01$), weakly positive with sulfate (0.52) and weakly negative with OD (-0.48) at a significant level ($P<0.05$).

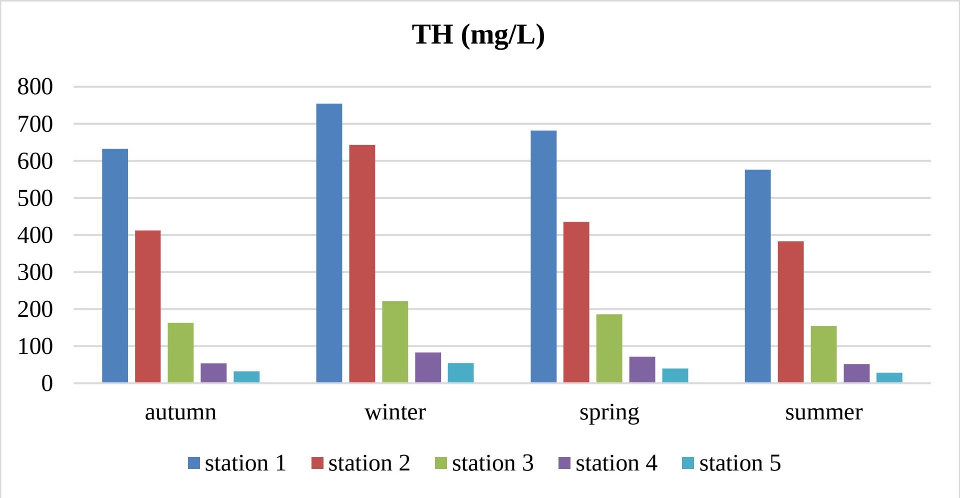

Figure 8: Seasonal changes in total hardship in the study sites

E. Chlorides

The concentrations of chlorides range between (63.77mg/L) during the spring season in the third station and (1140.5mg/L) during the winter season in the fourth station (Figure 9.4), with an average of (500mg/L) and a standard deviation of (330). The results of the analysis of variance show that there are no significant differences in the concentrations of chlorides between the filtration plants or between the seasons of the year. The statistical analyzes for finding the Pearson correlation coefficient show that there are two negative correlations between chloride concentrations and the water and air temperatures that are previously indicated at a significant level ($P<0.01$), and another weak negative correlation at a significant level ($P<0.05$) of (-0.52) with BOD. The high concentration of chloride in winter is due to the decomposition of organic materials present in industrial water waste, which increases the concentration of ions, including chloride [23]. In addition to what comes from wastewater that is rich in this ion, the majority of the water of the current study stations does not meet the chloride concentrations in the standard specifications for drinking water according to what is stated by the American Environmental Protection Agency [14].

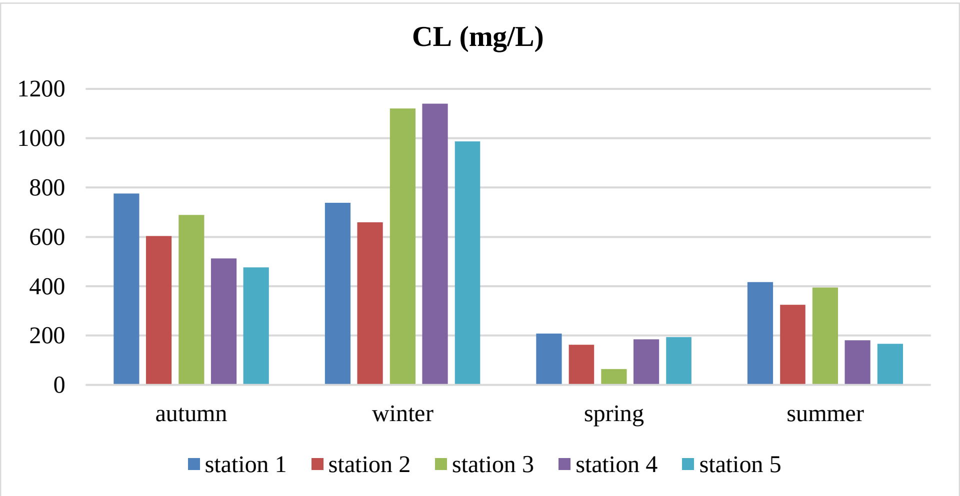

Figure 9: Seasonal changes in chloride concentrations at the study sites

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F. Phosphates

Phosphate concentrations range between (0.23mg/L) during the autumn season in the third filtration station and (1.62mg/L) during the winter season in the first station (Figure 10.4), with a total mean of (0.76mg/L) and a standard deviation of (0.37). High concentrations of phosphates are recorded in the first and second stations with the wastewater of Noori Canal for all seasons of the year compared to the waters of the Tigris River represented by the fourth and fifth stations. The results of the current study show that the phosphate values in some stations do not match the standard specifications of the American Environmental Protection Agency [14].

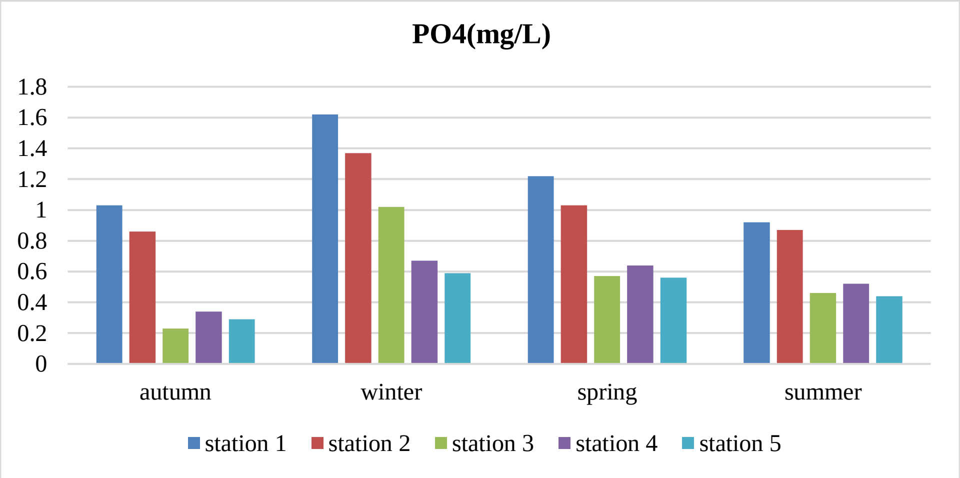

Figure 10: Seasonal changes in phosphate concentrations at the study sites

G. Total Organic Carbon (TOC)

The lowest value of total organic carbon is recorded at (1.14mg/L) during the winter in the fifth study site, and the highest value at (62.7mg/L) during the summer in the first study site (Figure 11.4), with a general average of (25.22mg/L). L) and standard deviation (19.27). The statistical analysis of variance shows that there are statistically significant differences between the study stations, and there are no significant differences between the seasons of the year. As for the correlation analysis, it shows the existence of multiple correlations regarding some of the study variables. The results show a weak correlation with oil residues and a strength of (0.47) at the level of significance ($P<0.05$). The rest of the relationships are discussed earlier. The results of the current study show that the recorded values of total organic carbon (TOC) in the waters of the Tigris River are lower than the values recorded in the wastewater of Noori Canal in most of the study stations.

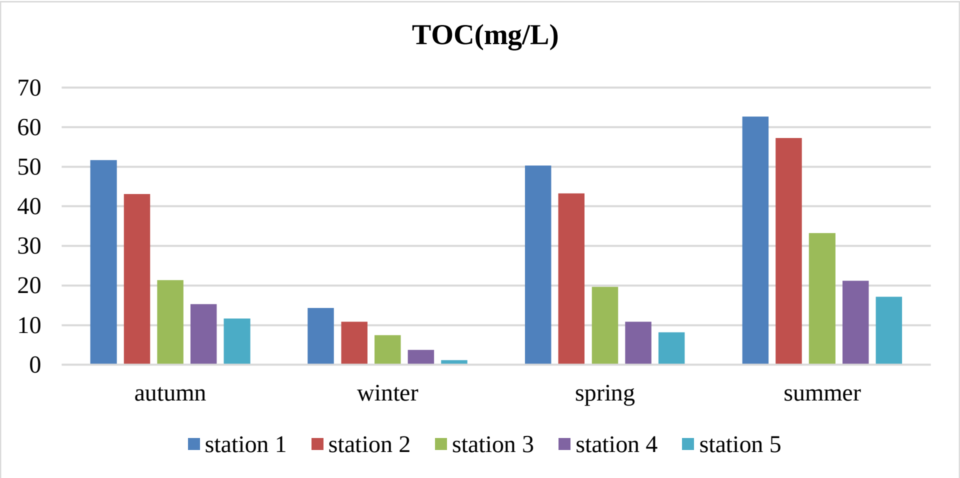

Figure 11: Seasonal changes of total organic carbon concentrations in the study sites

H. Waste Oil

The concentrations of oil residues in the current study range between (0.84mg/L) during the autumn season in the fifth study site. The highest value is at (14.35mg/L) during the spring season in the first study site (Figure 12.4), with a total average of (4.77mg/L) and a standard deviation (3.79). The results of the analysis of variance show statistically significant differences

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between the study stations only, and there are no differences between the seasons of the year. Significant correlations of oil residues with some of the study variables are discussed previously, so there is no need to mention them here. The results of the study show that high concentrations of oil waste oil values are recorded in the industrial waste water coming out of the operational and production units represented by the first, second and third stations for all seasons of the year with the highest value (14.35mg/L) of waste oil in the first study site during the spring season compared to the water of the Tigris River represented by the fourth and fifth stations, and for all seasons of the year. The lowest value (0.84mg/L) of waste oil is recorded in the fifth study site during the autumn season. The values recorded in some stations exceeded the permissible limits estimated at (10 mg/L) according to the specifications of the American Environmental Protection Agency [14].

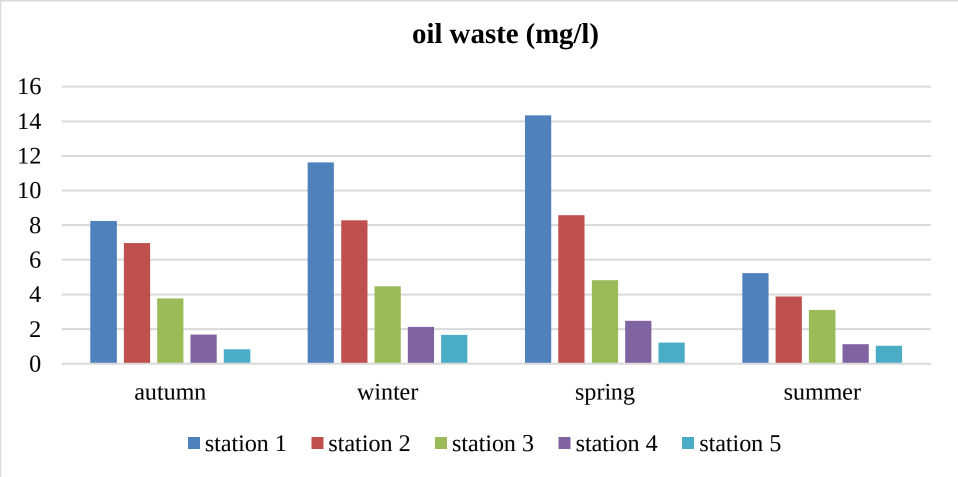

Figure 12: Seasonal changes in the concentrations of oil residues in the study sites

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