Evaluation of Some Physical and Chemical Properties of the Al-Husayniyah River Water in Karbala Governorate, Iraq

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Abstract

The study was conducted on the Al-Husayniyah River in Karbala Governorate. Four locations distributed along the river were selected to represent the study sites for evaluating some physical and chemical properties of the river water and monitoring the changes occurring in it during the period from August 2025 to May 2026. The study showed that the water of the Al-Husayniyah River was of good to average quality from an environmental perspective, as the values of pH, dissolved oxygen, and nitrates were within the limits suitable for aquatic life. However, electrical conductivity, total dissolved solids, and total hardness showed relatively high values, reflecting the level of natural mineral salts. In general, the results did not show clear indications of severe pollution. However, the high hardness and sulfates necessitate continued monitoring of water quality, especially in areas affected by agricultural and human activities.

Keywords:
Physicochemical properties; temperature; pH; Karbala; Al-Husseiniya River; water quality.

Introduction

These factors have caused an increase in the concentrations of salts and solids, in addition to changes in the values of pH, dissolved oxygen, total hardness, and total alkalinity in many rivers within Iraq (2). Previous studies have shown that aquatic environments face numerous problems, such as pollution by chemical, physical, and bacteriological substances, exceeding the standards adopted by the Iraqi state. (3), in their study of some physical, chemical, and biological characteristics of the waters of the Al-Daghara River in Al-Diwaniyah Governorate, found the river water to be very hard, alkaline, slightly saline, and well-aerated. A number of subsequent studies conducted on the waters of the Euphrates River also concluded that the river water is very hard, slightly saline, slightly alkaline, and well-aerated, in addition to fluctuations in other factors (4; 5). Furthermore, Khan's 2012 study of raw surface water at the Shatt al-Kufa station indicated the impact of drainage water and industrial and municipal sewage on the high concentrations of most pollutants in the waters of the studied station. Ibrahim (2012) also characterized the waters of the Euphrates

The Al-Husayniyah River in Karbala Governorate is considered the main source of water, branching off from the Euphrates River. It supplies vast areas of agricultural land with water, in addition to its use for domestic purposes and various human activities. It is also a source of drinking water. Therefore, studying its water quality is an urgent necessity to assess its environmental condition and the extent of its impact from natural and human pollutants, especially with the increasing pressures resulting from population growth and urban and agricultural expansion in recent years. Furthermore, the studies conducted on the Al-Husayniyah River are very few and do not provide sufficient information on the monthly changes in environmental factors in the river, compared to studies conducted on other Iraqi rivers in previous periods (1). Furthermore, Iraqi rivers are exposed to many sources of pollution resulting from the discharge of domestic sewage, industrial waste, and agricultural drainage water carrying salts, fertilizers, and chemical pesticides, in addition to the decrease in water releases and the increase in temperatures as a result of climate change.

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potential health and environmental concerns, including dangerously low levels of dissolved oxygen, exceeding the internationally accepted limit for oxygen concentration in drinking water. The aim of the study is to identify the quality of the water of the Al-Husseiniya River by measuring some physical and chemical properties and determining the temporal and spatial variation of these properties in the river water and its suitability for different uses.

River as having medium quality, according to the water quality index. The water is slightly polluted and unsuitable for drinking, requiring filtration to become potable. However, it is suitable for irrigation and industrial processes that do not require purified water, and it provides a suitable environment for most fish species. A study by (7) on the Euphrates River in Basra concluded that the water was moderately alkaline. (8), in their study on the Tigris River within the city of Mosul, indicated that some locations raise

Materials and Methods:

Babylon Governorate. This site is approximately 5 km from the Al-Hindiyah Dam. It is characterized by being situated within agricultural areas.

2- Site 2: Located in the Al-Salamiyah area within the Al-Husayniyah district, approximately 5 km from the first site. This section of the river is lined and runs between two main roads for vehicles, with shops and buildings located along its banks.

3- Site 3:The third site is located in the village of Al-Taf, within the Awn district, and is 7 km from the second site. This section of the river is characterized by an increase in population centers and commercial establishments. It is also distinguished by its lower water level and narrower width compared to the previous sites.

4-Site 4:The fourth site is located in the Bab Baghdad area, after exiting the city center of Karbala, and is about 10 km from the third site. Shops and buildings are scattered along its length, and there is a noticeable amount of waste dumping. The water level is also significantly lower, and the river is considerably narrower and lined in this area.

1- Study Area:

The Husseiniya River is considered one of the vital water sources that feeds the holy city of Karbala. The digging of the Husseiniya River is one of the greatest achievements attributed to Sultan Selim the Magnificent, and it was named after him (the Suleimani River). It was completed in 942 AH/1535 AD. This river branches off from the Euphrates River on the right bank at the head of the Hindiya Dam in the Musayyib District, which lies within the governorates of Babylon and Karbala. It is approximately 27 kilometers long. It begins flowing after branching off from the Euphrates River and passes through the Al-Husayniyah and Al-Hur districts and the city center of Karbala. This river is considered the sole source of water for the city of Karbala, serving as a source for drinking, bathing, and other uses. Four locations along the river were selected to study the changes occurring in physical and chemical factors along its course:

1- Site 1: Located on the Al-Husayniyah River in the Umm al-Hamam (Al-Bu Ja'ad) area, within the administrative boundaries of

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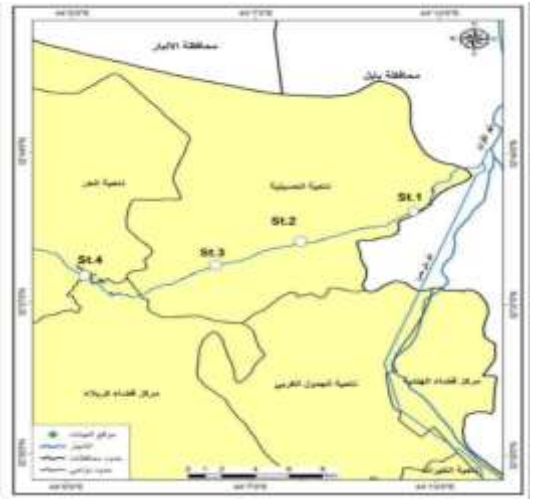

Figure (1) Map showing the study stations in the Al-Husayniyah River

Sample Collection:

solutions of pH values 4, 6, and 9 before each measurement. The electrical conductivity and total dissolved solids (TDS) were also measured using the same instrument. Electrical conductivity results were expressed in microsiemens/cm³, while TDS was expressed in mg/L. The azide modification method (9) was used to measure dissolved oxygen. Total alkalinity, total hardness, and calcium hardness were measured according to the method described by (10). Sulfate concentration was measured using the turbidity method described in (9). For plant nutrients, the method described by (11) was followed, which was used to measure nitrate concentration.

Results and Discussion

the current study are consistent with the study by (14). Water temperature variations may occur due to climatic changes and human activities (15). PH is a measure of acidity or alkalinity and the concentration of hydrogen ions in water. It is considered one of the fundamental factors in the chemical systems of natural waters due to its clear impact on the survival, growth, and reproduction of aquatic organisms (16). The highest pH value was recorded in September (7.76), and the lowest in November (6.2). It was observed that the change in pH range was minimal, which may be attributed to the addition of carbonates and bicarbonates to the water (17). Electrical conductivity and dissolved solids: Electrical conductivity is among the factors that are

Samples were collected monthly from the study sites from August 2025 to May 2026. Samples were collected using 1-liter polyethylene containers, with three replicates per sample from each of the studied sites.

3- Physical and Chemical Tests:

Air and water temperatures were measured directly in the field using a graduated mercury thermometer (0-100°C) at all study stations. Air temperature was measured in the shade, while water temperature was measured by immersing the thermometer 10 cm in water and recording the reading after 5 minutes. pH was measured using a multifunctional device, model C-600GY, manufactured by GYWJIOY, after pre-calibration with buffer

Water temperature directly affects other chemical and biological factors in water, controlling the rate of biological and chemical processes within aquatic ecosystems (12). No significant differences were recorded between the study stations for air and water temperatures, while there was a clear monthly variation in air and water temperatures. Water temperature also showed significant differences between months ($P<0.05$, $r=0.96$). The results showed a significant positive correlation between water and air temperatures. The effect of water temperature on air temperature may be attributed to the shallow depth of the river, as shallow water is known to be highly susceptible to temperature variations across seasons (13). The results of

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contributes to increased calcium concentration because calcium is used in cement manufacturing. The flow of water causes these compounds to dissolve and be released into the water. Many studies have shown that calcium predominates over magnesium (23.). 24) Since the main and natural source of these mineral ions causing hardness is the rocks, sediments, and soils through which river water flows (25), total hardness values are often high in river water as a result. Total alkalinity represents the water's content of carbonates, bicarbonates, hydroxides, and other ions. It is measured to determine water quality and its suitability for various purposes (33). The results of this study showed that total alkalinity exhibits a significant correlation with pH and dissolved oxygen, with a correlation coefficient of $r = 35$ at $p < 0.05$. Total alkalinity values ranged between 106 and 148 mg/L. The highest value was recorded in January at site 3, and the lowest value in August at the same site. The increased alkalinity there may be attributed to increased decomposition of organic matter and increased conversion of calcium carbonate to bicarbonate (23). The highest calcium value during the current study (185.6 mg/L) was recorded in December at site 3, and the lowest value (96 mg/L) in September at site 1. This increase is attributed to rainfall during the winter and the washing away of these salt-laden agricultural soils (26). Its decrease is attributed to its consumption by algae (10). The Al-Husayniyah River also carries high amounts of calcium, which may be a result of the Euphrates River passing through soils rich in calcium carbonate, in addition to the decomposition of organisms (27). The study showed a high correlation between calcium and hardness ($r=91$, $p<0.01$). Sulfate is one of the most common forms of sulfur found in natural waters, in the form of the sulfate ion, where sulfur exists as a sulfate ion combined with other ions present in the water (18). The current study recorded the highest value of sulfate (569.67 mg/L) during April at the first location, while the lowest value (285.22 mg/L) at the same location in January. These values considered good indicators in estimating the amount of dissolved substances in water, in addition to being one of the indicators that show the extent of water purity (18). The study did not show significant differences between stations, while significant differences appeared between months for electrical conductivity and total dissolved solids, and the correlation between them was $r=0.99$. Variation in the amount of dissolved solids in water affects the values of electrical conductivity because the relationship between them is direct (19). The highest value of electrical conductivity, 1490 microsiemens/cm, was recorded in November at the first site, and the lowest value, 938 microsiemens/cm, was recorded in May at the fourth site. The high values of electrical conductivity may be attributed to the high temperatures, increased evaporation rates, low water levels, and high flow velocity, and consequently, high concentrations of salts and ions in the water. Similarly, the study by (6) on the Diwaniyah River indicated a high level of dissolved solids. This confirmed the positive correlation of electrical conductivity with temperature, salinity, and dissolved solids (20).

Dissolved oxygen is essential for the respiration of fish and other aquatic organisms. A decrease in dissolved oxygen indicates pollution by organic matter that consumes oxygen. It is also the most responsive variable to seasonal changes, showing a strong inverse correlation with temperature ($r = -83$ at $p < 0.01$). High dissolved oxygen values may be attributed to lower temperatures, which increase gas solubility, or to good mixing of water layers (21). Conversely, low dissolved oxygen values may be attributed to higher temperatures, which in turn lead to increased microbial activity in decomposing organic matter, thus increasing oxygen consumption (22). Total hardness shows a strong seasonal effect and is characterized by a strong correlation with calcium ($r = 91$ at $p < 0.01$). One of the causes of high hardness is increased calcium concentration in the water. River lining also

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December at site three and the lowest value (0.982 µg/L) in October at site two. This increase may be attributed to agricultural activity, as nitrogen is present in most compounds and fertilizers (31). Nitrate concentrations remained within permissible limits, which is consistent with (32) study on the Euphrates River.

were observed to be higher than those recorded in other studies on the Euphrates River (28), which may be due to the oxidation of organic matter (29). Nitrogen, in its various forms such as nitrite, nitrate, ammonia, and various organic compounds, is one of the most influential elements in the aquatic environment (30). The study recorded the highest nitrate value (7.993 µg/L) in

Table (1) shows the changes in the physical and chemical properties of the water of the Al-Husayniyah River during the period from August 2025 to May 2026. The first line represents the range and the second line (standard deviation) ± the mean

Property	Station.1	Station. 2	Station.3	Station.4
Air Temperature (°C)	41-9 25.2±(9.50)	38-9 24.5±(9.23)	37-8 23.5±(9.29)	38-8 22.5±(8.98)
Water Temperature (°C)	39-6 22.15±(9.63)	32-6 20.9(8.66)	33-5.5 20.2±(8.84)	31.5.5 19.7±(8.39)
(PH)	7.9-6.2 7.33±(0.48)	7.8-6.35 7.25±(0.42)	7.75-6.42 7.3±(0.40)	7.6-6.5 7.18±(0.34)
Electrical Conductivity (micros/cm)	1490-1058 1280±(132.1)	1422-1124 1272±(95.1)	1425-1174 1306±(88.1)	1368-938 1232±(140.3)
Total Dissolved Solids (TDS) mg/L	825-460 666.60±(111.31)	842-550 691±(99.64)	815-574 655.82±(94.21)	890-458 691.55±(131.79)
Dissolved Oxygen (mg/L)	8.7-5.3 7.13±(1.23)	8.8-5.6 6.92±(1.08)	9.4-4.7 6.87±(1.40)	8.1-3.9 5.99±(1.30)
Total Basal Acidity mg/L	146-112 128±(11.07)	142-110 128.60±(11.33)	148-106 130.50±(13.14)	146-110 129.90±(12.26)
Total Hardness mg/L	860-420 567.40±(122.73)	668-428 541±(86.72)	750-436 551.08±(111.57)	690-428 541.80±(98.63)
Calcium mg/L	182.4-96 121.12±(26.35)	179.2-96 118.24±(26.15)	185.6-99.2 120.08±(27.21)	175.8-97.6 115.42±(22.84)
Sulfate mg/L	569.69-285.22 406.57±(91.80)	556.15-341.57 420.41±(76.99)	494.39-323.99 394.95±(63.14)	500.70-313.62 374.37±(57.22)
Nitrate µg/L	7.117-0.992 3.95±(1.87)	5.515-0.982 3.35±(1.42)	7.993-1.169 3.88±(1.79)	6.266-2.081 3.67±(1.33)

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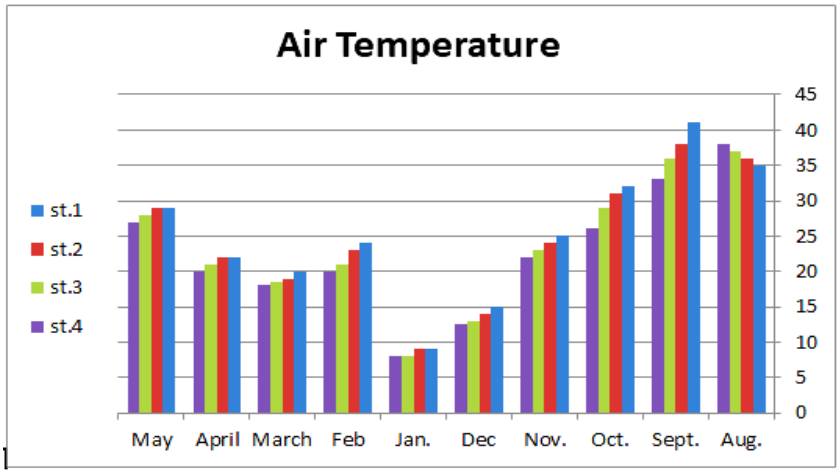

Figure (2) Monthly changes in air temperature values C̊

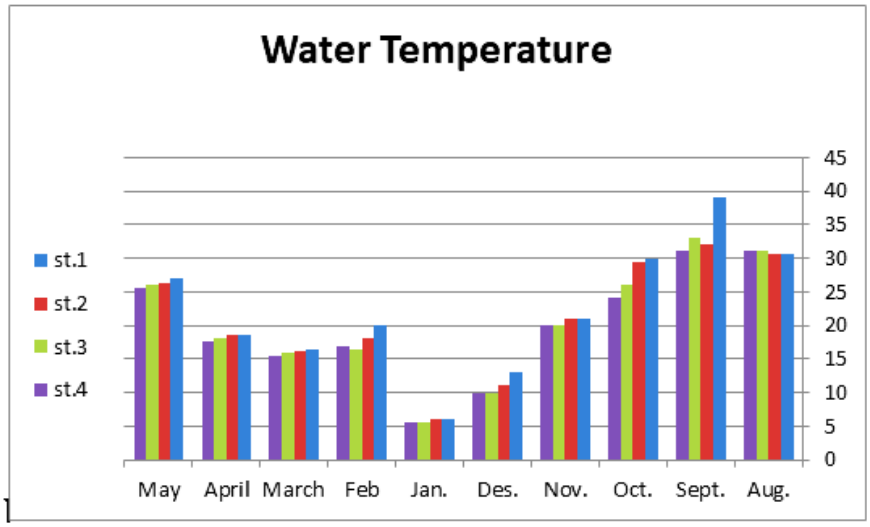

Figure (3) Monthly changes in water temperature values C°

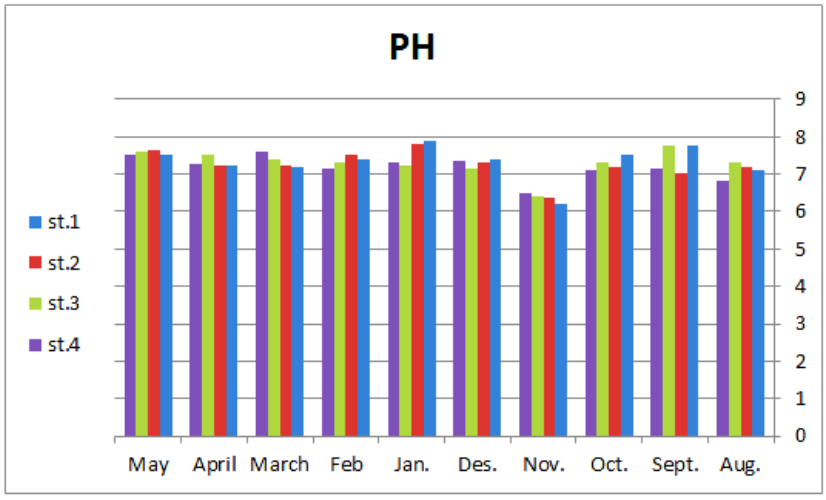

Figure (4) Monthly changes in pH values

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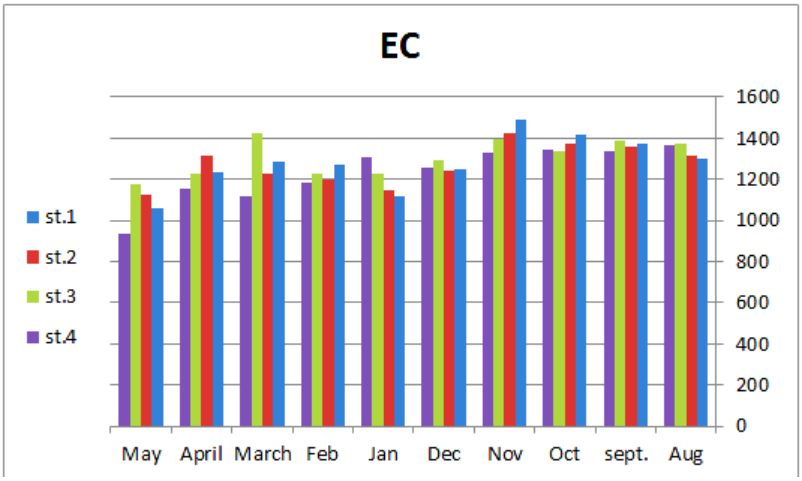

Figure 4. Monthly variations in electrical conductivity values (µS/cm).

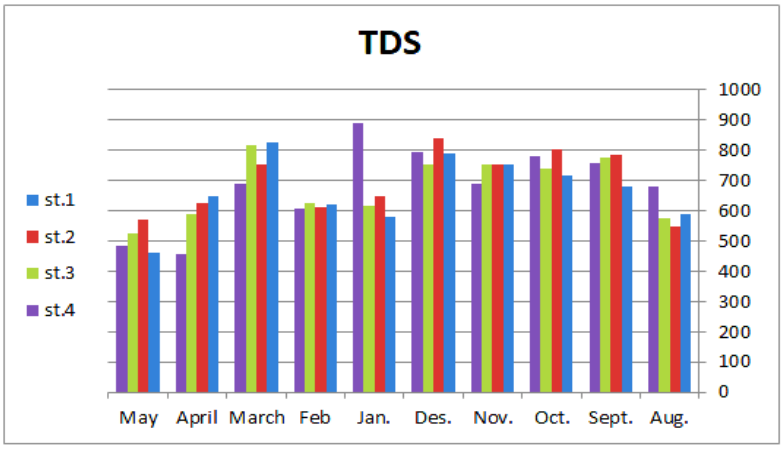

Figure (6) Monthly changes in total soluble solids in mg/l

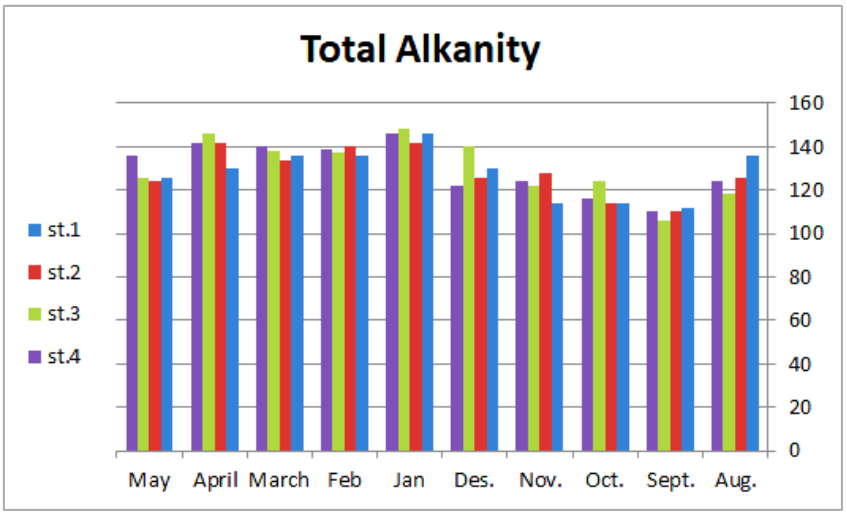

Figure (7) Monthly changes in the values of oxygen dissolved in mg/l

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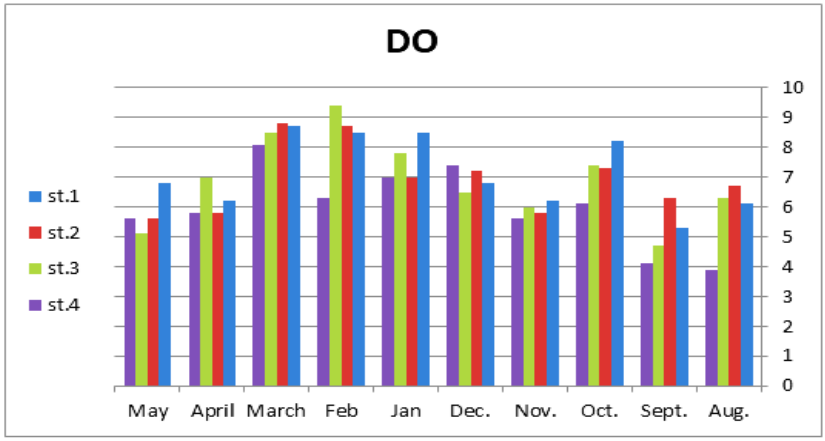

Figure (8) Monthly changes in total basal values in mg/l

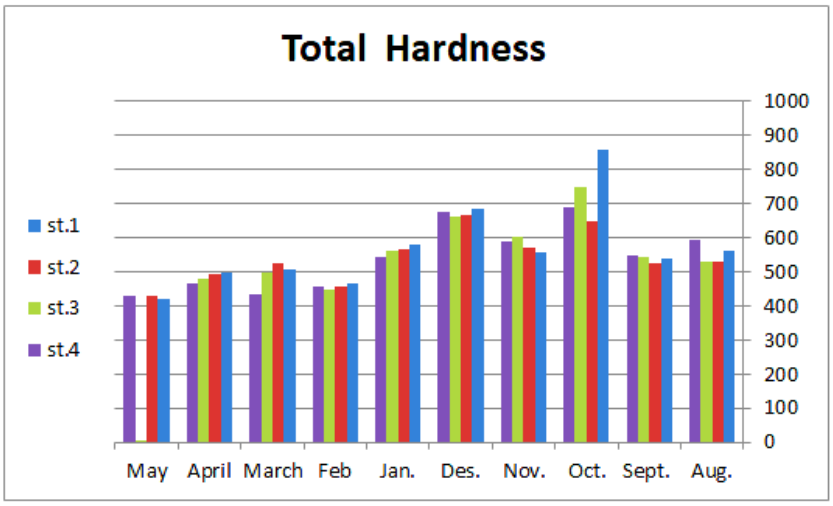

Figure (9) Monthly changes in total hardness values in mg/L

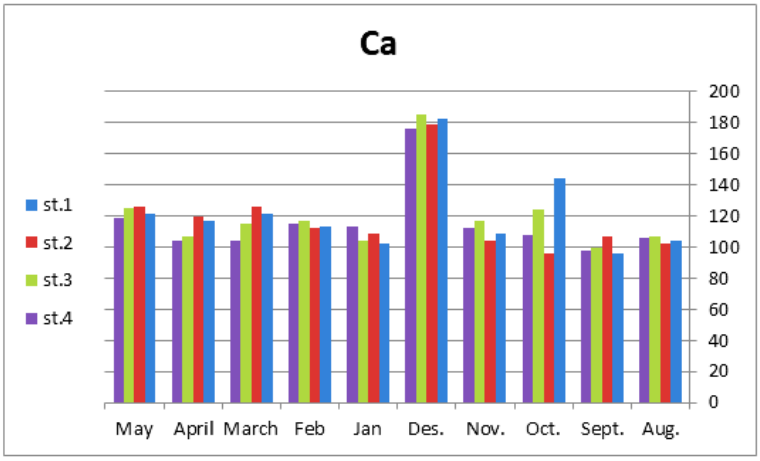

Figure (10) Monthly changes in calcium values in mg/L

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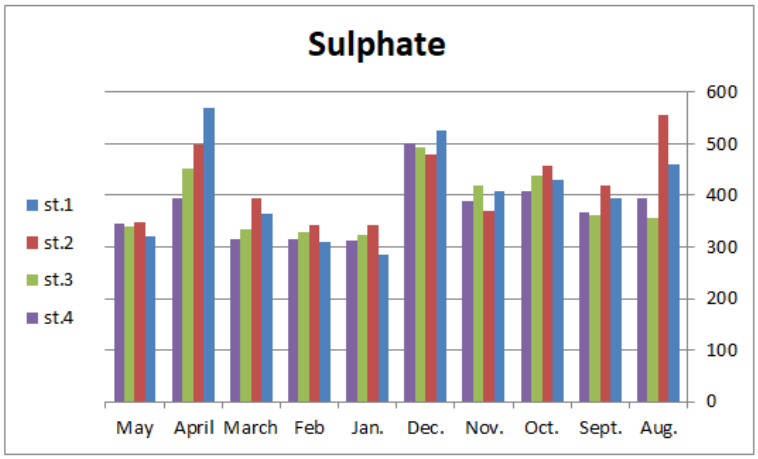

Figure (11) Monthly changes in sulfate values in mg/L

7- The total alkalinity values remained within the normal limits for rivers, demonstrating the water's ability to withstand sudden changes in pH.

8- Sulfate concentrations showed relatively high values compared to some previous studies on the Euphrates River. This may be due to the oxidation of organic matter and an increase in the concentration of dissolved salts.

9- Nitrate concentrations remained within environmentally acceptable limits, indicating the absence of serious pollution by nitrogen compounds during the study period.

10- The results showed that the water quality of the Al-Husayniyah River is primarily affected by seasonal climatic factors and the human and agricultural activities surrounding the river.

Recommendations:

1- Continued periodic environmental monitoring programs of the physical and chemical properties of the Al-Husayniyah River water throughout the year to monitor seasonal changes.

2- Conducting integrated studies linking physical and chemical properties with biotic communities, especially phytoplankton, zooplankton, and benthic organisms, as zooplankton are considered biological indicators of water quality.

3- Monitoring agricultural activities near the river and rationalizing the use of chemical

Conclusions

1- The study showed no clear spatial differences between the study stations for most physical and chemical properties, while clear temporal (monthly) differences emerged, indicating the impact of seasonal changes on water quality.

2- Water temperature showed a positive correlation with air temperature, indicating the rapid impact of climatic conditions on river water due to its shallow course.

3- pH values ranged from neutral to slightly alkaline, indicating suitable aquatic conditions for most aquatic organisms.

4- Electrical conductivity and total dissolved solids showed a strong positive correlation, confirming that changes in dissolved salt concentration are the main factor affecting the electrical conductivity of river water.

5- Dissolved oxygen showed an inverse relationship with temperature, increasing during the colder months and decreasing during the warmer months due to increased gas solubility and decreased biological activity decomposing organic matter.

6- The river water was characterized by high values of total hardness and calcium. This is attributed to the nature of the soil through which the Euphrates River flows, from which the Al-Husayniyah River branches, in addition to the effect of the concrete channel lining, which may contribute to increased calcium concentrations in the water.

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6- Strengthening measures to protect the river from the discharge of untreated domestic, agricultural, and industrial waste.

7- Adopting the results of this study as a reference database for future comparisons related to water resource management in the Al-Husayniyah River.

8- Conducting hydrological studies to assess the effect of water discharges and flow velocity on fluctuations in the physical and chemical properties of water.

fertilizers to reduce nutrient concentrations in the water.

4- Monitoring the impact of concrete channel lining, locks, and regulatory structures on water quality and concentrations of dissolved salts and elements.

5- Conducting future studies to assess the concentrations of heavy metals and organic pollutants in the river water and sediments.

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