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Seasonal Variations in the Chemical and Physical Properties of the Euphrates River in Saqlawiya

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Abstract

This study investigates the physicochemical characteristics of the Euphrates River in Al-Saqlawiya, Anbar, during the winter to summer seasons (October 2022 - July 2023). Water samples were collected from five sites, and parameters including temperature, turbidity, pH, electrical conductivity, total dissolved solids, dissolved oxygen, biochemical oxygen demand, nitrates, nitrites, phosphates, and chlorides were analyzed. Mean values for these parameters varied across the seasons, with the highest values for temperature (29.56°C), turbidity (3.12 NTU), and electrical conductivity (1535.8 µS/cm) observed during the summer. In contrast, the lowest values for these parameters were observed during the winter (18.4°C, 1.11 NTU, and 1399.6 µS/cm, respectively). These findings provide valuable insights into the seasonal variations in the water quality of the Euphrates River, highlighting the need for continued monitoring and management strategies to ensure its sustainability.

Introduction

Water contamination poses a worldwide risk to biodiversity and human health. Urbanization and industrialization have increased the use of chemical pesticides, mining, and other human-induced processes to enhance global food security. These actions lead to the degradation of water bodies and a rise in morbidity rates [1, 2]. Water pollution is commonly defined as alterations in the biological, physical, and chemical attributes of water, resulting in modifications to its fundamental features, including colour, odour, and taste. These modifications have detrimental impacts on human health [3]. Water is particularly vulnerable to contamination due to its property as a universal solvent, enabling it to dissolve more chemicals than other liquids. The dissolution of agricultural and chemical fertilizers, pesticides, and numerous industrial pollutants has also been found to be beneficial [4-6]. Studies have shown that these characteristics can be affected by factors such as industrial waste, irrigation water, sewage, cleaning materials, organic waste, and rainfall [7]. The concentrations of these qualities may fluctuate throughout the year, and certain values may

be beyond the acceptable thresholds established by organizations like the World Health Organisation[8]. Although certain indicators may be within the recommended ranges, conditions such as turbidity, dissolved oxygen, and biochemical oxygen demand may not meet the acceptable standards for drinking water. The usefulness of river water for many uses, including drinking, agriculture, and aquatic life, is influenced by its physical and chemical qualities[8]. In Southwest Asia, the Euphrates River holds the distinction of being the longest river in the region. The river spans a distance of 2786 km and covers an approximate area of 440,000 km^2[9]. This catchment region is shared by five different countries. Iraq accounts for 47%, Turkey for 28%, Syria for 22%, Saudi Arabia for 2.97%, and Jordan coming in at 0.03%. Turkey is the source of the river, which flows southward towards Syria and eventually in the direction of Iraq. At Qurna, which is located in the southern region of Iraq, it flows into the Tigris River [10]. The Euphrates River in Iraq has witnessed chemical and physical changes [11]. The current study included collecting water samples at five selected stations in the city of Saqlawiyah, starting from the Saqlawiyah Bridge and along the Euphrates River, one of the important water sources in Iraq, and determining its physical and chemical characteristics.

Materials and methods

Samples Collection Sites

Table 1: Five sites have been selected and will be described

Sites	Location	Samples collection Coordinates	
		°N	°E
S1	The Saqlawiyah Bridge serves as the focal point connecting the Saqlawiyah region with the Fallahat region. The existence of certain data along the riverbanks sets it apart. The facility is situated near the sand industries, with the untreated water being directed directly into the river.	43	33
S2	The Saqladia district is situated close to the Saqlawiyya Bridge, at a distance of around 200 metres. Near the farm, there are sand manufacturers situated on the opposite side.	43	33
S3	It is situated at a distance of around 800 meters from Saqlawiyah Bridge and is distinguished by the existence of agricultural fields and a residential zone.	43	33
S4	The distance from the Saqlawiya Bridge is 1 kilometre. The river bank is adorned with reed and papyrus, as well as a water station.	43	33
S5	It is located 2 km from the Saqlawiyah Bridge and is characterized by an abundance of plants on its bank, represented by reeds and papyrus. There is a water filtration station, and on the opposite side, there are ponds for raising fish,	43	33

and raw water is poured directly into the river.

Sample Collection Method

Water samples were collected from five locations on the banks of the Euphrates River in the Saqlawiyah area and along the river. Sample collection began in the summer and went on to winter. Then, samples were taken from the surface water layer at a distance of 30 cm from the upper layer of water using a polypropylene bottle with a capacity of 1 L to measure physicochemical parameters. The samples were transferred to conduct laboratory tests. Some tests were conducted simultaneously in the field, and others were conducted in the laboratory tests within 24 hours of collecting samples, with two readings for each measurement. The average of the two readings was approved as the final result.

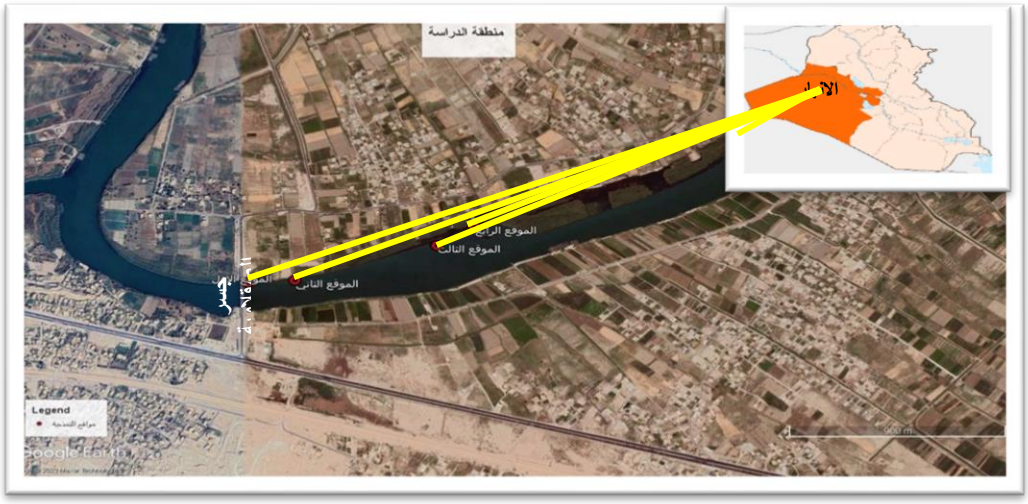

Figure 1: Map of the study site

Physical and chemical properties

The river water samples were taken from the chosen locations (S1–S5) under the standard sampling methodology (IS: 2498, 1966 – Part I). Regularly, observations were recorded to study factors such as temperature, turbidity, pH, and Electrical conductivity to characterize the nature and extent of pollution. By the standard criteria and procedures established by the American Public Health Association (APHA) [12] , various metrics, including Total Dissolved Solid (TDS), Demand oxygen (DO), Bio-chemical Oxygen Demand (BOD), nitrate (NO_3^-), nitrite (NO_2^-), Phosphate (PO_4^{3-}), and chloride (Cl^-) were examined. The mean value was determined after each analysis was performed three times to ensure accuracy [13].

Statistical Analysis

The data were analyzed utilizing the statistical program Statistical Analysis System - SAS (2018) to investigate the impact of geographical locations and the different seasons of the year on the characteristics being investigated. The LSD test was utilized to compare the significant differences that were found between the means [14].

Results and discussion

The study shows seasonal variations in numerous physicochemical parameters at distinct sites (S1–S5). The temperature of water is a critical factor in aquatic systems as it has a direct impact on dissolved oxygen (DO) levels [15]. The results were obtained by measuring

the atmospheric air temperature in all sites on the Euphrates River in the Saqlawiyah region and different seasons: summer and winter. We noticed from the results, as indicated in Table 1, that there were no significant differences in the air temperature for the five sites during one season, while there were There are substantial differences in the overall average air temperature according to the seasons (43.27, 21.20, and 18.20) °C for summer, autumn, and winter, respectively. The atmospheric air temperature was associated with the water temperature for the studied sites, as shown in Table 2; the water temperature was (29.56, 27.60, and 18.40) °C for the summer and winter seasons, respectively. This is consistent with studies, as data analysis proves that the water temperature rises/decreases when the air temperature increases/decreases, but it does not change by the same amount as the air temperature. Water takes much longer to change its temperature than air[16].

Table 1: Temperature values of water samples collected in this study

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	29.3	29.4	29.8	29.2	30.1	29.56
Autumn	27	27	28	28	28	27.60
Winter	18	18	18	19	19	18.40
Average location	24.76	24.80	25.26	25.40	25.70	−−−

Turbidity is a term that describes the condition of suspended solids in water. This condition encompasses a wide range of items, including waste debris, sewage, and plankton products[17]. Turbidity was measured at the five sites three times a year: autumn, winter, and summer. Table 2 shows that the degree of turbidity increases with a decrease in water temperature in the winter by an average of (3-12) NTU. In contrast, the lowest turbidity values were recorded in the summer, with an average of 1.11 for the five sites. Regarding these results, Site 1 had the highest turbidity value during the season, (7.9) NTU S2. Turbidity measures the extent to which water contains impurities in a lake or river. It can be caused by various factors such as silt, clay, algae, cuttings of plants, melting glaciers, sawdust, or chemicals in the water[18]. The research results are consistent with scientific fact, as turbidity in rivers and lakes can vary over the seasons, as increased rainfall in winter leads to increased turbidity due to soil runoff[19].

Table 2: Turbidity values (NTU) of water samples collected in this study

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	1.2	1.4	0.88	0.94	1.13	1.11
Autumn	2	7.9	1.6	2	1.8	3.06
Winter	2.3	4.5	3.8	2.9	2.1	3.12
Average location	1.83	4.60	2.09	1.94	1.67	−−−

pH of water during seasons

The pH level of water can indicate the presence of chemical or heavy metal contamination [20]. Variations in the quantities of inorganic and organic pollutants may be responsible for this pattern of variance. All of the locations had pH levels that were lower than the acceptable range, which was established by the World Health Organization in 2011 and ranged from 6.5 to 8.5 [21]. There was no significant difference between the five sites and between the seasons of the year. Still, the results recorded a non-significant increase when the water temperature decreased. There was also a non-significant decrease in its levels during the summer with the rise in water temperature, and this is consistent with[22]. Seasonal temperature changes lead to a change in pH, which is generally higher in the coldest months of the year (December to April) and lower in the warmer months (July to September). Kumari *et al*.[23] and Sharma *et al*. [24], conducted comparative investigations on the physicochemical properties of the Narmada River. They observed a pH range of 7.4–7.7 as the minimum and 8.8–9.7 as the maximum at various locations, which closely aligns with the current study's findings Gupta *et al*. [25], and Edokpayi *et al* [26], in the pH range 5.9–8.00 and 6.5–8.9.

Table 4: pH values of water samples collected in this study

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	7.28	6.77	7.17	6.86	7.4	7.09
Autumn	7.36	7.50	7.79	7.73	7.25	7.52
winter	7.54	8.08	8.03	7.84	7.8	7.85
Average location	7.39	7.45	7.66	7.47	7.48	---

Electrical conductivity of water

The electrical conductivity (EC) of water experiences an increase when the concentration of ions or dissolved particles in the water increases. EC value should not exceed 1000 µS/cm, as stipulated by the World Health Organization's (2011) criteria. In the present study, electrical conductivity values were higher during the autumn season, that is, with moderate water temperatures, at a rate of 8.1535 EC µs/cm for the five sites, while the electrical conductivity values approached a decrease in the winter and summer seasons (14350, 1399.8) EC µs/cm, respectively. The reason for this may be attributed to the high percentage of salts in the autumn, and this does not agree with studies that confirm that conductivity depends on water temperature, as an increase in temperature by one degree Celsius causes an increase in conductivity of 2%[27].

The results may be interpreted in light of the scientific fact that electrical conductivity is directly proportional to the concentrations of dissolved ions and that the concentration of dissolved salts, in turn, is inversely proportional to the drainage rates and water levels.

Table 5: Electrical conductivity (EC µs/cm) values of water samples collected in this study

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	1361	1355	1339	1479	1465	1399.8
Autumn	1534	1537	1470	1562	1576	1535.8

Winter	1358	1403	1471	1501	1442	14350
Average location	1417.67	1431.67	1426.67	1514.00	1494.33	---

Total dissolved salts (TDS) in water during the seasons

It is clear from Table 6 that the values of total salts dissolved in the water during the seasons of the year for the five sites were the highest in the autumn at a rate of 766 mg/L for all sites, while they were lowest during the summer at a rate of 700.0 mg/L. At the same time, there were no significant differences between the five sites studied during one semester.

Table 6: Total dissolved salts (TDS) (mg/L) values of water samples collected in this study

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	682	680	669	736	733	700.0
Autumn	766	770	732	780	786	766.8
Winter	691	703	735	750	721	720.0
Average location	713.00	717.67	712.00	755.33	746.67	---

Dissolved Oxygen (DO) in water during the seasons

The DO is an important indicator in assessing water quality and is vital for the survival of all aquatic organisms. Oxygen influences numerous water indicators, including biochemical and aesthetic aspects such as odor, clarity, and taste. DO concentrations at sites S1–S5 range from 4.8–8.9 mg L^{-1} in summer, 7.5-9 in autumn, and 10–12.1 in winter. In winter, S1- S5 shows values higher than the permissible limit of (4-6 mg L^{-1}), indicating significant oxygen removal. The results (Table 7) indicate significant differences in the samples taken from sites 1 to 5 for the summer, autumn, and winter seasons. At the same time, there was no significant difference in the samples taken from all study sites in the spring. The high dissolved oxygen concentration was caused by high organic matter and nutrient discharge near the river site, which resulted in increased microbial activity during the decomposition process [28]. Sharma *et al*. [24], found dissolved oxygen (DO) concentration to range from 6.5 to 15 mg L−1, which is higher than the range recommended by WHO. Yisa and Jimoh [28], reported dissolved oxide concentrations ranging from 3.10 to 520 mg L^{-1} for the Landszow River.

Table 7: Demand Oxygen (mg/L) values of water samples

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	8.9	5.1	7.2	5	4.8	6.20
Autumn	7.5	8.3	8	8.1	9	8.18
Winter	10	10.8	11.2	9.7	12.1	10.76
Average location	8.80	8.06	8.80	7.60	8.63	---

Biological oxygen demand (BOD) in water during the seasons

Biological oxygen demand (BOD) is used to measure the amount of organic matter that can be broken down by biological processes in a given sample. The laboratory analyses show

that the BOD value fluctuated between 4 mg/L (S1) –12 mg/L (S5) in summer, 2mg/L (S2) –7mg/L (S1) in autumn, and 3 mg/L (S5) –7mg/L (S3) in winter. The rise in BOD levels season may be attributed to elevated microbial activity during the decomposition of organic materials in the presence of oxygen. Mena-Rivera *et al*.[29], Sharma *et al*. [30], Isiuku & Enyoh [31], and Adeola Fashae et al,[32] found similar results.

Table 8: Biological oxygen demand (mg/L) values of water samples

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	4	7	6	9	12	7.6
Autumn	7	2	3	5	3	4.0
Winter	6	5	7	5	3	5.2
Average location	5.67	4.67	5.33	6.33	6.00	–––

Nitrate values in water

Nitrate serves as the primary nitrogen source for aquatic plants. However, high amounts of nitrates can have harmful effects and lead to eutrophication in aquatic ecosystems. The growing concentration of nitrates in water resources is a serious and growing problem associated with water scarcity. According to the World Health Organization (2011), the nitrite concentration was found to be less than or higher than the permitted limit of 3 mg/L. Table 9 shows the seasonal changes in nitrate values in the studied sites, which were highest and with a large difference during the autumn season at a rate of 10.46 mg/L and decreased during the summer and winter seasons. At a rate of (3.66 and 1.98) mg/L, respectively. There were significant differences in the level of nitrates between the sites, as they were highest in the control site and Site 1 at a rate of (7.93 and 8.46) mg/L, respectively. High levels of nitrate in water can be the result of surface runoff or seepage from fertilized soil, wastewater, landfills, animal feed, or septic systems[33].

Table 9: Nitrate values (mg/L) of water samples collected in this study

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	5.3	3	6	3	1	3.66
Autumn	15.6	20.2	3.3	13.1	0.1	10.46
Winter	2.9	2.2	1.6	0.1	3.1	1.98
Average location	7.93	8.46	3.63	5.40	1.40	---

Seasonal changes in nitrite values in water

Nitrite has the molecular formula NO^{-}_{3}, so it consists of one nitrogen atom surrounded by two oxygen atoms, with a net negative charge of one. Nitrites are highly soluble in water and are commonly found in groundwater. European Union drinking water quality standards stipulate less than 50 mg/L for nitrates in drinking water. Table 10 shows the seasonal changes in nitrite values in the studied sites. The highest rate was at Site 1 during the summer, reaching a rate of 0.35 mm/L, while the nitrite percentage reached the highest

amount in the winter for the control site, reaching 0.4 mg/L. As for the rest of the sites, the rate of nitrite was small for all seasons studied, ranging between 0-0.1 mg/L. This can be explained in light of the study[34], which indicates that nitrite values in water are closely related to human activities, and this relationship had a clear seasonal change trend. It is also affected by the different areas of the river, depending on the slope of the land.

Table 10: Nitrite values (mg/L) of water samples collected in this study

Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	0.02	1	0.02	0.02	0.05	0.22
Autumn	0.01	0.02	0.01	0.03	0.03	0.02
Winter	0.4	0.05	0.15	0.07	0.03	0.14
Average location	0.14	0.35	0.06	0.04	0.04	---

Phosphate values during the seasons in water

Phosphate is a major nutrient that leads to the depletion of soil fertility. It also pollutes lakes, rivers, and oceans in a process known as eutrophication. This leads to algae blooms that contaminate drinking water supplies and create oxygen-deficient dead zones, which can kill fish and other aquatic species. Phosphorus pollution is a major driver of biodiversity loss and contributes to the degradation of the ecosystems on which humanity depends. Phosphate levels exceeding the permissible limit can be attributed to direct discharge. For raw municipal wastewater. As researchers reported at different time points Wastewater, which contains a high percentage of organic materials, is the main source of phosphate pollution (Singh et al., 2016). In addition, phosphates can also be part of Industrial waste, detergents, fertilizers, and agricultural waste discharge of chemicals into the river system. In present study the concentration of phosphate increased during the winter, reaching the highest value of 0.57 mg/L at (S1), followed by the autumn and then summer, at a rate of (0.304 and 0.024) mg/L over Respectively, as shown in Table 11, the study [35] showed that high water temperatures increased the amount of phosphate.

Table 11: Phosphate values (mg/L) of water samples collected in this study

Sites / Seasons	S1	S2	S3	S4	S5	Average seasons
Summer	0.02	0.03	0.01	0.01	0.05	0.024
Autumn	0.57	0.37	0.23	0.17	0.18	0.304
Winter	0.2	2	0.2	0.1	0.1	0.520
Average location	0.26	0.80	0.15	0.09	0.11	---

Chloride values in water during the seasons

Chloride makes the water of lakes, rivers, and ponds acidic, which harms the agricultural and plant systems that depend on this water, which leads to a lack of nutrients in the aquatic ecosystem and thus affects aquatic life. The results were almost similar during the three seasons for chloride concentration, with a slight increase during the winter season compared to the rest of the seasons, as the average reached 129.2 mg/L, and the lowest value

was during the autumn and summer seasons (113.6 and 115.8) mg/L, while the differences between the sites were significant. The highest is in site 4, and the lowest is in the control site, the control site (127.20 and 108.70) mg/L, respectively, as shown in Table 12. Studies have indicated that the chloride concentration in river water can be affected by factors such as flow and temperature[36]. In addition, the presence of chloride in water can indicate pollution and have harmful effects on ecosystems[37].

Table 12: Chloride values (mg/L) of water samples collected in this study

Sites / seasons	S1	S2	S3	S4	S5	Average seasons
summer	106	106	113	128	126	115.8
autumn	99.4	106.5	113.6	127.8	120.7	113.6
winter	120.7	127.8	127.8	134.9	134.9	129.2
Average location	108.70	113.43	118.13	130.23	127.20	---

Conclusion

This study revealed significant seasonal variations in the physicochemical characteristics of the Euphrates River in Al-Saqlawiya, Anbar. The highest temperature, turbidity, and electrical conductivity values were observed during the summer, indicating potential concerns for aquatic life and human health. These results highlight the need for continued monitoring and implementation of effective management strategies to mitigate pollution and ensure the sustainable use of this vital water resource. Further research is recommended to investigate the long-term trends in water quality and develop comprehensive solutions for protecting the Euphrates River ecosystem and the well-being of communities that depend on it.

Conflict of interest

The authors declare no competing interests.

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Non

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التغيرات الموسمية في الخصائص الكيميائية والفيزيائية لنهر الفرات في الصقلاوية

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الخلاصة:

تلعب المسطحات المائية السطحية دوراً حاسماً كمصدر مياه أساسي لمختلف احتياجات الإنسان، بما في ذلك الاستهلاك والشؤون الداخلية والزراعة والعمليات الصناعية، فضلاً عن دعم الحياة المائية والأنظمة البيئية. إنّ درجة الحرارة ومحتوى الأكسجين المذاب والطلب على الأكسجين الكيميائي الحيوي من الخصائص الكيميائية والفيزيائية لمياه النهر التي تتأثر بهطول الأمطار ومياه الري والنفايات الصناعية. وكثيرًا ما تتقلب هذه الميزات مع المواسم، بل إنّ بعضها يتجاوز الحدود المقبولة التي وضعتها منظمات مثل منظمة الصحة العالمية. تحدد الخصائص الفيزيائية والكيميائية لمياه النهر ما إذا كانت صالحة للشرب والزراعة والحياة المائية، ويعتبر نهر الفرات أحد مصادر المياه الرئيسية في العراق.

في هذه الدراسة، تم جمع عينات المياه من خمسة مواقع لنهر الفرات، خلال فصلي الشتاء والصيف من تشرين الأول 2022 حتى تموز 2023؛ تم تحليل المعلمات الفيزيائية والكيميائية لعينات المياه. متوسط قيم درجة حرارة الماء والهواء والعكارة والأس الهيدروجيني وEC وTDS وDO وBOD والنترات والنيتريت والفوسفات والكلوريد خلال فترة الصيف والخريف والشتاء كانت (29.56،27.6 و18.4 درجة مئوية)، 1.11، 3.06 ، و 3.12 ((NTU، 7.09)، 7.52، و 7.85)، 1399.6، 1535.8، و 1435 (مايكروسمنز/ سم)، 700.0، 766.8 و 720 ملجم / لتر، 3.66، (6.2، 8.18، و 10.76) ملجم / لتر و (7.6 و 4.0 و 5.2) ملجم / لتر 10.46 و 1.98 ملجم / لتر و 0.22 و 0.304 و 0.520 ملجم / لتر و 115.8 و 113.6 و 129.2 ملجم / لتر على التوالي.