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Impact of Hindiya Dam on the Limnological Features of Euphrates River to the North of Babil Governorate, Iraq

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Abstract:

Five sites were chosen to the north of Babil Governorate in order to identify the limnological features and the impact of the Hindiya Dam during 2019. Site2 was located near the dam to reflect the ecological features of this site, whereas other sites, S1 was located at the upstream of the dam as a control site. Moreover, the two other sites S3 and S4 were located down the dam. The results of the study showed a close correlation between air and water temperature at all sites. Also there were significant differences in average of thirteen out of eighteen water parameters.Water temperature, total alkalinity, bicarbonate, DO, POS, TH and Mg^{+2} ions decreased from 22.76˚C, 203.33 mg/L, 146.75 mg/L, 8.8 mg/L, 100.023%, 438 mg/L, 35.55mg/L, respectively on S2 to 22.66 ˚C, 200.28 mg/L, 145.58 mg/L, 8.35 mg/L, 95.45%, 422.66 mg/L, 28.81 mg/L, respectively at site below the dam. While, turbidity, TSS, Ca^{+2}, SO_2^{+4}, NO_3^{-2} and PO_4^{-2} increased from 13.32 NTU, 23.08 mg/L, 116.89 mg/L, 107.5 mg/L, 1.027 mg/L and 0.019 mg/L, respectively on S2 to 26.574 NTU, 26.83 mg/L, 119.23 mg/L, 137.5 mg/L, 1.145 mg/L and 0.032 mg/L, respectively at the site below the dam. However, no apparent dam effect was reported in EC, S, TDS, pH values at Euphrates River. No significant differences of all characteristics were found among sites except, turbidity, TSS, Mg^{+2}, SO^{+4} and PO_4^{-2}. It can be considered that the Euphrates River is very hard, oligohaline, slightly alkaline, well ventilated and clear to turbid. In addition, the turbidity and TSS values exceeded permissible limits of water quality for aquatic life in most samples especially in site below the dam. However, the river was considered by BOD_5 to be doubtful in its cleanliness water. Calcium, magnesium, nitrate and phosphate values in this study were within permissible limits.

Keywords: Euphrates River, Freshwater, Hindiya Dam, Permissible limits, Physical-chemical properties.

Introduction:

Water's physical and chemical properties are an important factor in assessing water quality and validity and give an idea of the water content of organic, inorganic compounds and elements [1]. Also, water plays a major role in life of aquatic lives, quality of water affected by change in atmospheric and geological circumstances[2].

For forty decades, the limnology of Iraqi water bodies has received considerable attention and several studies have been recorded in various parts of Iraqi water bodies such as [3-20]. However, the current study dealt with one of the major dams of the Euphrates River to the north of Babil Governorate, for which we can include the major aims in the following points: investigating the ecological characteristics of river, and studying additional basic knowledge on physical-chemical properties under the effect of the dam during the 2019, Therefore, this studycan be considered the first of its kind by dealing with this aspect of the work.

Material and Methods:

Study area Description

Hindiya Dam is situated on the Euphrates River to the south of Musayyib City to the north of Babil Governorate, Iraq. The Dam length is 250 m and has 36 dams' spillways, 5m wide of each one. It was designed for treatingsediment matter of the one of two major branches of the Euphrates in this area called Hilla River. Hindiya Dam was constructed from 1911 to 1913.A new canal in addition to the Hillah River was excavated. Willcocks supervised on the work whereas it was done by a British contractor named John Jackson. The dam was developed in 1927 [21]. Hindiya Dam contains other canals in addition to the Hindiya and the Hilla branches which are called the Kifil and Beni Hasan[22].

Description of Study Sites

Five sites were chosen for the collection of study samples onEuphrates River near Hindiya Dam (Fig.1). **1. Site 1:** This site is located before the Babylon Cement Factory south of the Musayyib City about 1Km upstream the dam at longitude 44° 16' 05"and latitude 32° 44'18". Euphrates River and is 328m wide. **Site 2:** It represents the Hindiya Dam site characterized as wider among other sites about 366m width at longitude 44°16' 07"and latitude 32° 43' 42". **Site 3**: It is located about 400m down Hindiya Dam with 235m width at longitude 44°16' 06"and latitude 32° 43' 29". **Site 4:** This site is 293 m wide and located about 5Km down Hindiya Dam at longitude 44°15' 16"and latitude 32°41' 24"**. Site 5:** It is 231 m wide and located about 10Km downstream site 4, and about 15Km downstream the Hindiya Dam at longitude 44°13' 12"and latitude 32° 35' 50".

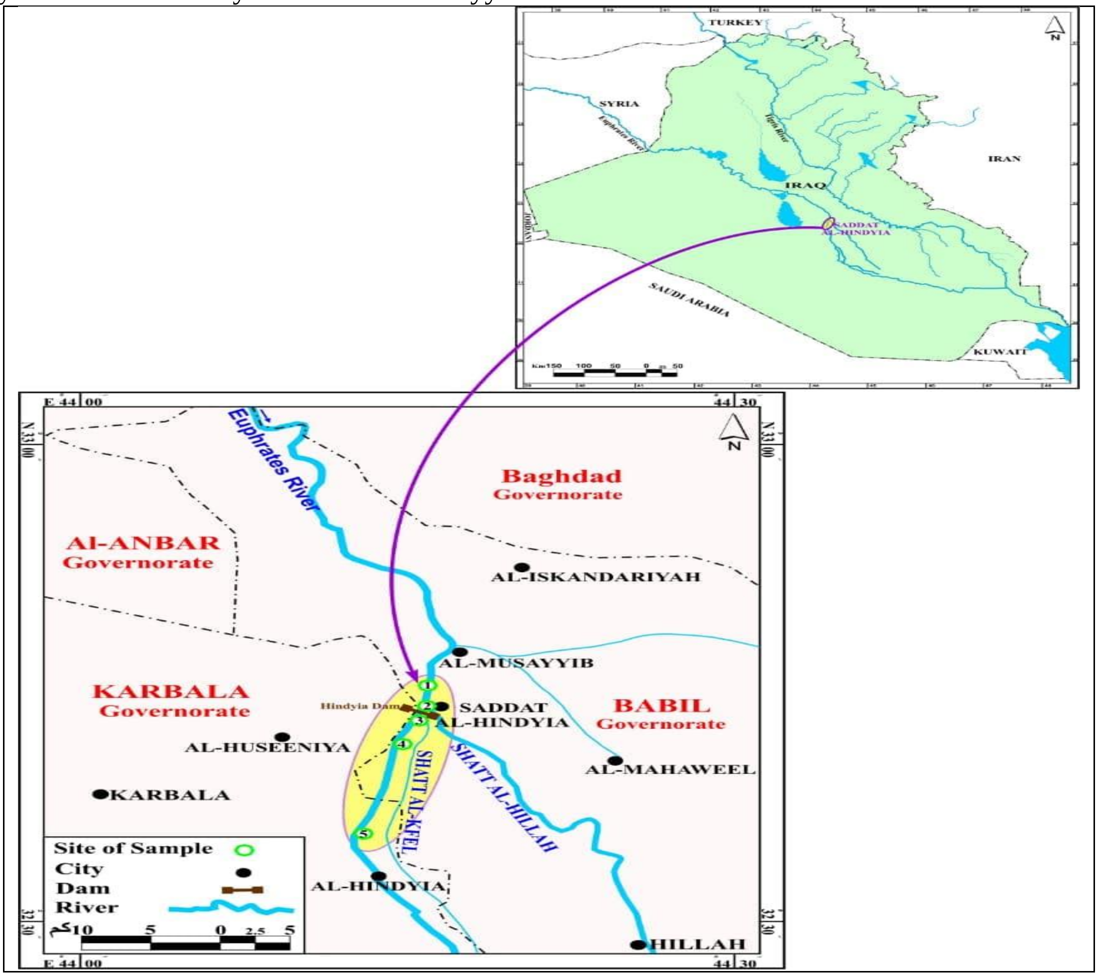

Figure 1.Map of Hindiya Dam with locations of the studied sites.

Water discharges were in range between lower value of 116.92 m^3/sec. in February 2019 while the greatest value was 409.89 m^3/sec. in July2019. Water velocity of Euphrates River study sites during study period was in range between the lower value of 0.46 m/sec. in February 2019 while the greatest value was 0.64 m/sec at November 2019 (Ministry of Water Resources, 2019personal communication) (Fig. 2).

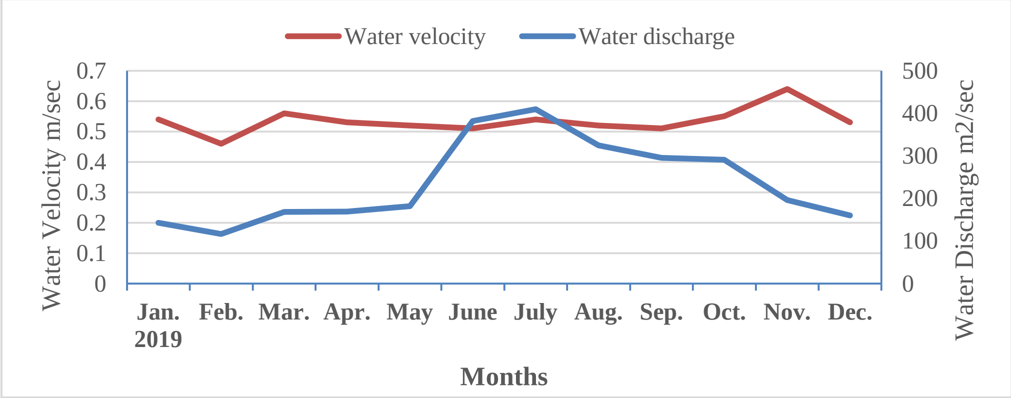

Figure2. Water discharges and velocity of Euphrates River during period study.

Samples were collected monthly during year 2019, by using polyethylene containerswithcapacity 2 L and washing well with river water before using it.

Physical and chemical parameters included - Air and water temperature which were measured by using a precise mercury thermometer. Dissolved oxygen and Biological oxygen demand used the modified Winkler method [23]. The percentage of oxygen saturation was calculated as reported in Mackereth *et al.* [24], electrical conductivity, salinity, pH, and Total Dissolved Solid in water by HANA (HI9811). The Total Suspended Solids were measured according to the method mentioned in APHA [23]. The turbidity was measured by the turbidity meter Jenwa Company Model-6035. Total hardness, calcium, and magnesium were measured according to Lind [25]. Sulphate used the method described by Brands and Tripke [26], the nutrients (Nitrate), measured as in APHA [23], the effective phosphate was measured according to the method APHA [23]. Finally, the Degremont method [27] was used to measure the bicarbonate in the water of the studied sites.

Results and Discussion:

The air temperature having clear variation seasonally (Fig.3 and 4) and (Table 1) might be due to the air temperature reflection of fluctuations in Iraq weather characterized as long, hot and dry summers. In contrast, it has short and cool winters because of Iraq's location between the Arabian desert areas that give the effect of the subtropical aridity and the Arabian Gulf that give the effect of the subtropical humidity [28]. The current findings proved that the dam affected water temperature apparently on site 3 downstream the dam which caused decreasing water temperature values in this site after opening spillways the dam and releasing colder water from hypolimnetic layer of reservoir to site 3 [29].

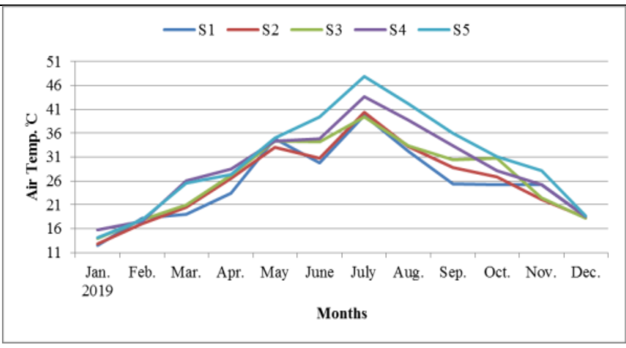

Figure 3. Variation of air temperature during the period study.

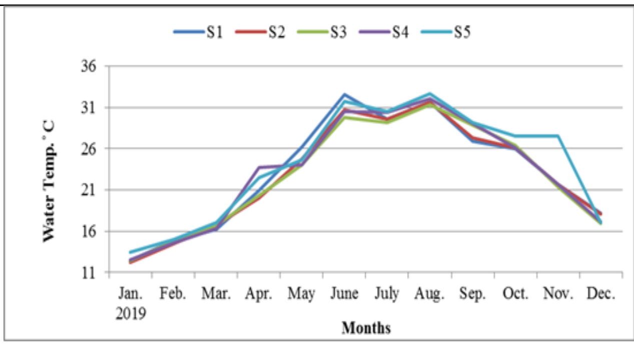

Figure 4. Variation of the water temperature during the period study.

Figure 5 and 6 and, Table 1 showed the results of electrical conductivity and salinity .The range of electrical conductivity recorded on site 1upstream the dam was from 690µS/cm(0. 44‰) to 1320µS/cm(0.84‰). The lowest value of electrical conductivity and salinity in was October whereas the highest values were in January, respectively. The electrical conductivity values in Hindiya Dam site were unchanged which varied from 680 µS/cm(0.44‰) in October to 1340 µS/cm(0.86 ‰) value in January, respectively. The electrical conductivity values in sites (downstream the dam) varied from 690 µS/cm(0.43‰) in October to 1380 µS/cm(0.88‰) value in January, respectively. The

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statistical analysis of EC and salinity had no significant difference among sites P > 0.05 (Table 1).

It has been shown that Hindiya Dam has no effect on electrical conductivity and salinity values at Euphrates River and this case could be due to the high water discharges in the river at 2019, which led to disappear of the dam effect on EC and salinity values [30]. Freshwater salinity levels are 0.5 ppt or less. Salinity levels are referred to as oligohaline (0.5-5.0 ppt), mesohaline (5.0-18.0 ppt), polyhaline (18.0-30.0 ppt), or euhaline, where salinity levels of more than 30.0 ppt are the same as those of the ocean [31].

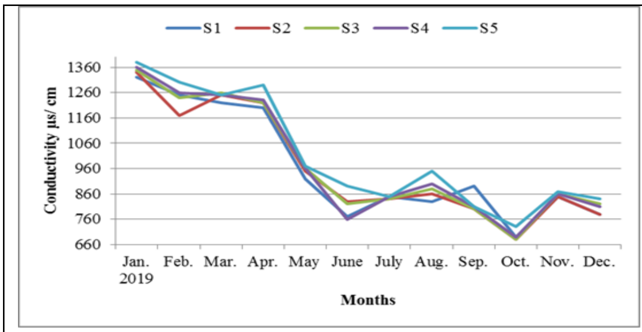

Figure 5. Variations of the conductivity during the period study.

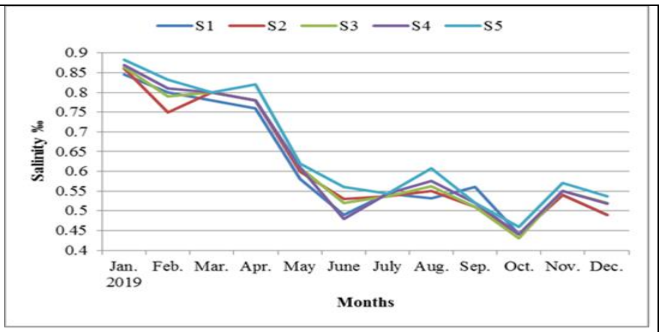

Figure 6. Variations of the salinity during the period study.

Figure 7 and Table 1 showed thatsite 1 recorded a minimum level of 3.84 NTU in November, while the maximum level in Julywas31.25 NTU. The turbidity values at the Hindiya Dam site were substantially unchanged and ranged from1. 58 NTU to 33.31 NTU reported in August and March 2019, respectively.

The turbidity range at sites downstream the Hindiya Dam site was significantly increased, espe cially at site 3, and then gradually decreased to lowe r values at site 5.The turbidity values ranged from the lowest value of 4.34 NTU at site 5 in April to the highest turbidity value of 45.71 NTU in November 2019 at site 3. The statistical analysis revealed that no significant difference between all turbidity sites (P > 0.05) except site 3 was identified (P≤ 0.05) (Table 1).

Table 1 and Fig. 7 illustrate that site 3 (downstream the dam) had the highest turbidity average compared with other sites which might be related to the frequent fluxes resulting from the opening of dam spillways leading to the release of sediments settled in the lower reservoir layer [32]. Or, it may be because of the higher velocity currents at site3 below the dam resulting from opening the dam spillways [33]. Whereas, the lower turbidity average near Hindiya Dam was because of the lentic state of reservoir water on this site led to the settling of particles and sediment downward bottom [34]. It was believed that both causes are mentioned to increase turbidity values at sit 3 downstream the dam contributed in increase turbidity values at site 3. Site 5 had low turbidity average which could be due to it being far from the city about 10 Km and it was far from sewage and effluents as compared with other sites [35].Turbidity values exceeded permissible limits of water quality for aquatic life which was 5 NTU [36]in most samples, especially in site 3 (downstream the dam) which might be due to the dam effect on site 3.

The pH values did not show an even notice dam impact on pH values at Euphrates River during 2019, and no significant differences P>0.05 among sites were remarked(Fig. 8 and Table 1). Also, a narrow range of this parameter was recorded which was from 7- 8.18. So Euphrates River was considered weak alkaline as it is known in Iraqi freshwater [37]. The pH values remained stable at levels in narrow range owing to the high buffering capacity resulting from high content of calcium bicarbonate [38]. Overall, these local and global studies agreed with this study finding such as (4 ; 5)

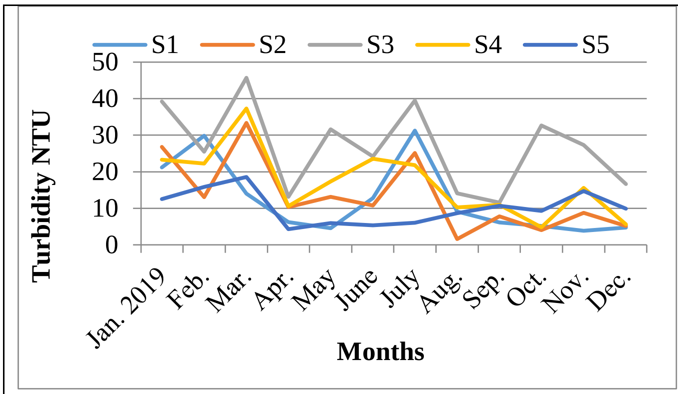

Figure 7 .Variation of the turbidity NTU value during the period study.

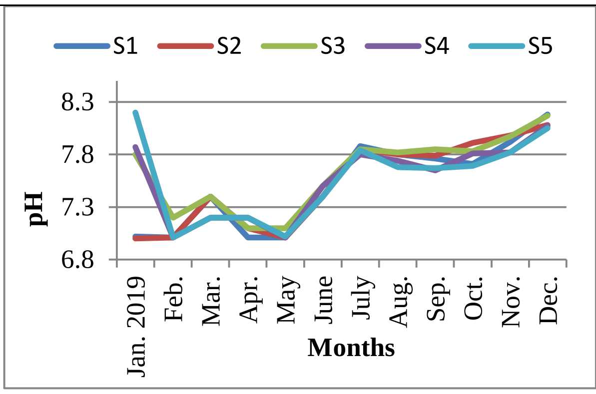

Figure 8. Variation of pH values during the period study.

According to our findings of TDS, it is proved that no apparent dam effect and no significantdifferences P>0.05 are detected by statistical analysis(Fig. 9 and Table 1).

All the water sources are usually categorized as freshwater (TDS < 1000 ppm), based on the classification system of Pradhan and Pirasteh [39]. Or, it is known as brackish (1000–10.000 ppm) water. Whereas, with extremely high TDS (12.000 ppm), it is known as salty water, almost identical to seawater. So, Euphrates River classified as fresh water because of its TDS values were less than 1000 ppm which ranged from 340 ppm to 690 ppm .

Figure 10 and Table 1 show total suspended solid (TSS) values.The results showed that, at site 1 upstream of the dam, the TSS value differed from the lower value of 1 mg / L in May, while 52 mg / L was the highest value recorded in June. While TSS values at the Hindiya Dam site ranged from 3 mg / L to 65 mg / L, the lowest value was recorded in February, whereas in July the highest value was recorded. The values at site 3 downstream of the dam increased and then at sites 4 and 5 decreased. Thevalues of sites Dam downstream ranged from 2 mg / L at site 4 in May to 56 mg / L at site 4 in May. Statistical study of the difference between sites showed that there was no significant difference between sites 2 and 4 P ≥ 0.05, which showed significant differences with other sites(Table 1).

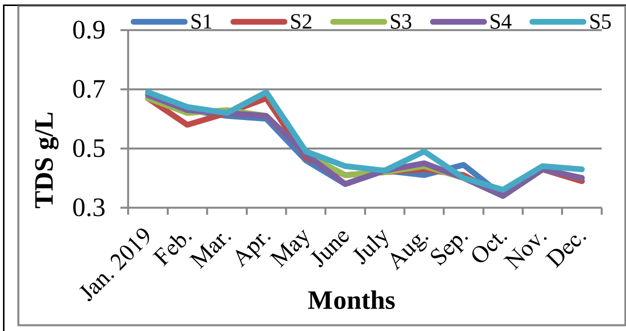

Figure 9. Variation of total dissolved solids value during the period study.

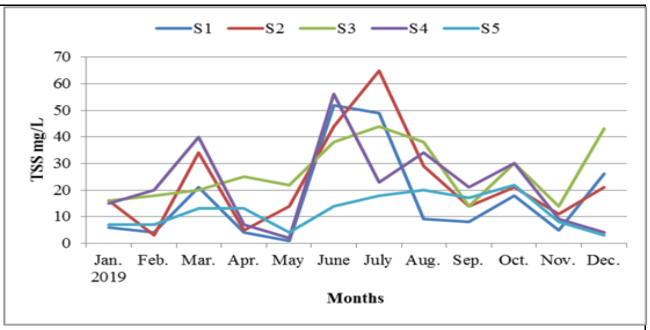

Figure 10. Variation of the total suspended solids values during the period study.

The result of this study indicates that the dam affected on water TSS values especially on site3 (downstream the dam) by causing increasing TSS values after opening the dam spillways, This contributed to the release of sediments found in the lower reservoir layer [32]. Or, owing to the higher velocity currents at site 3 resulted from opening the dam spillways [33]. It can be said that both causes mentioned to higher TSS values at sit 3 downstream the dam contributed in increase TSS values at site 3.USEPA [40] divided water into three classes based on the TSS value: less than 20 mg / L as low turbidity water, between 20 and 80 mg/L as moderate turbid, and more than 150 mg / L as turbid water. So, water quality of Euphrates River ranged from clear to turbid in study area.

Figure 11 and Table 1 show the values of total alkalinityvalues at site 1 (upstream of the dam), the total alkalinity values ranged from 152 mg / L in January to 237.8 mg / L in October. At Hindiya Dam site, the values raised slightly, the maximum value of total alkalinitywas 244 mg/L which reported in October. Whereas, the minimum value was 158.6 mg/L as reported in March. Total alkalinity levels at sites downstream of the dam decreased relative to the site of the dam, ranging from 152.5 mg /L at site 4 in March to 244 mg/L at site 3 (December), site 4 (April and October) and site 5 (March).

Figure 12 and Table 1 show the values of bicarbonates at site 1(upstream of the dam), which ranged from 90 mg/L in February to 170 mg/L in May, July and October. Bicarbonates were slightly raised at the Hindiya Dam site, with a maximum bicarbonate concentration of 190 mg/L recorded in May. In comparison, the minimum concentration recorded in February was 115 mg/L. The bicarbonate average values at sites downstream of the dam were especially high in site 4, the lower value was in February, varying from 112 mg/L to 220 mg/L, while the highest value was in May, and both values were on site 3 .

No significant differences in total alkalinity and bicarbonate P > 0.05 have been identified. among sites (Table 1).

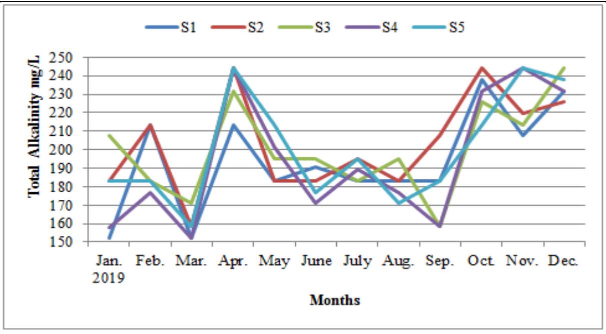

Figure 11. Variation of the total alkalinity values during the period study.

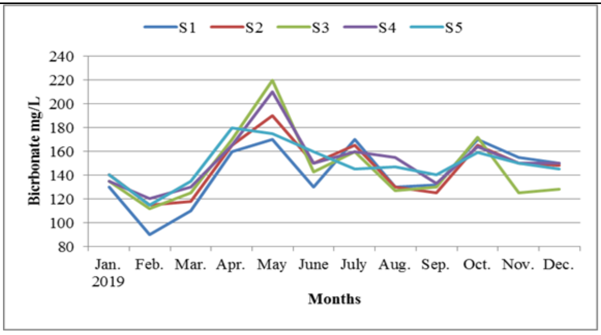

Figure 12. Variationof bicarbonate values during the period study.

It can be seen from the Figure above that the dam affected water alkalinity and bicarbonate values especially on Hindiya Dam site which caused increasing the values in this site compared with other sites might be related with lack of macrophytes in reservoir led to increasing CO_2 concentrations that have also been converted to bicarbonates after dissolution in water have contributed to higher bicarbonate concentrations [41]. Exception site 4 had the maximum values of bicarbonate only may owing to its location within the city could be because of sewage and waste water released at this site contributed to a rise in bicarbonate concentrations to higher values compared with other sites[35]. The current study showed that alkalinity values were over the normal limits allowed by Iraqi and international standard water, which were 20-200 mg / L $CaCO_3$[23]. Also, it was observed that Iraqi waters had alkalinity characteristics because of presence carbonate salts [42].

Figure 13 and Table 1 show the dissolved oxygen concentrations for surface water in study area of Euphrates River. At site 1 (upstream of the dam), the value of dissolved oxygen ranged from 7.2 mg/L in October to 12 mg/L in May, while the value of dissolved oxygen decreased at the site near Hindiya Dam compared with the site1 which its highest value recorded during January was 12.5 mg / L, and the lowest value recorded in July and August was 6 mg / L. However, values of sites downstream of the dam decreased at site 3 relative to the dam site, while these values were steadily increased until they were approximately equal to site1, with values ranging from 5 mg / L at site 3 in July to 12 mg / L at site 5 which reported in February and March.

Whereas, Fig.14 and Table 1 show that the percent oxygen saturated (%) values for the surface water of the study area. The percentage of oxygen saturated (%) on site 1 (upstream of the dam) ranged from 84.56 % in December to 147.7 % in May, While the highest percentage of saturated oxygen (%) on site near Hindiya Dam in June was 142.66 %, and in July the lowest value was 79.26 % . The percent saturated oxygen (%) values at the site near Hindiya Dam were lower compared to site 1. Sites below the dam, however, showed values ranging from 66.05 % at site 3 in July to 163.7% at site 5 in June. For DO and P.O.S., no significant differences were shown by statistical analysis during the study period recorded between sites P > 0.05 (Table 1).

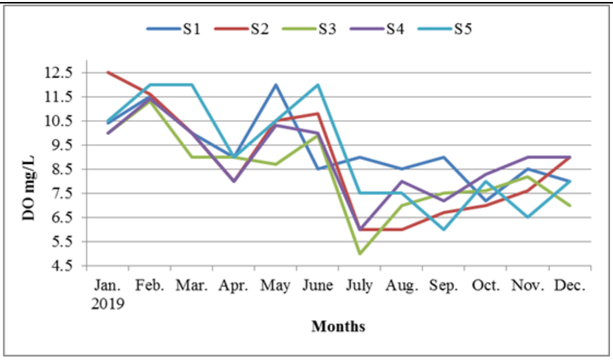

Figure 13. Variation of dissolved oxygen value during the of period study.

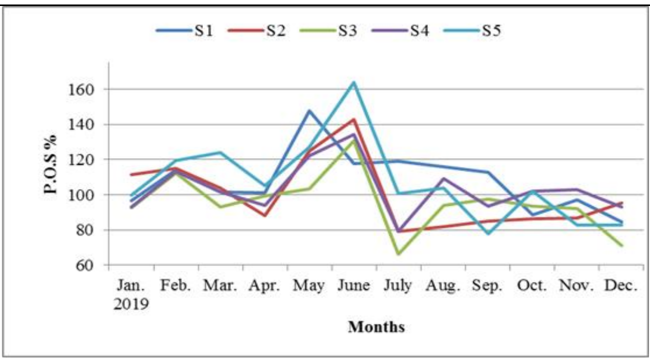

Figure 14 .Variation ofthepercentage of oxygen saturation value during the period study.

it was proved that the dam affected on water DO and P.O.S. level especially on site 3 (below the dam), which was recorded with depletion DO and P.O.S. could be due to reservoir bottom through release hypolemintic layer with depletion dissolved oxygen and P.O.S. typically by opening dam spillways into site 3 [43].

Figure 15 and Table 1 show the results of biological oxygen demand. The total amount of demand for biological oxygen was from 1.5 to 7 mg / L at site 1 (upstream of the dam). The lower number was in November and December, while in July and September it was higher. At site near Hindiya Dam, biological oxygen demand values were declined slightly, The values were in the range of 2 to 8.9 mg/L. The lower value was in May, while the maximum value was in February and March. BOD_5 ranged from 0.5 to 8.8 mg/L at sites downstream from the dam. The statistical analysis showed that there was no significant difference between biological oxygen demand sites of $P > 0.05$ (Table 1).

Odum [44] divided the water into two types based on BOD_5 as BOD_5 = 2 clean, BOD5 = 5 or more was doubtful in its cleanliness. Therefore, Euphrates River was doubtful in its cleanliness.
Our findings showed that no apparent dam effect on BOD_5 levels at Euphrates River during 2019.

Figure 16 and Table 1 show the values of total hardness of the water of River Euphrates in the study area. The total hardness of the site (upstream of the dam) was found to range from 280 to 575 mg / L. In June 2019, the lowest value was, while in March 2019, the higher value was. Total hardness values ranged from 336 to 552 mg / L at the site near Hindiya Dam. The lowest value was in October, while during the month of January the higher value was. Hardness levels ranged from 308 mg / L at site 3 in June to 568 mg / L at site 4 in February at sites downstream the dam.

It was shown by statistical analysis that no significant difference among sites $P > 0.05$(Table 1).

Our findings proved that dam had a clear effect by raising in total hardness at Euphrates River on Hindiya Dam site, may be owing to the limestone substrate composed of Hindiya storage water[45]. USEPA [46] classified water into four forms based on total hardness as non- hard water with $CaCO_3$ concentrations less than 50 mg/L, water has range from50-100 mg/L, have been classified as moderate hard water, values between 100- 200 mg/L classified as hard water and more than 200mg/L classified as very hard water. So it can consider Euphrates River as very hard water according to total hardness values in the present study.

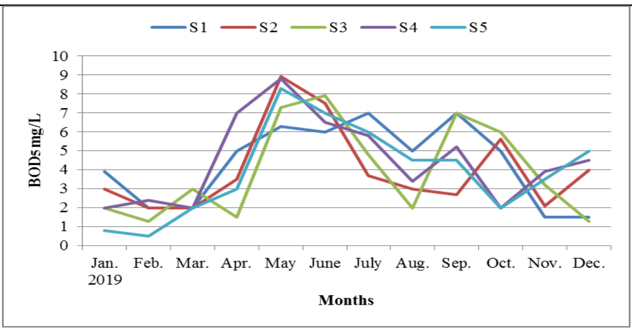

Figure 15. Variation of the biological oxygen demand value during the period study.

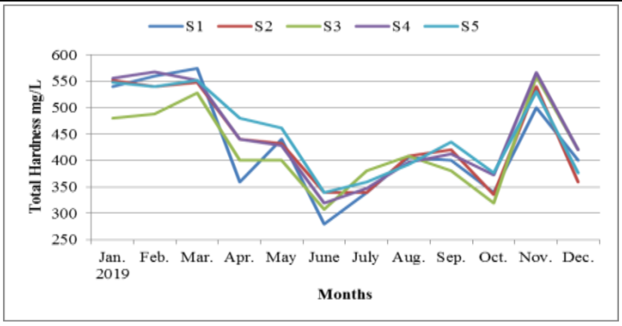

Figure 16. Variation of the totalhardness values during the period study.

Figure 17 and Table 1 showedthecalcium values ranged from 88.17 mg/L to 180.3 mg/L at site 1 upstream of the dam between June and March 2019, it was reported. On the other hand, at the Hindiya Dam site, lower values were reported than at site 1, ranging from 64.12 to 160.32 mg/L in October and November 2019, respectively. Calcium hardness levels were greater at sites downstream of the dam than at Hindiya Dam sites, ranging from 86.16 to 192.38 mg/L at sites 4 in December and November respectively. The statistical analysis showed that there was no significant difference P>0.05 among sites for calcium ions (Table 1). Hindiya Dam site had the lowest average of calcium ions compared with other sites as showed in Table 1. This could be either due to co-precipitation of phosphorous with $CaCO_3$ which was important in moderating the productivity of deep impoundments with smaller littoral zones. Or owing to very hard water in reservoirs and lakes drive to precipitation process of calcium carbonates and some nutrients which led to decrease calcium ions values in water of reservoirs and lakes [47].

While, site 4 had the highest average of calcium ionscompared with other site values, which could be associated with increased discharge of city sewage effluents containing large concentrations of calcium salts [35]. In this study, the calcium values were within the acceptable limits in natural waters of 200 mg / L [48].

Figure 18 and Table 1 show magnesium values during the study period. It was reported that the values ranged from 12.02 to 62.81 mg / L at site 1 (upstream of the dam)during September and June 2019, respectively. On the other hand, Hindiya Dam site values ranging from 14.46 to 58.39 mg / L were recorded, the findings suggested that the lower values were in September, while the higher values were in February 2019. The magnesium hardness values were lower at sites downstream of the dam than the dam site ranging from 10.07 to 58.39 mg/L at sites 5 in August and February 2019, respectively. Statistical analysis found that there was no significant difference between all P > 0.05 sites except site 3 (Table 1).

It was proved that the dam affected site 3 downstream the dam which caused decreasing values of magnesium concentrations which may be related to the presence of sulphates in this site, after the discharge of water from the reservoirbottom via the opening of dam spillways [49], which resulted in the reaction of sulphur compounds with magnesium and magnesium precipitation and reduced their values in the water column in Hindiya Dam reservoir [50]. While, the higher average of magnesium concentrations was on site 1 (upstream the dam) might be related to this site received wastewater from a local wastewater sources [51]. In this study, the magnesium values were within acceptable limits in natural waters of 150 mg/L [48].

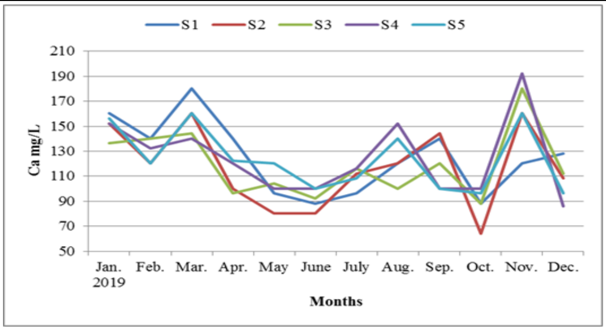

Figure 17.Variation of the calcium value during the period study.

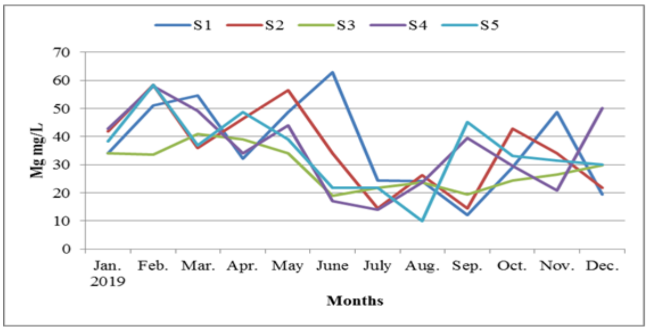

Figure 18 .Variation of magnesium value during the period study.

Figure 19 and Table 1 show sulphate values during the study period. It is shown that during October and August 2019, the values ranged from 40 to 200 mg/L at site 1 (upstream of the dam), respectively. On the other hand, the recorded values at site near Hindiya Dam were from 50 to 200 mg/L, the lower values were recorded in October, while the higher values were recorded in January. The amount of sulphate at sites downstream of the dam was lower with values varying from 70 to 250 mg/L at sites near Hindiya Dam. The lowest values were in June at sites 3 and 5, while the higher values were in January at sites 3 and 4. No significant variations were demonstrated through statistical analysis. among sites 2 and 3 P > 0.05, while, 1,5 and 3.4 which appeared significant difference with site 2 P ≤ 0.05 (Table 1).

Our finding provides that Hindiya Dam site had a lower sulphate average compared with other sites as showed in Table 1 might be due to change hydrological condition from lotic water to lentic water into reservoir, this led to precipitation of sulphate ions into bottom [52].

Whereas site 4 had a higher average of sulphate compared with other sites as a consequence of discharges of sewage effluents from the city [33]as well as may be due to the chemical nature of the groundwater. This is more abundant in the southern regions of Iraq which led to leaching sulphate ions to river water [53].

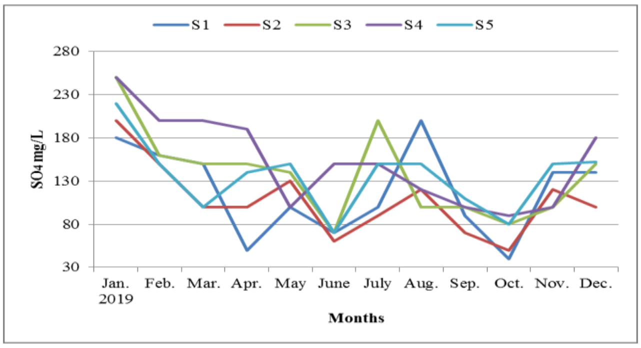

Figure 19.Variation of sulphate value during the period study.

Figure 20 and Table 1 show nitrate values during the study period . It showed that, between June and February 2019, the values ranged from 0.17 to 3 mg / L at site 1 upstream of the dam. On the other hand, on site near Hindiya Dam, the values of this parameter were reported ranging from 0.12 to 3 mg / L, the results suggested that the lower values were in August, whereas the higher values were in February and the values were higher compared to site 1. The amount of nitrate at sites downstream of the dam increased slightly, ranging from 0.1 to 3.61 mg / L. The lower values were in August at sites 5, while the higher value was in February at sites 3. Statistical analysis revealed that there was no significant difference between sites $P > 0.05$ (Table 1).

It was noted that the dam affected by increase the values of this parameter in site 3 (downstream the dam) (Table1) which might be due to the impound of river by the dam caused increment of diversity and soil microbial biomass on this site thus increasing nutrient concentrations especially nitrate ions [54]. Also, Hindiya Dam site had high average could be due to nitrate-rich reservoir bottom, formed by decomposition processes of organic matter in the hypolimnetic layer [49]. However, by reviewing nitrate values, it was found lower values than permissible limit for purpose of aquatic life 48.2 mg/L [36].

Figure 21 and Table 1 show phosphatevalues during the period studied.It has been shown that, during April and March 2019, the values ranged from 0.01 mg/L to 0.046 mg/L at site 1 upstream of the dam. On the other hand, the values ranged from 0.006 to 0.047 mg/L at site 2. The lowest values were in July, while those in October were higher. The amount of phosphate at sites downstream of the dam was increased slightly at site 3, then decreased from 0.004 to 0.11 mg/L at the last two sites 4 and 5. The lower values were in August at site 3, while the higher value was in November at the same site. It was reported by statistical analysis that there was no significant difference $P > 0.05$ among sites 1, 4 and sites 2, 5 that had significant differences $P \leq 0.05$ with other sites (Table 1).

It was found that the lower phosphate average was in reservoir zone on site 2 compared with most sites as showed in Table 1 owing to an increment of precipitation processes which decreased nutrient concentrations [52]. While, the high average was recorded on site 3 compared with other sites might be due to that this site was under dam impact by influxes of hypolimentic layer during opening of spillways of the dam. This layer was rich with phosphate that came from decomposition processes of organics and phytoplankton damage [49]. Our findings agreed with researcher such as Ling *et al.*[49]when investigated Bakun Dam in Malaysia. Also, Adesakin *et al.*[55]when they investigated Opa Reservoir in Nigeria. While, it was recorded the lowest average on site 5 compared with other sites could be due to it is far from sources of anthropogenic activities especially sewage effluents [33].

The permissible range of phosphate concentration in surface water according to Water Watch [56]is from 0.005 to 0.02 mg / L. So according to the recorded values of phosphate that water of Euphrates River was far from permissible range.

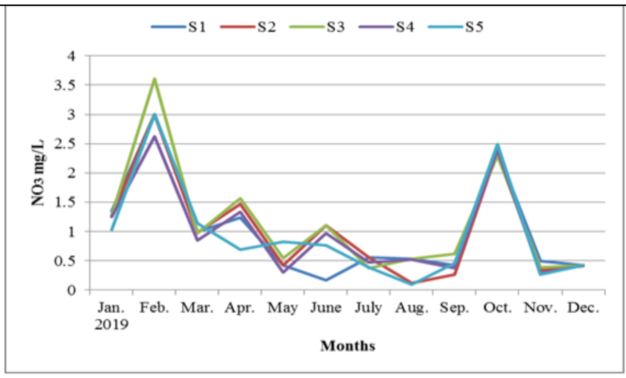

Figure 20.Variation of nitrate values during the period study.

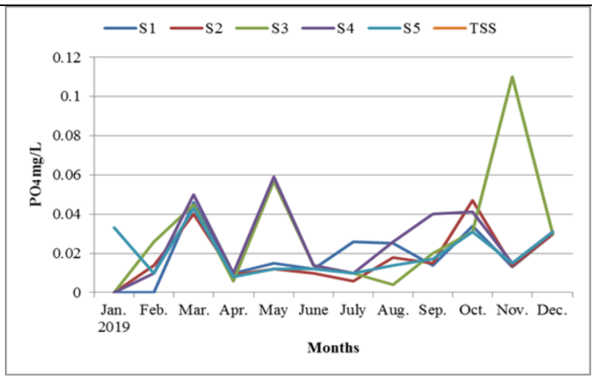

Figure21.Variation ofphosphatevaluesduringtheperiod study.

Table 1. Minimum and maximum (First Line), mean and standard error (Second Line), for physical and chemical characteristics at study sites during the period study.

Site Parameters	1	2	3	4	5	LSD value
Air Temp. ˚C	12.5-39.7 25.33±2.247	12.8-40.3 25.858±2.292	14-39.4 26.933±2.324	15.8-43.7 28.725±2.514	14.1-47.8 30.25±2.976	5.298 NS
Water Temp. ˚C	12.5-32.6 23.1±1.936	12.2-31.6 22.766±1.887	12.4-31.3 22.666±1.876	12.5-32 23.175±1.948	13.5-32.6 24.058±1.980	2.371 NS
Turbidity NTU	3.84-31.25 12.408±2.85 b	1.58-33.31 13.32±2.857 b	11.59-45.71 26.574±3.281 a	4.87-37.31 16.947±2.68 b	4.34-18.56 10.16±1.30b	6.832 *
EC µS/cm	690- 1320 964.16±63.22	680-1340 964.16±63.36	680-1350 977.5±65.04	690-1360 978.33±66.662	730-1380 1010.83±65.66	137.62 NS
Salinity ‰	0.44-0.844 0.6133±0.04	0.44-0.86 0.6155±0.04	0.43-0.864 0.622±0.041	0.44-0.87 0.624±0.042	0.46-0.883 0.646±0.041	0.209 NS
pH	7.01-8.18 7.508±0.121	7-8.08 7.527±0.121	7.1-8.17 7.632±0.103	7.01-8.07 7.556±0.104	7.01-8.2 7.565±0.114	0.483 NS
TDS g/L	0.34-0.67 0.482±0.032	0.34-0.67 0.486±0.033	0.34-0.67 0.487±0.032	0.34-0.68 0.487±0.033	0.36-0.69 0.509±0.034	0.179 NS
TSS	1-52 16.916±5.038bc	3-65 23.08±5.11 ab	14-44 26.83±3.27 a	2-56 21.75±4.65 ab	3-22 12.166±1.829 c	7.631 *
Total Alkalinity	152-237.8 194.275±7.914	158.6-244 203.333±7.742	158.6-244 200.283±7.312	152.5-244 194.65±10.044	158.6-244 200.283±8.555	18.94 NS
$HCO_3^=$ mg/ L	90-170 141.416±7.367	115-190 146.75±6.47	112-220 145.5833±8.717	120-210 151.833±6.696	115-180 149.25±5.081	12.50 NS
DO mg/ L	7.2-12 9.3±0.409	6-12.5 8.808±0.647	5-11.3 8.35±0.484	6-11.4 8.933±0.436	6-12 9.125±0.634	1.249 NS
The Percentage of Oxygen Saturation (P.O.S) %	84.56-147.7 108.08±4.908	79.26-142.66 100.023±5.715	66.05-130.72 95.45±4.842	79.26-134.2 103.191±4.284	77.92-163.7 107.44±6.852	14.663 NS
BOD_5 mg/ L	1.5-7 4.35±0.611	2-8.9 4.0±0.642	1.3-7.9 3.941±0.729	2-8.8 4.458±0.649	0.5-8.3 3.925±0.699	0.941 NS
Ca^{+2} mg/L	88.17-180.3 124.909±8.454	64.12-160.32 116.89±9.397	88.16-180.36 119.23±7.77	86.16-192.38 124.40±8.87	96.19-160.32 123.41±7.23	17.521 NS
Mg^{+2} mg/ L	12.02-62.81 36.75±4.603 a	14.46-58.39 35.554±4.205 a	18.91-40.8 28.81±2.148 b	14-57.89 35.175±4.112a	10.07-58.39 34.576±3.77 a	4.771 *
$SO4^{-2}$ mg/ L	40-200 118.33±14.76bc	50-200 107.5±11.87 c	70-250 137.5±14.981 a	90-250 152.5±14.93 a	70-220 135.16±11.6 ab	17.305 *
NO_3^{-2} mg/L	0.17-3 0.997±0.252	0.12-3 1.027±0.258	0.382-3.61 1.145±0.279	0.288-2.62 0.982±0.229	0.1-3 0.964±0.257	0.348 NS
PO_4^{-2} mg/L	0.01-0.046 0.0225±0.003Ab	0.006-0.047 0.019±0.004 b	0.004-0.11 0.032±0.008a	0.01-0.059 0.027±0.005ab	0.008-0.043 0.018±0.003b	0.012 *

NS: no significant difference when total letters are similar (P> 0.05). *: significant difference when some letters are different (P < 0.05) . **: highly significant difference when some letters are different (P < 0.01) .

Conclusion:

It can be concluded that the Euphrates River is very hard, oligohaline, slightly alkaline, well ventilated and clear to turbid. In addition, the turbidity and TSS values exceeded permissible limits of water quality for aquatic life in most samples especially in site below the dam. However, the river was considered by BOD_5 to be doubtful in its cleanliness water. Calcium, magnesium, nitrate and phosphate values in this study were within permissible limits

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in Ministry of Science & Technology.

Authors' contributionsstatement:

This work was carried out in collaboration between all authors. 'Idrees A. A. Al-Bahathy' performed the statistical analysis and wrote the first draft of the manuscript. 'Muhanned R. Nashaat' designed the study, wrote the protocol and managed the analyses of the study. 'Muhanned R. Nashaat' managed the literature review. 'Idrees A. A. Al-Bahathyand Muhanned R. Nashaat' collected the samples and analyzed all parameters. All authors read and approved the final manuscript.

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تأثيـر ســــدة الهنديــة في الملامـح اللمنولوجيـــة لنـهر الفرات شمــال محافظة بابـل،العـــــراق

مهـــــــــند رمـــــــزي نشــــــــأت[1] **أدريـــس علي عبـــد الخـضر البحـــاثي[2]**

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الخلاصة :

تم اختيار خمسة مواقع في شمال محافظة بابل لمعرفة الخصائص الفيزيائية والكيميائية لنهر الفرات وتأثير سد الهندية عليها خلال عام 2019.اذيقع المواقع الثاني بالقرب من السد لتعكس السمات البيئية له، في حين أن المواقع الأخرى، S1 يقع عند اعلى السد كموقع مرجعي.علاوة على ذلك، تم تحديد الموقعين الآخرين S3 وS4 تحت تأثير السد. أظهرت نتائج الدراسة وجود علاقة قوية بين درجة حرارة الهواء والماء في جميع المواقع. كما توجد فروق ذات دلالة إحصائية في متوسط ثلاثة عشر من أصل ثمانية عشر خاصية، أذ انخفضت درجة حرارة الماء والقاعدية الكلية والبيكربونات والأوكسجين المذاب ونسبة الاشباع بالأوكسجين والعسرة الكلية والمغنيسيوم من 22.76°م و203.33 ملغم/لتر و146.75 ملغم/ لتر و8.8 ملغم/لتر و100.023٪، 438ملغم/لتر و35.55ملغم/لتر على التوالي في موقع S2 إلى 22.66°م و200.28ملغم/لتر و145.58 ملغم/ لتر و8.35 ملغم/لتر و95.45٪ و 422.66 ملغم/لتر و28.81 ملغم/لتر على التوالي في الموقع أسفل السد. ينما زادت قيم كل من الكدرة وTSS وCa^{+2} و$SO2^{+4}$ و$NO3^{-2}$ وPO_4^{-2} من 13.32 NTU و23.08 ملغم/ لتر و116.89ملغم/لتر و107.5ملغم/لتر و1.027 ملغم/لتر و0.019 ملغم/لتر، على التوالي في موقع S2 إلى NTU26.574 و 26.83 ملغم/لتر و 119.23 ملغم/ لتر و 137.5 ملغم/لتر و1.145 ملغم/لتر و0.032 ملغم/لتر على التوالي في الموقع أسفل السد. ومع ذلك، لم يسجل أي تأثير واضح للسد في EC وS وTDS وpHعند نهر الفرات. كما ولم تظهر فروق ذات دلالة إحصائية في جميع الخصائص بين المواقع باستثناء االعـكورة وTSS وMg^{+2} وSO^{+4} وPO_4^{-2}. يمكن أن يعّد مياه نهر الفرات عسر وقليلة الملوحة وذو قاعدية خفيف وجيدة التهوية وغير عكر. بالإضافة إلى ذلك، تجاوزت قيم العكارة والمواد الصلبة الذائبة الحدود المسموح بها لنوعية المياه للحياة المائية في معظم العينات خاصة في الموقع أسفل السد. ومع ذلك، عَدّ النهر مشكوك فيه في نقاوته من خلال قيم BOD_5. كما كانت قيم الكالسيوم والمغنيسيوم والنترات والفوسفات في هذه الدراسة ضمن الحدود المسموح بها.

الكلمات المفتاحية: نهر الفرات، مياه عذبة، سدة الهندية، الحدود المسموح بها، المعايير الفيزيائية والكيميائية.