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The Effect of Tharthar-Tigris Canal on the Environmental Properties of the Tigris River Northern Baghdad, Iraq

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Abstract:

The present study is considered the first on this sector of the Tigris River after 2003. It is designed for two aims, the first is to demonstrate the seasonal variations in physicochemical parameters of Tharthar-Tigris Canal and Tigris River; the second is to explain the possible effects of canal on some environmental properties in the Tigris River. Water samples were being collected monthly. Six sampling sites were selected, two on Tharthar Canal and four along the Tigris River, one before the confluence as a control site and the others downstream the confluence with the canal. For a period from January to December 2020, nineteen physicochemical parameters were investigated including air and water temperature, turbidity, electrical conductivity, salinity dissolved oxygen, percent oxygen saturation, biological oxygen demand, pH, total hardness, calcium, magnesium, sulphate, total dissolved solids, total suspended solids, total alkalinity, bicarbonate, nitrate and phosphate. The results showed that air and water temperatures were close in both Tigris and canal. The waters were well aerated, slightly alkaline and over saturation was recorded several times, while biological oxygen demand values did not exceed 5 mg/L along study period. The high values of conductivity, salinity, total dissolved solids, total hardness, calcium and sulphate ions in Tharthar water increased in the Tigris River below the confluence. Whereas, the low values of turbidity, TSS, total alkalinity and bicarbonate in the arm diluted in the main river. It has been concluded that Tharthar Canal affected the Tigris River by either increasing or diluting of the Tigris chemical components.

Keywords: Physicochemical parameters, River confluence, Tharthar Lake, Tharthar-Tigris Canal, Tigris River.

Introduction:

Rivers are a major source of water. Although they involve just 0.006 percent of Earth's freshwater, rivers supply drinking water for numerous communities around the world. Water withdrawal from rivers is also used in industrial operations and for irrigation of farmland. Rivers afford opportunities for recreational activities and aesthetic enjoyment [1]. Physicochemical parameters of rivers have been greatly deteriorated due to anthropogenic and industrial activities[2]. Tharthar-Tigris Canal or "Dhira'a Dijla" is human-mediated river that obtains its characteristics from Tharthar Lake [3].

River channel confluences are sites of significant hydraulic and morphological change within fluvial networks. The local and downstream effects of confluences can have profound effects on the physical water parameters and aquatic animal structures [4, 5].The portion of the river system affected by merging of flows at a junction is defined as Confluence Hydrodynamic Zone (CHZ). Also, confluences play a crucial role in the health of lotic water system and regulate the dynamic of sediment downstream the joining point [6]. So, the present study is considered the first on this sector of the Tigris River after 2003. It is designed for two aims, to demonstrate the seasonal variations in physicochemical parameters of Tharthar-Tigris Canal and the Tigris River and to explain the possible effects of canal on some environmental properties in Tigris River.

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Materials and Methods:

Study area

Tharthar-Tigris Canal was constructed and began to operate in 1988. It is diverted from the left side of division regulator which is located on Tharthar-Euphrates Canal, then it continues to the east for 65 km until confluence with Tigris River northern of Baghdad City. It is designed to discharge water up to 600 m^3/s to the Tigris River directly [3,7].

Samples collection

The samples were being collected monthly from January to December 2020. Six sites were chosen, two on Tharthar Canal and four along the Tigris River (Fig.1). The first one is located along the main stream of the Tigris River about 2.4 km before the confluence of Tharthar Canal with Tigris River at 33°29'04.5"N latitude and 44°18'06.3"E longitude. This site was considered as a reference station known as upstream Confluence Hydrodynamic Zone (CHZ). The second site is located on Tharthar Canal above the entrance of Sabaa Al-Bour City at 33°28'27.2"N, 44°07'49.6"E about 20 km downstream the drop regulator on the Canal. The third site is located on Tharthar Canal before the entrance to the main street leading up Sabaa Al-Bour City (33°28'43.0"N and 44°14'06.9"E) about 7.5 km before the confluence of the canal with the Tigris. The fourth site is located on the Tigris River, about 300 meters from the joining of Tharthar Canal with the Tigris River, known as immediately downstream the Confluence Hydrodynamic Zone (CHZ) at 33°27'46.4"N and 44°18'10.3"E. The fifth site lies in the Tigris River near Al-Muthana Bridge area at 33°25'43.0"N, 44°20'39.4"E about 6 km below the confluence of Tharthar Canal with the Tigris River. The sixth site is located on the Tigris River near Al-Graia'at Floating Bridge in Al-Kadhimiya City (33°23'07.5"N, 44°20'15.1"E) about 12.6 km downstream the confluence of Tharthar Canal with the Tigris River.

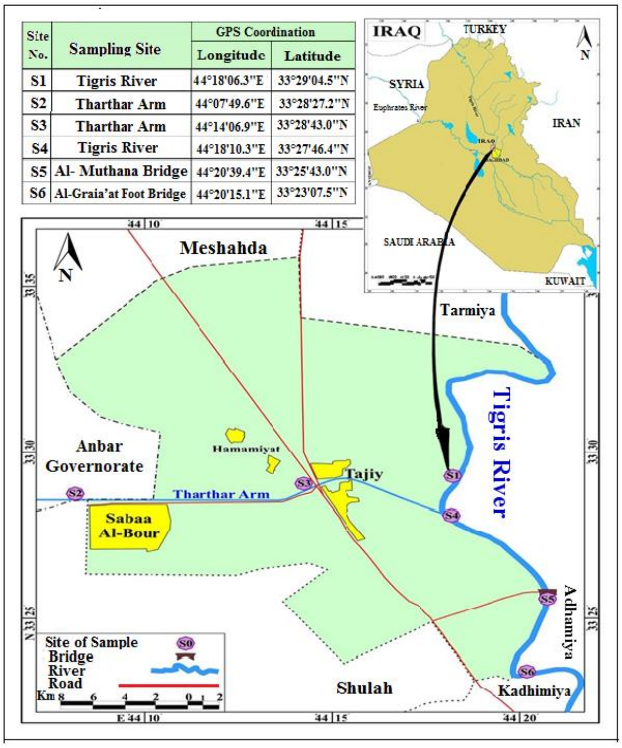

Figure 1. A map showing the study sites on Tigris River and Tharthar-Tigris Canal. Map Scale 1/10000.

The rates of water discharge ranged from 474 m^3/s in April to 681 m^3/s in July for the Tigris River. On the other hand, in Tharthar-Tigris Canal it ranged from 83 m^3/s in August to 250 m^3/s in January, as shown in Fig. 2. (The data obtained from Ministry of Water Resources, 2020. personal communication).

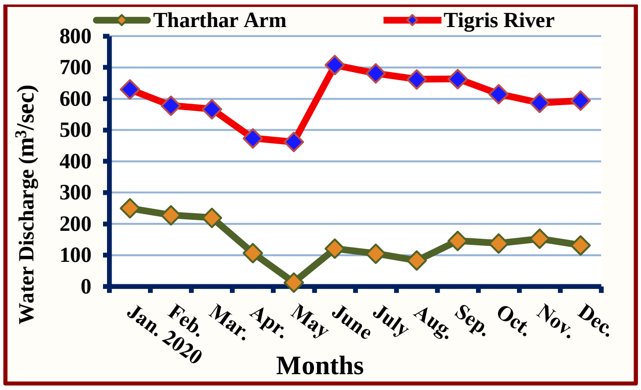

Figure 2. Seasonal variation of water discharges in Tigris River and Tharthar-Tigris Canal during the study period.

Sample measurements

All samples were taken near stream bank about 8-10 m from the shore line at depth 30-50 cm, taking into account not to take samples of stagnant water [8]. It was kept in a well stopped polyethylene bottle 1000 ml at 4°C in a refrigerator for the next day for analysis to minimize the changes in the

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composition due to bacteria. Some properties were conducted in the study site directly, such as air and water temperature, electrical conductivity, pH and total dissolved solids. Air temperature was measured in the shade by using digital air thermometer while, water temperature, electrical conductivity, salinity, total dissolved solid sand pH were measured by HANA (HI9811). Turbidity was measured by the turbidity meter Jenwaw company Model-6035. Dissolved oxygen and biological oxygen demand were measured by using Azide modification of Winkler titration method [8]. The percentage of oxygen saturation was calculated as reported in EPA [9]. Total suspended solids were measured according to the procedure stated by Spellman [8]. Total hardness, calcium and magnesium were measured according to standard methods [10]. Sulphate ion was made according to the procedure described by Brands and Tripke[11]. Reactive phosphate was measured by using the ascorbic acid method [8]. UV-Spectrophotometric Screening Method was used for the determination of nitrate as described in standard methods by Baird *et al*. [10]. Finally, sulfuric acid titration method were used for determining total alkalinity as described by Spellman [8].

Statistical analysis

The data were analysed by using one-way ANOVA, SPSS V.16. Duncan's multiple range tests were used to compare the means of the studied sites parameters to detect differences.

Results and Discussion:

The results showed that air temperatures fluctuated seasonally. The highest values were in summer, whereas, the lowest values were in winter (Fig. 3). This may be related to the Iraqi climate characterized by hot, dry in summers and cold, rainy in winters [12].

The statistical analysis for air temperature showed significant differences (P≤ 0.05) among the sites of the river and the canal. Whereas, no significant differences were manifested (P> 0.05) between site 2 and site 3 in Tharthar Canal (Table 1).

Moreover, the values of water temperatures increased in summer especially in July and decreased in winter as shown in Fig. 4.

The statistical analysis showed no significant differences (P> 0.05) in water temperatures between sites on Tigris River and that on the canal (Table 1).

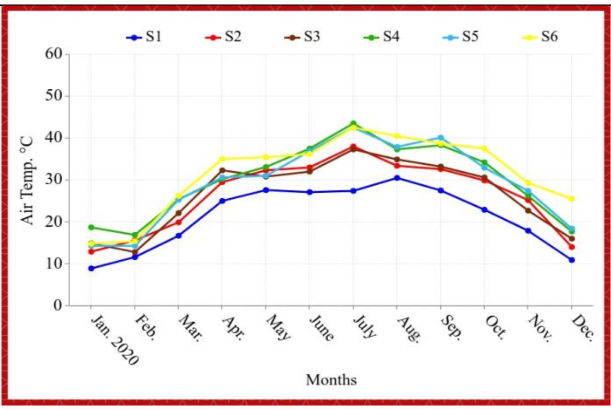

Figure 3. Variations of air temperature during the study period

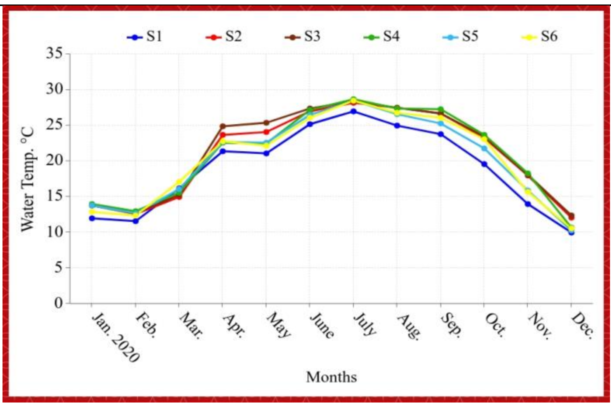

Figure 4. Variations of water temperature during the study period

The data of electrical conductivity and salinity content in Tharthar Canal and the Tigris River are represented in Table 1 and Figs. 5 and 6. At site 1 upstream CHZ, electrical conductivity and salinity ranged from 530-1110 µS/cm with salinity unite from 0.33-0.71‰ in August and March, respectively. Whereas in Tharthar Canal, they ranged from 660-2070 µS/cm with salinity unite from 0.42-1.3‰ in January and May, respectively. By contrast, the highest and lowest readings of electrical conductivity and salinity were recorded at site 4, they ranged from 660-1110 µS/cm with salinity unite from 0.42-070‰ in January and June, respectively. In addition, the values ranged from 620-970 µS/cm with salinity unite from 0.39-0.62‰ in August and July, respectively downstream CHZ.

Furthermore, the highest average values of electrical conductivity and salinity in the canal increased their values in the Tigris from 788.33 µS/cm, 0.504‰ in site 1 upstream CHZ to 942.5 µS/cm, 0.603‰ in site 4 at immediately downstream CHZ, respectively as shown in Table 1. High value of salinity in Tharthar Canal was related to the source of water, it receives water from Tharthar Lake characterized as brackish water, this fact was mentioned by Al-Ansari *et al*. [13].

For temporal variation, the highest values of electrical conductivity and salinity were recorded in spring season especially in May, in sites 2 and 3 on the canal (Figs. 5 and 6). This increase may be related to the decreasing of discharge rate, the average rate was 13 m^3/s recoded in May 2020 as shown in Fig. 2.

Our results are compatible with other previous confluences studies conducted on the Tigris River. Al-Saadi *et al.* [14] showed that the high values of conductivity in Al-Adaim River increased the conductivity of the Tigris River from 427 µS/cm before the confluence to 498 µS/cm after the confluence. Ramadhan *et al.* [15] found that high values of conductivity in Tharthar canal increased the conductivity of Tigris River downstream the confluence zone. Also, Nashaat *et al.* [16] showed that high values of conductivity and salinity in Diyala River increased their values in the Tigris River below the confluence of two rivers.

According to Hanrahan [17] Tharthar Canal is considered as oligohaline water, whereas, the Tigris River is considered as freshwater, then turned to oligohaline water in site 4 at immediately downstream CHZ.

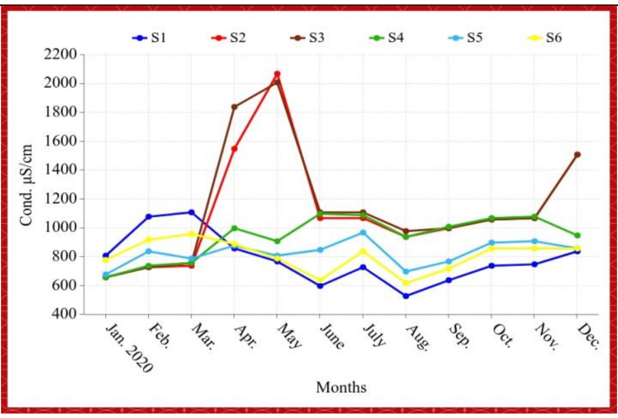

Figure 5. Variations of conductivity during the study period

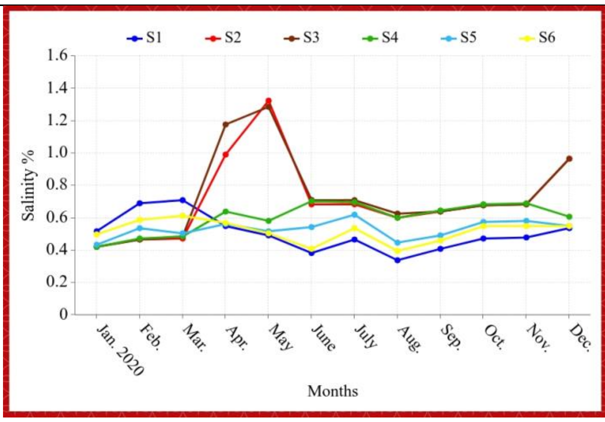

Figure 6. Variations of salinity during the study period

Table 1 and Fig. 7 show that turbidity values at site 1 upstream CHZ ranged from 8.16 to 131 NTU recorded in March and May, respectively. In the Tharthar Canal, they varied from 3.68 NTU in April to 22.33 NTU in July. Whereas, the minimum value was 10.9 NTU in November and the maximum values was 114 NTU in May in site 4 at immediately downstream CHZ. Also, it ranged from 11.73 - 137 NTU in February and May, respectively downstream CHZ. The statistical analysis indicates significant differences ($P \leq 0.05$) between the Tigris River and Tharthar Canal and no significant differences were found out ($P > 0.05$) between sites 2 and 3 on Tharthar Canal (Table1).

Seasonally, the values of turbidity in the Tigris River increased in spring season especially during May. While, they never changed in the two sites of the canal, during the four seasons of the year (Fig. 7). This case may be related to the differences in the amounts of discharged water of both rivers particularly in May (Fig. 2).

For spatial variation, the low mean values of turbidity in Thathar Canal (site 2 and 3) decreased the value of turbidity in the Tigris River from 34.75 NTU upstream the confluence to 28.65 NTU at immediately downstream CHZ. Then they increased gradually downstream away from the confluence (Table 1). This result corresponded with Kassim *et al.* [18] and Abdul Jabar *et al.*[19] who reported that low values of turbidity in Lower Zab Tributary reduced the turbidity of Tigris River downstream the confluence of two rivers. Nashaat *et al.* [16] showed that the low values of turbidity in Diyala River reduced the mean value of turbidity in the Tigris River from 45.44 NTU before the confluence to 43.18 NTU after the confluence. Also, Nashaat and Al-Bahathy[20] found that turbidity in the Euphrates River increased downstream Hindiya Dam relating that to the frequent fluxes from opening dam spillways which led to release sediments which were settled in the bottom layer of the dam.

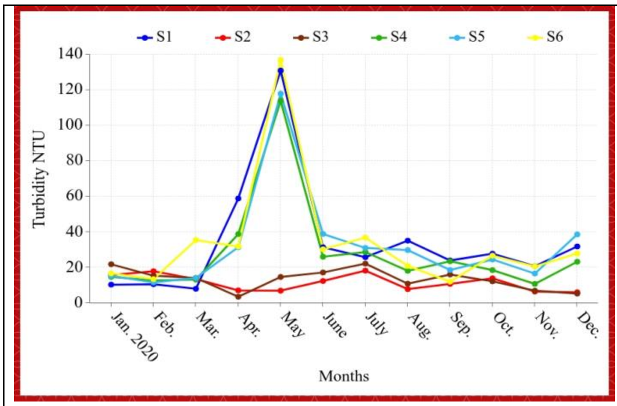

Figure 7. Variations of turbidity NTU values during the study period.

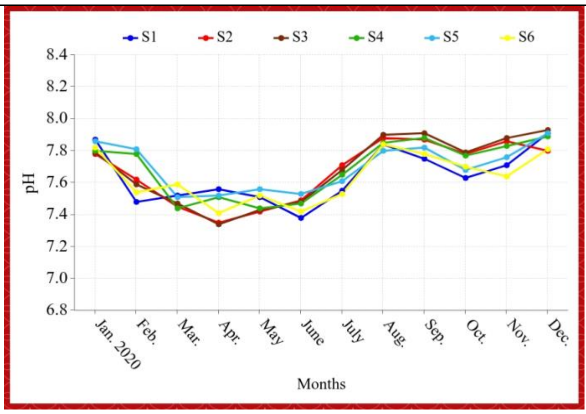

Figure 8. Variations of pH values during the study period.

The values of pH in Tharthar Canal and Tigris River were slightly alkaline (Fig. 8), and no significant differences (P> 0.05) were found among all studied sites (Table 1). The results of this study are parallel with the most previous studies conducted on the Tigris River such as Ramadhan *et al*. [15] and Alazawii[21]. Additionally, Hassan *et al*. [22] showed that pH values of Tharthar Canal and Tigris River within narrow range were slightly alkaline.

Our results showed that waters in both Tharthar Canal and Tigris River was well aerated and the values of DO didn't fall below 6.5 mg/L and oxygen saturation level above 100% was recorded many times in all study sites over the year (Table 1). The statistical analysis revealed no significant differences (P> 0.05) among all sites for DO and POS (Table 1).

Seasonal variations in DO and POS values are recorded in Figs. 9 and 10. The minimum values of DO were recorded in summer season and the maximum were in winter season. In addition, the minimum values of POS were recorded during summer at all sites on Tigris River, conversely associated with the two sites on the Canal. This is mainly due to the inverse relationship that exists between dissolved oxygen and temperature. Cold water holds more dissolved oxygen than warm water because colder water molecules are less active. This inhibits dissolved oxygen ions. These results are supported by other previous local studies [23, 24]. Based on Pennington and Cech[25] DO level in the present study was within the permissible limit as mentioned above.

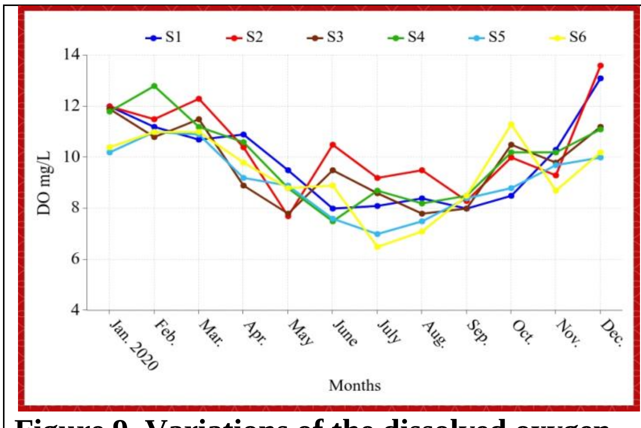

Figure 9. Variations of the dissolved oxygen value during the study period.

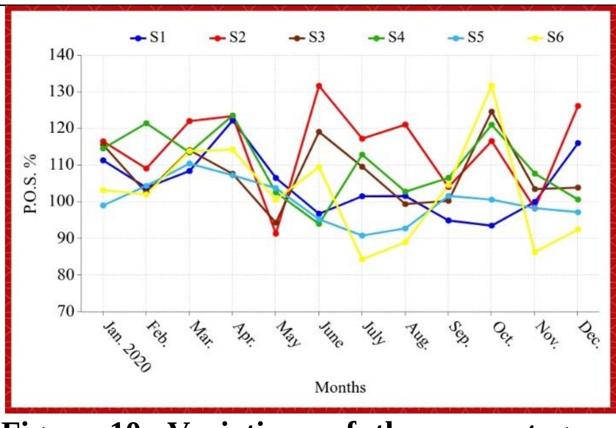

Figure 10. Variations of the percentage of oxygen saturation value during the study period.

Fig. 11 and Table 1 shows the results of BOD_5 at site 1 upstream CHZ ranged from 1.4 mg/L in August to 3.6 mg/L in December. On the Canal, the lowest value was 0.9 mg/L in November and the highest value was 3.5 mg/L in February. Whereas, the minimum amount was 1.5 mg/L in August and the maximum was 3.6 mg/L in February at site 4 immediately downstream CHZ. While, the minimum amount was 0.9 mg/L in August and the maximum was 4.3 mg/L in February downstream CHZ.

The statistical analysis of BOD_5 showed no significant difference among all studied sites (P> 0.05) and the mean values for all sites were equal which was recorded 2 mg/L (Table 1).

According to Li and Liu [26] the values of BOD_5were doubtful in its cleanliness and did not exceed 5 mg/L along study period.

Seasonally, in the Tigris River the maximum and minimum values of BOD_5 were in winter and summer. Whereas, on the Canal, the maximum and minimum values were in spring and autumn seasons, respectively. This may be associated with the raising of water temperature in spring leading to increased biodegradable of organic matter. These results agree with other previous studies conducted on the same river[16, 27, 28]

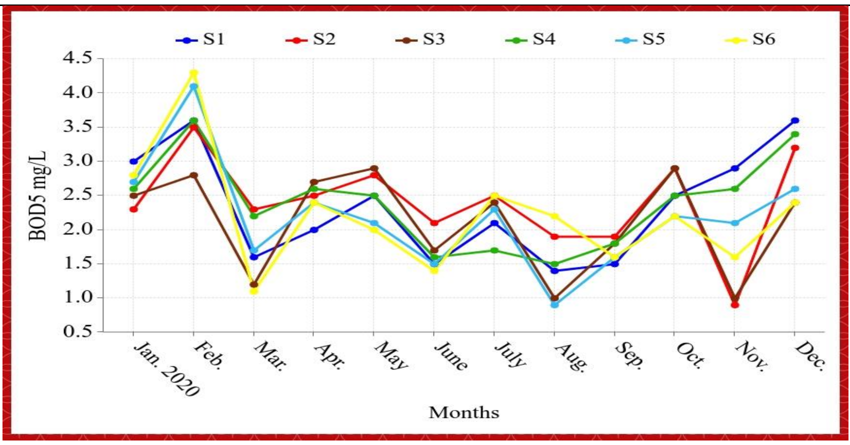

Figure 11. Variations of the biological oxygen demand value during the study period

The values of total hardness and calcium hardness in both Tharthar Canal and Tigris River are represented in Table 1 and Figs. 12 and 13. At site1 upstream CHZ they ranged from 284 and 68.13 mg/L to 440 and 124.25 mg/L, respectively. On the Canal, they ranged from 288 and 93.12 mg/L to 960 and 228.45 mg/L, respectively. Whereas, in site 4 at immediately downstream CHZ they ranged from 300 and 72.144 to 556 and 176.35 mg/L, respectively while, they ranged from 288 and 60.12 mg/L to 460 and 148.296 mg/L downstream CHZ.

The statistical analysis for total hardness and calcium hardness indicates significant differences (P≤ 0.05) between the two rivers and no significant differences (P> 0.05) between the two sites on Tharthar Canal (Table 1).

Also, the results showed that the high mean values of total hardness and calcium hardness in Tharthar Canal increased their values in Tigris River from 354 and 86.52 mg/L before the confluence to 431, 123.91 mg/L in site 4 at immediately downstream CHZ, then returned to the first state downstream away from the confluence zone as we recorded in sites 5 and 6 (Table 1).The highest levels of total hardness and calcium ion in Tharthar Canal water comes from chemical weathering of sedimentary rocks in Tharthar Lake containing this ion such as marl, limestone and gypsum [3].

According to Spellman [8]Tharthar Canal water is considered very hard water above 300 mg/L. While, the Tigris River water ranged from hard to very hard water. The real cause of hardness in the Tigris River is the nature of catchments area through which the Tigris River flows [29].

These results are in line with several previous confluences studies conducted on the Tigris River. Al-Saadi *et al*. [14]observed that high values of total hardness in Al-Adaim River increased the hardness of Tigris River from 345 mg/L before confluence to 384 mg/L after confluence. Also, Al-Lami *et al*.[30] showed that the high value of hardness in the Tharthar Canal raised the hardness of the Tigris River. Furthermore, Nashaat *et al*. [16] found that Diyala Tributary increased the calcium values of Tigris River downstream the confluence of both rivers.

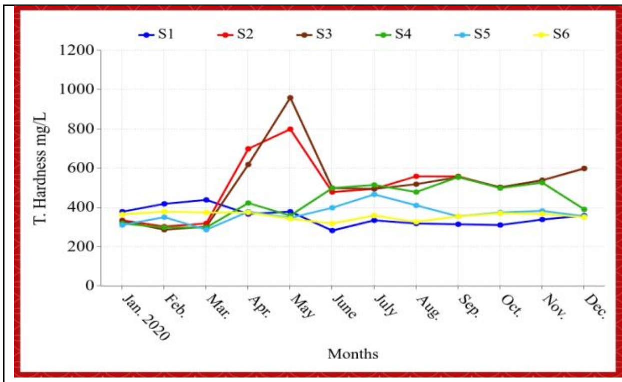

Figure 12. Variations of total hardness value during the study period

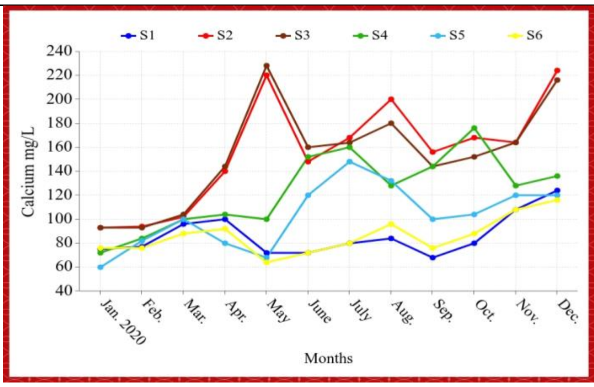

Figure 13. Variations of calcium value during the study period

Fig.14 and Table 1 show the values of magnesium hardness. In site 1 upstream CHZ, the values of magnesium hardness ranged from 12.01in December to 56.39 mg/L in November. In the Canal, the lowest value was 9.45 mg/L in December and the highest value was 129.18 mg/L in November. Whereas, the minimum and maximum values ranged from 12.04 to 50.45 mg/L in March and November, respectively in site 4 immediately downstream CHZ. While, it was ranged from 9.12 mg/L in March to 46.24 mg/L in February downstream CHZ.

The statistical analysis indicates significant differences ($P \leq 0.05$) between the river and the canal and no significant differences ($P > 0.05$) between the two sites in Tharthar Canal (Table 1).

For spatial variations, thehighest average value is recorded 40.34 mg/L in Tharhar Canal. While, the lowest average value recorded 26.68 mg/L at site 5 in Tigris River (Table 1). The highest level of Mg^{2+} in canal water can be attributed to the weathering of rocks, particularly magnesium-silicate [3].

For temporal variation, magnesium ion values in both river and canal decreased in summer. Whereas, increased in spring and autumn in the canal (Fig. 14). This may be related to differences in rate of discharge, volume of water and geological and structure [30].Similar results were also obtained in other Iraqi inland water[16, 23].

Fig. 15 and Table 1 show sulphate values during the study period. At site 1 upstream CHZ, the values ranged from 10 mg/L in October to 50 mg/L in February. In the canal, the lowest value was 20 mg/L in March and July to 90 mg/L in August. Whereas, the minimum and maximum value of sulphate ranged from 30 in March and December to 60 mg/L in April, May and November in site 4 immediately downstream CHZ. While, it was ranged from 20 mg/L in January, March, July, August and October to 60 mg/L in November downstream CHZ.

The statistical analysis indicates significant differences ($P \leq 0.05$) between the two rivers and no significant difference ($P > 0.05$) between sites 5 and 6.

For spatial variations, the highest average value was in site 2 on the arm reached 59.16 mg/L. While, the lowest average value recorded 13.48 mg/L in site 1 on Tigris River before the confluence. This leads to increase the concentration of sulphate ions in site 4 downstream CHZ reached 45 mg/L (Table 1).

For seasonal variation, sulphate ions in Tharthar Arm water were more than this in the Tigris River during all the seasons of the year as explain in Fig. 15.The high values of sulphate in the canal water were attributed to gypsum nature of Tharthar Lake from which the canal takes its water [3]. Our results are parallel with Kassim *et al.* [18] who showed that high values of sulphate in Lower Zab increased the concentration of sulphate ions in Tigris River after the confluence of two rivers. Alao, Lamare and Singh [31] found that high value of sulphate ions in Lunar River increased their value in Lukha River from 163.25 mg/L before confluences to 1512.50 mg/L after the confluences of two rivers.

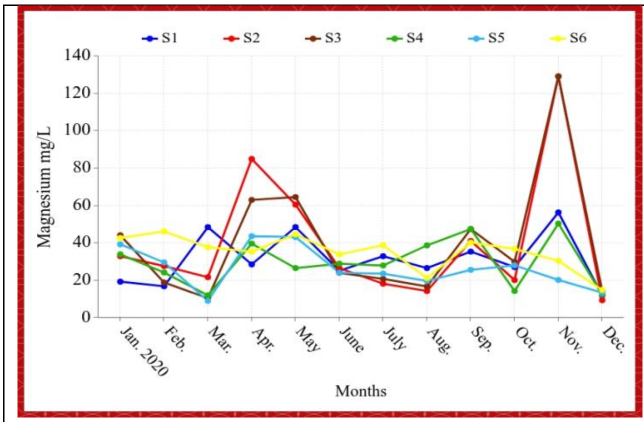

Figure 14. Variations of magnesium value during the study period.

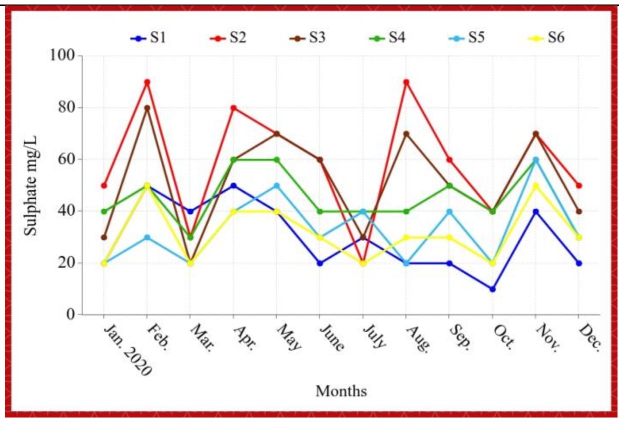

Figure 15. Variations of sulphate value during the study period.

The data of total dissolved solids are represented in Table 1 and Fig. 16. In site 1 upstream CHZ, the values of TDS ranged from 260 mg/L in August to 560 mg/L in March. On the Canal, the lowest value was 330 mg/L in January to 1400 mg/L in May. Whereas, the minimum and maximum value of TDS ranged from 330 to 560 mg/L in January and June, respectively in siet4 immediately downstream CHZ. While, it was ranged from 310 mg/L in August to 480 mg/L in July downstream CHZ. In addition, statistical analysis showed that no significant differences (P> 0.05) among all studied sites (Table 1).

For spatial variations, the highest mean value was in the canal. While, the lowest mean value was in site1. This lead to elevate the concentration of TDS in Tigris River from 395 mg/L upstream CHZ to 471mg/L in site 4 immediately downstream CHZ. This may be related to variations in topography, hydrology, geology, precipitation and local climate between the river and the canal [7,29].

For temporal variation, the highest values of TDS recorded in spring season especially in May on Tharthar Canal. This may be attributed to the decreasing in the rate of discharge (Fig. 2). These results are compatible with other previous confluences studies conducted on the same river [15, 16, 21].

As for TSS, in site 1 upstream CHZ, the values of TSS varied from 1 mg/L in February to 118 mg/L in May. On the Canal, the lowest value was 4 mg/L in April and the highest value was 29 mg/L in July. Whereas, the minimum and maximum value of TSS ranged from 2 to 102 mg/L in March and May, respectively in site 4 immediately downstream CHZ. While, it was ranged from 1 mg/L in February to 125 mg/L in May downstream CHZ (Fig. 17).

The statistical analysis indicates significant differences (P≤ 0.05) between both rivers. While, no significant differences were recorded (P> 0.05) between the two sites on the canal and among all sites on the Tigris River (Table 1).

For spatial variations, the highest mean value of TSS recorded in Tigris River upstream and downstream the confluence compared with sites 2 and 3 on the Canal. For this the mean value of TSS in Tigris River decreased from 34.25 mg/L in site 1 to 25.91 mg/L in site 4 at immediately downstream CHZ, due to the mixing of Tharthar water with Tigris (Table 1).

Seasonally, TSS concentration in Tigris River increased during spring season particularly in May. While, it never changed in the two sites of the Canal, during the four seasons of the year as shown in Fig. 17. This may be related to the differences in discharged water amounts for both rivers especially in May (Fig. 2).

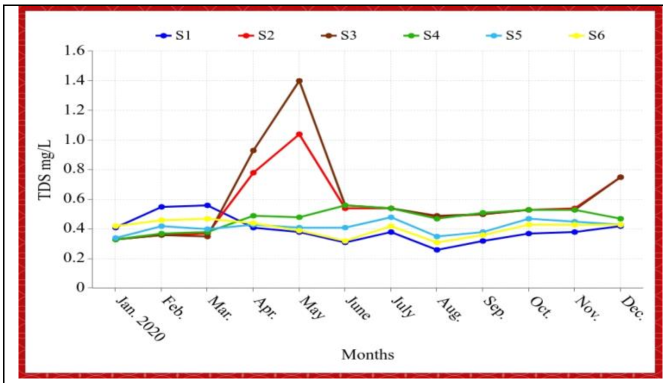

Figure 16. Variation of total dissolved solids value during the study period.

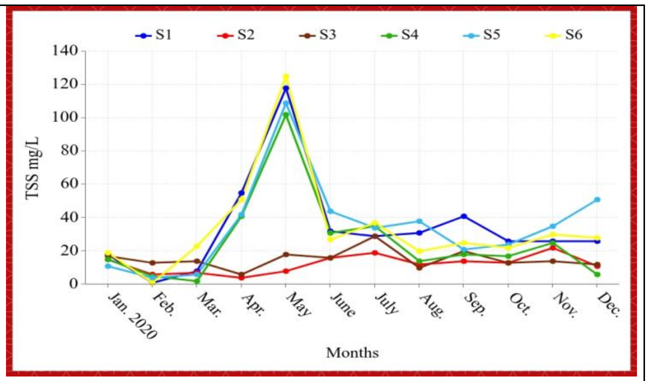

Figure 17. Variation of total suspended solids value during the study period.

Our result is parallel with Payne *et al.* [32] who observed that the value of TSS in Lower Mississippi River declined after the confluence with Ohio River. Furthermore, low TSS value of Illinois River reduced its values in Mississippi River from 69.2 to 60.2 mg/L downstream the confluence.

The values of total alkalinity and bicarbonates in Tigris River and Tharthar Canal are shown in Table 1 and Figs. 18 and 19. In site 1 upstream CHZ, the values of total alkalinity and bicarbonates ranged from 152.5, 145 to 231.8, 212 mg/L, respectively. On the Canal, the lowest values were 67.1, 75 and highest values were 176.9,177 mg/L, respectively. Whereas, in site 4 ranged from 73.2, 80 to 183, 191 mg/L, respectively. While, they ranged from 109.8,128 to 186, 205 mg/L downstream CHZ, respectively.

The statistical analysis of both total alkalinity and bicarbonate revealed significant differences ($P \leq 0.05$) between Tharthar Canal and Tigris River and no significant differences ($P > 0.05$) between sites 2 and 3 on Tharthar Canal (Table 1).

For spatial variation, the highest average value of total alkalinity and bicarbonate recorded upstream CHZ were 176.14 and 185.33 mg/L, respectively. While, the lowest average values recorded on Tharthar Canal were 105.51 and 120.5 mg/L, respectively (Table 1). This leads to a decrease in their values in site 4 at immediately downstream CHZ, then, quickly after, they came back to the first state.

High values of total alkalinity in Tigris River water are mainly due to bicarbonate ions which are abundant in Iraqi inland waters. This was pointed out in many previous studies [19, 22, 29].

For temporal variation, the highest values of total alkalinity and bicarbonate were recorded in the winter season especially in January. While the lowest values recorded summer and autumn. A similar result on the same river were obtained by [16, 33, 34].

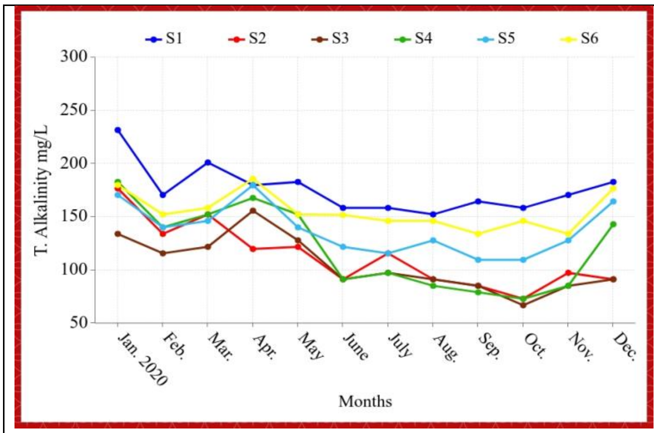

Figure 18. Variation of the total alkalinity values during the study period.

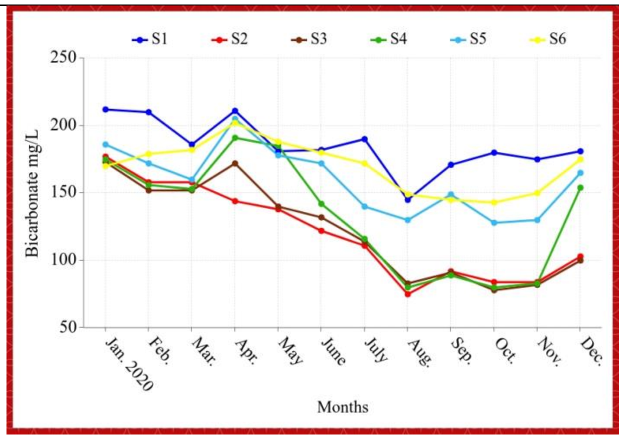

Figure 19. Variation of bicarbonate values during the study period.

Table 1 and Figs. 20 and 21 show the values of nitrate and phosphate in Tharthar Canal and Tigris River. At site 1 upstream CHZ, the values of nitrate and phosphate ranged from 0.68, 0.0033 to 1.07, 0.02 mg/L. On the Canal, they were ranged from 0.269, 0.0002 to 1.29, 0.019 mg/L, respectively. Whereas, in site 4immediately downstream CHZ ranged from 0.29, 0.0015 to 0.93, 0.0193 mg/L, respectively. While, they ranged from 0.49, 0.00025 to 0.998, 0.023 mg/L downstream CHZ, respectively.

Statistical analysis of nitrate and phosphate showed that no significant difference among all studied sites ($P > 0.05$) (Table 1).

For spatial variation, the highest mean values of nitrate and phosphate were at site 1 upstream CHZ. Whereas, the lowest mean values were on the Tharthar Canal. This, in turn, decreased the mean values in site 4 at immediately downstream CHZ (Table 1).

These results are compatible with Al-Dhamin *et al.*[35] pointed out the low values of nitrate and phosphate in Al-Tharthar-Euphrates Canal, which lowered their values in the Euphrates River from 3.4 and 0.4 mg/L before the confluence to 2.7 and 0.3 mg/L after the confluence, respectively.

For temporal variation, the maximum values of nitrate were recorded during the spring season, especially in April. Whereas, the minimum values were during summer especially in June for both rivers (Fig. 20). The high values in spring could be attributed to the rainfall, higher rainfall washes out nitrate from the land into the river [36]. The same finding was also obtained by Hassan *et al.* [22] related that to the increasing of nutrient plant in the spring season and decreasing in the summer season.

For phosphate ions, the lowest values were in the spring season, while the highest values were during summer, especially in sites 5 and 6 (Fig. 21). This increase can be attributed to the decomposition of organic materials containing phosphate compounds in addition to the presence of urban waste such as sewage.

Our findings are supported by several previous confluences studies implemented on the Tigris River, Al-Lami[30] observed that phosphate ions in Tharthar Canal lower than in Tigris River. Therefore, Tharthar water reduced phosphate concentration of Tigris River from 0.0102 mg/L before confluence to 0.00726 mg/L after the confluence. Furthermore, Al-Lami *et al.* [29]showed that the concentrations of phosphate ions along Tigris River, ranged from undetected concentrations to 0.124 mg/L. Also, Al-Azzawe[27] found that phosphate values in Tigris River within allowable limit and fluctuated between 0.003 mg and 0.12 mg. Hassan *et al.* [22] reported a higher mean value of phosphate ions downstream the confluence of Tharthar Canal with Tigris River. They recorded 0.42 mg/L compared with the present study, which was 0.0064 mg/L. This could be attributed to the differences in methods was applied to assess the phosphate ions

In short, nitrate concentrations in all sites were within an acceptable level of nitrate in stream ecosystems, less than 1 mg/L[8]. Additionally, phosphate concentrations in Tharthar Canal and Tigris River northern Baghdad City remained within low values. Furthermore, they were slightly higher than the standard value (0.01 mg/L) in pristine streams as stated by EPA [37] and Allan *et al.* [38]. This may be returned to unaffected by human activities.

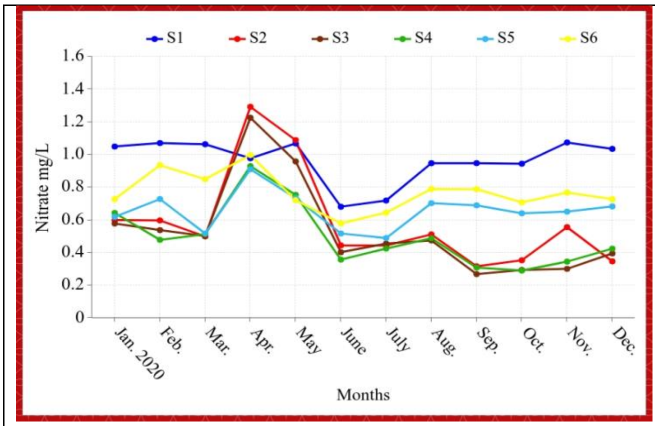

Figure 20. Variations of nitrate values during the study period

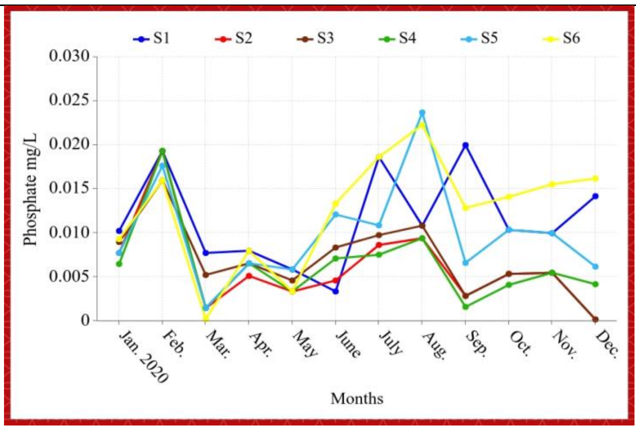

Figure 21. Variations of phosphate values during the study period.

Table 1. Minimum and maximum (First Line) mean and standard error (Second Line) for physical and chemical characteristics at study sites during 2020.

Site Parameter	Tigris River	Tharthar-Tigris Canal		Tigris River			LSD value
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	
Water Tempe. (˚C)	10-27 18.90±1.717	12.1-28.2 21±1.8078	12.4-28.4 21.34±1.837	10.7-28.7 20.916±1.838	10.3 - 28.5 20.23±1.78	10.6 - 28.5 20.35±1.819	2.72 NS
Air Temp. (˚C)	9- 30.6 21.26 ± 2.199 c	13 - 38.1 26.45 ± 2.49 b	12.9 - 37.4 26.73 ± 2.45 b	17- 43.6 30.01 ± 2.57 ab	14.4 - 42.6 29.4 ±2.791 ab	14.9 - 42.6 31.51±2.677 a	5.19 *
Turbidity (NTU)	8.16-131 34.75±9.603 a	6.2-18.37 11.53±1.300 b	3.68-22.33 13.503±1.71 b	10.9-114 28.65± 8.094 a	11.73-118 32.49±8.238 a	12.2-137 34.26±9.636 a	8.55 *
EC (µS/cm)	530-1110 788.33 ± 49. b	660-2070 1122.5±116.9 a	660-2010 1153.5 ±122.6 a	660-1100 942.5 ±43.06 ab	680-970 830±24.58 b	620-960 811.66±30.62 b	216.02 *
Salinity (‰)	0.339-0.710 0.504±0.031	0.4224-1.324 0.718±0.074	0.4224-1.286 0.7382±0.07	0.4224-0.704 0.603 ± 0.027	0.4352-0.6208 0.531 ± 0.015	0.396-0.6144 0.519 ± 0.01	0.281 NS
pH	7.38-7.91 7.642 ± 0.049	7.35-7.88 7.66 ± 0.055	7.34-7.93 7.68 ± 0.061	7.44-7.89 7.692 ±0.051	7.51-7.91 7.69 ± 0.425	7.41-7.84 7. 63]±0.044	0.944 NS
DO (mg/L)	8 - 13.1 9.891 ± 0.49	7.7 - 13.6 10.35 ± 0.499	7.8 - 11.9 9.691 ± 0.428	7.5 - 12.8 9.96 ± 0.468	7 - 11 9.1 ± 0.38	6.5 - 11.3 9.35 ± 0.44	1.26 NS
POS (%)	93.61-122.3 104.82±2.49	91.44-131.74 114.88±3.44	94.43-124.70 107.96±2.58	94.10-123.68 110.20±2.67	90.90-110.54 100.20±1.67	84.41-131.85 102.75 ±3.94	13.94 NS
BOD_5 (mg/L)	1.4-3.6 2.35 ± 0.23	0.9-3.5 2.4 ± 0.197	1-2.9 2.108 ± 0.21	1.5-3.6 2.38 ± 0.193	0.9 -4.1 2.18 ±0.228	1.1-4.3 2.2083±0.239	0.579 NS
Total Hardness ($mg CaCO_3/L$)	284-440 354.66±13.2 b	304-800 516.66±42.96 A	288-960 518.33±51.40 a	300-556 431.33±27.16 ab	288-468 369.33 ±13.45 b	320-380 358.25±5.57 b	142.3 *
Ca^{2+} (mg/L)	68.13-124.25 86.52 ± 4.94 c	93.16-224.44 156.72±12.95 A	93.12-228.45 153.78± 12.45 a	72.14-176.35 123.91±9.23 ab	60.12-148.29 103.04±7.70 bc	64.12-116.23 86.17 ± 4.39 c	31.85 *
Mg^{2+} (mg/L)	12.014-56.39 31.48 ± 3.94 bc	9.459-129.18 40.60 ± 10.13 A	10.57-129.18 40.34 ± 9.68 a	12.04-50.45 29.77 ± 3.72 bc	9.124-43.698 26.68 ± 3.16 c	14.944-46.24 35.30 ± 2.67 ab	6.52 *
SO_4^{2-} (mg/L)	10-50 13.48 ± 3.89 d	20-90 59.16 ± 6.45 A	20-80 51.66 ± 5.618 ab	30-60 45 ± 3.1383 b	20-60 33.33 ± 3.760 c	20-50 31.66 ± 3.217 c	9.31 *
HCO_3^- (mg/L)	145-212 185.33±5.516 a	75-177 120.5±9.8510 c	78-173 122.41±10.25 c	80-191 133.66±12.19 bc	128-205 159.58±7.11 b	143-202 169.58±5.43 b	28.44 *
TDS (mg/L)	260-560 395 ± 0.025	330-1.040 563 ± 0.05	330-1.400 605 ± 0.08	330-560 471 ±0.02	340-480 414 ±0.012	310-470 406 ±0.014	0.298 NS
NO_3^- (mg/L)	0.6817-1.074 0.9654±0.038	0.317-1.293 0.588±0.0865	0.2698-1.226 0.533±0.082	0.2913-0.93 0.497±0.055	0.49-0.911 0.6577±0.033	0.58-0.998 0.7704±0.033	0.366 NS
PO_4^{2-} (mg/L)	0.00337-0.02 0.0115±0.001	0.0002-0.0193 0.0061±0.004	0.0002-0.016 0.0070±0.001	0.0015-0.019 0.0064±0.001	0.0015-0.0237 0.0099±0.001	0.00025-0.022 0.0125±0.001	0.0109 NS
TSS (mg/L)	1-118 34.25±8.615 a	4-22 12.25±1.557 b	6-29 15.16±1.650 b	2-102 25.91±7.753 a	4-109 34.91±8.056 a	1-125 34±8.934 a	9.516 *
Total Alkalinity (mg/L)	152.5-231.8 176.14±6.46 a	73.2-176.9 112.68±8.79 d	67.1-156 105.51±7.384 d	73.2-183 120.99± 8.3 d	109.8-180 138.01±6.83 bc	134.2-186 155.51±4.91 ab	18.38 *

Means having with the different letters in same column differed significantly.
* ($P \leq 0.05$). NS: Non-Significant.

Conclusion:

It can be concluded that the water properties of the Tharthr Canal and Tigris River are different in terms of many parameters such as flow rate, conductivity, salinity, TDS, TSS, turbidity, total hardness, calcium, magnesium, sulphate, total alkalinity, bicarbonate, nitrate and phosphate. Thus, Tharthar water impact Tigris water within and downstream the confluence zone, changes its properties from fresh to oligohaline, hard to very hard water, increased TDS, calcium and sulphate ions. Whereas, the values of turbidity, TSS, total alkalinity and bicarbonate have been reduced. Finally, pH values of both rivers tend to be alkaline, and the levels of DO and nitrate fall within the 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 Education.

Authors' contributions statement:

B.C. conceived of the presented idea. A.C. developed the theory and performed the computations. B.C. verified the analytical methods. B.C. encouraged A. to investigate [a specific aspect] and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript

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تـأثـير قـناة الـثرثار دجـلة في الخصائص البيئيـة لنـهر دجـلة شمال بـغداد، الـعراق

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الخلاصة:

هذه الدراسة تعتبر الأولى من نوعها بعد العام 2003. صُممت من اجل هدفين: الأول توضيح تأثير التغيرات الموسمية في مؤشرات الماء الفيزيائية والكيميائية لقناة الثرثار- دجلةفضلا عن نهر دجلة والثاني تقييم مدى تأثير القناة على بعض الخصائص البيئية للنهر عند منطقة الدراسة. جمعت عينات الماء شهريا للفترة من كانون الثاني الى كانون الأول 2020. تم دراسة تسعة عشر مؤشراً بيئيا شمل درجات حرارة الماء والهواء والكدرة والتوصيلية الكهربائية والملوحة والاوكسجين الذائب ونسبة الاشباع للأوكسجين والمتطلب الحيوي للأوكسجين والاس الهيدروجيني والعسرة الكلية والكالسيوم والمغنيسيوم والكبريتات ومجموع المواد الصلبة الذائبة ومجموع المواد الصلبة العالقة والقاعدية الكلية والبيكاربونات والنترات والفوسفات. بينت النتائج ان مياه النهر والقناة تتأثر بدرجة حرارة الهواء وانها جيدة التهوية وتميل نحو القاعدية بدرجة طفيفة جدا. كما ان الاوكسجين تجاوز نسبة الاشباع مرات عديدة وان المتطلب الحيوي للأوكسجين لم يتجاوز درجة 5 ملغم/لتر. بينت الدراسة أيضا ان القيم العالية للتوصيلية وللملوحة وللمواد الصلبة الذائبة وللعسرة الكلية وللكالسيوم وللكبريتات للقناة زادت من قيمها في نهر دجلة بعد الالتقاء مباشرة بينما القيم الواطئة للكدرة وللمواد الصلبة العالقة وللقاعدية الكلية وللبيكاربونات للقناة قللت من قيمها في النهر أسفل منطقة الالتقاء مباشرة. عموماً يمكننا ان نستنتج ان ذراع الثرثار يؤثر بنهر دجلة من خلال زيادة او نقصان الخصائص الفيزيوكيمياوية للنهرضمن منطقة الدراسة.

الكلمات المفتاحية: المعايير الفيزيائية والكيميائية، التقاء النهرين، بحيرة الثرثار، قناة الثرثار- دجلة، نهر دجلة.