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Interactions between the Ecological Dejiala River Properties, Southern Iraq

Intisar F. Abed*[1], Muhanned R. Nashaat[2]

[1]College of Education for Pure Sciences/ Ibn Al-Haitham, University of Baghdad, Baghdad, Iraq

[2]Ministry of Science & Technology, Baghdad, Iraq

Abstract

This study was the first of its kind on the Dejiala River, which is considered one of the main branches of the Tigris River in Wasit Province. Therefore, the study aimed to investigate of some physical and chemical properties of water in the Dejiala River. Monthly sampling stations were conducted for 12 months, which was starting from January to December 2016, during those five stations was chosen which divided along about 58 Km of river; each station was located at a distance of ±10 Km. The results of the study showed a clear correlation between air and water temperature in all stations. Turbidity was recorded a value ranging from 2.36-116 NTU. It was found that the water of the Dejiala was Oligohaline, weak alkaline and well ventilated due high concentrations of dissolved oxygen. The Dejialah River considered as questionable clean water according to BOD_5 value. While the total alkalinity values were recorded from 30.5-427 mg/L, so these values were higher than the normal permissible limits for the Iraqi and international water standards, which is 20-200 mg /L $CaCO_3$. It was also found that the water of the Dejiala River was very hard, as well as the it was within the permissible limits of natural water (200 mg/L Ca and 150 mg/L Mg). As for sulphate concentrations it has ranged from 40-150 mg/L, while bicarbonate was recorded values ranged from 120-180 mg/L. On the other hand, the TDS and TSS were recorded values ranged from 0.2-0.61 g/L and 1-171 mg/L, respectively. While nitrates recorded values from 0.787-2.505 mg/L which was below the normal permissible limits (15 mg/L) for the Iraqi water standards. Also, orthophosphates were recorded value from 0.011-0.082 mg/L.

Keywords: Physical properties, chemical properties, Dejiala River, Al-Kut Barrage.

التداخل بين عوامل نهر الدجيلة البيئية، جنوب العراق

انتصار فيصل عبد*[1]، مهند رمزي نشأت[2]

[1]كلية التربية للعلوم الصرفة ابن الهيثم، جامعة بغداد، بغداد، العراق

[2]وزارة العلوم والتكنولوجيا، بغداد، العراق

الخلاصة

أجريت هذه الدراسة وهي الأولى من نوعها على نهر الدجيلة أحد الفروع الرئيسية لنهر دجلة في محافظة واسط. والتي هدفت إلى التعرف على بعض الخصائص الفيزيائية والكيميائية لمياه النهر أجريت النمذجة لمحطات الدراسة شهرياً مدة 12 شهراً ابتداءً من شهر كانون الثاني ولغاية كانون الأول 2016 تم من خلالها اختيار خمس محطات مقسمة على طول النهر البالغ 58 كم، بحيث تبعد كل محطة عن الأخرى مسافة ± 10كم. أظهرت نتائج الدراسة توافقاً واضحاً بين درجة حرارة الهواء المحيط ودرجة حرارة الماء في كل المحطات. وسجلت الكدرة قيماً تراوحت ما بين 2.36–116 NTU. وجد من خلال نتائج الدراسة الحالية أن

*Email: muhanned_nashaat@yahoo.com

مياه نهر الدجيلة هي مياه مويلحة Oligohaline، فضلاً على أنها ذات قاعدية خفيفة ، كما أنها ذات تهوية جيدة فقد سجلت تراكيز عالية من الأوكسجين ، كما تعد مياه نهر الدجيلة مشكوك في نظافتها حسب المعدلات المسجلة لقيم المتطلب الحيوي للأوكسجين.فيما سجلت القاعدية الكلية قيماً تراوحت ما بين 30.5−427 ملغم/لتر وقد ظهرت قيم القاعدية الكلية أعلى من الحدود الطبيعية المسموح بها للمواصفات القياسية للمياه العراقية والعالمية والتي تبلغ من 20−200 ملغم/ لتر كاربونات الكالسيوم. كما تبين أن مياه نهر الدجيلة عسرة جداً ومن خلال نتائج الدراسة الحالية تبين أن نهر الدجيلة يقع ضمن المحددات المسموح بها للمياه الطبيعية (وهي 200 ملغم/ لتر للكالسيوم و150 ملغم/لتر للمغنسيوم). أما تراكيز الكبريتات فقد تراوحت ما بين 40− 150 ملغم/لتر، بينما سجلت البيكاربونات قيماً تراوحت ما بين 120−180 ملغم/لتر. من جهة أخرى فقد سجلت المواد الصلبة الذائبة الكلية والمواد العالقة الكلية قيماً تراوحت ما بين 0.2−0.61 غم/لتر و1−171 ملغم/لتر على التوالي. بينما سجلت النترات قيماً ما بين 0.787−2.505 ملغم/لتر وهي أقل من الحدود المسموح بها (15 ملغم/لتر) حسب نظام صيانة الأنهار العراقية. كما سجلت الفوسفات الفعالة قيماً ما بين 0.011−0.082 ملغم/لتر.

Introduction

Physical and chemical properties are very important in ecosystems by influencing and determination of water quality, this is done by comparing these factors with the international water quality standards, these factors vary continuously depending on the nature of the geological and climatic conditions of the study area [1]. In addition to that its plays a direct role in intensity and distribution of aquaculture [2]. Many researchers in Iraq dealt with the physical and chemical properties of the Euphrates and Tigris Rivers in their environmental studies such as- [3;4; 5; 6; 7;8;9]. While this study considered as the first of its kind on the one of the main branches of the Tigris River called Dejiala River, in Wasit Province. Which we can include it's the main objectives by investigating some of the physical and chemical properties of the water of the Dejiala River in Wasit Province.

Material and Methods

Study Area

A number of dams have been built on the Tigris River to prevent flooding, including the Mosul, Samarra and Al Kut dams. In 1938 came the idea of establishing the Dejiala River Project for the purpose of reclaiming the surrounding land. In 1945, water was opened on the Dejiala River for the first time. The length of this river is 58 Km, and the width of this river at the beginning of 14 m and the depth of the water is 2.35 m, and it irrigates about 395.562 Acres of land around it[10].

Water discharges at the current study in the Dejiala River ranged from 11.1-28.7 m^3/s, the lowest values during April 2016, while the highest values were during February 2016 whereas the water current ranged from 0.385-0.549 m/s, with the lowest values during April 2016, while the highest values were in February of the same year[10] Figure-1.

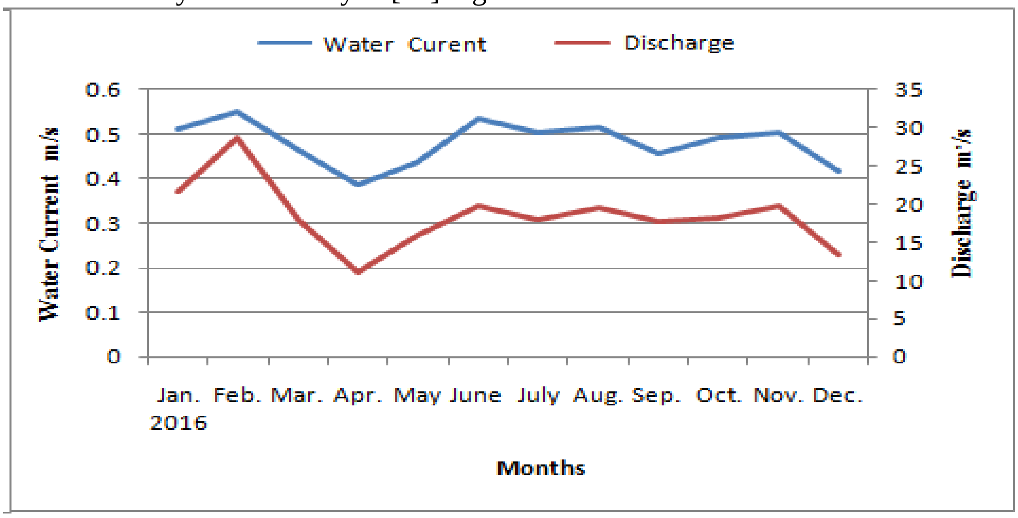


Figure 1- Seasonal variation of the Dejiala River current and discharge water values during the period study.

Study Station Description

Monthly sampling stations were conducted for 12 months was starting from January 2016 to December 2016, during those five stations was chosen (Figure-2) which divided along about 58 Km of river; each station is located at a distance of ±10 Km. The first one was located under lies between the latitude 32.29 ° N; 45.49 °E about 150 Km away from Al-Kut Barrage, and the second was located in the Wafidea District under lies between latitude 32.27 ° N; 45.58 ° E. The third station was about 10 Km away from the second station under lies between the latitude 32.26°N; 46.8°E. The fourth station was at the New Dejiala District under lies between the latitude 32.20° N; 46.15 °E. Whereas the fifth station was located under lies between the latitude 32.10° N; 46. 18 °E after the checkpoint of 36 Km which at the end of the Dejiala River before its decay.

Water samples from the surface layer were taken about 20cm underwater by using 2.250-liter polyethylene containers. Physical and chemical parameters included: - Air and water temperature were measured by using a precise mercury thermometer. Dissolved oxygen and Biological oxygen demand was used the modified Winkler method [11]. The percentage of oxygen saturation was calculated as reported in Mackereth *et al*. [12], 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 [11]. The turbidity was measured by the turbidity meter Jenwaw Company Model-6035. Total hardness, calcium, and magnesium were measured according to Lind [13]. Sulphate used the method described by Brands and Tripke [14], the nutrients (Nitrate), measured as in APHA [15], as to effective phosphate was measured according to the method APHA [16]. Finally, the Degremont method [17] was used to measure the bicarbonate in the water of the studied stations.

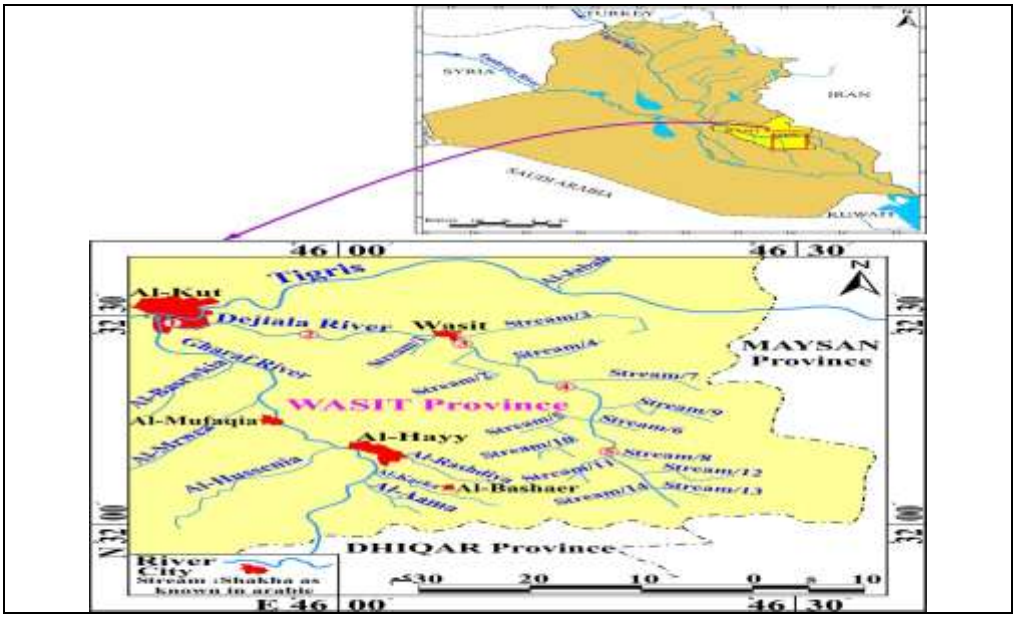


Figure 2- A map showing the studied stations on the Dejiala River.

Results and Discussion

Air temperature values ranged from 12.9 to 40 °C, with the lowest values recorded during December at station 3, while the highest values during July at station 5. Statistical analysis showed significant differences $p \leq 0.05$ among stations (Table-1, Figure-3). Also, there was a significant positive correlation between air temperature with water temperature, total hardness, TSS, and phosphate at $p \leq 0.01$, r= 0.967, r= 0.690, r= 0.883, r= 0.684 respectively, and positive correlation between air temperature with both sulfates and nitrates at $p \leq 0.05$, r = 0.433, r = 0.440, respectively (Table-2).

Surface temperature ranged from 12.5-30.2 ° C, with the lowest values during December at stations 1 and 3 while the highest values during July at station 5. Statistical analysis showed no any significant differences in $p>0.05$ among the stations Table-1, Figure-4). Also, there was a significant correlation between water temperature with air temperature, total hardness, TSS, and phosphate at $p \leq 0.01$, r = 0.967, r = 0.728, r = 0.896, r = 0.651 respectively, and a positive correlation with total alkaline and

POS was found at p≤0. 05, r = 0.484, r = 0.434, respectively (Table-2). It was clear that water temperature and air temperature was accompanied with the increase and decrease on its values at all study stations, which explain the strong correlation between water and air temperature.

Table 1- The variation in Physical and Chemical Properties of the Dejiala River during the Period from January to December 2016. (First line Range and second line Average ± Standard Deviation).

Station / Parameter	1	2	3	4	5
Air Temp. ˚C	13.4-35 25.34 ± 7.12 B	13.5-36.9 26.72 ± 7.66 AB	12.9-37.3 27.59 ± 8.05 AB	14.6-38.1 27.86 ± 8.18 AB	15.1-40 29.16 ± 8.87 A
Water Temp. ˚C	12.5- 29.6 21.73± 6.38 A	13-29.5 21.97 ± 6.36 A	12.5-28.8 21.72 ± 5.82 A	13.2-29.5 22.04 ± 5.89 A	14-30.2 22.39 ± 5.52 A
Turbidity NTU	4.71-59 27.51 ± 17.55 B	2.36-59 22.69 ± 16.46 C	3.73-71 29.83 ± 23.79 B	4.4-116 34.11 ± 31.25 A	6.46-98 36.75 ± 29.89 A
EC µS/cm	370-1052 690.25 ± 287.14 B	830-1081 936.25 ± 77.22 A	830-1220 952.25 ± 103.89 A	480-1180 910.66 ± 162.79 A	870-1170 949.5 ± 85.46 A
Salinity ‰	0.236-0.673 0.471 ±0.13 B	0.531-0.691 0.606 ± 0.05 A	0.531-0.780 0.609 ± 0.06 A	0.307-0.755 0.582 ± 0.10 AB	0.556-0.748 0.607 ± 0.05 A
pH	6.8-8.1 7.28 ± 0.44 A	6.9-8.3 7.51 ± 0.47 A	7 -8.2 7.51 ± 0.37 A	7-8.4 7.61 ± 0.39 A	7.2-8.5 7.68 ± 0.43 A
Alkalinity mg\L	219.6-335.5 276.2 ± 37.06 A	231.8-366 271.45 ±38.53 A	213.5-427 273.99 ± 57.25 A	30.5-396.5 263.31 ± 87.50 A	195.2-360 270.95 ± 40.18 A
DO mg/ L	5.5-10.5 7.79 ± 1.78 A	5-11 7.32 ± 2.53 A	4.1-11 7.41 ± 3.04 A	5.1-10.8 8.52 ± 3.30 A	5.2-11.7 9.91 ± 3.28 A
POS(The percentage of Oxygen Saturation) %	70.94-113.268 86.34 ± 18.81 B	60.88-118.662 79.63 ± 24.46 B	53.246-115.638 78.51 ± 35.04 B	66.233-110.132 94.41 ± 35.81 AB	68.692-133.138 109.99 ± 33.81 A
BOD_5 mg/ L	2.5-6.4 4.41 ± 1.59 A	1.8-7.4 4.28 ± 1.90 A	1.2-5.1 3.18 ± 1.07 B	1.8-7.3 3.76 ± 1.88 AB	2-6.7 4.54 ± 1.77 A
T.H mg/ L	316-496 406 ± 59.58 A	320-468 397.66 ± 48.16 A	320-520 404.66 ± 54.63 A	328-540 392 ± 54.36 A	320-500 392.33 ± 48.19 A
Ca^{+2} mg/L	60.12-160.37 108.48 ± 30.71 A	80.16-150.31 117.33 ± 21.50 A	80.16-140.35 112.07 ± 21.05 A	68.136-140.28 101.2 ± 18.09 A	80.16-140.28 111.58 ± 17.15 A

Mg^{+2} mg/ L	19.35-51.15 32.87 ± 10.57 A	19.36-48.87 26.96 ± 8.77 A	21.81-93.4 34.91 ± 20.70 A	14.49-48.68 34.49 ± 9.97 A	20.34-36.41 27.65 ± 4.66 A
SO^{+4} mg/ L	40-125 92.08 ± 27.25 A	45-150 99.58 ± 28.56 A	50-125 82.5 ± 22.81 A	50-150 95.83 ± 29.22 A	50-150 92.08 ± 30.18 A
$HCO_3^{=}$ mg/ L	120-180 159 ± 18.36 A	140-175 160.83 ± 10.35 A	149-180 162.83 ± 9.88 A	144-175 159.16 ± 10.11 A	142-175 162 ± 9.55 A
TDS mg/L	0.2-0.51 0.378 ± 0.09 A	0.41- 0.57 0.472 ±0.05 A	0.41-0.61 0.482 ± 0.06 A	0.42 -0.59 0.480 ±0.05 A	0.44-0.58 0.481 ± 0.04 A
TSS mg/L	3-65 25.08 ± 19.76 C	6-65 29.16 ± 19.13 BC	2-79 37.41 ± 29.19 B	3-85 36.08 ± 30.98 B	1-171 57.25 ± 55.42 A
NO_3^{-2} mg/L	0.935-2.505 1.50 ± 0.42 A	0.833-2.333 1.41 ± 0.40 AB	0.89-1.831 1.39 ± 0.31 AB	0.881-1.897 1.35 ± 0.33 AB	0.787-1.802 1.22 ± 0.32 B
PO_4^{-2}µg/L	0.011-0.049 0.034 ± 0.011 A	0.019-0.054 0.037 ± 0.010 A	0.019-0.063 0.040 ± 0.013 A	0.016-0.082 0.040 ± 0.018 A	0.015-0.062 0.034 ± 0.014 A

*All average with different letters within one row mean significant differences ($p \leq 0.05$).

Table 2- Correlation coefficient values (r) between the physical and chemical characteristics in the Dejiala River during the period study.

	A.T	W.T	Tur.	EC	Sal.	pH	TA	DO	BOD_5	%	TH	Ca	Mg	SO_4	HCO_3	TDS	TSS	NO_3	PO_4
A.T	1	0.967**	0.238 NS	0.260 NS	0.215 NS	0.147 NS	0.383 NS	0.035 NS	0.228 NS	0.399 NS	0.690**	-0.217 NS	0.241 NS	0.433*	0.315 NS	0.057 NS	0.883**	0.440*	0.684**
W.T		1	0.069 NS	0.233 NS	0.159 NS	0.098 NS	0.484*	0.000 NS	0.229 NS	0.434*	0.728**	-0.210 NS	0.247 NS	0.379 NS	0.279 NS	0.035 NS	0.896**	0.321 NS	0.651**
Tur			1	-0.500*	-0.388 NS	-0.166 NS	-0.346 NS	-0.127 NS	-0.216 NS	-0.323 NS	-0.327 NS	0.029 NS	-0.136 NS	-0.025 NS	-0.004 NS	-0.476*	-0.075 NS	0.805**	0.163 NS
EC				1	0.941**	0.544**	0.389 NS	0.367 NS	0.404 NS	0.479*	0.620**	-0.487*	0.203 NS	0.476*	0.346 NS	0.906**	0.408 NS	-0.240 NS	0.295 NS
Sal					1	0.716**	0.439*	0.546**	0.543**	0.600**	0.648**	-0.615**	0.149 NS	0.648**	0.513*	0.958**	0.329 NS	-0.227 NS	0.434*
pH						1	0.710**	0.957**	0.931**	0.855**	0.627**	-0.552**	-0.009 NS	0.941**	0.932**	0.731**	0.136 NS	-0.345*	0.733**
TA							1	0.670**	0.784**	0.842**	0.794**	-0.488*	0.228 NS	0.736**	0.768**	0.492*	0.344 NS	-0.317 NS	0.763**

DO								**1**	**-0.961****	**0.796****	**0.470***	**-0.479***	**-0.095 NS**	**0.885****	**0.952****	**0.586****	**0.020 NS**	**-0.410 NS**	**0.647****
BOD_5									**1**	**-0.887****	**0.628****	**-0.453***	**-0.030 NS**	**0.921****	**0.969****	**0.567****	**0.236 NS**	**-0.429***	**0.741****
%										**1**	**0.850****	**-0.528****	**-0.033 NS**	**0.905****	**0.859****	**0.616****	**0.404 NS**	**-0.326 NS**	**0.828****
TH											**1**	**-0.481***	**0.284 NS**	**0.751****	**0.623****	**0.570****	**0.714****	**-0.142 NS**	**0.804****
Ca												**1**	**0.256 NS**	**-0.570****	**-0.502***	**-0.626****	**-0.171 NS**	**-0.193 NS**	**-0.501***
Mg													**1**	**-0.028 NS**	**0.002 NS**	**0.048 NS**	**0.175 NS**	**-0.152 NS**	**0.049 NS**
SO_4														**1**	**0.948****	**0.610****	**0.390 NS**	**-0.156 NS**	**0.896****
HCO_3															**1**	**0.516****	**0.229 NS**	**-0.232 NS**	**0.822****
TDS																**1**	**0.154 NS**	**-0.301 NS**	**0.377 NS**
TSS																	**1**	**0.140 NS**	**0.554****
NO_3																		**1**	**0.125 NS**
PO_4																			1

**= Significant correlation at p≤0.01. * = Significant correlation at p≤0.05. NS = Non significant correlation.

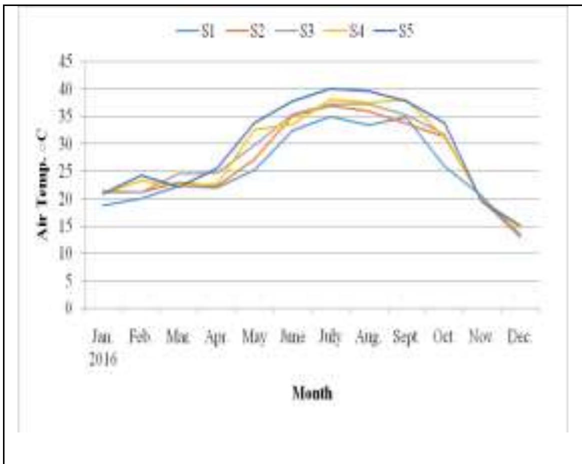


Figure 3- Variation of the air temperature on the Dejiala RiverDuring the period study.

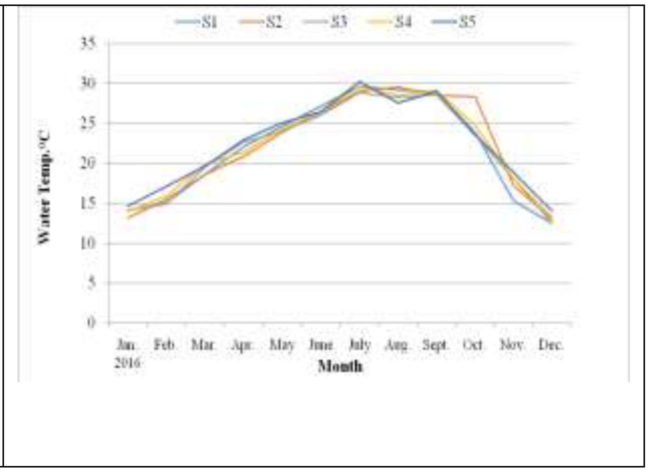


Figure 4- Variation of the water temperature values on the Dejiala River during the period study.

The turbidity values ranged from the highest value was 116 NTU at station 4 during June whereas the lower value was 2.36 NTU at station 2 during March. The results of the statistical analysis showed that there were significant differences p≤ 0.05among stations Table-1, Figure-5.

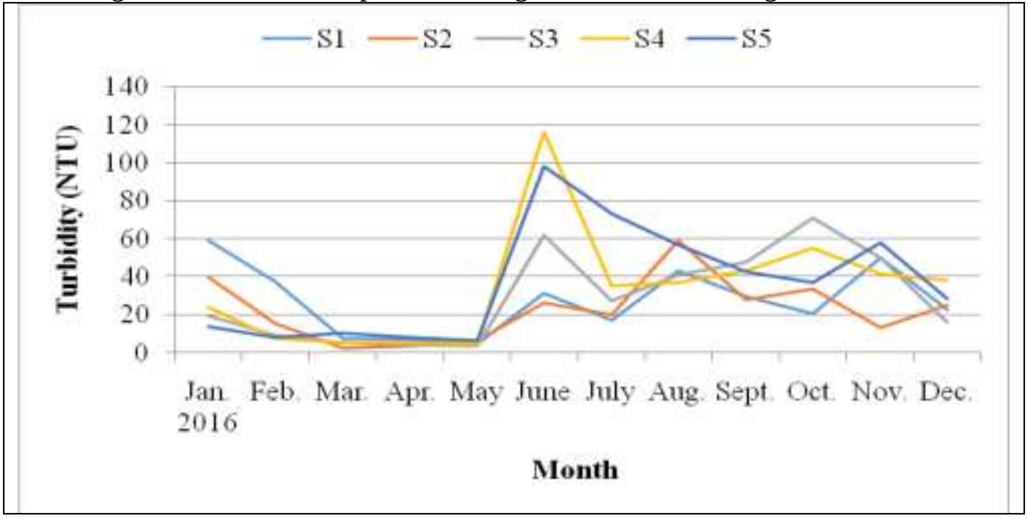
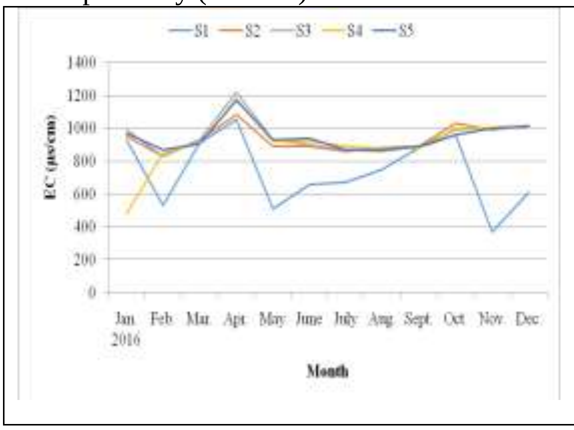


Figure 5- Variation of the water turbidity NTU values in the Dejiala River during the period study.

The study showed a strong positive correlation with nitrate at p≤0.01, r = 0.805, and a significant negative correlation was observed with both the electrical conductivity and TDS at p≤0.05, r = -0.500, r = -0.476, respectively (Table -2). The values of the turbidity showed clear variation during current study, so the increase in their values during the summer may be due to the increase in organic matter which resulting from the decomposition of plants in this season or may be due to the lack of plants which works to deposition of suspended materials leading to their rise [18]. Whereas the low turbidity values in March, April and May may be due to the slow water flow (Figure-1) leading to the deposition of a large amount of suspended solids or the dissolving of some of these substances over time with low temperatures [19].

The values of the electrical conductivity of the Dejiala water ranged from the highest value of 1220 µs/cm with 0.78‰ of salinity at station 3 during April and the lowest value 370 µs/cm with 0.23‰ of salinity at station 1 during November (Table-1, Figure-6). The statistical analysis showed there was significant difference p≤0.05 among station. Also the study showed positive correlation between the electrical conductivity with salinity, pH, total hardness and total dissolved solids at p≤0.01, r = 0.941, r = 0.544, r = 0.620, r = 0.906 respectively, on the other hand there was positive correlation was observed with the of POS and sulphate at p≤0.05, r = 0.479, r = 0.476, respectively, and a significant negative correlation relationship was observed with turbidity and calcium at p≤0.05, r = -0.500, r = -0.487 respectively (Table-2).



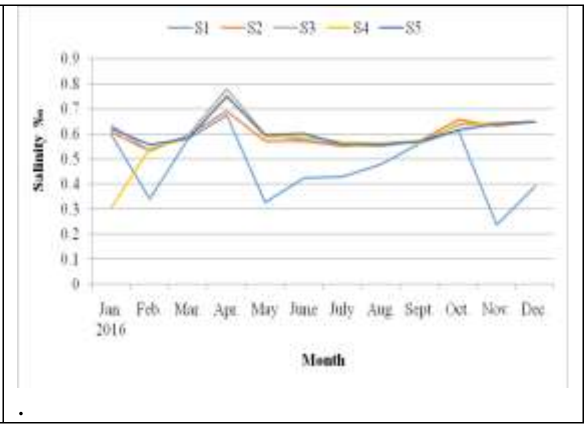


Figure 6- Variation of the electrical Conductivity water values On the Dejiala River during the period study

Figure 7- Variation of salinity water values on the Dejiala River during the period study

As for salinity the results of the statistical analysis showed that there was significant difference $p \leq 0.05$ among station (Table-1, Figure-7). A significant positive correlation was found between salinity with EC, pH, DO, BOD_5, POS, TSS, sulphate, and TDS at $p \leq 0.01$, r = 0.941, r = 0.716, r = 0.546, r = 0.543, R = 0.600, r = 0.648, r = 0.648, r = 0.958, respectively. There was also a significant negative correlation between salinity with calcium at $p \leq 0.01$, r= -0.615. A positive correlation was found with total alkaline, bicarbonate and phosphate at $p \leq 0.05$, r = 0.439, r = 0.513, r = 0.434, respectively Table-2.

It showed an increase in the values of electrical conductivity in the spring, especially during April, may be due to this river was located within agricultural lands, so all salts that reach to the river as a result of draining canal may increase concentrations of natural salts of the river [20]. While the decrease in values of electrical conductivity in the autumn, especially during November may be due to the act of dilution which resulting from rainfall, high water levels and the values of the flow velocity (Figure-1) which reached to 0.503 m/s, and 19.8 m^3 / s respectively [21]. Our study also reached for the water of the Dejiala River is Oligohaline according to the classification of EPA [22].

It was found from the present study that the water quality of the river is weak alkaline due to the pH values within a narrow range changed and may be related with regulatory capacity and water was rich with calcium bicarbonate [23]. The results of this study are consistent with most previous studies indicating that Iraqi waters tend to light alkaline with a narrow range of pH values [24; 25; 26]. The results of the statistical analysis showed that there were no any significant differences in $p > 0.05$ between the studied stations (Table-2, Figure-8). Also a significant positive correlation was found between pH, electrolysis, salinity, total alkaline, dissolved oxygen, BOD_5, percentage saturation oxygen, total hardness, sulphate, bicarbonate, TDS and phosphate at $p \leq 0.01$, r = 0.554, r = 0.716, r = The correlation between the pH and the calcium at $p \leq 0.01$ r= 0.733, r = 0.955, r = 0.267, r = 0.941, r = 0.932, r = 0.731, 0.01, r = -0.552 (Table-3).

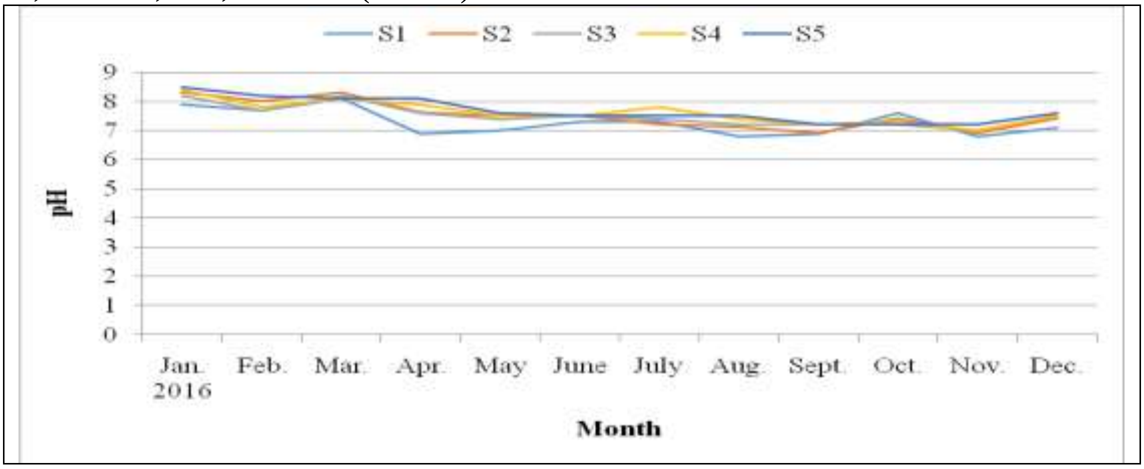


Figure 8- Variation of pH values on the Dejiala River during the period study.

During the current study, the total alkaline water of the Dejiala was recorded with values of 427 mg /L during August at station 3 and 30.5 mg /L in May at station 4. The results of the statistical analysis showed no any significant differences $p > 0.05$ among stations (Table-1, Figure-9). Also a strong positive correlation was observed between the total alkaline with pH, DO, BOD_5, POS, TH, sulphate, bicarbonate and phosphate at $p \leq 0.01$, r = 0.710, r = 0.670, r = 0.784, r = 0.842, r = 0.794, r = 0.736, r = 0.768, r = 0.763, respectively. There was also a significant positive correlation between total alkalinity with water temperature, salinity, and total dissolved solids at $p \leq 0.05$, r = 0.484, r = 0.439, r = 0.492 respectively. A negative correlation was also found with calcium at $p \leq 0.05$, r = 0.488, (Table-2).

The current study showed total alkalinity values were over the normal limits allowed for the Iraqi and international standards of water, which is 20-200 mg/L $CaCO_3$ [16]. Also, it was observed that the alkalinity of the Dejiala River was attributed to the bicarbonate alkalinity, due to the availability of bicarbonates in the Iraqi water body [27; 28], so the bicarbonate alkalinity characteristics were common in Iraqi. It was known that bicarbonates were present within ranges of pH 7-9, so it was clear that the water of the Dejiala River was neutral to a light alkalinity due to the water is within a range of less than 8.5, thus the form of carbon dioxide in the water is bicarbonate [29].

The results of the dissolved oxygen values on the Dejiala River showed the lowest values 4.1mg/L (133.138%) during July at station 3 while the highest values was11.7mg/L (53.246%) in January at station 5. The results of the statistical analysis showed no any significant differences $p > 0.05$ among the stations (Table-1) and (Figures-10, 11). Also a significant positive correlation between dissolved oxygen with salinity, pH, alkalinity, POS, sulphate, bicarbonate, TDS and phosphate at $p \leq 0.01$, r = 0.546, r = 957, r = 0.670, r = 0.796, r = 0.885, r = 0.952, r = 0.586, r = 0.647 respectively, There was also a significant negative correlation between dissolved oxygen with BOD_5 at $p \leq 0.01$, r = -0.961, and a positive correlation between dissolved oxygen with total alkalinity was found at $p \leq 0.05$, r = 0.470, and a negative correlation between dissolved oxygen with calcium at $p \leq 0.05$, r = -0.479 (Table-2).

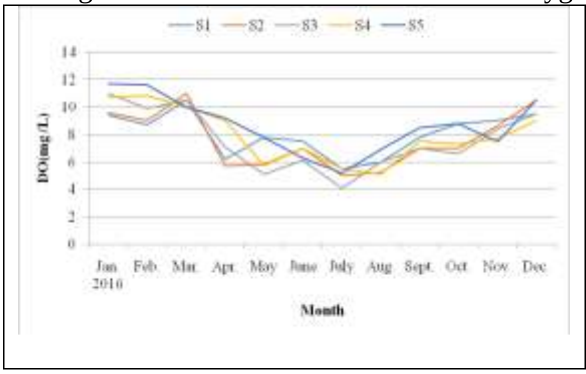


Figure 10- Variation of the dissolved oxygen values On the Dejiala River during the period study.

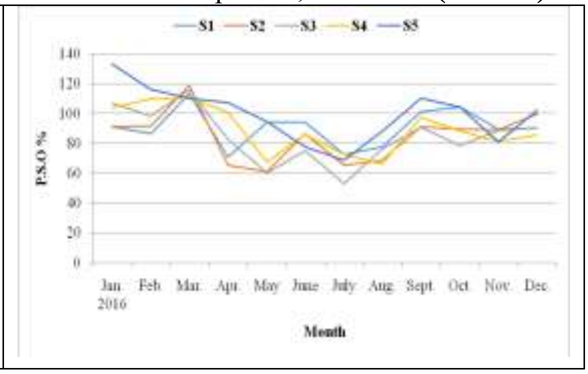


Figure 11-Variation of the Percentage Oxygen Saturation values on the Dejiala River during the period study.

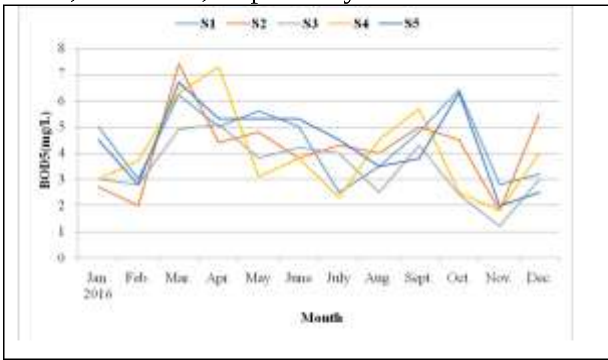
During the current study, the high values of dissolved oxygen were observed during the winter, especially in January while the lowest values were recorded in the summer during July. This may be due to lower winter temperatures which allowing greater oxygen dissolving in the water, as well as increased movements and water disturbance leading to increased dissolving of atmospheric oxygen in the water [30; 31]. And vice versa in the summer. It was indicated from the current study that the river with high potential for self-purification according to the high percentage saturation oxygen recoded values [32].

The results of the BOD_5 on the Dejiala showed that the values ranged from 1.2 to 7.4 mg/L, the lowest values during November at station 3, while the highest values during March at station 2. The results of the statistical analysis showed that there was significant difference $p \leq 0.05$ among stations (Table-1, Figure-12). A strong positive correlation was found between BOD_5 with salinity, pH, total alkalinity, POS, total hardness, sulphate, bicarbonate, TDS and phosphate at $p \leq 0.01$, r = 0.543, r = 0.931, r = 0.784, r = 0.887, r = 0.628, r = 0.921, r = 0.969, r = 0.567, r = 0.741, respectively, Also a significant negative correlation was found with DO at $p \leq 0.01$, r = -0.961 and a significant negative correlation between the BOD_5 with both of calcium and nitrate at $p \leq 0.05$, r = -0.453, r = -0.429, respectively (Table-2).

The higher BOD_5 values in the study area were exceeded the allowable levels of 5 mg/L [33] in some months, due to the presence of organic pollutants which may be sewage discharges that consume oxygen, as well as the water which storage through dams and reservoirs causing many unwanted side effects [34]. Odum [35] divided the water into two types depending on BOD_5 as BOD_5 = 2 Clean, BOD_5 = 5 or more are doubtful in its cleanliness, Thus, it can be noted that Dejiala River was doubtful in its cleanliness.

The results of the total hardness recorded the lowest value (316 mg/L) during November at station 1, while the highest values (540 mg/L) during December at station 4. The results of the statistical analysis showed no any significant differences $p > 0.05$ among stations (Table-1 and Figure-13). There was a strong positive correlation between total hardness with air and water temperature, EC, salinity, pH, total alkalinity, BOD_5, POS, sulphate, bicarbonate, TDS, TSS and phosphate at $p \leq 0.01$, r = 0.690, r = 0.728, r = 0.620, r = 0.648, r = 0.794 r = 0.627, r = 0.628, r = 0.850, r = 0.751, r = 0.623, r = 0.570, r = 0.714, r = 0.804 respectively. There was also a significant positive correlation between total hardness with DO at $p \leq 0.05$, r= 0.0470 and negative correlation with calcium at $p \leq 0.05$, r = -0.481 (Table-2).

As for calcium, the values ranged from 60.12-160.37 mg/L, which recorded the lowest values and highest at station 1 during February and August, respectively, the results of the statistical analysis also showed no any significant differences among the studied stations (Table-1) and (Figure-14). There was a significant negative correlation between calcium with salinity, pH, POS, sulphate, and TDS at $p \leq 0.01$, r = -0.615, r = -0.552, r = -0.528, r = -0.570, r = -0.626, respectively, also there was a significant negative correlation between calcium with EC, total alkalinity, DO, BOD_5, total hardness, bicarbonate and phosphates at $p \leq 0.05$, r = -0.487, r = -0.488, r = -0.479, r = -0.453, r = -0.481, r = -0.502, r = -0.501, respectively Table-2.



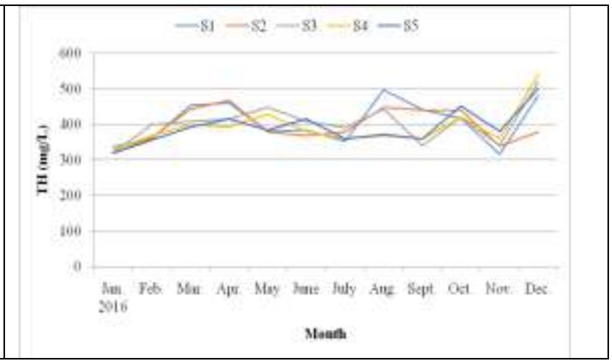
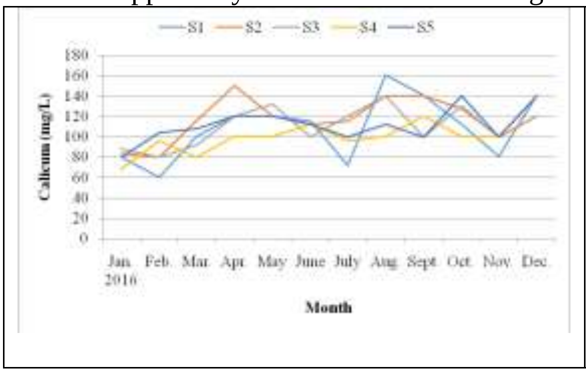


Figure 12-Variation of the BOD_5 values on the Dejiala River during the study period.

Figure 13- Variation of the total hardness values on the Dejiala River during the study period

On the other hand, the magnesium values ranged from 14.49 to 93.4 mg/L, with the lowest values during September at station 4 while the highest values were in June at station 3 (Table-1) and (Figure-15). The results of the statistical analysis found no any significant differences $p \leq 0.05$ among stations, with do not appear any correlation between magnesium with other parameter (Table-2).



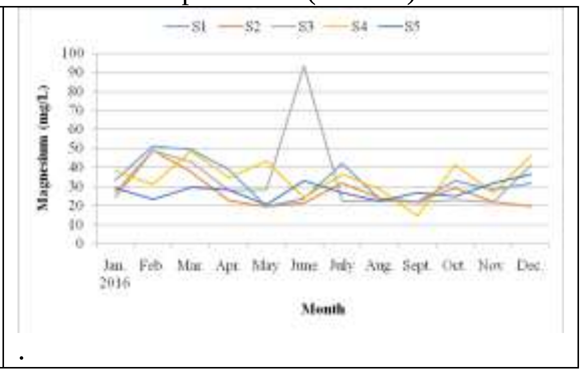


Figure 14- Variation of the calcium values on the Dejiala River during the study period.

Figure 15- Variation of the magnesium values on the Dejiala River during the study period.

Kevin [36] divided water into four types depending on total hardness as The values less than 50mg/L calcium carbonate as non-hard water, the water has values ranging from 50 to100 mg/L is moderate hard water, values from 100 to 200 mg/L is hardness water, and more than 200 mg/L calcium carbonate as a very hard water. According to total hardness values recorded in the present study, it can be noted that Dejiala River was very hard water [36].

The results of the present study show that the Dejiala River is within the permissible limit of natural water of 200 mg/L for calcium and 150 mg/L for magnesium [37]. It was showing from the present study that calcium concentrations are higher than magnesium concentrations at all stations that may be related with the strongly interacted for carbon dioxide with calcium than magnesium, so large amounts of calcium are converted to dissolve bicarbonate [38].

Sulphate values have been shown to increase (150mg/L) at stations 2, 4, 5. This may be due to the presence of farm land with adjacent to the river that uses sulphate fertilizers, especially in the agricultural season, for purpose to increase the productivity of field crops [11]. The results of the statistical analysis showed no any significant differences p>0.05 among the studied stations (Table-1 and Figure-16).

A significant positive correlation was found between sulphate with salinity, pH, total alkalinity, DO, BOD_5, POS, total hardness, bicarbonate, TDS and phosphates at $p \leq 0.01$, r = 0.648, r = 0.941, r = 0.736, r = 0.885, r = 0.921, r = 0.905, r = 0.751, r = 0.948, r = 0.610, r = 0.896 respectively, , also there was a significant negative correlation between sulphate and calcium was found at $p \leq 0.01$, r = -0.570 and a positive correlation between sulphates with air temperature and EC was found at $p \leq 0.05$, r = 0.433, r = 0.476 respectively (Table- 2).

It was recorded the values of bicarbonate in the Dejiala River, ranging from the lowest values(120 mg/L) in May at station 1, while the highest values(180 mg/L) during July at both of stations 1 and 3. The results of the statistical analysis showed no any significant differences p> 0.05 among stations (Table -1 and Figure 17). There was a strong positive correlation between bicarbonates with pH, total DO BOD_5, POS, total hardness, sulphate, TDS and phosphate at $p \leq 0.01$, r = 0.932, r = 0.768, r = 0.952, r = 0.969, r = 0.859, r = 0.623, r = 0.948, r = 0.516, r = 0.822, respectively, Also a positive correlation between bicarbonate with salinity was observed at $p \leq 0.05$, r = 0.513. There was also a significant negative correlation between bicarbonate with calcium at $p \leq 0.05$, r = -0.502 (Table-2).

Figure 16- Variation of sulphate values on the Dejiala River during period study.

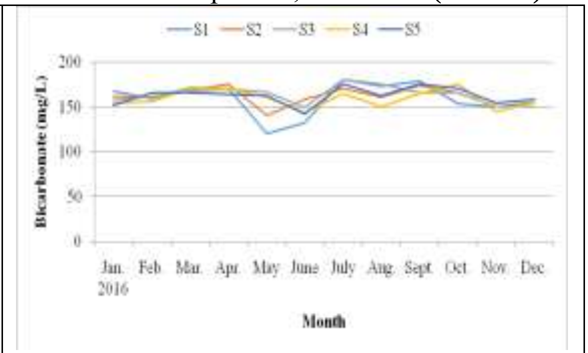


Figure 17- Variation of the bicarbonates ValuesOn the Dejiala River during the period study

The increase of bicarbonate at stations 1 and 3 may be due to the effect of wastewater [39] or may be associated with reduced discharges, turbidity and increase productivity or may be due to organic decomposition processes and its relationship to the increase and decreased level of carbon dioxide.

It was observed TDS elevation at station 3 (0.61 g/L) due to the fact that this station was surrounded by agricultural land. The salts that reach from the irrigation land also bring the water from some agricultural water to the river directly which increases the natural salts in the river water [6]. The results of the statistical analysis showed that there were no significant differences p>0.05 between stations (Table-1 and Figure-18). A positive correlation was found between TDS with EC, salinity, pH, DO, BOD_5, POS, total hardness, sulphate and bicarbonate at $p \leq 0.01$, r = 0.906, r = 0.958, r = 0.731, r = 0.586, r = 0.567, r = 0.616, r = 0.570, r = 0.570, r = 0.610, r = 0.516, respectively. A significant negative correlation was found between TDS with calcium at $p \leq 0.01$, r = -0.626 and a positive correlation was found with the total alkalinity $p \leq 0.05$, r = 0.492. There was also a negative correlation between TDS with turbidity at $p \leq 0.05$, r = -0.476 (Table-2).

It was found from the result that the values of TDS were within the permissible limits of 1.5 g/L [40]. Our result agrees with some previous studies such as: - Al-Kanani [41] when he recorded values was ranging from 4.21-7.77 g/L in the Tigris River, and Al-Khalidi [42] on the Shamiya River when he recorded values ranging from 0.4752-0.7 g/L.

The results of the present study showed the highest values of TSS (171 mg/L) with lowest values (1mg/L) was recorded at station 5 in June and February respectively. The results of the statistical analysis showed significant differences $p \leq 0.05$ among stations (Table-1 and Figure-19). A strong positive correlation was found between TSS with air and water temperature, total hardness and phosphates $p \leq 0.01$, r = 0.883, r = 0.896, r = 0.896, r = 0.714, r = 0.554 respectively (Table-2).

It was found high variation between stations, especially at station 5, may be due to the rain extent from the neighboring areas of the river or through agricultural activities [43]. USEPA [43] divided the water into three types depending on the TSS, as the concentration below 20 mg/L was pure, water with a TSS from 20-80 mg/L is low turbidity water, and values higher than 150 mg/L are turbid, so according to the recorded values of TSS, the water of the Dejiala River is turbid.

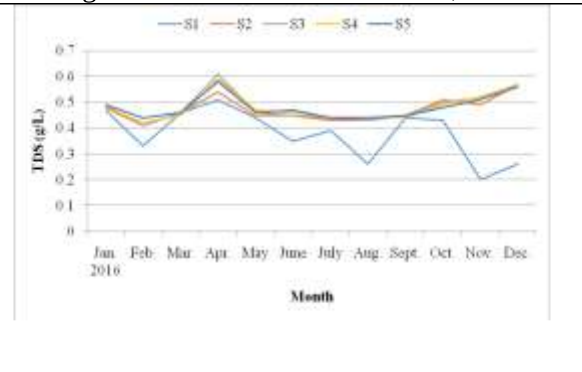


Figure 18- Variation of TDS values on the Dejiala River during the period study

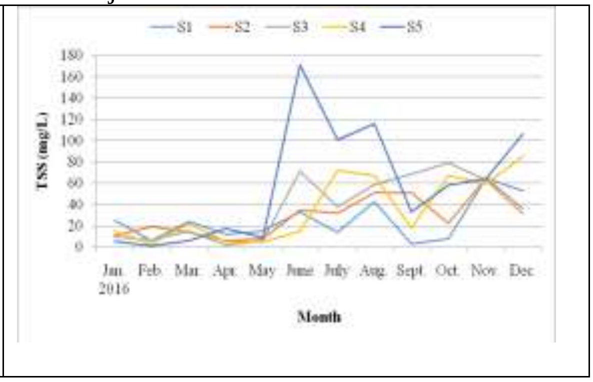


Figure 19- Variation of the total suspended solids values on the Dejiala River during the period study

It was showing from the result of nitrate, both of stations 1, 2 (2.205 mg/L) were recorded a significant increase in values due to the presence of this station near an agricultural area, so it receives a large amounts of agricultural wastewater that it carry of nitrogen fertilizers, which eventually return to the river, in addition to household wastes and animal waste disposal directly to the river [44]. The results of the statistical analysis showed no significant differences P> 0.05 among stations (Table-1 and Figure-20). There was a significant positive correlation between nitrate with turbidity at $p \leq 0.01$, r = 0.805. There was also a positive correlation between nitrate with air temperature at $p \leq 0.05$, r = 0.440 (Table-2). By observing the results of nitrate, we find it was less than the normal permissible limits (15 mg/L) for the Iraqi water standards [45].

The results of the phosphate in the Dejiala River showed the lowest value (0.011 mg/L) was recorded during December at station 1, while the highest value (0.082 mg/L) was recorded during April at station 4. The results of the statistical analysis showed no any significant differences p> 0.05 among stations (Table-1 and Figure-21). A significant positive correlation was found between phosphates with air and water temperature, pH, total alkalinity, DO, BOD_5, POS, total hardness, sulphate, bicarbonate and TSS at $p \leq 0.01$, r = 0.684, r = 0.651, r = 0.733, r = 0.763, r = 0.647, r = 0.741, r = 0.828, r = 0.804, r = 0.896, r = 0.822, r = 0.554 respectively. Also, the positive correlations were between phosphates with salinity $p \leq 0.05$, r = 0.434 and was found a significant negative correlation between phosphate with calcium at $p \leq 0.05$, r = -0.501.

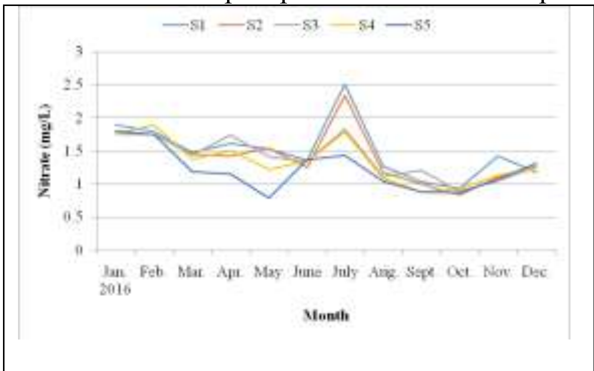


Figure 20- Variation of nitrate values in the Dejiala River during period study

Figure 21- Variation of the phosphate values on the Dejiala River during the period study

The increase of phosphate at station 4 may be due to the agricultural activity that located in near with river bank which using chemical fertilizers [3]. The results of this study agree with the study of Al-Nemrawi [46] when studying the Tigris and Euphrates Rivers, which ranged from ND to 0.023 mg/L in the Tigris River, while the values in the Euphrates River ranged from ND to 0.0412 mg/l, also agree with the study of Fleih [47] when he recorded on the Tigris River values ranging from 0.016-

0.19 mg /L. The results of this study are conflicting with Al-Saadi *et al.* [3] (5.4-27.1 mg/L), Al-Kubaisi *et al.* [48] (2.62-3.49 mg /L) in the Euphrates River, Al-Sarraf [49] (11-32 mg/L) in Tigris River, Al-Khalidi [42] (0.13-1.75 mg/L) in the Shamiya River, and Al-Azawii *et al.* [50] (3.03-176.5 mg/ L) in the Tigris River, This difference between the current study with previous studies may be due to the fact that the human, agricultural and industrial pressure on the Dejiala River was less than the previous rivers may be Dejiala River is a branch of the Tigris River, or may be due to the difference in the nature of drainage discharges from one river to another.

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