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The physico-chemical properties of southern part of Diyala River water

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Abstract

The present study aimed to assess the water quality status of Diyala River (Iraq).Some physical and chemical properties were studied also the impact of Rustumiya station for sewage treatment. water samples of Diyala River were collected for four seasons through 2015, to examine the following parameters (water temperature, pH, E.C., salinity, T.D.S., T.H., Ca., Mg., T.S.S., D.O., B.O.D., CL, SO4, NO3 and PO4). It observed by the results that the proportions of these variables have exceeded the Iraqi rivers conservation system No, 65 1967, especially at the third station of the River has been affected greatly as posed streams Rustumiya station to the river, which negatively affects aquatic life on one hand and on the farmland on both sides the river on the other hand, where the river water used for irrigation.

Keywords: Diyala River, water quality, physical and chemical properties.

الصفات الفيزياوية والكيمياوية للجزء الجنوبي من مياه نهر ديالى

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الخلاصة

هدفت الدراسة الحالية إلى تقييم حالة نوعية المياه في نهر ديالى (العراق). كما تم دراسة بعض الخصائص الفيزيائية والكيميائية لتأثير محطة الرستمية لمعالجة مياه المجاري. تم جمع عينات المياه من نهر ديالى لمدة أربعة مواسم خلال عام 2015، لدراسة العوامل التالية (درجة حرارة الماء والحامضية والتوصيلية الكهربائية والملوحة والاملاح الذائبة الكلية والعسرة الكلية والكالسيوم والمغنيسيوم والمواد العالقة الكلية والاوكسجين المذاب والمتطلب الحيوي للأوكسجين والكلورايد والكبريتات والنترات والفوسفات). وقد لوحظ من خلال النتائج أن نسب هذه المتغيرات قد تجاوزت نظام المحافظة على الأنهار العراقية رقم 65 لسنة 1967، وخاصة في المحطة الثالثة للنهر، وقد تأثرت بشكل كبير من مطروحات محطات الرستمية إلى النهر، مما يؤثر سلبا على الحياة المائية من جهة وعلى الأراضي الزراعية على جانبي النهر من جهة أخرى، حيث تستخدم مياه النهر للري.

Introduction

Water contamination is the pollution of water bodies (e.g. lakes, rivers, seas, aquifers and groundwater). This type of environmental degradation happens when pollutants are directly or indirectly released into water bodies without adequate treatment to prevent harmful compounds. Surface waters are most exposable to contamination due to their easy accessibility for disposal of

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wastewaters [1]. Contamination is constantly becoming a serious problem, mainly caused by the disposal of untreated sewage and nitrates industrial waste, from animal waste and chemical fertilizers.

In the capital city of Baghdad, the surface water experiencing impact of traditionalist contaminations. Baghdad city has rivers, the main river Tigris River and Diyala River in boundary of Baghdad City (Diyala Bridge) eastern of Baghdad as is shown in Figure-1[2].

Diyala provincial council confirmed at the beginning of 2013, that 60% of the pollution in the province's rivers and streams are a result of the citizen's actions and demanded the spreading of environmental preservation awareness to maintain the necessary components of life [3].

Most rivers and streams in Diyala province suffer from an exponential increase in environmental contamination rates coming from various factors namely the negligence of citizens and the Irregularities of many service administrations that discharge their waste directly into the rivers. Diyala River is considered to be one of the main rivers in the province extends through more than 150 km. the path of the begin from Iran and it is considered to be one of Tigris most important feeders.

Study Area

The Diyala River is an important tributary of Tigris River that flow through Iran and Iraq which drains an area of 32,600 km2 [4]. Diyala River arises near Sanandaj in the Zagros Mountains in Iran, forming the Iran- Iraq border for over 30 km. With a total length of 574 km [5], the river has a drainage area of 32,600 km^2, of which 25% are located in Iran and 75% in Iraq [6]. Diyala joins Tigris 15 km south of Baghdad [5]. The most important branches of the river are Tangro, Sarawan and Wand. It passes through Hemreen mountain series and divided into several streams such as the north Diyala, Al-Khalis, Rose, Haronia, Shahraban, Mahrute and Khraisan. Three dams were established on the river, namely Darbandekhan (3×10^9 m^3), Diyala (regulated dam) and Hemreen (4×10^9 m^3). where station 1(st.1) was located 1.8km north Rustamiya wastewater plant, while st.2 at new Diyala bridge after the outflow north Rustamiya in Diyala River where it away from the first station 2.8 km, st.3 located at AL_Rasool bridge after the outflow south Rustamiya in Diyala River where it away from the second station about 9.6 km, the fourth station it's located at the meeting point of Diyala tributary with the Tigris River Figure-1.

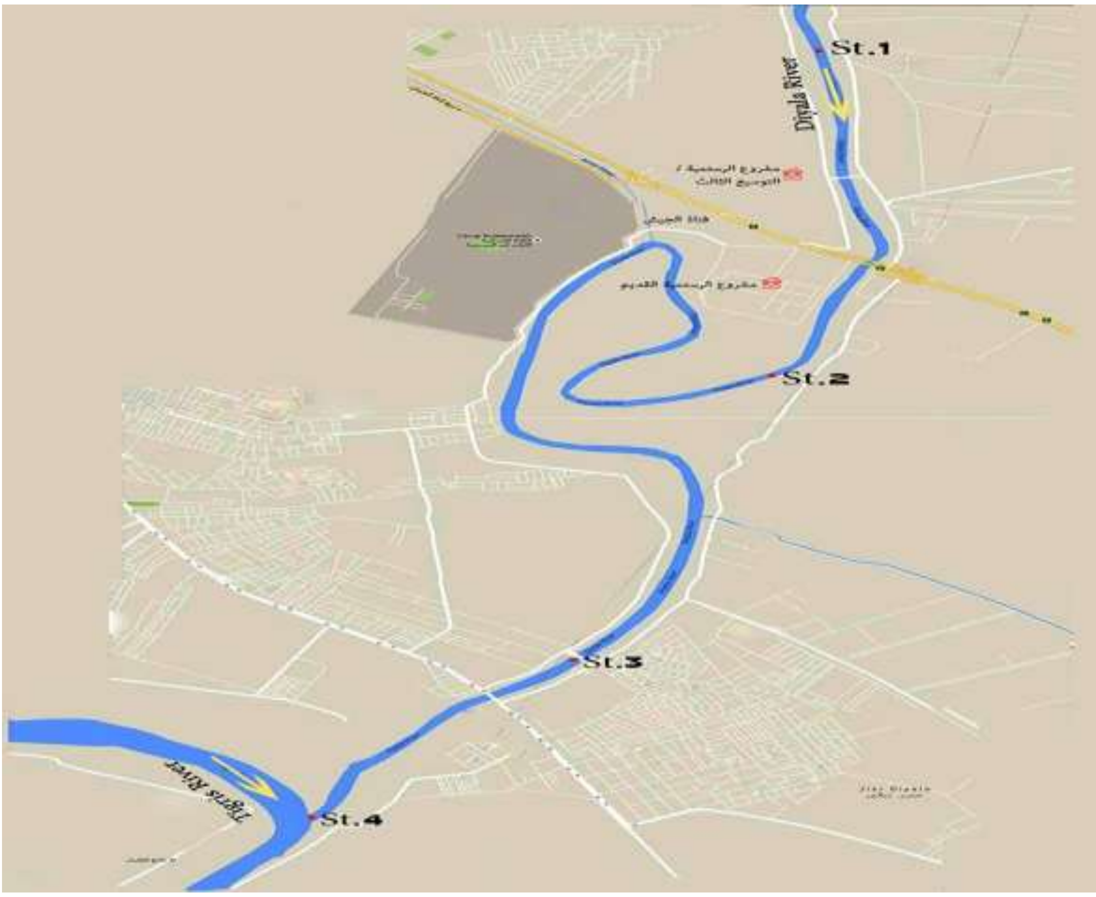

Figure 1-study area showing the sampling stations.

Procedures and Methods

Water temperature was measured in the field with a mercury thermometer (0-50 ^{o}C) graduated up to 0.1 intervals, at the depth of 20cm. Electrical conductivity and pH value were measured directly in the field by using portable pH-meter model(WTW pH. 720). Dissolved oxygen and BOD_5 were determined by using Winkler's method. Other parameters like total suspended solids (TSS), total hardness, calcium (Ca^{+2}), magnesium (Mg^{+2}), Nitrate (NO^{-3}), chlorides (Cl^{-}), Phosphate (PO4), were determined following standard methods [7]. Total hardness and calcium were estimated using EDTA titration. Sulphate determined by using UV-spectrophotometer at a wavelength of 420nm, while nitrate measured by UV-spectrophotometer at a wavelength of 220nm. Phosphate was determined by spectrophotometer at wavelength of 860nm.The Statistical Analysis System- SAS [8] program was used to effect of difference factors (Station and Season) in study parameters. Least significant difference –LSD test was used to significant compare between means in this study.

Results and discussion

The overall range in water temperature (W.T.) was at minimum values (10c˚) in winter and at maximum values (30c˚) in summer. The variations in temperature may be due to different timings of collection, contrasting the seasons and the effect of atmospheric temperature. The statistical analysis showed that there was a significant difference in water temperature between seasons and there were no significant differences among stations Table-1. The significant positive (r = 0.846, 0.634) correlation between water temperature and pH, BOD respectively was observed in present study. The negative correlation was observed between water temperature and Mg^{+2}, DO, $NO_3$and PO_4.

pH values be with alkaline side throughout the duration of the study period in all the studied stations which is common in Iraq's inland waters [9] High value of pH was (8.1) recorded in summer at station 3 where lower value was (7.2) in winter at st.1 and in autumn at st.2 this may be due to the decomposition of organic matters which is noticed in a major amounts in this stations. This value was within the Iraqi standards for water quality in 1998 [10] and maintenance Iraqi rivers system in 1967 [11]. The statistical analysis showed that there was no significant difference in pH degree between seasons and there were no significant differences among stations Table-2. The results showed strong positive correlation (r = 0.846) correlation between water temperature and pH was observed in present study. The negative correlation(r =-0.524) was observed between pH and, NO_3.

Within a period study recorded the highest values of the EC and salinity (3200µS/cm, 2‰) respectively, at st.3 during the spring, while the lowest values was (1025 µS/cm, 0.65‰) respectively, at st.1 during spring. higher values readings of conductivity and salinity may be due to the rainfall will be drift the salts from the area which surround the river and the discharge of the Rustumiya sewage treatment plant (RSTP), then increase salts concentration as so as increase of many pollutants concentration [12]. These values were similar to those recorded in this river by other studies [13, 14, 15]. The statistical analysis showed that there was a significant difference in EC& salinity between seasons and there were no significant differences among stations Table-(3, 4). The results showed strong positive correlation between EC & salinity and TDS, TH, Ca, Mg and TSS was observed in present study. The negative correlation(r =-0.524) was observed between EC, salinity and pH.

The total dissolved solids (TDS) values were showed high value (2115mg\l) at st.3 during spring while the low value (1150mg\l) recorded at st.1 during winter. High value may be due to the rainy seasons and period of high discharge. These values exceeded the Iraqi standers for water quality in 1998. The statistical analysis showed that there was a significant difference in TDS between seasons except in st.1 and there were significant differences among stations except in autumn (Table-5). The results showed strong positive correlation (r=0.805 and 0.751) between TDS and Ca & TSS respectively.

Total Hardness (TH), Ca, Mg and Total Suspended Solids (TSS) during study period were recorded high values (1055 mg\l, 225 mg\l, 200 mg\l and 295 mg\l) respectively at st.3 during spring may be due to high rate of rain and the large amounts of sewage water which discharged from (RSTP) to the river. The statistical analysis showed that there was a significant difference in (TH) between seasons and there were significant differences among stations except in autumn and winter Table-6. Also the statistical analysis showed that there was a significant difference in (TSS) between seasons and there were significant differences among stations (Table-9). Positive correlation (r=0.638, 0.692, 0.687 and 0.751) were observed between TSS and (TH, Ca & Mg) respectively.

Depletion of dissolved Oxygen (D.O.) was observed in Diyala River at st.3 during summer this may be due to the oxidative and fermentative degradation of organic matter drained with sewage from the (RSTP).and the raise of temperature to 30 ^{o}C that leads to decline dissolved oxygen concentration in water. High value of D.O. (10.7 mg\l) was recorded at st.1 during spring. This may be due to the increase aeration because of rainfall, in addition to the decrease of temperature in winter that increases the oxygen solubility [16]. Higher water flow during winter is suggested to contribute significantly in elevating dissolved oxygen concentrations the disturbance of water could lead to the increase of dissolved oxygen in water [17]. The statistical analysis showed that there was a significant difference in (DO) between seasons except in st.1 and 4 and there were significant differences among stations (Table-10). The results reveals negative correlation (r= -0.59, -0.703, - 0.89 and - 0.76) between DO and (W.T., E.C., TDS and TSS) respectively.

As for the results of vital oxygen demand it was high during the summer (195 mg\l) at st.3. While the lowest value during the winter (1.1 mg\l) at st.1. BOD_5 values were found above the maximum permissible levels for protection of aquatic life 1998. The high BOD_5 value during summer was probably linked to the level of organic matter load from sewage, industrial or urban discharges as reported by Chapman [18]. The BOD_5 results from station 3 were higher than other stations because the high discharge sewage. Generally, the increase of BOD_5 in Diyala River returned to the river affect by agriculture area which surround the river especially in study area, this agriculture area enriched by organic matter. The statistical analysis showed that there was a significant difference in (BOD) between seasons except in st.1 and there were significant differences among stations (Table-11). The results showed positive correlation (r= 0.634, 0.726, 0.842 and 0.704) between BOD and (W.T., E.C., TDS and TH) respectively.

The high value of chloride ion (400 mg/l) was recorded at st.3 during spring while the low value (78 mg/l) was at st.1. The increase of Cl^- value at station 2 indicates to pollution by sewage in the waters of Diyala River due to the discharged sewage from Al-Rustamiya plant enriched with organic matter, this phenomenon was proved by [19, 13, 20, 9]. The statistical analysis showed that there was a significant difference in (Cl^-) between seasons and there were significant differences among stations except in autumn (Table-12). The results showed strong positive correlation (r= 0.942) between Cl^- and (SO_4) and negative correlation (r= -0.668 between Cl^- and NO_3.

According to the results the lowest value of (SO4=) was 290 mg\l at st.1 during spring while the highest value was 990 mg\l at st.3 during summer. The higher concentrations of sulphate were detected at study area at station 3, and this may be due to untreated domestic sewage of the Al-Rustamiya and from the agriculture area which surround the river. The values obtained for each of the locations in Diyala River are exceed the permissible limit for both Iraqi standards for drinking water which was 200 mg/L, and within WHO standards drinking water (2004), which was 250 mg/L and Iraqi standards for water quality (1998), which was 150 – 250 mg/L. The statistical analysis showed that there was a significant difference in (SO4=) between seasons and there were significant differences among stations (Table-13).

Data of NO3= in this study showed the high value was 1.4mg\l at st.1 during summer and the low value was 8.8mg\l at st.2 and 3 during winter. The high level of nitrate may be returned to be due to Al- Rustamiya discharges and local run-off from the adjacent crop field in these areas where the farmers had used Nitrogen-fertilizers, as well as bacterial activity which convert nitrite to nitrate and the decomposition of organic compounds. And the lowest values may be attributed to the consumption of nitrate by phytoplankton growth and reduction of nitrate to nitrite in the bottom [21, 22]. The statistical analysis showed that there was a significant difference in (NO3=) between seasons and there were significant differences among stations except in spring (Table-14).

Phosphate in Diyala River water varied from 0.15mg\l to 3.7 mg/L. The phosphate concentrations increased during summer in the study at station 3 and decreasing during autumn at station 1. The statistical analysis showed that there was a significant difference in (PO_4) between seasons and there were significant differences among stations (Table-15).

Table 1-The seasonal variation of Water temperature (C) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	10.33	21.00	29.00	17.33	5.72 *
St 2	10.33	21.00	29.00	17.33	5.72 *
St 3	10.33	21.00	29.00	17.33	5.72 *
St 4	10.33	21.00	29.00	17.33	5.72 *
LSD value	2.50 NS	3.75 NS	3.92 NS	2.64 NS	---
* (P<0.05), NS: Non-significant..					

Table 2-The seasonal variation of pH at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	7.53	7.80	7.56	7.23	0.74 NS
St 2	7.50	7.67	7.76	7.33	0.82 NS
St 3	7.23	7.70	7.86	7.67	0.76 NS
St 4	7.46	7.70	7.67	7.50	0.63 NS
LSD value	0.83 NS	0.77 NS	0.79 NS	0.67 NS	---
NS: Non-significant.					

Table 3- The seasonal variation of E.C (µS/cm) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	2230.00	1187.00	2670.00	1886.67	464.78 *
St 2	2381.67	2645.00	2930.00	1960.00	396.77 *
St 3	2483.33	2906.67	2995.00	1995.00	478.21 *
St 4	2430.00	2790.00	2893.33	1903.33	462.35 *
LSD value	483.12 NS	502.39 *	312.94 NS	251.07 NS	---
* (P<0.05), NS: Non-significant.					

Table 4-The seasonal variation of Salinity (‰) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	1.42	0.75	1.70	1.20	0.431 *
St 2	1.52	1.69	1.86	1.25	0.406 *
St 3	1.58	1.83	1.89	1.27	0.378 *
St 4	1.54	1.80	1.84	1.20	0.329 *
LSD value	0.339 NS	0.485 *	0.359 NS	0.225 NS	---
* (P<0.05), NS: Non-significant.					

Table 5-The seasonal variation of TDS (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	1214.67	1445.33	1455.00	1271.67	269.04 NS
St 2	1643.33	1816.67	1912.33	1357.33	385.92 *
St 3	1686.67	1937.00	1955.33	1366.67	341.06 *
St 4	1655.00	1988.33	1790.67	1303.33	329.52 *
LSD value	248.03 *	271.66 *	262.94 *	169.42 NS	---
* (P<0.05), NS: Non-significant.					

Table 6-The seasonal variation of T.H. (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	781.67	513.33	728.00	731.67	98.33 *
St 2	850.00	853.33	883.33	751.67	72.96 *
St 3	850.00	968.33	893.33	791.67	103.89 *
St 4	763.33	930.00	776.67	741.67	97.31 *
LSD value	89.42 NS	102.68 *	84.52 *	77.24 NS	---
* (P<0.05).					

Table 7-The seasonal variation of Ca (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	138.33	134.33	128.33	128.67	31.07 NS
St 2	146.67	196.00	154.67	129.33	42.92 *
St 3	166.67	199.33	164.67	140.67	37.85 *
St 4	156.33	170.67	144.67	131.67	37.02 *
LSD value	36.85 NS	51.72 *	47.49 NS	22.75 NS	---
* (P<0.05), NS: Non-significant.					

Table 8-The seasonal variation of Mg (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	156.32	92.12	145.71	146.52	48.23 *
St 2	170.90	159.73	177.00	151.19	37.68 NS
St 3	166.02	186.44	177.00	158.19	32.06 NS
St 4	147.49	184.48	153.53	148.20	35.13 *
LSD value	38.04 NS	44.35 *	37.59 NS	29.63 NS	---
* (P<0.05) , NS: Non-significant.					

Table 9-The seasonal variation of TSS (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	58.67	54.00	88.00	52.67	28.81 *
St 2	72.33	81.00	253.00	76.67	49.15 *
St 3	118.33	277.33	258.67	99.33	46.97 *
St 4	106.33	194.33	166.67	80.67	41.88 *
LSD value	26.71 *	38.92 *	33.05 *	28.65 *	---
* (P<0.05).					

Table 10-The seasonal variation of DO (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	10.13	8.86	7.86	9.13	2.98 NS
St 2	8.23	2.86	3.83	7.53	2.74 *
St 3	5.60	1.70	1.06	4.76	2.68 *
St 4	7.00	4.30	4.73	6.43	2.94 NS
LSD value	3.09 *	2.86 *	2.77 *	3.18 *	---
* ($P<0.05$), NS: Non-significant.					

Table 11- The seasonal variation of BOD (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	2.30	2.70	1.67	2.06	1.44 NS
St 2	23.60	124.00	146.33	12.80	36.72 *
St 3	42.00	144.00	194.33	30.00	32.88 *
St 4	34.33	92.33	153.33	20.67	29.06 *
LSD value	16.75 *	25.66 *	31.09 *	14.32 *	---
* ($P<0.05$) , NS: Non-significant.					

Table 12-The seasonal variation of Cl (mg/l) at stations.

Station	**Season**				LSD value
	Winter	Spring	Summer	Autumn	
St 1	243.33	109.00	273.33	250.67	49.32 *
St 2	311.67	311.67	359.67	254.67	57.94 *
St 3	314.67	375.00	391.00	291.33	51.02 *
St 4	283.33	266.67	308.33	266.67	43.95 *
LSD value	46.69 *	52.09 *	41.33 *	43.72 NS	---
* ($P<0.05$) , NS: Non-significant.					

Table 13-The seasonal variation of SO_4 (mg/l) at stations.

Station	Season				LSD value
	Winter	Spring	Summer	Autumn	
St 1	685.00	423.00	763.33	430.67	109.55 *
St 2	740.67	840.67	890.00	515.00	97.41 *
St 3	772.67	862.00	933.33	570.00	118.64 *
St 4	725.00	845.00	816.67	525.67	106.32 *
LSD value	62.58 *	135.73 *	87.44 *	75.96 *	---
* (P<0.05).					

Table 14-The seasonal variation of NO_3 (mg/l) at stations.

Station	Season				LSD value
	Winter	Spring	Summer	Autumn	
St 1	2.56	4.67	1.63	2.13	1.79 *
St 2	7.60	5.13	3.20	2.33	2.07 *
St 3	8.10	5.67	4.20	4.73	1.96 *
St 4	4.23	5.40	3.20	2.53	1.83 *
LSD value	2.39 *	1.86 NS	1.94 *	1.66 *	---
* (P<0.05) , NS: Non-significant.					

Table 15-The seasonal variation of PO_4 (mg/l) at stations.

Station	Season				LSD value
	Winter	Spring	Summer	Autumn	
St 1	0.93	0.34	0.45	0.167	0.469 *
St 2	1.67	2.60	1.40	0.753	0.702 *
St 3	2.30	3.20	3.60	2.48	0.665 *
St 4	1.73	2.87	1.90	1.46	0.652 *
LSD value	0.667 *	0.508 *	0.684 *	0.631 *	---
* (P<0.05).					

Conclusions

1- The physico-chemical parameters were exceeded their standard limits concerning of aquatic life protection particularly at station 3 except water temp., pH and NO_3.

2- The Rustumiya sewage treatment plant had major role in the deterioration of the Diyala River water quality at the study area

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