LIMNOLOGICAL STUDY OF DIYALA RIVER, IRAQ

F. M. Hassan[1*] N. A, J. Al- Zubaidi[2] O. S. Youssef[2]
Prof. Prof. Researcher
[1]Dept. Biol., Coll. Sci. for Women, Univ. of Baghdad
[2] Dep. Biol., Coll. Educ. Pure Science for Women, Univ. Diyala
fikrat@csw.uobaghdad.edu.iq

ABSTRACT

This study was conducted to evaluate the physicochemical and biological (epiphytic algae) properties of Diyala river. Eighteen environmental parameters were selected in addition to the qualitative study of epiphytic algae (total number of algae and chlorophyll a). Two macrophytes (*Phragmites australis* and *Certatophyllum demersum*) were selected for the benthic study. The results showed that the river was alkaline, very hard, brackish water and good aerated. The trophic level is ranged from oligotrophic to mesotrophic according to the results of total phosphorus, total nitrogen, and chlorophyll a. The study revealed that the upper part of the river differed in its properties from the middle and the lower part in the environmental characteristics and the Algal benthic quantities.

Key words: benthic algae, environmental factors, lotic systems, trophic level, limnology.

مجلة العلوم الزراعية العراقية -2018 :49(3):452-462 حسن وآخرون

دراسة لمنولوجية لنهرديالى، العراق

فكرت مجيد حسن[1] نجم عبد الله جمعة الزبيدي[2] عمر شعلان يوسف[3]
أستاذ أستاذ باحث
[1]قسم علوم الحياة – كلية العلوم للبنات– جامعة بغداد، العراق
[2] قسم علوم الحياة – كلية التربية للعلوم الصرفة، جامعة ديالى، العراق
fikrat@csw.uobaghdad.edu.iq

المستخلص

اجريت هذه الدراسة لتقيم الخصائص الكيميائية والفيزيائية والبايولوجية (الطحالب الملتصقة على النباتات) لمياه نهر ديالى لمياه نهر ديالى اختيرت ثمان عشر عاملا بيئيا بالاضافة الى دراسة كمية للطحالب الملتصقة (العدد الكلي و الكلوروفيل أ). واختيرت نباتيين (القصب والشمبلان) لدراسة الطحالب الملتصقة عليها. اظهرت نتائج الدراسة بان مياه النهر قاعدية و عسرة جدا وذات تهوية جيدة. حاله العناصرالغذائية فيها تتراوح بين فقيرة ومتوسطة الحالة بالاعتماد على نتائج الفسفور الكلي والنتروجين الكلي والكلوروفيل أ. استنتجت الدراسة بان اعالي النهر تختلف بخصائصها البيئية عن الوسط واسفل النهر وكذلك في كمية الطحالب القاعية.

الكلمات المفتاحية: الطحالب القاعية، العوامل البيئية، بيئة المياه الجارية، الحالة الاغتذائية، لمنولوجية لنهرديالى.

*Received:29/11/2017, Accepted:18/1/2018

INTRODUCTION

The world bank (38) announced that the availability of water in the Middle East and North Africa were facing the water scarcity in the present and in the future. Iraqi water resources are suffered from the shortage of water supply from the upstream of the Tigris and the Euphrates rivers and the Tigris river tributaries for many reasons (3). This scarcity will effect on the water quality of rivers and increases the effect of water pollution (24). The monitoring water body is important to save these water resources through determining the physicochemical and biological parameters (13, 15, 37). The study of these parameters is considered as important indicators of water quality and for evaluation purpose of assessing their suitability for different uses of water (17). Furhan et al. (17) investigated the water quality of River Soan (Punjab, Pakistan) by determining the physicochemical parameters and phytoplankton, to evaluate the river water quality. This study showed that the river has a good quality. Another study also used physicochemical parameters for water quality evaluation for the tributaries of the river Beas in Himalayan region in India, they found that the water quality is within the acceptable limits (7). In addition, Marques et al. (26) reported that the water chemistry of river-related is to its physiographical features. Hassan et al. (21) found that the Diyala river water quality is ranged from poor to marginal by using some environmental factor and applied Water quality index. Madhloom et al. (24) found that some studied environmental factors are exceeded the acceptable limits at the lower reaches of the river. Other studies reported the effect of pollution on water quality of the Diyala river (30, 40). Macrophytes and Benthic algal communities were played a role in river ecosystems by different processes such as increase productivity, cycling nutrients, reduce the erosion process from the river banks and food source of other organisms (28, 34). Benthic algae (epiphytic) was used as bioindicators and Biomonitoring the river water quality (9, 10, 12). Bellinger and Sigee (10) reported that the diatoms are used as bioindicators, and these groups of algae have the ability to resist the alteration in the environmental condition in a lotic ecosystem. Shaawiat and Hassan (32) used the diatomic community as water quality indicators, and the study results indicated that the river was clean with moderately polluted. The objective of this tady to investigate the physicochemical properties of the Diyala river and qualitative study of benthic algae in Diyala River.

MATERIAL AND METHODS

Site Study: Diyala river is the largest tributaries of the Tigris river (with length 386Km inside Iraqi territory) (Figure 1). This tributary is characterized by its meandering during its course (5). Its catchment is divided into three parts, where these parts are different in its morphology and its altitude from the sea level (5). The first part (A) represented the upper reaches of the river (55-65m above sea level), while the third part (C) was the lower reach of river before joining into the Tigris river (35-45 m above sea level), and the second part (B) was between them and represented the middle part of the river (Table 1). Three sites were selected, the first site (Al-Sadour) is located 10km from Hemren dam, the second site is located in the Baqubah city (a 50 Km from Baghdad city), while the third site (Diyala bridge) is represented the lower reaches river (a 17K, from Baghdad city). The climate of the study area is characterized by hot desert climate (CSO, 2012-2013).

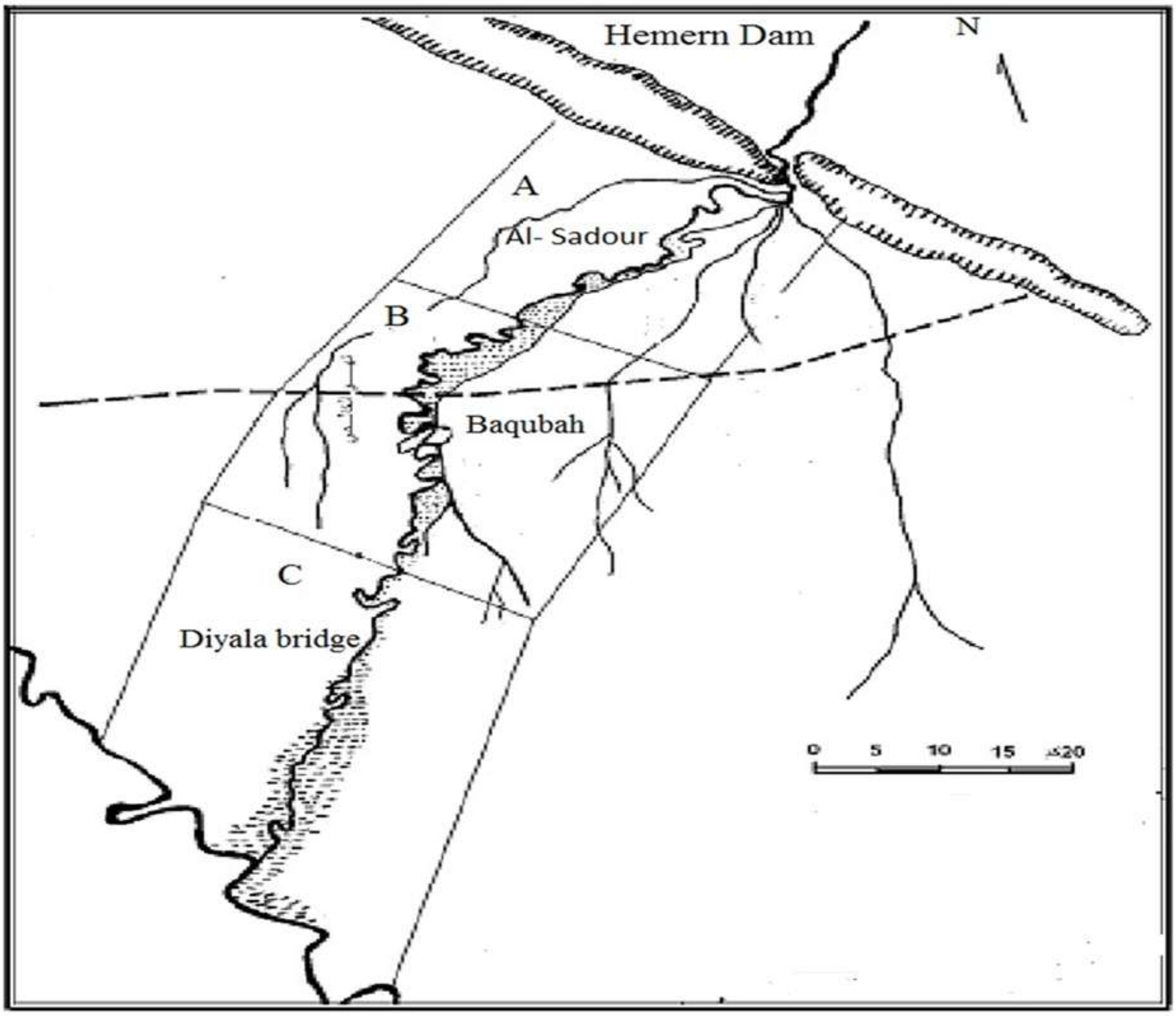


Figure 1. Map of the study area (followed Al-Qayim (5)

Table 1. Coordinates and some morphometric properties of Diyala River.

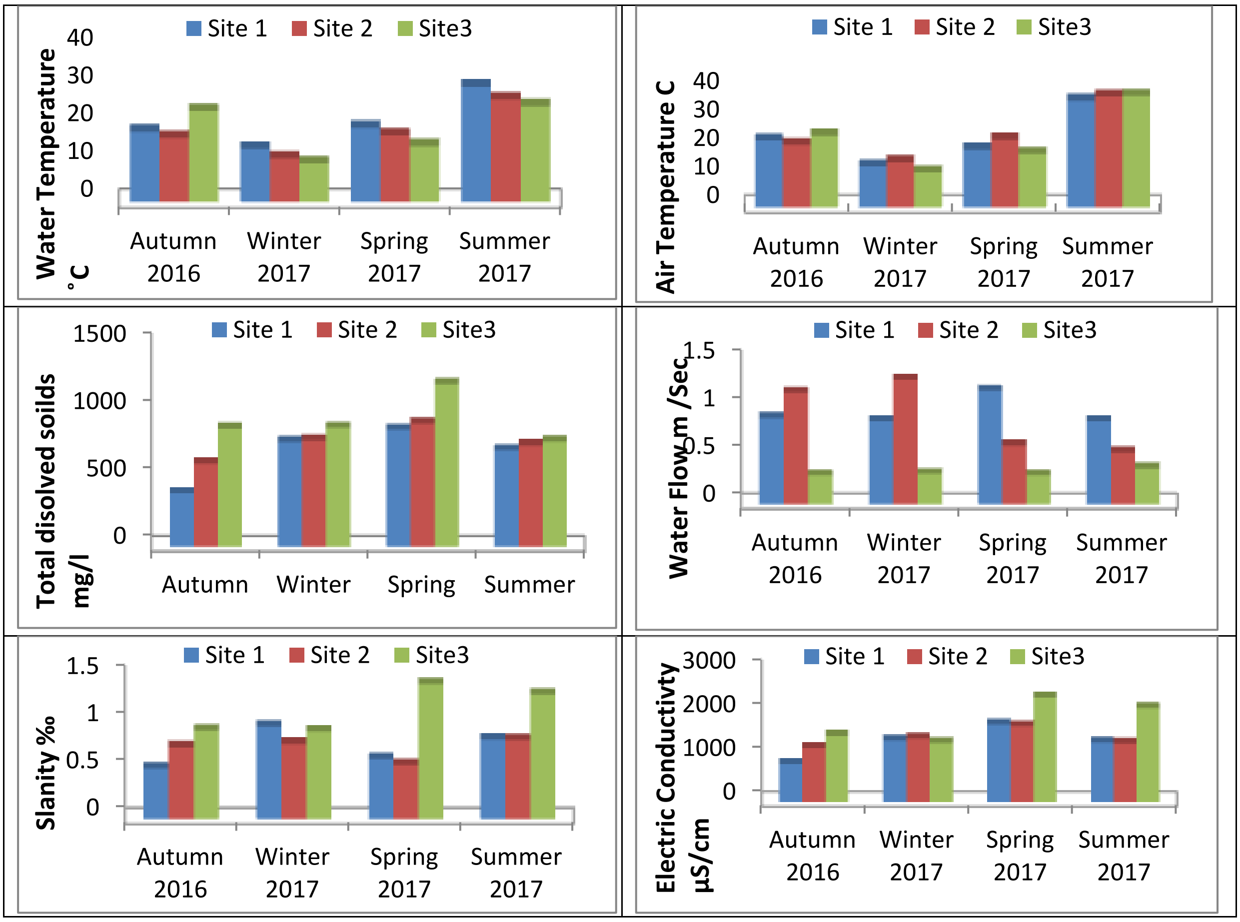
Sites	Longitude (eastwards)	Latitudes (northward)	Meanders degree	Slop cm/Km	Depth m	Elevation m
1	44.22 °39' 34"	54.92 58' 44"	1.4	43	1.64	65
2	41.87 °44' 33"	54.29 37' 44"	2.42	17	3.04	46
3	40.69 °61' 33"	25.05 °32' 44"	1.5	26	3.2	35

Sampling

Eighteen environmental factors were determined and collected monthly with three replicates from each site, the results were expressed as seasonally. All selected factors were measured according to APHA (6). These factors included as follows: Temperature (air (TA) and water TW), water flow (WF), electric conductivity (EC), light penetration (LP), turbidity (Tub), total dissolved solids (TDS), total suspended solids (TSS), pH, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), salinity (S‰), total alkalinity (TA), total hardness (TH), calcium (Ca) and magnesium (Mg), moreover, total nitrogen (TN), total phosphorus (TP) and silicate (SiO_3). Also, the total number of epiphytic algae and chlorophyll-a were studied. The epiphytic algae were collected from two macrophytes (*P. australis* and *C. demersum*). The macrophytes samples were collected from sites and kept in plastic bags with a little of the river water in the field with a buffer formalin (4%) to a set of sample and another set without preservative solution. In a laboratory, foramm wet weight (WW) from each plant was used for quantitative study of epiphytic algae following the perception method (16). Haemocytometer method was used for counting the non diatomic algae (25) and micro transect method for diatoms count. used determination of chlorophyll-a Jaschinski et al. (23). was the extraction of chlorophyll-a done by Aceton (90%).The statistical package for the social sciences (SPSS) was used.

RESULTS AND DISCUSSION

The Iraqi climate is characterized by obviously wet and dry seasons, with high temperature in summer and low in winter (11). This phenomenon is clear in this study (Figure 2) the temperature values were ranged from 12.23 ̊C in winter at site 2 to 46.26 ̊C in summer at site 3 for air temperature, while for water temperature were 10.23 ̊C to 30.35 ̊C in winter and summer at site 3 and 1, respectively. Water flow has a big role in recirculation of physicochemical characteristics of the river and impact on aquatic organisms in the water column (37). The minimum value of water flow recorded at site 3 (0.3m/Sec) and the maximum value was 1.3 m/Sec at site 2. Al-Qayim (5) mentioned that the part B (site 2) is characterized by more meandering and fast water flow. A significant correlation noticed between water flow, light penetration and pH (0.568 and -0.569, P< 0.05). The lowest value (29.1 cm) of light penetration recorded in winter at site 3 and the high value was 77.16 cm at site 1 in the spring. This finding related to the low water flow in site 1 and it's a way of pollution, while the lowest value recorded at site 3 due to the discharge of sewage into the river and weather condition (22). The statistical analysis result showed a significant difference temporary and spatial except in site 3. A positive correlation noticed between light penetration and dissolved oxygen and a negative correlation with biochemical oxygen demand and turbidity (P< 0.05). Light penetration is inversely correlated to turbidity (29, 37). The lowest value of turbidity (8.08 NUT) recorded in spring at site 1 and the highest value was 43.54NUT in summer at site 3. Only a significant difference noticed temporary, and its value correlated significantly with pH, total al alkalinity and total hardness (r= 0.568, r= 0.586, r= 0.659, P< 0.05, respectively)



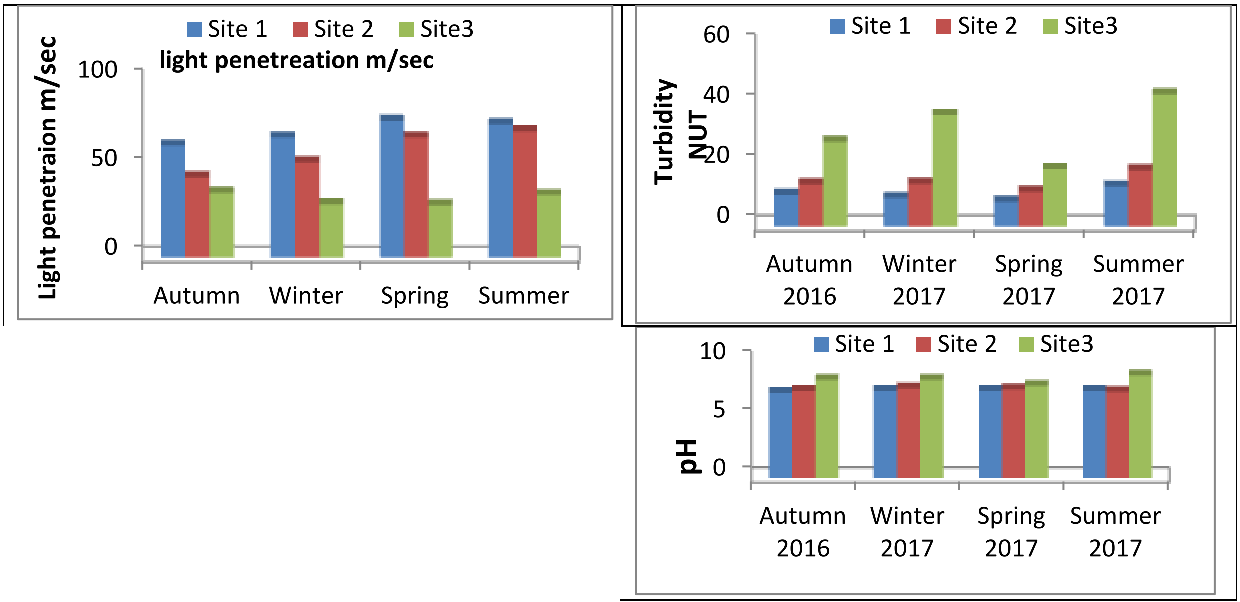


Figure 2. Seasonal variation of some physicochemical factors in Diyala river during the we study period

The Iraqi water ecosystems are characterized by high capacity of buffering with narrow range variations of pH due to high contents of bicarbonate and carbonate in Iraqi water systems (10, 23). The TDSwas ranged from 654 mg/l at site 1 in March 2016 to 1109mg/l at site 3 in November 2015 (Table 2, Figure). There are many factors affect the TDS values such as The high values of turbidity in this study is caused by the water flow, the geophysical properties of the river, in addition to anthropogenic sources (18). TSS and TDS values were ranged from 0.127 mg/l and 395.5 mg/l in spring and autumn at sites 2 and 1, respectively, and 395.5 mg/l and 0.620mg/l and 1203.00mg/l in winter and spring at sites 1 and 3, respectively. A significant difference was recorded among sites and seasons except in site 3 ($P< 0.05$). The highest values of these factors are caused by anthropogenic, weather factors and geological features of the area (19). The results of EC and salinity were ranged from 867.33µS/cm and 0.53‰ in winter and autumn at site 1, respectively, and 2370µS/cm and 1.305‰ in summer at site 3. According to these results, the water river is classified as brackish water (33). The Iraqi water aquatic systems are known as the high capacity of the buffering system (1, 14). pH values were 7.3 in autumn at site 1 and 8.8 in summer at site 3. A significant difference is noticed temporary and spatial for pH values, except between summer and spring at sites 1 and 2 ($P< 0.05$). Total alkalinity values is ranged from 54.2 mg /l in autumn at site 1 and 122.33 mg/l in winter at site 3. The alkalinity is indicated to the carbonate and bicarbonate content in water (6) and the variation of its value was related to the primary productivity status and hydrology properties of the water system (20). Significant differences are noticed temporary and spatial except in summer and at site 3, also a significant correlation with pH ($r= 0.754$, $P< 0.05$). The results showed that the dissolved oxygen values were recorded higher than 4mg/l along the study period (Figure 3). The lower value recorded on site 3 and the highest values at site 1 in autumn and spring, respectively. Temporary significant differences were noticed except in autumn. A significant correlation between dissolved oxygen and light penetration and water flow obtained ($r= 9.09$, $r= 0.665$, $P< 0.05$). BOD values ranged from 1.26 mg/l to 34.3 mg/l in winter and summer at sites 1 and 3, respectively. The high values of BOD indicated to the polluted river (36). Total hardness values are ranged from 295.9 to 704.6 mg $CaCO_3$/l in summer and winter at site 1 and 3, respectively. These results indicated that the water river ranged from hard to very hard (37). A temporary and spatial significant difference of hardness values is noticed except at site 2. Many factors are controlled the hardness values such as the soil erosion from the river banks causes rain and irrigation of agricultural areas (35). Calcium concentrations ranged from 78.38mg/l to 137.8 mg/l in summer and autumn at sites 1 and 3, respectively. While the lowest magnesium concentration was 20. 24 mg/l in autumn at site 1 and the highest concentration was 79.71mg/l in spring at site 3. There was a significant correlation between calcium and some factors such as pH, TDS, total alkalinity, total hardness, turbidity, electrical conductivity, salinity and BOD (r=0.679, r= 0.725, r= 0.652, r= 595, r= 0.770, r= 0.711, P< 0.05). The high values of calcium caused by the nature of calcareous sediment of the river (32).

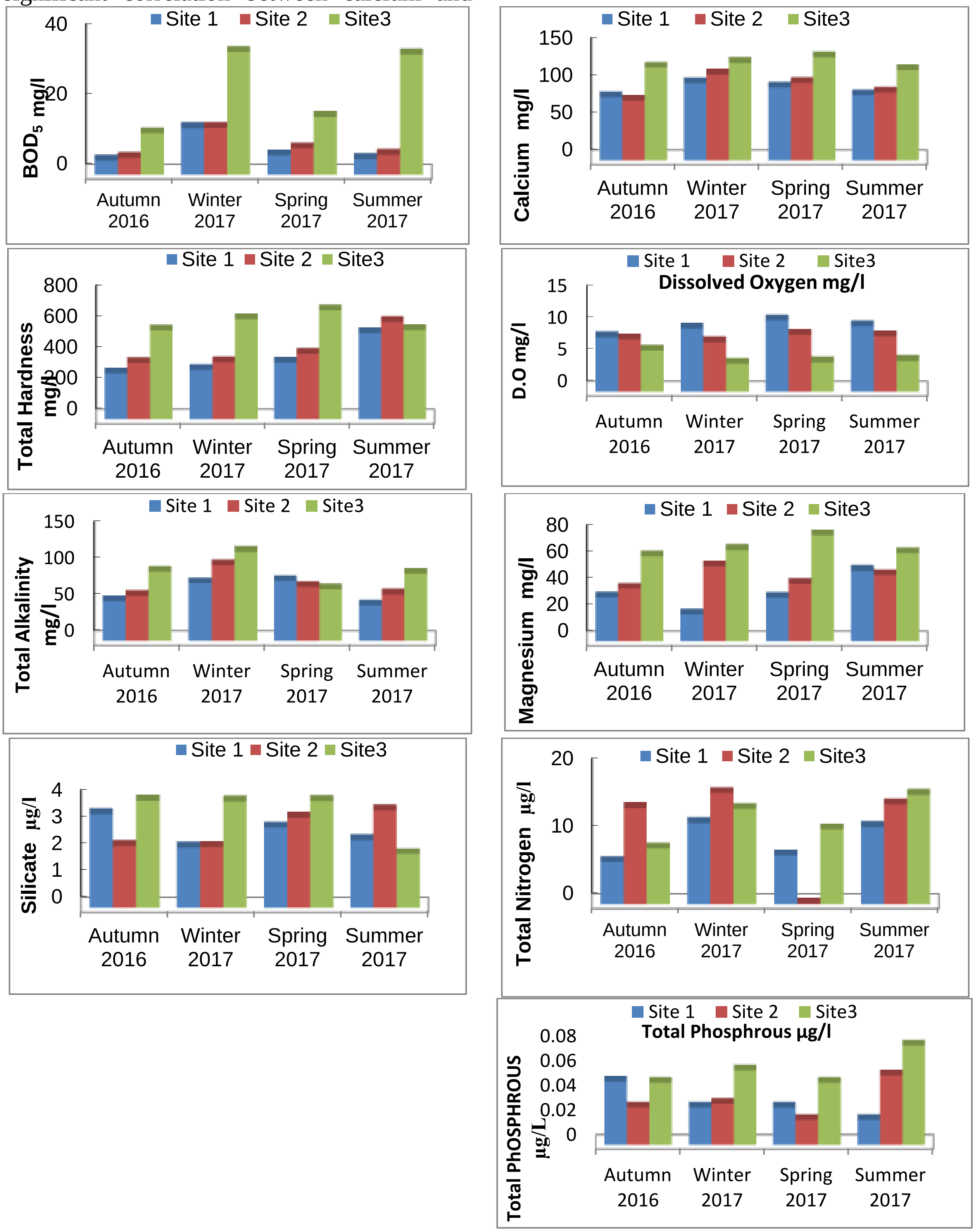


Figure 3. Seasonal variation of some chemical factors in Diyala river during thwe study period

Table 2. Seasonal variation (means ± standards deviation) of the studied factors in Diyala River

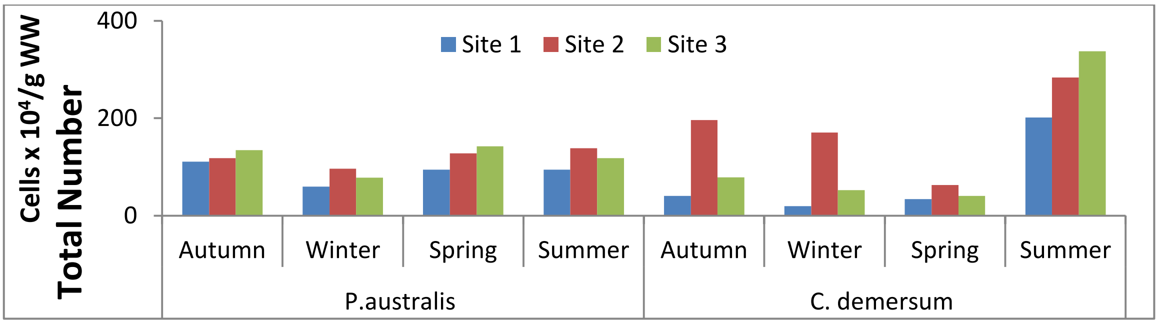
Factors	Seasons	Autumn 2016	Winter 2017	Spring 2017	Summer 2017
Air Temperature	Site 1	23.3±0.16ab	14.2±0.15b	20.16±0.24b	46.26±0.16b
	Site 2	21.74±0.28b	15.80±0.25a	23.61±0.22a	38.69±0.33a
	Site 3	25.04±0.63a	12.23±0.19c	18.68±0.15c	38.8±0.52a
Water Temperature	Site 1	18.6±0.2b	14±0.25a	19.65±20a	30.35±0.28a
	Site 2	16.9±0.20c	11.05±0.29b	17.56±56b	26.95±15a
	Site 3	23.9±0.28a	10.23±0.24c	14.76±0.37c	25.23±1.43a
pH	Site 1	7.3±0b	7.5±0.04a	7.6±0.07b	7.5±0.05b
	Site 2	7.6±0.06b	7.7±0.07b	7.6±0.1b	7.4±0.02a
	Site 3	8.4±0.1a	8.4±0.18b	7.9±0.03a	8.8±0.015a
Light penetration	Site 1	63.3±0.60a	67.8±0.6a	77.16±0.60b	75.3±0.22a
	Site 2	45±0.70b	54±0.86b	67.8±1.16b	71.3±0.36b
	Site 3	36.3±0.16c	29.8±0.44c	33.16±0.6a	35.0±0.08c
Water flow	Site 1	0.9±0.5b	0.86±0.03b	1.183±0.10a	0.86±0.03a
	Site 2	1.16±1.16a	1.4±0.07a	0.61±0.03b	0.54±0.02b
	Site 3	0.2±0.01c	0.31±0.04c	0.3±0.01c	0.37±0.01c
Total suspended solids	Site 1	0.15±0.005b	0.39±0.29a	0.086±0.004c	0.137±0.007b
	Site 2	0.143±0.003b	0.136±v0.0007a	0.17±0.00003b	0.25±0.002a
	Site 3	0.62±0.001a	0.192±0.0004a	0.14±0.0003a	0.243±0.02a
Total dissolved solids	Site 1	395.5±1.6c	775±8.74a	863.6±8.9c	715.5±0.62b
	Site 2	616.6±3.2b	785.6±4.04a	908.6±0.84b	749.3±v1.54a
	Site 3	871.6±3.8a	877±3.78a	1203±4.6a	788.5±1.75a
Total alkalinity	Site 1	54.26±1.42c	972.5b	82.33±1.42c	92.283±0.65a
	Site 2	71.8±1.6b	105.1±2.56b	74±1.6b	63.5±0.38a
	Site 3	95.±0.92a	122.33±1.2a	70.66±0.92a	48.583±1.75a
Total hardness	Site 1	556.6±1.59c	318.6±2.66c	368±4a	295.9±2.6c
	Site 2	365.3±2.95b	369.3±4.8b	424±0.8b	630.1±159.1b
	Site 3	575.13±4.42a	704.6±41.25b	647±6.92a	576.7±8.72a
Turbidity	Site 1	10.33±0.92b	9.33±0.66c	8.08±0.24c	13±0.21c
	Site 2	13.83±1.3b	14±1.44b	11.3±0.34b	18.41±0.13b
	Site 3	27.8±3.21a	36.6±2.77a	18.75±0.13a	43.54±1.1a
Dissolved oxygen	Site 1	8.48±0.51a	9.83±0.72b	11.1±0.08a	10.22±0.06a
	Site 2	8.17±0.23a	7.7±0.3a	8.9±0.34b	8.63±0.1b
	Site 3	4.33±0.33c	6.4±1.01a	4.5±0.12c	4.68±0c.11
Biochemical demand	Site 1	2±0.6b	1.29±0.72b	2.5±0.2b	2.43±0.06c
	Site 2	3.8±0.91b	1.3±0.72b	2.5±0.55b	2.68±0.09b
	Site 3	11.83±0.66a	35±1.89a	16.5±0.86a	34.3±0.42a
Salinity %o	Site 1	0.53±0.001c	0.97±0.01a	0.63±0.002b	0.83±0.003b
	Site 2	0.75±0.001b	0.79±0.02b	0.57±0.02c	0.82±0.02b
	Site 3	0.93±0.002a	0.91±0.06ab	1.32±0.01a	1.40.01a
Electrical conductivity	Site 1	867.±3.3b	867.33±3.8b	1755.1±3b	1355.9±8.79b
	Site 2	1225.6±2.1b	1449.3±5.3a	1715±3.6c	1333±2.8b
	Site 3	1501±2.88a	1345.±5.48c	2370±29.9a	2135±2.5a
Calcium	Site 1	84.3±0.16b	102.5±0.95c	97.21±0.53b	70.84±2.49b
	Site 2	86.66±2.07b	114.3±2.82b	103.2±1.6c	90.57±0.52b
	Site 3	137.8±1.84a	130.33±1.41a	123.93±3.2a	120.2±0.39a
Magnesium	Site 1	20.25±0.21c	32.86±0.2c	32.6±0.76c	53.19±1.03b
	Site 2	39.74±2.30b	56.6±2.3b	43.4±3.6b	49.86±0.17c

	Site 3	**64.1±1.68a**	**67.9±1.68a**	**79.71±2.55a**	**66.5±1.02a**
total phosphorus	**Site 1**	**0.071± 1.4a**	**0.03±0.005a**	**0.03±0.005a**	**0.01±0.01b**
	Site 2	**0.02±0.005a**	**0.033±0.008a**	**0.02±0.005a**	**0.05±0.003a**
	Site 3	**0.05±0.03a**	**0.06±0.005a**	**0.05±0.01a**	**0.08±0.00a**
Total nitrogen	**Site 1**	**0.06±0.032c**	**12.03±0.68c**	**7.18±0.08b**	**11.46±0.11c**
	Site 2	**14.25±0.079b**	**16.47±0.07a**	**6.213±v0.08c**	**14.8±0.21b**
	Site 3	**8.21±0.018b**	**14.16±0.065a**	**11.07±0.65a**	**16.2±0.16a**
Silicate	**Site 1**	**349.8.±0.8b**	**224.4±0.02b**	**299.3±0.02c**	**252.7±0.01b**
	Site 2	**231.4±0.002c**	**226.3±0.005b**	**335.4±0.043b**	**362.3±0.09b**
	Site 3	**398.2±0.08a**	**396.2±0.35a**	**397.1±0.17a**	**446.1±0.02a**
Chlorophyll-a *P. australis*	**Site 1**	**26.23±1.31a**	**11.71±0.3c**	**14.56±0.1a**	**8.64±0.21a**
	Site 2	**19.04±0.23b**	**13.5±0.3a**	**13.76±0.017a**	**9.03±0.03a**
	Site 3	**19.93±0.40b**	**12.66±0.27b**	**14.18±0.95a**	**7.161±0.16b**
Chlorophyll-a *C. demersum*	**Site 1**	**14.43±0.1b**	**10.5±0.34c**	**27.98±0.47a**	**16.55±0.39a**
	Site 2	**16.43±0.26a**	**20.66±0.49a**	**25.86±0.12a**	**30.52±0.76a**
	Site 3	**17.833±0.44a**	**18.78±0.08b**	**26.93±0.61a**	**34.94±3.81a**

Lower total phosphorus and total nitrogen concentrations were 0.01 µg/l and 6.21 µg/l in autumn at sites 2 and 1, respectively (Figure 3). The highest values were 0.08 µg/l during the summer at sites 3 and 16.46 in winter at site 2. Yang and Zhuang (39) reported that the TP and TN are the main pollution indicators in a Huai river –China. The results of these factors in this study indicated that the river was classified as oligotrophic (8). The Iraqi surface water systems are characterized by high concentrations of silicate and higher than the algae growth need to silicate (76.08µg/l) This finding also noticed by other studies in Iraq (2; 31). The total number of epiphytic algae showed temporary and spatial differences among the study period. The lowest total number of epiphytic algae on *P.australis* recorded in the spring ($359x10^4$ cells/g WW) at site 1 and the highest was $516.9x10^4$ cell/g WW at site 3 in autumn (Figure4). The total number of epiphytic algae on *C. demersum* recorded less number in contrast with *P. Australis*, and its total is ranged from 7 $x10^4$ cells/g WW in winter at the site 1to 138.1 $x10^4$ cells/g WW in summer at site 2. These results referred to the ability of *P.australis* to tolerate a different environmental conditions (Salman et al. 2014). Diatoms are the predominant algal group in this study, which corresponds to other studies (2, 4). Chlorophyll a concentration of epiphytic algae on *P.australis* ranged from 7.16 µg/cm^2 to 26.23 µg/cm^2 in summer and autumn at sites 3 and 1, respectively. While on *C. demersum* the minimum concentration was 10.5 µg/cm^2 in winter at site 1and the maximum was 34.94 µg/cm^2 in summer at site 3 (Figure 4). These results indicated that the algal composition was different on the host plants and it is not compatible with the results of the total number of epiphytic algae except in the summer (32). Chlorophyll a peaked in autumn for *P. australis* at all sites, while on *C. demersum* obtained in summer at sites 3and 2, whereas the peak at site 1 attained in spring. This may be due to algal composition,geomorphological characteristics of the selected sites and impact of pollution, site 1 is away from the city impact, while the other sites undergo the pollution impact. The trophic level of the river was mesotrophic according to the chlorophyll-a concentration (8). The water of Diyala rivere was alkaline, brackish,and hard water, and good aeration. Different water flows were recorded due to the geomorphology of the river which impacts on other environmental factors. The trophic level of the river ranged from oligotrophic to mesotrophic.

Acknowledgement

Authors thanks Dr Hala Al Haidri for English proof reading.



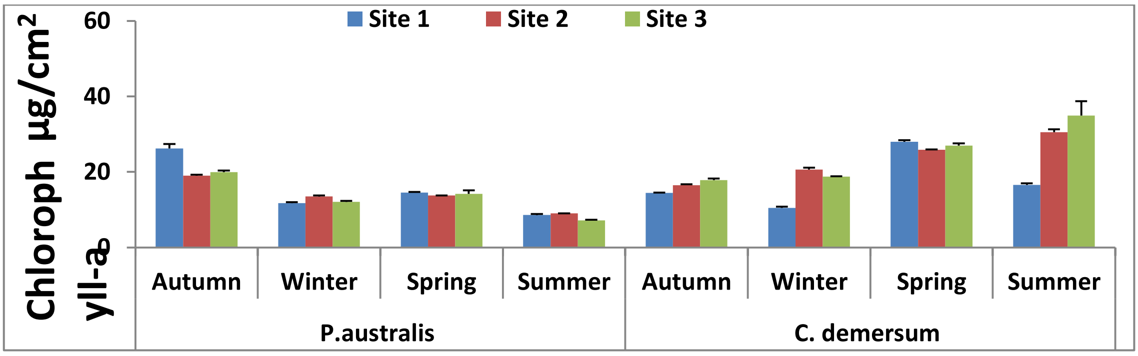


Figure 4. Seasonal variation in total number of epiphytic algae and chlorophyll a. in Diyala river during the study period

Table 2. The correlation between the environmental factors in Diyala River during the study period

	T.W.	T.A	pH	LP	WF	T.S.S	T.D.S	T.A	T.H	Turb	E.C	D.O	BOD5	S‰	Ca	Mg	TP	SiO3	T.N	ChA.Phr
T.W.	1																			
T.A	.920**																			
PH	-.331-*	-.361-*																		
LP	.337*	0.232	-.764-**																	
WF	-.186-	-.213-	-.569-**	.568**																
T.S.S	-.289-	-.245-	.366*	-.274-	-.312-	1														
T.D.S	-.195-	-.179-	.338*	-.313-	-.380-*	0.049														
T.A	-.513-**	-.465-**	.754**	-.536-**	-.257-	.410*	0.304													
T.H	0.242	0.301	.435**	-.469-**	-.702-**	0.212	.448**	0.192												
Turb	0.101	0.232	.659**	-.727-**	-.683-**	.371*	0.154	.586**	.568**											
E.C	0.016	0.084	0.235	-.388-*	-.416-*	-.122-	.642**	0.208	.448**	.338*										
D.O	0.259	0.099	-.720-**	.909**	.665**	-.388-*	-.302-	-.506-**	-.557-**	-.796-**	-.408-*									
BOD5	-.269-	-.118-	.622**	-.707-**	-.557-**	.501**	0.266	.739**	.429**	.847**	.415*	-.748-**								
S‰	0.018	0.11	.340*	-.658-**	-.569-**	0.184	.468**	0.226	.575**	.571**	.724**	-.662-**	.617**							
Ca	-.352-*	-.313-	.770**	-.732-**	-.634-**	0.293	.616**	.711**	.532**	.595**	.652**	-.733-**	.725**	.679**						
Mg	-.014-	0.077	.597**	-.726-**	-.646-**	0.187	.567**	.465**	.774**	.673**	.628**	-.755-**	.624**	.768**	.797**					
TP	0.092	0.202	.372*	-.528-**	-.549-**	0.171	0.052	0.292	.377*	.648**	0.219	-.593-**	.553**	.481**	.376*	.385*				
SiO3	.396*	.367*	.605**	-.468-**	-.846-**	0.144	.449**	0.258	.791**	.678**	.478**	-.553-**	.439**	.467**	.581**	.700**	.424*			
TN	.343*	.377*	.351*	-.532-**	-.365-*	0.177	-.150-	0.094	.441**	.625**	-.096-	-.491-**	0.328	.403*	0.117	.384*	.583**	.419*		
ChA.Phr	0.167	0.063	-.168-	0.244	0.087	-.482-*	0.255	-.312-	-.047-	-.338-*	.428**	0.263	-.401-*	-.136-	-.081-	-.169-	-.136-	0.11	-.318-	
ChA.Cer	-.021-	-.131-	.388*	-.339-*	-.072-	-.310-	0.292	0.134	0.133	0.016	0.296	-.111-	-.154-	-.001-	0.229	0.253	-.094-	0.3	0.075	.502**

Significant (P<0.05) , **Non-Signinfificant (P<0.05)

REFERENCES

1. Abbas, A. A. A. and F. M. Hassan, 2017. Water quality assessment of Euphrates river in Qadisiyah province (Diwaniyah river), Iraq. The iraqa J. Agric. Sci., 48 (6): (in press).

2. Al Hassany, J. S. and H. E. Al Bayaty, 2017. Screening of epiphytic algae on the aquatic plant Phragmites australis inhabiting Tigris river in Al-Jadria site, Baghdad, Iraq. Baghdad Science Journal, 14 (1): 85- 98.

3. Al-Ansari, N. A. 2013. Management of water resources in Iraq perspectives and prognoses Journal Engineering, 5: 667-684

4. Al-Handal, A. Y., S. A. Dawood, W. Angela and T. A. Mujtaba 2014. Epiphytic diatoms of the Mesopotamian wetland: Huwaiza marsh, South Iraq. Diatom 30: 1–15

5. Al-Qayim, B. A. 2006. Morophotectonic of Diyala River, Iraq. Bulletin of the College of Arts, Baghdad University. 78: 230-250.

6. APHA, American Public Health Association. 2005. Standard Methods for the Examination of Water and Wastewater, 21st ed. Washington, DC.pp:541

7. Awasthi, A.,R. Dhanze, U. Tiwari, and R. Singh, 2010. Limnological study of tributaries of river Beas in upper reaches of Himalayan region as a source for setting up industry for natural mineral water. Ecology, Environment and Conservation, 16(2), 243–247

8. Bayram, A. and M. Kenanoğlu, 2017. Temporal variation of total nitrogen and total phosphorus in surface water from the lower Goruh river basin, Turkey. Acta Physica Polonica A, 132 (3): 712- 716

9. Bellinger, B. J., C. Cocquyt, C., and C. M. O'reilly, 2006. Benthic diatoms as indicators of eutrophication in tropical streams. Hydrobiologia 573 (1): 75-87

10. Bellinger, E. G. and D. C. Sigee, 2010. Freshwater Algae: Identification and Use as Bioindicators. pp. 99-134

11. Central Stastical Organization (CSO). 2013. Annual Statistical Abstract. Issued by the Iraqi Ministry of Planning.pp: 1-41

12. Doung, T. T., A. Feurtet-Mazal, M. Coste, D. K.Dand, and A. A. Boudou, 2007. Dynamics of diatom colonization processes in some rivers influenced by urban pollution (Hanol, Vietnam). Ecological Indictors, 7(4): 839-851

13. EPA. 2014. Sediments. In Water: Pollution Prevention and Control. Retrieved from http://water.epa.gov/polwaste/sediments

14. Ewaid, S. H. and S. A. Abed, 2017. Water quality index for Al- Gharraf river, southern Iraq. Egyptian Journal of Aquatic Research, 43:117-122.

15. Fulazzaky, M. A. 2013. Assessing the suitability of stream water for five different uses and its aquatic environment. Environmental Monitoring and Assessment, 185(1),523–535. https://doi.org/10.1007/s10661-012-2572-6

16. Furet, J. E. and K. Benson-Evan, 1982. An evaluation of the time required to obtain complete sedimention of fixed algal particles prior to enumeration. British Phycology, 17 (3): 253-258

17. Furhan, I., A. Muhammad, and K. Nazia, 2006. Limnological study of River Soan (Punjab), Pakistan.Agriculturae Conspectus Scientificus Poljoprivredna Znanstvena Smotra, 71 (2), 65–73

18. Göransson, G.,M. Larson, and D. Bendz, 2013. Variation in turbidity with preciption and flow in a regulated river system-river Gota Alv, SW Sweden. Hydrology and Earth System Science, 17 (7): 2529-2542

19. Gupta, N., K. K. Yadav, V. Kumar, and D. Singh, 2013. Assessment of physicochemical properties of yamuna river in Agra City. International Journal Chem Tech Research 5 (1): 528-531

20. Hanh, P. T. M., N. V. Anh, D. T. Ba, S. Sthiannopkao, and K. W. Kim, 2010. Analysis of variation and relation of climate, hydrology and water quality in the lower mekong river. water Science and Technology: Journal of the International Association on Water Pollution Research, 62 (7), 1587–1594.

21. Hassan, F. M., K. D. Al-Jibouri,K. D. W. And A. A. Hakman, 2017. No title water quality assessment of Diyala river in Diyala province, Iraq. Mesopotamia Environmental Journal, 4 (1): 52–61.

22. Iqbal, F., M. Ali, B. A. Khan, B. A., S. Ahmad, M. Qamar,. and K. Umer, K. 2004. Seasonal variations of physico-chemical characteristics of river Soan water at Dhoak Path Bridge (Chkwal), Pakistan. Int. J. Agric. Bio., 6 (1): 89-92

23. Jaschinski, S, D. C. Bepohl, and U. Sommer, 2011. The trophic importance of epiphytic algae in a freshwater macrophytes system (*Potamogeton perfliatus L.*) stable isotope and fatty acid analyses. Aquat. Sci. J., 73:91-101

24. Madhloom, H. . , N. Al-Ansari, J. Laue, and A. Chabuk, 2017. Modeling spatial distribution of some contamination eithin the lower reaches of Diyala river using IDW interpolation. Sustainability, 10 (1): 22. 10.3390/su10010022

25. Martinez, M. R., R. P. Chakroff, and J. B. Pantastico, 1975. Not no direct phytoplankton counting technique using the haemocytomenter. Phi. Agric., 58: 1-12

26. Marques, P. H. C., T. H. De Oliveira, and E. D. C. Machado, 2003. Limnological study of Piraquara river (Upper Iguaçu basin): spatiotemporal variation of physical and chemical variables and watershed zoning. Brazilian Archives of Biology and Technology, 46(3), 383–394

27. More Y. S. and S. N. Nandan 2001. limnological study of panzara dam and river of Maharashtra. Ecol. Env. and Cons., 7 (3): 337-339.

28. Ȍterler, B. 2017. Community structure, temporal and spatial change of epiphytic algae on three different submerged macrophytes in a shallow lake. Pol. J. Environ. Stud. 26 (5): 2147-2158

29. Perlman, H. 2014. Water Properties and Measurements. In USGS Water Science School.Retrieved from http:// water.usgs. gov/edu/characteristics.html

30. Rasheed, K. 2016. Study the effect of two waste treatment plants in the Al-Karkh and Al-Rusuafa of Baghdad region in 2015. J. Int. Environmental Application and Science, 11 (2): 176-179

31. Salman, J. M., F. M. Hassan S. J. Hadi, and A. A. Motar, 2014. An ecological study of epiphytic algae on two aquatic macrophytes in lotic ecosystem. Asian Journal of natural and applied sciences, 3(3): 37–52

32. Shaawiat, A. O. and F. M. Hassan, 2017. Qualitative and quantitative study of epiphytic diatoms on two macrophytes In a lotic ecosystem, Iraq. Indian Journal of Ecology, 44 (3): 504–5015

33. SWRCB, 2002. Electrical Conductivity/Salinity Fact Sheet. In The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment State Water Resources Control Board. Retrieved from http://www.swrcb.ca.gov /water_issues/ programs/ swamp/ docs/cwt/ guidance/ 3130en.pdf

34. Vadeboncoeur, Y. and A. D. Steinman, 2002. Periphyton function in lake ecosystems. The Scientific World Journal, 29 (2): 1449-1468

35. Walling, D.E. 1990. Linking the Field to The River: Sediment Delivery from Agriculture land. In Boardman, J. I. D. L. Foster and J. A. Dearing (Eds.). Soil Erosion on Agriculture Land (pp. 129-152). Chichester: John Wiley and Sons. Retrieved from pp: 129-152

36. Weiner, E. R. 2000. Application of Environmental Chemistry. Lewis Publishers, London/New York. pp. 347.

37. Wetzel, R. G. 2001. Limnology: Lake and River Ecosystems (3pd ed. San Diego, CA: Academic Press.pp:1006

38. World Bank. 2018. Beyond Scarcity: Water security in the Middle East and North Africa. MENA Development Report; Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/ 10986/27659

39. Yang G, and D. Zhuang, 2014. Research on the Correlation between Cancer and the Huaihe River Water Environment. In: Atlas of the Huaihe River Basin Water Environment: Digestive Cancer Mortality. Springer Netherlands, pp:1-26

40. Yousir, S. A., A. Mouhamad; S. Fadhel, and M. Iqbal, 2016. Monitoring of Diyala River, Iraq: A comparative study of river, soil and plant receiving treated water from Al-Rustamiya wastewater treatment plant. Physical Chemistry, 18 (1):(in press).