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Use of indices of algae and water quality to assessment of Tigris river in AL-Gheraiat area in Baghdad city,Iraq

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Abstract

This work incorporates phytoplankton decent variety and its physicochemical properties in Tigris river with various conditions, for example, (Temperature of water and air, pH, total suspended solids (TSS), total dissolved solids (TDS), water flow, Light Penetration, turbidity, dissolved oxygen, biochemical oxygen demand (BOD₅), total alkalinity, hardness, calcium, magnesium, and micronutrients. During the study period in Al- Gheraiat area, there were 199 species of phytoplankton; diatoms were the most common. Their growing peak was in spring 2017 comparing to summer and autumn 2016. Water quality, understudy, was arranged according to Shannon and Winner's index in addition to Palmer's Pollution index. The quality of the river water has been proved to be of moderate pollution according to Shannon and Winner's index and of high organic pollution according to Palmer's Pollution index.

Keywords : Phytoplankton ,Tigris river, Shannon index, Palmer index

Introduction

There is a great interest in water environment where the hydrosphere constitutes 80% of the total area of the earth. It includes all forms of stagnant, flow, saline and fresh water, including water confined between different parts of nature in the shape of humidity or moisture; all those water molecules associated with objects internally and externally [1]. Water sources are polluted as a result of throwing household, industrial, and agricultural wastes into the sources causing an increase in the proportion of nutrients, mineral, and organic substances. These substances in turn are necessary for the growth and reproduction of the Phytoplankton such as algae. This excessive growth leads to phenomenon called Eutrophication [2, 3]. Phytoplankton is an important factor that affects the quality of water, useful indicators to explain the conditions of the ecosystem because of its rapid response in terms of species composition and density to change water conditions. Phytoplankton as a group of diverse organisms that are existed in the water column and cannot swim against the water current.[4,5]. phytoplankton is the Primary Producer of the water system and its main base in the food chain , which produces 50- 80% of the oxygen needed by the world and absorbs half of its produced CO₂ which is one of the global warming causes [6]. The main objective of studying the phytoplankton community is to identify the species in Tigris and their relationship with the environmental variables and indices in order to evaluate river water of the study area Al-Gheraiat.

Method and Materials

Water samples have been collected from study area Al- Gheraiat by taking one sample from the river center for the period from Autumn 2016 till Summer 2017; three repeat. of the upper surface and with a depth of 20-30 cm . The samples have been transferred directly to the laboratory for testing, analyzing and measuring. Three readings for every parameter are required according to APHA [7]. The samples of the Phytoplankton have been collected by using a phytoplankton net a mesh size of 20µm. The net was set against water stream and moved by the boat for 10-15 minutes. After pulling the net, the contents were collected in clean polyethylene bottles and stored by adding Lugol's Solution. The phytoplankton identified by using light microscope by following the keys of Prescott, Husted and other mentioned keys [12 ,13,14 ,15,16,36]. Biological indices was used ,as indicator of biodiversity and water pollution.

Shannon_ Wiener diversity (H) $H = -\sum P_i \ln P_i$

P_i:represents the ratio density species to the total density community phytoplankton .determine pollution level according to (Table 1)

Table 1. Scores of water quality according Shannon index [33].

Category	Water Quality	Value Shannon index
I	Clean	More than 3
II	moderate pollution	1-3
III	High pollution	Less than 1

Palmer’s Pollution Index (PPI) is the method adopted by Palmer in (1969) which name a list of 20 species of algae. Each species has scores ranging from 1 to 5 according to the species tolerance of organic pollution, the scores of the species are collecting indicted in the model, the amount of organic pollution can be determined.

Table 2. Algal genera pollution index. [31]

Genus	Score	Genus	Score
<i>Anacyctis</i>	1	<i>Micractinium</i>	1
<i>Ankistrodesmus</i>	2	<i>Navicula</i>	3
<i>Chlamydomonas</i>	4	<i>Nitzschia</i>	3
<i>Chlorella</i>	3	<i>Oscillatoria</i>	5
<i>Closterium</i>	1	<i>Pandorina</i>	1
<i>Cyclotella</i>	1	<i>Phacus</i>	2
<i>Euglena</i>	5	<i>Phormidium</i>	1
<i>Gomphonema</i>	1	<i>Scenedesmus</i>	4
<i>Lepocinlic</i>	1	<i>Stigeoclonium</i>	2
<i>Aulocosira</i>	1	<i>Synedra</i>	2

Table 3.Pallmer pollution values

Degree of Pollution	Pollution Index
Moderate organic pollution	less than 15
Potential for high organic contamination	15-19
High organic pollution	20 or more

Al-Gheraiat : is the study area which is located in the northeast of Baghdad , latitude(33.39°) and length (44.35°) using GPS (Global Position System) ,surrounded by Tigris River on three sides that Its a tourist area that have many restaurants and parks in which have a greater impact on the water of the river .

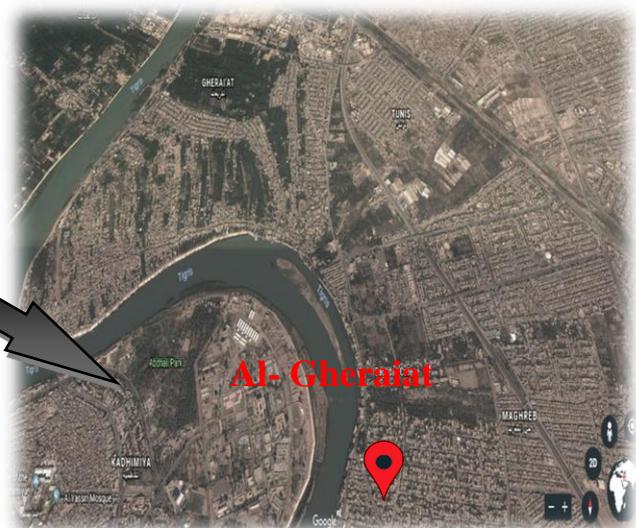
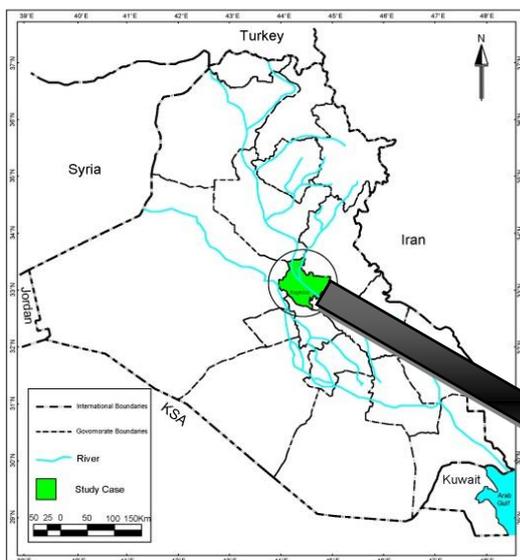


Figure 1. (Google Earth)Map of Iraq (on the left) and study area (on the Right)

Statistical Analysis

The statistical analysis system [23] was used for statistical analysis .

Results and Discussion

Physico-chemical water characteristics were illustrated in Table(4) which distinct seasonal variations in all parameters were recorder . Many studies confirmed that Tigris water is tend to be alkaline[10,18].The high values of water temperature in Summer and the low value in Winter when affected by surrounding air. The which explains the nature of Iraq's climate which characterized by high temperatures in summer and by low temperatures in winter, with thermal variation between night and day[19].Further the electrical conductivity(EC) values were low in Summer ,While high values in Winter The salinity and electrical conductivity values were similar in increase and decrease because a strong relationship between both EC and salinity [20]. In spring and summer there is a significant increase in water levels due to the melting of snow and the rapid flow of the river because of its large slope and the difference in the quality of the rocks. This may lead to water dilution and thus decrease in the values of electrical conductivity [21]. The pH is a measure of the acidity in a solution that acids produce hydrogen ions (H⁺) and bases produce hydroxide ions (OH⁻) in a solution. In present study pH ranged from 7.94 to 8.07 , All aquatic systems in Iraq have been characterized by its buffer and alkaline [12, 47,48,50,51,52,53,54] .

It is a common feature in Iraq inland water buffering because of high content of calcium bicarbonate [22]Total dissolved solid ranged 473-743 mg/L where highest values were recorder in winter [48] and low values in Summer this may be because of soil washing by rainwater [24]. while the high value of TSS have been recorded in Summer because of the activities on the river in the study site during the collection of samples during the season. Light Penetration values were ranged from 87 cm in winter to 35 in summer noticed less values during summer may be causes increase turbidity ,increase total suspended solid as reversible with PL[56] . Turbidity values were ranged from 18 NTU in spring to 91 NTU high values causes by soil washing , rains ,water level of river and geological features[57]. Alkalinity of water is its capacity to neutralize a strong acid and is characterized normally due to the presence of Bicarbonate, Carbonate and Hydroxide compounds of Calcium, Magnesium, Sodium and Potassium. The Alkalinity in natural system are mainly include Carbonate, Bicarbonate and Hydroxide. Iraq's internal water are characterized by being alkaline, alkalinity mainly of bicarbonate salts that was affected by other factors like CO₂ , wastewater and temperature . [25, 48]. In present study , total alkalinity ranged from minimum 140 mg/L in the autumn to the maximum of 159 mg/L this study are concurrent with most studies on the Tigris [11, 26]. Concentration of total hardness ranged between (292-355 mg/L) were recorder in autumn and summer ,total hardness was found highest in river Tigris during study period that may be due to calcareous natural of Iraqi soil [10], The reason for low total hardness in Summer may be due to consumption of CO₂ by algae for photosynthesis [28]. Higher concentrations of Ca⁺ (96 mg/L) in winter were mostly due to the decrease in the solubility of

CaCO₃ The results study recorded that Calcium concentration is higher than magnesium concentration which due to solubility of CO₂ in water and its reaction with calcium in contrast to magnesium which tend to deposition [29]. DO is an important water quality parameter in estimating water pollution [27]. In the present study ,DO was found maximum of (9.55 mg/L) in the winter and minimum of (7.48 mg/L) in summer ,the main reason of maximum DO may be due to the reduced rate of decomposition by decreased organisms activity at low temperature, decrease of DO may occur in summer due to increase in temperature ,increasing the activity of organisms that decompose the organic matter , consuming large quantities of oxygen for the purpose of oxidation process [30]. In the present study BOD ranged between 0.86 mg/Lin spring to 1.80 mg/L in winter ,the value of BOD showed a great fluctuations during period study , the results caused by the pollution level in river and relationship with DO [55] , not affected by the change in temperature mainly. Reactive phosphate, nitrite , nitrate are considered to be the critical limiting nutrient ,causing eutrophication of fresh water systems , were present in minimum possible concentration during the study period . Reactive phosphate ranged between 0.0005-0.03 mg/L) , nitrite ranged between(0.001-0.009 mg/L) in autumn and summer the increase and decrease depends on activity organisms[29] , nitrate ranged between 0.65 mg/L in autumn to 1.86 mg/L in winter because few phytoplankton that consume nitrates or not to be reduced nitrate to nitrite because low temperature and good aeration all of that cause increase nitrate [58].

Table 4. Physico-chemical characteristics of Tigris River s water during study period (2016-2017)

Parameters	Autumn 2016	Winter 2017	Spring 2017	Summer 2017
Air temperature (C°)	26± 1.65	13± 0.75	16 ± 0.83	33± 1.58
Water temperature (C°)	19.5± 1.13	11.0 ± 0.42	15.5± 0.61	29.0± 1.38
Dissolved Oxygen (mg/L)	8.37 ± 0.76	9.55 ± 0.82	9.39 ± 0.77	7.48 ± 0.56
Biochemical Oxygen Demand (mg/L)	1.68 ± 0.0	1.80± 0.09	0.86± 0.05	0.91 ± 0.09
pH	8.07 ± 0.72	8.05 ± 0.65	7.94 ± 0.70	7.96 ± 0.81
Total dissolved solid (mg/L)	655 ± 42.75	743 ± 37.52	665 ± 40.66	473 ± 29.32
Total suspended solid (mg/L)	37 ± 1.1054 ±	36 ± 1.07	26 ± 1.25	118 ± 6.43
Electric Conductivity(μ/cm)	1054 ±113.76	1149 ± 96.25	1089 ± 107.33	811 ± 86.35
Salinity %	0.50 ± 0.04	0.60 ± 0.06	0.60 ± 0.06	0.50 ± 0.04
Turbidity	26 ± 1.15	31 ± 1.42	18 ± 0.85	91 ± 4.06
Light Penetration (cm)	86 ± 3.64	87 ± 3.08	80 ± 3.41	35 ± 2.19
Alkalinity(mg CaCO ₃ /l)	140±7.28	157±8.33	159±9.64	148±8.42
. Total hardness (mg/L)77	355 ± 28	345 ± 31.64	319 ± 25.10	292 ± 26.33
Calcium (mg/L)	79 ± 2.61	96 ± 4.07	75 ± 2.92	71 ± 2.47
Magnesium(mg/L)	34 ± 2.12	38 ± 2.74	35 ± 1.93	29 ± 1.26

Total Phosphate (mg/L)	0.0005 ± 0.0001	0.004 ± 0.0005	0.007 ± 0.0003	0.015 ± 0.0009
Nitrite(mg/L)	0.001 ± 0.0002	0.002 ± 0.0004	0.008 ± 0.0004	0.006 ± 0.0001
Nitrate(mg/L)	0.65 ± 0.05	1.55 ± 0.08	1.20 ± 0.04	1.07 ± 0.06

Mean±SD

The values of Phytoplankton Biodiversity index ranged between (1.8-3) during study period in Al- Gheraiat area which were higher in general Table (5) , biological diversity is directed to adapting to the environmental conditions of diversity, the quality of water is suitable for increasing diversity due to the availability of wide ranges of growth and increase of species, but the opposite occurs in critical conditions that lead to disruption of the aquatic environment due to exposure to pressures and disturbances caused by pollution or human activities led to reduce diversity [28,42 ,46], studied area is considered as moderate pollution by classification [33] . In the same table shows value of palmer index ranged between (19-31) the results of the Palmer index showed that the water of the Tigris River (with certain organic pollution) Approximate to record for studies on Gujarat River , Kali River[43,44] and the results recorded Above what was recorded on the Shami River[45]

Table 5. Values of Shannon and palmer indices during study period(2016-2017) in Al- Gheraiat area

Indices	Autumn 2016	Winter 2017	Spring 2017	Summer 2017
shannon	1.8	3.0	2.9	2.9
palmer	19	23	23	31

A group of 199 Phytoplankton have been identified and it is found that Bacillariophyceae are dominated by(28 genus) and (123 species) , (61.8%) and this was matching with various studies [8 ,9 ,45] followed by Chlorophyceae (22 genus, 38 species , 19.1%), Cynophyceae (11genus. 24 species , 12.1%) as noted by [50]. The highest number of taxa (genera and species) which might be due to the exposure of this site to different pollutant and availability of nutrients [48] . Pyrrhophyceae (3genus , 3 species and 1.5 %), Euglenophyceae (2genus , 8 species and 4%) and finally Cryptophyceae, Chrysophyceae (1genus) for each one (Table 6) and Fig. 2 .The second group of dominant algae was Chlorophyceae, followed by cyanophyceae Table (6) , this dominancy was expected due to many studies that done on the Iraqi aquatic ecosystems [8,11,32].

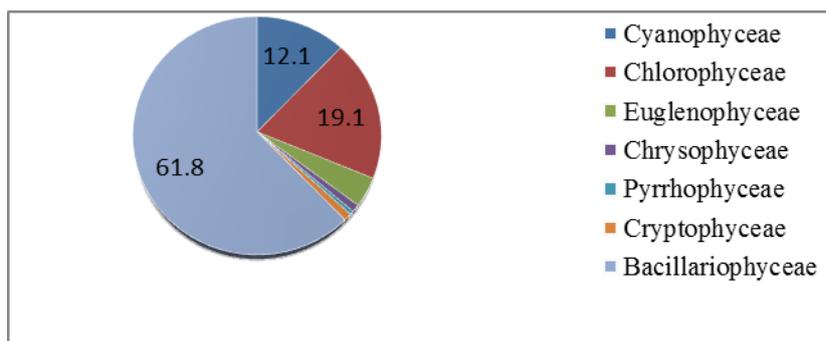


Figure 2: Percent of Phytoplankton Classes in Al- Gherai'at area

Table 6 . Percent of Phytoplankton Classes Al- Gheraiat area

Classes	Genus	Species	percentage %
<u>Cynophyceae</u>	11	24	12.1
<u>Chlorophyceae</u>	22	38	19.1
<u>Euglenophyceae</u>	2	8	4
<u>Chrysophyceae</u>	1	2	1
<u>Pyrrhophyceae</u>	3	3	1.5
<u>Cryptophyceae</u>	1	1	0.5
<u>Bascillariophyceae</u>	28	123	61.8
Total	68	199	100

Table 7. Total number of phytoplankton (cell/l)×10³ in the Al- Gheraiat area Tigris River during study period 2016-2017

Taxa	Autumn	Winter	Spring	Summer
Cyanophyceae				
<i>Anabaena</i> sp.	3.7	0.8	0.35	0.2
<i>Aphanocapsa elachista</i> West	-	1.15	0.3	0.2
<i>Chroococcus limnaticus</i> Lemmermann	-	-	-	0.08
<i>Chroococcus limenticus</i> var. <i>elegans</i> G.M.Smith	3.7	-	-	-
<i>Chroococcus dispersus</i> (Keissl)Lemmermann	-	-	-	0.03
<i>Chroococcus</i> sp.	8.75	2.1	-	0.17
<i>Chroococcus turgidus</i> (Kütz)Naegeli	0.5	-	-	0.24
<i>Coelosphaerium dubium</i> Grunow	0.15	-	-	-
<i>Lyngbya</i> sp.	0.55	-	0.75	-
<i>Merismopedia</i> sp.	-	-	3.6	0.39
<i>M. glauca</i> (Ehr.) Naegeli	-	1.5	0.9	0.7
<i>Nostoc</i> sp.	-	0.55	0.8	0.54
<i>Oscillatoria amoena</i> Gomont	-	-	0.8	0.35
<i>Oscillatoria curviceps</i> Agardh	-	-	-	0.16
<i>Oscillatoria formosa</i> Bory	0.8	-	-	0.09
<i>Oscillatoria limnetica</i> Lemmermann	1.95	-		0.25
<i>O. limosa</i> (Ag.) Gomont	1.5	0.4	2.25	-
<i>O. princeps</i> Vaucher	0.25	-	-	-
<i>O. tenuis</i> Agardh	0.35	3.05	0.35	0.1

<i>Phormidium</i> sp.	0.3	-	-	-
<i>Spirulina</i> sp.	-	-	3.15	-
<i>Spirulina laxa</i> G.M.Smith	-	-	0.85	-
<i>Spirulina major</i> (Witt.) Kützing	0.75	-	-	0.11
Chlorophyceae				
<i>Ankistrodesmus falcatus</i> (Cord.) Ralfs	0.85	2.25	3.9	0.16
<i>Ankistrodesmus</i> sp.		1.25	1.4	-
<i>Botryococcus</i> sp.	0.65	-	0.9	-
<i>Carteria</i> sp.	-	0.55	2.6	-
<i>Chlamydomonas</i> sp.	-	-	-	0.17
<i>Chlorella vulgaris</i> Beijerinck	0.05	-	-	-
<i>Cladophora</i> sp.	-	-	-	15.7
<i>Coelastrum reticulum</i> (Dang.) Senn	0.15	1.95	5.65	0.03
<i>Cosmarium</i> sp.	0.9	-	-	-
<i>Cosmarium botryis</i> Meneghinii	0.4	-	-	-
<i>Cosmarium laeve</i> Rabenhorst	1	-	-	-
<i>Crucigenia</i> sp.	-	-	-	0.04
<i>Eudorina</i> sp.	-	0.55	0.6	-
<i>Mougeotia</i> sp.	3.7	0.15	1.25	3.4
<i>Monoraphidium</i> sp.	-	1.95	-	-
<i>Tetrahedron minimum</i> (A.Braun) Hansg	-	-	-	0.1
<i>Oedogonium</i> spp.	8.8	2.8	0.75	37.1

<i>Oocystis elliptica</i> West	-	1.05	1	-
<i>Pediastrum. clathratum</i> Lemmermann	1.85	0.5	0.65	-
<i>P. clathratu</i> var. <i>duodenarium</i> (Bail)Lemmermann		0.8	0.5	-
<i>P. duplex</i> Meyen	2.35	1.9	1.6	0.06
<i>P. duplex</i> var. <i>reticulatum</i> Langerheim	1	-	-	-
<i>P. glanduliferum</i> Bennet		0.35	2.55	-
<i>P. simplex</i> Meneghinii	0.45	-	3.15	
<i>Scenedemus abundans</i> (Kirch)	-	-	-	0.93
<i>S. arcuatus</i> var. <i>tetradesmoides</i> G M.Smith	1.7	-	-	0.26
<i>S. bijuga</i> (Turp.) Lagerheim	-	1.1	1.45	0.71
<i>S. dimorphus</i> (Trup.) Kützing	-	3.1	2.25	0.03
<i>S. calyptratus</i>	-	2.65	1	
<i>S. quadricauda</i> (Turp.)De Brébisson	1.15	1.5	0.8	0.41
<i>S.opliensis</i> P.Richter	1.25			1
<i>Spirogyra</i> sp.	0.45	1.7	0.5	2.1
<i>Staurastrum</i> sp.	0.65	-	-	0.23
Euglenophyceae				
<i>Euglena</i> sp	-	-	0.7	-
<i>Euglena acus</i> Ehrenberg	-	-	0.3	0.23
<i>Euglena viridis</i> (Müll.) Ehrenberg	0.4	0.3	0.85	-
<i>Phacus caudate</i> Huebner	-	-	0.3	-
<i>Phacus orbicularis</i> Huebner	-	0.1	0.2	0.18

<i>Phacus</i> sp.	0.1	-	-	-
Chrysophyceae				
<i>Dinobryon divergens</i> Lmhof	-	-	-	0.24
<i>Dinobryon sertularia</i> Ehrenberg	-	-	-	0.21
Pyrrhophyceae				
<i>Ceratium hirundinella</i> (Müll.) Dujardin	-	0.4	-	0.15
<i>Peridinium cinctum</i> Ehrenberg	0.3	3.25	3.6	0.09
Cryptophyceae				
<i>Cryptomonas</i> sp .	-	-	-	0.12
Bacillariophyceae				
A.Centrales				
<i>Aulacoseira granulata</i> (Ehr.) Ralfs	-	-	-	42.81
<i>A. italica</i> Ehrenberg	-	-	8.27	-
<i>C. meneghiniana</i> Kützing	248.1	14.7	140.59	-
<i>Cyclotella ocellata</i> Pantocsek	49.6	7.43	-	49.42
<i>Stephaenodiscus astera</i> (Ehr.) Grunow	16.5	7.43	-	41.35
B.Pennales				
<i>Cocconeis pediculus</i> Ehrenberg	-	-	-	33.09
<i>Coccones placentula</i> Ehrenberg	-	-	74.43	33.09
<i>C. placentula</i> var. <i>euglypta</i> (Ehr.) Cleve	-	-	-	33.09
<i>C. solea</i> (Brèb) Smith	8.27	-	-	-
<i>C. aspera</i> Ehrenberg	-	-	-	8.27

<i>C. cistula</i> (Hempr.) Grunow	-	7.43	-	-
<i>C.leptoceros</i> Ehrenberg	-	7.43	-	16.54
<i>Diatoma elongatum</i> (Lyng.)Agardh	-	-	23.81	-
<i>F. crotonensis</i> Kitton	-	-	24.81	-
<i>Gymphoneis olivaceum</i> (Horn.) Dawson	-	-	7.43	16.54
<i>G.olivaceum</i> Lyugbye	-	-	-	16.54
<i>G.parvulum</i> (Kütz.)Grunow	-	-	16.54	16.54
<i>Navicula atoms</i> (Kütz.) Grunow	-	-	8.27	-
<i>N. cryptocephala</i> Kützing	-	11.1	-	33.08
<i>N. cryptocephala</i> var. <i>intermedia</i> Grunow	-	-	8.27	-
<i>N. lanceolata</i> (Ag.)Kützing	-	-	-	16.54
<i>N. oblonga</i> Kützing	-	-	16.54	-
<i>N. radiosa</i> Kützing	-	-	-	16.54
<i>Nitzschia acicularis</i> W.Smith	-	-	-	8.27
<i>N. amphibia</i> Grunow	-	-	8.27	-
<i>N. dissipata</i> Kützing	-	-	-	8.27
<i>N. longissima</i> (Bréb.) Ralfs	33.08	-	-	-
<i>N.obtusa</i> W.Smith	-	-	8.27	-
<i>N. palea</i> Kützing	16.5	7.43	33.08	16.54
<i>N. sigmoidea</i> (Ehr.) W.Smith	-	-	8.27	-
<i>N. vermiculorls</i> Kützing	-	-	16.54	-
<i>Rhoicosphenia curvata</i> (Kütz.) Grunow	-	7.43	16.54	24.81

<i>Surirella robusta</i> Ehrenberg	-	-	-	8.27
<i>S. ovata</i> Kützing	8.27	-	16.54	-
<i>Syndra acus</i> Kützing	-	-	-	16.54
<i>S. ulna</i> (Nitz.) Ehrenberg	8.27	-	41.35	16.54
Total	439.99	145.43	589.37	522.26

The study recorded a clear increase in the total number of phytoplankton(589.37 cell/l×10³) during Spring 2017 and 522.26 cell/l×10³ in Summer2017 as shows (Table 7)and recorder less number of phytoplankton145.43 (cell/l×10³) in rainy season , This increase is due to the length of daylight hours and intensity of light[11] . as remarkable recorded increase in Bacillariophyceae the reason for this due to their ability to tolerate the variation conditions of the aquatic environment [48] and species respond quickly to changes in water and sediments [37 , 45 ,47,48, 49] noted running water condition was more suitable for Diatoms growth while still water was favorable conditions for Blue-green and Green algae . Bacillariophyceae groups were dominant according to the total number of species because of its fast reaction to changes in the physical, synthetic and organic factors in the aquatic environment , and in addition the capacity to withstand, develop and duplicate under various ecological varieties, for example, high temperature, light power, saltiness and plant supplements[34,35].Some species have been characterized by the presence within the period of study such as *Cyclotella meneghiniana*, *Nitzschia palea*,*Syndra ulna* because, their ability the presence of these species is due to withstand the environmental factors and it prefers to live in water that have alkaline nature instead of living in saline water[17] *Cyclotella meneghinana* was exist during the study period as species recorder high density (140.59-248.1(cell/l)×10³) this species use as an indicator of water rich in nutritious salts, which is organically contaminated[38] Where agreed with Palmer's index as in (Table 5) where the area is contaminated with confirmed organic contamination, Numerical abundance and high diversity are affected by nutrient concentrations in water[39] . Variation of phytoplankton may be due to an increase in hardness in addition alteration in light penetration, nutrient concentration on along length of river this factors were limited increase phytoplankton [40] Some species of green algae disappear due to their inability to tolerate high temperatures[36,41]

Conclusion

The water quality of the Tigris river moderate pollution according to Shannon and Winner’s index and of high organic pollution according to Palmer’s Pollution index.

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