Journal of Engineering and Applied Sciences

MEDWELL PUBLICATIONS SINCE 2000

Diurnal Variation of Total Count for Algae and Chlorophyll and Relation with Physical and Chemical Parameters of Euphrates River/North-Western of Baghdad

Amin Abooud Kbin Al-Ghafily

Department of Biology, College of Education for Pure Science (Ibn Al-Haitham), University of Baghdad, Baghdad, Iraq

Key words: Alagae, Caanophyceae, Chlorophyceae, Bacillariophyceae, chemical properties

Corresponding Author:
Amin Abooud Kbin Al-Ghafily
Department of Biology, College of Education for Pure Science (Ibn Al-Haitham), University of Baghdad, Baghdad, Iraq

Page No.: 3640-3647
Volume: 15, Issue 21, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences

Abstract: The current study included some physical and chemical properties at one location in the Euphrates River/North-Western of Baghdad and its relationship to the total count of algae and chlorophyll concentration to identify daily changes. The physical and chemical properties included the estimation of the temperature of air and water which was characterized by the height during the daytime and the decrease during the night, ranging between (17-26)°C for air and (17-19)°C for water. The values of the pH tended to the alkalinity by registering values above (7) and no daily changes appear clear. The electrical conductivity was the highest value (1310) μS cm^{-1} and the lowest (743) μS cm^{-1}. The salinity values followed the values of electrical conductivity and ranged from (0.42-0.81)‰. CO_2 concentrations ranged from 1.51-3.62 mg L^{-1} while total acidity reached values ranging from (755-6481) mg L^{-1} and total alkalinity (214-367) mg L^{-1}. The results showed that there was no apparent decrease in the concentration of dissolved oxygen at the study site and did not reach complete depletion in station with the lowest concentration of dissolved oxygen in water (5.8) mg L^{-1} and highest (7.8) mg L^{-1}. Plant nutrient ranged from (0.004-0.077) μg of nitrogen atom-nitrite/L while phosphate concentrations ranged (0.64-4.10) μg of phosphorus atom-phosphate/L and silica concentrations reached between (189-412) μg of silicon atom-silicate/L. (35) species of algae belong to (31) genus which the class in clued Bacillariophyceae, Cyanophyceae, Chlorophyceae, Euglenophyceae and Pyrrophyeae. As for the quantitative study, the total count of algae in the Euphrates river for samples studied ranged from (76×10^3) cell/L and (475×10^3) cell/L. Chlorophyll concentration was estimated in the river and the concentrations ranged from (5.43) μg chlorophyll-a/L at (16) o'clock and (0.91) μg chlorophyll-a/L at (24) o'clock.

INTRODUCTION

The Euphrates River stems from the mountainous region of South Eastern Turkey, North of the land of Rum which is >3,000 m above sea level and reaches 2,900 km and the Euphrates River continues to run South until it arrives North Western of Baghdad which has been selected as the site of the current study.

Iraq possesses many large bodies of water in the form of rivers, lakes and marshes, estimated at (18879) km^2. The importance of algae in the river environment as primary products with the ability to convert inorganic materials into organic materials[1]. The algae is a means to determine the stability of the aquatic ecosystem and the rivers are conceders as the continuous flux ecosystems and pass through different areas from upstream to downstream and this leads to a change in some of its physical and chemical properties[2] which in turn affect the quality and quantity of aquatic organisms.

Environmental studies in Iraq date back to the middle of the sixth decade of the 20th century but very few of them have been concerned with daily variations while the vast majority of them have examined the quarterly changes of physical, chemical properties and algae. A study of Al-Nimma[3] considered as pioneer studies on the Tigris and Euphrates rivers while Maulood *et al.*[4] conducted a limnological study on the Tigris, Euphrates and Shatt Al-Arab Rivers.

Al-Saadi *et al.*[5] conducted a study on the environmental characteristics of the upstream Tigris and Euphrates Rivers and their relationship to the development of fish resources in Iraq. Zidan *et al*.[6] conducted an environmental study that included chemical and physical pollutants affecting the Euphrates River in Al-Ramadi and Fallujah and other study to Salman[7] on possible pollution of the Euphrates River between Al-Hindia dam and Al-Karma Regions. The study of Al-Ghafily and Al-Tamimi[8] is one of the important studies on the daily changes of phytoplankton and its relationship to some environmental factors in one location of Al-Habbaniyah Lake. The Tigris River has received remarkable attention from a number of researchers, most of which have focused on physical and chemical factors and their impact on the quality and quantity of algae[9-11].

MATERIALS AND METHODS

Sample collection method: Water and algae samples were collected in one sample per hour for 24 h and for the period from 9 a.m. to 25 April until 8 a.m. on 26 April. The sampling location is generally based on the nature and quality of the water source and the sampling site is homogeneous, taking into account the ease of access to the site and obtaining the sample. The samples were collected from the deep stream by mixing a sample of depth (0.2) m with another sample of depth (0.8) m and the equal size of each then taking from it (5) L after that the sample were transported to polyethylene containers for laboratory measurements and analyses. Some measurements were made directly in the field.

Physical and chemical factors: The mercury thermometer is used to measure the air temperature directly at the specified sampling location and temperature measurement after it has been confirmed in °C. The measurement must be done directly at the site.

For the calculation of the pH was done using a digital portable pH meter model pH 90 made Wiss. Techn Werkstatten D812 Company in the field. The electrical conductivity was measured using a digital portable conductivity meter model F91 the Wiss. Techn Werkstatten D812 company. The salinity values obtained from the electrical conductivity values shown by Golterman *et al*.[12] and according to the following equation:

$$\text{The salinity‰} = \frac{\text{The electrical conductivity} \times 14.78}{1589}$$

The results are expressed in ‰. The total acidity was measured according to Golterman *et al*.[12] and the results were expressed in mg L^{-1}. The method described by APHA, AWWA and WPCF.[13] was followed in estimating the total alkalinity values and expressed the results mg L^{-1}. To calculate the concentration of carbon dioxide[12], method was adopted and the results were expressed in mg L^{-1}. To calculate the concentration of dissolved oxygen, it has been measured by following the Winkler method[14] described by APHA, AWWA and WPCF[13].

To measure the concentration of the nitrite ion (NO_2), the method described by Parson *et al.*[15] was used by colorimetric method using the optical spectrum device spectrophotometer and at a wavelength (543 nm) nanometer and expressed the results in μg nitrogen atom-nitrite/L. In order to obtain phosphate concentration, the method described by Parson *et al*.[15] is followed by the method of colorimetric using the optical spectrum device spectrophotometer and at a wavelength (885 nm) nanometer and the results are expressed in μg phosphorus atom-phosphate/L. The silicate was found in the method described by Parson *et al*.[15] by following the method of colorimetric using the optical spectrum device spectrophotometer and at the wavelength (810 nm) and the results expressed in μg silicon atom-silicate/L.

Phytoplankton

Qualitative study: The samples were collected using a phytoplankton net with a diameter of 55 micron, after being flooded and pulled several times and towed and lifted vertically and then emptied of the contents with small glass bottles, after that added a Logel solution.

The samples were examined using the light microscope and the high power of magnification (100x) where the algae were diagnosed to the level of the species and sometimes to the level of genus based on the following available sources for the no diatoms algae[16-20].

The diatoms were diagnosed after their structures were clarified and the slides were examined by light microscope and using the oily lens (100x) and were adopted in the diagnosis of algae on the following basic sources[21-23].

Quantitative study: To calculate the total count of phytoplankton, the sedimentation method described by Furet and Benson-Evan[24] was used by taking a liter of the sample after well-shake, placed in a 1 L glass cylinder and added 10 mL of Lugol's solution and left without stirring for 10 days. After that, it was pull the upper part of the water using the siphon, keeping in mind that the cylinder is not moved during the pulled until the last 100 mL and transferred to another cylinder of 100 mL. Then, left without stirring for a week after that the upper part of the water was pulled up to the last 10 mL transported to a small storage vial.

The number of diatoms (Bacillariophyceae) is calculated by following the method of the micro-transect using the permanent slides as follows:

The number of cells in 1 mL of the original form = The number of cells calculated in a single transverse section×the conversion coefficient×the drop size correction coefficient.

As for the non-diatoms algae, the method of the haemocytometer described by Martinez *et al*.[25] was used where a minimum of 30 μ fields were counted and then the count was obtained in the single microscopic field where the number of non-diatoms cells was calculated at (1) mL of the original sample.

Number of cells in 1 mL of the original sample = number of cells in one microscopic field size×the number of microscopic field sizes in 1 mL of the original sample.

Measurement of chlorophyll-a: To find the concentration of chlorophyll-a the method developed by Parson *et al*.[15] was followed by the filtration of 500 ml of the water sample using membrane filtration papers 0.45 μ. Before the completion of the filtration process added 2 mL of magnesium carbonate to prevent the decomposition of chlorophyll to phytoviteen. The membrane paper was then placed after the filtration was completed and the remaining water in the paper was disposed of and used acetone (90%) as a solvent to extract chlorophyll pigment from algae.

The readings were mediated by spectrophotometer SP8-100 UV/VIS on wavelengths (630, 640, 665, 750) nm and using 90% acetone compared to Blank the absorption amount was subtracted at all wavelengths 630, 645, 665 nm as a comparison of the turbidity blank. Then, it was calculated the chlorophyll concentration according to the following equation:

$$\mu\text{g chl.a/L} = \text{C/VC}\left(\text{Chlorophyll a}\right) = 11.6E665 - 1.31\ E645 - 0.14\ E630$$

The results are expressed in μg-chlorophyll-a/L.

RESULTS AND DISCUSSION

Physical and chemical factors (Table 1)

Temperature degree: The temperature is the most important environmental factor because of its impact on the physical, chemical and biological characteristics of the water. Whereby it effectively affects the dissolving of gases in water, particularly the dissolving of oxygen and carbon dioxide. As well as it is an important factor in determining the activity and effectiveness aquatic organisms. The air temperature of the samples studied ranged between (17)°C at (3) o'clock and (26)°C at (16) o'clock and the water temperature went the same pattern but with fewer ranges, ranging from (17-19)°C.

A wide range between night and daytime characterized the air temperature during the daytime of study where it reached (9)°C and this is identical to Al-Shalash[26]. As well as it was showed the rise and decrease in the temperature of the air is compatible with the rise and fall in the temperature of the water but with fewer ranges as (2)°C and this corresponds to the rest studies on water bodies in Iraq[27].

pH value: The pH expresses of the activity and efficacy of hydrogen ion in water as it refers to the numerical value of logarithm the inverse of hydrogen ion concentration. The value of pH for water between (0-14) and in general most natural water tends to be slightly alkalinity because of the presence of carbonates and bicarbonates. Low pH values effect on the balance of carbonates and bicarbonates, resulting in the release of carbon dioxide (CO_2) and this affects the livelihood of aquatic organisms.

During the current study, the Euphrates River waters were was special on the alkaline side throughout the daytime. Most of the Iraqi water is alkalinity and this is evident during the current study where the pH values (7.14-7.69) have ranged and this is consistent with many previous studies[28, 29].

The increase and decrease in the values of pH during this study did not reflect the values of the total alkalinity and this indicates the regulatory capacity in the

Table 1: Physical and chemical properties of the Euphrates River

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
9	16	18	7.41	743	0.45	3.02	1030	286	6.8	0.008	0.84	283	2.27	400
10	17	17	7.27	804	0.49	2.71	1030	214	6.4	0.016	2.03	289	1.51	228
11	18	19	7.65	861	0.53	1.81	1030	214	6.1	0.019	2.66	220	4.09	209
12	20	19	7.64	795	0.49	2.41	824	286	6.0	0.009	0.64	211	3.11	285
13	21	18	7.16	1064	0.66	2.41	1098	214	6.3	0.004	0.81	237	2.52	19
14	22.5	19	7.29	1079	0.68	1.81	1098	214	6.2	0.007	1.12	209	4.78	133
15	24	19	7.43	1118	0.69	2.71	1373	214	6.4	0.005	1.89	189	5.21	190
16	26	19	7.57	1237	0.75	3.62	1373	143	6.7	0.013	1.24	247	5.43	114
17	24	19	7.62	1221	0.73	2.11	1545	214	6.8	0.018	2.36	257	4.17	133
18	25	18	7.61	1187	0.66	2.11	1236	214	6.1	0.021	2.47	310	3.03	304
19	21	19	7.13	1065	0.66	2.11	1648	214	5.8	0.047	3.11	324	3.22	114
20	20	18	7.52	970	0.60	2.41	961	286	6.8	0.051	3.24	319	2.74	342
21	19	18	7.50	969	0.60	1.81	1030	214	7.1	0.009	3.18	336	2.92	456
22	18	19	7.59	1007	0.62	1.51	1030	357	7.5	0.062	2.98	384	2.02	342
23	18	18	7.69	931	0.57	2.11	1098	286	7.6	0.074	3.68	345	0.98	19
24	18.5	18	7.67	1198	0.74	1.81	1030	286	7.8	0.077	3.92	388	0.91	190
1	18	18	7.65	1207	0.75	1.51	892	357	7.1	0.054	4.03	412	1.18	247
2	18	18.5	7.65	1310	0.75	2.71	1030	286	7.2	0.047	3.77	408	1.29	57
3	17	18.5	7.52	1264	0.81	3.62	1098	286	7.5	0.043	4.10	386	2.09	247
4	15	18	7.67	1125	0.78	2.11	1304	286	7.4	0.038	3.85	341	2.13	209
5	15	18	7.65	1078	0.69	2.41	1098	357	7.6	0.031	3.24	318	2.06	133
6	15	17	7.67	973	0.66	2.41	892	286	7.7	0.021	3.08	333	2.61	57
7	14	18	7.32	921	0.57	2.71	755	367	6.9	0.019	2.21	305	3.19	323
8	14	18	7.55	883	0.54	2.71	824	286	6.1	0.012	1.91	291	3.39	114

1 = Sampling time; 2 = Air temperature (°C); 3 = Water temperature (°C); 4 = pH; 5 = Electrical conductivity (µS cm^{-1}); 6 = Salinity‰; 7 = Carbon dioxide (mg L^{-1}); 8 = Total acidity (mg L^{-1}); 9 = Total basicity (mg L^{-1}); 10 = Dissolved oxygen (mg L^{-1}); 11 = Nitrites (NO_2) µg nitrogen atom-nitrite/L; 12 = Phosphates PO_4 µg phosphorus atom-phosphate/L; 13 = Silicates SiO_3 µg silicon atom-silicate/L; 14 = Chlorophyll-a µg L^{-1}; 15 = Total number of phytoplankton cell×10^3/L

waters of the Euphrates River on the one hand and the alkaline universe of the bicarbonate on the other hand[30].

Electrical conductivity and salinity: Highest read of electrical conductivity values (1310) µS cm^{-1} at (2) o'clock and lowest (743) µS cm^{-1} at (9) o'clock. The results showed differences in the values of electrical conductivity of the samples studied and the extent of a daily variability reached (567) µS cm^{-1} and this represents a wide range of the daily changes in the study site. The salinity values ranged between (0.81)‰ at (2) o'clock as a maximum and (0.45)‰ at 9 o'clock as a minimum. Many researchers have referred to the parallel relationship between electrical conductivity and salinity[31]. According to the salinity values recorded in the current study, the Euphrates River are freshwater according to Reid[32] classification. This study are similar to many previous studies conducted on the Tigris and Euphrates Rivers[5, 33].

Carbon dioxide: The daily changes in the values of carbon dioxide at the study site of the Euphrates River were low, the high values were recorded in the daytime at (16) o'clock with (3.62) mg L^{-1} and low at night at (22) o'clock with (1.51) mg L^{-1}.

The carbon dioxide gas concentrations are directly reflected in the total acidity values that produced in natural waters by the presence of carbon dioxide which can enter the surface water from the atmosphere as well as its potential presence within the water as a result of bio oxidation processes of organic materials by bacteria.

Total acidity: It is noted from the results that the total acidity in the Euphrates River water did not decrease from (755) mg L^{-1} while the highest reading reached (1648) mg L^{-1}, the results of total acidity showed a daily variability of 893 mg L^{-1}.

The acidity in natural waters produces from the presence of carbon dioxide in the water and is called carbonic acid and water contains the mineral acid resulting from the subtraction of industrial wastes containing mineral acids and some of its salts into this water.

Total alkalinity: The total alkalinity values in the Euphrates River ranged from (214)-(357) mg L^{-1} with a daily variation of 143 mg L^{-1} and the Euphrates River waters showed no clear daily changes. The alkalinity is defined as an indicator of the water content of carbonate, bicarbonate and hydroxides. The current study indicates that the alkalinity is the alkalinity of the bicarbonate and this is consistent with many studies on the Iraqi water bodies[34, 35]. It is necessary to determine the water alkalinity for the purpose of determining its uses, controlling corrosion, treating water and tackling algae growth problems.

pH indicates the regulatory capacity in the Euphrates River on the one hand and the alkaline universe of the bicarbonate on the other hand, a result that is consistent with Al-Lami *et al.*[36] study.

Dissolved oxygen: Daily changes in the dissolved oxygen concentrations showed that the lowest concentrations were recorded at (19) o'clock and 5.8 mg L^{-1}. The highest concentrations were (7.8) mg L^{-1} at (24) o'clock and the oxygen dissolved in water is one of the most important factors determining the quality of water because of effecting on the natural equilibrium of organisms in the aquatic environment. The lack of oxygen cause damage in the presence of aquatic organisms and the oxygen is a good indicator of organic pollution[37]. The speed that the depletion of the biological oxygen during the water depends on the movement of surface water and waves that lead to more mixing[38].

Plant nutrients

Nitrite: The highest concentration of nitrite (0.077) µg nitrogen atom-nitrite/L. at (24) o'clock and at least (0.004) µg nitrogen atom-nitrite/L at (13) o'clock. The most of the forms in which nitrogen compounds are found in water are nitrate, nitrite, ammonia and organic nitrogen. The nitrogen compounds come to water from rainwater and domestic and industrial wastewater polluted by these compounds.

The phenomenon of nitrite deficiency when increasing oxygen concentrations was observed in this study as observed by a number of Iraqi researchers[39] in the marshes of southern Iraq and in the Tigris River by Saadallah[40].

Phosphate: The highest concentration of phosphate (4.10) µg phosphorus atom-phosphate/L. at (3) o'clock while the lowest concentration of phosphate (0.64) µg phosphorus atom-phosphate/L. at (15) o'clock, the phosphate is of great importance in the aquatic environment as it is a major nutrient and exists in two organic and inorganic form Issawy.

Phosphorus compounds reach river through the arrival of fertilizers, animal wastes and household residues containing cleaning detergents to water[9]. The values were high during the sampling and this is due to the high water levels with the impact of rainfall[41]. The phosphate concentrations recorded in the current study are approached by other studies[42, 43].

Silicate: The highest concentration of the sample is for studied samples (412) µg silicon atom-silicate/L. at (1) o'clock and lowest (189) µg silicon atom-silicate/L. at (15) o'clock and daily variation (223). The Iraqi waters generally contain high concentrations of silicates[44]. So, the dominion of the diatoms are observed on other algae groups in the Iraqi environment[45].

The increased concentration of silicates may be due to the washing of soils by rainwater and the continuous bottom movement of the river[30]. While the low concentrations of silicates in the river may be due to the activity of many diatoms and their consumption of silicates and this is consistent with Al-Jumaily[46] study, the silicates are considered an essential materials in the structure of diatoms[47].

Algae

Qualitative study: The (35) species of algae belonging to (31) genus were diagnosed during the study and the diatoms (Bacillariophyceae) were predominant whereas (19) species belonging to (15) genus were included. While the class of blue greens algae (Cyanophyceae) (8) species belong to (8) genus. The green algae class (Chlorophyceae) included (6) species belonging to (6) genus while one species each of the class of the Euglenophyceae and Pyrrophyeae and among the diagnosed algae there are four species belonging to four genus observed during study: *Bacillaria poxillfar*, *Cyclotella comta*, *Cocconeis placentula*, *Diploneis ovalis* (Fig. 1).

This study concluded that diatoms (Bacillariophyceae) are the prevalence groups of the algae[11], especially Pennales while the central diatoms were confined to a few genus (*Cyclotella*, *Cocconeis*, *Coscindiscus*) as well as the genus that included the largest number of species are (*Cylotella*, *Gyrosigma*, *Nitzschia*). The diatoms were followed the blue-green algae (Cyanophyceae) then a class of green algae. This is consistent with a number of previous studies[45].

While Talling indicated that green algae class (Chlorophyceae) was dominated by the blue-green algae (Cyanophyceae) and was astonished at the time by the lack of blue-green algae (Cyanophyceae) in the Tigris and Euphrates Rivers. Al-Saadi *et al*.[48] predicted an increase in the number of blue-green algae (Cyanophyceae) in Iraqi waters. The two groups of Euglenophyceae and Pyrrophyceae included very few specific numbers of species that were not particularly important in terms of the total number of species recorded in this study compared to the numbers of other groups and this is consistent with many studies conducted on the Iraqi water bodies[49].

Quantitative study: The total count of algal samples studied in the Euphrates river ranged from (76×10^3 cell/L) as a minimum at (23) o'clock and (475×10^3 cell/L) as a maximum of (12) o'clock. The group of diatoms (Bacillariophyceae) was present continuously throughout the duration of the study and formed the vast majority of the total number of algae and it was observed that two clear increases, the first at (12) o'clock and reached the numbers (247×10^3 cell/L) and the second at (5) o'clock with (228×10^3 cell/L) (Fig. 2).

The dominance that was observed for the diatoms (Bacillariophyceae) in this study was recorded in a number of previous studies on the Iraqi water

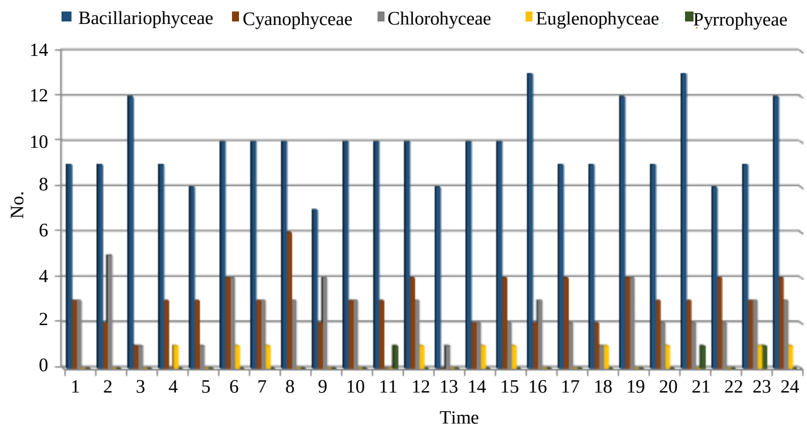

Fig. 1: List of algae family diagnosed in the Euphrates River

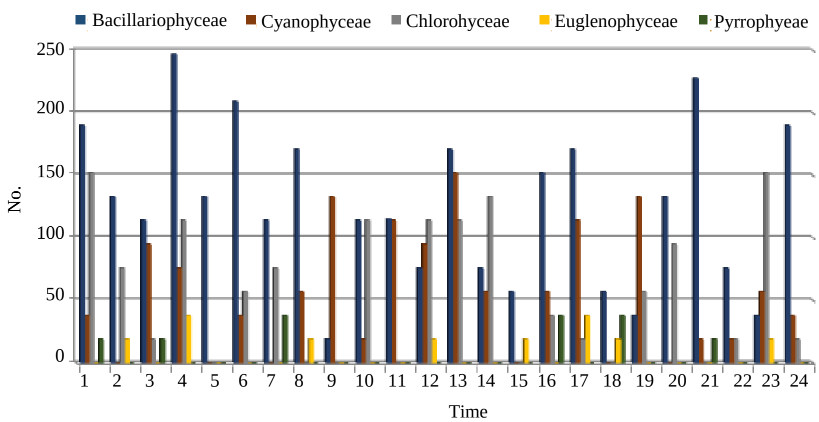

Fig. 2: Total count of cells of algae family (cell×10^3/L) recorded during the study period

bodies[11, 45, 49]. As for the blue green algae (Cyanophyceae), the daily changes showed a single increase at (21) o'clock (152×10^3 cells/L). *Oscillatoria tenuis*s pecies recorded a clear increase in numbers (133×10^3 cells/L) and the rest genus of Cyanophyceae showed a fluctuation in their appearance. The species returned to green algae (Chlorophyceae) group showed two peaks during the sampling period, the first at (9, 6) o'clock and (152×10^3 cells/L), the second at (22) o'clock (138×10^3 cells/L). *Botryococcus braunii* recorded numbers (95×10^3 cells/L) at (22) o'clock while Euglenophyceae and Pyrrophyeae did not record more than (38×10^3 cells/L) compared to the rest of the algae classes.

Chlorophyll-a: The highest reading of chlorophyll concentration (5.43) µg L^{-1}. was recorded at (16) o'clock and the lowest (0.91) µg L^{-1} at (24) o'clock, although, slight changes were recorded in chlorophyll-a-but a convergence of sampled readings was observed.

The concentration of chlorophyll-a in many researches and studies was used to denote the numbers and productivity of algae as well as a clear function of the condition of the water body in terms of availability or unavailability of materials[50]. In Iraq was applied in several bodies of water such as the study conducted at Al-Saqlawiyah[40] and the upstream of Euphrates[48].

The results show that the daily variations of chlorophyll-a have not coincided with the total count of studied algae for these samples which may be attributed to the presence of filamentous algae[51].

CONCLUSION

Whereas the chlorophyll-a concentrations in filamentous algae are more than their contentions in phytoplankton as it is characterized by large size and size of its plastid and therefore, contains greater concentrations of chlorophyll[52].

REFERENCES

01. Lamberti, G.A., 1996. The Role of Periphyton in Benthic Food Webs. In: Algal Ecology, Fresh Water Benthic Ecosystem, Stevenson, R.J., M.L. Bothwell and R.L. Lowe (Eds.)., Academic Press, San Diego, California, pp: 533-573.
02. Allan, J.D., 2006. Stream Ecology; Structure and Function of Running Waters. Springer, Dordrecht, The Netherlands, Pages: 388.
03. AL-Nimma, B.A.B., 1982. A study on the limnology of the Tigris and Euphrates Rivers. M.Sc. Thesis, Salahaddin University-Erbil, Erbil, Iraqi Kurdistan.
04. Maulood, B.K., H.A. Al-Saadi and R.A.M. Hadi, 1993. A liminological study of Tigris, Euphrates and shatt Al-Arab, Iraq, Mu’tah. J. Res. Stud., 8: 53-67.
05. Saadi, H.A., A.A.Z. Lami and T.I. Qasim, 1999. Study of the environmental characteristics of the Upper Tigris and Euphrates rivers and their relation to the development of the fish wealth in Iraq. J. Environ. Res. Sustainable Dev., 2: 20-31.
06. Zidan, T.A., A.I.A.K. Rahman and O.M. Saoud, 2009. Environmental study of chemical and physical pollutants affecting the Euphrates river in Al-Rumadi and Fallujah. Anbar Univ. J. Pure Sci., 3: 1-11.
07. Salman, J.M., 2006. An environmental study of potential pollution in the Euphrates river between Al-Hidia dam and Al-Kufa area. Ph.D. Thesis, University of Babylon, Hillah, Iraq.
08. Al-Ghafily, A.A.K. and A.N.A.M. Al-Tamimi, 2009. The daily change of phytoplankton and its relation to some environmental factors in one of the sites of Lake Al-Habbaniyah. Ibn Al- Haitham J. Pure Appl. Sci., 22: 1-10.
09. Dulaimi, A.I.H., 2013. An environmental and diagnostic study of algae in the Tigris river for the city of Al-Dhuluiya and its suburbs within the governorate of Salah Al-Din. M.Sc. Thesis, College of Science, Tikrit University, Tikrit, Iraq.
10. Al-Sinjari, M.N.F.M., 2001. Environmental study on algae in the Tigris river. M.Sc. Thesis, College of Science, University of Mosul, Mosul, Iraq.
11. Al-Maqdmi, B.A.A.H., 2016. Study of the community of algae diatoms in the Tigris river between Baghdad and Al-Dijail. Ph.D. Thesis, College of Education for Pure Sciences, University of Baghdad, Baghdad, Iraq.
12. Golterman, H.L., R.S. Climo and M.A.A. Ohnstad, 1978. Methods for Physical and Chemical Analysis of Fresh Waters. 2nd Edn., Blackwell Scientific Publications, Oxford, Pages: 213.
13. APHA, AWWA and WPCF., 2005. Standard Method for the Examination of Water and Wastewater. 21st Edn., American Public Health Association, Washington, DC., USA.
14. Winkler, L.W., 1888. The determination of dissolved oxygen in water. Berlin Deutsch. Chem. Ges., 21: 2843-2844.
15. Parson, T.R., Y. Maite and C.M. Lalli, 1984. A Manual of Chemical and Biological Methods for Sea Water Analysis. Pergamon Press, Oxford, England, UK.,.
16. Desikachary, T.V., 1959. Cyanophyta. Council of Agricultural Research, New Delhi, India, Pages: 686.
17. Fritsch, F.E., 1965. The Structure and Reproduction of the Algae. Vol. 2, Cambridge University Press, Cambridge, England,.
18. Prescott, G.W., 1979. How to Know the Fresh Water Algae. 3rd Edn., William C. Brown Co., Dubuque, Iowa,.
19. Hinton, G.C.F. and B.K. Maulood, 1982. Contribution to the flora of Iraq: The non-diatom flora of the Southern Marshes. Nova Hedwigic, 37: 49-63.
20. Bold, H.C. and M.J. Wynne, 1985. Introduction to the Algae. Prentice-Hall, Inc., New Jersey, USA., pp: 141-144.
21. Patrick, R. and C. W. Reimer, 1975. The Diatoms of the United States Exclusive of Alaska and Hawaii. Vol. 2, Academy of Natural Sciences, Philadelphia, Pages: 213.
22. Hadi, R.M., A.A. Al-Saboonchi and Y.A.K. Haroon, 1984. Diatoms of the Shatt al-Arab river, Iraq. Nova Hedwigia, 39: 513-557.
23. Munir, M., R. Qureshi, M. Arshad, A.K. Chaudhry and M.K. Laghari, 2012. Taxonomic study of bacillariophyta from Kallar Kahar lake Chakwal, Punjab, Pakistan. Pakistan J. Bot., 44: 1805-1814.
24. Furet, J.E. and K. Benson-Evans, 1982. An evaluation of the time required to obtain complete sedimentation of fixed algal particles prior to enumeration. Br. Phycol. J., 17: 253-258.
25. Martinez, M.R., R.P. Chakroff and J.B. Pantastica, 1975. Note on direct phytoplankton counting technique using the haemocytometer. Phil. Agric., 59: 1-12.
26. Al-Shalash, A.H., 1966. The climate of Iraq. The Cooperative Printing Presses Workers Society, Amman, Jordan.
27. Al-Ghurairi, W.A.S., 2014. Environmental study of algae in the Al-Yusufiya River Baghdad, Iraq. M.Sc. Thesis, College of Science for Women, University of Baghdad, Baghdad, Iraq.
28. Kassim, T.I. and A.W. Sabri, 2001. Effect of Samraa dam reservoir in the community of the algae of the Tigris river. J. Water Resour., 20: 15-32.

29. Al-Saadi, A.J.N., 2013. Biological diversity of the soft and some environmental factors affecting it in the Euphrates river in central Iraq. Master Thesis, University of Babylon, Hillah, Iraq.
30. Al-Mathnani, A.S.M. and I.M.A. Salman, 2009. Ecosystems. 1st Edn., University of Sebha, Casablanca, Libya, Pages: 552.
31. Jakson, D.F., 1979. Algae and Man. Plenum Press, New York, USA., Pages: 434.
32. Reid, G.D., 1961. Ecology of Inland Waters and Estuaries. Reinhold Publications Co., New York, pp: 375.
33. AL-Lami, A.A., T.I. Kassim and A.A. AL-Dylymei, 1999. A limnological study on Tigris River, Iraq. Sci. J. Iraqi Atomic Energy Commission, 1: 83-98.
34. Al-Fatalawy, H.J.J., 2011. Environmental study, quality and quantity of algae in the Euphrates river between Al-Hindia and Al-Manathira- Iraq. Ph.D. Thesis, University of Babylon, Hillah, Iraq.
35. Al-Taie, A.T.K., 2010. An environmental study of algae in some parts of the Northern part of the public estuary. M.Sc. Thesis, University of Baghdad, Baghdad, Iraq.
36. Al-Lami, A.A., A.W. Sabri, T.I. Kassim and K.A. Rasheed, 1996. Phytoplankton of Samara reservoir (Iraq). Acta Hydrobiol., 33: 77-86.
37. APHA. AWWA. WPCF., 2003. American Public Health Association Standard Methods for the Examination of Water and Wastewater. 20th Edn., APHA. AWWA. WPCF., Washington, USA.,.
38. Wetzel, R.G., 1983. Limnology. 2nd Edn., Saunders College Publishing, Philadelphia,.
39. Hadi, R.A.M., A.H.A. Al-Mousawi and A.M. Al-Zubaidy, 1989. A study on the primary productivity in Shatt Al-Arab estuary at Basrah, Iraq. J. Biol. Sci. Res., 20: 593-606.
40. Saadallah, H.A.A., 1988. Environmental study on the effect of the façade of Saqlawiyah on the Tigris river in the city of Baghdad. M.Sc. Thesis, University of Baghdad, Baghdad, Iraq.
41. Ramakrishanan, N., 2003. Bio-monitoring approaches for water quality, assessment in two water bodies at Tiruvannamalai, Tamil Nadu India. Proceedings of the 3rd International Conference on Environment and Health, December 15-17, 2003, University of Madras, Chennai, India, pp: 374-385.
42. Rashid, K.A., 1999. The use of some zooplankton species is a vital indicator of heavy water pollution. Ph.D. Thesis, Al-Mustansiriya University, Baghdad, Iraq.
43. Sulaiman, N.I. and M.L. Aldoori and N.M. Al-Mawla, 2002. A comparative environmental study of three water bodies in Diyala governorate, Iraq. Mu'tah J. Res. Stud., 17: 39-60.
44. Al-Sarraf, M.A.A.A., 2006. A taxonomic environmental study of phytoplankton in Al-Audaim and Diyala and their impact on the Tigris river. Ph.D. Thesis, Department of Biology, College of Science for Women, University of Baghdad.
45. Al-Tamimi, A.N.A.M., 2006. Algae use biological evidence to contaminate the lower part of the Diyala river with organic matter. Ph.D. Thesis, University of Baghdad, Baghdad, Iraq.
46. Al-Jumaily, A.K.H., 2011. Study of the limnology of the Tigris river within the province of Salah Al-Din/Iraq. M.Sc. Thesis, Tikrit University, Tikrit, Iraq.
47. Gnanamoorthy, P., V. Karthikeyan and V.A. Prabu, 2014. Field Emission Scanning Electron Microscopy (FESEM) characterisation of the porous silica nanoparticulate structure of marine diatoms. J. Porous Mater., 21: 225-233.
48. Al-Saadi, H.A., T.I. Kassim, A.A. Al-Lami and S.K. Salman, 2000. Spatial and seasonal variations of phytoplankton populations in the upper region of the Euphrates river, Iraq. Limnologica-Ecol. Manage. Inland Waters, 30: 83-90.
49. Kadhem, N.F., 2014. Study of some physical and chemical properties and their effect on the diversity of algae attached to mud in Al-Abbasia/Kufa river. J. Univ. Babylon Pure Appl. Sci., 22: 701-725.
50. Hutchinson, G.E., 1967. A Treatise on Limnology. I. Introduction to lake Biology and Limnoplankton. Vol. 2, John Wiley and Sons, New York, pp: 1115.
51. Strickland, J.D.H. and T.R. Parsons, 1972. A Practical Handbook of Seawater Analysis. 2nd Edn., Fisheries Research Board of Canada, Ottawa, Canada,.
52. Round, F.E., 1964. The Ecology of Benthic Algae. In: Algae and Man, Jakson, D.F. (Ed.)., Plenum Press, New York, USA., pp: 138-184.