DOI: https://doi.org/10.53350/pjmhs22166379

ORIGINAL ARTICLE

Biodiversity of Phytoplankton in Two Aquatic Ecosystems (LOTIC and LENTIC) During the Autumn Season

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ABSTRACT
Phytoplankton have been studied in quantity and quality in two aquatic ecosystems represented by two sites in the lake of Baghdad Island tourist as a lotic ecosystem and two sites of the Tigris River, one north of the lake and the other south as an lentic ecosystem, and the study was conducted in the autumn of 2021, where 69 species were diagnosed in the environment of the two ecosystems studied, distributed to 14 species of Chlorophyta, 21 species of Cyanobacteria, 29 species of diatom (1 belongs to Centrales order and 28 to Pennales order), 3 species of Euglenophyta and two species of the Chrysophyta division. The dominance of algae belonging to the genus of; Pinnularia, Synedra, Ankistrodesmus, Chroococcus, Oscillatoria, Synechacoccns, Navicula and Nitzschia during the autumn period and at all Sites. Some species showed high density such as: Ankistrodesmus falcatus, Chroococcus disperses, Chroococcus minor, Oscillatoria limnetica, Synechacoccns aeruginosus, Navicula sp. and Nitzschia longissima. The quantitative results showed that the mean density of the phytoplankton in the lotic aquatic ecosystem exceeded that the lentic aquatic ecosystem when recorded (378.68 × 103 cells/L and 334.21×103 cells/L) respectively. Air temperature values were recorded (20-36) °C and while water temperature ranged between (16-25.5) °C, NTU (5.8-19.5) 4), TDS (421-620) mg/L, as well as EC (1027-1380) µS/cm, whereas pH value was (7.4-8.4), (DO) (6.4-8.6), and BOD (204-305). Also, by measuring the values of the essential macronutrients for algae growth, it was found that the values of concentrations NO3 (0.468-0.986), PO4- (0.038-0.061) SO4- (175.6-293.37), and SO3 (3.9-6.9) mg/L respectively.
Keywords: Phytoplankton, Biodiversity, Lotic Ecosystem, Lentic Ecosystem, Physiochemical factors.

INTRODUCTION

Algae play an important role in maintaining the balance of all aquatic ecosystems, whether on land, they are an essential source of food for the rest of the microorganisms directly or indirectly, and a major guarantee of the purification of the ecosystem from carbon dioxide and its replacement with oxygen needed to breathe all organisms. Algae generally live on the surface of the water and at different depths and are found in all sources of water exposed to sunlight. Most algae are aquatic and grow in pond, lake, reservoir, river and ocean, and floating microalgae formation of a large proportion of them and are called phytoplankton (H. A. Al-Saadi, 2006c; Reynolds & Guillaume, 1998).

Phytoplankton play an essential role in the food chain in water, carrying out photosynthesis to produce nutrients and carbohydrates used in metabolism or often stored in the form of starch or oils, so algae in general and phytoplankton in particular are the primary products in many aquatic ecosystems, and are one of the main sources of nutrition for fish, larvae, crustaceans and mollusks, all of which are the most important sources of food for humans (Pal & Choudhury, 2014; Prescott, 1962).

Algae are subject to a range of environmental conditions that help them grow and reproduce, represented by temperature and are considered to be one of the most important physical factors influencing the distribution and spread of organisms in the aquatic environment, affecting the chemical and physical qualities of water directly or indirectly through their effect on mean vital processes such as photosynthesis, respiration and osmotic regulation, as well as their effect on water density and viscosity (Vallina, Cermeno, Dutkiewicz, Loreau, & Montoya, 2017; Walter, DODDS, & Matt, 2017)

Temperature also plays an important role in influencing the dissolved ability of gases in water where the relationship between oxygen dissolved ability and temperature is reversible, which in turn adversely affects the biological oxygen demand as the temperature has a close relationship with respiration. Phytoplankton are an important factor that algae need for growth and are mainly nitrogen and phosphorus compounds, as well as sulfates and silicates. Nitrogen is a necessary element for algae growth and is involved in the synthesis of amino acids and proteins (Al-Magdamy & Al-Salman, 2021; Locke & Sprules, 2000; Monaco, Prouzet, & Functions, 2015) Nitrate, nitrite and ammonia salts are generally present in the aquatic environment, and the increased concentration of nitrate salts in water leads to eutrophication, which negatively affects other aquatic organisms (H. A. Al-Saadi, 2006a; Montagnes, Franklin, & oceanography, 2001). Many studies have dealt with the diagnosis of many species of phytoplankton, calculating their numbers, studying their distribution and their affected by environmental factors. Several lists have been issued containing different species of algae, including the one issued by (Maulood, Hinton, Al-Dosky, & Sciences, 1980), which he called the blue green algae in Arbell, which includes fifty-seven species of blue green algae. There is also a list of 79 species of Desmides algae for Basra prepared by (Al-Handal, 1995), and in general the environment of phytoplankton in Iraq needs further studies due to the wide variety in internal water sources.

The study aims to diagnose phytoplankton in sites of lake Baghdad tourist city and Tigris River (north and south) lake within two water ecosystems, one lentic and the other lotic and identify their species and some environmental conditions affecting their presence due to the importance of these sites due to the increase and diversity of industrial and agricultural projectiles and the drainage water that are received to the water environment in addition to the presence of fish breeding tanks along the river sides.

Study area: The study was applied in an area located north of Baghdad, the capital of Iraq, and the area is confined between latitude and longitude as shown in table (1).

Table 1: Longitudes and latitudes of the sites identified in the study

Sites	Latitudes	Longitudes
Sit1	33.454015 N	44.323514 E
Sit2	33.428418 N	44.346507 E
Sit3	33.448987 N	44.342422 E
Sit4	33.443484 N	44.344068 E

Figure 1: Map of study area and Selected sites (www.bing.com/maps, 2022).

*St 1= Al-Fahama site, St 2 = Al-Muthanna Bridge site, which represents lotic water environmental sites.

*St 3= Lake Start Site, St 4 = Lake End Site and represents lentic water environmental sites.

Two sites representing the lotic aquatic ecosystem have been selected, one feeding the lake with water in Al-Fahama site and the other being discharged into an area near Al-Muthanna Bridge and the symbols Site1 and Site2, respectively. Two sites representing lentic aquatic ecosystem were selected within the artificial lake of the tourist island of Baghdad, one with a mud cliff at the start of the lake and the other with rocky cliff at the end of the lake, and the symbols Site3 and Site4 were given respectively, as shown in a map representing the selected study sites.

MATERIALS AND METHODS

Sampling Collection: Water samples were collected from the four indicated sites in the study area (figure 1), of the upper surface layer at adept of 20-30 cm the riverbed and lake by 1-liter polyethylene containers. Some measurements were made field-by-field: temperature of air and water, pH, total dissolved solids, whereas electrical conductivity EC, turbidity and nitrate NO3, phosphate PO4, sulfate SO4, silicates SiO2, DO and BOD5, they were measured in the laboratory within 24 hours from the time of collection.

The samples were taken at three readings per measurement at each site and the rate was adopted in the results. Samples for the qualitative study of phytoplankton were collected by the phytoplankton network with a diameter of 20 μm by placing them in reverse of the water stream for 10-15 minutes and then dragging them out and emptying their contents in clean ethylene poly bottles and preserved by adding Lugol's Solution until laboratory testing.

Physicochemical Measurements: The temperature of air and water was measured within the study sites using graduated mercury heat at range 10-100+°C, while turbidity was measured by Turbidity meter from HACH company and before the samples were measured, the device was calibrated with available standard solution (NTU100, 10, 1.0, 0.1 Naphelo-Turbidity Unit) and then recorded readings of the samples and expressed them in Naphelo Turbidity Unit. To measure dissolved solids TDS, the conductivity meter was used from HACH company and expressed results in a mg/L, and to measure electrical conductivity and salinity, portable conductivity meter PW9525 was used by Philips to measure electrical conductivity and expressed its results in μS/cm. While the measurement of pH was calibrated of inolabi pH meter advice from Germany company and Winkler method was applied to measure the biological oxygen demand (BOD5) in mg/L (APHA, 1999). The phytonutrients such as nitrate NO3, phosphate, sulfate and silicates, the method of (Wood, Armstrong, & Richards, 1967) was used to reduce nitrate (NO3) to nitrite (NO2) after passing all samples to be measured on the cadmium-copper column and measuring the concentration of total nitrite ion and examining those samples at a wavelength of 543 nm by the Shimadzu SZ-160 spectrometer and the results were expressed in mg/L. As for measuring phosphates (PO4) , (Murphy & Riley, 1962) were used and the results were recorded at wavelength 885 nm by using Shimadzu-SZ 160 spectrometer. To measure sulfate (SO4-2) , the method described by American Public Health Association (APHA, 1999) was followed. The absorption of solution measured by the UV Spectrophotometer model 680 Shimadzu Japanese origin at a wavelength 380-420 nm, sulfate concentrations were calculated after the standard curve was prepared by using Ratioturbiometery device from HACH company with a wavelength 420-380 nm. To examine of silicates, the method described by (Al-Akidi, 2000) was adopted, then measure absorption at wavelength 810 nm with spectrophotometer type Shimadzu model 1700 Japanese made and the concentrations of above nutrients was calculated by mg/L.

Diagnosis and Numbered of Phytoplankton: The number of phytoplankton was diagnosed and calculated using sedimentation in the preservation and deposition of samples by adding Lugol's material at concentration 20% with the purpose of reaching Lugol's material at concentration 20% with observing any decrease in the Lugol's material stain of the sample throughout the sedimentation period where a few drops should be added for the purpose of stabilizing algae and preventing their decomposition by taking a sample of 1 liter per site and then preserve by adding Lugol's material with shaking it quietly to prevent the breakage of diatom skeleton under the influence of violent shaking and for the purpose of reaching the Lugol's material for all parts of the sample, then brought the samples to the laboratory where the method of deposition was used by placing a sample (1 liter) for each site after shaking well in a graduated cylinder 1 liter and preserved by adding the Lugol's material and leaving it without movement for 10 days, and then after 10 days was concentrated from 1 liter to 100 ml and preserve by adding Lugol's material as well without movement for 7 days, and after 7 days it was concentrated from 100 ml to 10 ml and then examined using German-made ZEISS compound light microscope. In, non-diatomic algae, temporary sections (glass slide) were prepared for purposing of qualities study and diagnosis of algae while heamocytometer was used for quantitative (count) and their numbered and the results was calculated cell/L after examination of slides at 400 power by using compound light microscope and based on several diagnostic sources for non-diatomic algae represented by (Hadi, 1981) and (Wehr & Classification, 2003) by using the following equation:

Number of cells in 1 ml of the sample = number of cells in one microscopic field × conversion factor

(Note that the conversion factor is 10.570824 = the number of sectors in the microscope × concentration coefficient)

Thus, the number of cells in the sample (1 liters) is:

Number of cells in 1 liter = number of cells in 1 ml × 103

As for the diagnosis and calculation of the preparation of diatomic algae, permanent sectiions were prepared and then examined using a compound light microscope and at the power of 1000 and using the oil lens because of the small size of diatoms and based on diagnostic sources represented by (Desikachary, 1959) and (Prescott, 1962) and (Felisberto & Rodrigues, 2004) and calculated the numbers of diatomic algae using the following equation:

Number of algae in 1 ml of sample = number of algae in the most regular diameter of a drop of 50 microliters × conversion factor

(Note that the conversion factor here varies in value by drop diameter)

Number of cells in 1 liter = number of cells in 1 ml × 103 ((Al-Imarah, Al-Shawi, Issa, & Al-Badran, 2006).

RESULTS AND DISCUSSION

Physicochemical Examinations: Iraq's climate is characterized by a significant variation in temperatures according to the seasons of the year, the temperatures of air and water showed a range of clear quarterly changes during the autumn, where the results show that the water temperature is affected by air temperature because of its daily and seasonal fluctuations, this phenomenon has been observed by many researchers, and that the local changes in air and water temperature may be due to the difference in the time of collection of samples at that day, as low temperatures were recorded at the beginning of the day and then rise as we approached midday (Al-Magdamy & Al-Salman, 2021). The air temperature for all sites reaching 20-36 °C while the water temperature reached 16-25.5 °C as in table (2). Each organism has an optimum temperature specific range for temperature and some organisms may adapt to high or low temperature ranges outside the specified range of the species (H. A. Al-Saadi, 2006a, 2006b). TDS values of 421-620 mg/L were also included in the study sites and are identical to (Al-Janabi, 2011) study, which had values of 476-628 mg/l at study sites on the Tigris River. The reason for the high values recorded during the month of October is due to the decrease in water levels observed during that month and the lack of rain, as well as due to the high temperatures as the highest water temperatures during the month of October, which reached 34 and 35°C for the start site of the island and the end respectively for the month of October table (2) and resulting in evaporation of water and increased concentration of dissolved solids materials. (Langmuir, 1997), noted that TDS values also increase when the amount of water in the waterway increases due to increased rock contact.

Water turbidity reflects the abundance or scarcity of phytoplankton and suspended substances such as clay, organic and inorganic materials, as these components have a role in impeding the permeability of light during the water column, and the turbidity arises in Tigris and Euphrates waters mostly due to solid suspended materials such as silt and clay (Al-Husseini & Alsalman, 2020; Langmuir, 1997; Moser, Callieri, & Weisse, 2009), it is close to (Al-Fatlawi, 2007) study which reached 735-1157.7 μS/cm, electrical conduction is the numerical value that indicates the solution's ability to conduct the electricity, and this value depends on the total concentration of dissolved ionized materials in the water and temperature (AL-Zamili). pH values in study sites for the autumn (October and November) ranged from 7.4-8.4 table (2).

The pH ranges in this study are within a narrow range, due to the frequent presence of carbon ions, and the bicarbonates that act as buffer action prevent changes in the concentration of hydrogen ion (H. A. Al-Saadi, 2006a-a). The results of the study also show that the waters of the island's start station and the end of the island are within the light base direction (7.8 and 8.4), respectively table (2). This is in line with previous studies conducted on Iraqi inland waters such as (Al-Temimy, 2004); (Abdullah, 2019) (Al-Husseini & Alsalman, 2020) in which values reached 7.56-8.40 on the Tigris River.

It is known that increased temperatures reduce the dissolved of gases in water, and dissolved oxygen in water is an important environmental factor that has an effect on water quality as well as control of the biological actions of organisms, and current results show that dissolved oxygen values did not decrease from 6.4 mg/L at a water temperature of 25°C table (2). Current results show that dissolved oxygen values did not decrease below 6.4 mg/L at a at water temperature of 25°C table (2). As well as cases of above saturation appeared in the water in autumn and in all sites, with the highest values recorded for the concentration of dissolved oxygen and the saturation rate during the autumn to 8.6 mg/L at a water temperature of 16°C. The results of the current study corresponded to several studies that indicated the nature of good ventilation across Iraq's water bodies (Al-Husseini & Alsalman, 2020; Al-Khalidi, 2004).

The Biological Oxygen diamond (BOD5) is a measure of the amount of oxygen needed for microbiology to complete the process of decomposition of organic matter and its conversion into carbon dioxide, water, and other materials (BioMagic, 2004), an indicator of organic pollution, which includes biodegradable organic compounds and when decomposed by aerobic bacteria, they deplete oxygen from water (H. A. A.-L. Al-Saadi, A.A. and Kassim, T.I. , 2000; Walter et al., 2017). The values recorded in the current study ranged from 2.4 mg/L to 3.5 mg/L table (2) and the lowest values were recorded at Al-Fahama site (Sit1), which was 2.4 mg/L, while the highest values recorded at the end of the Island site (Sit4) was 3.5 mg/L due to organic waste as remnants of parts of plants, animals, food, leaves and feces or organic waste such as dairy residues and others (Schaaf, 2002). Nitrate is one of the most important phytonutrients that contribute to the abundance of algae, with concentrations within the study sites of 0.468-0.986 mg/L.

Phosphate concentrations amounted to 0.038-0.061 mg/L in the study sites as in table (2), as is known, nitrates and phosphates are essential nutrients for aquatic organisms, particularly plants (H. A. Al-Saadi, 2006a-b) and these nutrients are very important in increasing the essential productivity of phytoplankton and other aquatic plants that form the basic base of the food chain (Li et al., 2022; Vallina et al., 2017). But despite the importance of these nutrients, their presence with high concentrations leads to the phenomenon of eutrophication, which generally affects the quality of water and the living of its organisms.

The sulphate concentration of the current study sites was 175.6-293.37 mg/L as in table (2), sulphate ion is available in water because of the dissolved of chemical fertilizers added for agricultural purposes, residues from tanning factory, pesticides, and sulfate dioxide gas. We note the increased concentration of sulfates at Al-Fahama (Sit1) from the rest of the sites due to the increase in the amount of waste loaded into the waters of the Tigris River compared to the site of the end of island (Sit4), which is the lowest concentration of sulfates because of the presence the algae in large quantities, which has reduced the concentration of sulphate where it is used as food. In the Tigris River, the study of (A. Al-Lami, Kassim, Sabri, & Rasheed, 1990), the sulphate concentration rate was 277 mg/L, and in the study of (Al-Fatlawi, 2007) it was between 196.3- 309.3 mg/L which corresponds to the current study, and the results of the study (H. A. A.-L. Al-Saadi, A.A. and Kassim, T.I. , 2000) on Lake Al-Qadisiyah were between 112-540 mg/L. The researchers stated that Iraqi waters are characterized by the fact that sulphate ion is available with high concentrations, which is the overcome negative ion, which is an important ion necessary for the growth of plants and algae (Al-Husseini & Alsalman, 2020).

Silicate is an important element of organisms in lakes, rivers and seas, as it is part of the earth's crust and is one of the main nutrients for the growth of diatoms in particular to build their skeleton, which cannot be replaced by any other element (Wen, Chen, & Biotechnology, 2000) as well as element of silicate is involved in the regulation of the synthesis of protein, fat, carbohydrates, and pigments such as chlorophyll and xanthophyll in algae cells (Behrenfeld, O'Malley, Boss, Karp-Boss, & Mundt, 2021), as the current study showed the concentration of silicate within the study sites from 3.9-6.9 mg/L, the highest concentration of them in the end of island (Sit3) because of abundance of diatomic algae. They are also increasingly concentrated in locations where decaying diatomic algae grow frequently in the re-solution of dead quarters in autumn, matching a study (Al-Daraji, 2015) and the concentration of silicates increases in winter and autumn and decreases in spring.

Table 2: Values of physiochemical examinations within the study sites for the autumn

Examinations	Study Sites							
	Sit 1		Sit 2		Sit 3		Sit 4	
	10/16	11/16	10/16	11/16	10/16	11/16	10/16	11/16
Air temperature	32	20	36	23	34	21	35	22
Water temperature	24	16	25.5	17.5	25	17	25	17
Turbidity NTU	19.4	15	23	18.6	12.7	8.3	10.2	5.8
TDS mg/L	536	421	597	467	572	432	620	486
EC.μS/cm	1321	1027	1362	1156	1331	1065	1380	1214
pH	7.4	8	7.5	8.1	7.8	8.2	8	8.4
DO	8.1	8.6	7.8	8.3	6.9	7.4	6.4	6.7
BOD_5	2.6	2.4	2.8	2.9	3.1	3.2	3.4	3.5
NO_3 mg/L	0.962	0.986	0.904	0.687	0.715	0.879	0.495	0.468
PO_4 mg/L	0.059	0.061	0.054	0.046	0.048	0.052	0.040	0.038

sulphate mg/L	284.45	293.37	258.11	249.40	227.28	226.86	182.51	175.60
Silicates mg/L	6.1	6.2	4.3	6.6	3.9	6.1	5.7	6.9

St 1= Al-Fahama site, St 2 = Al-Muthanna Bridge site, which represents lotic water environmental sites.
*St 3= Lake Start Site, St 4 = Lake End Site and represents lentic aquatic environmental sites.
Using the correlation coefficient, the relationship between the study variables can be statistically expressed as evidenced by table (3).

Table 3: Correlation coefficient between study parameters (N=24)

	Air Temp	Water temp	NTU	TDS	Ec	pH	DO	BOD5	NO3	PO4	SO4
Water temp.	0.99**										
NTU	0.36	0.36									
TDS	0.96**	0.94**	0.23								
Ec	0.94**	0.93**	0.24	0.97**							
pH	-0.66**	-0.69**	-0.65**	-0.49*	-0.52**						
DO	-0.31	-0.33	0.49*	-0.48*	-0.45*	-0.32					
BOD5	0.03	0.03	-0.58**	0.18	0.18	0.35	-0.54**				
NO3	-0.07	-0.03	0.58**	-0.31	-0.31	-0.54**	0.67**	-0.65**			
PO4	-0.06	0.00	0.40	-0.26	-0.26	-0.50*	0.61	-0.45*	0.82**		
SO4	-0.07	-0.05	0.68**	-0.29	-0.27	-0.55**	0.82**	-0.74**	0.87**	0.76**	
Si	-0.73**	-0.73**	-0.35	-0.63**	-0.55**	0.47*	0.18	0.08	-0.21	-0.14	-0.09

*,**significant at 0.05, and 0.01 probability level Table (4) also shows the rates of physiochemical examinations of study sites within lotic water environmental sites and lentic water environmental sites represented by pH values of 7.7, 7.8, 8 and 8.2, respectively, for Sites (Sit.1, Sit2, Sit3 and Sit4.), as well as the rest of the examinations are; water temperature, turbidity, TDS, electrical conduction, pH, DO, BOD5, sulfate, silicates, nitrates, phosphates.

Table 4: Rates of physiochemical factors for each study site during the autumn

Examinations	Study Sites			
	Sit 1	Sit 2	Sit 3	Sit 4
Air temperature	26	29.5	27.5	28.5
Water temperature	20	21.5	21	21
Turbidity NTU	17.2	20.8	10.5	8
TDS mg/L	478.5	532	502	553
EC.µS/cm	1174	1259	1198	1297
pH	7.7	7.8	8	8.2
DO	8.35	8.05	7.15	6.55
BOD_5	2.5	2.85	3.15	3.45
NO_3 mg/L	0.974	0.795	0.797	0.481
PO_4 mg/L	0.06	0.05	0.05	0.039
sulphate mg/L	288.91	253.755	227.07	179.055
Silicates mg/L	6.15	5.45	5	6.3

ANOVA analysis was also used to test and determine the effect of physical variables within the study sites described in table (5).

Table 5: ANOVA Table

Examinations	Study Sites				P-Value ¥	
	Sit 1	Sit 2	Sit 3	Sit 4		
Air temperature	6.61 ±26.00	7.13 ± 29.50	7.13 ± 27.50	7.13 ±28.50	0.845	N.S
Water temperature	4.40 ± 20.00	4.40 ± 21.50	4.39 ± 21.00	4.39 ± 21.00	0.946	N.S
Turbidity NTU	2.90 ± 17.20	3.74 ± 20.80	3.70 ± 10.38	2.58 ± 7.91	0.001	**
TDS mg/L	63.0 ± 478.50	71.45 ± 532.17	77.39 ± 501.50	73.46 ± 553.00	0.312	N.S
EC.µS/cm	161.0 ± 1174.0	112.9 ± 1259.0	145.7 ± 1198.0	92.0 ± 1296.0	0.371	N.S
pH	0.34 ± 7.70	0.37 ± 7.80	0.22 ± 8.03	0.24 ± 8.20	0.036	*
DO	0.36 ± 8.35	0.52 ± 8.05	0.59 ± 7.15	0.29 ± 6.55	0.001	**
BOD5	0.42 ± 2.50	0.19 ± 2.85	0.36 ± 3.15	0.48 ± 3.45	0.002	**
NO_3 mg/L	0.016 ± 0.974	0.119 ± 0.795	0.108 ± 0.797	0.028 ± 0.480	0.001	**
PO_4 mg/L	0.005 ± 0.060	0.006 ± 0.050	0.007 ± 0.050	0.004 ± 0.039	0.001	**
sulphate mg/L	9.48 ± 288.9	11.53 ± 253.75	7.49 ± 227.07	17.1 ± 179.05	**0.001**	**
Silicates mg/L	0.18 ± 6.15	0.127 ± 5.45	1.23 ± 5.00	0.71 ± 6.32	0.093	N.S

Data presented as Mean ± SD, ¥: One-way ANOVA were used to test between Sites, N.S: Not significant (P>0.05), *,** significant (P<0.05), and Highly significant (P<0.01)

Phytoplankton Community: The study sites are (Al-Fahama, Al-Muthanna Bridge, start of the Island, end of the Island) and referred to as symbols Sit1, Sit2, Sit3, Sit4 respectively, and during the duration of the autumn study (October and November) 69 species of phytoplankton were diagnosed in the qualitative study distributed to 14 species of Chlorophyta division, 21 species of Cyanobacteria division, 29 species of diatomic algae division (1 species for Centrales order,

28 species for Pennales order) and 3 species for Euglenophyta division and two species of Chrysophyta division. In the quantitative study, the total amount of phytoplankton within the study sites was 323.52, 362.6, 176.01, 434.75×103 cells/L respectively for October and 270.54, 553.07, 176.4, 549.69×103

cells/L respectively for November while a total number of algae per sites of 594.06, 920.67 and 352.4 1 and 984.44×103 cells/L respectively, whereas a total alga counts per sites of 297.03, 460.335, 176.205 and 492.22×103 cells/L, respectively. The results of the quantitative study showed that the rate of population density in the lotic water ecosystem exceeded that of the lentic water ecosystem, with values of 378.68×103 cells/L and 334.21×103 cells/l respectively and table (6) indicating this.

Table 6: Qualitative and quantitative presence of phytoplankton within study sites during the Autumn

List of algae species	Study Sites							
	Sit 1		Sit 2		Sit 3		Sit 4	
	Period study		Period study		Period study		Period study	
CHLOROPHYCEAE	October	November	October	November	October	November	October	November
Ankistrodesmus falcatus	31.71 *	52.85 *	21.14 *	42.28	10.57 *	*	21.14 *	*
Chlorella vulgareis					21.14 *		42.137	
Scenedesmus dimorphus		*					*	
Kirchneriella contorta							*	
Kirchneriella elongata		10.57		10.57 *				
K. lunaris							21.14	21.14
Scenedesmus sp.						*		
S. dimorphus							10.57	10.57
S. quadricaud				10.57 *			10.57 *	10.57 *
Selenastrum westii				10.57			*	
Ulothrix cylindricum				10.57				
U. subconstricta				10.57			*	*
Crucigenia terapedia		10.57 *				10.57 *		
C. quadrata				10.57				
Tetraëdron minimum	*		10.57	10.57	10.57		10.57	
T. muticum	21.14		10.57				10.57	
CHRYSOPHYCEAE								
Dinobryon tabellariae		10.57 *			*	*		
D. vanhoefienii					*			
CYANOPHYCEAE								
Chroococcus dispersus	42.28 *		21.14 *				63.42 *	
C. limneticus				31.71	*			
C. minor	52.85	31.71 *	21.14	42.28 *	84.56	63.42 *	95.13	73.99 *
C. minutus		10.57		10.57 *				
C. tenax								42.28 *
Cyanarcus hmiformis		10.57 *						
Hamatococcus lacustris				63.42				
Merismopedia minima				10.57	*			42.28 *
M. glauca					*			
M. punctata					*			
M. tenuissima	*		10.57					
Oscillatoria sp.		*				*		
O. angustissima				31.71				
O. lacustris	10.57						21.14	
O. limnetica	63.42	31.71 *	137.42 *	42.28 *	31.71 *	31.71 *	*	73.99 *
O. articulata		10.57						
O. terebriformis	10.57		63.42				*	
O. amphibia								84.56
Synechacoccns aeruginosus	21.14 *		31.71	21.14	*		31.71 *	
BACILLARIOPHYCEAE								
A- CENTRALES								
Cyclotella meneghiniana	52.38 *	20.95 *					43.65	
B-PENNALES								
Achnanthes hungarica						*		*
Cymbella aspera		6.98						
C. tumidula			*	7.85				
C. helvtica								8.73 *
C. naviculiformis						15.71 *		
Cymatopleura solea		7.85 *						
Diploneis ovalis				7.85				
Fragilaria brevistriata								6.98 *
F. intermedia		15.71						
F. construens				7.85				
Gyrosigma peisonia			*					
Gyrosigma acuminatum				7.85				
Navicula sp.	8.73		8.73 *		*		*	
N. acicularis				15.71 *		15.71 *		52.38 *
N. decussis				6,98				
N. integra				49.59				87.30 *
N. offine					*			
N. halophila			*					
N. pupula					*			
Nitzschia commutata	*	7.85				15.71		*
N. intermedia			8.73				*	
N. longissima	8.73	6.98 *	8.73		17.46	23.57 *		8.73 *
N. hantzschiana				7.85 *				

Pinnularia leptosome	*	*	8.73		*		*	*
P. microstauron								26.19
Rhopalodia gibba		6.98 *						
Synedra acus			*		*	*		*
S. tabulata		6.98 *		15.71				
Euglenyceae								
Euglena spirogyra			*					
Phacus caudatus		10.57 *						
Phacus acuminatus				10.52				
Total per month	323.52	270.54	362.6	558.07	176.01	176.4	434.75	549.69
Total for autumn per station	594.06		920.67		352.8		984.44	
Mean for autumn per station	297.03		460.335		176.205		492.22	
Mean for both running and residential water	378.6825				334.2125			

*Sit 1= Al-Fahama site, sit 2 = Al-Muthanna Bridge site, which represents lotic water environmental sites.

*Sit 3= Lake Start Site, sit 4 = Lake End Site and represents lentic aquatic environmental sites.

(*): Represents qualitative study

103/L×cell: - Quantitative study of beasts within the water column.

Current results showed a disparity in algae numbers within the study areas, a total number of algae was 984.44×10^3/L at in Sit4, with percentage 35% from the total percentage of phytoplankton which due to increased organic pollutants represented by dead plant residues and waste from bird waste. The other site that follows of increasing the number of algae is the Sit2, which has a total algae a count of 920.67×10^3/L and percentage 32%, which is a natural environmental indicator of the presence of several drainage that are drained directly into the river at this site as well as the increase in species numbers on the number of genera also indicates that water at the previous two sites has moderate environmental pollution, through which it is a good contributing factor to increase the algae density] (Al-Husseini & Alsalman, 2020; Al-Makdami, 2016). In addition, the increase in the number of algae in these two sites is due to the availability of cofactors that help their growth, such as dissolved oxygen in water with good ventilation and the abundance of dissolved elements such as nitrogen and phosphate, which are key nutrients for plants in general and algae in particular. Then comes sit1 with a total number of phytoplankton 594.06×10^3/L, a percentage of 21%. Then Sit3 has a total of phytoplankton 352.8×10^3/L represents the lowest site in the phytoplankton numbers, with percentage of 12% only of its total percentage, according to Sili et al. (2012) study to the lack of species in this region is due to the large presence of fish and crustaceans, which is a good diet (A. A. S. F. B. a. M. Al-Lami, R. , 2004)(Figure 2) shows the percentages of the presence of phytoplankton within the study sites.

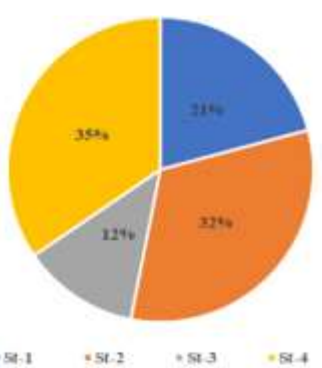

Figure 2: Percentages of the presence of phytoplankton within the study sites (lotic and lentic).

The current study also showed percentages of species presence distributed to algial division in the Autumn of 2021, where 69 species were diagnosed in the environment of the two studied systems, distributed to 14 species of Chlorophyta division and 21 species of Cyanobacteria division, 29 species of diatomic algae (one Centrales order, 28 Pennales order),3 species of Euglenophyta and two Chrysophyta division species as described in figure (3).

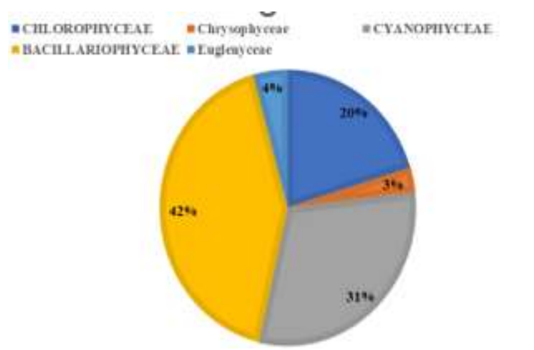

Figure 3: Percentages of algae species within the division classification for the current study.

Some of the dominant species of the current study were also observed in the Autumn and all the study sites are represented by the type of Ankistrodesmus falcatus, Chroococcus disperses, Oscillatoria limnetica, Chroococcus minor, Synechacoccns aeruginosus, Navicula sp. and Nitzschia longissimi Pearson chi-square was tested as in table (7).

Table 7: The dominant species within the study sites for the autumn study quantitative and qualitative study with the result of the Pearson chi-square test

List of algae species	Study Sites			
	Sit1	Sit2	Sit3	Sit4
CHLOROPHYCEAE				
Ankistrodesmus falcatus	*	*	*	*
CYANOPHYCEAE				
Chroococcus dispersus	*	*		*
Oscillatoria limnetica	*	*	*	*
Synechacoccns aeruginosus	*		*	*
Chroococcus minor	*	*	*	*
BACILLARIOPHYCEAE				
Navicula sp.		*	*	*
N. acicularis		*	*	*
Nitzschia longissima	*		*	*
Pinnularia leptosome	*		*	*
Synedra acus		*	*	*
Chi-Square Tests	P-value		0.019*	

*Sit 1= Al-Fahama site, sit 2 = Al-Muthanna Bridge site, which represents lotic water environmental sites.

*Sit 3= Lake Start Site, sit 4 = Lake End Site and represents lentic aquatic environmental sites.

Pearson chi-square test revealed a statistical indication between the Sites and the presence of phytoplankton species. In these results, the Pearson chi-square statistic is 10.00 and the p-value = 0.019. Therefore, at a significance level of 0.05, we can conclude that the association between the Sites and presence of phytoplankton types is statistically significant.

Algae in Iraqi local studies of the Tigris River have been characterized by the abundance of algal species and genera due to the high level of pollution of the Tigris River in general and available of all nutritional elements for algae such as nitrogen, phosphate, calcium and magnesium, although environmental factors are among the most important determinants of the growth of blue green algae and diatoms according to the study (Al-Hussieny, Hussain, Kame, Mohsin, & Studies, 2016), which matched the current study in terms of the abundance of algae prevailing due to the division of green algae blued first due to their competitiveness in taking and resisting important nutrients, then diatoms secondly and then green algae thirdly. The presence of algae prevailing in all study sites is due to the wide tolerance of most of these species to various environmental factors of temperature and environmental and site conditions (Al-Asadi, 2015). The environment of the Tigris River within Baghdad is suitable for most algae, but it is considered an environment suitable for green algae because the number of salts in the Tigris River is lower than in the Euphrates River and the southern marshes of Iraq, which is the right environment for diatomic algae. The lack of other algae species as indicated by (Al-Hussieny, Ali, & Biotechnology, 2017) who diagnose 1,000 species to nine sites on the Euphrates River was 42% of the diagnosed species.

CONCLUSIONS

1 The fourth site (the end of the island) recorded an increase in the number of phytoplankton diagnosed during the study period, followed by the second site (Al-Muthanna Bridge), then the first site (Al-Fahama) and then the third site (the start of the island).

2 Increasing the concentration of the element of silicates within sites that increase the algae density of the diatomic algae division.

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