ISSN NO: 2771-8840
Date of Publication: 04-09-2022

Seasonal variations in the phytoplankton community in a lentic ecosystem and its relationship to environmental variables (An applied study in the artificial lake of the island of Baghdad, Iraq)

Hind Mahdi Salih Al-Saeedi
Ibrahim M. A. Al-Salman
Department of Biology, College of Education for Pure Science (Ibn Al- Haitham), University of Baghdad, Iraq, Baghdad
hinda0571@gmail.com

Abstract
The current study was applied to a lentic aquatic ecosystem for the period from October 2021 to June 2022 in two sites within the lake of the tourist island of Baghdad, in addition to a control site representing the source of the lake's water and a dilution site representing the area of water exit from the lake and mixing with river water, and included the measurement of twelve physicochemical factors of the water of the lake environment and the sites of control and dilution and the identification of its qualitative and quantitative effect on the community of phytoplankton within the study area, in addition to the application of a number of evidence Biotechnology for Water Quality Assessment. The results showed the variation in the intensity of the average values of the physicochemical factors of the lake water affected by climatic variations and human activities between the seasons of the year and the study sites, with air and water temperatures recording averages of 23.78 °C and 17.75 °C respectively, and while turbidity recorded a high average value of 8.25 NTU, total dissolved solid recorded 440.5 mg/L. As for electrical conductivity, it indicated a surplus in the autumn and summer seasons, the general average reached dangerous limits of 958.7 close to the maximum allowable limit, while the pH recorded an average of 8.02, the average dissolved oxygen recorded 7.26 mg/L, and the Biodemand of oxygen was 3.03 mg/L. Nitrates, phosphates, sulphates and silica also averaged 2.07, 0.22, 252.6 and 3.06 mg/L respectively. While the qualitative study of Phytoplankton concluded that 107 species belonging to 43 genera were recorded at the four sites with 70 species belonging to 32 genera within the lake, and the diagnosed genera and their species were organized based on the sites and the seasons in which they appeared, and these genera belonged to eight species, seven of which appeared in the two lentic sites: Chlorohyceae, Bacillariophyceae, Cyanophyceae, Cryptophyceae, Dinophyceae, Chrysophyceae, Xanthophyceae and Euglenophyceae.
The average total numbers of phytoplankton recorded a variation between the seasons of the year as well as between the study sites, with the highest average of 356.447×10^3 cells/liter recorded during the autumn, while the summer recorded the lowest average of 181.957×10^3 cells/liter, and the site of the end of the lake recorded the highest average of 352.633×10^3 cells/liter, while the sites of the start of the lake was the lowest in the average number, recording 135.527×10^3 cells/liter. In the present study, a number of environmental indices were used to assess water quality, the relationship between sites, seasons, and the qualitative and quantitative presence of phytoplanktons: the Palmer's Pollution Index (PPI), Marglef index's, 1959, Shannon Wiener's diversity index (H)', Sorenson's Index, 1942, Bray and Curtise index, 1957. The Palmer Index recorded the highest seasonal average of pollution during the autumn at 25.25, locationally, the site of the highest average dilution recorded 22.25, the richness index and the Shannon Weiner index recorded the highest values of 6.50 and 2.246 at the dilution site, the highest similarity value of 0.977 was recorded between the two sites lentic the start and end of the island, while the highest difference value was 0.284 between the control site and the end of the island; this indicates a variation in water quality that may be specific to the growth of species of phytoplankton or supportive of the growth of other species. The Shannon Weiner index also came up with values ranging from 1.678 to 2.246 and by using it to infer water pollution, as Wilhm stated, it classifies water as medium pollution and the reason for its effect on the human activities of the region's population and the climatic variations that have misled the environment of the entire region. The results of the study also recorded two new species of algae, indicating a difference in the nature and

quality of water, one of which is of the type of Chlorophyceae and the other of the class of Bacillariophyceae :
Kirchneriella contorta var. elongata (G. M. Smith) Kom
Navicula integra (Fischer, 1927-1928)

Keywords: Phytoplankton, Lentic aquatic ecosystem, Physicochemical factors, Control site, Dilution site.

Introduction

Algae are defined as a group of organisms belonging to the kingdom of Protista, containing chlorophyll pigment and other representative pigments, as most of them are single-celled but some are multicellular such as seaweed, most algae have eukaryotic cells except blue-green which are prokaryotic cells and thus fall within the Monera kingdom. Algae are classified according to several features, including their environmental status in the algae community into algae that terrestrial algae, Aerial algae and Aquatic algae that are found in the aquatic environment and are either algae that grow upside or carried with water currents, called phytoplankton or algae that adhere to a surface and are called benthic algae and other designations (Mishra *et al*., 2019 , Liu *et al*., 2021).

Algae are generally aquatic organisms that can be used as environmental indices to study and assess the state of aquatic ecosystems (Hassan and Al-Salman, 2018) due to their sensitivity to any change in the surrounding environment. As their growth, diversity, densities and distribution change in rivers, lakes and other water sites significantly throughout the year as a result of the heterogeneity of physiochemical, hydrological and biological factors of water systems, for example, we note the progress of blue-green algae on green in some seasons in the environment of some rivers as a result of strong discharge or increased pollution rates, low levels and high freshwater temperatures (Farhan and Salman, 2019; Al-Husainy and Al-Salman, 2020 ; D'Alelio *et al*., 2022).

The importance of the research and its objectives:

1. Identify the level of heterogeneity in physicochemical factors in the lentic water system and the extent of their impact on the qualitative composition in the phytoplankyon community.
2. Apply a number of environmental indicators and indices to explain the extent of the relationship between the interrelated factors in the lentic water system.

Materials and Methods

The study represented by a lentic aquatic ecosystem was applied in the area of Al-Fahama, which is located on the Tigris River northeast of the city of Baghdad, where two sites were selected within the artificial lake of the tourist island of Baghdad, the first with a mud cliff at the start of the lake and represents the site of entry of the water of the Tigris River into the lake picture (1), and the second with a rocky cliff at the end of the island and represents the site of the collection of water of the island until it is discharged to the Tigris River again picture (2), and the symbols Sit.3 and Sit.4 were given respectively, while gave the code Sit.1 for the control site and the Sit.2 code for the dilution site. The study was located using the Geographical Positioning System (GPS) device and the Geographic Information System (GIS) software, as shown in Table 1 and Figure 1.

Table (1): Study locations using GPS and GIS software.

No.	Site	Latitude(East)	Longitude(North)	Distance from ...... to	Distance in kilometers
1	Sit.1	44.323514 E	33.454015 N	From Sit.1 to Sit.2	3.01
2	Sit.2	44.346507 E	33.428418 N	From Sit.2 to Sit.4	1.18
3	Sit.3	44.342422 E	33.448987 N	From Sit.1 to Sit.3	1.24
4	Sit.4	44.344068 E	33.443484 N	From Sit.3 to Sit.4	1.14

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

Figure 1: Sampling sites on the Tigris River and the tourist lake of Baghdad Island within Al-Fahama area / Baghdad Governorate (Google Earth, 2022).

*Sit.1: Site of Al-Fahama Center (Control), Sit.2, Site of Al-Muthanna Bridge (dilution).

* Sit.3: Lake Start Site, Sit.4, Lake End Site (representing lentic aquatic ecological sites).

Picture (1): The site of the start of the lake of the island of the tourist city of Baghdad Sit.3.

Picture (2): The site of the end of the lake of the island of the tourist city of Baghdad Sit. 4.

Water samples from the indicated sites in the study area were collected quarterly and at the rate of two months per season for the period from October 2021 to June 2022 from the bottom of the upper surface layer of water with a depth of approximately 30 cm by means of polyethylene containers with a capacity of 1 liter for the purpose of conducting laboratory analyzes and measurements within 24 hours of the time of collection of samples and by three readings per measurement at each site and the rate was adopted in the results. pH, total dissolved solid, electrical conductivity, turbidity, nitrate agents NO_3, phosphate PO_4, sulfate SO_4, silica, DO, BOD_5 were measured in the laboratory while air and water temperature was measured in the field. Phytoplankton included two types of study:

Qualitative Study: Its purpose is to diagnose and classify the algal species present in the study samples, and to achieve this the network of collecting phytoplankton with a diameter of 20 micrometers of holes was used to collect samples, as the network was immersed in water against the current of water for 10-15 minutes and withdrawn many times, then the filtrated samples were placed in polyethylene bottles and preserved by adding a solution to Lugol's solution. Non-diatomic algae were diagnosed and examined for 40x power using a German-origin Carl Zeiss light compound microscope and based on the following non-diatomic algae diagnostic references: (Desikachary, 1959 ; Prescott, 1979 ; Hinton and Maulood, 1982 ; Wehr and Sheath, 2003; Patrick and Riemer, (1975, 1966) ; Hadi *et al.*, 1984 ; Aboal *et al.*, 2003 ; Barroso *et al.*, 2007; Bellinger and Sigee, 2010 ; Hassan *et al.*, 2012; Munir *et al.*, 2012 ; Al-Hassany and Hassan, 2014). While permanent slides of the diatomic algae were made after dissolving their organic matter and clarifying their structures using concentrated nitric acid, then diagnosed and examined at the power of 100x using the light microscope mentioned above, and relying on the following references of diagnosis of diatomic algae

 ISSN NO: 2771-8840
Date of Publication: 04-09-2022

(Patrick and Remier, 1975 ; Vertes, 1972 ; Bourrelly, 1981 ; Hakansson, 1981 ; Checklist of Algal Flora in Iraq, 2013).

Quantitative Study: Its purpose is to calculate the number of algae cells and determine their density, and to achieve this the method of sedimentation and conservation of algae was followed using Furet and Benson-Evan (1982) method by taking 1 liter of sample water at each site and making a fixation of the phytoplankton by adding a Lugol solution and then using a Haemocytometer counting to calculate the number of cells of non-diatomic algae, while the transect micro method was used to calculate the number of diatomic algae cells.

Statistical analysis: IBM SPSS V was used for the purpose of statistical analysis, where two-way ANOVA was used to test the difference between seasons and sites, one-way ANVA was used to test the difference between locations, Chi square test was used for the presence of algae species within sites, in addition to estimating the correlation coefficient (Pearson) between the studied traits, and the least significant difference test (LSD) was used for the difference between averages in the case of significant impact of the factors under study. All tests were conducted at probability levels of 0.05 and 0.01.

Bioenvironmental indices

A set of bioenvironmental indices has been applied in the present study for the purpose of studying algae and monitoring diversity, biovariance, richness, similarity, difference, water quality and pollution, including:

- Palmer's Pollution Index (PPI): It is used to determine the amount of organic pollution in water by tracking a list of 20 genera of algae and specifying for each of them a number of 1 to 5 depending on the degree of tolerance of genus to organic pollution and when collecting points for the genera specified in the samples can determine the amount of organic pollution.
- Marglef index, 1959: It expresses the richness and fertility of a region in terms of numerical abundance and total quality regardless of sample size, and does not give importance to the existence of dominant or rare species but deals with them by one criterion.
- Shannon Wiener diversity index (H'): It calculates both the richness of the region in species and the heterogeneity in abundance between species, where the high values of this index indicate that dominancy is not concentrated in a few species but is distributed among several species.
- Sorenson index, 1942: This index measures the similarity coefficient between samples of two sites or samples under study, and is used in environmental studies to assess biocommunities in ecosystems.
- Bray and Curtise index, 1957: This index is based on Sorenson's similarity index and is used to show how much the sites differ.

Results and Discussion

1. **Physicochemical Tests:** Twelve physicochemical factors were measured during the study period within four sites identified in the methodology, Table 2.

Table (2): The environmental factors studied and their averages in each site and the general rate per factor in the total sites.

Factors	**Sites**						**General rate**
	Sit.1	**Sit.2**	**Average of two sites (Control and dilution)**	**Sit.3**	**Sit.4**	**Average of two sites (lentic water)**	
Temperature of air C°	23.62	26.25	24.94	22.93	24.62	23.78	24.35
Temperature of water C°	17.56	19.25	18.41	17.18	18.31	17.75	18.07
Turbidity (NUT)	28.76	31.46	30.11	9.68	6.83	8.25	19.18
TDS(mg/l)	374.62	422.37	398.5	420.62	460.37	440.5	419.49

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

EC(μs/cm)	827	920.87	873.9	915.87	1001.5	958.7	916.31
pH	7.92	7.82	7.88	8.01	8.02	8.02	7.94
DO(mg/l)	8.12	7.87	8.00	7.46	7.05	7.26	7.62
BOD_5(mg/l)	2.3	2.51	2.41	2.87	3.18	3.03	2.71
NO_3(mg/l)	4.92	6.47	5.70	2.35	1.78	2.07	3.88
PO_4(mg/l)	0.512	0.646	0.58	0.23	0.20	0.22	0.397
SO_4(mg/l)	151	198.75	174.9	235.62	269.62	252.6	226.62
SiO_2(mg/l)	3.47	3.35	3.41	2.75	3.33	3.06	3.22

Table 3 shows the general range of physicochemical factors at the study sites.

Table 3: The general range of physicochemical factors at control and dilution sites and at lentic sites during the study period.

Tests	**Studied sites**	
	Rate of Tests at environmental sites (Control and dilution)	**Rate of tests at environmental sites (lentic water)**
	Range Minimum-Maximum	**Range Minimum-Maximum**
Temperature of air C°	41.5 – 12.5	40.5 – 10.5
Temperature of water C°	32.0 – 8.5	32.0 – 7.5
Turbidity (NUT)	67.0 – 12.2	15.6 – 1.4
TDS(mg/l)	601 – 258	624 – 318
EC(μs/cm)	1365 – 532	1397 – 619
pH	9.2 – 6.9	9.4 – 6.8
DO(mg/l)	9.7 – 5.6	8.9 – 5.0
BOD_5(mg/l)	4.7 – 1.1	5.3 – 1.2
NO_3(mg/l)	8.5 – 3.9	3.7 – 0.9
PO_4(mg/l)	0.86 – 0.3	0.37 – 0.11
SO_4(mg/l)	232 – 125	299 – 193
SiO_2(mg/l)	4.16 – 2.36	4.06 – 2.07

Table 4 shows the Correlation Matrix between physicochemical factors and studied algae.

Table 4: Correlation Matrix between physicochemical factors and studied algae.

	Air Temp	**Water Temp**	**Turb**	**TDS**
Water Temp	0.988**			
Turb	0.176	0.201		
TDS	0.538**	0.506**	-0.185	
EC	0.605**	0.593**	-0.188	0.946**
PH	-0.67**	-0.670**	-0.218	-0.3
DO	-0.731**	-0.747**	0.087	-0.452*
BOD	0.770**	0.770**	-0.195	0.441*
NO_3	0.129	0.124	0.693**	-0.318
PO_4	0.091	0.075	0.692**	-0.336
SO_4	-0.101	-0.136	-0.660**	0.459*
SiO_2	-0.09	-0.041	0.334	-0.085
Algae	0.018	-0.022	-0.271	0.467**

Significant at 0.05, and 0.01 probability level , **,*

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

EC	PH	DO	BOD	NO_3	PO_4	SO_4	SiO2
-0.335							
-0.518**	0.396*						
0.567**	-0.402*	-0.770**					
-0.27	-0.168	0.301	-0.185				
-0.319	-0.132	0.350*	-0.255	0.93**			
0.394*	0.121	-0.308	0.193	-0.75**	-0.79**		
0.031	-0.003	0.139	-0.162	0.187	0.136	-0.109	
0.449**	0.114	-0.082	0.115	-0.242	-0.299	0.50**	0.275

Temperature is one of the climate factors that have an important role in different ecosystems, as it affects the properties of water in the aquatic ecosystem, especially the rate of melting gases, and this is evidenced by the negative relationship between the proportion of dissolved oxygen necessary in the breathing of most aquatic organisms and the temperature of the water, and thus is one of the determining factors for the effectiveness and activity of aquatic organisms (Al-Janabi, 2011). The seasonal heterogeneity of the phytoplankton community is also highly correlated with seasonal variations in temperature (Chalar, 2009), moreover. From the results of the study we find that the general temperature range of both air and water ranged between (10.5 - 41.5) °C and (7.5 - 32) °C respectively Table (3), which is a wide range that can cause clear variables in the diversity and density of phytoplankton during the seasons of the year. This conclusion is consistent with the current study and with the findings of the studies of researchers Al-Muthnani and Al-Salman (2009) and Mishra and Saksena (2009) as well as in line with the views of the researchers Al-Zubaidi (2012), Al-Yasari (2012) and Abdul-Amir *et al*. (2014), where the best growth of algae during the autumn season was recorded Table (20) where the water temperature was closer to optimum for most of the algae groups distribution in the Iraqi water environment. While no correlation between temperature and algae growth has been statistically recorded due to the moderation in temperatures recorded during the seasons of the year and their suitability for the growth of most known algae populations Table (4). It is clear from the results of the two tables (5 and 6) that the average air and water temperature recorded the lowest average during the winter and the highest average during the summer in line with what is known that one of the features of Iraq's climate is the rise in summer temperatures and their decline in winter (Al-Ghurairi, 2014). In accordance with the statistical results, which recorded significant differences in air and water temperatures between the seasons of the year and for all sites in probability ratios ($p \leq 0.05$), while no significant differences were recorded between the study sites.

It is also clear how heterogeneity in air temperature affects water temperature, which explains the nature of the positive correlation between them ($r=0.99$) and in accordance with most studies conducted on Iraqi inland waters (Al-Fatlawi, 2005; Al-Hassani, 2010 Al-Murib et al., 2019). Air temperature was also positively correlated with (total dissolved solid, electrical conductivity, oxygen biodemand), and negatively

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

significant correlation with (pH, dissolved oxygen) while the correlations were insignificant with other factors Table (4).

Table (5): Average quarterly values of air temperature (°C) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	26	29.5	27.5	28.5	3.87 NS
Winter	18.5	20.5	17	19	3.66 NS
Spring	20	23	18	21	4.61 *
Summer	30	32	29.5	30	3.57 NS
LSD value	5.93 *	5.88 *	6.02 *	5.49 *	---
(P≤0.05)*					

Table (6): Average quarterly values of water temperature (°C) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	20	21.25	21	21.25	2.91 NS
Winter	12	14.75	11.25	13	3.07 NS
Spring	15.25	16.5	14	15.25	2.98 NS
Summer	23	24.5	22.5	23.75	2.74 NS
LSD value	4.98 *	4.69 *	5.14 *	4.94 *	---
					(P≤0.05)*

Turbidity is an optical property of water that results from the diffusion and absorption of light by substances suspended in water rather than being transmitted straight through the aqueous medium, caused by the presence of solids suspended in water that include plankton and other microbiology (APHA, 2005). It is an influential factor in the organisms in water by blocking the passage of light to autophototrophic, directly affecting the growth rates and process of photosynthesis (Su *et al*., 2011), and thus the distribution and abundance of algae, including phytoplankton (Al-Saadi *et al*., 1986). In addition to its impact on public health when used for drinking purposes or in the food industry due to the possible presence of mineral elements or bacteria and fungi between the suspended minutes. From Table (7) we find that the lowest seasonal average of turbidity was 4.95 NTU at Sit.4 during the spring, as evidenced by Table (4) the existence of a positive significant correlation between turbidity and (nitrates, phosphates, silica) and a negative significant correlation with (sulfates, total dissolved solid, pH) while no significant correlation between turbidity and algae preparation was recorded and thus differed with studies applied to different water sites by researchers; Milad *et al*. (2012); Hamad and Al-Salman (2013). The reason may be that the causative factors of turbidity in the current study were confined to limited areas and their sources are the result of temporary human activities that vary in nature and activity from time to time.

Table (7): Average Quarterly Values of Turbidity (NTU) in study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	17.2	20.8	10.5	8	7.93 *
Winter	20.8	22.9	8.9	6.15	8.14 *
Spring	33.1	36.55	8.4	4.95	9.72 *
Summer	43.95	45.6	10.95	8.25	8.37 *
LSD value	8.62 *	11.37 *	6.42 NS	6.07 NS	---
					(P≤0.05) *

Total Dissolved solid (TDS): With its organic, inorganic and water-soluble substances that change the natural properties of water such as color, taste, smell, turbidity, salinity and light permeability (Al-Salman *et al*., 2012; Al-Zubaidi, 2012; Al-Nasrawi, 2014), and have negative effects on increasing its concentration in water sources, including a decrease in the permeability of light to water, which negatively affects the selffeeding neighborhoods producing food by photosynthesis. Moreover, it makes water unfit for human consumption because the process of treating this water is economically useless and requires the cleaning of basins, tanks and pipes continuously. It is clear from Table (8) that the highest values of the seasonal average were recorded in the autumn and summer season where the temperatures are the highest, while the lowest values were recorded during the spring and winter. This is consistent with what researchers Suleiman *et al.* (2009) and Shraddhal *et al*. (2011) have pointed out that temperatures play an important role in the process of dissolution, decomposition of compounds, increased salinity and TDS levels, while the results of statistical analysis showed significant differences between seasons while no differences were recorded between sites. Table 4 can observe the positive correlation between TDS and (air and water temperature, electrical conductivity, oxygen biodemand, sulfates, phytoplanktons) while recording a negative significant correlation with (dissolved oxygen, nitrates, phosphates, turbidity).

Table (8): Average quarterly values of total dissolved substances (TDS) in study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	478.5	532.0	502	553	107.38 NS
Winter	331.0	360.5	401	423	116.71 NS
Spring	289.5	341.5	354	388	108.63 NS
Summer	399.5	455.5	425.5	477.5	87.72 NS
LSD value	125.49 *	144.36 *	139.68 *	141.75 *	---
.(P≤0.05) *					

Electrical conductivity (EC): It is a numerical value that refers to the ability of water to conduct electric current, and depends on three factors, foremost of which comes the temperature, as it affects the movement and direction of different ions (APHA, 2005). The second factor is the concentration of ions and salts in water, as electrical conductivity increases with its concentration rises, while the third factor is the type of ions present and their concentration (Taleb *et al*., 2014). Studies also indicate that conductivity values are affected by temperatures, season change, total dissolved and suspended solid, rainfall, soil erosion, the arrival of pollutants and the nature of human activities in areas adjacent to water sources (Zeidan *et al*., 2009; Al-Sharifi, 2014). The results of the statistical analysis confirmed these conclusions, as the values of the conductivity were consistent with the results of the statistical analysis, which showed a positive moral correlation between the conductivity, air and water temperature, TDS and sulfates, but the values of the conductivity are supposed to rise in the spring, because the ionic composition of water is due to the interaction between rain, rocks, soil and plants living in nearby areas (Al-Saadi, 2013). But the current study did not agree with the above, as it recorded the lowest seasonal average value during the spring as a result of almost no rainfall in the current season with relatively low temperatures. It is noted that electrical conductivity recorded the highest value for the quarterly average of 1297 µS/cm in the autumn season signed Sit.4 Table (9).

Table (9): Average quarterly values of electrical conductivity EC (µS /cm) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	1174	1259	1198	1297	142.07 NS
Winter	636.5	693.5	777	816.5	158.52 *
Spring	564.0	667.0	693.0	775.5	171.36 *
Summer	933.5	1064	995.5	1117	155.94 *
LSD value	173.92 *	169.55 *	161.46 *	176.22 *	---
.(P≤0.05) *					

The pH is a numerical value that expresses the activity and effectiveness of the hydrogen ion in water, and in aquatic mediums significantly affects the survival, physiology, and growth of various aquatic organisms (Lawson, 2011). The pH value of most natural water is between (4-9) and the rise and fall from this value is due to the arrival of pollutants into the water, and the pH value results from the interaction of many factors, the most important of which are the heat of the water, the rate of production or consumption of CO_2 through respiration and the decomposition of organic matter or photosynthesis, in addition to the acidity and alkalinity of water (Yousry *et al.*, 2009). The results of the study in Table (2) indicate that the general average was 7.94, and it is clear from Table (10) that the difference between classes as well as between locations is not significant. The values were also within the permissible limits specified in the Iraqi Drinking Water Standard No. 417 of 2009 between (6.5 - 8.5) and the living of aquatic organisms (6.5 - 9), as they changed with a narrow range ranging between (6.8 - 9.4) Table (3). This indicates a limited impact on water quality and the growth and distribution of algae within the study area, and this was shown by the results of the statistical analysis where no significant differences were recorded between pH and algae number (Table 4) because we find that most important organisms in the water environment, including algae and aquatic plants, tend to have a neutral or light base medium (Al-Salman and Al-Muthnani, 2007) and the narrow range of fluctuation of this factor is due to the regulatory capacity of Buffer capacity, which resists variations in pH (Galic *et al.*, 2018). In addition to the role of aquatic plants and algae in regulating the proportions of carbon dioxide, bicarbonate and carbonic acid by drawing and subtracting CO_2 into the water by photosynthesis (Al-Muthnani and Al-Salman, 2009; Bruckner, 2011). The recorded results were consistent with local studies that indicated that Iraqi waters tend to be light basal and narrow range of variations (Al-Karaawi, 2014; Al-Azawii *et al.*, 2015).

Table (10): Average quarterly pH values at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	7.7	7.8	8.0	8.2	0.602 NS
Winter	8.2	8.0	8.25	8.1	0.668 NS
Spring	8.15	7.95	8.1	8.1	0.572 NS
Summer	7.65	7.55	7.7	7.7	0.439 NS
LSD value	1.08 NS	0.893 NS	0.703 NS	0.508 NS	---
.($P \leq 0.05$) *					

The dissolved oxygen factor DO is one of the important factors for the preservation of biology in the waters of rivers and lakes and is a proof of the safety and health of water bodies (Al-Eryani, 2005), and its main source is the process of photosynthesis of algae and aquatic plants, in addition to the movement of surface currents and the process of mixing between water and air near the surface of the water. An increased concentration of dissolved oxygen leads to the growth of aquatic organisms well (Othman *et al.*, 2001), while its deficiency causes problems for most aquatic organisms, especially if it reaches below 4 mg/L (Al-Salman and Al-Muthnani, 2007; Abdel Wahed, 2014). Most organisms need between (5–6) mg/L as a minimum, and since the recorded values were above the minimum in their range and general average, so DO is not expected to affect algae growth negatively, as evidenced by the absence of a correlation between the numbers of algae and dissolved oxygen (Table 4). Previous studies indicate that dissolved oxygen decreases with the increase of organic matter and respiration and that hyperthermia leads to a decrease in the value of dissolved oxygen (Badran, 2001). The current study agreed through its statistical results with the above referenced, as DO recorded a negative significant correlation with temperature and total and conductive dissolved substances, table (11) shows that the value of the minimum seasonal average of oxygen dissolved in water amounted to 6.35 mg/L in the summer Sit.4, while the highest value was 8.65 mg/L at the Sit.1 of the winter.

Table (11): Average quarterly values of dissolved oxygen DO (mg/L) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	8.2	7.95	7.15	6.55	1.31 *
Winter	8.65	8.3	7.95	7.55	1.04 NS
Spring	8.45	8.2	8.05	7.75	1.10 NS
Summer	7.2	7.05	6.7	6.35	0.994 NS
LSD value	1.35 *	1.19 *	1.26 *	1.29 *	---

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

.($P \leq 0.05$) *

The biodemand of BOD_5 oxygen is the amount of oxygen required by microbiology to be able to analyse the amount of organic matter aerobically over a given period of time and at specific temperatures into carbon dioxide and other simple chemical compounds (Al-Saadi, 2002; USEPA, 2007). It is an important measure of judging the organic pollution levels of any aquatic environment as the high BOD_5 value is evidence of water contamination with organic matter that is excreted into rivers from industrial and human wastewater (Al-Hafeedh, 2011). Rivers can also be classified based on the BOD value measured in the laboratory and under special conditions (1 very clean, 2 clean, 3 fairly clean, 5 questionable in its cleanliness, more than 10 poor) (Al-Saadi, 1986). We note from Table 12 that the seasonal average of the biodemand of oxygen recorded the highest value of 4.05 mg/L at the Sit.4 in the summer with high temperatures and low percentage of dissolved oxygen while the lowest values were recorded in winter and spring with low temperature and high DO. As is well known, the decrease in the value of oxygen dissolved in water leads to an increase in the value of the biodemand of oxygen (Mashkour, 2002). The results showed that the rate of oxygen biodemond in all sites was recorded (less than 5 mg/L) (Table 2) meaning that the water in the study area was clean to fairly clean, so no correlation was recorded between BOD_5 and algae preparation, while positive significant correlations were recorded with (air and water temperature, total dissolved solid, electrical conductivity), and negative with (pH, dissolved oxygen, phosphate, nitrate) Table (4).

Table (12): Average quarterly values of oxygen biodemond BOD_5 (mg/L) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	2.5	2.75	3.05	3.3	0.761 *
Winter	1.7	1.95	2.35	2.85	0.807 *
Spring	1.9	2.15	2.35	2.55	0.644 NS
Summer	3.1	3.2	3.75	4.05	0.895 *
LSD value	0.885 *	0.755 *	0.894 *	0.972 *	---

.($P \leq 0.05$) *

Nitrate NO_3 is a form of nitrogen compound in water, while algae can use two inorganic forms of nitrogen compounds, ammonium NH_4 and nitrate NO_3 (Hamad and Nidham, 2008). Nitrates are produced from multiple sources, including rainwater, puncture water from agricultural land where nitrogen compounds are used as fertilizer, domestic and industrial waste water and from the oxidation of ammonia in water. Nitrates recorded values ranging from (0.9-8.5) mg/L and thus fell within the permissible limits, which are below 50 mg/L based on Iraqi drinking water specifications, and 13 mg/L based on the living of aquatic organisms. The fluctuation of nitrate values during the seasons of the year is attributed to many factors, including the rate of flow of agricultural wastewater and the mass of plants and algae present in the water surface, as the highest averages of nitrate values were recorded in the spring and summer and the lowest during the autumn and winter seasons and inconsistent with previous studies that indicate the rise of nitrate values during the winter and their decrease in the summer season with the increase in the rate of rainfall in winter and the erosion of part of the soil of neighboring agricultural lands rich in nitrogen compounds (Wetzel, 2001; EPA, 2002). It is believed that the reason is a decrease in the rate of rainfall, with low numbers of phytoplankton recorded in addition to the decrease in agricultural activity in winter with the accompanying decrease in the rate of flow of agricultural wastewater, while the decrease in nitrate values in the autumn and winter seasons may be attributed to the increase in the productivity of phytoplankton (Table 20), pH also may play a role in modifying the concentration of nitrates and that acidic soils reduce their concentration (Barinova *et al.*, 2010). This conclusion was consistent with the results, as the pH recorded the lowest seasonal averages in the summer season (Table 10), and the results of the statistical analysis in Table (13) showed that the difference of sites was significant in probability ratios ($p \leq 0.05$) but the difference of seasons is not significant except for the Sit.2, which indicated a significant difference (1.44) between the seasons, positive significant correlations of nitrates were recorded with (phosphate, turbidity, silica, dissolved oxygen), while negative significant correlations with (sulfates, total dissolved substances, electrical conductivity, biodemand of oxygen) were recorded in Table (4).

Table (13): Average quarterly values of nitrate NO_3 (mg/L) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	4.5	5.15	2.15	1.2	1.74 *
Winter	4.9	6.5	2.1	1.6	1.57 *
Spring	5.2	7.2	2.6	1.95	1.66 *
Summer	5.1	7.05	2.55	2.4	1.63 *
LSD value	1.37 NS	1.44 *	0.903 NS	1.15 NS	---
.(P≤0.05) *					

Phosphate PO_4 is a phosphorus compound that is an essential nutrient for algae, representing an intermediate element in the energy metabolism processes of all living organisms (Schulze *et al*., 2005), and is needed by algae in the construction of nucleic acids (DNA, RNA), energy compounds (ADP, ATP) and plasma membranes in addition to its importance in breathing (Al-Husseini, 2020). The concentration of phosphates in water varies depending on the nature of the surrounding land, rock layers, population density, quality of agriculture as well as the amount of household waste released into river water (Yeoman *et al*., 1988 Guzha *et al*., 2019; Diaz *et al*., 2019). From table (14) we find that the lowest seasonal average value recorded for phosphate was 0.15 mg/L in the autumn season Sit.4, and the negative correlation between the numbers of phytoplankton and phosphate values can be observed where the lowest values of the average phosphate during the autumn season were recorded at the Sit.4 in conjunction with the recording of the largest number of phytoplankton (Table 20). It is also possible from Table 4 to observe the negative correlation between them, and this is believed to be related to the consumption of phosphates by algae and aquatic plants. It was also noted from the results of the statistical analysis a fluctuation in phosphate values during the study season, in line with the studies of a number of researchers in different locations of the Iraqi environment and concluded through them the presence of fluctuations in phosphate values during the months of the year and the different sites of samples and the nature of external influences that are thrown into the water environment (Al-Dahri, 2002; Diagomanolin *et al*., 2004; Salman, 2006; Al-Nasrawi, 2014).

Table (14): Average quarterly values of phosphate PO_4 (mg/L) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	0.455	0.525	0.215	0.15	0.233 *
Winter	0.515	0.65	0.215	0.17	0.219 *
Spring	0.545	0.72	0.27	0.21	0.262 *
Summer	0.535	0.69	0.255	0.285	0.217 *
LSD value	0.147 NS	0.208 NS	0.098 NS	0155 NS	---
(P≤0.05) *					

Sulfate SO_4 is an essential nutrient in all living organisms and has great importance in the growth of plants and algae, while increasing its concentration in water limits its suitability for irrigation and causes many health problems so the International Bulletin issued by WHO (2011) and the Iraqi Specifications for River Water Conservation and the Iraqi Drinking Water Standard No. 417 of 2009 recommend that the concentration of sulfate in water does not exceed 400 mg/L. Sulfate in the current study recorded a higher quarterly average value of 290 mg/L at the Sit.4 in the autumn season (Table 15), which is a high value but did not exceed the permissible limits, and the results of the statistical analysis Table (15) showed significant differences between sites but did not show a significant difference between the seasons except at the Sit.2 (71.56). This is believed to be related to a number of factors, including the geological nature of each site, the compounds that make up soil, rocks, depth, the nature of the pollutants that are thrown into the water, the amount of aquatic plants and algae that use sulfur in protein synthesis, as well as the presence of some microbiology and bacteria that may affect the amount of sulphates present in the water medium (Hamad and Nidham, 2008; Al- Muthnani and Al-Salman, 2009). As can be seen from Table 4, sulphates recorded a positive significant correlation with (total dissolved solid, electrical conductivity, pH, phytoplankton), and negative with (turbidity, nitrates, phosphates, dissolved oxygen).

Table 15: Average quarterly values of sulfate SO_4 (mg/L) at study sites with LSD values.

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	176.5	225	257.0	290	61.55 *
Winter	151.0	206	242.5	272	75.83 *
Spring	140.5	183.5	225.5	261.5	67.24 *
Summer	136.0	180.5	217.5	255	62.19 *
LSD value	34.58 NS	71.56 *	42.66 NS	48.05 NS	---
(P≤0.05) *					

Silica SiO_2 is a solid mineral material with a glass or crystalline appearance, but its main source in water is the erosion of Fladspar rocks, which make up about 60% of the earth's crust, and because it is one of the most abundant minerals in the earth's crust, so there is a percentage of silica in most water sources. It is found in nature in a variety of forms such as sand, sandstone, quartz and granite, in addition to its presence in the structures of animals, plants, algae, especially diatoms, as silica is the basic material in the structure of the skeletons of diatoms and its composition represents the basis (Gnanamoorthy and Prabu, 2014).

The results of the statistical analysis showed the existence of significant differences between all seasons and within all sites, and recorded the highest values of silica during the summer and in contrast to what was mentioned by Al-Samarrai (2009), Al-Jumaili (2011) and Al-Makdami (2016) that the concentration of silica decreases during the summer due to the absence of rainfall. It also differs with what Al-Mandeel (2005) said about the high concentration of silica in winter and its decrease in autumn, as the summer recorded the highest values and then came autumn and the results fluctuated between winter and spring, and it is believed that the reason is climate changes and lack of rainfall with a relative rise in temperatures during the winter than the expected and usual degrees in this season and high water levels for water releases with successive dust storms during the summer. Table 4 also shows a positive significant correlation with (turbidity, nitrates, phosphates).

Table (16): Average quarterly values of silica SiO_2 (mg/L) at study sites with LSD values.

Seasons	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Autumn	3.68	3.285	2.975	3.405	0.672 *
Winter	3.33	3.19	2.79	3.015	0.478 *
Spring	3.165	3.74	2.48	3.20	0.603 *
Summer	3.71	3.215	2.78	3.71	0.578 *
LSD value	0.508 *	0.492 *	0.407 *	0.511 *	---
.(P≤0.05) *					

2- Biological studies of the algae community:

During the period from October 2021 to June 2022, the qualitative study of phytoplankton concluded with the registration of 70 species belonging to 32 genera within the still waters of the lake, referred to as Sit.3 and Sit.4. While the total number of phytoplankton was recorded 107 species belonging to 43 genera in the four sites, it was found that the dominance in all sites was for the class Bacillariophyceae, which recorded 56 species belonging to 17 genera and a percentage of 42.06%, followed by the class of Cyanophyceae to record 22 species belonging to 7 genera and a percentage of 26.74%, then the class of Chlorohyceae with 20 species belonging to 12 genera and a percentage of 20.30% of the number of total algae. While the Euglenophyceae algae class ranked fourth with 3 species belonging to two genera and a percentage of 4.69%, while the Chrysophyceae class recorded 4 species belonging to one genus with a percentage of 3.71%, followed by Cryptophyceae algae class with one species and one genus that appeared in two study sites recording a percentage of 1.04%, then the Dinophyceae algae class with two species of different genera that were present at one study site and recorded a percentage of 0.925%. Finally, the zero algae class Xanthophyceae recorded one species and one genus with a percentage of 0.49% (Figure 2).

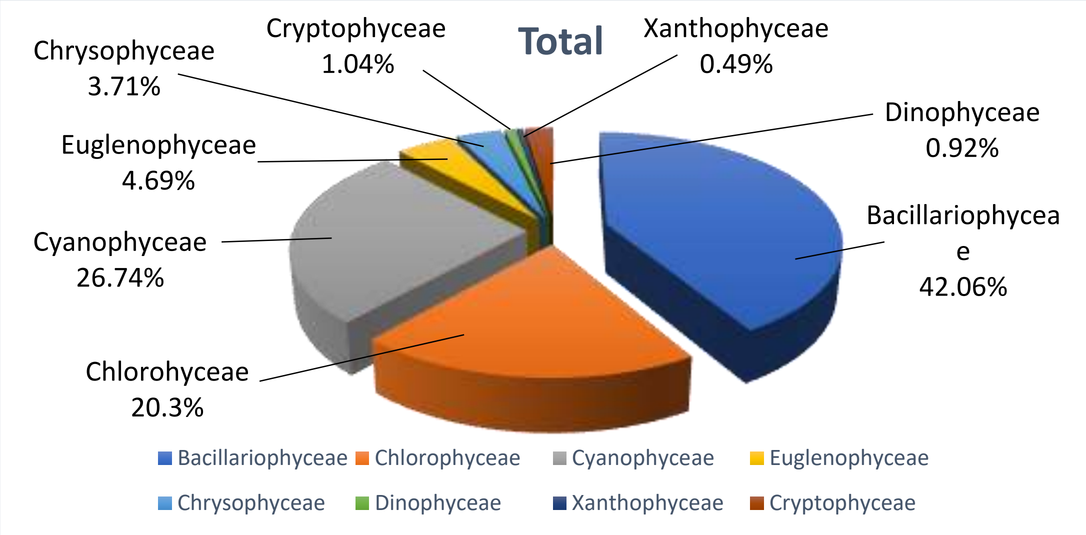


Figure 2: Percentage of phytoplankton classes diagnosed at all study sites.

From the results of the statistical analysis, it was found that there are significant differences for algae varieties in all study sites except the Euglenophyceae algae class and the Xanthophyceae algae class, whose differences were non-significant in probability ratios ($p \leq 0.05$), noting that the smallest significant difference (2.28) was recorded in the Cryptophyceae algae while the largest significant difference (7.38) was observed in the Bacillariophyceae algae (Table 17).

Table (17): Proportions of distribution of species of phytoplankton diagnosed in the study area for the period between 2021-2022 with LSD values

Classes	Sites				LSD value
	Sit.1	Sit.2	Sit.3	Sit.4	
Bacillariophyceae	%41.86	%47.05	%44.18	%35.18	7.38 *
Chlorophyceae	%16.27	%17.64	%23.25	%24.07	6.05 *
Cyanophyceae	%32.55	%29.41	%20.93	%24.07	6.19 *
Euglenophyceae	%4.65	%3.92	%4.65	%5.55	2.76 NS
Chrysophyceae	%2.32	%0.00	%6.97	%5.55	4.07 *
Dinophyceae	%0.00	%0.00	%0.00	%3.70	3.38 *
Xanthophyceae	%0.00	%1.96	%0.00	%0.00	1.97 NS
Cryptophyceae	%2.32	%0.00	%0.00	%1.85	2.28 *
.(P≤0.05) *					

Algae classes also recorded variations in biodiversity, distribution and appearance at different study sites, due to the variability of the environments they endemic, or as a result of their different rates of access to nutrients or exposure to pollutants or predators (Moura et al., 2013). The fourth site Sit.4 was superior in the number of species and genera over the rest of the sites as it recorded 52 species belonging to 28 genera, while the third site Sit.3 showed a decline in the number of species and genera over the rest of the sites by recording 39 species belonging to 22 genera, while the first site Sit.1 recorded 43 species dating back to 24 genera, and the second site Sit.2 recorded 51 species located within 26 genus (Table 18).

Table (18): The presence of genera and species of diagnosed phytoplankton in the four sites of the study area during the study period from 2021 to 2022.

Phytoplankton classes	Sites			
	Sit.1	Sit.2	Sit.3	Sit.4
Cyanophyceae				
Aphanocapsa quadricauda **Kütz.**	-	+	-	-
Chroococcus disperus **(Keissl) Lemmermann**	+	+	-	+
C. limneticus **Lemmermann**	+	+	+	+
C.minor **(Ktz.) Naegeli**	+	+	+	+
C.minutus **(Ktz.) Naegeli**	-	+	-	-

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

Phytoplankton classes	Sites			
	Sit.1	Sit.2	Sit.3	Sit.4
C. tenax **(Klrchn.) Hieron**	-	+	-	+
Cyanarcus hmiformis **Pascher**	+	-	-	-
Merismopedia elegans **A.Braum**	+	-	-	-
M. glauca **(Her.) Naegeli**	-	-	-	+
M. minima **Heck**	-	+	+	+
M. punctata **Heyen**	+	+	+	-
M. tenuissima **Lemmermann**	+	+	-	-
Oscillatoria amphibia **Agardh**	+	-	+	+
O. angustissima **West and West**	+	+	-	+
O. articulata **Gardner**	-	-	-	+
O. borneti **Zukalila**	-	+	-	-
O. lacustris **(Klebahn) Geitler**	-	-	-	+
O. limnetica **Lemmermann**	+	+	+	+
O. minima **Gicklhorn**	+	-	-	-
O. terebriformis **Agardh**	-	+	-	+
Oscillatoria sp.	+	+	+	
Phormidium sp.	+	+	-	-
Synechacoccns aeruginosus **Naegli**	+	+	+	+
Chlorophyceae				
Ankistrodesmus falcatus **(Corda) Ralfs**	+	+	+	+
Chlamydomonas angulosa **Ehrenberg**	-	-	+	-
C. polypyrenoideum **Prescott**	-	-	+	+
C. psedoperytyi **Prescott**	-	-	-	+
Chlorella vulgareis **Bejerinck**	+	+	+	+
Cosmerum sp.	-	-	-	+
Crucigenia quadrata **Morren**	-	+	-	-
C. terapedia **(Kirchn.) West & West**	+	-	+	-
Kirchneriella contorta **(Schmidle)**	-	-	-	+
** K. contorta var elongata*	-	-	-	+
Oocystis eremosphaeria **G.M.Smith**	-	+	-	-
Pediastrum boryanum **(Turp.) Meneghini**	-	+	-	-
Scendesmus bijuga **(Turp) Lagher.**	+	+	+	+
S. dimorphus **(Turp) Ktz.**	+	+	+	+
S. quadricauda **(Turp.) de. Brebisson**	-	+	+	+
Scenedesmus sp.	-	-	+	-
Selenastrum westii **G.M. Smith**	-	-	-	+
Tetraedron minimum **(A. Braun) Hansg.**	+	+	+	+
T. muticum **(A. Braun) Hansg.**	+	-	-	-
Ulothrix cylindricum **Prescott**	-	+	-	-
U. moniliformis **Kütz.**	-	-	+	-
U. subconstricta **G.S. West**	-	-	-	+
Euglenophyceae				
Euglena spirogyra **Ehrenberg**	-	+	+	+
Phacus acuminatus **Stoken**	+	+	+	+

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

Phytoplankton classes	Sites			
	Sit.1	Sit.2	Sit.3	Sit.4
P. caudatus **Huebner**	+	-	-	+
Chrysophyceae				
Dinobryon cylindericum **Iomf**	-	-	+	-
D. sertularia **Ehrenberg**	-	-	+	-
D. tabellariae **(Lemmermann) Pascher**	+	-	+	-
D. divergens **Imhof**	-	-	-	+
Bacillariophyceae				
Order: Centrales				
Cyclotella meneghiniana **Kütz.**	+	+	+	+
Order: Pennales				
Achnathes hungarica **Grnow**	-	-	-	+
Bacillaria paxihhifer **(Muell.) Heneley**	+	+	-	-
Coloneis ladogensis **Cleve**	-	+	-	-
Cymatopleura solea **(Breb.) W. Smith**	+	-	-	-
Cymbella aspera **(Her.) H. Paragallo**	+	-	-	-
C. aequalis **(W.Sm.) Krammer**	+	-	-	-
C. cesatil **Grum.**	-	+	+	-
C. helvtica **Kütz.**	-	-	-	+
C. leptoceros **(Her.) Grunow**	-	+	+	-
C. naviculiformis **Auersw**	-	-	+	-
C. tumida **(Breb.) van. Heurk**	-	+	-	-
Diatoma elongatum **(Lyngb.) Agardh**	-	-	+	-
D. vulgare **Kütz.**	-	-	+	-
Diploneis ovalis **(Hilse) Cleve**	-	+	-	-
D. smithii **(Breb.) Cleve**	-	-	-	+
Fragilaria brevistriata **Grunow**	-	-	+	+
F. capucina **Desmazieres**	-	-	-	+
F. construens **(Her.) Grunow**	-	+	-	-
F. intermedia **Grunow**	+	-	-	-
Gyrosigma acuminatum **(Ktz.) Rabenhorst**	-	+	-	-
G. peisonis **(Gru.) Hustedt**	-	+	-	-
Mastogloia smithii **Thw. Ex W.Sm.**	-	+	-	+
Navicula acicularis **Kütz.**	-	+	+	+
N. bacillum **Her**	-	+	-	-
N. brekkansis **J.B. Petersen**	-	-	-	+
N. crucicula **(W. Smith) Donkin**	+	+	-	-
N. cryptocephale **Kütz.**	+	+	-	-
N. cymbula **Donk**	-	+	-	+
N. decussis **Oestrup**	-	+	-	-
N. dicephala **Ehrenberg**	-	-	-	+
N. halophila **(Grum.) Cleve**	-	+	+	-
* *N. integra*	-	-	+	-
N. pupula **Kütz.**	-	-	+	-
N. saxophila **Bock**	-	-	-	+
N. trivialis **Betalot**	-	-	-	+

Phytoplankton classes	Sites			
	Sit.1	Sit.2	Sit.3	Sit.4
Navicula sp.	+	+	+	+
Nitzschia acicularis **(Ktz.) W.Smith**	-	+	+	+
N. commutate **Grunow**	+	-	+	+
N. gracilis **Hantzsh**	+	+	-	-
N. hantzschiana **Rabenhorst**	-	+	-	-
N. hungarica **Grunow**	+	-	-	-
N. intermedia **Hantzsch ex Cleve et Grun**	-	-	-	+
N. linearis **Gregory**	+	-	-	-
N. longissima **(Breb.) Ralfs**	+	-	+	+
N. romana **Grunow**	+	-	-	+
N. tryblionella **F.Minor**	-	+	-	-
Nitzschia sp.	-	+	-	-
Pinnularia globiceps **Greg**	+	-	-	-
P. leptosoma **(Grun.) Cleve**	+	+	-	-
P. linearis **Gregory**	+	-	-	-
P. microstauron **(Her.) O. Muella**	-	-	+	+
Rhopalodia gibba **(Her.) O. Muller**	+	-	-	-
Stauroneis phenicenteron **(Nitzsch) Ehrenberg**	-	-	-	+
Synedra acus **Kütz.**	-	-	+	-
S. pulchella **(Ralfs) Kuetzin**	-	+	-	-
S. tabulate **(Kütz.) Grunow**	+	+	+	-
S. ulna **(Nitz.) Ehrenberg**	+	-	-	-
Dinophyceae				
Ceratium hirundinella **(Muell.)Du Jardin**	-	-	-	+
Peridinium cinctum **(Muell.) Ehrenberg**	-	-	-	+
Xanthophyceae				
Vaucheria sp.	-	+	-	-
Cryptophyceae				
Cryptomonas erosa **Ehre**	+	-	-	+

***Sit.1: Site of Al-Fahama Center (Control), Sit.2, Site of Muthanna Bridge (Dilution)**
***Sit.3: Lake start Site, Sit.4, Lake end Site (representing lentic aquatic ecological sites)**
+ : Present, - : Not Found , * : New Registration

The results of the study also showed algae that have the ability to exist in a high percentage of species as phytoplankton, and in other studies found epiphytic or epipelic such as the genera *Navicula* and *Nitzschia* due to their possession of a frustule and their ability to migrate vertically in the sediment through the secretion of a mucous substance for ease of movement and protection (Poulíčková *et al.*, 2008; Andrejic *et al.*, 2012).

While there are algae that have shown a presence in all seasons of the year and all study sites *Chroococcus minor*, *Oscillatoria limnetica* of blue-green algae and *Ankistrodesmus falcatus* of green algae, and some species have been found at all sites in specific seasons such as *Synechacoccns aeruginosus* of blue-green algae and *Tetraedron minimum* of green algae. There are algae that have registered a presence in the static water sites Sit.3 and Sit.4 in specific seasons of the year while they have not shown a presence in the rest of the seasons, algae that have shown a presence in the autumn specifically without the rest of the seasons such as *Dinobryon cylindericum* algae from Xanthophyceae algae and *Navicula pupula*, *Synedra acus* from Pennales algae and *Ulothrix moniliformis* from green algae have registered an appearance on the site Sit.3.

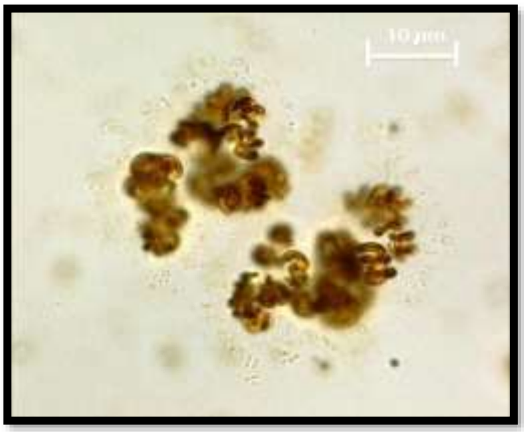
The algae *Cymbella helvtica* and *Nitzschia intermedia*, two of the Pennales algae, also showed a presence at the site Sit.4. Algae appeared that registered a presence in the spring while they did not register a presence in the rest of the year, *Chlamydomonas angulosa* of green algae was found on site Sit.3, and at the site Sit.4 found *Navicula dicephala*, *Navicula saxophila*, *Navicula trivalis*, *Navicula brekkansis* of Pennales algae and *Ceratium hirundinella* of Centrales algae. The algae also showed that *Diatoma elongatum*, *Diatoma vulgare* of Pennales algae that registered a presence at the site Sit.3, *Peridinium cinctum* of Dinophyceae algae, *Chlamydomonas psedoperytyi* and *Cosmerum* sp. of algae greens and *Stauroneis phenicenteron* of Pennales algae showed a presence at the site Sit.4. The current study recorded two new types of algae for the first time in Iraq. Based on the Checklist of Algal Flora in Iraq about Maulood *et al*. (2013) both phytoplankton one of them is of the green algae class Chlorophyceae and the other is of the Bacillariophyceae algae class, as shown in the description and photos below:

Kirchneriella contarta* var. *elongate

Kirchneriella contorta var. elongata (G. M. Smith) Kom

Syn.: *Kirchneriella elongata* G. M. Smith

Colonies composed of many cells irregularly distributed within a gelatinous envelope. Cells cylindrical, twisted with rounded apex, many times longer than wide, Cell size: 20-30 µm×2-3 µm. The species is probably cosmopolitan, but rare. This variety was absent in our material. It was recorded in Argentina from a temperate, mesotrophic shallow lake.

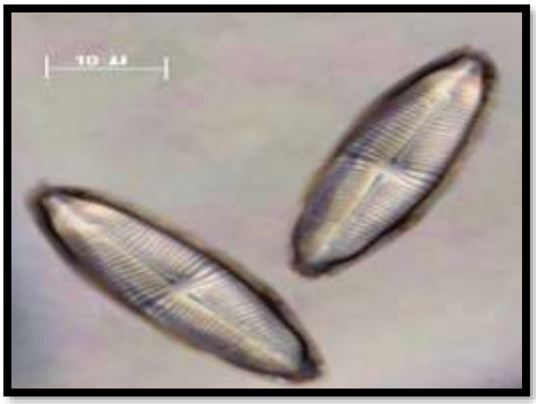


Picture (1): *Kirchneriella contarta* var. *elongate*

Navicula integra

Navicula integra (Fischer, 1927-1928) Pascher *et al.*,1930

Navicula integra is a raphed, pennate diatom with boat-shaped cells, it's length about (25 –37) µm, width (8–10) µm, the number of striae per 10 µm. It's presence in sea coast, inland waters with increased salinity, salt and polluted waters, fresh water.



Picture (2): *Navicula integra*

We conclude from the emergence of new species that a difference has occurred in the nature and quality of water due to the different levels of pollution, which has produced qualitative and quantitative variations in aquatic biology, including algae, and leading to the disappearance of certain species and the emergence of

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

other species, and this is consistent with the conclusions of the researchers Al-Daraji (2015) and Dbaje and Kosun (2013).

The results of Table 19 indicate that the number of phytoplankton ranged from the minimum value of 111.205 cells/ml^3 at the Sit.3 site for spring and the higher value of 492.22 cells/ml^3 at the autumn semester at Sit.4, with significant differences in all seasons of the year and all study sites. Note that the smallest and largest significant difference was (58.17, 81.44) respectively was calculated between the different seasons of the year at Sit.3 and Sit.2 respectively. while the general average number of wanderers was 241.015 cells/ml^3.

Table 19: Quarterly values of phytoplankton numbers (cell/ml^3) at study sites with LSD values.

Seasons	**Sites**				**LSD value**
	Sit.1	**Sit.2**	**Sit.3**	**Sit.4**	
Autumn	297.03	460.335	176.205	492.22	75.05 *
Winter	202.025	268.535	122.06	376.085	67.38 *
Spring	138.625	172.795	111.205	311.30	73.83 *
Summer	162.235	202.025	132.064	230.93	60.52 *
LSD value	62.37 *	81.44 *	58.17 *	65.72 *	---
					(P≤0.05) *

The autumn season recorded the highest values in the percentage of algae presence due to the moderation of temperature with the clarity of the atmosphere, high water levels and increased agricultural activity in the study area, followed by the winter with low temperature, short length of day and lack of illumination period with the tilt of the angle of sunshine fall where the rate of growth and metabolism in algae cells becomes slower due to the decrease in water temperature (Sin *et al.*, 2006), in addition to increasing the number of zooplankton that feed on phytoplankton and bottom algae in winter (Abdul-Amir and Hadi, 2017), then the spring season and the accompanying fluctuation in temperatures and lack of rainfall, while the percentage of summer did not exceed 18.87% due to high temperature, dust storms and high values of turbidity of water with increased evaporation, in addition to the decrease in the percentage of oxygen dissolved in water (Table 20).

Table (20): Average number of phytoplankton cell / ml^3 for sites and studied season and their percentages during the study period.

Season	**Sites**				**Average number of phytoplankton per season and their general average**	**Percentage of phytoplankton in each season**
	Sit.1	**Sit.2**	**Sit.3**	**Sit.4**		
Autumn	297.03	460.335	176.205	492.22	356.447	36.97%
Winter	202.025	268.535	122.06	376.085	242.176	25.12%
Spring	138.625	172.795	111.205	311.3	183.481	19.03%
Summer	162.235	202.025	132.64	230.93	181.957	18.87%
Average number of phytoplankton per site and their general average	199.978	275.922	135.527	352.633	241.015	
Percentage of phytoplankton in each site	20.74%	28.62%	14.05%	36.57%		

*** Sit.1: Site of Al-Fahama Center (Control), Sit.2, Site of Muthanna Bridge (Dilution)**
*** Sit.3: Lake start Site, Sit.4, Lake end Site (representing lentic aquatic ecological sites)**

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

cell× 10^3 : represents the rate of preparation of phytoplankton in 1 liter

Furthermore, the results of the study showed a variation in the average number and presence of phytoplankton according to the study sites and seasons of the year. The fourth site recorded the highest average and this may be attributed to nutrient availability, water stagnation and low turbidity and in accordance with Kadhem (2005) who pointed out that the increase in decomposing substances resulting from the excretion of waste and the presence of organic matter with increased illumination, low speed of water flow (stagnant water) and high temperatures lead to an increase in the number of algae. To be followed by the second site where the most receiving place for wastewater and seedles with the organic and inorganic substances they add to the water and this is evidenced by its recording of the highest proportions in nitrates and phosphates. Then the first site, where rocks abound and waste from agricultural land and fish farming ponds, has recorded the highest silica values, and finally the third and closest site to the first site with a lower proportion of nitrate, phosphate and silica, which is an important food component that enters into the composition of the silica wall of Bacillariophyceae algae (Shehata and Bader, 2010). This is shown by the positive correlation between the total number of phytoplankton and silica (Table 4). By calculating the total number of algae, we find that the lentic water represented by the third and fourth sites recorded the highest average (Table 21).

Table (21): Average preparation of phytoplankton cell/ml^3 for study sites during the study period.

Season	**Sites**			
	Sit.1	**Sit.2**	**Sit.3**	**Sit.4**
Autumn	297.03	460.335	176.205	492.22
Winter	202.025	268.535	122.06	376.085
Spring	138.625	172.795	111.205	311.3
Summer	162.235	202.025	132.64	230.93
Average number of phytoplankton at each site	199.978	275.922	135.527	352.633
Average number of phytoplankton in both lotic water and lentic water	237.95		244.08	

*** Sit.1: Site of Al-Fahama Center (Control), Sit.2, Site of Muthanna Bridge (Dilution)**

*** Sit.3: Lake start Site, Sit.4, Lake end Site (representing lentic aquatic ecological sites)**

cell× 10^3 : represents the rate of preparation of phytoplankton in 1 liter

References

1. Abdel Wahed, E.; Salta, M.A. and Muhammad, A.H., 2014. Identification of organic pollutants in the waters of the Tigris River. The Second Scientific Conference of the College of Science at the University of Karbala, February 26-27, Karbala - Iraq.
2. Abdul-Amir, H.M.T. and Hadi, S.S., 2017. Study of seasonal changes of the Mud-Adhered Algae Community of Al-Hussainiya River in the Holy Karbala Governorate. Karbala University Scientific Journal, 15 (3), 200-212.
3. Abdul-Amir, H.T., Hassan, F.M. and Salman, I.M., 2014. Environmental study of Bani Hassan stream - Holy Karbala Governorate. Baghdad Journal of Science, 11(3): 1327-1319.
4. Aboal, M., Alvarez-Cobelas, M.; Cambra, J. and Ector, L., 2003. Floristic list of non marine diatoms (Bacillariophyceae) of Iberian Peninsula, Balearic Islands, and Canary Islands. Updated taxonomy and bibliography In: A. Witkowski (ed.), *Diatom Monographs*. A.R.G. Gantner Verlag K.G., 4: 639 pp.
5. Al-Azawii, L.H.A.; Al-Azzawi; Muhammad N. and Nashaat, Muhnned R., 2015. The effects of Industrial institutions on Ecological factors of Tigris River Through Baghdad Province. *Int. J. of Adv. Res.*, 3(3), 1260-1278.
6. Al-Dahri, A.A-J., 2002. The validity of the treated wastewater in the State Phosphate Company for irrigation purposes. PhD thesis, College of Science, University of Anbar-Iraq, 138 pp.

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

7. Al-Daraji, I.K.A.-H., 2015. The use of phytoplankton biomarkers to assess the impact of human activities on the water quality of Beit Zuweina River, Diyala Governorate. MSc. Thesis, College of Education for Pure Sciences (Ibn Al-Haitham), University of Baghdad.
8. Al-Eryani, A.Q.A., 2005. Estimation of some qualitative characteristics and heavy elements and their effect on the soil and sewage of the city of Mosul and on plants irrigated therein and determining the efficiency of the sunflower. PhD thesis, Department of Biology, College of Science, University of Mosul, Iraq.
9. Al-Fatlawi, H.J.J., 2005. An Environmental Study on the Euphrates River between the Hindiya Dam and the City of Al-Kifl. MSc. Thesis, University of Babylon.
10. Al-Ghurairi, W.A.S., 2014. An ecological study of algae in Yusufiyah River, Baghdad, Iraq. MSc. thesis, College of Science for Girls, University of Baghdad, 91 pp.
11. Al-Hassani, J.S., 2010. Study of the environment and diversity of attached algae on some aquatic plants in Al-Hawizeh Marsh, southern Iraq. PhD thesis, College of Science for Girls, University of Baghdad - Iraq: 215 pp.
12. Al-Hassany, J.S. and Hassan, F.M., 2014. Taxonomic study of some epiphytic diatoms on aquatic plants from AL-Hawizah marshes, southern of Iraq. *Asian Journal of Natural and Applied Sciences*, 3(1), 1-11.
13. Al-Husseini, K.T and Alsalman, I.M.A., 2020. Quarterly Variation and their Impact on Phytoplankton Dynamics in the Gharaf River Environment-Southern Iraq. *Plant Archives*, 20(supplement-1), 1354-1360
14. Al-Husseini, K.T.H., 2020. Seasonal changes of the algal community in the water system of the Garraf River and its relationship with human activities. MSc. Thesis, College of Education for Pure Sciences (Ibn Al-Haitham), University of Baghdad.
15. Al-Jumaili, A.K.H., 2011. A study of morphology in the Tigris River within Salah al-Din Governorate / Iraq. MSc., Thesis, College of Science, Tikrit University, 98 pp.
16. Al-Karaawi, H.A.H., 2014. Study of biodiversity evidence to assess the zooplankton community in the Kufa River - Iraq. PhD thesis, University of Al-Qadisiyah - College of Education - Department of Biology.
17. Al-Makdami, B.A.-A., 2016. Study of the algae community (diatoms) in the Tigris River between Baghdad and the Dujail area. PhD thesis, College of Education (Ibn Al-Haitham), University of Baghdad.
18. Al-Mandeel, F.A.S., 2005. An ecological phylogenetic study of phytoplankton in the regulatory lake of Mosul Dam. MSc. Thesis, College of Science, University of Mosul.
19. Al-Murib, M., Wells, S. and Talke, S.A., 2019. Integrating landsat TM/ETM+ and numerical modeling to estimate water temperature in the Tigris River under future climate and management scenarios. *Water*, 11, 892.
20. Al-Muthnani, A.A.M. and Al-Salman, I.M.A., 2009. Ecosystems. First Edition, Sebha University Publications, Libya, 552 pp.
21. Al-Nasrawi, W.S., 2014. Evaluation of the efficiency of the Al-Hussein neighborhood water project and the main free water complexes in the Holy Karbala Governorate. MSc. Thesis, College of Education for Pure Sciences - University of Karbala, Iraq, 127 pp.
22. Al-Saadi, A.J.N., 2013. The biodiversity of freshwater and some environmental factors affecting it in the Euphrates River - Iraq. MSc. Thesis, College of Science, University of Babylon.
23. Al-Saadi, H.A., 1986. Aquatic Ecology. Basra University Press, Iraq: 574 pp.
24. Al-Salman, I.M. and Al-Muthnani, A.S.M., 2007. Ecosystems, Chapter Eight, Aquatic Ecosystem, First Edition, Sebha University Publications, Libya.
25. Al-Salman, I.M.; Al-Alwani, M.A. and Ibrahim, T.M., 2012. A comparative study of the quality of well water in the regions of Fallujah and Muqdadiya - Iraq. Ibn Al-Haitham Journal of Pure and Applied Sciences, 25(2): 8-17.
26. Al-Samarrai, Baida Abdul Qader Mahdi Saleh, 2009. An ecological and microbial study of liquefied water in Salah El-Din Governorate. MSc. thesis, Department of Biology, College of Science, University of Baghdad.

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

27. Al-Sharifi, A.A.K., 2014. Occupant pollution of some heavy metals and some environmental factors of the water of Bani Hassan Stream in the Holy Karbala Governorate - Iraq. MSc. Thesis, College of Education for Pure Sciences, University of Karbala, 122 pp.
28. Al-Yasari, W.A., 2012. Environmental assessment of the quality of drinking water in some purification plants in Babil Governorate - Iraq. MSc. Thesis, College of Science, University of Babylon, Babylon, Iraq.
29. Al-Zubaidi, K.A., 2012. The effect of Al-Diwaniyah textile factory wastes on the water quality and sediments of Al-Diwaniyah River - Iraq. Master Thesis, Department of Biology, College of Science, University of Al-Qadisiyah, Iraq.
30. Andrejic, J., Krizmanic, J. and Cvijan, M., 2012. Diatom species composition of the Nišava river and its tributaries Jerma and Temska rivers (Southern Serbia). *Archives of Biological Sciences*. 64. 1127-1140.
31. APHA, 2005. *American public Health Associations, Standard Methods for examination of Water and waste Water*, 20^{th} Ed. Washington. DC, USA.
32. Badran, M.I., 2001. Dissolved oxygen, chlorophyll a and nutrients: seasonal cycles in Water of Gulf Aqaba, Red sea. *Aquatic Ecosystem Health and Management*, 4 (2): 139-150 .
33. Barinova, S., Tavassi, M., Glassman, H. and Nevo, E., 2010. Algal indication of pollution in the lower Jordan River. *Applied Environmental Research*, 8(1), 19-38.
34. Barroso, A.D.; Leitesant, A.C. and Cabal, S.P.A., 2007. *Phytoplankton of duasbacarseserveir*. Es Pirito Santo. Brazil, Cexceptidatoms.
35. Bellinger, E.G.; Sigee, D.O., 2010. *A key to more frequently occurring freshwater algae*. Freshwater algae .John. Wiley and Soncitd.
36. Bourrelly, D.P., 1981. *Flore des diatomees diatomophy cees. Societe nouvelle des editions boubee*. II, place saint Michel Michel. 7500. Paei.
37. Bruckner, M.Z., 2011. *Water and soil characterization – pH and Electrical conductivity*. Life research methods, Environmental sampling FMLA -Texas Univ. 10L 12. USA: 115pp.
38. Chalar, G., 2009. The use of phytoplankton patterns of diversity for algal bloom management. *Limnological*, 39, 200-208.
39. D'Alelio, D.; Russo, L.; Del Gaizo, G. and Caputi, L., 2022. Plankton under Pressure: How Water Conditions Alter the Phytoplankton–Zooplankton Link in Coastal Lagoons. *Water*, 14, 974.
40. Dbaje, S. and Kosun, E., 2013. Laxonomic note, on Marker, planktonic foraminifera to tom boy fild, offshore western Niger delta Nigeria. *IJST*, 2(9), 622- 627.
41. Desikachary, T.V., 1959. *Cyanophyta. Indian Council of Agricultural Rese- arch*. New Delhi, India: 686 pp.
42. Diagomanolin, V., Farhang, M., Khanzari, G. and Jafarzadeh, N., 2004. Heavy metals (Ni, Cr, Cu) in the Karoon water way River. *Iranian Journal of Toxicology*, 151: 63-69.
43. Díaz, S., Settele, J., Brondízio, E.S., Ngo, H.T., Agard, J., Arneth, A., Balvanera, P., Brauman, K.A., Butchart. S.H.M., Chan, K.M.A., Garibaldi, L.A., Ichii, K., Liu, J., Subramanian, S.M., Midgley, G.F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., Polasky, S., Purvis, A., Razzaque, J., Reyers, B., Chowdhury, R.R., Shin, Y.J., Visseren-Hamakers, I., Willis, K.J. and Zayas, C.N., 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science*, 366(6471), eaax3100.
44. EPA, 2002. *A Guidance Manual to Support the Assessment of. Contaminated Sediments in Freshwater Ecosystems*. Volume III - Interpretation of the Results of Sediment Quality Investigations, United States, 207pp.
45. FAO, 1992. *Food and Agriculture Organization. Waste water treatment and use in agriculture* . Technical papers No. 47 FAO Roma Italy.
46. Farhan, M.N. and Salman, I.M., 2019. Physicochemical changes of the artificial pond water of the Martyr's Monument and their potential impacts on the ecosystem and biological community. The Third Women's Conference, Ministry of Science and Technology, 1-14.
47. Furet, J.E. and Benson Evans, K., 1982. An evaluation to of the time required to obtain complete sedimentation of fixed algal particles prior to enumeration. *British Phycology Journal*, 17: 253-528.

48. Galic, N., Hawkins, T. and Forbes, V., 2018. Adverse impacts of hypoxia on aquatic invertebrates: A meta-analysis. *Science of The Total Environment*, 652.
49. Gnanamoorthy, P. and Prabu, V.A., 2014. A bloom of invasive marine Haptophyta, *Phaeocystis globos* a from the Manapad estuary, Gulf of Mannar, South east coast of India. Elixir Applied Biology, (2014), 21314-21317
50. Guzha, A.C., Rufino, M.C., Okoth, S., Guzha, A.C. and Nóbrega, R.L.B., 2019. Impacts of land use and land coverchange on surface runoff, discharge and low flows: Evidence from East Africa. *Journal of Hydrology: Regional Studies*, 15, 49-67.
51. Hadi, R.A.M., Al-Saboonchi, A.A. and Haroon, A.K.Y., 1984. Diatoms of the Shatt al-Arab river, Iraq. *Nova Hedwigia*, 39, 513-557.
52. Hakansson, H. and Loker, S., 1981. Stephanodiscus Ehrenberg 1846, a revision of the species described by Ehrenberg. *Nova Hedwigia* 35(1), 117-150.
53. Hamad, A.A. and Salman, I.M.A., 2013. A monological study of some physicochemical factors for the water of the Bani Hassan stream and their relationship with the level of bacterial contamination. The Fifth International Conference on Environmental Sciences 3-5 December, University of Babylon - Iraq. Special Issue/ Conference Proceedings: 293-283.
54. Hamad, I. and Nidham, A.A.A., 2008. Microbiology Environment. Theoretical Part, Second Edition, Damascus University Publications, Syria, 242 pp.
55. Hassan, F., Hadi, R., Kassim, T. and Al-Hassany, J., 2012. Systematic study of epiphytic algal after restoration of Al-Hawizah marshes, southern of Iraq. *African Journal of Aquatic Science*, 3, 2008-8019.
56. Hinton, G.C.F. and Maulood, B.K., 1982. Contribution to algal flora of Iraq ; The non-diatom flora of the southern marshes. *Nova Hedwigia*, 37, 49-63.
57. Kadhem, N.F., 2005. Algae diversity and its relationship with some physical and chemical properties of the Hilla River. Master's Thesis, College of Science, University of Babylon, Iraq.
58. Lawson, E.O., 2011. Physico-Chemical Parameters and Heavy Metal Content of Water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. *Advances in Biological Research*, 5, 8-21.
59. Liu, M., Hou, T., Nkimbeng, M., Li, Y., Taylor, J.L., Sun, X., Tang, S. and Szanton, S.L., 2021. Associations between symptoms of pain, insomnia and depression, and frailty in older adults: a cross-sectional analysis of a cohort study. *The International Journal of Nursing Studies*, 117, 103873.
60. Mashkour, S.K., 2002. The effect of heavy and industrial waters of the city of Samawah on the course of the Euphrates River. Al-Qadisiyah Journal, 7(2), 29-38.
61. Maulood, B.K., Hassan, F.M., Al-Lami, A.A., Toma, J.T. and Ismail, A.M., 2013. *Checklist of Algal Flora in Iraq*. Republic of Iraq By Ministry of Environment, Baghdad. Ministry of Environment, Iraq.
62. Milad, S.F., Luji, M.N. and Al-Salman, I.M.A., 2012. A methodological study of the water of Ain Tawergha, northwest Libya, to assess its suitability for aquaculture. Fourth Conference on Environmental Sciences, December 5-6, University of Babylon, Iraq.
63. Mishra, A., Medhi, K., Malaviya, P. and Thakur, I., 2019. Omics approaches for microalgal applications: Prospects and challenges. *Bioresource Technology*, 291.
64. Mishra, S.R. and Saksena, D.N., 2009. *Aqology. Ecyolog*, 1st. Ed A.P.H. PUBL. Corporation New Delhi, India
65. Moura, A., Severiano, J., Aragão-Tavares, N. and Dantas, Ê., 2013. The role of a cascade of reservoirs and seasonal variation in the phytoplankton structure in a tropical river. *Brazilian journal of biology = Revista brasleira de biologia*. 73, 291-298.
66. Munir, F., Nielsen, K., Garde, A.H., Albertsen, K. and Carneiro, I.G. 2012. Mediating the effects of work-life conflict between transformational leadership and health-care workers' job satisfaction and psychological wellbeing. *The Journal of Nursing Management*, 20(4), 512-521.
67. Othman, M. R.; Samat, A. and Hoo, L.S., 2001. Effect of water quality to fish abundance and chlorophylla (selected aquatic organisms) in Laba river system. *Malaysian Journal of Medical and Biological Research*, (12), 1178-1182.

ISSN NO: 2771-8840
Date of Publication: 04-09-2022

68. Patrick, R. and Reimer, C.W., 1975. *The Diatom of the United States*. The academy of natural sciences of Philadelphia No.: 13 -31.
69. Poulíčková, A., Hašler, P.; Lysáková, M. and Spears, B., 2008. The ecology of freshwater epipelic algae: an update. *Phycologia* 47, 437-450.
70. Prescott, G.W., 1979. How To Know the Freshwater Algae. The Pictured Key Nature Series, 3rd edn, Wm C. Brown Company Publishers, Dubuque, Iowa, USA., 293pp.
71. Salman, J.M., 2006. An Environmental Study of Possible Pollution in the Euphrates River between Al Hindiya Dam and Kufa City - Iraq. PhD thesis. College of Science - University of Babylon, Iraq.
72. Schulze, E.D., Beck, E. and Müller-Hohenstein K. 2005. Plant ecology. Berlin/Heidelberg: Springer, 702 pp.
73. Shannon, C.E. and Weaver, W. (1949) *The Mathematical Theory of Communication*. University of Illunois Press, Urbana.
74. Shehata, S.A. and Bader, S. A., 2010. Water quality changes in Nile cariar, Egypt. *The Journal of Applied Sciences Research*, 6 (9), 1457-1465.
75. Shraddha, R.V., Savita, D. and Praveen, J., 2011. Evolution of Water Quality of Normade River With Reference To Physiolopical Hoshangabad City. Mp. India Rea. Chemical Science, 1(3), 40: 48.
76. Sin, H.N., Yusof, S., Hamid, N.S.A. and Rahman, R.A. 2006. Optimization of hot water extraction for sapodilla juice using response surface methodology. Journal of Food Engineering 74, 352-358.
77. Suleiman, M.; Al-Salman, I.M. and Al-Saidi, M.A., 2009. Evaluation of some physicochemical and biological properties of the lakes of the Hamira Agricultural Project - Libya. The First International Conference on Biodiversity, November 26-28, Sebha University, Libya.
78. Taleb, A.H.; Hassan, F.M. and Saadoun, W.A., 2014. An ecological study of diatomaceous phytoplankton in Yusufiyah River, Iraq. Baghdad Journal of Science, 11(3), 1301-1326.
79. Wehr, J.D. and Sheath, R.G., 2003. *Freshwater Algae of North America: Ecology and Classification*. Academic Press, 918 pp.
80. Wetzel, R.G., 2001. *Limnology lake and river ecosystems*, 3rd ed., Academic Press, New York.
81. WHO, 2011. *Guidelines for Drinking-Water Quality*, 3rd ed. Incorporating first and second addenda, Vol, 1:210-220 Recommendation.(WSH) Geneva
82. Wilhm, J.L., 1975. Biological Indicators of Pollution. In: Whitton, B.A., Ed.. *River Ecology*. Blackwell Scientific Publication, Oxford, 375-402.
83. Yousry, M., El-Sherbini, A., Heikal, M. and Salem, T., 2009. Suitability of water quality status of Rosetta branch for west Delta water conservation and irrigation rehabilitation project. *Water Sciences*, 46, 47-60.
84. Zeidan, T.A., Abdel Rahman, I.A.K. and Saud, O.M., 2009. An environmental study of chemical and physical pollutants affecting the waters of the Euphrates River in Ramadi and Fallujah. Anbar University Journal, 3(3), 1-11.