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Impacts of the Physico-chemical Properties of Al-Chibayish Water Marshes on The Biodiversity of Phytoplankton

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Abstract

Phytoplankton, as one of the most important primary producers in aquatic ecosystems, has been widely used to indicate the health of ecosystems. Nine physico-chemical parameters of water, as well as the phytoplankton community, of Al-Chibayish marsh were studied. Samples were collected from four sites and analyzed every two months from January to October 2019.

Seasonal variations in physical and chemical properties were observed at all sites during the study period. The results indicated that 154 species of phytoplankton were recorded. The highest percentage of species was recorded to be 64.28% for Bacillariophyceae (diatoms) (Centrales 3.24% and Pennales 61.03%), followed by Chlorophyceae (16.23%), Cyanophyceae (11.68%), and Charophyceae and Euglenophyceae (3.24%), while Pyrrophyceae recorded the lowest value (1.29%) The numbers of phytoplankton species were 102, 94, 102, 99 in sites 1, 2, 3 and 4 ,respectively, during the study period. The total density of phytoplankton ranged from 223.769 cells x10^3 during January to 2784.693 cells x10^3 during September in site 2, with a clear increase during March and September, while the lowest number was 223.796 - 237.248 cells x10^3 in January and May, respectively. The dominance of diatoms was observed in all sites by 49.07% of the total density of phytoplankton, while the lowest abundance was 0.04% for the Pyrrophyceae. The results of the statistical analysis showed significant differences among sites and months, concerning the physical, chemical, and biological factors measured during the study period, at p-value <0.05.

Kewwords: phytoplankton, diatoms, physical and chemical properties of water, Al-Chibayish marshes.

تأثير الخواص الفيزيائية والكيميائية لمياه لأهوار ألجبايش على التنوع الحيوي للعوالق النباتية

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الخلاصه

تعد العوالق النباتية، باعتبارها واحدة من أهم المنتجين الأساسيين في النظم البيئية المائية ، على نطاق واسع وتعد دليل على صحة هذه النظم البيئية. تم دراسة 9 من الخصائص الفيز الخصائص الفيزيائية عوالق نباتية من هور الجبايش من 4 محطات خلال الدراسة الحالية. تم جمع عينات المياه وتحليلها كل شهرين من كانون الثاني إلى تشرين الاول 2019 لأربعة مواقع مختلفة في هور الجبايش. ولوحظت التغيرات الموسمية في الخصائص الفيزيائية والكيميائية في جميع المواقع خلال فترة الدراسة. وسجلت الدراسة 154 نوعًا من العوالق

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النباتية. أعلى نسبة من الأنواع تعود إلى Bacillariophyceae (diatoms) ‎%64,27 (centrales,‎ ‏٪3,24 , pennales ‎61,03 %‎) ، تليها Chlorophyceae ‎16,23 %‎ ، Cyanophyceae ‏11,68 %، بينما نسبة Charophyceae و Euglenophyceae ‎3,24 %‎ ، بينما سجلت Pyrrophyceae أقل نسبة ‎1.29٪‎. بلغ عدد أنواع العوالق النباتية 102 و 94 و 102 و 99 في المحطات 1 و 2 و 3 و 4 على التوالي.

تراوح إجمالي عدد العوالق النباتية بين (223.769) خلية ×10^3 خلال شهر كانون الثاني إلى (2784.693) خلية ×10^3 خلال شهر أيلول في المحطة (2) ، مع زيادة واضحة في إجمالي عدد العوالق النباتية خلال شهري آذار وأيلول ، بينما كان أقل عدد (223.796 – 237.248) خلية × 10^3 في كانون الثاني وأيار على التوالي. وقد لوحظ في هذه الدراسة أن انتشار الدياتومات في جميع المحطات وصل إلى ‏49.07٪ من إجمالي عدد العوالق النباتية ، بينما أقل وفرة كانت ‎0.04٪‎ في Pyrrophyceae. أظهرت نتائج التحليل الإحصائي وجود فروق ذات دلالة إحصائية بين المواقع والأشهر بالنسبة للعوامل الفيزيائية والكيميائية والبيولوجية التي تم قياسها خلال فترة الدراسة عند مستوى الاحتمال ‎P <0.05.

Introduction

The Iraqi Marshlands, or Mesopotamian Marshlands which are listed as one of the UNESCO World Heritage Sites, used to be the largest wetland ecosystem of Southwest Asia (20,000 km2) [1, 2]. The changes in environmental factors, such as temperature, salinity, amount of sunlight, and accessibility to specific nutrients, affect phytoplankton abundance and distribution [3]. Phytoplankton are important for monitoring water quality since it is the first group of organisms that respond to changes in nutrient conditions of the environment [4]. Diatoms have been usually used to detect changes in marshes water quality due to the specific sensitivity of this species to a wide range of ecological conditions, such as salinity, organic matter, nutrients, and pH [5, 6]. Generally, phytoplankton have an important role in quality assessment of the marsh and river bodies, as a significant indicator of water environment [7, 8]. High iron concentrations can cause metal binding to the cell wall, which could reduce growth by inhibiting nutrient uptake or by efflux pumping of metals at the plasma membrane [9]. The current study aimed to study phytoplankton distribution and some physico-chemical properties of water in four sites of Al-Chibayish marsh.

Materials and Methods

Water samples were collected from four sites (Figure 1) in Al-Chibayish marsh every two months beginning from January 2019 to October 2019. Sampling of phytoplankton was achieved using a phytoplankton net, with mesh size of 24 µm, which was thrown in the water and pulled in at an appropriate speed for 10-15 minutes. The phytoplankton samples were transferred into 5-liter polyethylene containers. The sedimentation method was used to count phytoplankton [10] using the Lugol's solution [11], while the diagnosis was performed based on related references [12, 13]. Water temperature was measured immediately in the field by a precise mercury thermometer (range 0 to 100 ºC). The values of turbidity, electrical conductivity (EC), total dissolved solids (TDS) and pH were measured by using HANNA Instrument HI-9811). The expression of results was in µS/cm unit for conductivity and mg/l for TDS [14], whereas turbidity was expressed with the Nephlometric Turbidity Unit (NTU). Salinity was determined by multiplication of EC values by $640*10^{-6}$ [15]. HANNA Instrument (HI-9146) was used to measure DO. Atomic Absorption spectrophotometer (Perkin Elmer 1100 B) was used for heavy metal (Fe) determination; Measurements were in mg/l and samples were tested as soon as possible [16].

Site description

The first site, located at longitude 38R 0692562 and latitude UTM 3432683, is affected by the quality of water coming from the Euphrates River in the case of high discharge. The second site is located in the middle of the central marshes in an area called AL-Baghdadi, characterized by an open and shallow water area, at longitude 38R 0693956 and latitude UTM 3436763. The third site is located in an area called Yishan Hallab, at longitude 38R 0694335 and latitude UTM 3441173, which receives water from Auda marsh. The fourth site is located near Abu Zarag marsh, with a shallow water area at longitude 38R 0690358 and latitude UTM 3436791. The Statistical Analysis System-SAS [17] program was used to analyze the effects of different factors on the study parameters. Least significant difference (LSD) test was used to compare between values in this study (P<0.05).

Figure 1-Sampling sites in Al-Chibayish marsh in southern Iraq (Google earth)

Results and discussion:

1- Air and water temperature: Air temperature ranged from 17.5°C in site 4 during January to 38°C in site 2 during July (Table-1)**.** The value of water temperature ranged from 12.1°C in site 4 during January to 34.5°C in site 3 during July (Table-2).

Table 1-Air temperature in °C of the studied sites

Months	S1	S2	S3	S4	LSD value
January	18.2	19.0	18.0	17.5	2.62 NS
March	26.7	24.2	26.5	25.0	2.49 NS
May	34.5	35.6	35.0	32.7	2.95 NS
July	36.5	38	37.2	37.0	2.73 NS
September	35.3	36.0	36.5	35.5	2,.73 NS
October	34.2	33.2	34.6	33.0	1.98 NS
LSD value	5.69 *	5.38 *	6.02 *	5.85 *	---

* ($P<0.05$), NS: Non-Significant.

Table 2-Water temperature in °C of the studied sites

Months	S1	S2	S3	S4	LSD value
January	13.5	14.0	12.8	12.1	2.37 NS
March	23.5	24	22	23	1.96 NS
May	25.3	23.6	24	25	2.55 NS
July	32.6	33	34.5	33.5	3.41 *
September	31	31.5	33	32.1	2.18 NS
October	28.5	27.6	30.2	29.3	2.81 NS
LSD value	4.97 *	5.61 *	5.77 *	5.63 *	---

The seasonal variations in air and water temperature were clear in the studied sites during the study period. Whereas the highest temperature was during summer season, the lowest was at winter. Many researchers confirmed these results, indicating that water temperature follows air temperature in many marshes and water bodies [18, 19]. Significant differences in water and air temperature ($P<0.05$) were recorded during these periods at all sites.

2- The pH values ranged from 7.42 in site 3 during January and 8.09 in site 2 during May. These results are consistent with previous reports of the slight alkalinity of the southern Iraq marshes [20]. The alkaline characteristic of Iraqi waters is mainly due to the availability of calcium carbonate [21], as well as the limestone nature of the marsh deposits and the nature of soil [22]. There were no significant differences (P<0.05) in pH during the study period at all sites (Table-3).

Table 3-pH of Sites

Months	S1	S2	S3	S4	LSD value
January	7.49	7.63	7.42	7.56	0.427 NS
March	7.56	7.93	7.69	7.48	0.531 NS
May	7.63	8.09	7.85	7.7	0.502 NS
July	8.0	7.9	7.8	8.0	0.335 NS
September	7.55	7.88	7.76	7.69	0.402 NS
October	7.5	7.7	7.9	7.7	0.561 NS
LSD value	0.663 NS	0.591 NS	0.507 NS	0.601 NS	---

3- Electrical conductivity, salinity and total dissolved salts

The highest value of EC was 17700 µ.s/cm, recorded in site 3 during July (summer), while the lowest value was 3050 µ.s/cm, recorded in site 1 during October (autumn) (Table-4)

Table 4-E.C µS/cm of Sites

Months	S1	S2	S3	S4	LSD value
January	3960	4300	5680	8180	348.52 *
March	5550	9150	8910	4840	271.09 *
May	3140	8030	9910	7930	249.54 *
July	5600	14200	17700	7700	384.92 *
September	3910	5160	3860	3810	277.35 *
October	3050	3970	7310	3660	296.03 *
LSD value	198.45 *	239.06 *	215.84 *	251.37 *	---

The present study showed variances in water salinity values which ranged from 2‰ in site 1 during October to 11.2‰ in site 3 during July (Table-5).

Table 5-Salinity mg/l of Sites

Months	S1	S2	S3	S4	LSD value
January	2.5	2.7	3.6	5.2	2.42 *
March	3.5	5.8	5.7	3	2.51 *
May	8.5	5.1	6.3	5	2.77 *
July	3.2	8.1	11.2	4.1	3.49 *
September	2.5	3.3	2.4	2.4	1.85 NS
October	2.0	2.5	4.6	2.3	2.48 *
LSD value	2.79 *	2.66 *	3.05 *	2.83 *	---

TDS is a determinant of the growth and propagation of phytoplankton [23]. TDS values ranged from 1570 mg/l in site 1 during October to 9860 mg/l in site 3 during July.

Table 6-TDS mg/l of Sites

Months	S1	S2	S3	S4	LSD value
January	2492	2650	3585	5082	162.53 *
March	3350	5560	5320	2810	170.19 *
May	1915	5112	6321	5030	198.30 *
July	3534	8720	9860	4865	327.53 *
September	2450	3250	2420	2395	161.25 *
October	1570	1990	3630	1830	175.08 *
LSD value	173.46 *	217.02 *	185.42 *	191.56 *	---

Significant differences (P<0.05) in the values of EC, salinity, and TDS were recorded in all sites during the study period. An earlier work [24] revealed that Iraqi marshes water is brackish. An

extremely high value (21.45 ‰) was recorded in Al-Hammar marshes [25], whereas another study in the same marsh reported a value of 6.33 ‰ [26].
An extremely high value of salinity (11.2 %) was recorded in site 3 during July. The main reason for this result is the salty water input to the marshes from the draining channels and dry areas. It was reported that water discharging rate of 190 m^3/s during May 2019 caused a maximum restoration rate of Al-Chibayish marshes since 2003, that reached to 79.4% from the total central marsh area [27]. The highest salinity value in site 3 was decreased from 11.2% during July to 4.6% during October in the same site. Besides, water discharge increased from 48.64 m^3/s in November 2018 to 220.25 m^3/s in April 2019, then dropped from 111 m^3/s in October to 65 m^3/s in November 2019. This difference in quantities of water supplied to the marshes led to a washing process with a wide difference in the values of salinity range during the study period [27]. However, under normal marsh conditions, the highest salinity values were recorded during summer, which was caused by a decrease in water levels and an increase in evaporation rate [28]. Additionally, the marsh has been subjected to years of drying that led to an increase in the precipitation of salts in sediments [29]. The results of this study are supported by those of an earlier study [30].
4- Water turbidity ranged from 2.8– 20.2 NTU, where the lowest value was 2.8 NTU in site 2 during July, while the highest value was 20.2 NTU in site 4 during January. There were significant differences (P<0.05) among turbidity values recorded in all sites during the study period (Table-7).

Table 7-Turbidity NTU of Sites

Months	S1	S2	S3	S4	LSD value
January	4	12.36	7.29	20.2	3.29 *
March	4.8	6.2	15.8	12.3	2.95 *
May	8.5	19.7	13	16.5	3.44 *
July	7.82	2. 8	7.73	9.2	3.17 *
September	4.9	7.5	5.8	3.6	2.96 *
October	3.88	3.2	11.38	19.0	3.81 *
LSD value	2.86 *	3.28 *	3.07 *	3.55 *	----

In addition, the lowest turbidity values were in July, due to the dropped discharge flow of water from 87 m^3/s in June to 77 m^3/s in July [27]. Therefore, the marshes become more stagnant and shallow, as supported by previous studies [31, 18, 32]. Also, turbidity values were reported to increase in winter and decrease in summer [33, 34].
5- Dissolved oxygen (DO) is one of the most important factors for all living organism [35]. The maximum DO value (6.9 mg/l) was recorded in January at a site 1, while the minimum value (2.32 mg/l) was detected in September at the same site. The increase in air velocity causes a higher rate of gas exchange between air and surface water, leading to an increase in rainfall. The quantities of water flow were reported to increase to 105.79 m^3/s in January, with the decrease in water temperature, thus leading to an increase of DO concentrations in water [36, 37]. The results showed significant differences (P<0.05) in DO values among study sites, as shown in Table-8.

Table 8-D.O mg/l of sites

Months	S1	S2	S3	S4	LSD value
January	6.90	3.90	4.50	3.10	2.75 *
March	6.5	3.82	3.51	4	2.81 *
May	6.0	4.5	5.0	5.5	1.73 NS
July	4.3	3.23	4.39	4.81	1.88 NS
September	2.32	3.36	3.68	4.60	2.39 *
October	3.15	4.92	3.5	2.52	2.41 *
LSD value	2.69 *	1.87 NS	1.92 NS	2.88 *	---

6- The concentrations of iron ranged from 0.01 mg/l in sites 1 and 2 during May to 2.10 mg/l in site 3 during October, with the highest values being recorded during October in all sites (0.852, 0.680, 2.10, 1.995 mg/l) , as shown in Table-9.

Table 9-Fe mg/l of Sites

Months Fe	S1	S2	S3	S4	LSD value
January	0.800	0.055	0.193	0.037	0.239 *
March	0.140	0.440	0.280	0.260	0.198 *
May	0.010	0.010	0.013	0.170	0.094 *
July	0.273	0.186	0.114	0.122	0.098 *
September	0.020	0.017	0.080	0.014	0.0546 *
October	0.852	0.680	2.10	1.995	0.308 *
LSD value	0.241 *	0.207 *	0.572 *	0.463 *	---

In addition, site 1 recorded 0.800 mg/l in January, whereas slightly higher values 0.440 mg/l were recorded in site 2 in May. Fe concentrations in all other sites did not exceed the allowable limits (0.3 mg/l) set by the Iraqi law standards for water sources [38], except the values recorded in October. The results showed significant differences in Fe concentrations during the seasons in all sites (Table-9). The high values of Fe in site 3 may be due to the discharge of wastewater from human and industrial activities in the Tigers River. The discharge water inters Al-Auda marsh and finally reaches to Al-Chibayish marsh near site 3, as shown in Figure-1. Another reason could be the increased water flow from 95 m^3/s in September to 111 m^3/s (70.35 m^3/s from Euphrates River) in October [27], which is a high discharge that might increase iron concentration in Al-Chibayish marsh.
7.1. Qualitative study of phytoplankton: A total of 154 taxa of phytoplankton were classified into six divisions of Bacillariophyceae, Chlorophyceae, Cyanophycean, Euglenophyceae, Carophytceae, and Pyrrophyceae, respectively. Among these, 59 genera were found in all of the four sites during the study period (Table-10). The present study agrees with studies conducted on Tigris River which identified 98 species [39] and 107 species of algae [40], along with another report that identified 123 species on Alwand River [41]. Generally, Bacillariophyceae had a higher relative abundance at all sites (99 taxa; 64.28%), of which 5 taxa (3.24%) belonged to Centrales 94 taxa (61.03%) to Pennales. In addition, 25 taxa (16.23 %) of the total species belonged to Chlorophyceae and, 18 taxa (11.68% .) to Cyanophyceae. Only 5 species (3.24%) were identified as Charophyceae and Euglenophyceae, whereas two taxa (1.29%) belonged to Pyrrophyceae. Diatoms showed complete dominance over phytoplankton groups, which is consistent with previous results [39] (Table-10, Figure-1).

Table 10-Numbers and percentage of phytoplankton species in the studied sites

Sites		**Total**	
Phytoplankton Class	**SP.**	**G.**	**Ratio of species (%)**
Chlorophyceae	**25**	**16**	**16.23**
Cyanophyceae	**18**	**7**	**11.68**
Charophyceae	**5**	**3**	**3.24**
Euglenophyceae	**5**	**2**	**3.24**
Pyrrophyceae	**2**	**2**	**1.29**
Bacillariophyceae	**99**	**29**	**64.28**
Order Centrales	**5**	**3**	**3.24**
Order Pennales	**94**	**26**	**61.03**
Total	**154**	**59**	**100%**

The genus *Oscillatoria* (Cyanophyceae) was represented by 8 species in all of the studied sites (5, 6, 5, and 5 species in the sites 1, 2, 3 and 4, respectively), while *Scenedesmus* (Chlorophyceae) was represented by 3 species. Species which were observed during the entire period in all sites were *Chlorella vulgaris* Bejerinck, *Chlamydomonas sp., Euglena sp., Phacus sp., Cyclotella meneghiniana keutzing, Achnanthes exigua Grun, Amphora coffeaeformis (Kützing), Diploneis ovalis (Hilse) Cleve, Nitzschia palea (Ktz.) W.Smith, Navicula specula (Hickie) Cleve, Pinnularia lundii Kustedt*, and *Synedra acus Kuetzing***.**

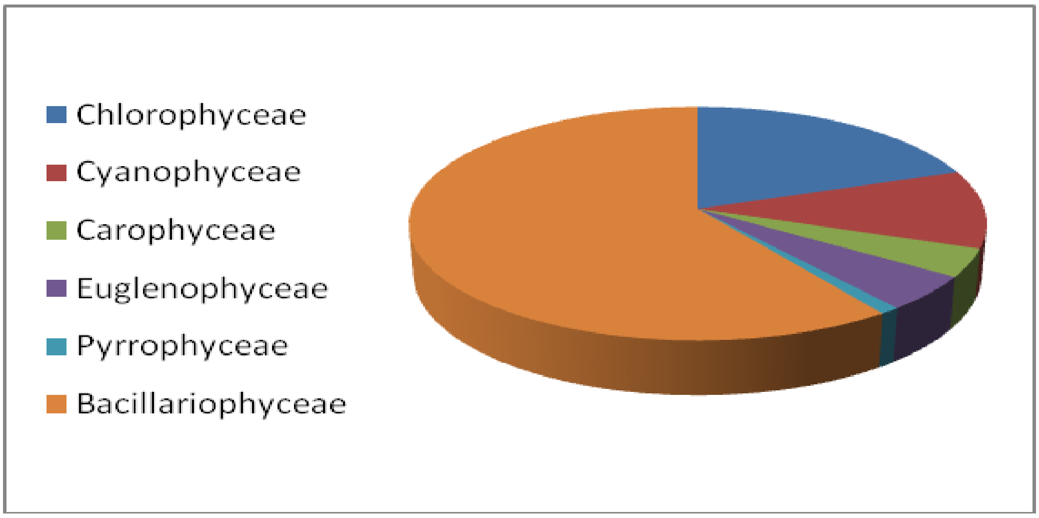

Figure 1-Percentages of phytoplankton classes in all sites according to their total number of species**.**

7.2 Phytoplankton total density

Phytoplankton total count was measured during the study period and ranged from the lowest value of 223.796 cellx10^3/l in site 2 during January 2019 to the highest value of 2784.693 cellx10^3/l recorded in the same site during September 2019, as shown in Figure-2.

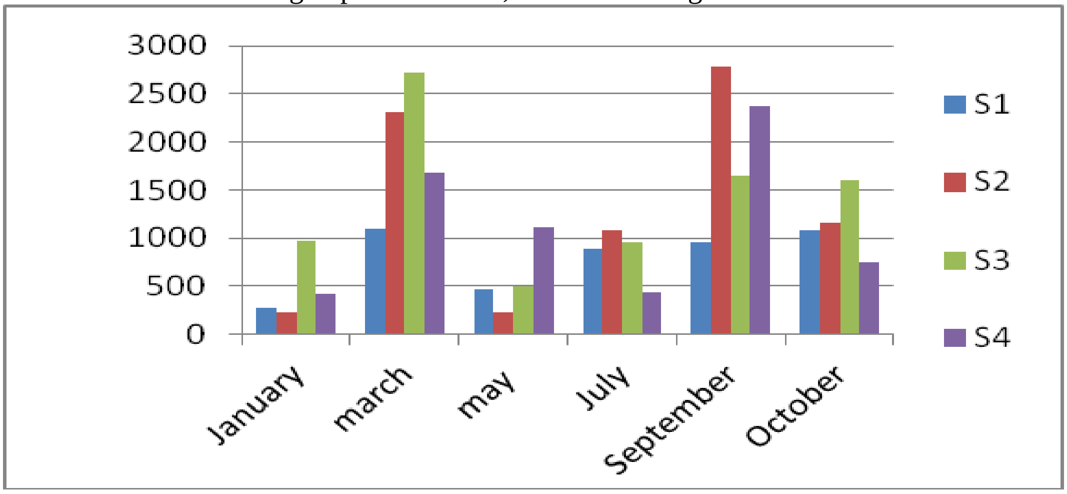

Figure 2-Monthly variations in phytoplankton total density in the studied sites**.**

The highest density of non-diatoms algae reached 2194.803 cellX10^3/l during September in site 3, while the lowest density was 51.948 cellx10^3/ l during May in sites 1, 2, and 3, as show in Figure-3.

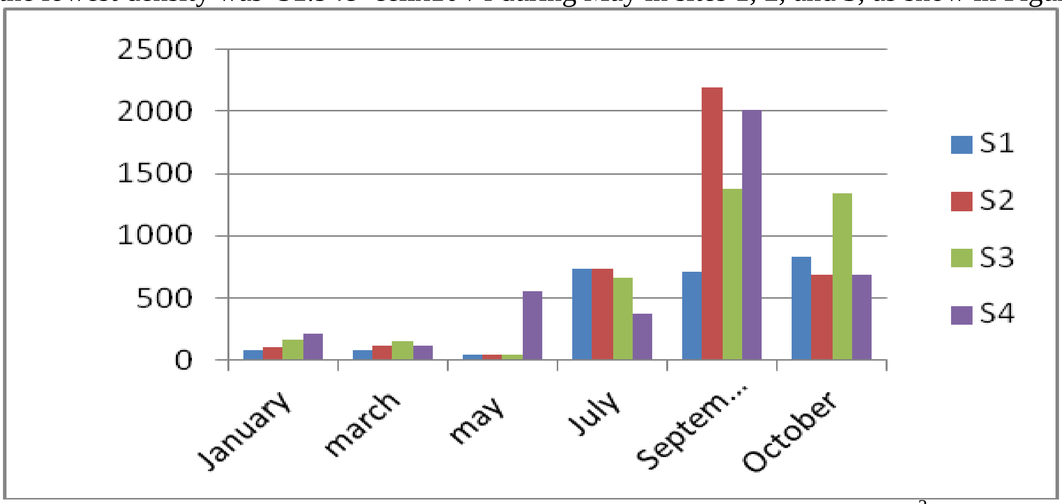

Figure 3-Density of non diatoms algae during study periods (cell x 10^3/ l).

The highest density of diatoms was 2563.68 cell x10^3/ l in site 3 during March, while the lowest was 57.54 cellx10^3/l in site 4 during October, as shown in Figure-4.

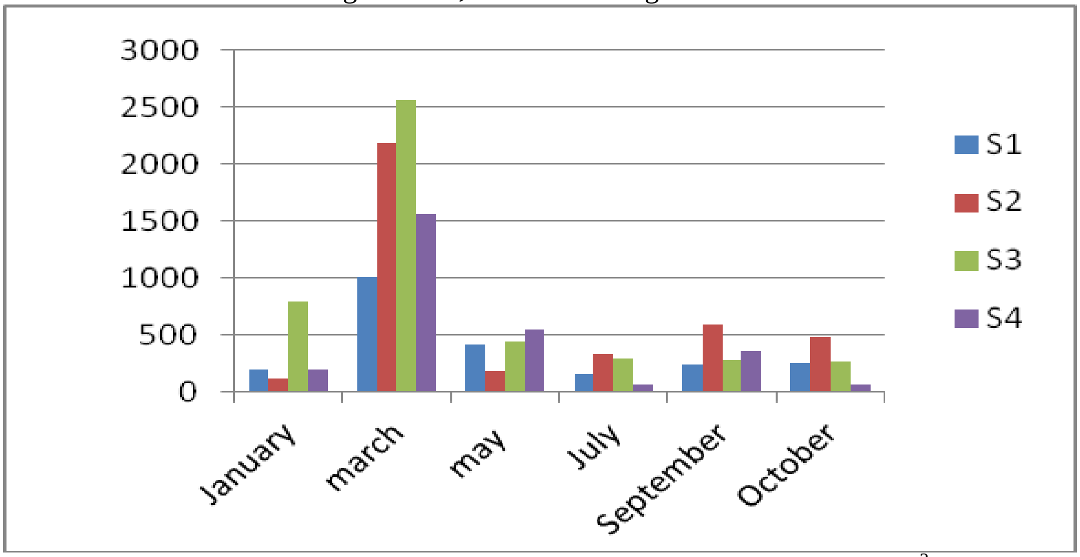

Figure 4-Density of diatoms algae during all study periods (cell x 10^3/ l).

Seasonal variations showed that the highest density of phytoplankton was obtained during autumn (September) and spring (March), while the lower densities were observed in autumn (October) and winter (January) 2019, as shown in Figure-2. The results showed that the differences in temperature might be associated with the variation in phytoplankton growth and biomass [42,43]. These results agree with previous studies conducted by several researchers who noticed that the total count of phytoplankton increases in summer and spring [44-46]. However, the results disagree with other reports [47,48] which found that the total count of phytoplankton increases in autumn and spring. Diatoms were the dominant groups, represented by 49.07% of the total cells count throughout the study period, as shown in Figure-4, while Pyrrophyceae was the lowest group with0.04%. These findings agree with previous studies which recorded that diatoms was the dominant group observed in Iraqi water bodies [49,50]. Site 3 recorded the highest percentage in phytoplankton total density (30.29 %) during the study period, while site 2 had 28.09% of the total density. Sites 1 and 4 recorded 17.02 and 24.41% of phytoplankton total density, respectively. The results showed that site 3, during March, had the highest total density of Centrales (340.12 cell x10^3/l) with a percentage of14.89 %. (Figure-5), while no density of Centrales was observed in site 1 during January and July.

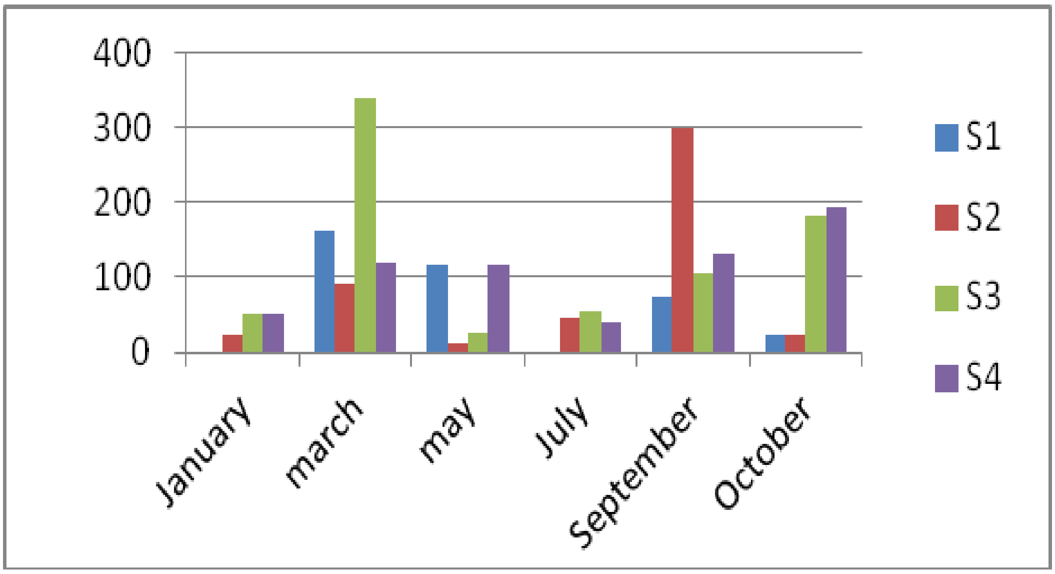

Figure 5-Density of Centrales in all sites.

The results also showed that site 3 had the highest total count of Pennales (2079.98 cell x10^3/l; 17.58%) during March, while the lowest was 26.16 cellx10^3/l in site 4 during July, as shown in Figure-6.

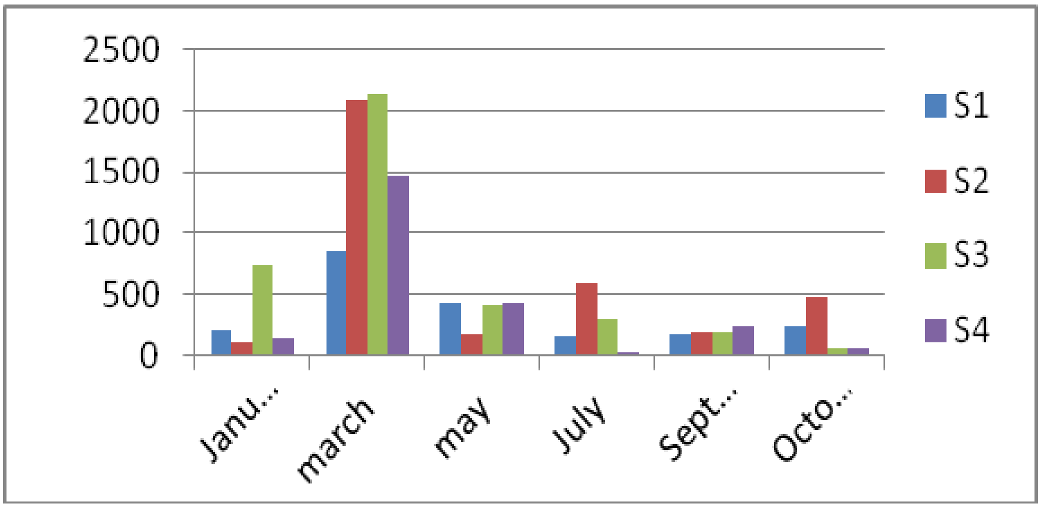

Figure 6-Density of Pennales in all sites.

The results showed that the sites 2 and 4 had the highest total counts of Chlorophyceae (1597.4 and 1610.38 cellx10^3/l, respectively) during September, while the lowest value was 0 in site 1 during May (Figure-7).

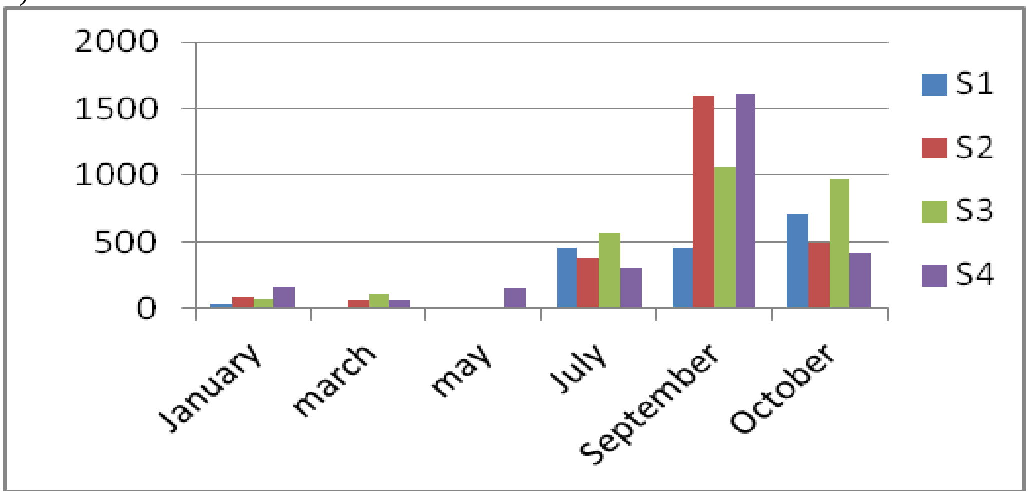

Figure 7-Density of Chlorophyceae in all sites

The results showed that site 2 had the highest total count of Cyanophyceae (558.44 cell x10^3/l, 25.59%), while the value was dropped to 0 in all sites during March (Figure-8).

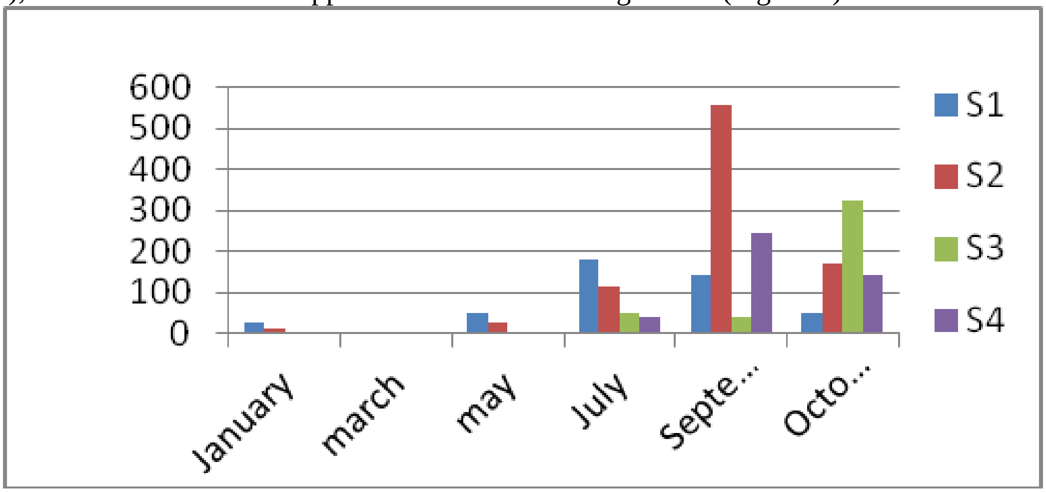

Figure 8-Density of Cyanophyceae in all sites**.**

The results showed that site 4 had the highest total count of Euglenophyceae (402.59 cellx10^3/l) during May, with highest species density (311.688 cellx10^3/l) to *Euglena polymorpha Dangeread*, was and lowest value of 0 in sites 1 ,2 and 4 during January (Figure-9).

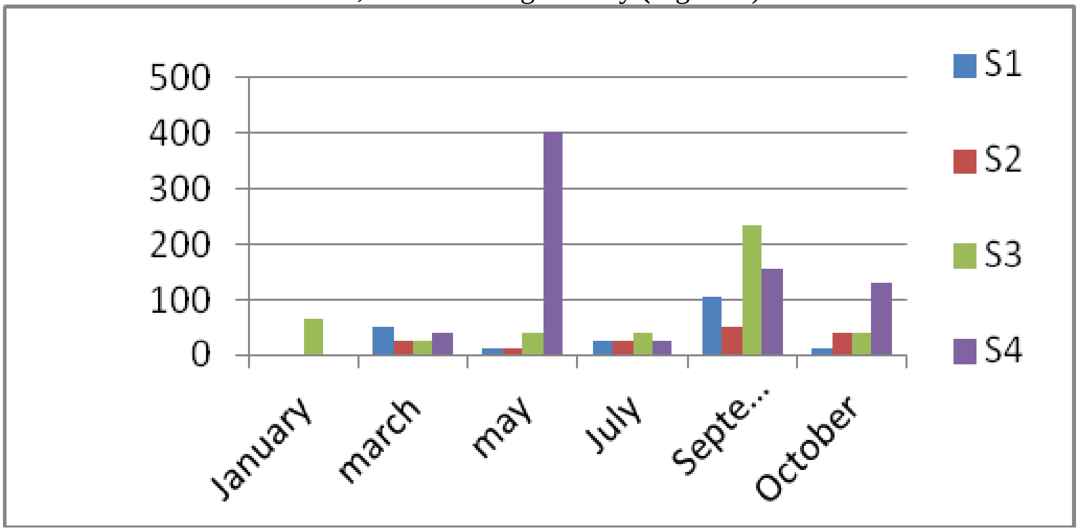

Figure 9-Density of Euglenophyceae in all sites

Phytoplankton species tend to grow during spring, summer, and early autumn with the increase of water temperature and nutrients availability reported in warm regions [51,52]. The current study agree with previous reports [53, 40, 28]. The studied sites are characterized by observing many species, such as *Cyclotella meneghiniana* , *Nitzschia palea* , *Nitzschia frustulum*, *Nitzschia romana*, and *Synedra acus*, with highest population density (2029.87 , 1656.983, 780.11, 1046.99, and 1165.35 cell x 10^3/l, respectivily) in all sites during the study period. *A. minutissima* was recorded at higher densities 1569.6 cellx10^3/l in site 2 during March, which is consistent with previously reported results [54]. An earlier work[55] found that the maximum density of *C. meneghiniana* occurs at 25°C in laboratory conditions. The present study showed that some species represnted pollution indicators in the marshes, such as *Oscillatoria sp* , *Lyngbya sp* and *Euglena sp*. These finding are in agreement with those reported earlier [56], which noticed that the numbers of these species of phytoplankton are increased in regions with wastwater dirctly discharged to water bodies. In addition, population density of *Euglena polymorpha* had a highest cell count of 311,688 cell x 10^3/l in May, despite high salinity value.

There was a clear effect of temperature on distribution and density of phytoplankton; the lowest total density of non-diatoms was 467.883 cell x 10^3/l in all sites during March, at temperature of 22-24 ˚C, while the highest total density was 6298.695 cell x 10^3/l in all sites during September, at highest temperature of 33-31 ˚C (Figure-3, Table-1). Conversely, for diatoms, the highest density was 7,320.44 cell x 10^3/ l in March (4) for all sites at a temperature ranged 22-24 C˚, while the lowest density of diatoms was 846.2 cell x 10^3/l during July for all sites, at a temperature of 34.5-32.6.5 ˚ C (Table-1).

The high concentration of iron (2.1 mg/l) in site 3 during October led to an increase in the density of Cyanophyta algae (324.67 cell x 10^3/l) in the same site. This density was the highest value compared with other sites in October, as shown in Figure-8. Higher iron requirements for certain species can also induce community changes, such as those occurring in phytoplankton communities, where higher iron values cause a shift towards N-fixing Cyanophyta species over green algae [57,58]. In this case, iron levels change and the species with higher iron requirements, such as Cyanophyta, could grow faster, resulting in a change in phytoplankton dominance [57, 58]. The results showed a significant difference in Fe concentration during all seasons in all sites (Table-9).

The quantitative study of phytoplankton density show the high impacts of salinity and TDS values on the density of Cyanophyta; when TDS values ranged from 5560 to 2810 mg/l (Table-6) , the density became 0 in all sites during March, whereas only one species of Cyanophyta (*Chroococcus sp.*) was recorded in sites 1 and 4. High salinity values affect phytoplankton growth by inhibiting nutrient uptake or by efflux pumping of metals at the plasma membrane [9].

The fluctuation of phytoplankton species over the study period is attributed various conditions, such as grazing, resource limitation, habitat disturbance, availability of substrates, control of biomass and growth of phytoplankton, and effects of parasitism [59]. Also, water currents in this marsh were very slow (almost stagnant), so that the sediment had a better chance to absorb more nutrients, leading to increased diversity [60]. During summer, higher temperatures and water evaporation are factors that lead to decreased biomass of phytoplankton populations [61].

Conclusions

There were significant variations between values of the chemical and physical parameters of all sites and seasons in Al-Chibayish marsh during this study**.** Water temperature had a clear influence on the abundance and growth of phytoplankton; the highest density of diatoms algae was recorded in March, while the non- diatoms algae had the lowest density in the same period. However, the opposite trend of algae distribution occurred during September. The highest salinity value was recorded during May and July, due to the washing of dry marsh areas with the beginning of the flood stream in mid-April of 2019. High salinity values negatively affected in the diversity and abundance of phytoplankton, especially in the third site during May and July. The high concentration of iron in site 3 during October caused an increase in the density of Cyanophyta algae, which was the highest value compared with other sites in October**.**

The amount of water that discharge from the inlet and outlet of marshes must be controlled to maintain a good circulation of water, leading to the preservation of diversity and abundance of phytoplankton and other ecosystem organisms. This can be achieved by discharging the water flow from Al-Chibyaish marsh through the Euphrates River and then to the Shatt al-Arab. Nevertheless, a regular water outlet can lead to increased concentration of salts and heavy metals increased water temperature and decreased dissolved oxygen, which affects negatively the ecosystem of the marsh.

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