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

Firas AbdulHassan Jaafar, Ahmed Saad Abdulwahhab*
Department of Biology, College of Science, University of Baghdad, Baghdad, Iraq

Received: 5/5/2020 Accepted: 15/6/2020

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 Pyrophyceae 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 \( \times 10^3 \) during January to 2784.693 cells \( \times 10^3 \) during September in site 2, with a clear increase during March and September, while the lowest number was 223.796 - 237.248 cells \( \times 10^3 \) 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 Pyrophyceae. 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.

Keywords: phytoplankton, diatoms, physical and chemical properties of water, Al-Chibayish marshes.
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 °C). 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 Nephelometric 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-Baghadi, 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).
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).

| 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.

| 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).

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
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 m3/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 m3/s in November 2018 to 220.25 m3/s in April 2019, then dropped from 111 m3/s in October to 65 m3/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 | 11.38 | 3.6  | 2.96 *    |
| October | 3.88 | 3.2 | 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 m3/s in June to 77 m3/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 m3/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  | 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 enters 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 m³/s in September to 111 m³/s (70.35 m³/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, Carophyceae, and Pyrophyceae, respectively. Among these, 59 genera were found in all of the four districts 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 Pyrophyceae. Diatoms showed complete dominance over phytoplankton groups, which is consistent with previous results [39] (Table-10, Figure-1).

| 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                 |
| Pyrophyceae         | 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 Beijerinck, Chlamydomonas sp., Euglena sp., Phacus sp., Cyclotella meneghiniana keutzinger, 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.
7.2 Phytoplankton total density

Phytoplankton total count was measured during the study period and ranged from the lowest value of 223.796 cellx$10^3$/l in site 2 during January 2019 to the highest value of 2784.693 cellx$10^3$/l recorded in the same site during September 2019, as shown in Figure-2.

![Figure 2](image2.png)

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

The highest density of non-diatoms algae reached 2194.803 cellX$10^3$/l during September in site 3, while the lowest density was 51.948 cellX$10^3$/l during May in sites 1, 2, and 3, as show in Figure-3.

![Figure 3](image3.png)

**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 cell x10^3/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 with 0.04%. 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 of 14.89 %. (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 x 10^3/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.](image)

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](image)

The results showed that site 2 had the highest total count of Cyanophyceae (558.44 cell x 10^3/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.](image)
The results showed that site 4 had the highest total count of Euglenophyceae (402.59 cellx10^3/l) during May, with the 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 agrees 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, respectively) 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 represented 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 wastewater directly 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 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-Chibayaish 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.

Acknowledgements
This work was carried out with the support of the Department of Biology and all the staff members of the department. Special thanks to the Director and staff of CRIM (Center of the Restoration of Iraqi Marshland) for accomplishing this work.

References
1. Richardson, C. J. and Husain, N.A. 2006. Restoration the Garden of Eden: an ecological assessment of the Marshes of Iraq. BioSci, 56(6): 477-489.
2. AlMaarofi, S. S., Douabul, A. A., Warner, B. G. and Taylor, W. D. 2014. Phosphorus and nitrogen budgets of the Al-Hawizh marshland after re-flooding. Hydrobiologia, 721(1): 155-164.
3. Marshall, H.G. 2009. Phytoplankton of the York River. J. Coast. Res. 2009, 57: 59-65. [CrossRef]
4. Mitra, A., K. Banerjee, and A. Gangopadhyay. 2004. Introduction to Marine Plankton, 102. New Delhi: Daya Publishing House.
5. Van Dam H, Mertens A, Sinkeldam J. 1994. A coded checklist and ecological indicator values of freshwater diatoms from The Netherlands. Neth J Aquatic Ecol, 28: 117–133.
6. Kelly, M. G. and Whitton, B. A. 1995. The trophic diatom index: a new index for monitoring eutrophication in rivers. Journal of applied phycology, 7(4): 433-444.
7. Bergström, A. K. (2010). The use of TN: TP and DIN: TP ratios as indicators for phytoplankton nutrient limitation in oligotrophic lakes affected by N deposition. Aquatic Sciences, 72(3): 277-281.
8. Florescu H M, Cimpean M, Momeu L, Leonte L, Bodea D, Battes KP. Ecological analyses on benthic diatom and invertebrate communities from the Someșul Mic catchment area (Transylvania, Romania). Studia Universitatis Babes Bolyai, Biologia. 2015; 60(1): 69-87.
9. Spijkerman, E. 2007. Phosphorus acquisition by Chlamydomonas acidophila under autotrophic and osmo-mixotrophic growth conditions. Journal of experimental botany, 58(15-16): 4195-4202.
10. Furet, J. E. and Benson-Evans, K. 1982. An evaluation of the time required to obtain complete sedimentation of fixed algal particles prior to enumeration. British Phycological Journal, 17(3): 253-258.
11. Lind, O.T. 1979. Handbook of common methods in limnology C.V. Mosby, St Louis .199 pp.
12. Pentecost, A. 1984. Introduction to freshwater algae. Richmond Pub.
13. Bellinger, E. G. and Sigee, D. C. 2010. Introduction to freshwater algae. Freshwater algae: Identification and use as bioindicators, 1-40.
14. Apha, AWWA.WPCF. 1985. Standard methods for the examination of water and wastewater, 16, 445-446.
15. Richards, L. A. 1954. *Diagnosis and improvement of saline and alkali soils*. Handbook, No. 60, Washington, DC.
16. APHA (American Public Health Association). 1998. *Standard methods for the examination of water and waste water*, 20th Ed. American Public Health Association, Washington, DC.
17. SAS. 2012. *Statistical Analysis System*, User’s Guide. Statistical. Version 9.1th ed. SAS.Inst. Inc. Cary, N.C. USA.
18. Al-Kenzawi, M. A. H. 2007. Ecological Study of Aquatic Macrophytes in the Central Part of the Marshes of Southern Iraq, MSc Thesis, College of Science for Women, Biology Department, University of Baghdad, Iraq.
19. Gemayelah, Wuthij Akili Al-Rikabi, & Abdul Rahman Abdul Jabbar Al-Kubaisi 2014. A study of the physical and chemical properties of the central marsh waters in southern Iraq after rehabilitation. *Baghdad Journal of Science*, 11(2 special issue of the second women's conference): 991-998.(In Arabic)
20. Hinton, G.C.F. and Maulood, B.K. 1980. Some Diatoms from Brakish water Habitats in Southern Iraq. *Nova Hedwigia*, 33: 475-486.
21. Brown, A.L. 1980. *Ecology of fresh water*. Heinemann Educational Books Ltd.
22. Antoine, S. E. 1983. Limnological investigation in the polluted Rabat Canal and Shatt Al-Arab River, Basrah, Iraq. *Nova Hedwigia*, 38: 497-518.
23. Potapova, M. and Charles, D. F. 2003. Distribution of benthic diatoms in US rivers in relation to conductivity and ionic composition. *Freshwater biology*, 48(8): 1311-1328.
24. Maulood, B.K. and Hinton, G.C.F. 1979. Tycho planktonic diatoms from a stenothermal spring in Iraqi Kurdistan. *Br. PhyC. J.*, 14: 175-183.
25. Al-Zubaidy, A.M. 1985. Ecological study for algae (for phytoplankton) in some marsh area west of Qurna in south Iraq. M.S.C. Thesis. College of Science, University of Basrah. 235P.
26. Al-Rekabi, H.Y. 1992. Ecological and physiological study on some aquatic plants in Al-Hammar marsh. M.Sc. Thesis, University of Basrah.
27. CRIM (Center of Restoration of the Iraq Marshland). 2019. Report of the water quality of southern Iraqi marshes.
28. Al-Sarraf, M.A. 2006. Ecological and Taxanomical Study for Phytoplankton in Al-Adaim and Diyala Tributaries and their Effects on Tigris River. PhD Thesis Baghdad University. College of Science for women. (In Arabic)
29. Al-Abbawy, D. A. H. 2009. Qualitative, Quantitative and Ecological Study of Aquatic Macrophytes in Southern Iraqi Marshes During 2006 And 2007. Ph. D. Thesis. University of Basrah. Iraq. 205 p.
30. Salman, J. M., Hadi, S. H., & Mutaer, A. A. 2013. Spatial and temporal distribution of phytoplankton and some related physical and chemical properties in Al-Abasia river (Euphrates), Iraq. *International Journal of Geology, Earth & Environmental Sciences*, 3(3): 155-169.
31. Squires, M. M., Lesack, L. F. W. and Huebert, D. 2002. The influence of water transparency on the distribution and abundance of macrophytes among lakes of the Mackenzie Delta, Western Canadian Arctic. *Freshwater Biology*, 47(11): 2123-2135.
32. Al-Musawi, T. J. K. 2009. Water quality of quality of Al-Hammar marsh south Iraq. *Journal of Engineering*, 15(3): 3999-4008p.
33. Wetzel R G. 2001. Limnology, lake and river ecosystems. 3th Ed. Academic Press, An Elsevier Science imprint, San Francisco, New York, London, 2001, 729.
34. Al-Mousawi A H, Al-Saadi H A and Hassan F M. 1994. *Bas J Sci.*, 12(1): 9.
35. EPA (Environmental Protection Agency). 2013. Domestic wastewater treatment systems, Ireland. www.epa.ie/whatweado/advice/wastewater
36. Hussain, N. A. and Taher, M. A. 2007. Effect of daily variations, diurnal fluctuations and tidal stage on water parameters of East Hammar marshland, Southern IRAQ. *Marsh Bulletin*, 2(1): 32-42p.
37. Al-Kenzawi, M. A. H. ; Al-Haidary, M. J. S. ; Talib, A. H. and Karomi, M. F. 2011. Environmental Study of Some Water Characteristics at Um-Al-Naaj Marsh, South of Iraq. *Baghdad Science Journal*, 8(1): 531-538 p.
38. Law 25, 1967. Rivers Maintaining System and General Water from Pollution No 25, 1967, No. 25 of 1967, Iraqi Official Gazette, 1446(16): July 1967, p. 108, Vol. 2
39. Al-Saadi, H. A., Kassim, T. I., Al-Lami, A. A., & Salman, S. K. 2000. Spatial and seasonal variations of phytoplankton populations in the upper region of the Euphrates River. *Iraq. Limnologica-Ecology and Management of Inland Waters*, 30(1): 83-90.

40. Farkha, T. K. J. 2006. *A study of distribution of phytoplankton and aquatic fungi in the loti water in Baghdad district and the effect of environmental factors* (Doctoral dissertation, Ph. D. Thesis. College of science, Al-Mustansiriya University in Botany).

41. Ismail, A. M. and Hassan, F. H. 2007. Seasonal Variations of the Phytoplankton in Alwind River-Iraq. *Iraq Journal of Aquatic Research*, 2: 89-99.

42. Lau, S. S. S. and Lane, S. N. 2002. Biological and Chemical Factors Influencing Shallow Lake Eutrophication: a long-term study. *J. Sci. Total Envir.* 288: 167-181.

43. Peterson, C.G. and Stevenson R.J. 1989. Seasonality in River Phytoplankton: Multivariate Analyses of Data from the Ohio River and Six Kentucky Tributaries. *Hydrobiologia*, 182(2): 99-114.

44. Al-Lami, A. A.; Kassim, T.I and Al-Dulymi, A.A. 1999. A limnological study on Tigris River, *Iraq. Sci. J. I.A.E.C*. 1: 83-97.

45. Kassim, T.I., Sabri A.W. and Salman, S.K. 2005. The Effect of River Lesser-Zab on the Phytoplankton of River Tigris, *Iraq. Dirasat, Pure Scie.*, 32(1): 69-79.

46. Kassim, T.I, H.; Al-Saadi, H.A.; Farhan, R.K. 2006. Vertical Distribution of Phytoplankton in Habbaniya Lake, *Iraq. Marsh Bulletin*, 1(1): 19-31.

47. Kassim, T. I., Sabri, A. W., Al-Lami, A. A. and Abood, S. M. 1996. The impact of Sewage treatment plant on phytoplankton of Diyala and Tigris River, *J. Environ. Sci. Health*, 31(5): 1067-1088

48. AL-Rubaae,M. A. 1997. Environmental study on Al-Adhaim river and their effect on Tigris river. M. Sc. Thesis, College of education for women -Baghdad University. (In Arabic)

49. Al-Saadi, H.A., Al-Lami., A.A., and Jafer, M.A. 2000a. Limnological characters of Al-Adhiam river and their effects on Tigris river-Iraq. 1st National Scie. Conf. in Envi. Poll. And Means of Prote., Baghdad, Nov. 5-6(2000): 10-20.

50. Al-Kubaisi, A.A, Al-Saadi.H.A and Ismail A.M. 2001. An ecological study in Tigris river pre and after crossing Baghdad city, *Iraq. J. ecol. and devel. research*, 4(2): 52-78. (In Arabic)

51. Al-Nimma, B. A. B. 1982. A study on the limnology of the Tigris and Euphrates rivers. *Sc. This University of Salahaddin Erbil, Iraq.*

52. Sulaiman, N. I, Al-Saadi, H. A. and Ismail, A. M. 1999. Effect of Northern Saria drainage canal on the algal composition of Diyala River, *Iraq. Iraqi. J. Biol. Sci.*, 18: 57-67.

53. Al-Saadi, H.A.; Sulaiman, N.I. and Ismail, A.M. 2000c. A qualitative Study on Algae of Saria Stream at Baquba City, *Iraq. J. of Diala*, 8(2): 24-40.

54. Al-Saadi, H. A. and Al-Lami, A. A. 1992. Seasonal variations of phytoplankton in some marsh areas in southern Iraq. *J. Coll. Educ. Women, University of Baghdad*, 3: 56-61.

55. Mitrovic, S. M., Hitchcock, J. N., Davie, A. W. and Ryan, D. A. 2010. Growth responses of Cyclotella meneghiniana (Bacillariophyceae) to various temperatures. *Journal of plankton research*, 32(8): 1217-1221.

56. Al-Tamimi, A.A. 2006. Using algae as bioindicators for organic pollution in the lower part of Diyala River. PhD thesis, University of Baghdad College of Science. (In Arabic)

57. Downs TM, Schallenberg M. and Burns CW. 2008. Responses of lake phytoplankton to micronutrient enrichment: a study in two New Zealand lakes and an analysis of published data. *Aquat Sci*, 70: 347–360.

58. Molot LA, Li G, Findlay DL. And Watson SB. 2010. Iron-mediated suppression of bloom-forming cyanobacteria by oxime in a eutrophic lake. *Freshw Biol*, 55: 1102–1117.

59. Pouliková, A., Hašler, P., Lysáková, M. and Spears, B. 2008. The ecology of freshwater epipelic algae: an update. *Phycologia*, 47(5): 437-450.

60. Kassim,T.A and AL-Saadi H.A. 1995. Seasonal variation of epiphytic algae in a marsh area (southern Iraq). *Acta Hydrobiol.*, 37(3) : 153-161.

61. Jackson G., Zingmark R., Iewitus A.G., Tymowski R.G. and Stuckey J. 2006. Spatial and Temporal Dynamics of Epiphytic Microalgae on the Cordgrass Spartina alterniflora in North Inlet Estuary, South Carolina. *Estuaries and Coasts*, 29(6B): 1212-1221.