Phytoplankton community within Al-Auda marsh in maysan province southern Iraq

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Abstract:
Phytoplankton assemblage in relation to physical and chemical characteristics of water in Al-Auda marsh of Maysan province southern Iraq was assessed from November 2012 to July 2013. Six sampling sites were chosen to examine all phytoplankton species in the study area. A total of 246 species and seventy-five genera have been recognized belonging to twelve phytoplankton classes as follows: Bacillariophyceae (106 taxa), Chlorophyceae (34 taxa), Euglenophyceae (29 taxa), Cyanophyceae (29 taxa), Conjugatophyceae (19 taxa), Mediophyceae (10 taxa), Cryptophyceas (5 taxa), Coscinodiscophyceae (4 taxa), Chrysophyceae (4 taxa), Dinophyceae (3 taxa), Trebouxiophyceae (2 taxa) whereas Compsopogonophyceae recorded only (one taxon). The finding showed class Bacillariophyceae dominated with (43.09%), followed by Chlorophyceae of (13.82%), then (11.79%) for each of Cyanophyccean and Euglenophyceae. Mean ± standard deviation for water temperature was ranged between (14.3±1.6°C) during winter to (35.6±1.81°C) during summer, electrical Conductivity (2020±186μ.s/cm) during autumn to (6390±875μ.s/cm) during summer, total Phosphate 0.01±0.0 μg/l during winter to 0.3±0.08 μg/l during spring, and total nitrogen varied from 1.8±0.8 μg/l during winter to 6.9±0.5 μg/l during autumn. Seasonal distribution indicated that phytoplankton flourished predominantly during the summer and spring. The diversity index (H) recorded the highest value in spring and lowest value in autumn, Richness (D) and Evenness (E) indices achieved the highest values in spring, the lowest values in autumn. The Jaccard index (Ss%) recorded the highest similarity between autumn and winter, the lowest similarity was between autumn and spring. The results revealed Al-Auda marsh is mesotrophic according to phytoplankton composition.

1. Introduction
Wetlands are the most active habitats in the world, covering at least 6 percent of the earth’s surface. They play a vital role in hydrological and biogeochemical cycles, protecting and harboring a large portion of the planet’s biodiversity, and providing numerous services to humanity [1]. Wetlands serve as purifiers of natural water, removing and absorbing many pollutants from surface water, such as phytoremediation (i.e. removal of contaminants using plants) and bioremediation (i.e. degradation of contaminants using less harmful species), habitat for flora and fauna, feeding areas for animals, and tourism [2]. These complex habitats are supported by aquatic biodiversity, with a high number of specific plant and animal species found only within these environments. Due to human activities such as agriculture, mining, and urban development, wetlands are disappearing worldwide [3]. Phytoplankton is a primary producer and plays large role for many species as a food source, fix carbon dioxide contributing ~40% of annual global production, and provide oxygen to an aquatic environment for several species [4]. Due to the variation of physicochemical and biological water characteristics, and trophic status (oligotrophic/eutrophic), phytoplankton has a spatial and temporal distribution. Many phytoplankton organisms are called bioindicators and their populations are used to demonstrate the ecological state of the area through biological indices of an aquatic ecosystem [5]. Phytoplankton communities are responsive to changes in the climate, so any change will lead to changes in their...
diversity and dominance [6]. After 2003, the restoration of Iraqi marshes resulted in the blooming of various species of phytoplankton [7,8] especially in Abu-Zirig, Al-Hammar, Al-Hawizeh, and central marshes. From these works, a total of 275 algae taxa have been identified, belonging to six major groups present in the restoration marshes of the Al-Hawizeh, central and southern Iraqi marshes. The trophic status of any water body may be displayed by distinct phytoplankton taxa or multiple ratios between different classes [9]. Diatoms can be used to monitor climatic changes, including changes in the trophic status of water bodies [10]. Al-Auda Marsh, one of eight small Iraqi marshes, is considered to be an ICB 072 Important Bird Area (IBA) within the Maysan Province. Few studies on algae diversity have been published in Al-Auda Marsh. These studies centered on the abundance of the algae population, taxonomy, and diversity. Recorded 193 phytoplankton species by [11] and found that Al-Auda marsh, with high salinity and low dissolved oxygen levels, has poor water quality conditions compared to its Al-Haddam River source. In some aquatic plants of Al-Auda marsh, [12] studied the composition of epiphytic diatoms and described 111 diatom species.

Moreover, the Phytoplankton community and four biodiversity indices have recently been studied by [13] in Al-Auda marsh, where 146 species were described. The purpose of this study is to evaluate some of the physical and chemical factors and its effect on the abundance and presence of the phytoplankton community in Al-Auda marsh to identified the marsh function.

2. Methodology Material and Methods
2.1. Study area
Al-Auda Marsh, located about 35 km south of Al-Ammara City (Latitude/Longitude: 31 ° 33' N, 46 ° 51' E) and 5 km north of Al-Maymunah district, is one of the water bodies in the southern Iraq province of Maysan. The Al-Auda wetlands cover an area of around 7,500 ha in total. It has a length of about 20 km, a width of 10 km and a surface area of 105 km². The marsh was bordered by the northern province of Maysan, the southern central marshlands, the eastern district of Al-Maymunah, and the western rural region of Saited Ahmed Al-Refay (Figure 1).

![AL-AUDA MARSH](image-url)

Figure 1. Location Al-Auda marsh in Maysan province southern Iraq [14].
Six sites in the Al-Auda Marsh were chosen during the study period (table 1), using the Geographical Positioning System (GPS), because they represent the different types of habitats found in the marsh. On the north side of the Al-Auda Marsh, site 1 was located. At the south end of site 1, site 2 was situated. Site 3 was located in center of marsh. Site 4 was an open field of water in a marsh near Al-Auda Village. Site 5 is adjacent to Nasser-Allah Village. Site 6 was located south of the marsh nearby village of Al-Battat.

Table 1. Location of survey sites in Al-Auda Marsh, along with main descriptive characteristics.

| Site   | Location  | Latitude (North) | Longitude (East) | Vegetation and activities                                      |
|--------|-----------|------------------|------------------|----------------------------------------------------------------|
| Site 1 | Braidah   | 46°50’10”.38     | 31°36’25”.09     | Low vegetation, less human activity, and a fisherman's presence |
| Site 2 | Al-Adla   | 46°50’25”.85     | 31°35’22”.57     | (Open area) Med vegetation and less human activities             |
| Site 3 | Center marsh | 46°49’47”.82   | 31°34’30”.46     | Fewer human activities and the presence of fishermen, P. australis and T. domingensis |
| Site 4 | Al-Auda   | 46°51’13”.72     | 31°34’33”.75     | Vegetation Med, (Open Area), human activities and the presence of fishermen's presence |
| Site 5 | Umm Al- Mashahef | 46°52’07”.43  | 31°33’49”.95     | Free-floating plants, human activities, and the presence of fishermen dominated |
| Site 6 | Al- Battat | 46°54’09”.76     | 31°32’55”.74     | Low vegetation, lower human activity, and fishermen's presence  |

2.2. Sampling and data analysis
2.2.1. Water samples
Physical and chemical water parameters such as Water temperature (°C), Electrical conductivity (EC μ.S/cm) was measured directly in the field by using digital portable WTW Multi-meter model (Multi 350i meter). To determine the Total nitrogen (TN) the persulfate method [15] was used by oxidation of all nitrogenous compounds to nitrate using Alkaloid potassium persulfate (K₂S₂O₈) solution as a digestion reagent, autoclaved at 100-110 °C for 30 min., slowly cooled to room temperature, borate buffer solution was added, then mixed by inverting at least twice. Total nitrogen (TN) is determined by analyzing the nitrate in the digestate. Total phosphate (TP), in the samples (100 ml) was digested according to [15], using water-bath (100°C), by adding concentrated H₂SO₄(1 ml) and concentrated HNO₃ (5 ml), when the sample became about (1 ml) in volume, it was cooled and (20ml) of distilled water were added. One drop (0.05 ml) phenolphthalein indicator was added, NaOH (1N) was also added until the sample color became pink. The volume was completed to 100 ml with distilled water, treated as reactive phosphate as described in [16].

2.2.2. Determination abundance and composition of phytoplankton species
From November 2012 to July 2013, phytoplankton samples were collected monthly from Al-Auda marsh study sites and the results were reported seasonally. One liter of each station was preserved by acid Lugol’s solution (1ml /100 ml sample) in one-liter Duran cylinder and left to settle for 10-15 days, then concentrated to 100 ml and the process is repeated to reach 10 ml [17]. The diatoms were clarified by using concentrated nitric acid, then by using permanent slides. Whilst, the temporary slides were prepared for non-diatom species. Species of phytoplankton have been classified using an inverted light microscope. The microtransect method was used for diatom counting (100 x), for non-diatom algae counting, the hemocytometer slide (400 x) was used [18]. References to the identification of algal species [19-21]. This protocol allows us to determine the species composition, abundance of phytoplankton by counting phytoplankton from preserved water samples using the Utermöhl inverted light microscopical method [22].

2.3. Indices on Biodiversity
In conjunction with the investigated environmental status, four biodiversity indices were applied [23]. These indices are the Shannon Index, Richness Index, Evenness Index, and Jaccard Index. Shannon-Weaver index of diversity was obtained by the following equation H= -∑pi lnpi [24]. Using the
The Jaccard Similarity Index (Ss %) was used to assess the degree of similarity between months of analysis using the following ISJ=$[a/(a+b+c)] \times 100$ equation [27]. Additionally, the relative abundance (Ra%) was calculated from equation $n_i/N \times 100$ [28].

2.4. Assessment of the degree of contamination based on species diversity index

As species diversity value $> 3 =$ clean, $1-3 =$ moderately polluted and $< 1 =$ heavily polluted, a relationship between species diversity and pollution status of a wetland was proposed. The pollution status for the autumn, winter, spring, and summer seasons was assessed in this analysis on the basis of the diversity indices of Shannon-Weaver following with [29].

2.5. Statistical Analysis

Two statistical packages, Statistical Package for Social Sciences (SPSS) version 22, mean ± SD (standard deviation) for water parameters between sites and seasons using variance analysis (ANOVA) were used to treat the data in this work. In order to calculate the degree of linear association between phytoplankton assemblage and water physicochemical characteristics, the Pearson correlation matrix [30] was used. Biodiversity indices are also determined by the Multivariate Species Diversity Analysis Software. All these experiments were performed at a probability of a statistical significance level of 5 percent ($P \leq 0.05$).

3. Results

This study was conducted on a monthly basis over a period of nine months, between November 2012 and July 2013, while the results were seasonally based. The study months were divided into 4 seasons (November and December), representing the autumn season; represented by the winter season (January and February); represented by the spring season (March and April); represented by the summer season (May, June and July). In the current analysis, six sites have been selected: Site 1 (Braidah), Site 2 (Al-Adla); Site 3 (Al-Auda marsh centre); Site 4 (Al-Auda); Site 5 (Umm Al-Mashahef) and Site 6 (Al-Battat) Figure 1.

3.1. Water Sampling

3.1.1. Water Temperature (°C)

In the study areas, the differences in water temperature were examined. The mean and SD of the water temperature ranged from (14.3±1.6 °C) during the winter at site 1 to (35.6±1.81 °C) during the summer at site 6 (Figure 2). Non-significant variations ($P \leq 0.05$) in water temperature values between sites were thus observed.

![Figure 2](image.png)

**Figure 2.** Seasonal variations in mean of Water Temp.(°C) of water samples in Al-Auda marsh.

3.1.2. Electrical Conductivity (EC) μ.S/cm

Mean EC values seem clear, the highest mean and SD value (6390±875μ.s/cm) recorded at site 6 during summer, the lowest value (2020±186μ.s/cm) revealed at site 5 during autumn (Figure 3). The results showed clear significant differences ($P \leq 0.05$) in EC values among sites.
Figure 3. Seasonal variations in mean value of E.C (μ.s/cm) of water samples in Al-Auda marsh

3.1.3. Total Phosphate (TP) μg/L

The present findings showed differences in the values of Total Phosphate (TP) in all sites tested. Nonetheless, the mean Total Phosphate (TP) value at all sites analyzed ranged from 0.01±0.0 μg /L at site 6 during the winter to 0.3±0.08 μg /L also at the same but during the spring (Figure 4). Significant variations (P≤0.05) in TP between sites have been observed.

Figure 4. Seasonal variations in mean values of Total Phosphate (μg/L) samples in Al-Auda marsh

3.1.4. Total Nitrogen (TN) μg/L

Changes were observed in Total Nitrogen (TN) values. The findings showed that mean and SD (TN) values ranged from 1.8±0.8 μg /L during winter at site 6 to 6.9±0.5 μg /L during autumn at site 5 (Figure 5). Significant differences(P≤0.05) in TN values between study sites were observed.

Figure 5. Seasonal variations in mean values of Total Nitrate(μg/L) samples in Al-Auda marsh.
3.2. Assemblages of Phytoplankton

In the 9 divisions of Bacillariophyta, Chlorophyta, Euglenozoa, Cyanobacteria, Charophyta, Cryptophyta, Ochrophyta, Mioza, and Rhodophyta, a total of 246 phytoplankton taxa and 75 genera have been described belonging to the 12 classes of Bacillariophyceae, Chlorophyceae, Euglenophyceae, Conjugatophyceae, Mediophyceae, Cryptophyceae, Cyanophyceae, Coscinodiscophyceae, Chrysophyceae, Dinophyceae, Trebouxiophyceae and Compsopogonophyceae at all examined sites (Table 2). Bacillariophyceae was the dominant group of algae with the highest relative abundance of 43.09%, Compsopogonophyceae recorded the lowest relative abundance 0.41% of the phytoplankton community in the Al-Auda marsh during the study period (Figure 6).

![Figure 6. Proportion of each phytoplankton taxa found in Al-Auda Marsh](image)

The results of this work showed variations in the number of phytoplankton species recorded over four seasons of the current study within Al-Auda marsh. Thus, the highest number of 184 species were existence during summer, while the lowest number of 128 species were occurrence during the autumn of the phytoplankton community (Table 2).

Diatom *Nitzschia* of Bacillariophyceae (Pinales) is considered one of the important genera. It represented 15 species in all examined sites, the highest species of 14 was recorded in the summer, while the lowest species of 10 was a presence in the spring. Genus *Cymbella* of Pinales diatom was represented by 10 species, with the highest of 9 species reported in the summer, 7 in the autumn and winter, and the lowest of 6 species reported in the spring. Also, the genus *Gomphonema* of Pinales diatoms represented by 10 species, the highest of 9 species occurring in both autumn and winter, while the lowest of 3 species was found in spring. Then genus *Synedra* of Bacillariophyceae (Pinales) was described by 8 species, with 7 species being the highest in the summer and 2 species being the lowest in the autumn. As well as, the genus *Navicula* of Pinales diatom was represented by 7 species, the highest of species 7 found in both spring and summer, while the lowest of 2 species done during the autumn. On the other hand, the genus *Cyclotella* of Mediophyceae class (Centrales) represented by 7 species, the highest of seven species were found in both spring and summer, while the lowest of two species were found in autumn. Overall, the genera *Nitzschia*, *Cymbella*, and *Gomphonema* of Bacillariophyceae (Pinales) were more recorded of 15,10 and 10 species, respectively in all testing sites during the study period (Table 2).
Table 2. Table shows the presence/absence species in Al-Asada marsh during the four study seasons and common species

| Line of algal taxa | Seasons | Autumn 2012 | Winter 2013 | Spring 2013 | Summer 2013 | Common Species |
|--------------------|---------|-------------|-------------|-------------|-------------|----------------|
| **PHYLUM: CHLOROPHYTA** |         |             |             |             |             |                |
| **CLASS: CHLOROPHYCEAE** |         |             |             |             |             |                |
| *Chlorella elipsoidea* | |             |             |             |             |                |
| *Chlorella vulgaris* | |             |             |             |             |                |
| **PHYLUM: BACILLARIOPHYTA** |         |             |             |             |             |                |
| **CLASS: BACILLARIOPHYCEAE** |         |             |             |             |             |                |
| *Stephanodiscus* | |             |             |             |             |                |
| *Stephanodiscus astrea* | |             |             |             |             |                |
| *Chaetoceros subcoronatus* | |             |             |             |             |                |
| *Cyclotella* | |             |             |             |             |                |
| *C. striata* | |             |             |             |             |                |
| *C. stelligera* | |             |             |             |             |                |
| *C. meneghiniana* | |             |             |             |             |                |
| *C. kuetzingiana* | |             |             |             |             |                |
| *Coscinodiscus lacustris* | |             |             |             |             |                |
| *A. italica* | |             |             |             |             |                |
| **PHYLUM: PHYLUM: CHAROPHYTA** |         |             |             |             |             |                |
| **CLASS: CONJUGATOPHYCEAE** |         |             |             |             |             |                |
| *Gloeocapsa aurantiaca* | |             |             |             |             |                |
| *G. affine* | |             |             |             |             |                |
| *G. globata* | |             |             |             |             |                |
| **PHYLUM: CHLOROPHYTA** |         |             |             |             |             |                |
| **CLASS: CHLOROPHYCEAE** |         |             |             |             |             |                |
| *Monoraphidium* | |             |             |             |             |                |
| *M. minutum* | |             |             |             |             |                |
| *M. contortum* | |             |             |             |             |                |
| **PHYLUM: CHLOROPHYTA** |         |             |             |             |             |                |
| **CLASS: CHLOROPHYCEAE** |         |             |             |             |             |                |
| *Closterium* | |             |             |             |             |                |
| *C. dianae* | |             |             |             |             |                |
| **PHYLUM: RAPHIDOPHYTA** |         |             |             |             |             |                |
| **CLASS: CONVEXOPHYCEAE** |         |             |             |             |             |                |
| *Staurastrum minimum* | |             |             |             |             |                |
| **PHYLUM: BACILLARIOPHYTA** |         |             |             |             |             |                |
| **CLASS: SYMPLANTICOPHYCEAE** |         |             |             |             |             |                |
| *Cladophora* | |             |             |             |             |                |
| *C. glomerata* | |             |             |             |             |                |
| **PHYLUM: BACILLARIOPHYTA** |         |             |             |             |             |                |
| **CLASS: BACILLARIOPHYCEAE** |         |             |             |             |             |                |
| *Chlorella* | |             |             |             |             |                |
| *C. elipsoidea* | |             |             |             |             |                |
| **PHYLUM: BACILLARIOPHYTA** |         |             |             |             |             |                |
| **CLASS: BACILLARIOPHYCEAE** |         |             |             |             |             |                |
| *Pediastrum* | |             |             |             |             |                |
| *P. tetrus* | |             |             |             |             |                |
| *P. simplex* | |             |             |             |             |                |
| *Meyen* | |             |             |             |             |                |
| *P. duplex* | |             |             |             |             |                |
| *P. braunii* | |             |             |             |             |                |
| **PHYLUM: BACILLARIOPHYTA** |         |             |             |             |             |                |
| **CLASS: BACILLARIOPHYCEAE** |         |             |             |             |             |                |
| *Cladophora* | |             |             |             |             |                |
| *C. glomerata* | |             |             |             |             |                |
| **PHYLUM: BACILLARIOPHYTA** |         |             |             |             |             |                |
| **CLASS: BACILLARIOPHYCEAE** |         |             |             |             |             |                |
| *Chlorella* | |             |             |             |             |                |
| *C. elipsoidea* | |             |             |             |             |                |
| **PHYLUM: BACILLARIOPHYTA** |         |             |             |             |             |                |
| **CLASS: BACILLARIOPHYCEAE** |         |             |             |             |             |                |
| *Cladophora* | |             |             |             |             |                |
| *C. glomerata* | |             |             |             |             |                |
| Species | Author | Year |
|---------|--------|------|
| *S. ovalis* | Kützing | 1849 |
| *N. romana* | Grunow | 1854 |
| *N. palea* | Grunow | 1854 |
| *N. frustulum* | Grunow | 1854 |
| *N. dissipata* | Grunow | 1854 |
| *N. viridula* | W. Smith | 1881 |
| *N. cryptocephala* | W. Smith | 1881 |
| *G. macrum* | Cleve | 1881 |
| *G. fasciola* | Cleve | 1881 |
| *G. acuminatum* | Cleve | 1881 |
| *G. constrictum* | Cleve | 1881 |
| *G. angustatum* | Cleve | 1881 |
| *F. crotonensis* | Cleve | 1881 |
| *Eunotia* | Cleve | 1881 |
| *Epithemia* | Cleve | 1881 |
| *E. sorex* | Cleve | 1881 |
| *C. pusilla* | Grunow | 1854 |
| *C. microcephala* | Grunow | 1854 |
| *C. differta* | Grunow | 1854 |
| *Cymbella affinis* | Grunow | 1854 |
| *C. placentula* | Grunow | 1854 |
| *Cocconeis pediculus* | Ehrenberg | 1856 |
| *Campylodiscus clypeus* | Ehrenberg | 1856 |
| *Bacillaria paxillifer* | Ehrenberg | 1856 |
| *A. venata* | Grunow | 1854 |
| *Ralfs sp.* | Grunow | 1854 |
| *var. vulgare* | Ehrenberg | 1856 |

Note: The table above lists some species of diatoms and their authors. The years indicate the publication year of the species or the author who described them.
| Species/Genus                  | Phylum                      | Class               | Division             | Order               | Family              | Genus                  |
|-------------------------------|-----------------------------|---------------------|----------------------|---------------------|---------------------|------------------------|
| Compsopogon occidentalis      | RHODOPHYTA                  |                      |                      |                     |                     |                        |
| P. excentricum                | PHYLUM: RHODOPHYTA          |                     |                      |                     |                     |                        |
| Peridinium cinctum            | PHYLUM: CRYPTOPHYTA         | CLASS: CRYPTOPHYCEAE|                      |                     |                     |                        |
| Glenodinium quadridens        |                              |                     |                      |                     |                     |                        |
| Dinobryon                     |                              |                     |                      |                     |                     |                        |
| D. cylindricum                |                              |                     |                      |                     |                     |                        |
| D. divergens                  |                              |                     |                      |                     |                     |                        |
| Cryptomonas                   |                              |                     |                      |                     |                     |                        |
| Cryptomonas erosa             |                              |                     |                      |                     |                     |                        |
| Phacus                        |                              |                     |                      |                     |                     |                        |
| P. totus                      |                              |                     |                      |                     |                     |                        |
| P. pleuronectes               |                              |                     |                      |                     |                     |                        |
| P. orbicularis                |                              |                     |                      |                     |                     |                        |
| K. Hübner                     |                              |                     |                      |                     |                     |                        |
| P. curvicuda                  |                              |                     |                      |                     |                     |                        |
| P. chloroplastes              |                              |                     |                      |                     |                     |                        |
| Phacus acuminatus             |                              |                     |                      |                     |                     |                        |
| Lepocinclis                   |                              |                     |                      |                     |                     |                        |
| L. sphagnophila               |                              |                     |                      |                     |                     |                        |
| L. ovum                       |                              |                     |                      |                     |                     |                        |
| L. fusiformis                 |                              |                     |                      |                     |                     |                        |
| L. glabra                     |                              |                     |                      |                     |                     |                        |
| Euglena                       |                              |                     |                      |                     |                     |                        |
| E. polymorpha                 |                              |                     |                      |                     |                     |                        |
| E. oxyuris                    |                              |                     |                      |                     |                     |                        |
| E. proxima                    |                              |                     |                      |                     |                     |                        |
| E. elastica                   |                              |                     |                      |                     |                     |                        |
| E. acus                       |                              |                     |                      |                     |                     |                        |
| Spirulina                     |                              |                     |                      |                     |                     |                        |
| S. princeps                   |                              |                     |                      |                     |                     |                        |
| S. major                      |                              |                     |                      |                     |                     |                        |
| S. laxa                       |                              |                     |                      |                     |                     |                        |
| Oscillatoria nodulosa         |                              |                     |                      |                     |                     |                        |
| O. rubescens                  |                              |                     |                      |                     |                     |                        |
| O. tenuis                     |                              |                     |                      |                     |                     |                        |
| O. princeps                   |                              |                     |                      |                     |                     |                        |
| O. minima                     |                              |                     |                      |                     |                     |                        |
| O. limnetica                  |                              |                     |                      |                     |                     |                        |
| O. formosa                    |                              |                     |                      |                     |                     |                        |
| Oscillatoria amphibia         |                              |                     |                      |                     |                     |                        |
| Nostoc granulare              |                              |                     |                      |                     |                     |                        |
| M. tenuissima                 |                              |                     |                      |                     |                     |                        |
| M. punctata                   |                              |                     |                      |                     |                     |                        |
| M. glauca                     |                              |                     |                      |                     |                     |                        |
| Merismopedia elegans          |                              |                     |                      |                     |                     |                        |
| Lyngbya limnetica             |                              |                     |                      |                     |                     |                        |
| Gomphosphaeria                |                              |                     |                      |                     |                     |                        |
| C. turgidus                   |                              |                     |                      |                     |                     |                        |
| C. minutus                    |                              |                     |                      |                     |                     |                        |
| Chroococcus dispersus         |                              |                     |                      |                     |                     |                        |
| Aphanocapsa                  |                              |                     |                      |                     |                     |                        |
| Aphanocapsa endophytica       |                              |                     |                      |                     |                     |                        |
| Cymatopleura                  |                              |                     |                      |                     |                     |                        |
| S. vaucherea                  |                              |                     |                      |                     |                     |                        |
| S. ulna                       |                              |                     |                      |                     |                     |                        |
| S. pulchella                  |                              |                     |                      |                     |                     |                        |
| S. fasciculata                |                              |                     |                      |                     |                     |                        |
| S. capitata                   |                              |                     |                      |                     |                     |                        |
| Surirella                     |                              |                     |                      |                     |                     |                        |
| S. robusta                    |                              |                     |                      |                     |                     |                        |
| Meister var (Nitz.) skvortzow sp. |                              |                     |                      |                     |                     |                        |
| C. turgidus                   |                              |                     |                      |                     |                     |                        |
| C. minutus                    |                              |                     |                      |                     |                     |                        |
| Chroococcus dispersus         |                              |                     |                      |                     |                     |                        |
| Aphanocapsa                  |                              |                     |                      |                     |                     |                        |
| Aphanocapsa endophytica       |                              |                     |                      |                     |                     |                        |
| Turpin S                      |                              |                     |                      |                     |                     |                        |
| Meister var (Nitz.) skvortzow sp. |                              |                     |                      |                     |                     |                        |
| C. turgidus                   |                              |                     |                      |                     |                     |                        |
| C. minutus                    |                              |                     |                      |                     |                     |                        |

**TOTAL:** 246 species
Among other classes, the Bacillariophyceae class had a greater relative abundance of 43.09% of the phytoplankton community (Figure 6). Thus, it is composed of 28 genera and 106 algae species. This group having high abundance at all study seasons where varied from 36.99% in spring to 48.44% in autumn. The second rank of 34 species belonging to 13 genera was held by the Chlorophyceae, comprising 13.82% of the phytoplankton community, with the highest relative abundance of 15.62% during the Autumn, while the lowest relative abundance was 14.13% during the summer (Table 3).

The Chlorophyceae is known to occur primarily in freshwater. It was mainly dominated by the genus Scenedesmus quadricauda. Non-motile of plankton community belonging to chlorophytes and Conjugatophyceae classes (Scenedesmus, Monoraphidium, and Coelastrum) respectively, under moderate conditions. Regarding the genus Scenedesmus of Chlorophyceae represents 9 species, the highest of 7 species were present in spring, while the lowest of 6 species were recorded for each of autumn, winter, and summer seasons. Nevertheless, both Cyanophyceae and Euglenophyceae occupied the third rank of 29 species distributed into 11 and 4 genera respectively, thus giving a percentage of 11.79% for each class of the phytoplankton community. However, Cyanophyceae ranged from 11.96% was recorded in the summer to 14.06% in the autumn. Furthermore, the species Anabaena planctonica, Oscillatoria limnetica, and Lyngbya limnetica of Cyanophyta were among the most abundant Cyanophyta in fresh and brackish water. Regarding the Euglenophyceae class was varied between 3.13% during autumn to 15.61% during spring (Table 3). Where the genus Phacus of Euglenophyceae was represented by 14 species, the highest of 12 species was recorded in the spring, while only one species was found in the autumn. The genus Euglena represented by 8 species, the highest of 8 species was the frequency in both spring and summer seasons, 2 species were reported in the autumn. Whereas genus Lepocinclis of Euglenophyceae was represented by 6 species, the highest number of 6 species was an existence in spring, the lowest number only one species seems in autumn (Table 2).

Table 3. Distribution of the identified algae classes with their relative abundance based on the studied seasons in Al-Auda marsh.

| Class Algae       | Autumn 2012 | Winter 2013 | Spring 2013 | Summer 2013 | No. Specie in each Class | Relative abundance % | No. Genera in each Class | Common Species |
|-------------------|-------------|-------------|-------------|-------------|--------------------------|----------------------|-----------------------|----------------|
| Bacillariophyceae | 62          | 48.44       | 65          | 46.76       | 128                      | 100%                 | 18                    | 28             |
| Chlorophyceae     | 20          | 15.62       | 20          | 14.39       | 34                       | 11.96%               | 13                    | 13             |
| Conjugatophyceae  | 7           | 5.47        | 6           | 5.03        | 19                       | 11.79%               | 6                     | 5              |
| Coelnidophyceae   | 3           | 2.34        | 3           | 2.16        | 4                        | 1.09%                | 2                     | 3              |
| Mesochnophyceae   | 6           | 4.69        | 6           | 4.32        | 10                       | 3.47%                | 3                     | 2              |
| Cyanophyceae      | 18          | 14.06       | 18          | 12.95       | 29                       | 11.09%               | 11                    | 9              |
| Euglenophyceae    | 4           | 3.13        | 12          | 8.63        | 29                       | 11.96%               | 4                     | 4              |
| Crytovibonophyceae| 4           | 3.13        | 12          | 2.16        | 2                        | 1.09%                | 5                     | 3              |
| Chrysophyceae     | 1           | 0.78        | 1           | 0.72        | 1                        | 0.81%                | 1                     | 1              |
| Trebouxionophyceae| 1           | 0.78        | 1           | 0.72        | 1                        | 0.81%                | 1                     | 1              |
| Total             | 128         | 100%        | 139         | 100%        | 172                      | 100%                 | 75                    | 68             |

Conjugatophyceae class has occupied the fourth rank with 19 species of 6 genera giving a percentage of 7.72%, ranged from 5.03% was recorded in the winter to 8.09% done in the spring. Also, Mediophyceae class occupied the fifth rank of 10 species belong to 3 genera having 4.06%, ranged from 3.47% in the spring to 4.69% in the autumn 2012. While, only one genus and one species were recorded of Compsopogonophyceae class giving a percentage of 0.41% of the total phytoplankton community, where lied between 0.72% in the winter to 0.78% in the autumn (Table 3). Moreover, there are 68 common species among the four seasons during the study time, were distributed as follows: 28 species of Bacillariophyceae, 13 of Chlorophyceae, 9 of Cyanophyceae, 5 of Conjugatophyceae, 4 of Euglenophyceae, 3 of Coscinodiscophyceae, then 2 species of Mediophyceae, whereas only one species belonged to each of Cryptophyceae, Chrysophyceae, Dinophyceae and Trebouxiphyceae (Tables 2, 3).
3.2. The phytoplankton existence

According to studied sites, the highest species of algae (200 species) was recorded in site 1, while the lowest species of algae (169 species) was presented in site 6. The results of the current study showed a difference in algae species recorded among examined sites within the Al-Auda marsh. Nevertheless, the Bacillariophyceae class has recorded the highest occurrence of 90 species in site 1, while the lowest existence of 14 species were detected in site 6. In Chlorophyceae the highest frequency of 30 species was reported in both 4 and 5 sites, while the lowest presence of 24 species was found in site 6. Cyanophyceae class recorded the highest presence of 25 species was found in site 4, while the lowest of 22 species were in each of 2, 3 and 6 sites. Regarding Euglenophyceae the highest existence of 21 species was recorded in both 2 and 4 sites, while the lowest existence of 17 species was reported in both 5 and 6 sites. Then Conjugatophyceae the highest occurrence of 14 species were detected in site 1, while the lowest occurrence of 8 species was identified in site 3. Whereas Compsopogonophyceae recorded the presence of only one species in each of 1, 3, 4, and 6 sites, while not recorded any species in both 2 and 5 sites (Table 4).

Table 4. Number of algal species which detected of six studied sites in the Al-Auda marsh

| Class Algae             | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 |
|-------------------------|--------|--------|--------|--------|--------|--------|
|                         | NO. sp.| %     | NO. sp.| %     | NO. sp.| %     |
| Bacillariophyceae       | 90     | 45     | 83     | 44.39  | 85     | 46.7   | 81     | 41.75  | 73     | 41.01  | 76     | 44.97  | 28     |
| Chlorophyceae           | 28     | 14     | 27     | 14.44  | 26     | 14.29  | 30     | 15.46  | 30     | 16.85  | 24     | 14.2   | 13     |
| Conjugatophyceae        | 14     | 7      | 13     | 6.95   | 8      | 4.39   | 12     | 6.19   | 13     | 7.3    | 10     | 5.92   | 6      |
| Coscinodiscophyceae     | 4      | 2      | 4      | 2.14   | 4      | 2.2    | 4      | 2.06   | 4      | 2.25   | 4      | 2.37   | 2      |
| Mediophyceae            | 10     | 5      | 8      | 4.28   | 8      | 4.39   | 9      | 4.64   | 8      | 4.49   | 7      | 4.14   | 3      |
| Cyanophyceae            | 23     | 11.5   | 22     | 11.76  | 22     | 12.09  | 25     | 12.89  | 23     | 12.92  | 22     | 13.02  | 11     |
| Euglenophyceae          | 19     | 9.5    | 21     | 11.23  | 19     | 10.44  | 21     | 10.82  | 17     | 9.55   | 17     | 10.06  | 4      |
| Cryptophyceae           | 4      | 2      | 4      | 2.14   | 3      | 1.65   | 3      | 1.55   | 3      | 1.69   | 1      | 0.59   | 3      |
| Chrysophyceae           | 2      | 1      | 2      | 1.07   | 2      | 1.1    | 4      | 2.06   | 3      | 1.69   | 4      | 2.37   | 1      |
| Dinophyceae             | 3      | 1.5    | 1      | 0.53   | 3      | 1.65   | 2      | 1.03   | 2      | 1.12   | 1      | 0.59   | 2      |
| Trebouxiophyceae        | 2      | 1      | 2      | 1.07   | 1      | 0.55   | 2      | 1.03   | 2      | 1.12   | 2      | 1.18   | 1      |
| Compsopogonophyceae     | 1      | 0.5    | -      | 0      | 1      | 0.55   | 1      | 0.52   | -      | 0      | 1      | 0.59   | 1      |
| Total                   | 200    | 100    | 187    | 100    | 108    | 100    | 94     | 100    | 81     | 99.99  | 100    | 100    | 76     |

There are clear variations in the percentage of algae classes revealed in all examined sites during the four study seasons in the Al-Auda marsh. However, the Bacillariophyceae class had the highest values in all the study sites, where the percent was varied between 39.36 % of 32 species in site 4 during the winter 2013 to 44.44 % in site 2 of 36 species during the autumn 2012. Followed by Chlorophyceae and Cyanophyceae class had the highest values from between 11.11% in site 6 of 8 species during the autumn and 23.85% in site 4 of 24 species during the winter. Then Conjugatophyceae class was ranged from 7.25% in site 4 of 10 species during the summer to 16.67% in site 6 of 12 species during the Autumn 2012. Also, Coscinodiscophyceae class recorded the highest presence of 4.82% in site 3 of 4 species during the autumn and the lowest percent of 2.38% in site 1 from 3 species during the Winter. Whereas the lowest percentage of the phytoplankton community was identified for Compsopogonophyceae which ranged from 0.0% in both 2, 5 sites of zero species during the autumn, site 2 during the winter to 1.39 % in site 6 of only one species during the autumn. Moreover, this class not recorded any species during the spring and summer seasons. Therefore, all these phytoplankton classes were illustrated in (Table 5).
Table 5. Numbers of Algae species detected in study sites of Al-Auda marsh of all seasons from period Autumn 2012 to Summer 2013, the first line represents the number of algae species of each class, while the second line represents the percentage of each class.

| Classes of Algae | Autumn 2012 | Winter 2013 | Spring 2013 | Summer 2013 |
|------------------|-------------|-------------|-------------|-------------|
| Bacillariophyceae| 41          | 33          | 34          | 48          |
| %                | 39.42       | 37.35       | 35.92       | 36.92       |
| Chlorophyceae    | 16          | 11          | 11          | 13          |
| %                | 15.38       | 13.58       | 12.79       | 13.91       |
| Conjugatophyceae | 12          | 8           | 9           | 9           |
| %                | 11.54       | 8.88        | 10.84       | 11.13       |
| Cryptophyceae    | 3           | 8           | 8           | 8           |
| %                | 8.65        | 9.88        | 9.64        | 9.13        |
| Euglenophyceae   | 3           | 1           | 1           | 1           |
| %                | 2.88        | 2.47        | 1.22        | 1.15        |
| Euglenophyceae   | 3           | 1           | 1           | 1           |
| %                | 2.88        | 2.47        | 1.22        | 1.15        |
| Trebouxiophyceae | 2           | 1           | 1           | 1           |
| %                | 1.92        | 1.23        | 1.39        | 1.49        |
| Dinophyceae      | 2           | 2           | 2           | 2           |
| %                | 1.92        | 1.23        | 1.39        | 1.49        |
| Coelomorophyceae | 1           | -           | -           | -           |
| %                | 0.96        | 1.22        | 1.16        | 1.08        |

Total No. of algae species in each site: 104
The results of the current study showed there is a discrepancy seasonally in the qualitative community of phytoplankton, distinguish summer 2013 being the highest in the total species recorded of algae from other seasons in this study. The present study has observed 12 species of algae frequent repeatedly during four seasons as some of them were common among the study sites within Al-Auda marsh as Ankistrodesmus falcatus, Scenedesmus acuminata, Cyclotella meneghiniana, Amphiprora alata, Bacillaria paxillifer, Cocconeis placentula, Cocconeis placentula var. euglypta, Nitzschia palea, Nitzschia longissima, Oscillatoria limnetica, Euglena convulata and Peridinium cinctum.

3.3. Correlation between phytoplankton and physical and chemical properties of water

Phytoplankton assemblage varied from positive to negative along the gradients in physical and chemical properties of water [31,32]. In this study, Bacillariophyceae showed strong positive correlation with water temp. \(r = 0.832\), EC \(r = 0.762\) and total phosphate \(r=0.921\), but observed weak negative correlation with total nitrogen \(r=-0.462\). In respect the Chlorophyceae class appeared a strong positive correlation with water temp. \(r = 0.918\), moderate positive correlation with total nitrogen \(r = 0.648\), weak negative correlation with EC \(r = -0.469\) and moderate negative correlation with total phosphate content of water \(r = -0.571\). Weak positive correlation was reported for Conjugatophyceae with water temp. \(r = 0.385\), weak negative correlation with EC \(r = -0.438\), total nitrogen and total phosphate \(r=- 458\) and \(r=- 387\) respectively. Coscinodiscophyceae class showed weak negative correlation with water temp. and total phosphate, whereas the correlation was moderate negative with EC and total nitrogen. In Trebouxiophyceae the weak negative correlation was with water temp., EC and total phosphate, but strong positive correlation with total nitrogen. Whereas the Compsopogonophyceae class achieved a weak negative correlations with all water parameters in this study (Table 6). As well as, there was a moderate positive correlation of Mediophyceae class with EC \(r=0.623\) and moderate negative correlation with Water temp., total nitrogen \(r=-589\), \(r=-0.548\) respectively, but strong negative correlation with total phosphate \(r=-0.739\). Water temperature and total nitrogen achieved a strong and moderate positive correlation \(r = 0.891\) and \(r=0.642\), whilst EC and total phosphate was weak and moderate negative correlation \(r=-0.441\) and \(r=-0.682\) with Cyanophyceae class, respectively.

On the other hand, Euglenophyceae class showed strong positive correlations with water temp., EC and total phosphate \(r=946\), \(r=0.846\) and \(r=0.859\) respectively, while was moderate positive correlation \(r=0.671\) with total nitrogen. Then the class Cryptophyceae showed strong, moderate positive correlation with EC, water temp. and total nitrogen \(r = 0.773\), \(r=0.558\) and \(r=0.595\) respectively, and strong negative correlation with total phosphate \(r = -0.718\). There was strongly positive correlation for Chrysophyceae with water temp. \(r=0.732\), weakly positive correlation with EC \(r=0.474\), strongly negative correlation with total nitrogen \(r=-0.703\) and moderately negative correlation with total phosphate \(r=-0.588\). Besides, a moderately positive correlation was reported by EC \(r = 0.623\) and a weak positive correlation of water temp. \(r = 0.421\) with Dinophyceae, whilst appeared each of total nitrogen and total phosphate \(r=-0.528\) and \(r=-0.495\) moderately correlation negative with this class respectively (Table 6).

Table 6. Pearson’s correlation matrix for phytoplankton assemblages and physicochemical characteristics of water in the Al-Auda marsh.

| Class Alga          | Water Temp. (°C) | EC (μ.S/cm) | Total Nitrogen (μg/l) | Total Phosphate (μg/l) |
|---------------------|------------------|-------------|-----------------------|------------------------|
| Bacillariophyceae   | 0.832            | 0.762       | -0.462                | 0.921                  |
| Chlorophyceae       | 0.918            | -0.469      | 0.648                 | -0.571                 |
| Conjugatophyceae    | 0.385            | -0.438      | -0.458                | -0.387                 |
| Coscinodiscophyceae | -0.449           | -0.535      | -0.668                | -0.429                 |
| Mediophyceae        | -0.598           | 0.623       | -0.548                | -0.739                 |
| Cyanophyceae        | 0.891            | -0.441      | 0.642                 | -0.682                 |
| Euglenophyceae      | 0.946            | 0.846       | 0.671                 | 0.859                  |
| Cryptophyceae       | 0.558            | 0.773       | 0.595                 | -0.718                 |
| Chrysophyceae       | 0.732            | 0.474       | -0.703                | -0.588                 |
| Dinophyceae         | 0.421            | 0.623       | -0.528                | -0.495                 |
| Trebouxiophyceae    | -0.184           | -0.254      | -0.737                | -0.181                 |
| Compsopogonophyceae | -0.274           | -0.385      | -0.189                | -0.227                 |

\(r ≤ 0.3\)= Weak correlation ; \(0.3 ≤ r < 0.7\)= Moderate correlation ; \(r ≥ 0.7\)= Strong correlation
3.5. Biodiversity Indices

The seasonal variations in values of diversity index (H), Richness index (D), and Evenness index (E) for the phytoplankton community in the Al-Auda marsh were calculated of 246 species in all six examined sites. The overall value of the diversity index was (3.16) which ranged from (1.85) at site 6 during the autumn to (4.51) at site 2 during the spring. The maximum diversity remained relatively constant at site 2 and site 1 as $H = 4.51$ and $H = 4.32$, respectively, during the spring and summer, while during the autumn, it declined to 1.85 at site 6, that may due to heavy rain during the autumn. Overall value of Richness index (D) recorded (2.72), which differs from (1.94) at site 6 during the autumn to (3.69) at site 1 during the spring. Nevertheless, the richness index defined maximum value as $D=3.69$ and $D=3.54$ at both 1 and 2 sites during the spring respectively, and minimum value $D=1.94$ found at site 6 during the autumn. Additionally, the overall value of the Evenness index (E) was (0.69), where the highest value appears (0.94) at site 2 during the spring and the lowest value (0.46) at site 6 during the autumn (Table 7). Thereby, the evenness index achieved maximum value as $E=0.94$ and $E=0.91$ that indicated a more even distribution of phytoplankton species in the community at both 2 and site 1 sites during spring and autumn respectively, which suggested moderate variation of phytoplankton species in the distribution. On the other hand, the Evenness index values were ranging from 0-1. As the value is 0 when the dominance of one species and the value becomes 1 when the distribution of an individual’s distribution equally between species [26], these indices are calculated by program Multivariate analysis species Diversity.

Table 7. Biodiversity indices values in Al-Auda marsh during the study period.

| Index                | Site | Autumn 2012 | Winter 2013 | Spring 2013 | Summer 2013 |
|----------------------|------|-------------|-------------|-------------|-------------|
| Shannon-Weaver Index (H) | 1    | 2.64        | 3.32        | 4.47        | 4.32        |
|                      | 2    | 2.58        | 2.78        | 4.51        | 4.12        |
|                      | 3    | 2.39        | 2.75        | 3.87        | 4.03        |
|                      | 4    | 2.18        | 2.54        | 3.65        | 3.38        |
|                      | 5    | 2.14        | 2.33        | 3.11        | 3.21        |
|                      | 6    | 1.85        | 2.26        | 3.86        | 3.66        |
| Richness Index (D)   | 1    | 2.23        | 3.11        | 3.69        | 3.29        |
|                      | 2    | 2.19        | 3.29        | 3.54        | 3.16        |
|                      | 3    | 2.3         | 3.07        | 3.4         | 2.85        |
|                      | 4    | 2.13        | 2.82        | 2.67        | 2.74        |
|                      | 5    | 2.35        | 2.33        | 2.56        | 2.81        |
|                      | 6    | 1.94        | 2.17        | 2.14        | 2.42        |
| Evenness Index (E)   | 1    | 0.59        | 0.70        | 0.93        | 0.91        |
|                      | 2    | 0.61        | 0.62        | 0.94        | 0.86        |
|                      | 3    | 0.57        | 0.63        | 0.81        | 0.88        |
|                      | 4    | 0.53        | 0.58        | 0.75        | 0.72        |
|                      | 5    | 0.51        | 0.52        | 0.66        | 0.69        |
|                      | 6    | 0.46        | 0.50        | 0.84        | 0.80        |

3.6. Degree of pollution based on species diversity index

To calculate the degree of contamination of that wetland, the species diversity index of any given wetland is used since the level of pollution is often proportional to the loss of species diversity. [33]. In this study, Shannon-Weaver’s diversity index $H'$ ranged between 1.85 at site 6 during Autumn and 4.51 at site 2 during Spring that indicate moderately polluted at all study sites during the autumn whereas clean water at all sites during the spring and summer seasons in the Al-Auda marsh [29,34]. Phytoplanktons act as primary producers and food for a variety of aquatic organisms. It also acts as efficient bioindicators to measure water quality [35]. A proper assessment of phytoplankton assemblages and physicochemical characteristics of water is of vital importance to understand the status of water quality in an aquatic habitat. So, the results of this study are of particular value for future monitoring and assessment of wetland pollution. The implications of the findings of this study may be integrated into the development of sustainable wetland management. Future studies should be performed to determine the relationship between soil nutrient and benthic organisms in the wetland located at Al-Auda marsh southern Iraq.
3.7. Jaccard similarity index (Ss %):

Concerning seasonal similarity of phytoplankton species distribution, the Jaccard index showed the highest similarity (87%) was between autumn and winter, while the lowest similarity (33%) was between autumn and spring (Table 8).

Table 8. Jaccard similarity index among study seasons in Al-Auda marsh.

| Season | Autumn | Winter | Spring |
|--------|--------|--------|--------|
| Autumn |        |        |        |
| Winter | 87     |        |        |
| Spring | 33     | 39     |        |
| Summer | 41     | 48     | 70     |

Moreover, the spatial similarity was approximately equal among the study sites, where the Jaccard index showed the highest similarity (77%) was between 1 and 2 sites, while the lowest similarity (66%) was between 2 and 6 sites (Table 9).

Table 9. Jaccard similarity index among study sites in the Al-Auda marsh.

| Site | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|------|--------|--------|--------|--------|--------|
| Site 1 | 77     |        |        |        |        |
| Site 2 | 73     | 71     |        |        |        |
| Site 3 | 70     | 71     | 70     |        |        |
| Site 4 | 72     | 68     | 67     | 72     |        |
| Site 5 | 70     | 66     | 68     | 70     | 68     |

A few researchers on the phytoplankton in the Al-Auda marsh were carried out in the comparison with other Iraqi marshes (Table 10). Iraqi marshes became responsive to rehabilitation after the southern marshes desiccation by ex-government [36].

Table 10. The difference in phytoplankton community structure in southern Iraqi marshes during four decades.

| Marshes | Number of species | References |
|---------|-------------------|------------|
| Central Marshes | 68 | [37] |
| Al-Hammar marsh | 59 | [38] |
| Al-Midayna & Al-Chebayesh | 100 | [39] |
| Al-Hammar & Um Al-Shwaiga | 196 | [40] |
| Al-Hammar marsh | 116 | [41] |
| Al-Hammar marsh | 120 | [42] |
| Abu-Zirig marsh | 164 | [7] |
| Al-Hawizeh marsh | 85 | [43] |
| Central Marshes | 89 |        |
| Al-Hammar marsh | 64 |        |
| Al-Hawizeh marsh | 199 | [44] |
| Central Marshes | 215 |        |
| Al-Hammar marsh | 179 |        |
| Al-Auda Marsh | 193 | [11] |
| Al-Auda Marsh | 146 | [13] |
| Al-Auda Marsh | 246 | Present study |

4. Discussion:

In the food chain of the marsh, phytoplankton plays a vital role in carbon and oil, so it is important to research its species composition to recognize the impact of their interaction with other variables of the environment and marsh hydrology [45]. A total of 246 phytoplankton species were detected in Al-Auda marsh belonging to 75 different genera. Bacillariophyceae record (106 species) that were the dominant group during the study period indicated the stability of marsh conditions and this dominance
of diatoms were noticed in other previous studies on this marsh as [11,13] also observed in other Iraqi marshes [44]. These findings differed from other studies in Iraqi marshes, which recorded the following sequences of major classes: Bacillariophyceae, Chlorophyceae, Cyanophyceae, whereas other classes were less important [11,12 and 46]. The highest number of species (184 species) recorded in summer, while 128 found in the autumn. This might be related to the hydrology regime and dilution of the nutrient associated with high level of water in marsh [45].

The phytoplankton species composition response to re-flooding was noticed by other researchers [11]. These responses differ in terms of total identified phytoplankton which ranged from 193 species during the period from November to August 2007 after re-flooding in 2004 till the present study 246 species in the period 2012-2013 in which the marsh had a good hydrology and vegetation cover. While in the study [13] the species identified 146 species of phytoplankton. This indicates that the phytoplankton community did not respond similarly to re-flooding [47]. This response may be because the phytoplankton community dynamics were affected by complicated interactions between physical, chemical, and biological factors [46]. Spatial variations were noticed for many species. The highest number (200 species) were recorded in site 2, followed by (194 species) in site 4, the lowest number (169 species) was revealed in site 6. These results suggest that the non-dried sites (site 1 and site 4) have more response to re-flooding than the semi-dry section (site 6). The slight differences observed in algae taxa in examined sites, due to light penetration, and the changes in physical conditions [48]. Bacillariophyceae was dominant in site 2 (44.44% and 44%) during autumn and Summer respectively (Table -5). The previous studies in the Al-Auda marsh noticed that the percentage of identified diatoms was 69.43% of the total number of species [11] during the period between 2006-2007, in study [13] the percentage of diatoms reached 61.64%, whereas in the present study decreased to 43.09% between 2012-2013, this may due to the variations in re-flooded the study areas within marsh through this study. The domination of diatoms in internal Iraqi water is a common phenomenon, due to their capability to withstand a wide range of changes in environmental conditions and the availability of silica in the Iraqi basins which is used in the diatom frustule structure [49]. Dominant abundance of diatoms may be an indication of the mesotrophic conditions of the water bodies [50]. Flooding and drought events may result in altering the productivity and community composition that in turn lead to changes in trophic status of an aquatic ecosystem [51].

The domination of diatom is a well-known phenomenon as shared many studies were done on the Iraqi aquatic ecosystems [40,44]. On the other hand, the Bacillariophyceae class recorded the highest relative abundance of 43.09% in autumn, this may due to light intensity and long photoperiod [52] decomposition of organic materials [9] aeration conditions, and availability of food resources [10], while the lowest abundance of Bacillariophyceae 36.99% were reported in spring as a result of high temperature that causing in the decrease of dissolved oxygen, or differences in concentrations of nutrients in water [53]. Examination highest relative abundance of Chlorophyceae in Summer while the lowest relative abundance recorded in Autumn. This coincides with increasing the temperature and light transmittance. Both Cyanophyceae and Euglenophyceae occupied the third rank with 29 taxa, this may due to more activity of Cyanophyceae in autumn that had responded to conditions increased nutrient in water, light transmittance in addition to low-temperature [54]. While the low abundance in spring that due to decreased concentrations of nutrients, light intensity, and lack of dissolved oxygen with higher temperatures [55]. The seasonal variations were clear in existence algae in all examined sites where the highest number of algae achieved (157) and (150) species were recorded in (sites 1 and 2) in spring and Summer respectively. The results showed that the highest species of algae was recorded in summer and spring season, this may due to many factors that have a role in the occurrence of algae such as temperature, light density, and diluted factor [56], in addition to the activities of agriculture and sewage have thrown into the study area. On the other hand, the decrease species of algae in autumn because the algae affected by the movement of waves and variation of water surface, therefore be vulnerable to severe conditions [57], this result was supported by those reported by a previous study [58].
Overall, the genera *Nitzschia*, *Cymbella*, and *Gomphonema* of Bacillariophyceae (Pinnales) were more recorded species of 15, 10 and 10 species, respectively in all testing sites during the study period. The dominant species *Nitzschia* palea was one of the most common species in the genus *Nitzschia*, which is often found in organically polluted water [59]. Regarding the *Achnanthes minutissima* was one of the dominant pinnales diatoms probably because this species is more resistant than larger diatom cells. This would partly be due to its large surface to volume ratios [60]. Pinnales diatoms, common genera such as *Achnanthes*, *Fragilaria*, *Navicula*, and *Nitzschia* [61], are typically the dominant algal classes of nutrient-rich, temperate freshwater wetlands. [61]. The genus *Navicula* and *Cymbella* of Pinnales diatom have been considered as indicators for pollution, that it is absent or appear in case the pollution [62]. The results showed an increase in the abundance of centric diatoms belonging to Mediophyceae class (*Cyclotella* spp.) of 7 species compared to other species in all study sites during summer this disagrees with [13]. As well as, *Cyclotella* was also recorded as the dominant species in other studies [63]. However, the oligotrophic conditions during flooding events may occur due to decreased water temperature and increased turbidity which correspond to the decline in the photosynthesis process [13]. While, the *Cylcotella meneghiana* is not only euplanktonic but can also be benthic or potamoplanktonic [64]. The short life cycle of diatoms and their response to environmental changes give a relative state of habitat restoration [65]. Moreover, the current study recorded a high number of Euglenophyceae during spring and summer of (14 and 8 species) were belonged to *Phacus* and Euglena genera respectively, while only 1 of *Phacus* and 2 species of *Euglena* was reported in autumn, this result could be due to the rainfall in this period, increasing organic matter and nutrient loading, thus providing appropriate environmental conditions for Euglenophyceae, where the Euglenophyceae structure depends on a variety of biotic and abiotic environmental factors [66]. Furthermore, the *Anabaena sp.*, *Oscillatoria limnetica*, and *Lyngbya limnetica* of Cyanophyta were among the most abundant Cyanophyta in fresh and brackish water, most of these species prefer relatively alkaline, warmer, saline, and nutrient-rich waters [67].

Regarding the biodiversity indices, the Shannon-Wiener index values were more than 1 during the study period in all sites of the marsh, which indicates a high diversity of phytoplankton species [51]. The diversity reaches its highest value whenever all species are present with the same numerical abundance, while decreasing in index values (less than 1) indicates domination of certain species of phytoplankton owing to appropriate environmental conditions. The variations of phytoplankton composition reflect the changes in water conditions, thus used to evaluate the status of the aquatic environment. Shannon-Weaner index is directly proportional to the number of species in the sample and the similarity of the species distribution [23]. In the six studied sites of marsh, species diversity was relatively high, which indicates good environmental conditions to the development of many species, according to [68], while decrease diversity in autumn and winter may due to increasing the level of water in marsh through flooding, rainfall, decline in photosynthesis process lack of lighting and low temperature, this result agreed with [69].

The present study revealed from the richness index that maximum value 3.69 was done in site 1 during Spring, while the minimum value 1.94 was detected in site 6 during Autumn 2012. From the seasonal variation of richness index values, it is clear that the highest values are recorded during the Spring and Summer seasons, while the lowest values recorded during Autumn and Winter seasons, which indicates the high diversity in Al-Auda marsh and that the environmental conditions were suitable for the phytoplankton growth and diversity [46] this result agrees with other studies [13, 45]. In comparison between dry period (spring and summer seasons) with the wet period (Autumn and winter seasons), has an increase in temperature, irradiance, and newly circulated nutrients as a result producing favorable conditions for many species, in contrast during the wet period, only a few species persisted under high stress that coincided with the flood period, the phytoplankton abundance and diversity were dropped, and the increase in water level due to flooding events caused the shifting in a water body from turbid, high algal abundance state to clear state [51]. On the other hand, Evenness index values exceeded 0.2 in all the studied areas and seasons, where the value ranged between 0.46 - 0.94, which indicates the distribution of the biomass among species within the community and they
were not [23]. The important point with biodiversity index was the decrease of indices values during Autumn and winter, where the flooding occurs decreasing phytoplankton diversity, biomass, and abundance, this shifting in phytoplankton composition corresponded with a decrease in diversity during this extreme flooding event [70]. Most of the detected phytoplankton species during the present study are of benthic origin, these results are supported by the previous studies [7,40 and 44]. Finally, through our observations during the current study no ecosystem management was executed of Al-Auda marsh, as well as the intervention of local population in the closure and opening of marsh inlets and different land exploitation confused describing some of the differences within the marsh.

5. Conclusion:
The results of the present study identified twelve classes of the phytoplankton community in Al-Auda marsh. Bacillariophyceae class was the dominant group in the other classes in the study area. *Nitzschia, Phacus, Cymella, and Gomphonemamost* species were predominant diatoms in all studied sites. The seasonal distribution revealed that phytoplankton mainly bloomed in the summer and spring seasons. The highest number of species was recorded in the summer, while the lowest number was identified in the autumn. There were positive and negative relationships of physical and chemical factors with phytoplankton that differed according to the response of each class. The results revealed Al-Auda marsh is a mesotrophic according to phytoplankton species composition.

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