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Impact of some environmental parameters on phytoplankton diversity in the eastern Al-Hammer marsh / southern Iraq

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Abstract:

Biodiversity is one of the important biological factors in determining water quality and maintaining the ecological balance. In this study, there are 223 species of phytoplankton were identified, and they are as follows**:** 88 species of Bacillariophyta and were at 44%,70 species of Chlorophyta and they were at 29 %, 39 species of Cyanophyta and they were at 16 %, 12 species of Euglenozoa and they were at 4 %, four species of Miozoa and they were at 3 %, and, Phylum Charophyta and Ochrophyta were only eight and two species, respectively and both of them were at 2%. The common phytoplankton recorded in the sites studied include *Nitzschia palea*, *Scenedesmus quadricauda*, *Oscillatoria princeps***,** and *Peridinium bipes*, These species recorded a significant positive correlation with Ec, Sio3, and WT. Phytoplankton including *Gomphosphaeria semen-Vitis, Dicloster acuatus*, *Tetrastrum heteracanthum,* and *Dictyocha fibula*, recorded a significant positive correlation with NO3, PO4, DO, and PH. Water temperature ranged between 14.200 -33.900 °c in Al-Mansoury and Al-Sada respectively. Electrical conductivity ranged between 2.790 - 11.900 ms/cm in Al-Sada and Al-Mansoury respectively. PH ranged between7.750-8.600 in Al-Dawody and Al-Mansoury respectively. Dissolved Oxygen (DO) ranged between 5.950 -13.000 mg/l in Al-Dawody and Al-Mansoury respectively.WT recorded negative correlation with pH (r= - 0.591), $NO3^{-2}$ (r= - 0.463) and DO (r= - 0.603). Nitrate ranged between 0.570-12.200 µg /l in Al- and Al-Sada respectively. Phosphate ranged between 0.003-0.154 µg/l, in Al-Dawody and Al-Mansoury respectively. Silicate ranged between 51.200-198.600 µg /l in Al-Baraka and Al-Dawody respectively. Shannon - Weiner index (H`) ranged between 2.275-3.162 in Al-Dawody and Al-Mansoury respectively. Simpson index ranged between 0.856-0.950 in Al-Mansoury and Al-Sada respectively, while the Evenness index was 0.514-0.933 in Al-Dawody and Al-Baraka respectively. Shannon- Weiner index (H`) recorded a significant positive correlation with the Simpson index .

Keywords: Al-Hammer marsh, Biodiversity index, Environmental parameters, Phytoplankton

Introduction:

Aquatic ecosystems are the main sources of the continuance of life for most organisms that live in the aquatic system[1]. Phytoplankton is the primary producers and significant source of nutrients in an aquatic ecosystem as they involve in the biogeochemical cycles of several elements to supply heterotrophic organisms with organic material. They are the essential biological characteristic that regulates productivity and nutrient cycling within food webs and carbon usage, along with water quality in determining the water ecosystems' ecological state. Phytoplankton availability is 40% of the world's primary production, and it is the foundation of the aquatic food chain[2,3]. Due to minor changes in nutrients and their brief life cycle, Phytoplankton reacts swiftly to environmental changes[4,5]. Changes in hydro-climatic, biological, and chemical factors of the aquatic ecosystem have affected the distribution and abundance of Phytoplankton communities which indicate the water quality[6]. Since Phytoplankton communities are generally more sensitive to pollution, therefore, they are the best biotic indicators of pollution in the aquatic habitat[7].

The study of the environment of the marshes was stopped for a long time due to the drying of the marshes 1990-2003, but after the rehabilitation of the Al-Hammer marsh there are not enough studies of the phytoplankton diversity in the Eastern Al-Hammer marsh, however, there are many studies covered physical and chemical factors and primary production. This study came to diagnose phytoplankton and the accompanying qualitative changes after drying and flooding, as in this study new species that are not registered in the Iraqi environment were recorded[8]. Some of these studies include limnological studies of traits of Al- Hammar marsh after restoration[9], which studied[10] Al-Hammar marsh after the flood; studied[11] evaluating water quality of Al- Hammar marsh with the GIS technique; studied[12] using indicators based on satellite images to evaluate the restoration plan for Al- Hammar marsh. Studied[13] Carlson's Trophic State Index. Following a significant rise in salinity over the 2018 summer, studied[14] the Eastern Al-Hammar marsh's Water Quality Index (WQI) was used as an indication and studied [15] of the primary productivity of phytoplankton in the southern marshes of Iraq. There are recent studies in the other marshes of Iraq, and some studies showed the phytoplankton diversity in the different marshes of Iraq and [16, 17] studied phytoplankton diversity in Auda marsh and studied[18] the effect of physical and chemical factors in the water of the Chabayish marsh.

This work aimed to study the phytoplankton diversity in the Eastern Al-Hammer marsh as well as aquatic environmental factors after it flooded in 2003, whereby the traits of its ecosystem have changed.

Materials and Methods:

Study area

In southern Iraq, there are a lot of marshes, permanent ones and seasonal ones, but the significant marshes are that three marshes act as Iraq's wetlands: Marsh of Al-Hammar, Hawizeh marsh, and the central marshes [19]. The Iraqi marshes have changed significantly during the past 40 years for many reasons, such as drying and constructing dams, etc., which resulted in changing several of its traits, flooded areas, environmental system, and biological diversity composition [20].

East Al- Hammer marsh Fig. 1 acts as part of the South Al- marshes. It stretches for more than 33 kilometers, with the maximum deep water extent of 1.00 – 6.00 meters, depending on the tide. During the conditions in the 1990s, the marsh was exposed to desiccating. The marsh flooded in 2003 and recovered its vegetation and wildlife to varying degrees[13]. The study was continued from December 2019 to November 2020, Phytoplankton was collected from four different sites by net (Al-Sada, Al- Mansoury, Al-Dawody, and Al-Baraka), Al-Sada site (N″ 30˚37.24.2 E″ 47˚40. 07.7) is a far 6 km away from the Karma Bridge. The depth is approximately 6 m, it contains animals, birds, and Crustaceans, as well as various fishing operations, fishing Fish, shrimp, and birds that were recently damaged due to the progression of the saline tongue. Al- Mansoury site (N″30˚40.31.4 E″47˚37. 22.9') is a distance from the site. Al-Sada is about 2 km away, and it is less area than the Al-Baraka site, but it is deeper than that and characterized this area is elongated in shape and called channel marsh, which contains branches and fish farms on the edges. It is one of the large marshes that are called Openness marsh. Al-Dawody site (N″ 30˚41.30.5 E″ 47˚35. 52.1)'is a narrow water channel of less depth, the height of the muddy land on two sides, the presence of many aquatic plants and the presence several different birds on the site Al-Baraka site (N″ 30˚41.47.8' E″ 47˚32. 59.6) is an open and shallow area. The depth does not exceed three meters; it reaches its depth of 0.5m on the Islands. It is a far 13 km from the first station and much aquatic life, fish, shrimp, and many types of birds, reptiles, and mammals are inhabited it.

Field and laboratory study

water temperature (ºC), electrical conductivity (EC) and pH were measured monthly using TRI METER (PH/EC-983) and DO determine by using an Oxygen meter (WTW). Nitrate, phosphate and silica were calculated based on [21]. The phytoplankton samples for this study were collected using a net of the size of about 20µm, we throw the net into the water and pulled it at a proper speed for 15 minutes, then collect the contents in the polyethylene bottle is clean and fixation in the field using formalin solution with a concentration of % 4 . For microscope research and species identification, all organic material in diatom and silico-flagellate frustules must be oxidized and removed so that the valve structure can be observed. The frustules were cleaned in this study by boiling them in hydrogen peroxide. The 10 mL diatom suspension was heated for 30-45 minutes in 20 mL 30 % H_2O_2 or until the suspension became transparent [22] 10 ml. The diatom suspension was allowed to settle at room temperature before being washed four times with distilled water and filtered using Whatman No. 1 filter paper to eliminate all organic contaminants permanent slides were made using Naphrax®. Algae morphology was screened (400x magnification). The Haemocytometer technique was used to count the non-diatom algae [23]. One drop of the sample was

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placed on a glass slide, covered with a glass cover slip, and viewed under a microscope with magnification 40x. using a microscope digital camera (SCMOS03000KPA) and cell dimension (diameter, length, and width) of investigated algae, and algae were diagnosed based on the results [24-26].

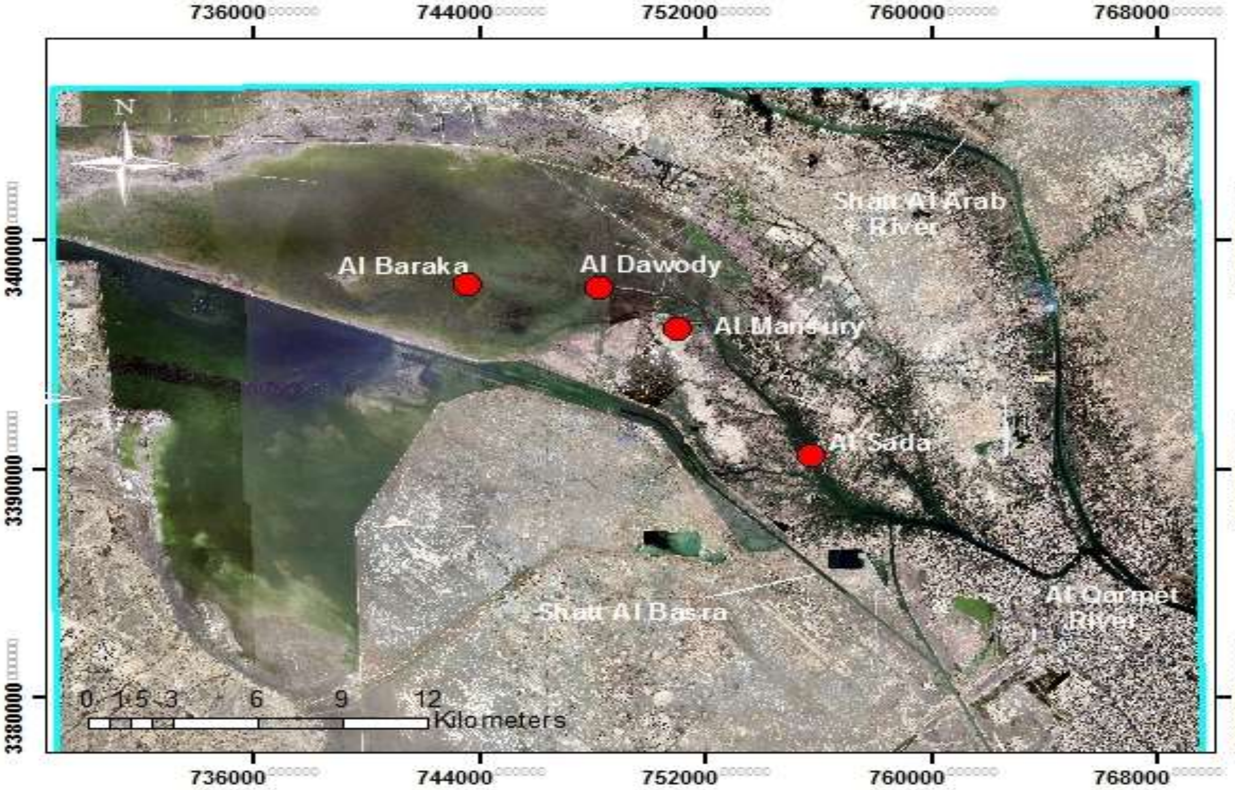

Figure 1. A map of sample collection sites from East Al-Hammer marsh, South of Iraq

Shannon - Weiner diversity index (H`): [27]
index value was calculated by using the formula.*
H` =- Σpilnpi Where, ‘pi’ equal ni/N
ni: is the number of individuals in each species
N: the total number of individuals in the sample
Simpson’s diversity index(D): [28]
This index represents the abundance ratio of individual species to that of total* abundance values. It was calculated using the following formula $D = 1/\Sigma pi^2$
pi: is the preparation of the species to total abundance value.
Pielou's evenness index (J): [29]*
J = H′/ln S
Where:
S : total species H’: diversity index
Margalef Index (D): [30]*
D = S-1 / ln N
S: total species
N: the total number of individuals in the sample

Results and Discussion:

Values of physical-chemical parameters showed variations in the current study among four sites over ten months. WT ranged from 14.200 °c in Al-Mansoury during January and 33.900 °c in Al-Sada during July, while ranging between 15.100-32.900°c in Al-Baraka and Al-Dawody respectively.WT recorded no Significant differences in all sites $p > 0.05$. some species appeared in the hot months such as *Nitzschia palea*, and *Oscillatoria princeps*, and some species appeared in the cold months such as *Gomphosphaeria semen-vitis*, *Dicloster acuatus* because WT is important for the physiology, behavior, distribution, survival, growth, and reproduction processes[31,32]. The solubility of gases and salts in water is influenced by temperature, this is a confirmed negative correlation between WT and DO (r= - 0.603) which is a significant component. Higher Electrical conductivity values of 11.900 ms/cm were observed in Al- Mansoury during May and a lower value of 2.790 ms/cm was observed in Al-Sada during November while ranging between 2.990 -11.400 ms/cm in Al-Baraka and Al-Dawody respectively due to decreased water discharges from Tigris and Euphrates and water entry from Arabian gulf across Shatt Al-Arab [33,34]. EC recorded Significant differences in all sites $p < 0.05$, most diatom species recorded in the current study adapted to be found in saline and brackish water[35].EC showed significant negative correlation with NO_3 (r= -0.328) this agree with[33-36] Table 1. Higher pH values of 8.600 were observed in Al-Mansoury during January and a lower value of 7.750 was observed in Al-Dawody during July while ranging between 7.840 - 8.530 in Al-Sada and Al-Baraka respectively. Increasing in pH may be the increase in the density of phytoplankton, the increase in the process of photosynthesis for algae and aquatic plants, and an increase in the consumption of carbon dioxide according to to [6,37]. This confirmed a significant positive correlation between PH and DO (r=0.630). Higher Dissolved Oxygen values13.000 mg/l were observed in Al-Mansoury during January and a lower value of 5.95 mg/l was observed in Al-Dawody during July while ranging between 7.540 -11.800 mg/l in Al-Sada and Al-Baraka respectively, the low values for (DO) in the hot months return to high temperatures and salinity[38] as well as an increase in activity organisms (bacteria) that decompose organic matter and consume oxygen, higher values for (DO) may be to increased photosynthesis rates by phytoplankton and aquatic plants, as well as a larger surface water area that allows for better mixing and oxygen compensation from the atmosphere [38], the current study agreed with the studies [36,39].

The maximum reactive Nitrate was 14.730 µg /l in Al-Sada in December, and the slightest in Al-Dawody 0.570 µg /l in August while ranging between 0.800 -11.740 µg /l in Al-Baraka and Al-Mansoury respectively. NO3 recorded Significant differences in all sites $p < 0.05$ .The maximum reactive phosphate was 0.154 µg /l in Al-Dawody in January slightest in Al-Mansoury 0.003 µg /l in May while ranging between 0.004 -0.141 µg /l in Al-Sada and Al-Baraka respectively, whereas the maximum reactive silicate 198.60 µg /l in Al- Baraka in July and lowest in Al-Dawody 51.200 µg /l in February while ranged between 61.6 -174.6 µg /l in Al-Mansoury and Al-Sada respectively, Sio3 showed a significant positive correlation with Wt (r=0.630). Po4 and sio3 recorded no Significant differences in all sites $p > 0.05$ these results agreed with[36]. In addition to the release of silica from sediments or the decomposition of diatom cells [40], these nutrients are rapidly eaten by the aquatic plants growing in the marsh. Phosphate (PO4) and nitrate NO3 concentrations were low[10]. Phytoplankton production is influenced by nitrogen, phosphorus, and inorganic phosphate. They respond quickly to the environment, disagreeing due to delicate nutrient alterations and their short life cycle[41,42]. The growth of phytoplankton lowers the levels of micronutrients in the surface layers, such as nitrates, phosphates, and silicates, and limits primary production. This, too, is largely influenced by local weather conditions and topography [43].

Phytoplankton identified approximately 223 taxa belonging to 93 genera, Bacillariophyta represented the highest percentage 44% belonging to 88 taxa,41 genera, they respond quickly to changes in the environment[44] the common genera *Nitzschia* 13 species and was one of common genera found at all sites due to the large range of environmental tolerance[45] and was from the common species *Gyrosigma* and *Tryblionella* found with eight species for both, *Navicula* six species, *Halamphora*, *Luticola* and *Surirella* found with three species for both, *Amphora*, *Campylodiscus*, *Cocconeis*, *Cyclotella*, *Cymatopleura*, *Cymbella*, *Entomoneis*, *Gomphonema*, Rhopalodia, *Tabularia* found with two species for both and recorded only one species for *Achnanthes brevipes* var. *intermedia*, *Bacillaria paxillifera*, *Coscinodiscus gigas*, *Diploneis smithii*, *Epithemia turgida*, *Mastogloia braunii*, *Pleurosigma elongatum* in the most sites, Bacillariophyta are dominant over the rest of the other groups, whether they are floating or attached[46-49] and most of species recorded in eastern Al- Hammar marshes were brackish water species agreement with[45,50].

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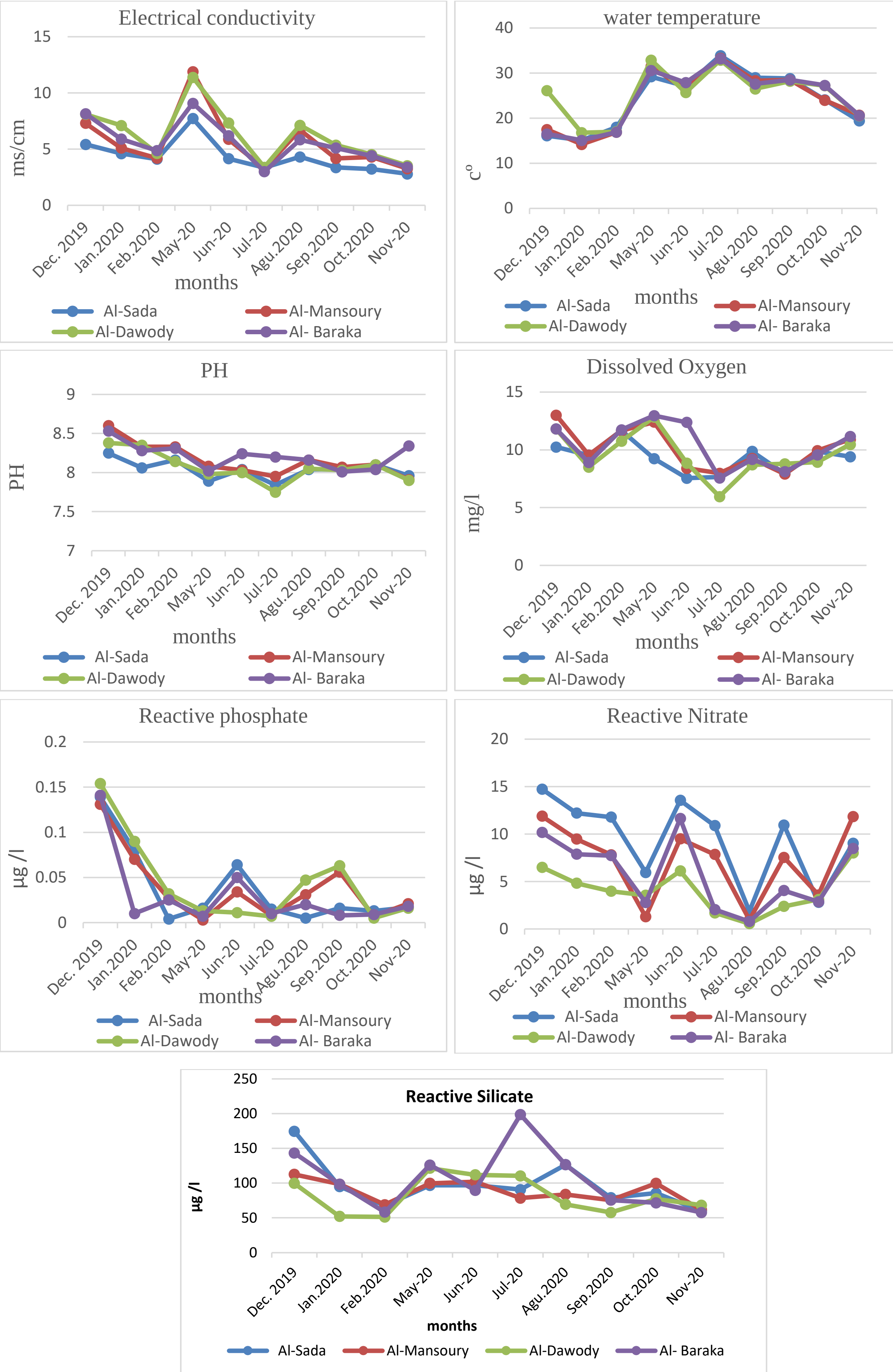

Figure 2. Physicochemical and *nutrients* parameters were variations in current study *2019-2020*

The second group, Chlorophyta 29 %, belongs to 70 taxa, and 27 genera. The common genera are *Scenedesmus* 17 species; *Cosmarium* seven species, *Oocystis* and *Tetraedron*, found with six species for both, *Pediastrum* five species *Crucigenia* and *Ankistrodesmus,* found with four species for both, The other groups were Cyanophyta 16 % belonging to 39 species 15 genera, common genera that *Oscillatoria* eight species. *Chroococcus* six species, *Merismopedia* and *Gomphosphaeria* found with four species for both, *Anabaenopsis* and *Spirulina* found with two species for both and recorded only one species for *Komvophoron minutum*, *Pseudanabaena galeata.* Euglenozoa 4% belonging to 12 species three, common genera that *Euglena* eight species and was from the common species, *Phacus* three species and recorded only one species for *Lepocinclis glabr*, Miozoa(3%)belonging to four species three genera, common genera that *Peridinium* two species., recorded only one species for, *Glenodinium armatum*, *Noctiluca scintillans* Table. 2.

The correlation between the common species and environmental parameters at all sites was studied using (CCA) *N. palea* distributed evenly in sites of the current study and has a strong positive correlation between EC, silicate, and WT. On the other hand, this species shows a strong negative correlation with NO3, PO4, and pH because a plateful of Silicate makes diatoms take NO3 and PO4 at a much faster rate to build their cellular materials[51] Fig 3. *S.quadricauda* has a strong positive correlation with NO3 and EC because can be grown in a great range of brackish or saline water[52]. O. princeps has a strong positive correlation with PO4 and PH, and a moderate positive correlation with NO3 because these factors are responsible for the growth[53]. On the other hand, this species includes a strong negative correlation with EC. *E. Proxima* recorded a significant positive correlation with PH and WT agreement with[18]. *P. bipes* distributed evenly in sites of the current study and showed a significant positive correlation with pH, NO3, and PO4 and showed a negative correlation with WT and EC. This indicates that the WT, pH, EC, nutrient nitrogen and phosphor play a pivotal role in the productivity and community structure of phytoplankton [6,54]. phytoplankton recorded during intermittent periods include *Gomphosphaeria semen-vitis, Dicloster acuatus, Tetrastrum heteracanthum*, and *Dictyocha fibula* have a strong positive correlation with NO3and PO4 because these nutrients limiting factors for the growth of phytoplankton**.** On the other hand, these species include a strong negative correlation with WT and EC, WT is important for the physiology, behavior, distribution, survival, growth, and reproduction processes[31,32].

The Shannon diversity indicator is widely used to determine diversity that considers both the number and evenness of species in a community. It is a number that ranges from 0 to 4. The Shannon index (H`) for phytoplankton was found to be the highest in Al-Dawody in May at 3.162 and indicates (less pollution) and lowest in Al-Mansoury in October at 2.275 indicate (more pollution) according to[55] that 0–1 (high pollution) 1–2 (moderate pollution), 2–3 (small pollution) and of 3–4 for inceptive pollution while ranged between 2.354 -3.045 in Al-Baraka and Al-Sada respectively.

The Simpson index (D) value ranges between 0 and 1, Simpson diversity index increases as a species evenness and increases richness [6] a strong positive significant correlation between the Simpson diversity index with the evenness index (r=.490) for phytoplankton was found to be the highest in Al-Dawody in May (0.950) and lowest in Al-Mansoury in October 0.856 while ranged between 0.873 -0.945 in Al-Baraka and Al-Sada respectively. Evenness Index was found to be the highest in Al-Baraka in May 0.933 and lowest in Al-Dawody in July (0.514) while ranging between 0.572 -0.877 in Al-Mansoury and Al-Sada respectively. The evenness index indicates all species have equal abundance in the sample of site[56]. Higher diversity values show the organism's suitability for the environment, more complicated ecosystems, as well as a more stable community.

The marsh has suffered from drying. As a result, the characteristics of its ecosystem have changed, and all its organisms have been affected, including algae. Other researchers noticed the phytoplankton species composition reaction to re-flooding[17]. After 2003, uncontrolled releases of Tigris and Euphrates River waters partially recovered some old marsh areas in southern Iraq, but restoration in others is failing due to the excessive soil and water salt concentrations[57].

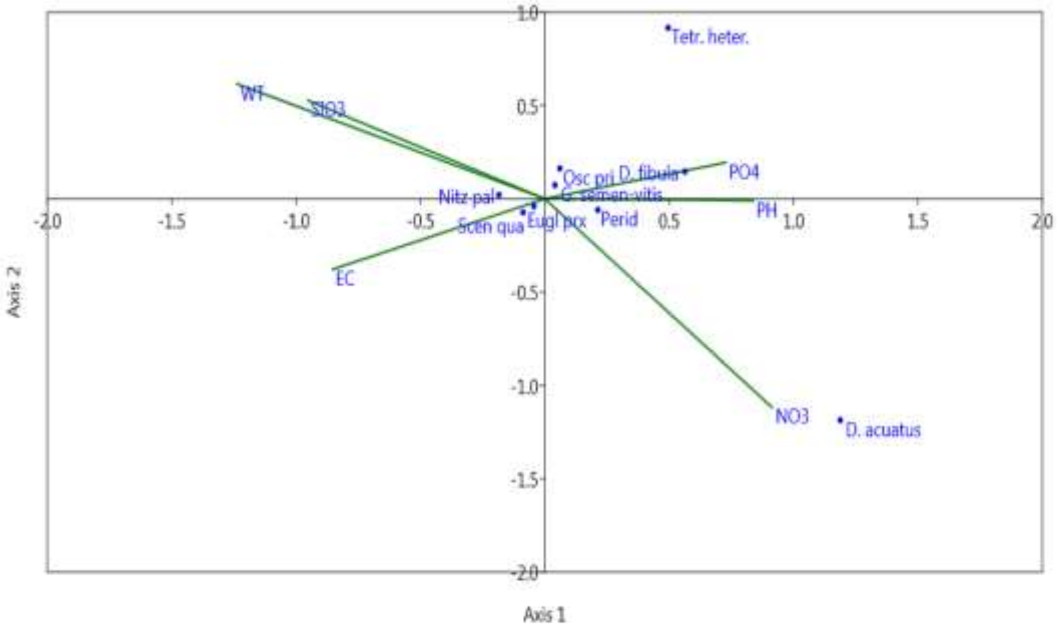

Figure 3. CCA- diagram of correlation between common species and phytoplankton *recorded during intermittent periods with environmental parameters*

Table 1. ***correlation between the environmental parameters and phytoplankton in*** **the eastern AL- Hammar marsh, southern Iraq during 2019-2020**

	Wt	Ec	PH	DO	NO3	PO4	SIO3	shan	Simp	even
Wt	1									
Ec	.130	1								
PH	-.591**	.225	1							
DO	-.603**	.231	.630**	1						
NO3	-.463**	-.328*	.113	.226	1					
PO4	-.103	.031	.247	.012	.164	1				
SIO3	.480**	.189	-.097	-.328*	-.328*	-.139	1			
shan	-.015	.111	.009	.184	-.017	-.069	-.138	1		
Simpson	.036	.108	.039	.175	.071	-.101	-.012	.934**	1	
even	.141	.127	-.017	.030	.157	-.115	.328*	.258	.490**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 2. Phytoplankton species were identified in the eastern Al-Hammar marsh, southern Iraq during 2019-2020

Phylum	Cyanobacteria(Cyanophyta)
Class	Cyanophyceae
Order1	*Chroococales*
Family1	*Chroococaceae*
Genus1	*Chroococcus* Naeg, 1849
	C. dispersus (Keissler) Lemmermann
	C. giganteus West
	C. limneticus Lemmermann
	C. minor (Kützing) Nägeli
	C. minutus (Kützing) Nägeli
	C. mipitanensis (Wolszynska) Geitler
	C. turgidus (Kützing) Nägeli
	C.sp.
Family2	Cyanothrichaceae
Genus1	Johannesbaptistia De Toni 1934
	J. pellucida (Dickie) W.R.Taylor &Drouet
Family3	Gomphosphaeriaceae
Genus1	*Gomphosphaeria* Kützing, 1836
	G. aponina Kützing
	G. aponina var. *cordiformis* Wolle
	G. aponina var. *delicatula* Virieux
	G. semen-vitis Komárek
Family4	Microcystaceae
Genus1	Gloeocapsa Kuetzing 1843
	G. aeruginosa Kützing
Genus2	*Microcystis* Kuetzing, 1846
	M. aeruginosa (Kützing) Kützing
	M. aeruginosa f. *flos-aquae* (Wittrock) Elenkin
2Order	Nostocales
Family1	Aphanizomenonaceae
Genus1	*Anabaenopsis* V.V.Miller,1923
	A. circularis (G.S.West) Wołoszyńska &V.V.Miller
	A. elenkinii V.V.Miller
Family2	Nostocaceae
Genus1	*Anabaena* Bory ex Bornet & Flahault, 1886
	A. flos-aquae (Bornet & Flahault) Elenkin
3Order	Oscillatoriales
Family1	Gomontiellaceae
Genus1	*Komvophoron* Anagn. and Kom. 1988
	K. minutum (Skuja) Anagnostidis &Komárek
Family2	Oscillatoriaceae
Genus1	*Lyngbya* C.Agardh ex Gomont, 1892
	L. aerugineocaerulea Gomont
Genus2	*Phormidium* Kützing ex Gomont, 1892
	P. ambiguum Gomont
Genus3	*Oscillatoria* Vaucher, 1892
	O. agardhii Gomont
	O. brevis Kützing ex Gomont
	O. curviceps C.Agardh ex Gomont
	O. limnetica Lemmermann
	O. limosa C.Agardh ex Gomont
	O. princeps Vaucher ex Gomont
	O. splendida Greville ex Gomont
	O. tenuis C.Agardh ex Gomont
4Order	Spirulinales
Family1	Spirulinaceae
Genus1	*Spirulina* Tupin and. Gardner, 1827
	S. gigantea Schmidle
	S. major Kützing ex Gomont
5Order	Synechococcales
Family1	Coelosphaeriaceae
Genus1	Coelosphaerium Naeg. 1849
	C. dubium Grunow
	C. kuetzingianum Nägeli
Family2	Merismopediaceae
Genus1	Merismopedia Meyen, 1839
	M. convoluta Brébisson ex Kützing
	M. elegans A.Braun ex Kützing
	M.glauca (Ehrenberg) Kützing
	M. punctata Meyen, nom. illeg
Family3	Pseudanabaenaceae
Genus1	*Pseudanabaena* Lauterborn, 1915
	P. galeata Böcher

Phylum	Chlorophyta
Class1	Chlorophyceae
Order1	Chlamydomonadales
Family1	Chlamydomonadaceae
Genus1	Carteria Diesing,1866
	C. cordiformis (H.J.Carter) Diesing
Genus2	Chlamydomonas Ehrenb,*1833*
	C. angulosa O.Dill
	C. globosa J.W.Snow
Family2	Chlorococcaceae
Genus1	Chlorococcum Meneghin,1842
	C. humicola (Nägeli) Rabenhorst
Family3	Goniaceae
Genus1	*Gonium* O.F. Müller, 1773
	G. pectorale O.F.Müller
Family4	Volvocaceae
Genus1	*Eudorina* Ehrenberg,1832
	E. elegans Ehrenberg
Genus2	*Pandorina* Bory, 1826
	P. morum (O.F.Müller) Bory
Genus3	*Pleodorina* W.R.Shaw, 1894
	P.californica W.R.Shaw
Order2	*Sphaeropleales*
Family1	Hydrodictyaceae
Genus1	*Pediastrum* Meyen, 1829
	P.boryanum (Turpin) Meneghini
	P. duplex Meyen
	P.duplex var. *reticulatum* Lagerheim
	P. simplex Meyen
	P. tetras (Ehrenberg) Ralfs
Genus2	*Tetraëdron* Kützing, 1845
	Tetraëdron caudatum (Corda) Hansgirg
	T.incus (Teiling) G.M.Smith
	T.minimum (A.Braun) Hansgirg
	T.muticum (A.Braun) Hansgirg
	T. regulare Kützing
	T.trigonum (Nägeli) Hansgirg
Family2	Neochloridaceae
Genus1	*Golenkinia* Chodat, 1894
	G. radiata Chodat
Family3	Radiococcaceae
	Gloeocystis Nägeli, 1849
	G. gigas (Kützing) Lagerheim
Family4	Scenedesmaceae
Genus1	*Coelastrum* Nägeli *,1849*
	C. astroideum De Notaris
	C.microporum Nägeli
	C.reticulatum (P.A.Dangeard) Senn
Genus2	*Scenedesmus* Meyen, 1829
	S. abundans (O.Kirchner) Chodat
	S.acuminatus (Lagerheim) Chodat
	S. acuminatus var. *inermius* (Playfair)Playfair
	S.acuminatus var. *minor* G.M.Smith
	S.acutus Meyen
	S.arcuatus (Lemmermann) Lemmermann
	S.armatus (Chodat) Chodat
	S.bernardii G.M.Smith
	S.bijugus (Turpin) Lagerheim
	S.bijugatus Kützing, nom. illeg.
	S.brasiliensis Bohlin
	S.dimorphus (Turpin) Kützing
	S.ellipticus Corda
	S. opoliensis P.G.Richter
	S. obliquus (Turpin) Kützing
	S.quadricauda (Turpin) Brébisson
	S.quadricauda var. *maximus* West & G.S.West
Genus3	*Tetrastrum* Chodat, 1895
	T. heteracanthum (Nordstedt) Chodat
	T. staurogeniiforme (Schröder) Lemmermann
Family5	Schroederiaceae
Genus1	*Schroederia* Lemmermann, 1898
	S. setigera (Schröder) Lemmermann
Family6	Selenastraceae
Genus1	Ankistrodesmus Corda, 1838, emRalfs, 1849
	A. acicularis (Braun) Korshikov
	A. convolutus Corda
	A.falcatus (Corda) Ralfs
	A.falcatus var. *acicularis* (A.Braun) G.S.Wes
Genus2	*Kirchneriella* Schmidle1893
	K. contorta (Schmidle) Bohlin
	K. obesa (West) West & G.S.West
Genus3	*Monoraphidium* Komárková-Legnerová, 1969
	M. contortum (Thuret) Komárková-Legnerová

Class2	Trebouxiophyceae
Order1	Chlorellales
Family1	Chlorellaceae
Genus1	Actinastrum Lagerheim,*1882*
	A. hantzschii Lagerheim
Genus2	*Chlorella* Beyerinck [Beijerinck], 1890
	C. ellipsoidea Gerneck
	C. vulgaris Beijerinck
Genus3	*Closteriopsis* Lemmermann, 1899
	C. longissima (Lemmermann) Lemmermann
Genus4	*Dicloster* C.-C.Jao, Y.S.Wei & H.C.Hu, 1976
	D. acuatus C.-C.Jao, Y.S.Wei & H.C.Hu
Genus5	*Dictyosphaerium* Nägeli, 1849
	D. ehrenbergianum Nägeli.
	D.pulchellum H.C.Wood
Family2	Oocystaceae
Genus1	*Chodatella* Lemmermann, 1898
	C. ciliata (Lagerheim) Lemmermann
Genus2	*Lagerheimia* R.Chodat, 1895, nom. Illeg
	L. ciliata (Lagerheim) Chodat
Genus3	*Oocystis* Nägeli ex A.Braun, 1855
	O. borgei J.W.Snow
	O.crassa Wittrock
	O. elliptica West
	O. lacustris Chodat
	O. natans G.M.Smith
	O. solitaria Wittrock
Order2	Trebouxiophyceae ordo incertae sedis
Family1	Trebouxiophyceae
Genus1	*Crucigenia* Morren, 1830
	C. crucifera (Wolle) Kuntze
	C.quadrata Morren
	C.rectangularis (Nägeli) Gay
	C.tetrapedia (Kirchner) Kuntze
Phylum	Charophyta
Class1	Zygnematophyce
Order1	Desmidiales
Family1	Closteriaceae
Genus1	Closterium Nitzsch ex Ralfs,1848
	C. moniliferum Ehrenberg ex Ralfs
Family1	Desmidiaceae
Genus1	*Cosmarium* Corda ex Ralfs, 1848
	C. abbreviatum Raciborski
	C. angulosum Brébisson
	C. botrytis Meneghini ex Ralfs
	C. contractum O.Kirchner
	C. granatum Brébisson ex Ralfs
	C. hammeri Reinsch
	C. meneghinii Brébisson ex Ralfs
Phylum	Euglenozoa
Class1	Euglenophyceae
Order1	Euglenida
Family1	Euglenidae
Genus1	*Euglena* Ehrenberg, 1830
	E. acus (O.F.Müller) Ehrenberg
	E. convoluta Korshikov
	E. elongata W.Schewiakoff
	E. gracilis G.A.Klebs
	E.oxyuris Schmarda
	E.polymorpha P.A.Dangeard
	E. proxima P.A.Dangeard
	E. spirogyra Ehrenberg
Family2	Phacaceae
Genus1	*Lepocinclis* Perty, 1849
	L. glabra Drezepolski
Genus2	*Phacus* Dujardin, 1841
	P. acuminatus A.Stokes
	P. caudatus Hübner
	P.curvicauda Svirenko
Phylum	Miozoa(*Dinophyta)*
Class1	Dinophyceae
Order1	Peridiniales
Family1	Peridiniales incertae sedis
Genus1	*Glenodinium* Ehrenberg,1836
	G. armatum Levander
Family2	Peridiniaceae
Genus1	*Peridinium* Ehrenberg, 1830
	P. bipes F.Stein
	P. cinctum (O.F.Müller) Ehrenberg
Class1	Noctilucophyceae
Order1	Noctilucales
Family1	Noctilucaceae
Genus1	*Noctiluca* Suriray, 1816
	N. scintillans (Macartney) Kofoid & Swezy
Phylum	Ochrophyta
Class1	Chrysophyceae
Order1	Chromulinales
Family1	Dinobryaceae
Genus1	*Dinobryon* Ehrenberg, 1834
	D. sertularia Ehrenberg
Class2	Dictyochophyceae
Order1	Dictyochales
Family1	Dictyochaceae

Genus1	*Dictyocha* Ehrenberg, 1837
	D. fibula Ehrenberg
Phylum	Bacillariophyta
Class1	Bacillariophyceae
Order1	Achnanthales
Family1	Achnanthaceae
Genus1	*Achnanthes Bory, 1822*
	A. brevipes var.*intermedia* (Kützing) Cleve
Family2	Achnanthidiaceae
Genus1	*Lemnicola* Round & Basson, 1997
	L. hungarica (Grunow Round & Basson
Family3	Cocconeidaceae
Genus1	*Cocconeis* Ehrenberg, 1836
	C. placentula Ehrenberg
	C. placentula var.*euglypta* (Ehrenberg) Grunow
Order2	Bacillariales
Family1	Bacillariaceae
Genus1	*Bacillaria* J.F.Gmelin, 1791
	Bacillaria paxillifera (O.F.Müller) T.Marsson
Genus2	*Nitzschia* Hassall, 1845
	N. amphibian Grunow
	N. amplectens Hustedt
	N. clausii Hantzsch
	N. dissipata (Kützing) Rabenhorst
	N. fasciculata (Grunow) Grunow
	N. filiformis (W.Smith)Hustedt
	N. hybrid Grunow
	N.kurzeana Rabenhorst
	N. obtusa W.Smith
	N. palea (Kützing) W.Smith
	N. sigma W.Smith
	N. sigmoidea (Nitzsch) W.Smith
	N.tryblionella Hantzsch
Genus3	*Tryblionella* W.Smith, 1853
	T. apiculata Gregory
	T. cf. *coarctata* (Grunow) Mann
	T. cocconeiforms (Grunow) Mann
	T. compressa (Bailey) Poulin
	T. granulata (Grunow) Mann
	T. hungarica (Grunow) Frenguelli
	T.levidensis W.Smith
	T. littoralis (Grunow)Mann
Order3	Cymbellales
Family1	Cymbellaceae
Genus1	*Brebissonia* Grunow, 1860
	B. lanceolata(C.Agardh) Mahoney & Reimer
Genus2	*Cymbella* C.Agardh, 1830
	C. cymbiformis C.Agardh
	C.tumida (Brébisson) van Heurck
Family2	Gomphonemataceae
Genus1	*Gomphonema* Ehrenberg, 1832
	G. intricatum var vibrio (Ehrenberg) Cleve
	G.parvulum var. *lagenula* (Kützing) Frenguelli
Family3	Rhoicospheniaceae
Genus1	*Rhoicosphenia* Grunow, 1860
	R. abbreviata (C.Agardh) Lange-Bertalot 1980
Order4	Licmophorales
Family1	Ulnariaceae
Genus1	*Ctenophora* (Grunow) D.M.Williams & Round, 1986
	C. pulchella (Ralfs ex Kützing) Williams & Round
Genus2	*Tabularia* (Kützing) D.M.Williams & Round, 1986
	T. fasciculata (C.Agardh) Williams & Round
	T.tabulata (C.Agardh)Snoeijs
Genus3	*Ulnaria* (Kutzing) Compère, 2001
	U.biceps (Kützing) Compère
Order5	Mastogloiales
Family1	Mastogloiaceae
Genus1	*Mastogloia* Thwaites ex W.Smith, 1856
	M. braunii Grunow
Order6	Naviculales
Family1	Naviculaceae
Genus1	*Caloneis* Cleve, 1894
	C. permagna (Bailey) Cleve
Genus2	*Gyrosigma Hassall, 1845*
	G. acuminatum (Kützing) Rabenhorst
	G. attenuatum (Kützing) Rabenhorst
	G. balticum (Ehrenberg) Rabenhorst
	G. eximium (Thwaites) Boyer
	G. fasciola (Ehrenberg) Griffith & Henfrey
	G. macrum (W.Smith) Griffith & Henfrey
	G. scalproides (Rabenhorst) Cleve
	G. sinensis (Ehrenberg) Desikachary
Genus3	*Haslea* Simonsen, 1974
	H. spicula (Hickie) Bukhtiyarova
Genus4	*Homoeocladia* C.Agardh, 1827
	H. subcohaerens var. *scotica* Grunow
Genus5	*Navicula* Bory, 1822
	N. digitoradiata (Gregory) Ralfs

	N. radiosa Kützing
	N. rhynchocephala Kützing
	N. salinarum Grunow
	N. schroeterii Meister
	N. subrhynchocephala Hustedt
Genus6	*Seminavis* D.G.Mann, 1990
	S. strigosa (Hustedt) Danieledis & Economou-Amilli
Family2	Amphipleuraceae
Genus1	*Vanheurckia* Brébisson, 1868
	V. lewisiana (Greville) Brébisson
Family3	Berkeleyaceae
Genus*1*	*Parlibellus* E.J.Cox, 1988
	P. crucicula (W.Smith)Witkowski,Lange-Bertalot Metzeltin
Family4	Diadesmidaceae
Genus	*Luticola* D.G.Mann, 1990
	L. cf. *mutica* (Kützing) Mann
	L. nivalis (Ehrenberg) Mann
	L. cf. *ventricosa* (Kützing) Mann
Family5	Diploneidaceae
Genus	*Diploneis* Ehrenberg ex Cleve, 1894
	D. smithii (Brébisson)Cleve
Family6	Naviculales_incertae_sedis
Genus	*Pseudofallacia* Y.Liu, J.P.Kociolek & Q.X.Wang, 2012
	P. tenera (Hustedt) Liu, Kociolek & Wang
Genus	*Sieminskia* D.Metzeltin & Lange-Bertalot, 1998
	S. wohlenbergii (Brockmann) D.Metzeltin &Lange-Bertalot
Family7	Stauroneidaceae
Genus	*Craticula* Grunow, 1868
	C. cuspidate (Kutzing) Mann
Family8	Pleurosigmataceae
Genus	*Pleurosigma* W.Smith, 1852,
	P. elongatum W.Smith
Order6	Rhopalodiales
Family1	Rhopalodiaceae
Genus1	*Epithemia* Kützing, 1844
	E. turgida (Ehrenberg) Kützing
Genus2	*Rhopalodia* O.Müller, 1895, nom. cons.
	R. gibba (Ehrenberg) O.Müller
	R.musculus (Kützing) O.Müller
Order7	Surirellales
Family1	Surirellaceae
Genus1	*Campylodiscus* Ehrenberg ex Kützing, 1844

	C. cf. *bicostatus* W.Smith ex Roper
	C. sp.
Genus2	*Cymatopleura* W.Smith, 1851
	C. elliptic (Brébisson) W.Smith
	C.solea (Brébisson)W.Smith
Genus3	*Petrodictyon* D.G.Mann, 1990
	P. gemma (Ehrenberg) D.G.Mann
Genus4	*Surirella* Turpin, 1828
	S.robusta Ehrenberg
	S.striatula Turpin
	S. tenera W.Gregory
Family2	Entomoneidaceae
Genus	*Entomoneis* Ehrenberg, 1845
	E. alata (Ehrenberg) Ehrenberg
	E. paladosa (W.Smith) Reimer
Order8	Thalassiophysales
Family1	Catenulaceae
Genus1	*Amphora* Ehrenberg ex Kützing, 1844
	A. fluminensis Grunow
	A. ovalis (Kützing) Kützing
Genus2	*Halamphora* (Cleve) Mereschkowsky, 1903
	H. ghanesis Levkov
	H. paraveneta(Lange-Bertalot, Cavacini, Tagliaventi & Alfinito) Levkov
	H. veneta (Kützing) Levkov
Class2	Coscinodiscophyceae
Order1	Coscinodiscales
Family1	Coscinodiscaceae
Genus1	*Coscinodiscus* Ehrenberg, 1839
	C. gigas Ehrenberg
Class3	Mediophyceae
Order1	Stephanodiscales
Family1	Stephanodiscaceae
Genus1	*Cyclotella* (Kützing) Brébisson, 1838,
	C. meneghiniana Kützing
	C. straita (Kützing) Grunow
Genus2	*Stephanodiscus Ehrenberg, 1845*
	S. neoastreae Håkansson & Hickel
Order2	Thalassiosirales
Family1	Thalassiosiraceae
Genus1	*Thalassiosira* Cleve, 1873
	T. eccentric (Ehrenberg) Cleve

Conclusions:

The current study indicated the diversity of phytoplankton species in the eastern Al- Hammar marsh following various environmental changes. High salinity in May due to the lack of water drainage from the Tigris and Euphrates rivers and the entry of the waters of the Arabian Gulf through the Shatt al-Arab. Bacillariophyta has been identified as the dominant phylum of phytoplankton and *most species* recorded in eastern Al- Hammar marshes were brackish water *species*. Some species discovered in the current study point to the environment having altered and that saltwater organisms have evolved to survive in freshwater.The physicochemical parameters were variated in the current study among four different *sites*.Common species affected with *Ec, Sio3 WT* while *phytoplankton* recorded during intermittent periods affected with *PO4, NO3, DO, and PH.* The biodiversity indices differed among the stations of the East Al-Hammar marsh, except that the third station, Al-Dawody, was characterized by the highest diversity in the Shannon index and *indicated (less pollution).*

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Basrah.

Authors' contributions statement:

EMJ analyzed the data, NJAM. and IJMAS suggested and developed the project. Both authors participated in writing the paper.

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تأثير المتغيرات الفيزيائية والكيميائية على تنوع الهائمات النباتية في هور شرق الحمار/جنوب العراق

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[3] قسم العلوم البحرية التطبيقية، كلية علوم البحار البصرة، العراق

الخلاصة :

ان التنوع الحيوي من العوامل البيولوجية المهمة في تحديد نوعية المياه والحفاظ على التوازن البيئي .لوحظ في الدراسة الحالية وجود 223 نوعا من الهائمات النباتية وكانت تنتمي الى 88 نوعا *Bacillariophyta بنسبة* 44% تليها Chlorophya تنتمي الى 70 نوعا بنسبة 29% وفي المرتبة الثالثة Cyanophytaوتنتمي الى 39 نوعا بنسبة 16%,اما Euglenozoa تنتمي الى 12 نوعا بنسبة 4% ، ثم تنتمي الى اربع أنواع Miozoa بنسبة 3% ، اما الأقسام Charophyta وOchrophya فجاءت بالمرتبة الأخيرة والتي تنتمي الى ثمانية أنواع للاولى ونوعان للثانية بنسبة مئوية 2%. من الأنواع الشائعة للهائمات النباتية التي سجلت في محطات الدراسة *Nitzschia* palea, *Scenedesmus* quadricauda, Oscillatoria princeps and *Peridinium bipes* *واظهرت علاقة ارتباط موجبة قوية مع* *Ec, Sio3 WT واما الانو*اع *Tetrastrum heteracanthum Dicloster acuatus, Gomphosphaeria semen-vitis* و *Dictyocha fibula* *, اظهرت علاقة ارتباط موجبة قوية مع* الاوكسجين المذاب ,الاس الهيدروجيني ,الفوسفات الفعالة والنترات الفعالة تتراوح قيمة درجة حرارة الماء بين 14.200 -33.900 c° في المنصوري والسدة على التوالي ، تتراوح قيمة التوصيلية الكهربائية بين 2.790 - 11.900 ms/cm في السدة والمنصوري. تتراوح درجة الاس الهيدروجيني بين 7.750 - 8.600 ، ويتراوح الاوكسجين المذاب (DO) بين 5.950-13.000 mg/l سجلت درجة حرارة الماء علاقة ارتباط سالبة مع *NO_3 (r= - 0.463) pH, (r= - 0.591)* و*DO (r= - 0.603)* ،بلغت اعلى قيمة للنترات الفعالة 14.730 µg/l بينما كانت ادنى قيمة 0.570 µg/l . بلغ الحد الأعلى للفوسفات الفعالة *0.154* µg/l بينما كانت قيمة الحد الادنى *0.003* µg/l, وبلغت اعلى قيمة للسليكات الفعالة 198.600 µg/l بينما كانت ادنى قيمة *51.200 µg /l. سجلت NO3* علاقة ارتباط سالبة مع *Sio3 (r= - 0.328)* و*EC (r= - 0.382)* بلغت اعلى قيمة لمؤشر شانون واوينر `*(H)* 3.162 وكانت ادنى قيمة 2.275 , بلغت اعلى قيمة لمؤشر سمبسون 0.950 وكانت ادنى قيمة 0.856*, وبلغ الحد الأعلى لمؤشر التكافؤ* 0.933 *اما الحد الادنى* 0.514 وسجل دليل شانون وواينرعلاقة ارتباط موجبة مع دليل سمبسون.

الكلمات المفتاحية: هور الحمار، ادلة التنوع الحيوي، المتغيرات البيئية والهائمات النباتية