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Relationships between environmental variables and both of planktonic and epiphytic diatoms in the East Hammar marshes, Southern Iraq

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Abstract:

The Mesopotamian marshlands are one of the most internationally important wetlands in the Middle East, as it constitutes a care ground for many species of birds migrating from Siberia and Europe as well as for its rich biodiversity. East Al-Hammar is a major marsh located in the southern part of Iraq. The relationship between diatom species and environmental variables in the east Hammar marsh was studied during the period from August 2018 to April 2019 in three stations.

A total of 69 taxa of diatoms belonging to 34 genera were identified. Diatom assemblages in east Hammar marsh included brackish water forms 30%, marine-brackish water forms 21%, fresh species 16%, and marine water forms 10% the rest 23% were variable uncertain ecological preference from fresh to marine. The results of canonical corresponds analysis (CCA) showed several important groups of diatom species were obtained by this analysis, the first group of diatom species include marine- brackish forms where have positive correlations with air and water temperature, EC and salinity, while the second group has positive relationship with hydrogen ion and alkalinity, diatom species in the third group have a positive correlation with transparency and dissolved oxygen. The fourth group has positive relationship with turbidity. Finally, CCA analysis shows five group of diatom species have a positive correlation with the nutrient and that can use as a bioindicator for water pollution.

Keywords: Diatoms, environmental variables, east Hammar marshes, CCA

Introduction:

Wetlands, as defined by the Ramsar convention on wetlands, include a wide variety of habitats such as marshes, peat lands, floodplains, rivers and lakes, as well as coastal areas such as salt marshes, mangroves, and sea grass beds. It also includes coral reefs and other marine areas no deeper than six meters at low tide, in addition to human-made wetlands such as wastewater treatment ponds and reservoirs (Ramsar Convention Secretariat, 2004).

Mesopotamian marshlands are one of the most internationally important wetlands in the Middle East, as it constitutes a nursing for many species of birds migrating from North Europe as well as for its rich biodiversity (Al-Handal *et al.*, 2016). A large amount of life exists in Mesopotamian marshlands, among the variety of living things Algae are important because they are the first part of the food chain and contain the species, which are important Bioindicator taxa in the determination of water quality (Bere, 2014). Diatoms are the dominant group of algae in marshland of Iraq; Diatoms are unicellular, photosynthetic, eukaryotic organisms that inhabit all bodies of water they are found in the wetland, springs, rivers, ponds, lakes, and in fresh, brackish and marine waters (Smol and Stoermer, 2010). They are either Planktonic (living in the open water) or benthic (growing associated with or attached to particular substrate). The abundance and distribution of diatoms in wetland exhibits spatial and temporal variation, many allogeneic factors including light, temperature, salinity, and nutrient, and autogenic factors under biological control such as competition, predation and parasitism interact to regulate spatial and temporal variation in wetland diatom ecosystems.

Diatoms occur everywhere, some are widely dispersed but many have narrow ecological preferences and are therefore useful for biomonitoring (Collins *et al.*, 2012; Bennion *et al.*, 2014), Using diatoms as Bioindicator of water quality has a long history in Many developing countries, researchers have shown that changes in diatoms assemblage are often associated with eutrophication, heavy metal contamination and pesticides (Stoermer and Julius, 2003)

Investigations on using diatoms as bioindicator to assess water quality in aquatic ecosystems of Iraq are rather rare. Eassa (2012) may have been the first to use diatoms indices for the assessment of water quality in Shatt al-Arab River, followed by Al-Saboonchi *et al*. (2012) who applied P-IBI for the assessment of water quality at Chebaish marsh. Recently, Al-Handal *et al.*, (2016) have been to use diatoms as indices for investigation of the marshes environmental condition during the past two centuries. A few studies was conducted the relationships between environmental variables and diatom assemblages in southern Iraq using multivariate analysis principal component analysis (PCA) and Canonical correspondence analysis (CCA). Al-Ankush (2013) approved out a study to monitor water quality of Shatt Al-Arab river by using CCA for benthic diatom assemblages, Al-Shaheen (2016) carried out a taxonomical and ecological study on the diatoms communities in Shatt Al-Arab river, were used PCA analysis to obtain correlation between environmental variables and diatom assemblages, also relationships between diatom species and their substrates.

The present study aiming to investigating the relation of diatoms distribution to changes in environmental parameters, both physical and chemical using direct observations and statistical analysis.

Materials and methods

Study area

The Mesopotamian marshlands in Southeastern Iraq are covering more than 15,000 km^2 consist of the confluence of the Tigris and Euphrates rivers. They were reduced after 2003 to less than 7% of their 1973 levels (8,926 km2 within Iraq). East Al-Hammar marsh is a major marsh located in the southern part of Iraq (Al-Kenzawi, 2009)

Station 1: is located at Al-Sadda region (N: 30º 36´ 36″, E:47º 40´ 17″), Station 2: was at Al-Salal region (N:30º 39´ 31″, E:47º 38´ 17″), Station 3: is located at Al-Burka region (N:30º 41´ 27″, E:47º 34´ 41″), (Fig.1)

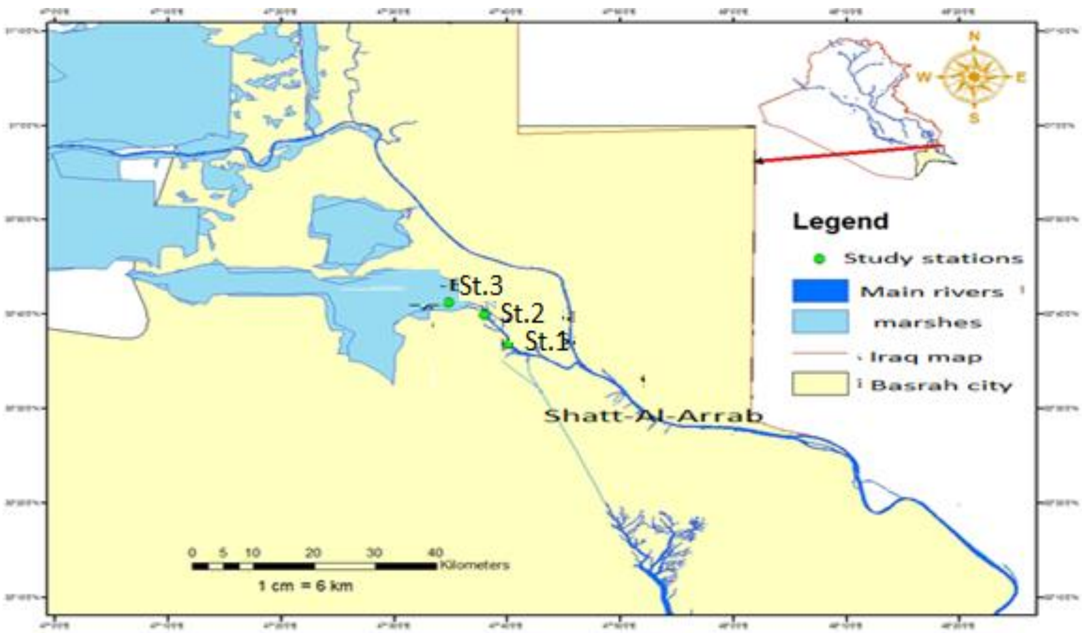

Figure 1: Map showing location of study sites at east Al-Hammar marsh.

Collection of samples

Samples for numerous analyses were collected seasonally from August 2018 to April 2019 in three stations at east Hammar marshes throughout lower level of low tide from all stations. Tides period was determining by using a Tidal Prediction Program (Total Tide) version 1,0,11,0 (United Kingdom Hydrographic Office, UK).

Measurements of environmental parameters

Two liters of water for chemical analysis were collected by a polyethylene bottles from15-30 cm under water surface, then kept in a cool box until return to laboratory for chemical analyses were done. Reactive nitrate, total and reactive phosphate and reactive silicate were measured according to Strickland & Parson (1972), Lind (1979) and APHA (1999, 2005).

Some of physical and chemical factors are measured locally at stations, which are included air and water temperatures, light transparency, salinity, electrical conductivity, turbidity, dissolved oxygen and hydrogen ion concentration by using various instruments.

Diatoms sampling and slides preparation

Planktonic diatoms were collected seasonally using 20 µm mesh size phytoplankton net (Wildco Supply Company, USA) which is hauled behind a motor boat for 15 minutes at its lowest speed. Diatoms samples were fixed by 4% formalin in marked plastic containers.

Epiphytic diatoms were also collected seasonally according to the methods which described by Kelly *et al*. (2001) and Taylor *et al*. (2007a). About 5-10 stems of emergent aquatic macrophyte were collected by cutting 5-6 cm of the stem, which is almost covered by water. The attached diatoms were scrapped and rinsed with distilled water. Also at least five stems and their healthy branches of submerged aquatic macrophyte were put it in a plastic bags then shaken vigorously with distilled water to dislodge attached diatoms. Resulting suspension poured into marked plastic container and preserved with 4% formalin.

Hot H_2O_2 method which described by Taylor *et al*. (2007a) and Al-Handal & Wulff (2008) was using for cleaned the diatoms for preparing it to microscopic examination. One volume of diatoms suspension was boiled in 1.5-2 volumes of H_2O_2 (35%) for 30-40 minutes or until the suspension return to the original size; left the suspension to be cool at room temperature then washed by distilled water through filter paper (Whattman No.1); clean diatoms material which remains in filter paper was transferred gently by clean plastic dropper to vials, marked and preserved with formalin.

Permanent slides of diatoms were made by put one milliliters of cleaned diatoms material on a cover slip and letting it to drying at laboratory temperature, and then overturned the cover slip on a clean slide having 0.5 ml of Nephrax (Brunel microscope Ltd, UK). The slide was heated for few seconds by a hotplate to remove all air bubbles may be found. Diatom species were examined and photographed by using KRUSS microscope (Germany) and digital camera OMAX A35180U3 (China)

Identification of diatoms species was done depend on several publications and literatures including Hustedt (1930, 1985), Patrick & Reimer (1966), Krammer & Lange-Bertalot (1988, 1991), Witkowski *et al.* (2000), Taylor *et al*. (2007b), Al-Handal (2009) , Al-Kandari *et al.* (2009) and Lange-Bertalot *et al*., (2017).

Statistical analysis

Multivariate statistical method (XLSTAT pro v.4 software) was used to analyze Canonical Correspondence Analysis (CCA) to clarify the correlation between diatoms species and environmental variables. Standardization (z-scale) of environmental variables were done before CCA were analyzed (Fan *et al.*, 2010). Components values are categorized as the followings: weak (0.50-0.30), moderate (0.75-0.50) and strong (>0.75) (Liu *et al*., 2003).

Results and discussion

Variations in environmental variables were measured in the present study are exposed in table 1. In general, the results of physical and chemical environmental factors were within the normal values of the studied area except salinity and electrical conductivity were recorded higher values than previously recorded rates except in one study in 2014 (Radee, 2014). Salinity was recorded in the present study may be because influenced by number of factors such as the quantity and freshness of incoming water, temperature and evaporation process, amount of rainfall, expansion of sea front as well as the quality of soil through which water passes (Al-Shaban, 1996). Salinity rises when less freshwater is discharged from Tigris and Euphrates allowing the tidal current from the Arabian Gulf to extend to southern parts of the Marshes, less freshwater discharge is attributed to the construction of several dams built on Tigris and Euphrates Rivers, this is fact confirmed by the present study. In total, 69 diatoms taxa belonging to 34 genera were identified.

Epiphytic species of diatoms were occur in the first order represented by 63 diatom species while planktonic diatoms taxa occupy the second order and represented by 50 species (Tab. 2), because Mesopotamian marshes are shallow wetlands with macrophyte covering sediment which explain the wide occurrence of epiphytic diatoms(Al-Handal *et al* ., 2016) The results of the present study showed that environmental factors such as salinity determined the diatom composition, the period from 2002-2009 showed relative recovery of diatom biodiversity where taxa of fresh water preferences reappeared and were dominated by *Surirella brebissonii*, During this period, the marshes were re-flooded by allowing water from Tigris and Euphrates Rivers to reenter the region, but since 2009 until present salinity has increased creating a brackish water habitat (Al-Handal *et al*. 2014). Diatom assemblages in east Hammar marshes included brackish water forms 30%, marine-brackish water forms 21%, fresh species 16%, marine water forms 10% the rest 23% were variable uncertain ecological preference from fresh to marine (Fig.2)

Table 1: Environmental parameters measured at all stations during the present study.

Parameters	Abbreviations	Values
Air temperature	AT	19.9-35.2 ◦ C
Water temperature	WT	18.4- 28.9◦ C
Secchi disc	TRA	55-77 cm
Turbidity	TUR	9.9-30 NTU
pH	PH	7.1-8.3
Salinity	SAL	3.5-14.7 PSU
Electrical connectivity	EC	5.6-23ms/cm
Dissolved oxygen	DO	4-8.8mg/l
Total alkalinity	TA	90-142mg/l
Reactive Nitrate	NO_3	5.9-12.5mg/l
Total phosphate	TP	0.79-1.95mg/l
Reactive phosphate	PO_4	0.41-0.99 mg/l
Reactive silicate	SiO_3	51.5-83 mg/l

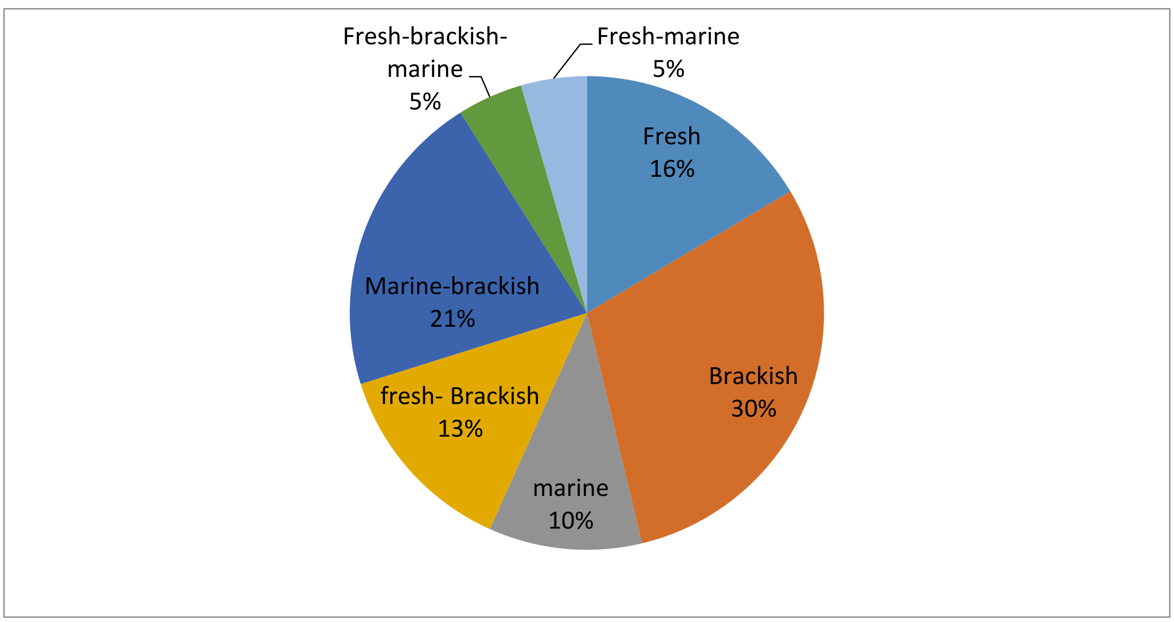

Figure 2: Environmental preference of all diatom species encountered during the present study period.

Table 2: occurrence and habitat of diatom species (m: marine, b: brackish, f: fresh, p: plankton, e: epiphytic)

Species	Habitat	occurrence
Amphora cf. holsatica Hustedt	m	P, e
Amphora mexicana A. Schmidt	f	e
Anomoeneis sphaerophra Pfitzer	f,m	e
*Bacillaria paxillifera (*O.F.Müller) T.Marsson	m, b	P, e
*Caloneis amphisbaena var. subsalina (*Donkin) Van der Werff& Hulls	b	P, e
Caloneis latiuscula (Kützing) Cleve	f	P, e
Campylodiscus cf. bicostatus W.Smith ex Roper	b	p
Campylodiscus clypes (Ehrenberg) Ehrenberg ex Kützing	m, f	p
Cocconeis placentula Ehrenberg	b, f	P, e
Cocconeis placentula var. euglypta (Ehrenberg) Grunow	b, f	P, e
Craticula cuspidate (Kutzing) D.G.Mann	b	P, e
Ctenophora pulchella (Ralfs ex Kützing) D.M.Williams & Round	b	P, e
Cyclotella meneghiniana (Kützing)	b, f	P, e
Cyclotella straita (Kützing) Grunow	b, m	P, e
Diploneis Smithii (Brébisson) Cleve	b	P, e
Diploneis sp.	un	P, e
Entomoneis alata (Ehrenberg) Ehrenberg	b	P, e
Entomoneis corrugata (Giffen) Witkowski, Lange-Bertalot & Metzeltin	b	P, e
Entomoneis paludosa (W.Smith) Reimer	m	P, e
Giffenia cocconei formis (Grunow) Round & Basson	m	P, e
Gyrosigma fasciola (Ehrenberg) J.W.Griffith & Henfrey	b, m	P, e
Gyrosigma macrum (W.Smith) J.W.Griffith & Henfrey	b, m	P, e
Gyrosigma acuminatum (Kützing) Rabenhorst	f,b	P, e
Gyrosigma attenuatum (Kützing) Rabenhorst	f,b	P, e
Gyrosigma cf. *parkeri* (Harrison) Elmore	f,b	p
Gyrosigma scalproides (Rabenhorst) Cleve	f	p

Gyrosigma sinense (Ehrenberg) Desikachary	m	P, e
Halamphora ghanensis Levkov	b, f	e
Homoeocladia subeohaereus var. *scotica* Grunow	b	P, e
luticola ventricosa (Kützing) D.G.Mann	f	e
Mastogloia elliptica vardansei(Thwaites) Cleve	b	P, e
Navicula digitoradiata (Gregory) Ralfs	b	e
Navicula metareichardtiana Lange Bertalot	b	e
Navicula sp.	un	e
Nitzschia bicapitata Cleve	m	e
Nitzschia bilobata W.Smith	m	P, e
Nitzschia cf. *prolongata* Hustedt	m	P, e
Nitzschia dissipata (Kützing) Rabenhorst	f	e
Nitzschia fusuformis Grunow	m	P, e
Nitzschia hybrid Grunow	b	P, e
Nitzschia microcephala Grunow	f	e
Nitzschia sigma (Kützing) W.Smith	f, m, b	P, e
Nitzschia sp1.	un	e
Nitzschia sp2.	un	e
Parlibellus crucicula (W.Smith) Witkowski, Lange-Bertalot & Metzeltin	b, m	P, e
Peterodictyon gemma (Ehrenberg) D.G.Mann	m	P, e
Plagiotropis lepidoptera (W.Gregory)Kuntze	f,m	P, e
Planothidium delicatulum(Kützing) Round & Bukhtiyarova	b, m	P, e
pleurosira laevis (Ehrenberg) Compère	b	e
Pseudofallacia tenera (Hustedt) LiuKociolek & Wang	b	P, e
Rhopalodia gibba (Ehrenberg) Otto Müller	f	e
Rhopalodia musculus (Kützing) Otto Müller	b, m	e
Sieminskia wohlenbergii (Brockmann) D.Metzeltin & Lange-Bertalot	b	P, e

Stephanodiscus astraea (Ehrenberg)Grunow	f	p
Surirella ovalis Brébisson	b	P, e
Surirella tenera W.Gregory	f	P, e
Surirella striatula Turpin	b	P, e
Surirella librile (Ehrenberg) Ehrenberg	f	P, e
Tabularia fasciculata (C.Agardh) D.M.Williams & Round	b, m	e
Tabularia tabulate (C.Agardh) Snoeijs	b, m	P, e
Tabularia sp.	un	P, e
Thalassiosira sp.	Un	p
Tryblionella apiculata Gregory	m	P, e
Tryblionella cf. coarctata (Grunow) D.G.Mann	b, m	e
Tryblionella granulata (Grunow) D.G.Mann	b, m	e
Tryblionla compressa (Bailey) Poulin	b, m	e
Ulnaria danica (Kützing) Compère & Bukhtiyarova	f,b	P, e
Ulnaria ulna (Nitzsch) P.Compère	f,m	P, e
Vanheurckia lewisiana (Greville) Brébisson	b	P, e

Marine-brackish water species dominated during summer 33% this reason may be due high values of salinity. While fresh water species dominated during winter 37% due to rainfall and decrease salinity values. Most of epiphytic diatom taxa were found on *Phragmites australis* 56 specie were recorded at station Al-Burka because of the presence throughout the whole period study, while the lowest number 12 specie were recorded on *Ceratophyllum demersum* at station Al-Sadda due to exist once during present study (Fig. 3).

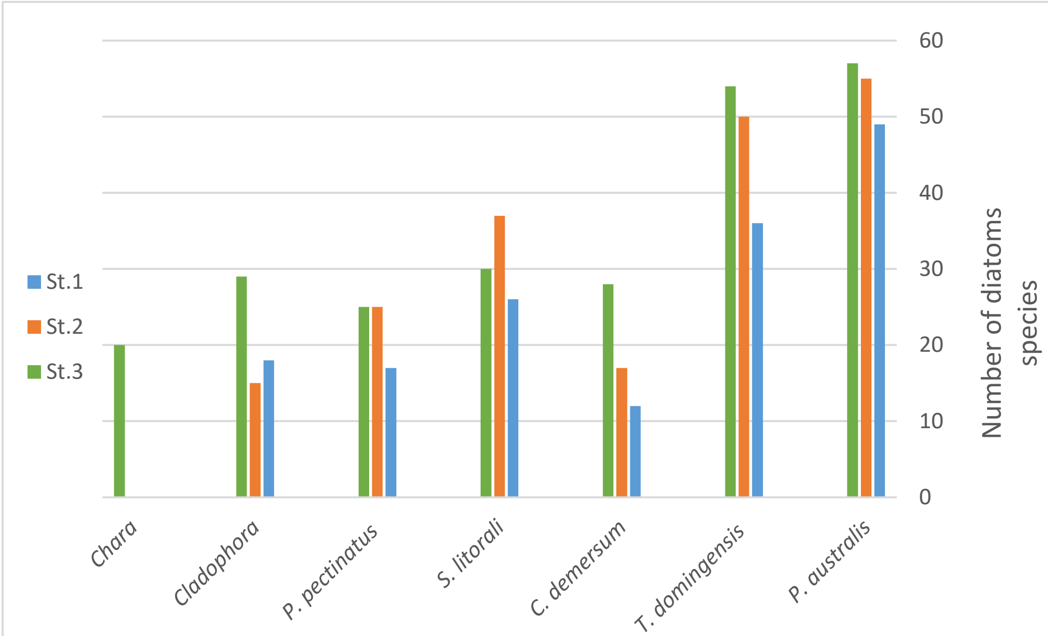

Figure3: Distribution of epiphytic diatoms on the different macrophyte and at all stations.

Centric diatoms constituted 7% of the total taxa (4 genera), the rest (93%) were pennate diatoms belonging to 30 genera. *Nitzschia* was the most common genus with 10 species and was found almost at all stations, this is may be due to the wide range of environmental tolerance of its species a case also observed previously by Al-Shaban (1996); Al-Essa, (2004); Al-Farhan, (2010); Jaffer, (2010); Al-Ankush, (2013) and Al-Shaheen (2016).

Higher numbers of diatom taxa were recorded in spring 2019 at stations Al-Burka. On the other hand, the lower species numbers for all stations were observed in autumn 2018 because the variation in environmental condition during period study.

Using raw data of numerous environmental parameters listed in tables only cannot giving clear image about the relationship between them and diatom species (Al-Shaheen and Al-Handal, 2017). However, there are some multivariate statistical approaches were can used to excerpt a useful information about the relationship; one of them is the Canonical Correspondence Analysis (CCA) which is a useful system for plummeting the large number of variables and knowing a set of dimensions which are difficult to noticed within a large set of variables (Legndre & Legendre, 1979).

The correlation between species composition, environmental parameters and seasonal at all stations was studied using CCA. According to eigenvalue-one criterion, all data matrix was reduced and just select the principal components which have eigenvalue greater than one (>1). The results are shown in figure 2, 3 and 4-exhibited 21 species of diatoms having different correlation with the environmental parameters were measured in this study.

1- Al-Sadda Station: The component of Al-Sadda station shown in (figure 4), accounted for 91.83% of the total variance.

First axis accounted 58.17% of the total variance, this axis has two groups of diatoms species, the first includes *Bacillaria paxillifera, Cyclotella meneghiniana, Homoeocladia subeohaereus* var. *scotica, Nitzschia sigma, Pseudofallacia tenera* and *Thalassiosira* sp. which have strong positive correlation with air and water temperature, turbidity, alkalinity, salinity, EC and phosphate, as well as moderate positive correlation with turbidity and summer season for specie *Nitzschia bilobata.* The second group includes *Surirella striatula, S. tenera, Entomoneis paladosa, E. alata* and *Rhopalodia gibba,* which have strong positive correlation with transparency, pH and DO. On the other hand, species of first group includes strong negative correlation with transparency, pH and DO, as well as moderate negative correlation with winter season, while the second group includes strong negative correlation with air and water temperature, turbidity, alkalinity, salinity, EC and phosphate, as well as moderate negative correlation with summer season.

The second axis accounted 33.66% of the total variance, this axis has species *S. striatula, S. tenera ,Homoeocladia subeohaereus* var. *scotica, Nitzschia sigma and Bacillaria paxillifera* which have strong positive correlation with nutrient NO_3 and SiO_3, as well as moderate positive correlation with spring season, while species *Tabularia tabulata* have moderate positive correlation with water temperature and turbidity.

Species	Abbreviations
Bacillaria paxillifera	BALPAX
Campylodiscus clypes	CAMCLY
Cocconeis placentula var. *euglypta*	COCEUG
Cyclotella meneghiniana	CYCMEN
Cyclotella straita	CYCSTR
Entomoneis alata	ENTALA
Entomoneis paladosa	ANTPAL
Gyrosigma attenuatum	GYRATT
Nitzschia sigma	NITSIG
Homoeocladia subcohaerens var. *scotica*	HOMCLD
Navicula digitoradiata	NAVDIG
Nitzschia bilobata	NITBIL
Surirella tenera	SURTEN
Nitzschia hybrid	NITHYB
Plagiotropis lepidoptera	PLAGLEP
Pseudofallacia tenera	PSETEN
Rhopalodia gibba	ROBAGI
Surirella striatula	SURSTR
Tabularia tabulata	TABTAB
Thalassiosira sp.	THALSP
Sieminskia wohlenbergii	SIEWOH

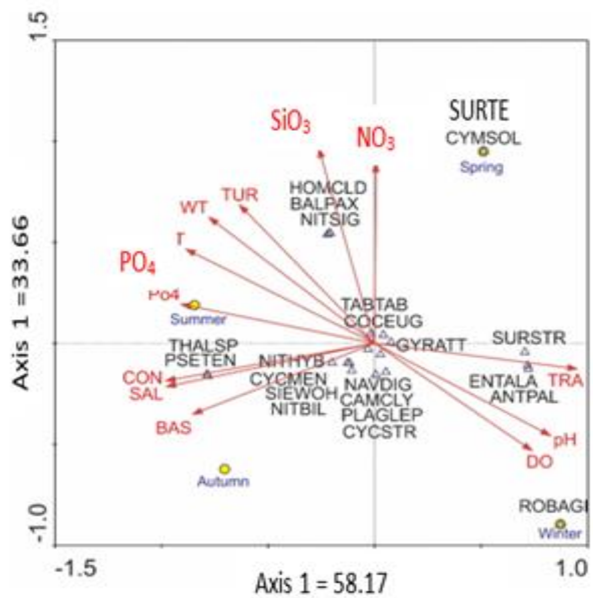

Figure 4: CCA diagram of correlation between diatoms Species with environmental parameters St1

2- Al-Salal Station: the component for this station shown in (figure 5), accounted for 91.29% of the total variance.

The first axis explained 58.94% of the total variance, this axis has two groups of diatoms species, the first one includes *S. striatula, S. tenera, R. gibba , E. paladosa* and *E. alata* which have strong positive correlation with DO and transparency. As well as moderate positive correlation with pH and winter season for species *Gyrosigma attenuatum* and *Cocconeis placentula var. euglypta.* The second group includes *Thalassiosira* sp., *Pseudofallacia tenera, Cyclotella straita* and *B. paxillifera*, which have strong positive correlation with air and water temperature, turbidity, alkalinity, salinity, EC and phosphate. While species *Sieminskia wohlenbergii, N. bilobata, N. hybrid and N. sigma* have moderate negative correlation with water temperature, turbidity and summer season. On the other hand, species of first group includes strong negative correlation with air temperature, alkalinity, salinity, EC and phosphate, as well as moderate negative correlation with water temperature, turbidity and summer season, while the second group includes strong negative correlation with DO and transparency, as well as moderate negative correlation with winter season and pH.

The **S**econd axis accounted 32.35% of the total variance, this axis has two groups of diatoms species, the first includes *S. tenera*, *Homoeocladia subeohaereus* var. *scotica*, *N. sigma and B. paxillifera* which have strong positive correlation with the nutrient NO_3 and SiO_3, as well as have moderate negative correlation with DO and pH. The second group includes *Plagiotropis lepidoptera*, *N. bilobata and N. hybrid* moderate positive correlation with DO and pH, as well as have strong negative correlation with nutrient NO_3 and SiO_3.

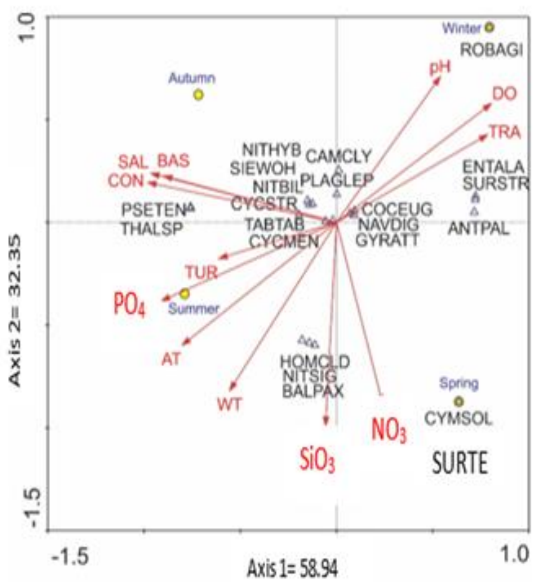

Figure 5: CCA diagram of correlation between diatom species with environmental parameters St2

3- Station Al-Burka: the component for this station shown in (Figure 6), explained for 89.98% of the total variance.

First axis accounted 62.82% of the total variance, this axis has two groups of diatoms species, the first includes *Thalassiosira sp. ,P. tenera , Homoeocladia subeohaereus* var. *scotica ,N. sigma, C. straita* and *B. paxillifera* which have strong positive correlation with air and water temperature, turbidity, alkalinity, salinity, EC and phosphate. As well as moderate positive correlation with alkalinity and summer season for species *N. bilobata.* The second group includes *S. tenera, S. striatula, R. gibba, E. alata and E. paladosa which* have strong positive correlation with DO and transparency, whereas species *Navicula digitoradiata* and *G. attenuatum have* moderate positive correlation with pH and winter season. On the other hand, species of first group includes strong negative correlation with DO and transparency, as well as moderate negative correlation with pH and winter season, while the second group includes strong negative correlation with air and water tem., turbidity, salinity, EC and phosphate, as well as moderate negative correlation with summer season and alkalinity.

Second axis accounted 27.16% of the total variance, this axis has two groups of diatoms species, the first includes *R. gibba*, *Campylodiscus clypes* and *S. striatula* which have strong positive correlation with pH, as well as moderate positive correlation with alkalinity for species *E. paladosa, P. tenera, N. hybrida*, *N. bilobata* and *Sieminskia* wohlenbergii. The second group includes *S. tenera*, *Homoeocladia subeohaereus* var. *scotica, N. sigma* and *B. paxillifera* positive correlation with nitrate and silicate. In general, the species of first group includes strong negative correlation with nutrient (NO_3 and SiO_3), while species of second group includes strong negative correlation with pH, and moderate negative correlation with alkalinity.

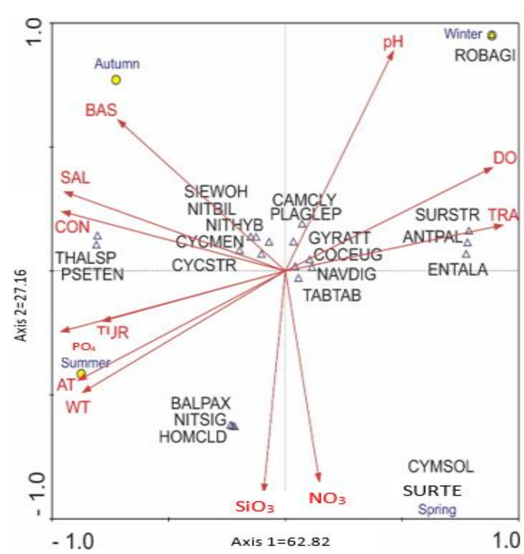

Figure 6: CCA diagram of correlation between diatom species with environmental parameters St.3.

The results of the analysis CCA of the stations in present study show that there are six species of diatoms *Thalassiosira sp.*, *P. tenera*, *N. sigma*, *B. paxillifera, Homoeocladia subeohaereus* var. *scotica* and *C. meneghiniana*, have strong positive correlation with air and water temperature, salinity and EC, With the exception of *Thalassiosira sp*. all other diatom species were truly marine to brackish forms which explain their strong correlation with salinity and EC. Taylor *et al.* (2007b) and Lange-Bertalot *et al*. (2017) referred that *N. sigma, B. paxillifera* and *C. meneghiniana* are widespread in very electrolyte-rich brackish waters.

Positive relationship of many diatoms species in the analysis CCA with pH and the total alkalinity reflects its preference for the alkaline environments, which are characterized by Iraqi waters in general and the marshes in particular (Al-Zubaidi, 1985; Al-Farhan, 2010; Jaffer, 2010). This is consistent with the classification of Hustedt (1937-1938) which places the following species *C. straita*, *C. meneghiniana*, *Campylodiscus clypes*, *Cocconeis placentula var. euglypta, E. paladosa, S. tenera, N. hybrida* within the alkaliphilous group (occurring at pH around 7 with broad distribution over 7), The species *C. placentula* var. *euglypta* has widespread in alkaline waters (alkaliphilous) (Patrick & Reimer, 1966), whereas other species *Nitzschia sigma*, *Gyrosigma attenuatum* and *Rhopalodia gibba* in the Alkalibiontic group (occurring only in alkaline water, pH above 7) (Hustedt (1937-1938).

On the other hand, we can observe six of diatom species showed a clear relationship in all stations with water transparency and dissolved oxygen, this is an obvious result because when increase of transparency of water led to higher permeability of light to deep depths in the water column and thus increase the process of photosynthesis as well as the amount of oxygen resulting from this process.

In contrast, several other species of diatoms can be observed *Tabularia tabulata*, *Sieminskia wohlenbergii*, *N. hybrida*, *P. tenera*, *N. bilobata*, *N. sigma* and *B. paxillifera*, which have a positive relationship with turbidity, as these species are adhered to both aquatic plants (epiphytic) or to clay (epipelic), which when mixing occurs to sediment due to strong winds, currents and human activities leading to rise to the water column to be temporarily among the plankton, a case recorded in previous studies in the marshes and Shatt Al-Arab river (Al-Zubaidi,1985; Al-Mousawi, 1990; Jaffer, 2010; Al-Shaheen, 2016).

With regard to the relationship of diatoms with nutrients, the analysis showed correlation of some species with one or more of the main nutrients were studied in the present study. This relationship may indicate that these species may be tolerant of organic pollution. Depending on Harding *et al*. (2004) the presence of *B. paxillifera* and *C. meneghiniana* may indicate for poor water quality and this is agreement with the Saprobian spectrum classification, which is put above two species in the Oligosaprobic group which means found in water has complete or fully oxidation of organic compounds and high concentration of inorganic nutrients (Kolkwitz and Manson, 1908). Taylor *et al*. (2007b) noted the widespread of *Cyclotella meneghiniana* in the plankton and benthos of rivers and lakes waters, which are rich by nutrients and electrolytes.

Both of *C. meneghiniana* and *R. gibba* are among of species that may use as indicate of polluted water and are characterized by their active ability to oxidize the organic compounds found in it which is termed alpha-mesosaprobic, on the other hand, the presence of species *Rhopalodia gibba*, *Surirella tenera* and *Gyrosigma attenuatum* are a bioindicator for moderately polluted water, beta-mesosaprobic (Harding *et al*., 2004).

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