Productivity and nutrients balance during wet and dry seasons in Huwaiza Marsh, Southern Iraq

Salman N.A.[1*]; Al-Saboonchi A.A.[2]

Received: May 2023 Accepted: August 2023

Abstract

Levels of nutrients in Huwaiza marsh as recorded by this study are higher than most of the previous levels recorded in Iraqi southern marshland. The highest phosphate concentration was 3.4 µg at P/l, while the lowest value was 0.65 µg at P/l). The nitrite levels were low in the range of 0.05 to 3.39 µg at N- NO_2/l, while nitrate levels were higher ranging from 0.240 to 20.01 µg at N-NO_3/l. The ratio of total nitrogen to total phosphorus (TN:TP), as potentially limiting factors of water productivity, exceeded the theoretical level of 16:1. It ranged from 17:1 during dry season to 23:1 during wet season, providing optimum growth opportunity for green algae. Differences in Chl.a concentration were closely correlated with TN: TP. Different Species of phytoplankton were recorded at three stations of Huwaiza marsh. Total number of species were higher at Lesan Ajeerda (77) during wet season following by (72) and (68) at Um Alnaaj and Al-Safia respectively. During dry season lower numbers of species were recorded reflecting less diversity. Diatoms were dominant at all stations. The highest number of phytoplankton was recorded in Lesan Ajeerda (1.86 x 10^6 cell/L), and the lowest in Al-Safia (0.14 x 10^6 cell/L). Chl. a values were high during dry season in all stations (7.9-12.2 mg/m^3) as compared with wet season (1.2–4.3 mg/m^3) due to increasing in number of Chlorophyta. Values of chl.a indicated that water of Lisan Ajeerda and Al-Safia stations are highly eutrophic as compared with Um Alnaaj water.

Keywords: Nutrients, Chlorophyta, Diatoms, Iraq, Huwaiza Marsh

1- Al-Manara College for Medical Sciences, Misan, Iraq
2- Kunuz University college, Basrah, Iraq
*Corresponding authors' Email: naderabed@uomanara.edu.iq

[DOI: 10.22034/INJBIR.2.1.65]

Introduction

Huwaiza marsh in Iraq covers an area eastern Tigris, extending from Alsheeb in Alimarah (Misan) province in the north, to Alswuaib in Basrah province in the south (Al-Ansari *et al*., 2012). The southern marshes were characterized by high primary productivity of both aquatic plants and phytoplankton as indicated by Bedair *et al.* (2007).

Our knowledge of the occurrence and distribution of phytoplankton, nutrient levels and productivity in the Sothern marshes is very limited with the exception of the following studies mostly that on ecology and productivity of phytoplankton on Hammar and Qurna marshes (Moulood *et al.,* 1981; Al-Aarajy, 1988; Al-Saadi and Al-Lami, 1992). Al-Saboonchi *et al*. (1982) recorded 63 genera related to five main groups of phytoplankton at Garma marsh. Total count of phytoplankton ranged between (16800-117960), (315-2177) cell per liter (Al-Saboonchi *et al*., 1982; Al-Zubaidy, 1985) respectively. Very limited studies dealing with seasonal variation of phytoplankton in Huwaiza marshes were published such as those of Jassim *et al*. (2006). The main aim of the present investigation is to have rational assessment of primary productivity of Huwaiza Marsh, during dry and wet seasons, by studying the distribution of nutrient salts, chlorophyll *a* and the populations of phytoplankton.

Materials and methods

Sampling stations description

As seen in Figure 1, three different stations represent various areas of Huwaiza Marsh were chosen as follows:

1. Um-Alnaaj: It represents the Northern part of Al-Huwaiza marsh
2. Lisan Ajeerda: It represents the median part
3. Al-Safia: It represents the southern part which is connected with Al-Suwaib river and then with Shatt Al-Arab River.

Analytical procedures

Phytoplankton samples were obtained by using plankton net (20 um) mesh size; haul behind a boat running at its lowest speed for 15 minutes, the samples kept in plastic bottle with 4% formalin solution. For quantitative study 100 liters of water from the station were passing through the plankton net. Total number (individual/l) = (total amount of phytoplankton in 30 microscopic field x area of filter paper) \ (area of 30 microscope fields x volume of filter sample in liter). Nutrients (NO_3, NO_2, PO_4, SiO_3) were measured by using Parson *et al*. (1984) methods.

For determination Chlorophyll. a, water sample was shaking and filtrated about (250-500) milliliter by filter paper 0.45 um mish size, with aiding vacuum pump type P.C.2508. Then 1 millimeter from $MgCO_3$ solution was added to prevent the breakdown of chlorophyll to phytophytine. Part of the paper (greenish part), was dissolved in 10 ml acetone (90%) for extracting chlorophyll-a, then kept in a refrigerated dark place for 20-24 hours with vials covered in aluminum foil. Vials were subjected to continuous shaking, then samples were placed in a centrifuge unit at 3000 rpm for 5 minutes. Chlorophyll was then measured using spectrophotometer at wave length

[DOI: 10.22034/INJBIR.2.1.65]

665 -750 nm and calculated in mg per m^3 (AOAC, 2012).

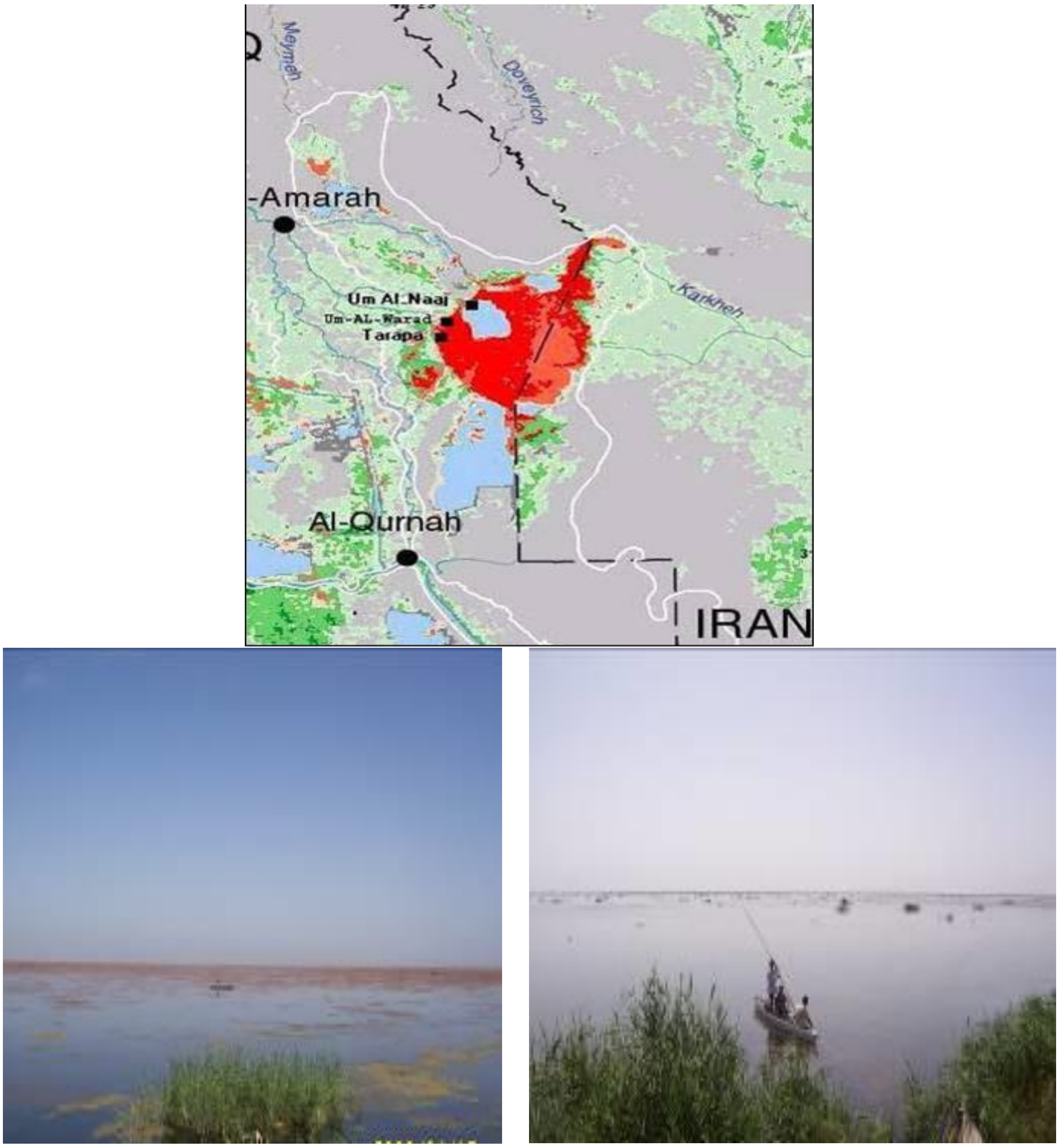

Figure 1: Map and photos of Huwaiza Marsh showing the sampling sites.

Results and discussion

Nutrients

Waters of the Southern Iraqi marshlands in general and Huwaiza marsh in particular are rich in nutrient especially nitrate and phosphate which enhance their suitability for wellbeing of aquatic plants and phytoplankton which are necessary for primary productivity and food chains (Qassim, 1986; Al-Lami, 2007). Levels of nutrient recorded in the present investigation in Huwaiza marsh are higher than most of the previous levels recorded by other studies on Iraqi southern marshland (Al-Imarah, 2006; Al-Saad *et al.*, 2008; Salman *et al.*, 2021).

[DOI: 10.22034/INJBIR.2.1.65]

Phosphorus (Phosphate PO_4)

The present results showed that the highest phosphorous concentration of 3.4 µg at P/l was recorded in April 2008 at Um-Alnaaj and Sep. 2007 at Lisan Ajeerda, while the lowest values (0.64 & 0.65 µg at P/l) were recorded during March & April, 2008 at Lisan Ajeerda (Fig. 2). The possible increase is due to additional input from agricultural land nearby or due to activity of phytoplankton, human and industrial effluent loads (Al-Imarah *et al*., 2006; Al-Shawi, 2006 and AL-Saad *et al*., 2008). In addition to that, various factors may affect the concentration of total phosphorous in aquatic system these include pH, water flow, adsorption on particulate matter and role of aquatic plants in cycling of phosphorous (AL-Saad *et al*., 2008; Salman *et al*., 2021).

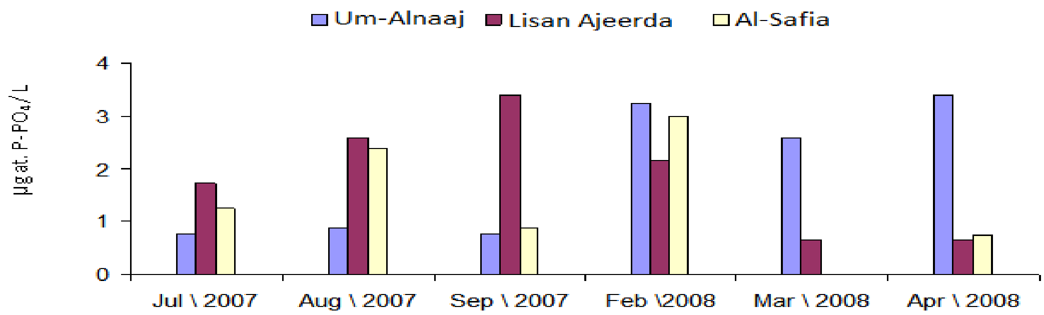

Figure 2: Variation of Phosphorus (Phosphate PO_4) concentrations in three sites of Huwaiza marsh

Nitrogen (Nitrite NO_2 and Nitrate NO_3

The recorded nitrites in Al-Huwaiza marsh were low in the range 0.05 to 3.39 µg at N- NO_2/l, while nitrates characterized by high values which were in the range 0.240 to 20.01 µg at N-NO_3/l (Fig. 3). A large fraction of total nitrogen of fresh water may occur as organic nitrogen in the form of dissolved and particulate organic detritus and generally are not available to photosynthesis organism, they represent major reservoir of nitrogen in aquatic ecosystem (Wetzel and Likens, 2000). The high concentration of total nitrogen was recorded during winter, while the lower value was obtained during dry season. This is possibly related to changes in water temperature and degradation processes (AL-Saad *et al*., 2008). Unlike phosphorus, nitrogen occur in a number of very distinct inorganic forms in aquatic ecosystem, N_2, NH_4, NO_2 and NO_3 also occur in a variety of organic forms in aquatic plants (Wetzel, 2001). Fluctuation in concentration of total nitrogen may depend on nitrogen uptake by phytoplankton and autochemotrophic bacteria.

Total nitrogen / total phosphorus ratio (TN: TP)

The most important nutrients causing the shift from lesser to more productive water are phosphorus and nitrogen. The relative abundance of different phytoplankton species depended only on the relative amount of nitrogen and phosphorus in the environment so that

[DOI: 10.22034/INJBIR.2.1.65]

optimal N:P ratio for a given species is equal to the ratio of its minimum cell requirements for these elements. In phosphorus limiting system an increasing in phosphorus will result in an increase in productivity, this phenomenon occurred during dry season at different stations of Huwaiza marsh, which associated with increasing in quantity of Chlorophyta (Salman *et al*., 2021). The ratio of total nitrogen to total phosphorus (TN:TP ratios) by mass, is used as an indicator of nutrient conditions that define factors potentially limiting water productivity. Al-Huwaiza marsh water tend to be a phosphorus-limited system since TN:TP ratio exceeded the level of 16:1. During dry season TN:TP ratio in all stations ranged between 17:1 to 18:1, but at wet season the ratio was higher ranging between 22:1 to 29:1. For algae this ratio gives optimum growth for green-algae, with increasing diversity. In case of Al-Safia station, the higher ratio recorded in both seasons possibly due to reduction in level of water and concentrated the nutrients. Relative abundance of different phytoplankton species depends mainly on the relative amount of nitrogen and phosphorus in the environment. Low ratio of TN:TP during dry season, will stimulate the growing of different species of Cyanobacteria. Differences in Chl.*a* concentration were more closely correlated with concentration of TN and TP (Table 1).

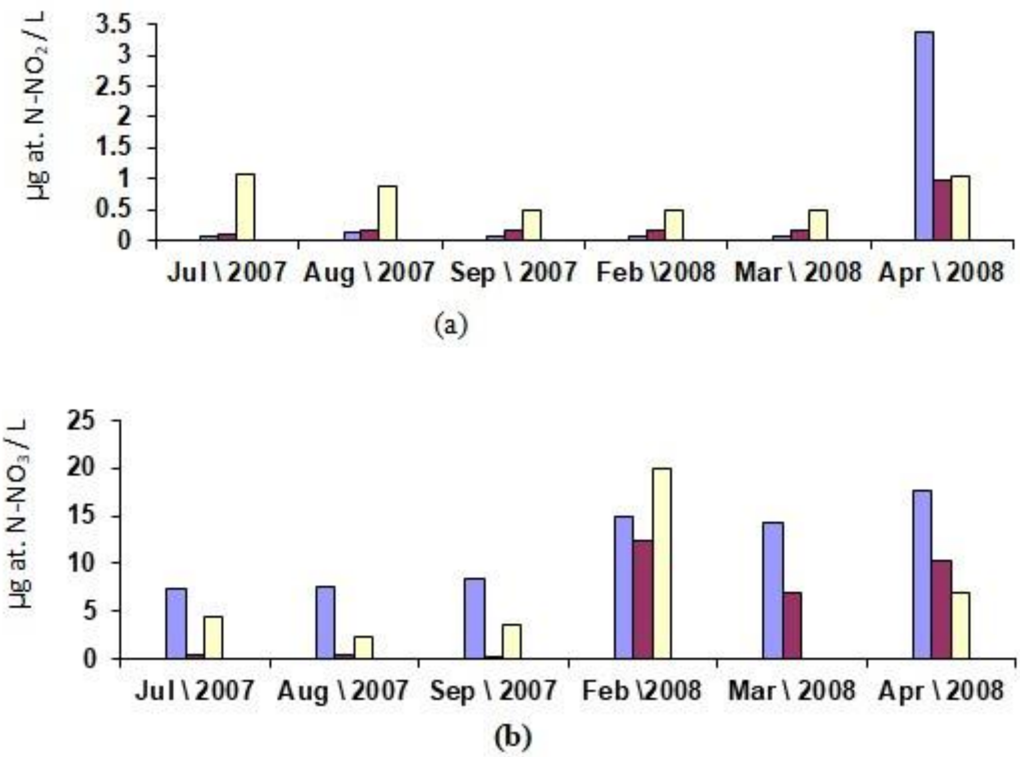

Figure 3: Variations of Nitrite NO_2 (a) & Nitrate NO_3 (b) s in the same three sites of Al-Huwaiza.

[DOI: 10.22034/INJBIR.2.1.65]

Table 1: Levels of TN: TP in relation to Chlorophyll a in the studied area.

Stations	Season	TN:TP	Chl.a mg/m^3
Um-Alnaaj	Dry.	17:1	7.95
	Wet	23:1	4.3
Lisan Ajeerda	Dry	17:1	12.15
	Wet	22:1	3.7
Al-Safia	Dry	18:1	11.21
	Wet	29:1	2.2

Silicates (SiO_3)

High levels of silicate were recorded at Um-Alnaaj reaching 70.30 µg at Si-SiO_3/l while low levels were observed at Lisan Ajeerda being 4.23 µg at Si-SiO_3/l (Fig. 4). As for the effect of seasons, it can be seen that silicate levels during wet season exceed those of dry season at Um-Alnaaj. Results of the present study are comparable with those of Al-Saad *et al*., (2008), but lower than data of Al-Lami (2007) (Table 2).

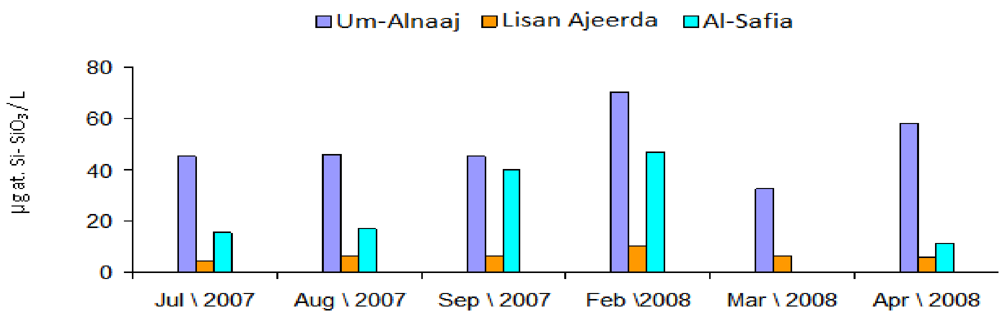

Figure 4: Variation of Silicates SiO_3 concentrations in three sites of Al-Huwaiza marsh.

Table 2: Comparison of nutrients levels at different sites of Iraqi Southern marshes.

Marshes sites	Nitrates (µg at N-NO_2^- /l)	Nitrites (µg at N-NO_3^- /l)	Phosphates (µg at P-PO_4^{-3} /l)	Silicates (µg atSi-SiO_3 /l)	References
Al-Basrah	0.095	1.63	0.68	190.0	Al-Lami, 1986; Qassim, 1986
Um Al-Hawaly	2.071	3.63	0.78	178.7	
Harer	0.335	9.23	0.89	181.0	
Al-Ghebaysh	0.030	0.055	0.22	11.9	Al-Aaraji, 1988; Hassen, 1988
Al-Hammar	0.001	0.20	0.09	11.9	
Al-Taar	0.001	0.01	0.01	77.0	
Al-Shafy	0.420	3.91	0.68	325	
Um Alshwaich	0.130	1.20	1.37	325	
South. Marshes	0.680	4.95	3.60	146	Al-Imarah *et al*., 2006
Um- Al-Ward	0.206	13.41	2.810	38.58	Al-Saad *et al*.,2008
Um- Al-Uneach	0.177	10.77	2.614	33.92	

[DOI: 10.22034/INJBIR.2.1.65]

Table 2 (continued):

Marshes sites	Nitrates (µg at $N\text{-}NO_2^-$ /l)	Nitrites (µg at $N\text{-}NO_3^-$ /l)	Phosphates (µg at $P\text{-}PO_4^{-3}$ /l)	Silicates (µg at $Si\text{-}SiO_3$ /l)	References
Al-Baghdadiah	0.182	4.84	0.678	49.04	
Al-Baghdadiah	0.298	3.67	0.781	27.71	
Al-Nagarah	0.660	1.301	0.750	49.92	
Al-Burka	0.086	1.355	0.712	52.02	
Um-Alnaaj	1.064	11.718	1.938	49.504	Present study
Lisan Ajeerda	0.504	5.11	1.85	6.586	
Al-Safia	o.708	7.472	1.648	26.038	

Productivity

Chlorophyll a

Seasonal variations in values of chlorophyll a at different stations are shown in Table 3. Higher values (7.9, 12.2 and 11.2 mg/m^3) were recorded during dry season at Um-Alnaaj, Lisan Ajeerda and Al-Safia respectively due to increasing in number of Chlorophyta. During wet season (Feb.–April), Chl. a values were lower being (3.6, 3.3 and 1.2) mg/m^3 for the three stations respectively. Variation between values at wet and dry season showing that Um Alnaaj was stable environment as compared with the other two stations (Lisan Ajeerda and Al-Safia) which showed higher variations in Chl.a values at wet and dry season.The monthly variation of Chl.a at some stations selected in Al-Huwaiza marsh showed two peaks, the first in spring (21 mg/m^3) and the other one in autumn (15 mg/m^3) and the lowest level were recorded at January (3 mg/m^3), Al-Huwaiza was more productive than the other Iraqi marshes because it has not been completely desiccated (Jassim, 1999; Richardson and Hussain, 2006; Al-Lami, 2007).

Table 3: Levels of Chl.a and total amount of phytoplankton at different stations.

Stations	***Chl. a*** **mg/m^3**	**T. No. of Phytoplankton. Cells*10^{-6}/l**
Um-Alnaaj Jul.2007	7.9	0.66
Um-Alnaaj Feb.2008	4.1	0.37
Um-Alnaaj Mar.2008	5.2	0.43
Um-Alnaaj Apr.2008	3.6	0.42
Lisan Ajeerda Sep 2007	12.2	1.86
Lisan Ajeerda Mar.2008	4.1	0.42
Lisan Ajeerda Apr.2008	3.3	0.26
Al-Safia Aug.2007	11.2	1.43
Al-Safia Feb.2008	1.2	0.14
Al-Safia Apr.2008	3.1	0.21

[DOI: 10.22034/INJBIR.2.1.65]

Phytoplankton

Total phytoplankton showing the same pattern, one peak in spring (2.62×10^6 cell / l) and the other one in autumn (1.4×10^6 cell /l). Dominant species were diatoms following by Chlorophyta then Cyanobacteria (Al-Mousawi *et al*., 1994). Different Species of phytoplankton were recorded at Huwaizah marsh as shown in Table 4. Total number of species were higher at Lisan Ajeerda (77 sp.) during wet season followed by (72 sp.) and (68 sp.) at Um-Alnaaj and Al-Safia respectively. Similarly, higher number of phytoplankton species was recorded at Lisan Ajeerda (67 sp.) and lower number at Al-Safia (52 sp.) during dry season. It was apparent that lower number of species was recorded during dry season as compared to wet season reflecting higher diversity during the later.

Table 4: Systematic list of Phytoplankton of middle part of Huwaiza Marsh.

List of taxa	Wet	Dry
Cyanophyta		
Anabaena affinis Lemm.	+	++
A.spiroides kclb.	+	++
Aphanizomenon sp.	+	+
Chroococcus disperses (keiss) Lemm.	+	+
Goeotrichia natans Rabh. ex Bor. & Flahault	+	-
Gomphosphaeria aponina Ktz.	+	-
Lyngbya aerugineo-coerulea (Ktz.) Gomont	+	++
L. contorta Lemm.	++	++
Merismopedia glauca (Ehr.) Ktz.	+	++
Oscillatoria angusta Koppe	+	++
O. limosa C. Ag. ex Gomont	+	++
O. princeps Vauch. ex Gomont	+	++
Spirulina major Vauch. ex-Forti	+	-
S. subsalsa Oer. ex Gomont	+	+
Spirulina sp.	-	++
Chlorophyta		
Actinastrum sp.	+	+
Chlorella vulgaris Beij.	+++	++
Cladophora secunda Ktz.	+++	++
C. fracta (Muller ex Vahl) Ktz.	++	+
Closterium sp.	+	++
Cosmarium cucumis Corda ex Ralfs	+++	+++
Microspora floccosa (Vauch.) Thur.	+	+++
Oedogonium crispum Witt. ex Hirn	+	-
Pediastrum sp.	-	+
Rhizoclonium crassipellitum West & West	++	+
Scenedesmus armatus (Chod.) Chod.	+	-
S. bijuga (Turp.) Lag.	++	+
Spirogyra affinis (Hass.) Petit.	+	+
Ulothrix tenerrima (Ktz.) Ktz.	+	+
U. variabilis Ktz.	++	+
Euglenophyta		
Euglena acus (Muller) Ehr.	+	+
E. elastca Prescott	+	+
Chrysophyta		
Vaucheria geminate (Vauch.) Cand.	+	-
Bacillariophyta		
Achnanthes inflata (Ktz.) Grunow	+	-

[DOI: 10.22034/INJBIR.2.1.65]

Table 4 (continued):

List of taxa	Wet	Dry
A. indica Ehr.	+	+
Amphiprora alata (Ehr.) Ktz	+	+
A. angustata Hendey	+	+
A. paluposa Smith	++	++
A. pelagica J. Brun	+	+
Bacillaria paradoxa Gmelin	+	-
B. paxillifer (Mull.) Marsson	+	++
B. subtilis (Ktz.) Elmore	+	-
Cocconeis placentula Ehr.	++	+
Cyclotella meneghiniana Ktz.	+	+
Cymbella affinis Ktz.	+	++
C. cistula (Ehr.) Kirch.	++	-
C. prostrata (Berkeley) Cleve	++	++
C. turgida (Ehr.) Hassall	+	+
Diatoma vulgare Bory	+	-
Epithemia argus (Ehr.) Ktz.	+	+
E. sorex Ktz.	+	+
E. zebra (Ehr.) Ktz.	+	+
Fragilaria capucina Desm.	+	++
F.construens (Ehr.) Grun.	-	+
F. crotonensis Kitton	+++	-
Gomphonema acuminatum Ehr.	++	+++
Gyrosigma attenuatum (Ktz.) Rab.	+	-
Mastogloia grevillea Smith	++	-
Melosira varians Ag.	++	++
Navicula cryptocephala Ktz.	++	+
N. cuspidata (Ktz.) Ktz.	++	++
N. minuscula Grun.	+	+
N. mutica (Ktz.) Freng.	+	++
N. parva (Meneg. ex Ktz.) Cl.	+	-
N. placentula (Ehr.) Ktz.	+	+
Neidium affine (Ehr.) Pfit.	-	+
Nitzscia acicularis (Ktz.) Smith	++	-
N.amphibia Grun.	-	++
N.commutata Gurn.	-	+
N. fasciculata (Gurn.) Grun.	++	++
N. longissima (Breb.) Ralfs	++	++
N. lorenziana Grun.	+	+
N.obtusa Smith	+	+
N. palea (Ktz.) Smith	+	++
Pinnularia viridis (Nitz.) Ehr.	+	+
Pleurosigma delicatulum Smith	+	+
Rhoicosphenia curvata (Ktz.) Grun.	+	++
Rhopalodia gibba (Ehr.) Muller	++	+
R. rhopala (Ehr.) Hust.	+	++
Synedra capitata Ehr.	++	+
S. ulna (Nitz.) Ehr.	+	+
Tabellaria fenestrate (Lyngb.) Ktz.	+	+
Total number of species	**77**	**67**

Diatoms were dominant at all stations. Higher number of phytoplankton was recorded at Lisan Ajeerda (1.86×10^6) cell/L, and lowest were recorded at Al-Safia (0.14×10^6) cell/l during Feb.2008 due to lowering the level of water with high salinity and pH at this station. Eutrophication of water plays vital role

[DOI: 10.22034/INJBIR.2.1.65]

in the distribution of taxa. For example, *Anbaena* and *Aphanizomenon* were recorded at three stations during dry season but with higher number at Al-Safia which coincide with the status of eutrophication at Al-Safia. Some genera that belong to Chlorococcals (*Pediastrum* and *Scenedesmus*) used indicator for trophic status of water. High quantities of *Scenedesmus* were recorded at Al-Safia at dry season which indicate the eutrophic status of water at this station. In case of genus *Cyclotella* and *Tabellaria* were associated with oligotrophic water; the quantity of that genus was recorded with low quantity at three stations. Smith (1983) found the non-nitrogen fixing algae tended to be dominant at higher of TN:TP ratio, these phenomena were noticed at wet season at three stations, and highest quantity were recorded at Lisan Ajeerda and Al-Safia.

Conclusions

1. Levels of nutrients in Huwaiza marsh as recorded by this study are higher than most of the previous levels recorded in Iraqi southern marshland.
2. The ratio of total nitrogen to total phosphorus (TN:TP), exceeded the level of 16: providing optimum growth opportunity for green algae.
3. Differences in Chl.a concentration were closely correlated with TN: TP.
4. Total number of species were higher at Lesan Ajeerda (77) during wet season.
5. During dry season lower numbers of species were recorded reflecting less diversity.
6. Diatoms were dominant at all stations.
7. The highest number of phytoplankton was recorded in Lesan Ajeerda (1.86 x 10^6 cell/L),
8. Chl. a values were high during dry season in all stations (7.9- 12.2 mg/m^3) as compared with wet season (1.2–4.3 mg/m^3.
9. Values of chl.a indicated that water of Al-Huwaiza Marsh is highly eutrophic.

Acknowledgment

Thanks are due to FAO-Iraq program which offored sponsorship to conduct the present research.

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