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EPIPELIC AND PHYTOPLANKTON ASSEMBLAGES CLOSE TO TWO NILE ISLETS AT GREAT CAIRO

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ABSTRACT

The epipelon and phytoplankton at two Nile islets were seasonally samples during 2007. Four stations two more human impacted and two less impacted at El-Zahb and El-Waraq islet were sampled. The epipelic microalgae were more regular in their distribution compared with phytoplankton between the more nad less impacted stations. Total epipelon, different groups and diversity were negatively correlated with TP during winter, whereas density of total epipelon and diatoms were negatively correlated with TP during autumn but with less intensity compared with winter. The phytoplankton assemblages showed high significant positive correlation with the different nutrient salts throughout the year. This response of phytoplankton communities towards these conditions in spite of their high increase indicated that this disturbance still in the intermediate strength that can not damage the phytoplankton populations. The microalgal diversity and abundance were compared with corresponding values at two reference sites at the River Nile mouth at Aswan. In average, biodiversity index was lower than the corresponding values at both reference sites. The Ecological Quality Ratio (EQR) resulted in the ratio of 0.76 which indicated an Ecological status of good level. On the other hand, based on the phytoplankton abundance, EQR were 6.8 and 10.4 for the River Nile at Aswan City and Aswan Reservoir, respectively, these ratios revealed a poor ecological status.

1. INTRODUCTION

The River Nile islets in Egypt are declared nature reserves. Studies show that the number of these islet is 144 (Egypt state information services http://www2.sis.gov.eg/En/Tourism/Egyptall/Enviormental). Along the main course from Aswan to the Delta barrage there are 95 islets, with area of 32500 feddans. In Rosetta Branch 30 islet are present with 3400 feddans. In Damietta Branch, there are 19 islets with an area of about 1250 feddan. The total area of the River Nile islet is about 32500 feddan equal 55 km^2. These islets spread over 14 Governorates (Aswan, Qena, Sohag, Assuit, Menya, Beni-Sewaif, Giza, Cairo, Qalyoubia, Monofia, Gharbia, Kafr-el-Sheikh, Dakahlia and Damietta).

At the islet, the gradient of physical factors formed by fetch, flow-related turbulence and the pronounced seasonal cycles in water floods (Hamilton and Lewis, 1988) resulted in seasonal variation in biotic communities and the establishment of species (Patrick, 1988). All these characteristics associated with cultural-eutrophication characters can be defined as disturbance factors (Reynolds, 1988) that may have a major selective influence over the microalgal population and, indeed, over ecosystem-level processes, including primary and secondary producers (Sousa, 1984).

The dense population of aquatic plants around these islets can affect their biological aquatic feature by increase residence time, increase nutrient concentrations and support different populations with species seeds and propagules (Cattaneo *et al.,* 1998). The

studied islets located in the most northern region of the River Nile, at which a total of 5 x 10^9 m^3 effluents of 116 factories concentrated their nutrient and other pollution.

This study aimed to study the phytoplankton and epipelon concurrent with the physical and chemical characteristics at the study area in comparison with Aswan Reservoir and the River at Aswan City as reference sites.

2. MATERIALS AND METHODS

2.1. Field stations

This study was carried out at two Nile Islets at Greater Cairo, El-Zahb and El-Waraq islets. At each islet, two sites were selected for studying different physical and chemical parameters as well as microalgal communities. One site subjected to more human impacted represented by fishing and housing activities while the other had low human impacts. The samples were seasonally collected year round during 2007 from winter to autumn, while epipelic populations were not collected during summer.

2.2. Water analysis

The methods described in the American Public Health Association (APHA, 1992) were used for the determination of the abiotic parameters except where noted. Total dissolved solids, electrical conductivity and pH values were measured during the time of sampling using Hydrolab (Mutlti Set 430i WTW) after calibration. COD was carried out using potassium permanganate method. Water alkalinity was determined immediately after sampling collection using phenolphthalein and methyl orange indicators. Calcium and magnesium were determined by direct titration against EDTA solution, while sodium and potassium was determined using flame photometer (Jenway Felsted Gi Dunmow Essex). Ammonia was determined by phenate method, Nitrite using colorimetric method and Nitrate by reduction method as described by Mullin and Riley (1956). Orthophosphate and total phosphorus were determined using stannous chloride and acid molybdate method as described in (APHA, 1992).

Table (1): The selected stations in the two Nile Islets during 2007.

St. No.	Name
1	South El-Zahb Islet
2	North El-Zahb Islet
3	South El-Waraq Islet
4	North El-Waraq Islet

2.3. Microalgal analysis

The phytoplankton samples (one liter) were collected from the mentioned stations in cleaned polyethylene bottles. The collected samples were preserved immediately using formaldehyde in a final concentration of 4%. 500 ml of well-shacked sample was poured into a graduated cylinder, and Lugol's Iodine solution (10 g pure iodine + 20 g potassium iodide + 200 ml dw + 20 ml glacial acetic acid) was added in the ratio of 1:100 (Sournia, 1981). The samples were left to settle for five days, then the supernatant was siphoned with a small plastic tube ending with a fine net of 20 µm mesh diameter, until the sample was concentrated to <50 ml. The reduced sample were adjusted to 50 ml and kept in plastic vial for microscopic examination. For the epipelic algae, sediments were collected using Ekman Grab sampler. The surface sediment (about 1 cm depth) of known area was transferred into 100 ml glass bottles. The samples were preserved immediately using formaldehyde. In the lab, the samples were stirred in tab water several times. Each time, the sample was left for a few seconds to permit the heavier sand particles to settle down and the supernatant with epipelic algae was poured into a graduated cylinder. Lugol's Iodine solution was added and the samples were left for 5-days and treated as described for phytoplankton samples.

Utermohl (1958) method was applied for microalgal counting and identification. According to this technique, a known volume of concentrated sample was placed in a counting chamber and examined at 10X eyepiece and 40X objective (100X objective used when needed) of an inverted microscope (Zeiss, Model: Axiovert 25c). This method permits the examination of pico and nano algal cells (Sournia, 1981). The main references used for identification and classification of phytoplankton were Heurck (1962), Patrick & Reimer (1975), Hustedt (1976), Prescott (1978), Toini Tikkanen (1986), Dillard (1991) and Mizuno (1990).

2.4. Data analysis

Similarity index based on Bray-Curtise (1957), Shanon-Whener diversity and evenness indices were developed by Primer 5.0 soft ware package. Correlation matrix and ANOVA analysis were performed using statistical package, Statistica V. 8.

3. RESULTS

3.1. Water analyses

Most of the studied water parameters showed considerable increase during autumn (Table, 2) due to the decrease in the River flow that resulted from the winter blocking of the Aswan High Dam as reported in previous studies (Touliabah, 1996). Using one-way Anova analysis, all the physical and chemical parameters showed non significant spatial variations in the area of study, although a considerable variations in environmental conditions were observed. The eutrophication as controlled by NO_3, NH_3, PO_4, and TP, were highest at station 2 of El-Zahb islet, whereas EC, TDS and major cations were highest at station 4 of El-Waraq.

3.2. Biota analysis

3.2.1. During winter

3.2.1.1. Phytoplankton

The results indicated that the total phytoplankton, diatoms and chlorophytes standing crops were higher at stations 2 and 3 (Fig. 1). It is worth to note that, the averages phytoplankton abundance at the two islets were not significantly differred. The highest and least phytoplankton standing crop of 2464.4 and 1820.8 cell x 10^4 l^{-1} were recorded at stations 2 and 1 of El-Zahb islet, respectively. Three distinct phytoplankton groups were recorded at the area of study which arranged in the descending order of Chlorophyceae > Bacillariophyceae >

cyanoprokaryotes with spatial average of 47.35, 39.86 and 12.79 10^4 l^{-1}, respectively. Based on the species square root abundance, the Bray-Curtise, similarity index indicated that the two station of El-Zahb islet were highly similar whereas the two stations of El-Waraq islet were less similar (Fig. 1). The cluster analysis showed one distinct group composed of stations of El-Zahb Islet while the stations of El-Waraq islet were represented separately. 54 species were recorded at the area of study, 30 were belonging to the chlorophytes, 15 to diatoms while 9 species were belonging to cyanoprokaryotes. The diversity of phytoplankton was high (H'= 2.8) at station 3 of El-Waraq islet but low (H'= 1.9) at station 1 at El-Zahb islet. *Cyclotella ocellata*, *C. operculata*, *Synedra delicatissima* and *S ulna* dominated the siliceous planktonic communities at the area of study. Cyanoprokaryotes were developed at the area of study with the coccoid *Microcystis aeruginosa*. Chlorophyta was represented by *Dictyosphaerium pulchellum* at the different locations, whereas *D. subsolitoria* and *Errerella bornhemiensis* peaked at El-Waraq islet.

Table (2): Seasonal variations in physical and chemical parameters at the different stations during the period of study. collected.

	Station 1				Station 2				Station 3			Station 4			
	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Autumn	Winter	Spring	Summer	Autumn
EC µS/cm	335	364	372	342	370	385	395	362	352	385	415	339	374	398	421
TDS mg/l	184	185	195	201	167	192	205	215	175	185	226	168	179	205	226
pH	8.65	8.48	8.18	8.64	8.59	8.52	8.21	8.54	8.53	8.19	8.64	8.56	8.41	8.26	8.54
DO mg/l	8.6	7.2	*	*	8.4	7.6	*	*	9.1	8.4	*	9.2	8.6	*	*
BOD mg/l	4.9	4.6	*	*	4.8	5.2	*	*	6.7	7.2	*	6.1	6.2	*	*
DO/BOD	1.8	1.6	*	*	1.8	1.5	*	*	1.4	1.2	*	1.5	1.4	*	*
COD mg/l	9.8	8.6	7.2	9.4	7.6	10.2	13.2	11.6	6.8	7.8	11.2	5.4	5.6	6.7	8.9
HCO_3 mg/l	126.0	135.0	156.0	148.0	135.0	145.0	162.0	155.0	130.0	139.0	152.0	126.0	132.0	128.0	165.0
SO_4 mg/l	28.0	27.5	24.0	28.0	35.0	33.1	28.9	33.6	32.0	38.9	41.6	28.0	26.7	28.2	31.1
Ca mg/l	19.0	18.6	16.0	21.0	22.0	19.8	18.2	24.2	21.0	20.6	26.2	18.0	16.5	18.2	21.5
Mg mg/l	23.0	25.6	21.0	26.0	25.0	26.8	18.9	23.2	23.0	28.4	24.5	20.0	22.1	22.6	24.8
Na mg/l	18.0	21.6	18.5	22.6	22.0	24.5	21.1	23.2	30.0	31.6	35.9	28.0	29.8	24.6	31.2
K mg/l	8.0	7.8	6.8	7.9	7.0	8.9	6.9	8.1	9.0	12.6	11.5	11.0	9.6	10.1	11.9
NO_2 µg/l	14	8	12	21	15	10	18	22	18	13	23	16	17	14	19
NO_3 µg/l	63	75	54	81	55	78	66	92	145	155	164	139	129	122	135
NH_3 µg/l	365	415	423	472	466	479	421	456	430	515	487	356	418	369	409
TP µg/l	509	451	440	527	530	571	545	609	531	598	563	478	510	453	529

*Not collected

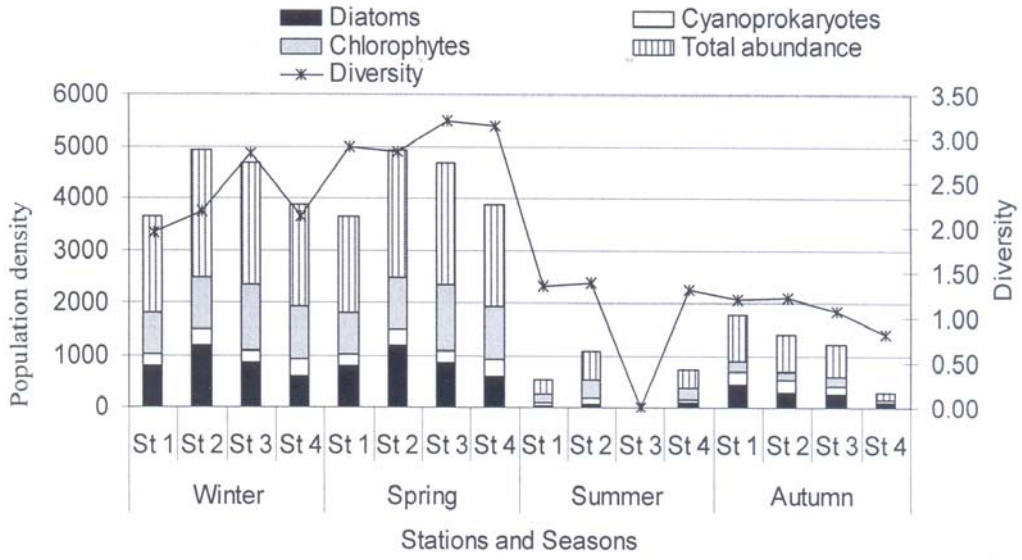

Fig. (1): Phytoplankton population density (cells x $10^4 l^{-1}$) and diversity at the area of study.

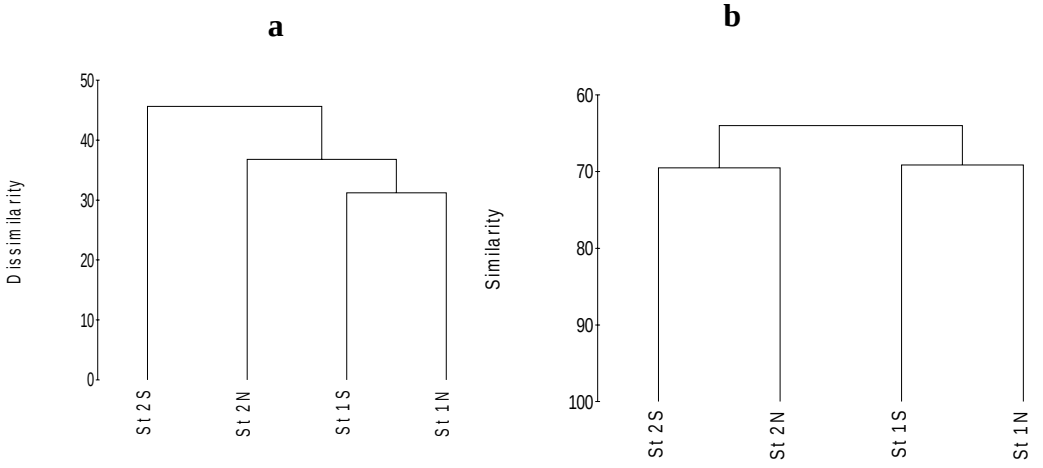

Fig. (2): Bray-Curtise (a) dissimilarity of phytoplankton and (b) similarity of epipelon during winter.

3.2.1.2. Epipelic microalgae

The total epipelon and diatoms abundances were maximum at stations 1and 4 at El-Zahb and El-Waraq, respectively (Fig. 3). The averages epipelon density at El-Waraq islet was 4281.2 cell x 10^4 cm^{-2}, while it was 2349.7 cell x 10^4 cm^{-2}, at El-Zahb islet. The maximum epipelon standing crop of 4789.1 cell x 10^4 cm^{-2} was recorded at station 4 of El-Waraq islet, whereas the minimum standing crop of 2125.0 cell x $10^4 cm^{-2}$ was found at station 2 of El-Zahb islet. Diatoms constitute more than 96% of the total epipelic microalgae, while both chlorophytes and cyanoprokaryotes were marginally present. The cluster analysis showed two distinct groups (Fig. 2) composed of the stations at each islet.

The epipelic community was highly diverse regards its species number (113 species) compared with the plankton community (54 species). The species recorded at the area of study were, 61 diatoms, 36 chlorophytes, and 16 of cyanoprokaryotes. *Cyclotella ocellata*, *C. operculata*, *Melosira granulata*, *Synedra acus* and *S delicatissima* dominated the siliceous epipelic communities at the area of study. Chlorophyta was represented by many genera (Table, 3) and species but they were not present enough to become dominant. Chlorophytes was occurred by *D. pulchellum* and *Scenedesmus* spp specifically *S. spinosus* and *S.* sp at the different locations. Diversity analysis showed higher values at stations 1 and 4 of El-Zahb and El-Waraq, respectively. The diversity of epipelon was highest (H'=1.8) at station 4 of El-Waraq islet and least (H'=0.87) at the station 2 of El-Zahb islet. In general, the mean epipelon diversity (1.01) was lower than the analogous phytoplankton diversity (2.27).

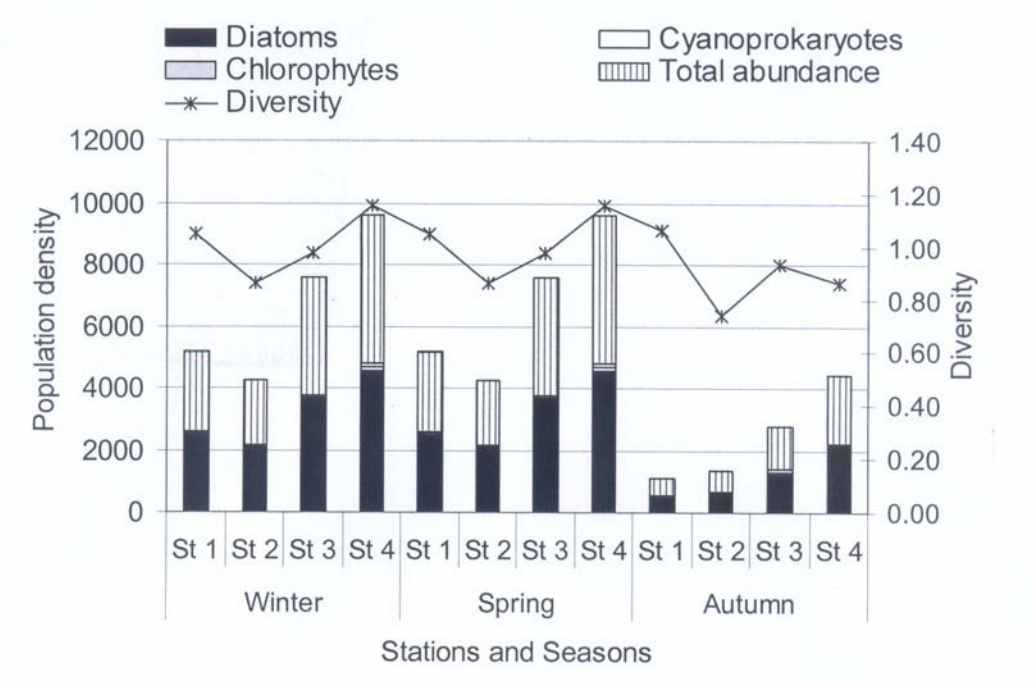

Fig. (3): Epipelon population density (cells x 10^4 cm^{-2}) and diversity at the area of study.

3.2.2. During spring

3.2.2.1. Phytoplankton

The total phytoplankton and different groups were more abundant at stations 2 and 3, except for cyanoprokaryotes which were more abundant at station 4 at El-Waraq. Chlorophytes were the most important planktonic group at the area of study with an average percentage abundance of 68%. Diatoms were partially abundant compared with chloropytes, where their average percentage abundance was 14.04%. Both chlorophytes and diatoms peaked at stations 2 and 3 of both islets. Cyanoprokaryotes had an average percentage abundance of 17.8%, they were high at station 2 of El-Zahb islet whereas they peaked at station 4 of El-Waraq. The highest and least phytoplankton abundance of 2616 and 1725.6 cell x 10^4 l^{-1} were recorded at the northern and southern stations of El-Zahb islet, respectively.

More species were recorded during spring compared with winter, especially those belonging to chlorophytes. 72 species were recorded at the area of study, 45 species were belonging to the chlorophytes, 15 of diatoms, 10 of cyanoprokaryotes, while 2 cryptomonodales species were recorded. The dissimilarity matrix classified the two stations of each islet separately, at level of about 35%, which revealed a great difference between the stations of each islet. The Shannon-Whener diversity values were non-significantly differs between the stations of one islet, but partially differs between the two islet of the study.

The majority of the leading species showed regular distribution among the different localities. *Cyclotella ocellata*, *Melosira granulata* and *Selenastrum gracile* were dominated at the northern stations of the two islets, whereas, *Monoraphidium contortum* and *Nephrocytium agardhianum* Naeg. were more abundant at the southern stations of the two islets. On the other side, some species were recorded in one islet but were not at the other. *Coelastrum reticulatum* and *Pediastrum simplex* recorded only at El-Zahb islet, while, *E. bornhemiensis* was found at El-Waraq islet.

3.2.2.2. Epipelic microalgae

The total epipelon and different groups were more abundant at stations 1 and 4. Diatoms were the most dominant group with average percentage abundance of 87.48% of the total epipelic microalgae, while cyanoprokaryotes were the least abundant group with average percentage abundance of 1.3%. The averages epipelon density at the two islets were 3459.89 and 3221.38 cell x 10^4 cm^{-2} for El-Zahb and El-Waraq islet, respectively.

Hundred and one species were recorded at the area of study; 55 were belonging to diatoms, 38 chlorophytes, whereas 8 species of cyanoprokaryotes. Both the highest number of species (61 species) and the least one (44 species) were recorded at stations 1 and 2 of El-Zahb islet, respectively. The number of species recorded at El-Waraq islet was 47 and 55 for the 3 and 4 stations, respectively. The Shannon-Whener diversity values were higher at stations 1 and 4. In average, Shannon-Whener diversity was higher (H'=1.16) at El-Waraq compared with the corresponding values at El-Zahb islets. The dissimilarity matrix cluster at the two stations of El-Waraq together in a single group at level of dissimilarity of 35.75%, whereas more dissimilarity level between the two stations of El-Zahb was showed at level of 45%. Three leading species were recorded; *Cyclotella ocellata* was more abundant at the highly impacted stations of both islets. On the other side, *Melosira granulata* was more abundant at the less impacted stations of both islets. *Scenedesmus spinosus* was more abundant at the south of both islets.

Table (3): Most of the important epipelic and planktonic microalgal species recorded at the area of study.

Bacillariophytes	*P. fragile* (Meneg.) Gom.	*S. ecornis* (Ehr.) Chodat
Achnanthes minutissima Kuetz	*P. papillaterminatum* Kiss.	*S. quadricauda* Brebisson
Cocconeis placentula Ehr.	*P. retzii* (Kuetz.) Gom.	*S. spinosus* Bold.
Cyclotella glomerata Bach.	**Chlorophytes**	*Selenastrum capricornatum* Printz
C. meneghiniana Kuetz.	*Actinastrum hantzschii* var *gracilis* G. M. Smith	*S. gracile* Rein.
C. ocellata Pant.	*Ankistrodesmus braunii* (Naeg.) Brun.	*Staurastrum natator* W.West
C. operculata (Ag.) Kuetz.	*A. falcatus* (Corda) Ralf.	*Tetraedron caudatum* (Corda) Hansgirg
C. socialis Shutt.	*Botryococcus protuberans* West & West	*T. minimum (A.Br.)* Hansgirg
Cymatopleura solea (Breb.) Smith	*B. sp*.	*Westella botryodes* Beyerinck
Cymbella microcephala Grun.	*Chlorella vulgaris* Beij.	
Eunotia sp	*Chlorococcum humicola* (Naeg.) Raben.	
Fragilria capucina Desm.	*Closterium parvulum* Naeg.	
Fragilria construens (Ehr.) Grun.	*Coelastrum cambricum* Archer.	
F. sp	*C. microporum* Naeg.	
Gomphonema gracile Ehr.	*C. reticulatum* (Dang.) Senn.	
Melosira granulata (Ehr.) Ralfs.	*Crucigenia rectangularis* (Braun.) Gay.	
M. granulata var *angustissima* O. M.	*C. tetrapedia* (Kirch.) West & West	
Navicula cryptocephala var veneta (Kuetz.) Cl.	*Dictyosphaerium pulchellum* Wood	
N. pupula Kuetz.	*D. subsolitoria* Chodat	
Nitzschia acicularis Smith	*Elakatothrix gelatinosa* Wille	
N. closterium Smith	*Errerella bornhemiensis* Conard	
N. filiformis (Smith) Hust.	*Golenkinia radiata* (Chodat) Wille	
N. gracilis Hantz.	*Kirchneriella irregularis* (Smith) Korschikov	
N. palea (Kuetz.) Smith	*K. lunaris* (Kirch.) Moebius	
N sublinearis Hust.	*K. obesa* (W.West) Schmidlre	
Synedra acus Kuetz.	*Legerheimia citriformis* (Lag.) Snow	
S. delicatissima Smith	*Micractinium pusillum* Fres.	
S. ulna (Nit.) Ehr.	*Monoraphidium contortum* (Thur.) Komar.	
Cyanophytes	*Oocystis borgei* Snow	
Chroococcus dispersus (Keiss.) Lemm.	*O. solitaria* Wittrock	
C. limneticus Lemm.	*Pediastrum duplex* Meyen	
C. minutus (Kuetz.) Naeg.	*P. simplex* Meyen	
Cylindrospormopsis raciborskii Wolos.	*Planktonema laterbraunii* Smith	
Gomphosphaeria compacta Lemm.	*Planktosphaera gelatinosa* G. M. Smith	
G. *aponina* Kuetz.	*Radiococcus nimbatus* (Wild.) Schm.	
Lyngbya epiphytica Hieron.	*Scenedesmus acuminatus* (Lagerh.) Chodat	
Merismopedia elegans Braun	*S. armatus* (Chodat) G.M.Smith	
M. tenuissima Lemm.	*S. bernardii* G. M. Smith	
Microcystis aeruginosa Kuetz.	*S. bicaudatus* (Hans.) Chodat	
M. flos-aquae (Witt.) Kirch.	*S. dimorphus* (Turpin) Kuetz.	
Phormidium dictyothallum Skuja		

3.2.3. During summer

3.2.3.1. Phytoplankton

The total phytoplankton, chlorophytes and cyanoprokaryotes were more abundant at station 2 of EL-Zahb. Chlorophytes were the most important planktonic group throughout the area of study with an average percentage abundance of 63.4%, whereas diatoms and cyanoprokaryotes shared the second position of dominance with percentage abundance of 18.3% and 17.6%, respectively. Both chlorophytes and cyanoprokaryotes were maximum at station 2 of El-Zahb islet, while diatoms peaked at station 4 of El-Waraq. The highest total phytoplankton abundance was recorded at station 2 of El-Zahb islet with maximum peak of 543.9 cell x 10^4 l^{-1} (Fig. 1). More species were recorded during summer compared with winter, especially those belonging to chlorophytes. 73 species were recorded at the area of study, 46 chlorophytes, 16 diatoms and 11 species were belonging to cyanoprokaryotes. The total number of species recorded was higher at station 2 of El-Zahb islet. Variations in diversity index ranged from 1.31 at station 4 of El-Waraq islet to 1.38 at station 2 of El-Zahb islet. The dissimilarity matrix classified the stations into two groups, the first composed of the stations of El-Zahb islet whereas the station of El-Waraq station was classified separately. The dissimilarity at the stations of each islet was at level of about 40%, which revealed a great difference between the stations of each islet (Fig. 4).

The two diatoms species, *Melosira granulata* and *Synedra acus* developed at station 4 of El-Waraq, whereas the cyanoprokaryotic, *Merismopedia elegans* and *Microcystis aeruginosa* flourished at station 2 of EL-Zahb islet. The chlorophytes *Dictyosphaerium pulchellum* and *Micractinium pusillum* were more present at station 2 of EL-Zahb islet, while *Coelastrum reticulatum* peaked at the less human impacted stations of both islets.

The summer epipelic samples were not available.

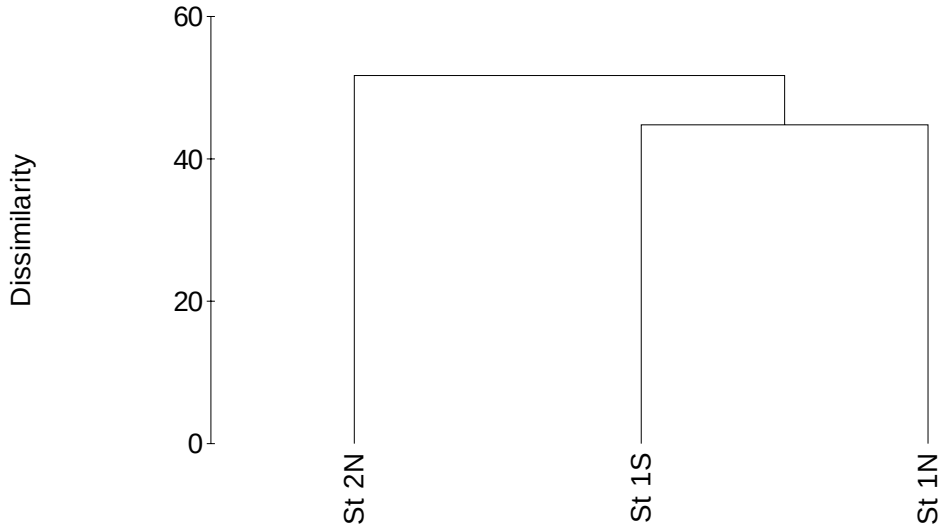

Fig. (4): Bray-Curtise dissimilarity of phytoplankton during summer.

3.2.4. During autumn

3.2.4.1. Phytoplankton

The total phytoplankton, chlorophytes and diatoms were more abundant at station 1 of El-Zahb islet whereas they had major peak at station 3 of El-Waraq**.** In contrary, cyanoprokaryotes were highly present at the highly impacted stations of both islets. Diatoms were the most important planktonic group throughout the area of study with an average percentage abundance of 51.8%, whereas chlorophytes and cyanoprokaryotes shared the second position of dominance with percentage abundance of 24.8% and 23.4%, respectively. Diatoms dominated the planktonic community with *Melosira granulata*, *Synedra acus* and *Cyclotella ocellata*. The highest total phytoplankton abundance was recorded at the less impacted station of El-Zahb islet with a maximum peak of 893.9 cell x 10^4 l^{-1}.

Seventy five species were recorded at the area of study; 36 species were belonging to chlorophytes, 26 to diatoms and 13 species were belonging to cyanoprokaryotes. The highest total number of species recorded was high at the highly impacted station of El-Zahb islet. Variations in diversity index ranged from 1.23 at station 2 of El-Zahb islet to 0.8 at station 4 of El-Waraq islet. The maximum number of species (47 species) was recorded at the two stations of El-Zahb islet, while the least number (37 species) were recorded at station 4 of El-Waraq islet. The dissimilarity matrix (Fig. 5) classified the area of study into two distinct groups at dissimilarity level of 35%.

Melosira granulata, *Synedra acus* and *Cyclotella ocellata* were the most important diatom species, they had a major peak at station 1 of El-Zahb islet, while they attained a minimum level at station 3 of El-Waraq islet. The cyanoprokaryotes were developed by the coccoid *Microcystis aeruginosa* which harbored its climax at the highly impacted stations specifically El-Waraq islet. Chlorophytes attained their highest abundance with the two chlorococcal species, *D. pulchellum* and *Scenedesmus ecornis* which flourished at the less impacted stations of both islets.

3.2.4.2. Epipelic microalgae

The total epipelon and diatoms were about 3 fold higher, in average, at El-Waraq islets compared with El-Zahb islet. The total epipelon and diatoms were more abundant at stations 2 and 4 of El-Zahb and El-Waraq islet, respectively. Diatoms were the most dominant group with average percentage abundance of 94.1% of the total epipelic microalgae. The total epipelon major peak of 2201 cell x 10^4 cm^{-2} was recorded at station 4 of El-Waraq islet, while the minor peak of 559.1 cell x 10^4 cm^{-2} was found at station 1 of El-Zahb islet.

The least number of epipelon species were recorded during autumn compared with other seasons. 65 species were recorded at the area of study; 35 were belonging to diatoms, 20 to chlorophytes, whereas 10 species were belonging to cyanoprokaryotes. The highest number of species (35 species) was recorded at the less impacted station of El-Zahb islet, whereas the least number (19 species) was recorded at station 2 of El-Zahb islet. The Shannon-Whener diversity values were non-significantly differs between the stations of one islet, but partially differs between the two islets. The Shannon-Whener diversity harbored maximum and minimum values of 1.06 and 0.7 at stations 1 and 2 of El-Zahb islet, respectively. As general, the dissimilarity matrix classified the stations of each islet separately into two groups at dissimilarity level of 40%.

Melosira granulata, *Synedra acus*, *Cyclotella* spp *and Fragilaria* spp were the most important diatom species. *Melosira granulata*, *S. acus* and *Cyclotella* spp had a major peak at station 4 of El-Waraq islet, while they attained minimum levels at station 2 of El-Zahb islet. On the other hand, *Fragilaria* spp distributed oppositely to the above mentioned species, they showed a

climax at the highly impacted stations of both islets.

Correlation matrix of the epipelon with environmental conditions presented in table 4. Total epipelon, different groups and diversity were negatively correlated with TP during winter but partially during spring.

Density of total epipelon and diatoms were negatively correlated with TP during autumn but with less intensity compared with winter. The phytoplankton assemblages showed significant high positive correlation with the different nutrient salts throughout the year (Table 5). Phytoplankton was negatively correlated with EC, TDS, DO, HCO_3, but positively in summer, with irregular relations in winter and spring.

Table (4): Simple linear correlation matrix between epipelic communities and some physical and chemical characters.

		EC	TDS	DO	BOD	COD	HCO_3	SO_4	Ca	Mg	Na	K	NO_2	NO_3	NH_4	TP
Winter	Diatoms	-0.48	-0.26	***0.98***	***0.83***	***-0.79***	-0.56	-0.51	-0.60	***-0.90***	***0.80***	***0.98***	0.61	***0.93***	-0.52	***-0.80***
	Cyanoprokaryotes	-0.54	-0.35	0.71	0.39	***-0.68***	***-0.62***	-0.64	***-0.80***	***-0.94***	0.43	***0.92***	0.12	0.58	***-0.70***	***-0.95***
	Chlorophyceae	***-0.71***	-0.13	***0.63***	0.27	-0.48	***-0.77***	***-0.80***	***-0.92***	***-0.95***	0.24	***0.88***	-0.06	0.47	***-0.85***	***-0.99***
	Total abundance	-0.49	***-0.26***	***0.97***	***0.81***	***-0.79***	-0.58	-0.53	-0.63	***-0.91***	***0.78***	***0.98***	0.58	***0.92***	-0.54	***-0.82***
	Diversity	***-0.88***	0.16	***0.70***	0.38	-0.32	***-0.93***	***-0.93***	***-0.97***	-0.96	0.23	***0.87***	0.01	0.53	***-0.95***	***-0.98***
Spring	Diatoms	0.01	***-0.88***	***0.91***	***0.71***	***-0.96***	***-0.70***	-0.09	-0.53	-0.52	***0.81***	0.51	***0.93***	***0.82***	-0.11	0.04
	Cyanoprokaryotes	-0.28	***-0.86***	***0.65***	0.25	***-0.91***	***-0.77***	-0.58	***-0.90***	***-0.90***	0.43	-0.02	***0.82***	0.38	-0.56	-0.32
	Chlorophyceae	-0.51	***-0.90***	0.48	0.08	***-0.89***	***-0.88***	***-0.72***	***-0.95***	***-0.94***	0.25	-0.18	***0.66***	0.24	***-0.72***	-0.54
	Total abundance	-0.02	***-0.89***	***0.90***	***0.69***	***-0.97***	***-0.71***	-0.13	-0.56	-0.55	***0.79***	0.48	***0.93***	***0.79***	-0.15	0.01
	Diversity	***-0.63***	***-0.97***	0.43	0.13	***-0.92***	***-0.99***	-0.64	***-0.84***	***-0.79***	0.25	-0.08	0.56	0.33	***-0.69***	-0.61
Autumn	Diatoms	***0.90***	***0.80***	***0.92***	0.64	-0.46	***0.87***	0.15	-0.08	-0.01	***0.69***	***0.91***	-0.59	***0.68***	-0.71	***-0.64***
	Cyanoprokaryotes	***0.63***	0.47	0.57	***0.78***	-0.08	-0.09	***0.62***	0.39	0.38	***0.86***	***0.71***	0.24	***0.83***	0.33	-0.43
	Chlorophyceae	***0.94***	***0.82***	***0.92***	***0.91***	-0.21	0.45	0.56	0.30	0.12	***0.97***	***0.98***	-0.12	***0.95***	-0.18	-0.54
	Total abundance	***0.92***	***0.82***	***0.93***	0.68	-0.44	***0.84***	0.20	-0.04	0.01	***0.73***	***0.93***	-0.55	***0.72***	***-0.66***	***-0.65***
	Diversity	-0.24	-0.49	-0.29	-0.15	-0.51	-0.55	-0.24	-0.36	0.95	0.01	-0.07	-0.03	-0.07	0.40	-0.55

EC; Electrical Conductivity, TDS; Total dissolved solids, DO; Dissolve oxygen, BOD; Biological oxygen demand, COD; Chemical oxygen demand, HCO_3, SO_4, NO_2, NO_3, NH_3, PO_4, TP and major cations Ca, Mg, Na and K. The Bold and italic numbers are significant ($P<0.05$)

Table (5): Simple linear correlation matrix between phytoplankton communities and some physical and chemical characters.

		EC	TDS	DO	BOD	COD	HCO_3	SO_4	Ca	Mg	Na	K	NO_2	NO_3	NH_4	TP
Winter	Diatoms	***0.91***	-0.27	***-0.78***	-0.51	0.30	***0.95***	***0.92***	0.92	***0.94***	-0.31	***-0.87***	-0.16	-0.63	***0.92***	***0.93***
	Cyanoprokaryotes	0.34	***-0.90***	0.06	-0.10	***-0.66***	0.26	0.19	-0.07	-0.25	0.21	0.29	-0.08	0.04	0.08	-0.29
	Chlorophyceae	0.30	-0.38	0.63	***0.87***	***-0.67***	0.24	0.35	0.33	-0.11	***0.92***	0.34	***0.99***	***0.78***	0.38	0.08
	Total abundance	***0.95***	-0.56	-0.24	0.10	-0.25	***0.93***	***0.97***	***0.92***	***0.65***	0.33	-0.45	0.45	-0.03	***0.97***	***0.74***
	Diversity	0.31	-0.13	0.47	***0.78***	-0.39	0.29	0.41	0.47	0.11	***0.77***	0.11	***0.94***	0.64	0.47	0.29
Spring	Diatoms	0.58	***0.98***	-0.47	-0.26	***0.92***	***0.98***	0.48	***0.70***	***0.64***	-0.34	-0.08	-0.56	-0.46	0.56	0.53
	Cyanoprokaryotes	0.29	-0.06	0.38	0.00	-0.21	0.07	-0.33	-0.52	***-0.60***	0.18	-0.19	0.53	-0.06	-0.20	0.16
	Chlorophyceae	0.76	-0.13	***0.79***	***0.97***	-0.28	0.16	***0.78***	0.40	0.38	***0.92***	***0.98***	***0.60***	***0.90***	***0.78***	***0.82***
	Total abundance	***0.96***	***0.70***	0.15	0.37	0.54	***0.89***	***0.80***	***0.73***	***0.66***	0.30	0.50	-0.01	0.17	***0.88***	***0.94***
	Diversity	0.24	***-0.69***	***0.90***	***0.92***	***-0.77***	-0.47	0.33	-0.10	-0.08	***0.93***	***0.82***	***0.80***	***0.98***	0.28	0.32
Summer	Diatoms	***0.83***	***0.82***	0.16	-0.32	0.54	***0.68***	***0.84***	***0.84***	***0.86***	***0.91***	***0.96***	***0.76***	***0.87***	***0.73***	***0.75***
	Cyanoprokaryotes	0.64	0.64	-0.45	-0.57	***0.95***	***0.71***	***0.69***	***0.66***	0.51	0.59	0.44	0.83	0.34	***0.66***	***0.76***
	Chlorophyceae	***0.89***	***0.89***	-0.37	***-0.67***	***0.98***	***0.89***	***0.92***	***0.91***	***0.81***	***0.87***	***0.77***	***0.98***	***0.68***	***0.87***	***0.94***
	Total abundance	***0.88***	***0.88***	-0.33	***-0.63***	***0.97***	***0.88***	***0.92***	***0.90***	***0.80***	***0.87***	***0.78***	***0.98***	***0.70***	***0.86***	***0.93***
	Diversity	1.00	1.00	-0.48	***-0.83***	***0.86***	***0.99***	***0.99***	***0.99***	***0.98***	***0.97***	***0.92***	***0.95***	***0.78***	***1.00***	***0.99***
Autumn	Diatoms	***-0.88***	***-0.92***	***-0.91***	***-0.67***	0.08	***-0.91***	-0.33	-0.19	0.45	***-0.63***	***-0.81***	0.38	-0.66	0.68	0.25
	Cyanoprokaryotes	***-0.80***	***-0.67***	***-0.82***	-0.50	***0.63***	***-0.85***	0.03	0.27	-0.16	-0.58	***-0.84***	***0.72***	-0.56	***0.77***	***0.77***
	Chlorophyceae	***-0.66***	***-0.62***	***-0.71***	-0.29	0.50	***-0.99***	0.16	0.32	0.15	-0.32	***-0.64***	***0.79***	-0.33	***0.94***	0.53
	Total abundance	***-0.84***	***-0.80***	***-0.88***	-0.55	0.39	***-0.96***	-0.09	0.09	0.17	***-0.57***	***-0.82***	***0.63***	-0.58	***0.81***	0.53
	Diversity	-0.83	-0.70	-0.85	-0.53	0.59	-0.86	***-0.02***	***0.23***	***-0.12***	***-0.61***	***-0.86***	***0.69***	***-0.60***	***0.75***	***0.75***

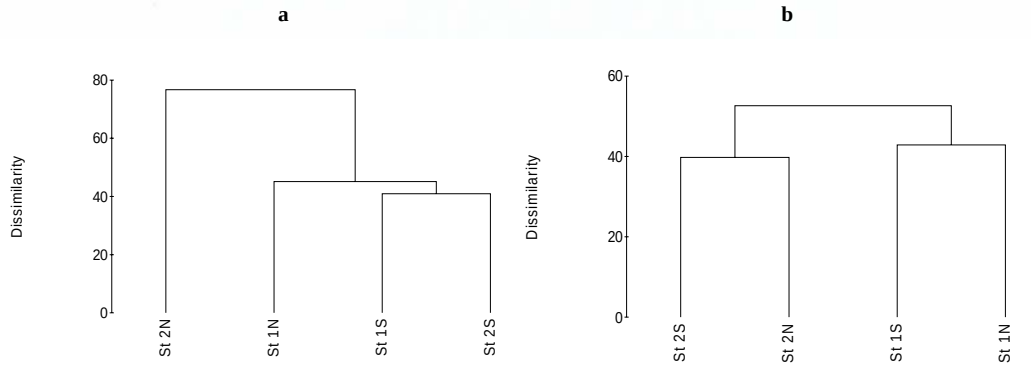

Fig. (5): Bray-Curtise dissimilarity of (a) phytoplankton and (b) epipelon during autumn.

4. DISCUSSION

Assessment of the ecological status of surface waters is increasingly needed for controlling water pollution all over the world. Phytoplankton and phytobenthos are of the biological elements known to respond to the anthropogenic impact, expressed itself mainly as nutrient enrichment. However, the composition of microalgal assemblage does not depend only on nutrients but also on biological factors (Balayla & Moss, 2004) and indirectly on meteorological and hydrological conditions (e.g. Mattson *et al.,* 2003). According to the EU Water Framework Directive (WFD, European Union, 2000), the ecological status of surface waters must be quantified mainly on the basis of biological indicators. WFD develop The Ecological Quality Ratio (EQR) to evaluate the ecological status at any area in relation to reference conditions. The implementation of the WFD requires the establishment of reference conditions for each water body type (Lepisto *et al.,* 2006). However, the data available from the River Nile at Aswan City and downstream of the Aswan High Dam in Aswan Reservoir can help as reference conditions based on the reference characters established by European Union (WFD, 2003). The phytoplankton status at Aswan City and downstream of the Aswan High Dam in Aswan Reservoir were available from Anonymous (2008 and 2009). Based on diversity index, The Ecological Quality Ratio (EQR) resulted in the ratio of 0.76 which indicated an ecological status of good level that agreed with (Tison *et al.,* 2007). On the other hand, based on the phytoplankton abundance, EQR were 6.8 and 10.4 for the River Nile at Aswan City and Aswan Reservoir, respectively. These ratios revealed a poor ecological status According to the Water Frame Work Directive (WFD, 2003).

Chlorophytes were the dominant planktonic group, at both reference sites and area of study, its percentage abundance did not exceeds 50% of the total phytoplankton abundance at the reference sites. Surprisingly, cyanoprokaryotes were represented by *Microcystis aeruginosa* with annual percentage abundance of 61.4 and 79.2%, at reference and studied area, respectively, with a great difference in the absolute abundance of 464 and 12.2 cells x 10^4 l^{-1}, respectively. The chlorophytes evenness at the reference sites showed a great equitability in the species distribution with average values of 0.92; at the studied area the evenness values were lower than 0.54 which revealed a clear dominance of a few number of species. The chlorophytes were represented at the studied area with the flourishing of *Dictyosphaerium pulchellum*, *Kirchneriella* spp, *Scenedesmus* spp and *Monoraphidium* spp. These species are character taxa of the environment rich in nutrient and considered as eutrophy-indicator species (Reynolds *et al.,* 2002). Diatoms were represented at the reference sites with *Cyclotella* spp. At the area of study, in addition to *Cyclotella* spp, *Melosira granulata* and *Synedra acus* had a big interest. The same results were reported in River Nile by Ishak *et al.* (1976), Ibrahim (1978) and Toulaibah (1996), Anonymous (2008).

The levels of TP measured during this study are of hypertrophic state as reported by OECD (1982), at these levels, epipelon communities reached a saturated uptake state for TP (Phillips *et al.,* 2005). When the flow rate of the river reduced in winter, epipelon populations had a high positive correlation with EC, TDS, HCO_3 and major cations. Whereas at the elevation of the river flow during autumn, epipelon populations had a high negative correlations. These relations naked a great response of epipelic populations to changes in ambient environment even if these changes are of minor interest. In this context, the good response of epipelon communities toward the surface water environment is considered as a

good warning of ecosystem disturbance (Gevery *et al.,* 2004 and Tison *et al.,* 2007).

The phytoplankton densities and diversity showed an irregular response towards the degree of human impact at both islets, where it sometimes increase at the more impacted stations (2 and 3) than at the less impacted stations. The response of phytoplankton communities towards the environmental conditions in spite of their high increase in densities indicated that the human impacts at different stations still in the intermediate strength that can not damage the phytoplankton populations. This may ascribed to the low human density habits the two islets that resulted in little activities and lower impact in the ecosystem around both islets. At islets the gradient of chemical factors formed by non-point nutrients flow, flow-related turbulence and the pronounced seasonal cycles in water floods, resulted in seasonal variation in biotic communities and the establishment of species without clear shift in species composition (Patrick, 1988). Different turbulence characteristics associated with cultural-eutrophication characters can be defined as disturbance factors (Reynolds, 1988 and Hamilton and Lewis, 1988) that may have a major selective influence over the microalgal population and, indeed, over ecosystem-level processes, including primary and secondary producers (Sousa, 1984). Connell (1978) introduced the Intermediate Disturbance Hypothesis to explain the high species diversity in tropical rain forest and coral reefs. In the view of this hypothesis, diversity and population density increase with disturbance that are intermediate in frequency and intensity. Reice (1985) and Padisak (1993) postulated that diversity increased after windy days and decreased in calmer periods regarding of disturbance intensity. Also, Cattaneo *et al.,* (1998) reported that intermediate disturbance may be useful to support plankton populations with different species seeds and propagules that increase both species diversity and richness.

5. CONCLUSION

The response of phytoplankton communities towards the River conditions in spite of their high increase indicated that this disturbance still in the intermediate strength that can not damage the phytoplankton populations. This study indicated that biodiversity index was lower than the corresponding values at reference sites. The Ecological Quality Ratio (EQR) resulted in a ratio of 0.76 which indicated an Ecological status of good status. On contrary, based on the phytoplankton abundance, EQR were 6.8 and 10.4 for the River Nile at reference sites, these ratios revealed a poor ecological status.

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