WATER QUALITY OF THE RIVER NILE AT MINIA, EGYPT AS EVALUATED USING ALGAE AS BIOINDICATORS

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Abstract

A sector of the river Nile at Minia governorate was studied for water quality estimation. Physicochemical and algal investigations were performed in the period May 2003- April 2004. The effect of discharge from a drainage stream that connects with the river was reflected on water chemistry and algal communities of the Nile. Receiving pollutants from the drainage stream affected the Nile water that became increased in electrical conductivity, COD, total alkalinity, NO_3^-, PO_4^{3-}, Cl^-, $Si_2O_3^{2-}$, Ca^{2+}, Mg^{2+}, Na^+, and K^+. Other parameters were decreased namely; visibility, dissolved oxygen and oxygen saturation. During the period of study, 167 algal taxa were recorded, 22.2% of which were cyanophytes, 3.6% euglenophytes, 27.5% chlorophytes and 46.7% were bacillariophytes. Being subjected to pollution the river Nile showed an increased diversity of species whereas the polluted drain accounted for the least species diversity, composed mainly of pollution-tolerant taxa. Size of algal populations was also increased as a result of discharge of pollutants into the river whereas the drainage stream showed the least dense algal populations. The drainage stream was characterized by the prevalence of the saprophilic Euglena spp. and cyanophytes such as *Oscillatoria amoena, O. chlorina, O. limosa, O. subbrevis, O. subtilissima* and *Phormidium mucosum*. Most of these species were also recorded in the river Nile indicting its contamination with organic matter and mineral salts. Diatom species with high affinity to organic matter and increased salt content were also detected in the river such as *Amphora inariesis, Gomphonema clevei, Navicula atomus, N. cuspidate, N. pygmaea, N. phyllepta, Nitzschia linearis, N. palea, N. umbonata,* and *Pleurosigma salinarum.*

Key words: River Nile, Water quality, Bioindicator algae, Upper Egypt.

Introduction

The river Nile constitutes the main source of freshwater in Egypt. In spite of the great importance of the river to life in Egypt and the presence of much environmental legislation, it is continually subjected to sources of eutrophication through discharge from domestic, agricultural and industrial sources which eventually lead to water pollution.

Eutrophication of water resources is an overgrowing global problem, which is a consequence of the enrichment of water with nutrients especially the limiting elements N and P (Round, 1981). It leads to increasing primary productivity of aquatic ecosystems, which accelerated by the continuous discharge of sewage (EL-Sherif, 1993) until exhaustion of nutrients imposes a competition stress on the aquatic autotrophic community. Exclusion of species with low competitive potential provides a load of organic matter to the environment that encourages the growth of the heterotrophic community and depletion of O_2 (Boney, 1989) which adversely affects the life of all aerobic aquatic biota and leads to pollution (Adam, 1993). Introduction of organic wastes as such from civil sewage to aquatic environments is more serious because it hastens the deterioration of water quality. The devastating effects of pollutants to the environment include disturbance in the ecological balance, species diversity, growth rate of species and interferes with food web and public health (Shaaban-Dessouki, *et al*., 2004). Moreover, certain algae at conditions of environmental stress secrete toxic substances, which produce about serious metabolic disorders when ingested by man and animals (Mohammed *et al*., 1990).

Water quality assessment requires two types of information; physicochemical and biological. Algal life in aquatic environments is governed by a number of physical, chemical and biological factors (Lay and ward, 1987 and Claps, 1996) therefore algae can often be utilized as biological indicators of environmental change since they are sensitive to fluctuations in the surrounding environment (Round, 1991). Combination of biological estimation and physicochemical data for assessment of the degree of pollution in aquatic ecosystems is more informative than using physicochemical data alone (Stevenson *et al*., 1996; El-Shahed and Ibrahim, 1999; El-Naggar *et al*., 2002). Since the pioneer work of Kolkwitz and Marsson, (1908), many lists of indicator algae have been produced such as those of Fjerdingstad (1964), Palmer, (1969) and Leclerq and Maquet, (1987).

In Egypt, many studies have dealt with the distribution and species composition of freshwater algal communities in different water resources, especially the Nile system, in relation to the physicochemical characteristics of water as well as in response to some environmental stresses (El-Naggar, 1977; El-Ayouty and Ibrahim, 1980; Kobbia *et al*., 1990; Kobbia *et al*., 1995a, b; El-Shahed and Ibrahim, 1999). In Minia district, few studies on algae of the river Nile have been conduced such as Shoulkamy, (1990) who studied phytoplankton of the river and some related streams in relation to aquatic fungi and Ibrahim, (1997) who studied sessile algal communities and used them to monitor water quality of the river Nile system.

This study aimed at using the results of physicochemical and algal analyses in assessing water quality of the river Nile as affected by the discharge from El-Moheit drainage canal. It also aimed at accumulating information on algae of the Nile, which may be useful for future monitoring studies that should be continuous and more frequent, regarding the importance of the river to life in such an arid country like Egypt.

Material and Methods

1- Area of study:

The studied sites were chosen to cover the area at which the Nile receives wastewater from El Moheit drainage canal. Discharge from this canal includes municipal sewage collected from Abu Qurqas and Minia towns, agricultural runoff from the catchment area as well as industrial wastes from the sugar factory at Abu Qurqas town. Five sampling sites were chosen to represent the studied area from the hydrobiological point of view and all of them were located on the west bank of the river Nile except Site 4 which was located on the south bank of the drainage stream:

Site (1) is located before the connection of El-Moheit canal with the Nile about 0.5 km east of the village Ettsa (Figure 1). The shore was rocky and water was speedy, clear and odorless. Cover of aquatic higher plants on the banks was composed of *Phragmitis communis* and *Eichhornia crassipes*.

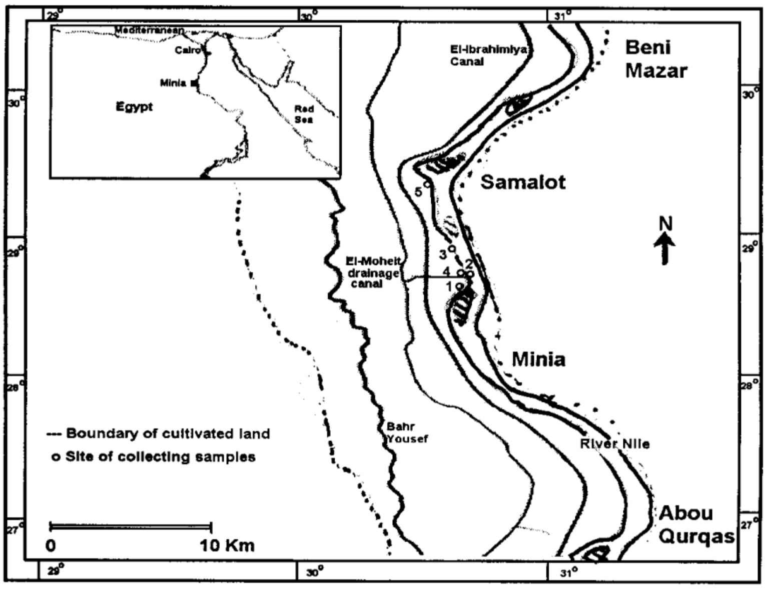

Figure (1): Localities of sample collection

Site (2) lies about 100 m after the point where the river receives wastewater from El Moheit drain. Water was brownish in color, turbid and had an unpleasant odor. The plant cover on the banks was represented mainly by *Typha australis*.

Site (3) is located about 3km to the north of Site 1. The shore and bottom were rocky and water was speedy, clear and odorless.

Site (4) is located on El Moheit drain about 200 m away from the connection with the river Nile. The shore and bottom were muddy; water was slowly running, brownish, turbid and had an unpleasant odor. Banks were inhabited by *Typha australis*. The bottom sediment was black and rotten.

Site (5) is found about 8 km to the north of Site 1 near the village El-sharaina. It was similar to Site 3 in shore and bottom structure and in water appearance.

2- Sample collection:

Samples for physicochemical and algal investigations were collected monthly from May 2003 to April 2004. Samples of benthic algae were collected from the different possible habitats such as surfaces of stones, gravel and aquatic plants and mud near the banks. The attached algae were removed by brushing an area of about 400 cm^2 of the solid objects and were re-suspended in 400 mL with water of a given site. Standard methods of collection reported by Prescott, (1982) were followed. After transportation to the laboratory, samples were examined for euglenoids before preservation with 2% formaldhyde solution.

3- Physico-chemical characteristics of water:

Measurements of temperature and transparency as well as fixation of samples for oxygen determinations were performed in the field. Transparency was measured using a Secchi disc of 20 cm diameter and pH was measured immediately after transportation of samples to the laboratory using a pH meter (LS Sargent Welch Scientific Co., London, UK). The dissolved oxygen was measured according to Winkler, (1962) and the percentage saturation of oxygen was calculated according to Truesdale *et al*., (1955).

Electrical conductivity was measured using a conductivity meter (WPA, Saffron Waden, England). Chemical analyses were performed according to the methods reported by; Anonymous (1992) for the chemical oxygen demand (COD); Mackereth *et al*., (1978) for total alkalinity; Adams (1991) for conversion of total alkalinity to inorganic carbon; Deutsche Einheitsverfahren Zur Wasser, Abwasser-Und Schlamm untersuchung, (1960) for nitrates (sodium salicylate method); American Public Health Association Publications, (1995) for orthophosphates; Adams, (1991) for particulate and total phosphorus; Jackson, (1960) for chlorides; Mullin and Reily, (1955) for silicates; Schwarzenbach and Biederman, (1948) for Ca^{2+} and Mg^{2+}. Na^+ and K^+ were determined using a flame photometer (M410 Ciba Corning Diagnostics, UK) according to Moore and Chapman, (1986).

4- Algal investigations:

Algae other than diatoms were identified in wet preparations whereas diatoms in permanent preparations (Barber and Haworth, 1981). Microscopic examination was made using a phase contrast microscope (Carl Zeis Jena Med2, Germany) and the algal taxa were identified according to the following references: Desikachary, (1959), Rüžička, (1977), Komarek and Fott, (1983), Zakrys, (1986), and Krammer and Lange-Bertalot, (1986, 1988, 1991a and b). Abundance of species was estimated according to three-degree scale; 1= rare and corresponds to 1- 5 specimens/ 10 microscopic fields; 2= moderate and corresponds to 6- 15 specimens/ 10 microscopic fields; 3= abundant and corresponds to more than 15 specimens/10 microscopic fields.

5- Statistical analysis:

Data of the physicochemical parameters of water are presented as annual mean values (n=12) to which the standard deviation was calculated. These data were numerically analyzed using the principal component analysis (Statgraphics Ver. 5 software) to produce an ordination pattern of the study sites.

Results

I- Physicochemical Characteristics of Water:

Mean annual values of the measured parameters presented in Table (1) varied for the different sites except temperature which was nearly the same in all sites throughout the period of study. The river Nile before receiving discharge from El-Mohiet drain (Site 1) was characterized by almost alkaline pH, high visibility and high oxygen content while the mean values of the other parameters were always the least compared to other sites.

El-Moheit drain canal, Site 4, was characterized by the highest electrical conductivity, COD, nitrate, phosphorus, chloride, silicate, calcium, magnesium, sodium, and potassium compared to the other sites studied. On the other hand, this site showed the lowest values of visibility, dissolved oxygen, oxygen saturation, total alkalinity and inorganic carbon compared to other sites. These features indicated pollution with organic wastes, increased salinity and deteriorated oxygenated state.

After receiving pollutants from El-Mohiet drain, the river Nile at Site 2 had an obvious increase in electrical conductivity, COD, total alkalinity, nitrates, phosphorus, chloride, silicate, calcium, magnesium, sodium and potassium whereas pH, visibility, dissolved oxygen and oxygen saturation were decreased in comparison with Site 1 i.e. before receiving pollutants.

As a result of further mixing pollutants with Nile water, Site 3 showed decrease in electrical conductivity, COD, chlorides, silicate, calcium and magnesium which were nearly similar to Site 1, however, the mean values of nitrate, phosphorus, sodium and potassium were still higher (Table 1) indicating eutrophication of this site.

Water of the river Nile at Site 5 showed some signs of improvement of water quality. Mean values of visibility, conductivity, dissolved oxygen, oxygen saturation, COD, total alkalinity, Inorganic carbon, chloride, silicate, calcium and magnesium were similar to their counterparts recorded at Site 1. In spite of this, water of the Nile was still more rich in nitrate, phosphorus, sodium and potassium than in Site 1 referring to increased trophy and salinity of the Nile water.

Table (1): Mean values (±SD) of the physicochemical parameters of the studied sites during the period from May2003 to April 2004.

Parameters		Site 1	Site 2	Site 3	Site 4	Site 5
Temp (°C)	Mean	20.8 ± 4.9	20.8 ± 4.9	20 ± 4.9	19.1± 5.4	20.8 ± 4.94
	Range	12.0 –26.0	12.0 – 6.0	12.0-26.0	12.0 – 27.0	12.0 – 26.0
pH	Mean	8.8 ± 0.30	8.1 ± 0.3	8.6 ± 0.3	7.4 ± 0.2	8.7 ± 0.4
	Range	8.33 –9.42	7.71 – .57	8.11-9.28	7.17 – 7.79	8.07 – 9.34
Visibility (Cm)	Mean	81.3 ±11.8	57.8 ±10.2	77.6 ± 7.9	30.1 ± 7.7	80.2 ± 8.4
	Range	70.0 - 110	46.0 – 80	67 – 95	20 - 50	70 – 100
E C (x 10^{-4} mhos)	Mean	1.9 ± 0.32	2.6 ± 0.4	2.2 ± 0.4	4.8 ± 0.9	2.1 ± 0.3
	Range	1.4 – 2.4	1.9 – 3.1	1.3 – 2.5	3.1 – 6.3	1.4 – 2.4
D O (mgL^{-1})	Mean	5.6 ± 2.2	4.1 ± 1.7	5.3 ± 2.1	0.3 ± 0.6	5.6 ± 2.2
	Range	2.3 – 9.3	1.4 – 6.3	1.9 – 8.4	0.0 – 2.1	1.9 – 9.2
OS (%)	Mean	61.3 ±19.7	45.0 ± 17.3	58.0±20.1	2.3 ± 5.9	59.9 ± 19.8
	Range	27.8 –86.2	16.5 – 59.3	23.7-68.3	0.0 – 19.3	23.7 – 85.7
C O D (mgL^{-1})	Mean	3.0 ± 1.0	5.4 ± 1.2	3.3 ± 1.0	17.8 ± 5.8	3.2 ± 1.2
	Range	1.4 – 4.4	2.7 – 6.6	2.0 – 4.9	9.6 – 33.3	1.3 – 4.9
T alk (mgL^{-1})	Mean	7.8 ± 2.7	5.4 ± 5.9	6.8 ± 3.0	3.1 ± 9.2	7.1 ± 3.4
	Range	4.0 – 12.0	0.0 – 21.7	4.0 – 14.0	0.0 – 31.7	4.0 – 15.3
I C (mgL^{-1})	Mean	1.8 ± 0.6	1.3 ± 1.5	1.6 ± 0.7	0.8 ± 2.4	1.7 ± 0.8
	Range	1.0 – 2.8	0.5 – 5.4	1.0 – 3.4	0.0 – 8.2	1.0 – 3.5
Nitrates (μgL^{-1})	Mean	22.8 ± 7.4	50.9 ± 13.5	32 ± 13.2	161.5± 48.4	24.9 ± 10.6
	Range	5.3 – 35.1	30.6 – 68.1	11.6–59.4	97.0 – 54.4	6.7 – 38.4
OP (μgL^{-1})	Mean	13.4 ± 9.5	53.3 ± 28.2	19 ± 10.5	386.7±138.5	21.2 ± 11.6
	Range	3.7 – 32.0	23.4 –03.4	6.2 – 37.0	120.8–652.3	9.2 – 45.2
PP (μgL^{-1})	Mean	23.3 ± 9.5	73.5 ± 28.3	30.9 ± 7.1	476.0±138.4	30 ± 8.3
	Range	9.8 – 37.5	36.5 -113.2	19.1–47.4	213.1–668.3	16.6 – 41.9
T P (μgL^{-1})	Mean	49.1 ±12.4	128.7±53.4	64.8±27.7	575.1±130.4	60.9 ± 15.5
	Range	28.9 –67.7	57.9 –46.8	37.5-134.2	329.8 801.2	37.8 – 77.5
Chlorides (mgL^{-1})	Mean	52.8 ± 7.4	74.9 ± 9.2	53.6 ± 7.7	282.8±100.9	52.1 ± 6.5
	Range	33.3 – 1.3	64.0 – 96.0	38.7 – 68.0	149.3–420.0	37.3 – 60.0
Silicates (mgL^{-1})	Mean	1.0 ± 0.6	1.4 ± 0.7	1.1 ± 0.6	3.8 ± 1.2	1.0 ± 0.6
	Range	0.1 – 2.1	0.5 – 2.6	0.6 – 2.2	2.7 – 6.2	0.2 – 2.2
Calcium (mgL^{-1})	Mean	23.9 ± 6.3	29 ± 7.5	23.8 ±6.8	50.7 ± 10.5	23.7 ± 7.0
	Range	5.5 – 29.5	6.4 – 34.7	4.3 –30.3	27.9 – 71.5	3.3 – 29.3
Magnesium (mgL^{-1})	Mean	12.3 ± 3.3	13.9 ± 4.4	12.7 ±3.2	23.2 ± 6.6	12.5 ± 3.5
	Range	9.8 –22.2	11.3 -27.2	10.1-22.4	9.2 – 33.9	9.6 – 23.0
Sodium (mgL^{-1})	Mean	16.8 ± 3.5	22.9 ± 1.6	20.1± 6.3	48.3 ± 10.5	19.1 ± 4.3
	Range	9.4 – 23.8	19.6 – 31.1	15.7-38.4	25.2 – 62.8	15.4 – 30.3
Potassium (mgL^{-1})	Mean	3.9 ± 0.9	5.6 ± 0.5	4.9 ± 1.6	11.9 ± 2.9	4.3 ± 1.3
	Range	1.9 – 5.1	4.8 – 6.4	4.1 – 9.7	5.8 – 18.0	3.8 – 8.4

Temp=Temperature, EC= Electric Conductivity, DO= Dissolved Oxygen, OS=Oxygen Saturation, COD= Chemical Oxygen Demand, T alk= Total alkalinity, IC= Inorganic Carbon, OP= Orthophosphates, PP= Particulate Phosphorous, TP= Total Phosphorous.

Principal component analysis for the first two components (Statgraphics software Ver. 5.0) of the annual mean values of the studied parameters resulted in a scatter plot (Figure 2). It appears from this Figure that Site 1 and 5 are segregated together since they had higher visibility, dissolved oxygen concentration, total alkalinity and inorganic carbon than other sites and lower values of the other studied parameters. Site 4 is located in the opposite side of Yaxis due to low visibility and dissolved oxygen and higher values of the other parameters e.g. the nutrients N, P and the measured cations. Sites 2 and 3 of the Nile that are subjected to pollution have intermediate values of the studied parameters (Table 1); therefore they are separated in a distinct group (Figure 2).

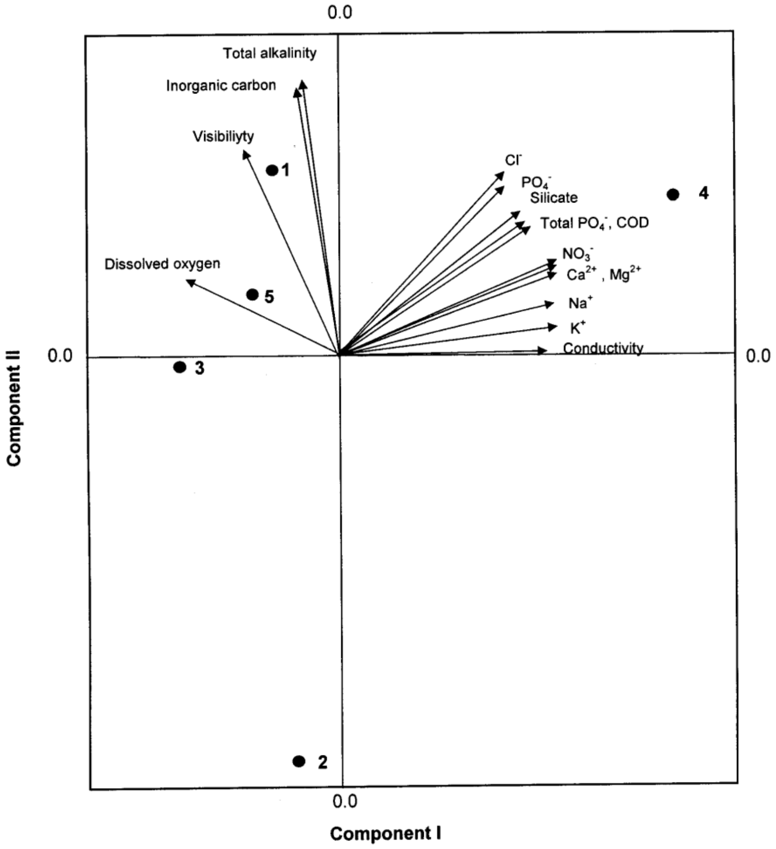

Figure (2): Principal component analysis of the mean annual values of the studied physico-chemical parameters for the sites of study

II- Characteristics of algal communities of the studied sites:

During the period of study, May 2003 to April 2004, 167 algal taxa were recorded (Table 2) of which 37 cyanophytes (22.2%), 6 euglenophytes (3.6%), 46 chlorophytes (27.5%) and 78 bacillariophytes (46.7%). The total number of algal species varied among the sites of study. It was obvious from Fig. (3) that the largest number of species was recorded at Site 2 as a result of enrichment of water with nutrients discharged from El-Mohiet drain into the river Nile. On the other hand, the least number of species was recorded to the drain (Site 4) which could result from severe conditions of pollution of its water. The other Sites (1, 3, and

5) were inhabited by a medium number of species. This pattern was similarly shown by Margaleff's coefficient for species diversity (Fig. 4).

It is obvious from (Fig. 5) that Site 2 had the larger total number of individuals than the other sites. This increase in population size referred to the increased concentrations of nutrients received from the drainage stream. On the contrary, total number of individuals at the drainage stream (Site 4) was the lowest in spite of high concentrations of nutrients, which could be attributed to the low light intensity and deteriorated oxidation state (Table 1).

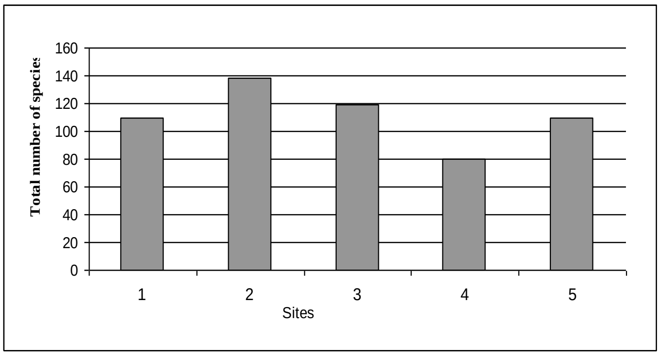

Figure (3): Total number of taxa recorded at the sites of study in the period from May 2003 to April 2004.

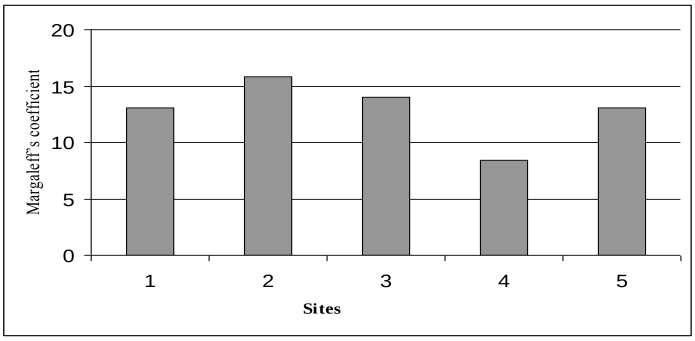

Figure (4): Diversity of species at the sites of study expressed as Margaleff's coefficient of diversity.

Populations of cyanophyta were abundant at the Site 4 as compared with the other sites whereas the density of green algal and diatom populations was smaller (Fig. 6). It was also shown that euglenophytes attained the densest populations at Site 4. Counts of Chlorophyta were the largest in Site 2 among all other sites. The smallest algal populations, especially diatoms and chlorophytes were found in Site 1 compared to the other sites on the river Nile because of the lower concentrations of nutrients.

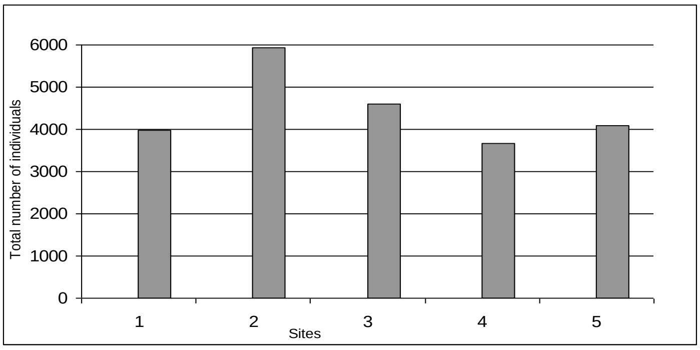

Figure (5): Total number of individuals in the studied sites during the period of study from May 2003 to April 2004

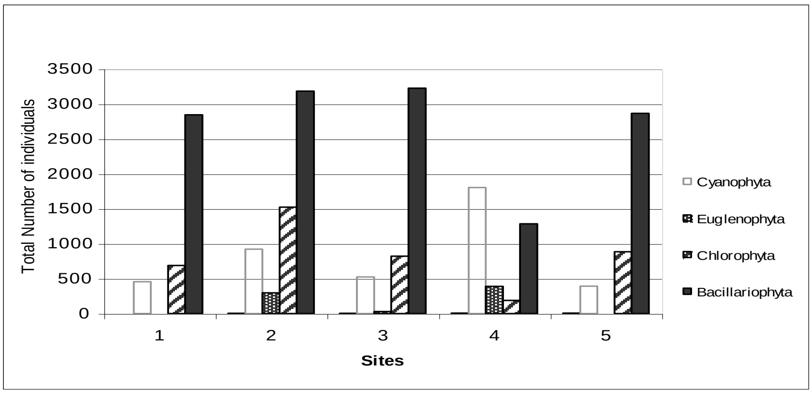

Figure (6): Total number of individuals of the different algal groups at the studied sites during the period of study from May 2003 to April 2004

It could be generally concluded from Fig. (7) that the largest number of species that belong to the major algal divisions was recorded at Sites 1, 2 and 4 for bacillriophytes, chlorophytes, and euglenophytes, respectively. This indicates low trophic level of water at Site 1; eutrophication at Site 2; and organic pollution at Site 4. On the other hand, the lowest number of species was recorded in Site 1 for cyanophytes and Site 4 for chlorophytes indicating the deteriorated conditions of water at the later site since it accounted for excessive nutrients.

Table (2) showed the prevalence of the saprophilic cyanophytes, *Achroonema articulatum, Oscillatoria amoena, O. amphibia, O. chlorina, O. laete virens, O. limosa, O. mougeotii, O. perornata, O. subbrevis, O. subtilissima* and *Phormidium mucosum* at Site 4, where they attained large frequencies, additionally indicates high content of organic matter in water. These species were also recorded in the river Nile, Site 2, but in smaller populations which may indicate a degree of organic pollution due to dilution of pollutants with Nile water.

Euglenophytes, being collectively saprophylic organisms, were recorded at Sites 2 and 4 further indicated that these sites are polluted with organic matter. These algae were not recorded neither in Site 1 nor in Sites 5 referring to the absence or scarcity of organic matter.

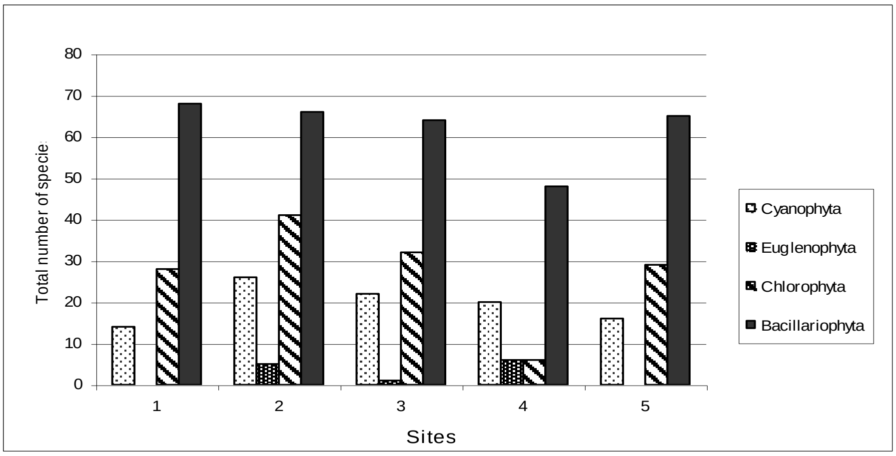

Figure (7): Share of different algal groups in algal communities at the studied sites during the period of study from May 2003 to April 2004

Members of Chlorophyta were mainly recorded in Sites 2 and 3 referring to the increased concentrations of nutrients mainly N and P. The absence or scarcity of chlorophytes in Site 4 in spite of excessive nutrients can be attributed to severe pollution and poor oxygenated conditions of water, which seem harmful to these organisms. Filamentous green algae gave a good indication of water quality despite they were represented by a few number of species. *Stigeoclonium tenue*, dominated in Site 2 which received organic effluents from El Moheit drain. *Cladophora glomerata,* an organism often appearing in waters recovered of organic pollution, frequently appeared in large populations at Site 3 and was increased at Site 5 that may show a degree of organic matter mineralization.

Table (2) shows that diatom species such as *Nitzschia linearis, N. palea, N. umbonata, Navicula cuspidate, N. pygmaea* and *Pleurosigma salinarum* had large frequencies at Site 4 moreover indicate high concentrations of organic matter and increase in salinity. As a result of discharge of organic pollutants and mineral salts into the river Nile, growth of saprobic and halophilic species such as *Amphora inariesis, Gomphonema clevei, Navicula atomus, N. phyllepta* and *Nitzschia palea* was supported in Sites 2 and 3 since these sites are contaminated with organic pollutants and salts.

Table (2): Occurrence and abundance of algal taxa in the studied sites during the period from May 2003 to April 2004. Three-degree scale 3 2 1 is used to outline the abundance of populations where 1=1-5, 2=6-15 and 3=over15 individuals per 10 microscopic fields at 40 X magnification.

Taxa	Ecological identity: Saprobity	Ecological identity: Salinity
CYANOPHYTA		
Achroonema articulatum Skuja		
A. lentum Skuja		
A. macromeres Skuja		
A. spiroideum Skuja		
Aphanotheca nidulans Richter		
Chroococcus minutus (Kütz.) Näg.		
Lyngbya cryptovaginata Schkorbatoff		
L. hieronymusii .Lemm		
L. lacustris. .Lemm		
Merismopedia minima Beck		
M. tenuissima Lemm.	β- α mesosaprobe	
Microcystis delicatissima (West) Starmach		
M. elabens Bréb.		
M. grevillei (Hassal) Elen.		
M. muscicola (Meneghini) Elen.		
Oscillatoria amoena (Kütz.) Gomo.		
O. amphibia. .Ag. ex Gomo		
O. chilkensis Biswas		
O. chlorina. .Kütz. ex Gomo	Polysaprobe	
O. claricentrosa f. bigranulata Rao		
O. cortiana Meneghini Gomo.		
O. foreaui Frémy		
O. jasorvensis Vouk.		
O. laete virens. . Gomo(Crouan)		
O. limosa Ag. ex Gomo.		

Table (2) continued

Taxa \ Sites	Site 1 (M J J A S O N D J F M A)	Site 2 (M J J A S O N D J F M A)	Site 3 (M J J A S O N D J F M A)	Site 4 (M J J A S O N D J F M A)	Site 5 (M J J A S O N D J F M A)	Ecological identity: Saprobity	Ecological identity: Salinity
Oscillatoria mougeotii Kütz.							
O. perornata Skuja							
O. proteus Skuja							
O. subbrevis Schmidle							
O. subtilissima Kütz.							
O. tenuis Ag. ex Gomo.						α- mesosaprobe	
Phormidium mucosum Gardner							
P. subincrustatum Fritsch et Rich							
Rivularia aquatica De Wilde							
Spirulina major (Kütz.) Gomo.							
S. subtilissima (Kütz.) ex Gomo.							
Synechocystis pevalekii Erceg.							
EUGLENOPHYTA							
Euglena acus. Ehr						β- mesosaprobe	
E. caudate Hübner							
E. pisciformis Klebs						β- α mesosaprobe	
E. spirogyra Ehr.							
E. viridis Ehr.						Polysaprobe	
Tracelomonas sp.							
CHLOROPHYTA							
Ankistrodesmus bernardii Kom.							
A. fusiformis Corda							
Chlamydomonas sp.							
Chlorella sp.							
Cladophora glomerata (L.) Kütz.						Oligosaprobe	
Coelastrum microporum Näg.							
Dictyosphaerium granulatum Hind.							
Golenkinia radiata Chod.							
Hyaloraphidium contortum Pasch. & Korš.						β- mesosaprobe	
Lagerheimia ciliata (Lagerh.) Chod.						.	
Monoraphidium arcuatum (Korš.) Hind.							

Table (2) continued

Taxa	Saprobity	Salinity
Monoraphidium convolutum (Corda) Kom.		
Mougeotia sp.		
Oedogonium sp.		
Oocystis sp.		
Pandorina sp.		
Pediastrum duplex Meyen	β- α mesosaprobe	
P. simplex Meyen		
P. sp.		
P. tetras (Ehr.) Ralfs		
Scenedesmus acuminatus (Lagerh.) Chod.	β- α mesosaprobe	
S. acutus Meyen	β- α mesosaprobe	
S. bicaudatus .Dedus		
S. danubialis Hortob.	β- α mesosaprobe	
S. dimorphus (Turp.) Kütz.		
S. dispar (Bréb.) Rabenh.		
S. ecornis (Ehr.) Chod.	β- α mesosaprobe	
S. ellipsoideus. .Chod		
S. ginzbergeri Kamm.		
S. intermedius. .Chod	β- mesosaprobe	
S. nanus Chod.		
S. obtusus Meyen		
S. polyglobulus. .Hortob		
S. protuberans Fritsch		
S. quadricauda (Turp.) Bréb.	β- α mesosaprobe	
S. sempervirens. .Chod		
Schroederia setigera (Schrod.) Lemm.	β- mesosaprobe	
Schizomeris leibleinii Kütz.		
Spirogyra sp.		
Staurastrum sp.		
Stigoclonium tenue (Ag.) Kütz.	α- mesosaprobe	
Tetraedron minmum (A. Br.) Hansg.	β- mesosaprobe	

Table (2) continued

Taxa	Saprobity	Salinity
Ulothrix implexa Kütz.		Salt tolerant
U. tenuissima Kütz		
U. variabilis Kütz.		
U. zonata (Weber et Mohr) Kütz.	Oligosaprobe	
BACILLARIOPHYTA		
Amphora coffeaeformis (Ag.) Kütz.		Salt tolerant
A. inariensis Krammer		Salt tolerant
A. montana Krasske		
A. ovalis (Kütz.) Kütz.	β- mesosaprobe	Salt tolerant
A. pediculus (Kütz.) Grun.	β- α mesosaprobe	Salt tolerant
Anomoeoneis sphaerophora (Ehr.) Pfitzer	β- α mesosaprobe	Oligohalobic
Bacillaria paradoxa Gmelin	.	Salt tolerant
Caloneis amphisbaena (Bory) Cleve	β- mesosaprobe	Oligohalobic
Cocconeis placentula Ehr.	β- mesosaprobe	Salt tolerant
Cyclotella meneghiniana Kütz.	β- mesosaprobe	Oligohalobic
C. ocellata Pantocsek		
C. stelligera Cleve & Grunow		
Cymatopleura elliptica (Bréb.) W. Smith	Oligosaprobe	Salt tolerant
C. solea (Bréb.) W. Smith	β- mesosaprobe	Salt tolerant
Cymbella caespitosa (Kütz.) Brun	β- α mesosaprobe	
C. cistula (Ehr.) Kirchner	β- mesosaprobe	Salt tolerant
C. muellerii Hust.		
C. tumida (Bréb.) Van Heurck	Mesosaprobe	
Epithemia sorex Kütz.	Oligosaprobe	Salt tolerant
E. turgida (Ehr.) Kütz.	Oligosaprobe	Salt tolerant
Fragilaria brevistriata Grun.	Oligo to eutrophic	
F. construens (Ehr.) Grun.	Oligosaprobe	
F. leptostauron (Ehr.) Hust.		
F. ulna (Nitzsch) Lange-Bertalot		
Gomphonema acuminatum Ehr.		
G. augur Ehr.	β- α mesosaprobe	

Table (2) continued

Taxa	Ecological identity: Saprobity	Ecological identity: Salinity
Gomphonema clavatum Ehr.		Salt tolerant
G. clevei Fricke	Oligosaprobe	
G. minutum (Ag.) Ag.	β- mesosaprobe	
G. parvulum (Kütz.) Kütz.	Mesosaprobe	
Gomphonitzschia ungeri Grun.		
Gyrosigma acuminatum (Kütz.) Raben.	β- α mesosaprobe	
G. parkerii (Harrison) Elmore		Salt tolerant
G. scalproides (Raben.) Cleve	β- mesosaprobe	Salt tolerant
Hanzschia amphioxs (Ehr.) Grun.	α- mesosaprobe	
Melosira granulata (Ehr.) Ralfs	Oligosaprobe	
M. italica (Ehr.) Kütz.	β- mesosaprobe	
Navicula atomus (Kütz.) Grun.	Polysaprobe	Salt tolerant
N. capitatoradiata Germain	β- α mesosaprobe	
N. cincta (Ehr.) Ralfs	α- mesosaprobe	Oligohalobic
N. cryptocephala Kütz.	β- α mesosaprobe	
N. cryptotenella Lange-Bertalot	β- α mesosaprobe	
N. cuspidata (Kütz.) Kütz.	α- mesosaprobe	Salt tolerant
N. gastrum (Ehr.) Kütz.	Oligosaprobe	
N. heimansii Van Dam & Kooyman		
N. Kotschyi Grun.	·	Salt tolerant
N. margalithii Lange-Bertalot		Salt tolerant
N. phyllepta Kütz.		Salt tolerant
N. pupula Kütz.	α- mesosaprobe	Salt tolerant
N. pygmaea Kütz.	β- α mesosaprobe	Salt tolerant
N. recens (Lange-Bertalot) Lange-Bertalot	β- α mesosaprobe	
N. rhynchocephala Kütz.	β- α mesosaprobe	
N. viridula (Kütz.) Ehr.	α- mesosaprobe	
Nitzschia calida Grun.		Salt tolerant
N. capitellata Hust.	Polysaprobe	
N. dissipata (Kütz.) Grun.	β- mesosaprobe	Salt tolerant
N. frustulum (Kütz.) Grun.		Oligohalobic

Table (2) continued

Taxa	Saprobity	Salinity
Nitzschia hungarica Grun.	α- mesosaprobe	
N. levidensis (W. Smith) Grun.	α- mesosaprobe	
N. linearis (Ag.) W. Smith	β- α mesosaprobe	
N. nana Grun.	β- mesosaprobe	
N. obtusa W. Smith		Salt tolerant
N. palea (Kütz.) W. Smith	α- mesosaprobe	
N. paleacea Grun.	α- mesosaprobe	
N. umbunata (Ehr.) Lange-Bertalot	Polysaprobe	Salt tolerant
N. vermicularis (Kütz.) Hantzsch	β- mesosaprobe	Salt tolerant
Pinnularia mesolepta (Ehr.) W. Smith		
Pleurosigma elongatum W. Smith		Salt tolerant
Pleurosigma salinarum Grun.		Salt tolerant
Rhoicosphenia abbreviata (Ag.)Lange-Bertalot	β- α mesosaprobe	Salt tolerant
Rhopalodia gibba (Ehr.) O. Müller		Salt tolerant
Stauroneis tackei (Hust.)Kram.&Lange-Bertalot		
Stephanodiscus subsalsus (A. Cleve) Hust.		
Surirella angusta Kütz.	Polysaprobe	Salt tolerant
Surirella capronii Bréb.	Mesosaprobe	Salt tolerant
Surirella ovalis Bréb.		Salt tolerant
Synedra gailloni (Bory) Ehr.		
Tabellaria flocculosa (Roth) Kütz.		

Discussion

The present results indicated that discharge of wastewater from El-Moheit drain adversely affected both the physicochemical and algal parameters of the river Nile, a phenomenon that was observed frequently at different parts of the Nile system in Egypt as reported by Mohamed et al., (1990); Abdel-Hamid et al., (1992); Adam, (1993) and Kobbia et al., (1995a, b) who studied nearly the same set of criteria which were used in this investigation. These authors similarly attributed changes in algal communities to deterioration of water quality as a consequence of being subjected to discharge from urban activities.

Response of algal community parameters to change in Nile water quality appeared as increased species diversity and population size that were attributed to enrichment with nutrient especially nitrogen and phosphorus which were received from wastewater. Increase in water concentrations of phosphorus and nitrogen, being limiting nutrients, enhances growth of not only algae but also all other aquatic autotrophs (Boney, 1989).

Patrick, (1972) established the concept that clean waters support a diverse number of species whose populations are small and that polluted waters have low number of species, few of which have high population size. Some authors later experienced this concept. Puig et al., (1991) reported that unpolluted streams have many species with moderate population size. Some other workers have considered species diversity enough to reflect water quality such as Molloy, (1992) who found low diversity in unpolluted streams. Species diversity as the sole means of water quality assessment was rejected by Sullivan (1986) who accepted instead, the ecological identity of the constituent species as more reliable measure. Watanabe et al., (1988) showed that dominance of species downstream could be used to monitor water quality. The method used to assess water quality in the present study is based on a composite range of criteria; physicochemical characteristics of water, species diversity, density of populations as well as the autecological information on individual taxa to avoid the mentioned controversies.

Biological assessment of water quality coincided with the assessment on physicochemical basis giving a comprehensive indication on water quality of the Nile. Species diversity and population size were increased in the river Nile as a result of receiving pollutants from the drainage stream while they were smaller in the Nile before connecting with the drain as well as in El-Moheit drain. Douterelo et al., (2004) had given similar results for some Spanish rivers. Reduced species diversity was concomitant with excessive nutrients in the drainage stream, that could be explained on basis of severe degradation of water quality and poor oxygenated state. It was experimentally shown that algal counts were decreased with increase in the percentage of added wastes (Adam *et al*., 1993). Some authors attributed decrease in algal growth at similar conditions to a competition stress imposed on the environment, which involves the production of toxins and other antimicrobial substances by aquatic inhabitants with high competition potential (Mohamed *et al*., 1990). It was noticed in the present results that the studied drain was dominated by cyanophytes whereas diversity of Chlorophyta was reduced that was attributed to severe pollution conditions. The experiments of Adam et al., (1993) have also shown that addition of wastewater in large concentrations resulted in lower counts of chlorophytes while blue greens were increased in numbers. These authors denoted green algae as sensitive algae to pollution.

Euglena, *Oscillatoria*, *Phormidium* were here considered as saprophilic algae indicating pollution of the Nile at the study area with organic matter in accordance with Fjerdingstad (1964) who classified these organisms in the α-mesosaprobic and polysaprobic zones being characteristic of waters with high organic matter content.

Chlorophyta, especially members of the Order: Chlorococcales as well as the filamentous *Stigeoclonium tenue*, were observed to appear and/or increase in counts after receiving pollutants from El-Moheit drain which was used as an indicator of water fertility. *Scenedesmus*, *Chlorella*, and *Stigeoclonium* were included in the list reported by Palmer, (1969) for the genera treated as pollution tolerant.

A number of diatom taxa were used in our data to indicate organic pollution such as *Nitzschia palea, N. linearis*, and *Gomphonema clevei*; increase in salinity such as *Pleurosigma salinarum*, *Amphora inariensis, N. phyllepta* and both organic pollution and increase in salinity such as *N. umbonata, Navicula cuspidate, N. pygmaea Navicula atomus*. Ecological information on these taxa is in agreement with those reported in the diatom monographs of Krammer and Lange-Bertalot (1986, 1988). Most of these species were previously given for polluted areas of the river Nile by Ibrahim (1997).

It is evident from the present investigation that river Nile showed signs of deterioration of its water quality, a problem that should receive much more care and alert so as to prevent the devastation of such vital freshwater resource to Egypt.

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استخدام الطحالب ككواشف بيئية فى تقييم نقاوة مياه نهر النيل بمحافظة المنيا، مصر.

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استهدف البحث دراسة نقاوة المياه فى قطاع من نهر النيل بمحافظة المنيا وقد تم لهذا الغرض جمع عينات شهرية لدراسة الخصائص الفيزيوكيميائية للمياه وعشائر الطحالب التى تقطنها وذلك فى الفترة من مايو 2003 حتى أبريل 2004 . وقد أظهرت الدراسة تغيرا فى هذه الخصائص نتيجة لصب مخلفات ملوثة فى نهر النيل عن طريق أحد المصارف المحملة بالصرف الصحى والزراعى والصناعى. أدت هذه المخلفات إلى ازدياد التوصيل الكهربى للمياه، والاحتياج الكيميائى للأكسجين والقلوية وتركيز كل من النترات والفوسفات والكلوريدات والكبريتات والصوديوم والبوتاسيوم والكالسيوم والمغنسيوم. كما أدت هذه المخلفات إلى نقص شفافية المياه والأكسجين الذائب والنسبة المئوية للتشبع بالأكسجين.

أمكن من خلال الدراسة تسجيل 167 نوعا من الطحالب كان من بينها طحالب يوجلينية بنسبة 3.6%، وطحالب خضراء مزرقة بنسبة 22.2%، وطحالب خضراء بنسبة 27.5% وطحالب عصوية بنسبة 46.7% من المجموع الكلى للأنواع التى تم تسجيلها.

وقد تأثرت خصائص العشائر الطحلبية فى نهر النيل بتعرضه للتلوث، الأمر الذى انعكس على زيادة التنوع البيولوجى للطحالب وأعدادها، فى حين أظهر المصرف تنوعا أقل وأعدادا قليلة وقد كانت معظم الأنواع تتميز بقدرتها على تحمل التلوث.

تميزت مياه المصرف بسيادة الطحالب اليوجلينية والخضراء المزرقة التى تتميز بتحملها للتلوث العضوى مثل أوسيلاتوريا أمينا، أ. كلورينا، أ. ليموزا، أ. سببريفيس، أ. سبتيليسيما، و فورميديوم ميوكوزم وقد تم تسجيل بعض هذه الأنواع فى مياه نهر النيل بعد إلقاء الملوثات فيه. كما ظهرت أيضا أنواع من الطحالب العصوية (الدياتومات) تميز البيئات الملوثة عضويا أو التى تتميز بارتفاع ملوحتها مثل أمفورا إنارنسيس، جومفونيما كليفى، نافيكولا أتوموس، نافيكولا فيليبتا، نافيكولا كاسبيداتا، نافيكولا بيجميا, نيتشيا أمبوناتا ، نيتشيا باليا و نيتشيا لينياريس.