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Seasonal succession of biomass and microalgal communities in some agricultural drainage at Minia governorate, Egypt

Shereen abdelsalam [1], Mustafa A. Fawzy[2], Wafaa A. Hafez[3] and Adel A. Fathi[4]

[1] *Researcher Assistance, Environmental Department, SWERI, ARC*
[2] *Biology Department, Faculty of Science, Taif University, 21974, Taif, KSA*
[2] *Botany & Microbiology Department, Faculty of Science, Assiut University, Egypt*
[3] *Senior Researcher, Environmental Department, SWERI, ARC*
[4] *Department of Botany and Microbiology, Faculty of Sciences, Minia University, Egypt*

Abstract:

The microalgal communities and related physico-chemical properties of some agricultural drainage at Minia, Egypt as well as, the qualitative and quantitative algal composition were seasonally studied. In total, 151 algal species were identified during the study. Bacillariophyceae was the most dominant algal group during the four seasons, followed by Chlorophyceae, Cyanophyceae, Euglenophyceae, Charophyceae and Dinophyceae. Among Bacillariophyceae, *Cyclotella striata* was the most abundant species, *Scenedesmus quadricauda* from Chlorophyceae, *Oscillatoria limosa* from Cyanophyceae, *Euglena proxima* from Euglenophyceae, *Staurastrum* sp. from Charophyceae and *Peridinium lomnicki* from Dinophyceae. The maximum algal biomass was recorded at site 1 in autumn (827.7µg/L); and the minimum value was recorded at site 4 in winter (26.7µg/L). Seven diversity indices were obtained that comprise Margalef's Index, Shannon-Wiener Diversity, Pielou’s Evenness, Fisher’s Index, Simpson Dominance Index, Simpson's Diversity Index and Berger-Parker Index. Water temperature, total alkalinity, chloride and phosphate were the most effective parameters affecting structure of microalgae during the different seasons.

Keywords: Microalgae, physico-chemical parameters, diversity indices, algal diversity, drainage.

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* Corresponding author email*:* adel_fathieg@yahoo.com (ISSN: 1110-8649)

Introduction

The steady increase in population and urban expansion has resulted in a concomitant increase in agricultural and industrial activities, which in turn has reflected an increase in the waste that is discharged into the aquatic environment (**Alnagaawy *et al.*, 2018**).

The irrigation and drainage canals perform the task of controlling the balance between the water required for irrigation and the drainage of excess water from the cultivated soil. Anthropogenic influences may lead to imbalances in this balance, which leads to special problems in the drainage channels (**El-Otify, 2015**). Analysis of chemical parameters for water provides a good indication of the chemical quality of aquatic system, but don't present the ecological effects on the ecosystem (**Rejagopal *et al.*, 2010**). Therefore, the trend is towards adding biological assessment to chemical parameters, as they complement each other to present the extent of the impact of water pollution on biological diversity in the ecosystem in water bodies (**Stevenson and Pan, 1999**).Phytoplankton provides unique information concerning an ecosystem's conditions and plays a vital role in maintaining balance of the aquatic ecosystem (**Field *et al.*, 2007**).

The average of ecological condition is attributed to Phytoplankton encountered in the water body. Therefore, they could indicate the quality of the water (**Saha *et al.*, 2000**).

Algae are found in both clean and polluted water so they can be used, especially microalgae as a sensitive indicator for environmental changes, as well as a biological sensor for the potentially toxic effects of heavy metals (**Durrieu *et al.*, 2011**).The use of microalgae as biological indicators are provides information on the surrounding physical and/or chemical environment at a particular site (**Bellinger and Sigee, 2010**).

The rate of rapid reproduction and sensitivity responses to eutrophication and chemical changes in the water gave algae the advantages that make it very ideal bioindicators in assessing water quality (**Larson and Passy, 2012; El-Otify, 2015**).The distribution, structure and biomass of microalgae are strongly influenced by chemical factors such as nutrients (**Kormas *et al.*, 2006**) and variable environmental effectors such like temperature, location, light, pH, water level, and seasonal changes (**El-Din *et al.*, 2015; Demir *et al.*, 2014**). Nutrients are important components in regulating growth of macro and microalgae (**Hernández-Carmona *et al.*, 2011**). **Tóth (2013)** stated that phosphorus and nitrogen increase in eutrophic water resulted in increase of planktonic algae. **Smith and Manoylov (2013)** also reported that the increase in temperature leads to an increase in the diversity of diatoms. **El-Otify (2015)** observed obvious differences in water quality and phytoplankton abundance as well as its community structure between the irrigation and drainage canals. He noticed that the diversities of species in the irrigation canals are relatively higher than those in the drainage canals. In addition, some Euglenoid and Cyanoprokaryotic phytoplankton found in the drainage canals while absent in the irrigation canals.

Egypt is rich with networks of canals for irrigation and drainage designed for agricultural uses. Agriculture in Egypt is mostly dependent on water from the river Nile. Irrigation canals used to transfer the water from the Nile to the fields however its water may be used for drinking, industrial purposes, navigation and fishing. The main drainage in most parts of upper Egypt discharge their water into the Nile by gravity without any treatment. These drains receive the excess of irrigation water which contains chemicals used for pests or herbs control, domestic wastes effluents from side bank habitations, municipal, rural domestic and industrial wastes (**Radwan *et al.*, 2004**). Drainage water usually contains a high salt concentration beside organic load, toxic chemicals, and nutrients and dissolved oxygen depletion (**El-Sadek *et al.*, 2003**).

The area of middle Egypt such like Minia governorate received less attention to the effects of water pollution especially in drainage canals on algal diversity. Therefore, the aim of the present study is to investigate species diversity, abundance of microalgae as well as biomass variation in different drains at Minia and the accompanied relationships to physicochemical factors that affect the phytoplankton succession.

Materials and Methods

1. Study area and sampling

Water samples were seasonally collected from five drains at four different pumping stations in south Minia, Egypt (Abu-Jabl, Tuna, Kab-kab, Hassan Pasha and Al-Muhit drain) (Table 1, Fig. 1) during the period from July 2017 to June 2018. Polyethylene bottles were rinsed firstly with sample water and then closed and dipped in the water to about 0.5 meter depth. For collecting the water samples, the bottle was opened inside the water and closed after collecting the sample. Samples were collected as three replicates at each of the five locations however were mixed in the lab to prepare an integrated sample. Samples used for algal survey was preserved immediately in 4% formalin solution for counting and stored under dark and cool condition. Sedgwick-Rafter cell 1 cm^3 was used for counting the microalgae (**Ganf, 1974**). The biomass of algae was estimated as chlorophyll (mg/L) according to (**Metzner et al., 1965**) .Species identification was performed according to **Kramer and Lange-Bertalot (1991)**; **Lund and Canter-Lund (1995)**.

2. Water analysis

The water temperature was measured in situ by Thermometer. The pH values were determined using a digital pH meter (pH Pen Jenco Electronics, U.S.A).Electrical conductivity was measured in water samples using conductmeter (JENWAY, UK 4510).Total dissolved solids were determined by the method adopted by (Jackson, 1958). Estimation of total alkalinity was performed according to the method described by **Mackereth *et al.* (1978)**. Nitrate was determined by sodium salicylate method (Deutsche Einheitsverfahrenzur Wasser- Abwasser -und Schlammuntersuchung, 1960). **Dewis and Freitas (1970)** method was used for the determination of orthophosphate. Estimation of chlorides was performed according to the method described by (**Jackson, 1960**).Na^+ and K^+ were determined by the flame photometric technique (**Williams and Twine, 1960**) using Dr Lange Flame Photometer M 71 D type Nr/LPG. Calcium and magnesium were determined using versene titration method (**Schwarzenbach and Biederman, 1948**). Dissolved Oxygen (DO) and Biological Oxygen Demand

(BOD) were determined by Winkler's method (**Winkler, 1888**). Ammonium (NH_4^+) was estimated by Nesslerization spectrophotometric method (**Allen and Coon, 1960**). Sulfate-sulfur was determined according to (**Sheen *et al*., 1935**) method. Turbidity was measured in water samples using (HACH 2100 Q).All variables were determined in triplicate for each sample.

Table.1. Description of the study sites

Site no.	Station	Study site	Longitudes	Latitudes
1	El-Badraman pumping station (DeirMawas)	Abu-Jabl Drain	30°73'29319"	27°66'61583"
2	Tuna pumping station (Mallawi)	Tuna Drain	30°71'29857"	27°88'40297"
3	Kab-kab pumping station (Abu Qirqas)	Kab-kab Drain	30°72'88707"	27°87'83862"
4	Monshaat El-Dahab pumping station (Minia)	Hassan Pasha Drain	30°71'12838"	28°22'39775"
5	--	Al-Muhit Drain	30°72'71142"	28°22'44156"

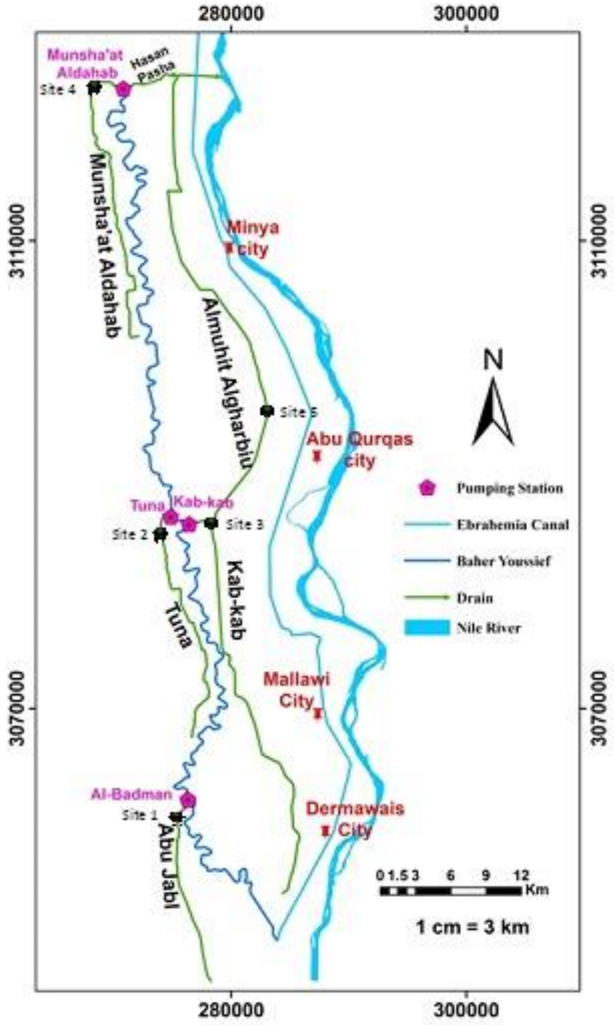

Fig. 1. Map of the study area.

3. Community structure analysis

Margalef's index (d') was used to measure richness of species (**Margalef, 1958**). Shannon-Wiener diversity (H', $\log_e$ based) was calculated depending on **Shannon-Wiene (1949)**. Species evenness was calculated using the Pielou's Evenness Index (J') (**Pielou, 1975**). A diversity index (Simpson Index) was derived from **Simpson (1949)**.The differences in the structure of algal community between the two studied factors (site and season) were examined by permutational multivariate analysis of variance (PERMANOVA). The analysis of PERMANOVA was carried out by PERMANOVA+ in PRIMER v6 software (**Anderson *et al.*, 2008**).

A distance-based redundancy analysis (dbRDA) plot allowed the visualization of the relationship between algal species composition and physico-chemical variables and highlighted the variability in species composition along the site and season factor using Bray Curtis similarity between algal species. The analysis of dbRDA was carried out by PERMANOVA+ in PRIMER v6 software (**Anderson *et al.*, 2008**).

Results and Discussion

1. Physico-chemical characteristics of the water samples

Recently, microalgae are used as a sensitive indicator for environmental changes (**Durrieu, *et al.*, 2011**). Its abundance and composition can be an excellent indicator and sensitivity to the environmental changes (**Varadharajan and Soundarapandian, 2014**).

The seasonal change of physico-chemical characteristics of the water samples are tabulated in [Table 2]. Seasonal variations in water temperature of the study sites showed wide range of temperature (19°C and 34°C). The data show that change in pH value was always in the alkaline side. The highest pH was recorded during autumn (8.6) at site2 and the lowest pH was recorded during summer (6.95) at site 5.

Table 2.Physico-chemical characters of the investigated water samples seasonally collected from the study area at El-Minia, Egypt

Sites and seasons / Parameter	Summer					Autumn					Winter					Spring				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Temp. (°C)	31	32	32	33	34	22	22.5	23	22	22	19.5	20	20	19	22	21	26	27	27	27
pH	7.6	7.6	7.9	8	6.95	8.2	8.6	8.2	7.8	8.4	7.9	7.7	7.8	7.9	7.4	7.6	8.4	7.8	8.5	8.4
EC (µmho.cm^{-1})	550	845	1136	1012	809	511	720	1036	1094	888	504	611	903	1145	1012	622	311	1027	840	869
TDS(mg/L)	392.2	602.5	810	721.6	576.8	364.3	513.4	738.7	780	633.1	359.4	435.7	643.9	816.4	721.6	443.5	221.7	732.3	598.9	619.6
Total alkalinity(mg/L)	197.5 ±13	265 ± 2.9	320 ±1.4	242.5 ±13.0	287.5 ±1.4	255 ±1.4	317.5 ±1.4	357.5 ±1.4	360 ±5.8	357.5 ±30.3	205 ±11.7	212.5 ±2.2	297.5 ±22.9	367.5 ±54.1	385 ±33.8	160 ±0.0	207.5 ±1.4	230 ±0.0	210 ±1.4	220 ±2.9
Nitrate-N (mg/L)	1.6 ±0.1	3.6 ±0.5	3.7 ±0.3	0.95 ±0.0	0.35 ±0.0	2.4 ±0.3	0.47 ±0.0	1.0 ±0.0	1.6 ±0.0	0.56 ±0.0	1.2 ±0.1	1.1 ±0.1	4.5 ±0.5	3.9 ±0.3	1.3 ±0.1	1.7 ±0.0	2.3 ±0.1	0.62 ±0.0	0.84 ±0.0	1.1 ±0.0
Phosphate-P(mg/L)	0.1 ±0.0	1.7 ±0.0	0.1 ±0.0	0.9 ±0.0	1.1 ±0.0	3.1 ±0.7	5.8 ±0.6	2.1 ±0.8	1.4 ±0.3	5.8 ±1.7	3.3 ±1.1	6.1 ±2.0	2.0 ±0.6	4.4 ±1.5	22.9 ±7.6	0.19 ±0.0	0.22 ±0.0	0.07 ±0.0	0.11 ±0.0	0.98 ±0.0
Chloride (mg/L)	70.9 ±0.0	70.9 ±0.0	106.4 ±0.0	124.1 ± 0.1	70.9 ±0.0	106.4 ±0.0	106.4 ±0.0	141.8 ±0.5	230.5 ±0.3	159.6 ±0.2	88.7 ±0.1	159.6 ±0.2	159.6 ±0.2	230.5 ±0.3	212.8 ±0.5	159.6 ±0.1	141.8 ±0.0	141.8 ±0.6	141.8 ±0.0	195 ±0.0
Sodium (mg/L)	62.6	139.4	222.0	184.7	134.9	70.5	148.3	171.0	157.3	139.4	58.7	143.8	130.5	217.3	148.3	161.9	157.3	236.1	189.4	134.9
Potassium (mg/L)	6.8	6.0	3.8	10.7	37.9	7.6	6.0	5.3	9.1	40.7	7.6	7.6	5.3	9.9	47.4	7.6	8.3	4.5	9.9	37.0
Calcium (mg/L)	62 ±1.2	90 ±1.2	116 ±1.2	114 ±1.2	90 ±1.2	58 ±1.2	75.6 ±0.4	99 ±0.7	108 ±1.2	77.4 ±1.2	55.8 ±0.6	57.6 ±0.2	111.1 ±0.5	114.8 ±1.0	111.8 ±1.0	64.7 ±0.5	32.8 ±0.6	103.2 ±0.5	75.9 ±0.8	78.8 ±0.3
Magnesium (mg/L)	17.1 ±0.0	33.4 ±0.3	37.7 ±0.1	33.4 ±0.3	30.5 ±0.5	18.9 ±0.1	26.4 ±0.3	35.5 ±0.5	34.8 ±0.6	28 ±0.5	17.6 ±0.2	19.1 ±0.2	35.5 ±0.3	38.6 ±0.5	37.9 ±0.4	21.5 ±0.0	11.0 ±0.6	35.4 ±0.1	26.2 ±0.5	26.4 ±0.1
DO (mg/L)	16.2 ±0.0	24.3 ±0.1	20.7 ±0.0	28.2 ±0.0	15.0 ±0.2	12 ±0.0	18.9 ±0.1	16.2 ±0.0	35.7 ±0.1	14.2 ±0.2	9.6 ±0.3	9.6 ±0.1	12.6 ±0.2	11.4 ±0.1	10.0 ±0.2	14.7 ±0.2	11.4 ±0.1	16.2 ±0.1	13.8 ±0.1	10.0 ±0.1
BOD (mg/L)	3.0 ±0.0	5.7 ±0.1	2.7 ±0.1	9.0 ±0.1	3.2 ±0.1	1.8 ±0.1	6.3 ±0.0	5.4 ±0.1	23.7 ±0.1	2.1 ±0.1	2.4 ±0.3	3.6 ±0.4	3.6 ±0.3	3.0 ±0.2	3.0 ±0.2	3.3 ±0.1	1.8 ±0.0	5.4 ±0.1	3.6 ±0.1	2.8 ±0.3
Ammonium (mg/L)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	2.2 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	1.2 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	7.2 ±1.4	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	3.0 ±0.1
Sulphate-S (mg/L)	0.4 ±0.1	0.44 ±0.0	1.0 ±0.1	1.0 ±0.0	1.5 ±0.0	0.4 ±0.0	0.32 ±0.0	0.4 ±0.0	0.8 ±0.0	0.4 ±0.0	0.32 ±0.0	0.35 ±0.0	0.25 ±0.0	0.28 ±0.0	0.44 ±0.0	0.28 ±0.0	0.28 ±0.0	0.8 ±.00	1.0 ±0.0	0.8 ±0.0
Turbidity (N.T.U)	14.4	6.57	25.5	4.83	9.4	9.04	15.9	23.2	8.98	111	9.17	1.85	2.51	1.29	12.1	15.7	9.3	34.8	5.9	1.3

EC: electrical conductivity, TDS: total dissolved solids, DO: dissolved oxygen, BOD: biological oxygen demand.

The electrical conductivity and total dissolved solids fluctuated within 311 µmho.cm^{-1}and 221.7mg/L during spring at site 2 and 1145 µmho.cm^{-1}, and 816.3 mg/L during winter at site 4, respectively. The biological activities of phytoplankton and epiphytic microalgae especially photosynthesis and respiration has been controlled by the temperature and pH of aquatic systems, (**Sukran *et al*., 2002**). **Lashari *et al*. (2009)** stated that, temperature measurements are useful in indicating trends for various chemical, biochemical and biological activities. The pH value ranged between 6.95 and 8.6; this variation is due to the presence or absence of free carbon dioxide and carbonate and planktonic density during various months (**Lashari *et al*., 2009**).**Toma (2011)** found that most aquatic organisms can tolerate to normal pH range (6.0-9.0), but they are most active when the pH value is around 7. On the other hand, variations in T.D.S may be attributed to the consumption of salt by algae and other aquatic plants, rate of evaporation as well as the size of the water body, and inflow of water (**Lashari *et al*., 2009**). The increase in E.C. value may be because of presence of salts and dissolved materials at the lake sediments (**Toma, 2011**). Content of total alkalinity in the water samples ranged between 160 mg/L at site 1 during spring and 385 mg/L at site 5 during winter. This increase may be due to the bacterial decomposition of organic substrates (**Abdel-Satar and Elewa, 2001**). The turbidity was high (111 N.T.U) at site 5 and low (1.29 N.T.U) at site 4 in autumn and winter, respectively [Table 2]. The turbidity at all sites was within the normal ranges of FAO except at site 3 in summer and spring (25.5 and 34.8 respectively) which was higher than permissible limits of **FAO (1985)**.

Nutrients such as NO_3, NH_4 and PO_4 play an important role in the productivity of aquatic ecosystems (**Graham *et al*., 2009**). In the present study, nitrate-nitrogen showed the maximum content during winter (4.5 mg/L) at site 3, whereas the minimum content was recorded in summer (0.35mg/L) at site 5. Phosphate-phosphorus was fluctuated within 0.07 mg/L at site 3 to 22.9 mg/L at site 5 during spring and winter, respectively [Table 2]. **Abdo (2013)** found that elevation in nitrate during cold months might be attributed to low consumption by phytoplankton as well as the oxidation of ammonia by nitrifying bacteria and biological nitrification. The low values of ammonium in some sites probably due to the utilization of NH_4^+ by phytoplankton, sewage and industrial discharges which use ammonium liquor or gas for their production processes (**Khalil *et al*.,**

2014). The high concentrations of total phosphorus and total nitrogen may be due to interaction between the water and sediment which contains dead plants and animal at the bottom of the lake, firm rock deposit and runoff from surface catchments causes release of nutrients to the water column (**Tamot and Sharma, 2006**). **Toma (2011)** explained the decline in PO_4 values in some sites and seasons may be because of the significant decline in phytoplankton biomass. The data of table [2] show that the content of chloride in the water samples ranged between 70.9 mg/L at site 1, 2 and 5 in summer and 230.5 mg/L at site 4 during autumn and winter was low in summer and high in autumn and winter. The high concentrations of chloride recorded in this study could be mainly attributed to drain water discharge or to high summer temperature which accelerate evaporations (**Al-Sheikh and Fathi, 2010; Fathi *et al.*, 2013**)

Monovalent and divalent cations play very important role in the productivity of inland water. The highest content of sodium was recorded in the water samples collected from site 3 (236.1 mg/L) in spring, while the lowest content of sodium was recorded in the water sample collected from site 1(58.7mg/L) in winter. Potassium concentration was the highest (47.4 mg/L) in winter at site 5 and the lowest value (3.8 mg/L) was recorded in summer at site 3. Both sodium and potassium play important role in the productivity of water (**Fathi *et al.*, 2013**). It is worthy to note that, potassium concentration in the present study higher than the acceptable ranges at all sites according to the FAO for irrigation water. On the other hand, calcium content was seasonally ranged between 116 mg/L at site 3 and 32.8mg/L at site 2 during summer and spring, respectively. The maximum value of magnesium was 38.6 mg/L at site 4 and the minimum was 11.0 mg/L that recorded at site 2 in winter and spring, respectively. **Elewa (1988)** found that the microorganisms play an important role in the exchange of calcium between sediments and submerged water as well as the calcium concentration in water was affected by the adsorption of the calcium ion on the metallic oxides.

Dissolved oxygen is an important parameter for identification of different water masses. The data of this investigation illustrated that the highest value of dissolved oxygen was 35.7 mg/L at site 4 in autumn and the lowest was zero that recorded at site 5 in all seasons. On the other hand, the biological oxygen demand was ranged from 23.7 mg/L at site 4 in autumn to zero that recorded at site 5 in all seasons. The maximum value of ammonium was 2.2, 1.2, 7.2 and 3.0 mg/L at site 5 in summer, autumn, winter and spring, respectively, and the minimum was zero that recorded at most sites and seasons. Dissolved oxygen (DO) content, plays a vital role in supporting aquatic life and the environment changes. Oxygen depletion often occurs during times of high community respiration, Hence DO have been extensively used as a parameter delineating water quality and to evaluate the degree of freshness of a river (**Hassan *et al*., 2010**). **El-Gamel and Shafik (1985)** stated that depletion in DO might indicate high organic matter and nutrients load. The relatively high concentrations of dissolved oxygen recorded in this study could be mainly attributed to light intensity rather than photosynthetic activity of phytoplankton due to the increased photosynthetic activity of phytoplankton populations (**Fathi and Flower, 2005; Fathi *et al*., 2009**). Biological Oxygen Demand (BOD) reflects the degree of organic matter pollution, in the present study BOD was within the normal ranges of FAO (≤ 6) except at site 4 in summers and at site 2, 4 in autumn. As well as, BOD at site 5 (Al-muhit drainage) was away from the acceptable ranges according to FAO, which agree with results obtained by **Ali *et al*. (2014)**. Sulfate-sulfur concentration ranged between 0.25 mg/L during the winter at site 3 and 1.5 mg/L during summer at site 5 [Table 2]. The increase in the concentration of sulfate during the hot period may be attributed to high air and water temperatures followed by high evaporation rate (**Toma, 2011**).

2. Community structure

Phytoplankton communities are sensitive to changes in their environment; therefore its biomass and many species are used as indicators for water quality (**Brettum and Andersen, 2005**). The biomass and abundance of microalgae varied between different sites and seasons. The present study recorded the maximum algal biomass at site 1 in autumn (827.7µg/L); on the other hand, the minimum algal biomass was recorded at site 4in winter (26.7µg/L) (Fig.2).

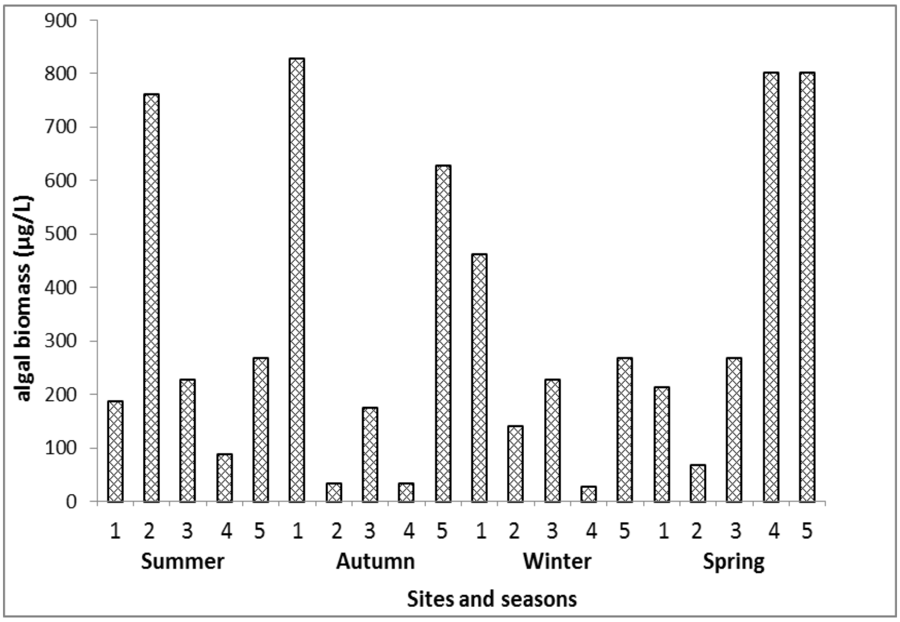

Fig. 2. Changes in algal biomass between the sites and seasons

In total, 151 algal species were identified, of which 78 species (18 genera) belong to Bacillariophyceae, 47species (22genera) belong to Chlorophyceae, 11 species (8 genera) belong to Cyanophyceae, 9 species (2 genera) belong to Euglenophyceae, 5 species (2 genera) belong to Charophyceae and 1 species (1 genus) belong to Dinophyceae (Table 3). Bacillariophyceae was the most dominant algal group during the four seasons (51.6%), followed by Chlorophyceae (31.1%), Cyanophyceae (7.3%), Euglenophyceae (5.9%), Charophyceae (3.3%) and Dinophyceae (0.66%).The total numbers of members of class Cyanophyceae ranged from (26×10^3ind. L^{-1}) in winter at site 4 to (3213×10^3ind.L^{-1}) in summer at site 5,while the highest numbers of individuals of class Bacillariophyceae (17152×10^3 ind. L^{-1}) was recorded at site 1 in winter and the lowest (2217×10^3ind. L^{-1}) was found in summer at site 1(Fig. 3).

Table. 3. Number of algal taxa (N, ind. × 104 L-1) in the investigated water samples seasonally collected from the study area at Minia, Egypt

Sites and seasons	Summer					Autumn					Winter					Spring				
Algal taxa	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Cyanophyta																				
Chroococcus limneticus Lemmermann								2												
Coelosphaerium sp.						3						1	1			1				
Merismopedia convoluta f. minor Wille in Hedin		2		8		5					33				5	3		3		5
Merismopedia tenuissima Lemmerm		2	38	15	5	3	4	50		4	5	4			1	9	4	4	1	13
Microcystis sp.								12		14	33	7	4			1		3	1	1
Nostoc sp.																			1	1
Oscillatoria waterbergensis M. I. Claassen			2	2	68		3		4	8	3				5				3	8
Oscillatoria limosa C.Agardh ex Gomont		2	18	6	213	8	3	6	8	20		5	3	1	11	8	15	7	9	9
Oscillatoria sp.			56	4	35	3	12	4	6	48	3	4	20	1	20	4	4	8	4	3
Pseudanabaena limnetica (Lemmermann) Komárek						1	5		2	2	3	1	3		1	5	1	1	1	5
Spirulina subsalsa Oersted ex Gomont												4			5		1	3		
Chlorophyta																				
Actinastrum hantzschii Lagerheim				4	2		4					1					4			
Ankistrodesmus angustus C.Bernard		6				2	15	12		6			1			1	1	4		
Ankistrodesmus densus Korshikov				2	6	1	4			4	3	1	1		1	4	4	1		
Ankistrodesmus falcatus (Corda) Ralfs						3	4	4		12	1	5	1		1	5				4
Chlamydomonas sp.						5	16	4	8					1			3		1	
Chlorella kessleri Fott &Nováková		26					8	2								1				
Chlorella sorokiniana Shihira & R. W . Krauss						5														
Chlorella sp.					26		7													
Chlorococcum sp.	7		12	2	2											1				
Chodatella citriformis J. W. Snow							4	2				1		1	3		3	1		
Closteriopsis longissima f. gigantea Heynig			2		4	4	11	4		6	3	4	3	1	3	1				1
Coelastrum astroideum De Notaris		4	22		2	4	5	16			4	5				1	4	11	3	
Coelastrum cambricum var.cubicum Playfair				16		1	4		2			1				1			1	

Table 3.Continue

Sites and seasons Algal taxa	Summer					Autumn					Winter					Spring				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Cosmarium botrytis f. minus Woronichin				6																
Cosmarium sp.		10	46									3			1	1	1			
Crucigenia fenestrate Schmidle						5	1	14		2						1		4		
Crucigenia irregularis var. pyrenogera R.H.Chodat			18		6										4				1	
Crucigenia rectangularis (Nägeli) Gay								14	4	2	3		1			7	3	8	3	3
Crucigenulla sp.								6								1	1			1
Dictyosphaerium ehrenbergianum Nägeliehrenbergianum								4			11		1			1		1	1	
*Dictyosphaerium granulatum*Hindák						1										4	1	3		1
*Dictyosphaerium pulchellum*Wood												5	3			3		3	1	
Errerellabornhemiensis W.Conrad						1	1					1				1		1		
*Eudorina*sp.				2	4															
Golenkinia paucispina West &G.S.West		2	14		4							1								
Micractinium pusillum var. elegans G. M. Smith			20				3					4	1	1			1			
Monoraphidium contortum(Thur.) Komárk- Legn.											3	5								
Monoraphidium sp.					6		1									3				
*Oocystis borgei*J. Snow	7	4	20				5	2		2	4	4	3		1	8	1	4	3	1
Pediastrum boryanum var. productum West				20									3			9	1	3		3
Pediastrum clathratum (Schröder) Lemmermann		2			6	1	3									9	1	3	1	5
Pediastrum duplex var. regulosum Raciborski	3		8	6	6			4	2	2	4					5	4	11	1	3
Pediastrum simplex Meyen	8	6	46	24	16	1	1	4	2	6	3	1	3	1	1	1	3	19	3	4
Pediastrum tetras var. obtusatum Raciborski		4			2	1														
Scenedesmus acuminatus var. biseriatus Reinhard		2	8		10	5	13	26	2	4	12	1	11		1	8	8	12	7	3
Scenedesmus armatus var. bicaudatus (Guglielmetti) Chodat				4			4		4			1	1			1		1		1
Scenedesmus ellipticus (West & G.S.West) Chodat						1	1	6			9		4		1		1		1	3
Scenedesmus dimorphus (Turpin) Kützing			2	6		1										3		1	5	
Scenedesmus incrassatulus var.mononae G. M. Smith						1	13	14	8	6	17	11	11	1	8	1	3	7	1	8

Table 3.Continue

Sites and seasons / Algal taxa	Summer					Autumn					Winter					Spring				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Scenedesmus insignis (W.& G.S.West) Chodat							4	2	6		1	1						1	1	
Scenedesmus obtusus f. ecornis Compére					14											1				
Scenedesmus platydiscus (G.M.Smith) Chodat							1	4	4		1					1				
*Scenedesmus quadricauda*Chodat	3	30	96	16	18	5	4	10	2	4	17	9	12	3	1	12	9	20	3	4
Scenedesmus sp.				18	2															
Schroederia setigera (Schröder) Lemmermann									4											
Tetraspora cylindrica var. bullosa C.Mayer	17	58	6				7			2	1					1	1	3		
Tetraedron minimum (A. Braun) Hansgirg		6					3	4		2	1	4	9		1	3	1	1		
Bacillariophyta																				
Amphora coffeaeformis (C. Agardh) Kütz.				2			1				1	1								
Amphora ovalis (Kütz.) Kütz						1	1	6	4			12	28	7	1	1	8	200	8	5
Amphora sp.								2										4		
*Bacillaria paradoxa*J.F. Gmel. in Linne									4					19	1				3	
Caloneis amphisbaena (Bory)Cleve					16							12		4	4	1		8		4
Caloneis sp.								2					4							
*Cocconeisplacentula*Ehrenb.	13	38	24	8	30	13	38	26	10	24	17	37	15	24	12	16	20	27	9	24
Cyclotella caspia Grunow						63	29	8			136	5	12	4	16	128	57	20	16	40
Cyclotella communies	37	34	402	38	364	130	184	254	30	34	336	76	72	8	108	304	196	168	12	72
Cyclotella meneghiniana Kützing		4		4	84		3	2												
Cyclotella striata (Kützing) Grunow	42	40	506	112	338	93	16	24	2		412	116	152	16	124	300	104	240	20	124
Cymbella affinis Kützing Prox								14					1							
Cymbella cistula (Ehrenberg) O. Kirchner	8	2	6		4	3	1	4	2	2	3		8	1			3	30	4	3
Cymbella Helvetica Kütz.			6																	
Cymbella naviculiformis Auerswald ex Heiberg							3					1	3				1	64	1	1
Fragilaria capucina Desmazières	3	2	2			9								4	1	3	3			1
Fragilaria fasciata Lyngbye				4	12	3		4		6	5	4	15		3		1	1		4
Fragilaria rumpens (Kütz.) G. W. F. Carlson					100								3							3
Fragilaria sp.				4	4			6	6			5		1	4	1	1	3	4	4

Table 3.Continue

Sites and seasons	Summer					Autumn					Winter					Spring				
Algal taxa	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gomphonema acuminatum Ehrenb. var. *acuminatum*					2									5			8			1
Gomphonema olivaceum var. vulgare (Kützing)											3	1			1				1	
Gomphonema sphaerophorum Ehrenberg		4		8																
Gomphonema sp.				2							1		1							
Gyrosigma acuminatum (Kützing) Rabenhorst				2			1													
Gyrosigma attenuatum var. typicum A. Cleve			4	2					8				15	7						
Gyrosigma constrictum Volkov							1	8	10		9		1		1			13		
Gyrosigma olivaceum (Hornemann) Brébisson										2								13		
Gyrosigma sp.	5			2												4	1	1	3	
Melosira granulata (Ehrenberg) Ralfs	10		6	8	18	4	4	4	4	2	9		7	7	20	5	1		3	11
Melosira italica (Ehrenberg) Kützing	13	12	12	14	28	20	7	4		2	7	12	9	4	1	21	21	5	8	11
Meridion circulare (Greville) C. Agardh		2	2	6	2	3	4	4	6		1	3	3	3	1		4	3	8	
*Meridion*sp.						1														
Navicula absoluta Hustedt				12																
Navicula apiculatoreinhardtii M. B. Edlund & N.Soninkhishig									2	4		3			7					
Navicula capitatoradiata H. Germ				6		11	16	34	56	6	12	16	31	19	9	3	7	4	5	3
Navicula cryptocephala Kützing											1									
Navicula cryptofallax var. tibetica D. A. Chudaev												1			1					
Navicula detenta Hustedt				2	18													1		1
Navicula digitoradiata (W. Gregory) Ralfs							5	10	2		1	3	5			1		4	4	1
Navicula elsoniana R. M. Patrick & Freese			32	20	2	1	1		18	2	3		4	8				1	3	1
Navicula gregaria Donkin							3								1		1	1		
Navicula hustedtii Krasske							5			2										
Navicula ingénue												4	1							4
Navicula kotschyi Grunow var. kotschyi					52			8												
Navicula longicephala Hustedt					2		4			10										
*Navicula seudolanceolata*Lange-Bertalot		2	18			3	8	22	2	6	3	16	7	4	3	9	27	29	5	1
Navicula sp.		4	2		10			4	28						4					3

Table 3.Continue

Sites and seasons	Summer					Autumn					Winter					Spring				
Algal taxa	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Navicula subrhynchocephala Hustedt										4	1				3					
*Navicula trivialis*Lange-Bertalot	22		58	4	2	17	12	28	24	14	8	3	25	24	3	16	3	3	1	1
Navicula volcanica Bahls&M.Potapova									2											
Nitzschia acicularis (Kützing) W.Smith				2	8		7			22						15		1		1
Nitzschia amphibian Grunov		2		2			8	2	14	2	51	4	1	8	1	1		7	3	3
Nitzschia apiculata (W.Gregory) Grunow	13	2	8	6	4		4	8			9	1	1	12		4	3	5	9	3
Nitzschia bacillum Hustedt				6			1	6			41									
*Nitzschia clausii*Hantzsch	2	4	2	2		4			10		1	4	3	3		1	1	3		
Nitzschia draveilensis					16								27	36	27			3	1	
Nitzschia eglei Lange-Bertalot															1					1
Nitzschia fruticosa Hustedt												4	3	3	1	1	1	1	3	
Nitzschia gracilis Hantzsch														9						
Nitzschia homburgiensis Lange-Bertalot							16	48	4	12	12							3		1
Nitzschia Lorenzana Wekell, J.C., R.M	5													1				5	7	1
Nitzschia palea (Kützing) W. Smith	2	26	100	8	228	16	12	72	32	48	73	49	101	75	72	27	36	69	37	13
Nitzschia pungens Grunow ex Cleve																	1			1
Nitzschia radicula Hustedt				2	2		12	2	32			1	12	7	24	4	12	7	4	
Nitzschia reversa W.Smith						7	5	10		2	1		3	1		8	5	3	7	4
Nitzschia sigmoidea (Nitzsch) W. Smith			2			3								5	1	4			1	
Nitzschia sp.		14	2		6		4	12	8			16		1	1					
Nitzschia umbonata (Ehrenb.) Lange.-Ber		4	4	4	38		17	6	2	4	8	3	3	9	1					
Nitzschia vermicularis (Kützing) Hantzsch				8	2		5	2	4	2	1	8		1			3	3		
Pinnularia sp.		4	26		4			22	2	12	4		4	1	5			28	1	
Pinnularia viridis (Nitzsch) Ehrenb	5	6	28	6	2	8	11	12	10	12	16	11	12	4	9	5	19	93	3	15
Pleurosigma longum Cleve		6	8		8	7						5								
Stephanodiscus sp.		2	8	2	4											1			1	
Surirella capronii Bréb. et Kitton			2	4	6		3	4	2	2	3	5	3	4	4		8	8	3	3
Surirella tenera var. tenera Gregory		6																		
*Synedra acus*Kützing		6	10	2	2	65	187	108	68	32	96	88	60	32	40	1	3	20	8	12
Synedra ulna (Nitzsch) Ehrenberg	42	4	12	22	36	149	425	396	118	114	428	304	136	84	204	92	16	12	15	37

Table 3.Continue

Sites and seasons	Summer					Autumn					Winter					Spring				
Algal taxa	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Euglenophyta																				
***Euglena acus* Ehrenb**			14	4			16	16	4	12	17			1	8	12	3	7	1	1
***Euglena gracilis* G.A. Klebs f. gracili**						3	37	8		2	9	8	3		8	7	1	3	13	
***Euglena oxyuris* Schmarda f. oxyuris**		2	12	2	4		8	2		20	8	7	1	1	5	4	1	5		
***Euglena proxima* P. A. Dangeard**							52	16		74					31					1
***Euglena sanguinea* Ehrenberg**							3			2		1								
***Phacus circulatus* Pochmann**			14	4	6		19	12		20	7					13	11	4		
***Phacus pleuronectes* f. gigas (Da Cuhna) Popova**			10				19	6		30					1	5		11	1	
***Phacus* sp.**							11									4	1		3	1
***Phacus trypanon* Pochmann**	3	2	18			7	8	12		48	9	1	1		25	9	1	3	1	
Charophyta																				
***Closterium littorale* F.Gay**											7			4						
***Closterium* sp.**					2															
***Staurastrum anatinum* Cooke & Wills**					2	1					3		4		1		1			1
***Staurastrum chaetoceras var. convexum* Grönblad**								2			1	3	3							1
***Staurastrum* sp.**							1	10		2	3		3			3		3	1	4
Dinophyta																				
***Peridinium lomnicki var. punktulatum* Er. Lindemann**								52	42				1						1	

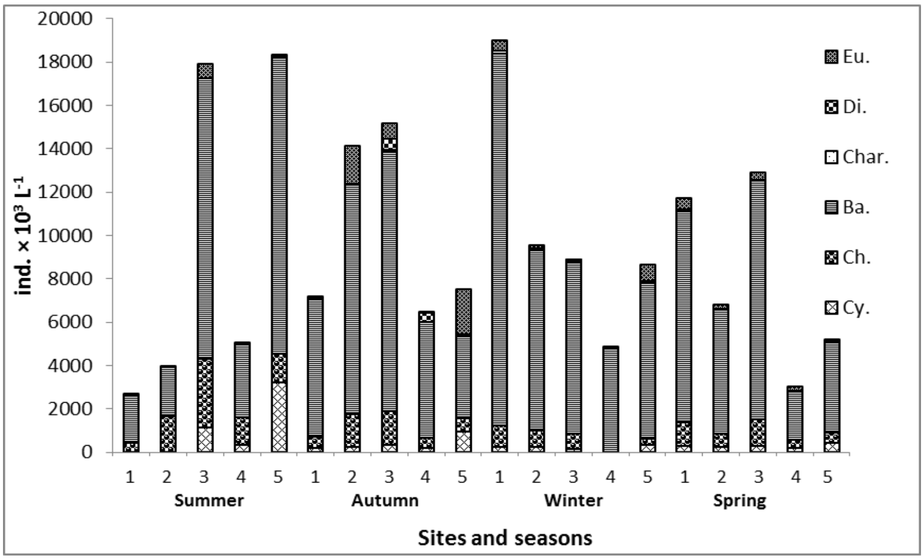

Fig.3. Abundance (ind. ×10^3 L^{-1}) of algae found in the study sites

On the other hand, the greatest numbers of individuals of class Chlorophyceae 200×10^3ind. L^{-1}) was recorded in summer at site 3 and the lowest (101×10^3ind. L^{-1}) was recorded in winter at site 4. Euglenophyceae individual's number was ranged from (26×10^3ind. L^{-1}) in winter at site 4 to (2080×10^3ind. L^{-1}) in autumn at site 5. The numbers of individuals of class Charophyceae (134×10^3ind. L^{-1}) exceeded in winter at site 1, whereas fall to (13×10^3ind.L^{-1}) in autumn at site 1 and 2, in winter at site 5 and in spring at site 2 and 4. The numbers of class Dinophyceae members were fluctuated from (13×10^3ind. L^{-1}) in winter at site 3 and in spring at site 4 to (520×10^3ind. L^{-1}) in autumn at site 3 (Fig. 3). On the other hand, Cyanophyceae was completely absent from site 1 in summer. In addition, Charophyceae was completely absent from site 1,2,3 and 4 in summer, and from site 4 in autumn, as well as, Dinophyceae was completely absent from all sites in summer, from site 1,2 and 5 in autumn, and found only at site 3 in winter and site 4 in spring (Fig. 3). Among Cyanophyceae, *Oscillatoria limosa* was the most abundant species (213×10^4ind. L^{-1}) recorded at site 5 in summer (Table 3). *Scenedesmus quadricauda* from Chlorophyceae was occurred in high numbers at site 3 in summer (96×10^4ind. L^{-1}). The highest number of Bacillariophyceae was occurred by *Cyclotella striata* (506×10^4ind. L^{-1}) in summer at site 3, *Euglena proxima* from Euglenophyceae was occurred in high numbers (74×10^4ind. L^{-1}) in autumn at site 5, *Staurastrum* sp. from Charophyceae was occurred in high numbers (10×10^4ind. L^{-1}) in autumn at site 3, and *Peridinium lomnicki* from Dinophyceae was occurred in high numbers (52×10^4ind. L^{-1}) in autumn at site 3 (Table 3).

The diversity indices such as Margalef's Index (d'), Shannon-Wiener diversity (H', loge based), Pielou’s evenness (J'), Fisher’sIndex (α), Simpson Dominance index (D), Simpson's Diversity Index (1-D) and Berger-Parker index (d) were studied based on the abundance of algae (Table 4). In the current study, the margalef's index showed that phytoplankton diversity was highest in autumn at site 2 (8.2), while the least diversity was recorded in summer at site 1 (2.7). The maximum value of Pielou’s Evenness index was estimated in spring at site 4 (0.9), whereas the minimum was estimated in winter and spring at site 1 (0.6).In spring, the parametric index of diversity (Fisher’s index) was recorded its highest value at site 4(11.9), while it recorded its lowest value in summer at site 1(3.3).The Shannon-Wiener diversity index ranged between 2.7 and3.7 in spring at site 1 and 4, respectively. On the other hand, Simpson's dominance index was ranged from (0.04) at site 4 to (0.2) at site 1in spring. It was observed that the highest value of Simpson's index of diversity was recorded at site 4 (0.96) in spring, while the value was less than (0.85) at site 1 in spring. Finally the highest value of Berger-Parker index was recorded in winter at site 2 (0.32) and the lowest was recorded in spring at site 4 (0.07).

The differences in the structure of algal community between the two studied factors (site and season) were examined by a distance-based per mutational multivariate analysis of variance, PERMANOVA. Two way-PERMANOVA on the assemblages of microalgae between the two studied factors revealed that the temporal variation based on the Bray-Curtis similarity was the most important factor that induced the variation in assemblages of algae (p=0.002), followed by the site that able to show the difference between algal species (p= 0.026, Table 5).

Table 4.Community parameters of some agricultural drains at Minia. Number of species (S), total abundance of individuals (N, ind. × 10^3 L^{-1}), Margalef́s Index (d'), Shannon-Wiener diversity (H', $\log_e$ based), Pielou's evenness (J'), Fisher's Index (α),Simpson Dominance index (D),Simpson's Diversity Index (1-D) and Berger-Parker index (d).

Season	Site	S	N	d'	J'	α	H' (loge)	D	1-D	d
Summer	S1	22	2700	2.66	0.87	3.28	2.69	0.090	0.91	0.15
	S2	42	4000	4.94	0.83	6.55	3.11	0.077	0.93	0.15
	S3	50	17936	5.00	0.69	6.28	2.70	0.142	0.86	0.28
	S4	56	5090	6.44	0.84	8.80	3.36	0.070	0.93	0.22
	S5	60	18353	6.01	0.68	7.72	2.80	0.109	0.89	0.20
Autumn	S1	52	7189	5.74	0.70	7.59	2.76	0.112	0.89	0.21
	S2	79	14132	8.16	0.68	11.04	2.96	0.130	0.87	0.30
	S3	74	15200	7.58	0.72	10.12	3.10	0.108	0.89	0.26
	S4	51	6480	5.70	0.81	7.55	3.19	0.070	0.93	0.18
	S5	57	7520	6.27	0.82	8.38	3.33	0.057	0.94	0.15
Winter	S1	67	19028	6.70	0.61	8.71	2.57	0.140	0.86	0.22
	S2	68	9578	7.31	0.67	9.89	2.83	0.136	0.86	0.32
	S3	67	8914	7.26	0.74	9.84	3.10	0.083	0.92	0.17
	S4	51	4860	5.89	0.79	7.95	3.12	0.076	0.92	0.17
	S5	65	8671	7.06	0.69	9.54	2.89	0.106	0.89	0.24
Spring	S1	75	11748	7.90	0.61	10.71	2.65	0.153	0.85	0.26
	S2	65	6822	7.25	0.69	9.95	2.90	0.123	0.88	0.29
	S3	78	12903	8.14	0.71	11.04	3.08	0.090	0.91	0.19
	S4	66	3049	8.10	0.88	11.89	3.71	0.038	0.96	0.07
	S5	65	5221	7.48	0.75	10.46	3.13	0.094	0.91	0.24

Table 5. Results of two-way PERMANOVA tests (with the site [Si] as a fixed factor and season (Se) as a random factor).

Source of variation	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Si	4	9629.5	2407.4	1.7082	0.026	998
Se	3	11741	3913.8	2.777	0.002	999
Res	12	16912	1409.3			
Total	19	38283				

df, degrees of freedom; SS, sum of squares; MS, mean squares; Res, residuals.

The dbRDA plots allowed the visualization of the relationship between algal species composition and physico-chemical variables and highlighted the variability in species composition along the site and season factor using Bray Curtis similarity between algal species (Fig. 4). Temporal and spatial variations in the composition of microalgae were correlated with physico-chemical properties of water. Water temperature, total alkalinity, chloride and phosphate were the highest abiotic variables correlated with variation in algal composition, for example, water temperature showed higher positive correlation to the algal community collected from site 1, 2, 4 and 5 in spring and summer seasons, while alkalinity, chloride and phosphate showed higher positive correlation to the algal community collected from site 2, 3, 4 and 5 in autumn and winter seasons (Fig. 4).

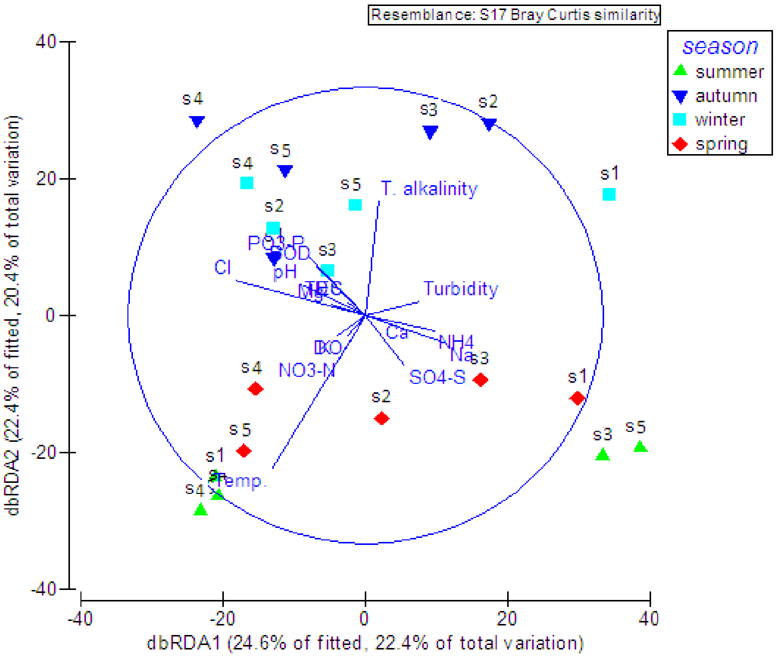

Fig. 4. Distance-based redundancy analysis (dbRDA). Relationships between the ordination of the sites and season based on microalgal species composition and environmental factors

Phytoplankton communities are sensitive to changes in their environment; therefore its biomass and many species are used as indicators for water quality (**Brettum and Andersen, 2005**). The biomass of phytoplankton may depend on biotic and abiotic conditions of the water body (**Toporowska *et al.*, 2008**). **Song *et al.* (2017)** found that algal biomass was enhanced when the level of nitrogen and phosphorus concentration was elevated in the water body. **Laugaste and Reunanen (2005)** also found that maximum algal biomass was estimated in autumn. Bacillariophyceae was the most dominant algal group in this study during the four seasons, this may be attributed to the highly competitive advantage on the nutrients over the other classes of algae (**Muller, 1996**), followed by Chlorophyceae, Cyanophyceae, Euglenophyceae, Charophyceae and Dinophyceae. These results were in agreement with **Elewa *et al.* (2009)** and Shehata *et al*.(2008), who pointed out that most of the recorded phytoplankton of Rosetta Branch, dominated mainly by Bacillariophyta and Chlorophyta, while Pyrrophyta and Euglenophyta were persisted as rare forms. **Shehata *et al.* (1996)**, **Salman *et al.* (2013)** and **Fawzy (2016)** found also the same results. Bacillariophceae are characterized as tolerant to mesosaprobic to polysaprobic conditions, and to high nitrogen content (**García *et al.*, 2012**) and often used as bioindicators for the ecological status of aquatic environments (**Pouličkowá *et al.*, 2004**).Cyanophyta often dominate the fresh-water phytoplankton community in surface waters, particularly in eutrophic system (**Codd *et al*., 1989**).

The highest algal species diversity was observed in winter and autumn; this is may be due to the highest values of some nutrients such as nitrate, phosphate and sulphate recorded in the winter and autumn (**Adam *et al.*, 2017**). **Sabae and Abdel-Satar (2001)** explained the relation between nitrate and total algal counts that, the minimum level of nitrate corresponded by maximum values of algal counts whereas, the decrease in nitrate concentrations in spring and summer months was might be due to the uptake of nitrate by natural phytoplankton and its reduction by denitrifying bacteria. Variation in the total number of microalgal species may be due to several factors such as chemical and physical factors (**Dere *et al*., 2002**) or the water quality and variation of nutrients (**Kupferberg, 2003**).Alterations in light intensity may also change the species richness, biomass and abundances of algae (**Takashi *et al.*, 2004**). **Aboellil and Aboellil (2012)** explained that density and distribution of epiphytic microalgae in

Nile River were dependent on the variation of pH, nutrient transparency of water and temperature. In the current study, *Oscillatoria limosa* (Cyanophyceae) was the most abundant species recorded at site 5 in summer. **Gadag *et al.* (2005)** stated that occurrence of *Oscillatoria* was indicating pollutants of biological origin. **Albay and Akçaalan (2003)** reported that Cyanophyta have a wide range of tolerance to physical disturbance including the fluctuation of water level and large amounts of suspended solids. On the other hand, *Scenedesmus quadricauda* from Chlorophyceae was occurred in high numbers at site 3 in summer which also indicate pollutants of biological origin according to **Gadag *et al.* (2005)**. *Euglena proxima* from Euglenophyceae was occurred in high numbers in autumn at site 5, it is act as an indicator of water quality with some species being indicators of organic pollution (**Costica, 2009**).Dominance of *Chlorella*, *Scenedesmus*, *Pediastrum*, *Oscillatoria*, *Melosira*, *Navicula*, *Nitzschia*, *Gomphonema*, *Euglena*, etc. were considered to be indicators of organic pollution (**Kshirsagar *et al.*, 2012**).

The highest number of Bacillariophyceae was occurred by *Cyclotella striata*in summer at site 3. **Ariyadej *et al.* (2004)** found that *Cyclotella meneghiniana* and *Melosira varians* might be used as bioindicators of the oligomesotrophic status in Banglang Reservoir, Yala Province.

In the present study, the greatest value of the Simpsons diversity index was observed in spring at site 4 and the least diversity was observed in spring that present at site (1) Shannon and Weiner diversity index (1949) represents entropy. **Wilhm and Dorris (1968)** after studying diversity in the range of polluted and unpolluted ecosystems concluded that the values of Shannon-Wiener diversity index greater than 3indicated clean water, values in the range of 1-3 considered moderate pollution and the values less than 1 described heavily polluted conditions. Applying this index in the present study, it was found that the highest value of Shannon-Wiener diversity index was observed in spring at site 4. Pielou’s Evenness index (1975) indicated that the species evenness is diversity index, a measure of diversity that determines how equal the community is numerically. The higher value is recorded in spring at site 4. Margalef's index has no limit value and it displays a variation that depends on the species number. Therefore, it is used for the comparison of sites (**Kocatas and Bilecik, 1992**) and takes into account only one component of diversity (species richness) reflecting the sensitivity to sample size. Values of Margalef's diversity index in this study were between 8.16 and 2.66 in autumn and summer at site 2 and 1, respectively. Fisher’s index (1943) is a mathematical calculation evaluates the diversity within a community. It relates a number of individuals and number of species. The data of Fisher’s index in autumn that present at site 2 and in spring at site 3 are very high and indicate an abundance of species. The Berger-Parker index (1970) is the number of individuals in the dominant taxon divided by the number of individuals. It is affected by the evenness of the indices (**Shannon and Weiner, 1949**).According to this study, site 4 in spring has the least Berger-Parker index and site 2 in winter has the highest index.

PERMANOVA analysis revealed that, temporal variation was the most important factor, beside the sites that induced variation in algal assemblage. Temporal variation in algal composition was correlated with physico-chemical properties of water.

The analysis of dbRDA highlighted the importance of water temperature, total alkalinity, chloride and phosphate that were more evident in changing the structure of microalgae during the different seasons. This environmental disturbance induced variation in the diversity and abundance of microalgae as well as chemical constituents (**Abou-Aisha *et al*., 1997**). **Sundbäck and Snoeijs (1991)** reported that the nutrients addition led to certain changes in species dominance of the diatoms, but changes were clearer at the macroscopic level (an increase in the filamentous green algae) than in the microflora. Thus, the seasonal investigation of microalgae showed, the variations of nutrient content affected the distribution, abundance and diversity of the microalgal communities, which, in turn, would reflect the physico-chemical analysis of water.

Conclusion

The study concluded that there was a seasonal variation of algae composition that mostly depending on the physico-chemical parameters. Temperature, total alkalinity, chloride and phosphate were the most effective parameters that affect the microalgal structure. *Cyclotella striata*, *Scenedesmus quadricauda*, *Oscillatoria limosa*, *Euglena proxima*, *Staurastrum* sp. and *Peridinium lomnicki* were the most dominant species in the freshwater drainage.

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التعاقب الموسمي للكتلة الحيوية والطحالب الدقيقة في بعض المصارف الزراعية بمحافظة المنيا، مصر

شيرين عبد الرؤف عبد السلام[١]، مصطفى فوزي[٢]، وفاء حافظ [٣] وعادل أحمد فتحي[٤]

١ – قسم علوم البيئة– معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية – مصر.
٢ –قسم البيولوجى–كلية العلوم– جامعة الطائف – المملكة العربية السعودية و قسم النبات والميكروبيولوجى–كلية العلوم– جامعة أسيوط.
٣– قسم علوم البيئة– معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية – مصر.
٤– قسم النبات والميكروبيولوجى–كلية العلوم– جامعة المنيا.

تم فى هذا البحث دراسة المجتمعات الطحلبية والخصائص الفيزيائية الكيميائية ذات الصلة لبعض المصارف الزراعية في منطقة المنيا ، مصر، وكذلك التقدير النوعي والكمي لهذه الطحالب موسمياً. ومن خلال الدراسة تم تحديد 151 نوعاً من الطحالب. حيث كانت الطحالب الدياتومية هى أكثر مجموعات الطحالب السائدة خلال الفصول الأربعة، تليها الطحالب الخضراء ثم الخضراء المزرقة ثم اليوجلينية ثم الكارية ثم البيرية. وقد اوضحت النتائج ان طحلب السيكوتيلا من أكثرالأنواع، أوسيلاتوريا من الطحالب الخضراء المزرقة ، يوجلينا بروموكسا من الطحالب اليوجلينية، ستياورسترم من الكارية ، بيرميدم من الطحالب البيرية. وقد سُجل الحد الأقصى للكتلة الأحيائية الطحلبية في الموقع 1 في الخريف (827.7 ميكروجرام/لتر)؛ وتم تسجيل الحد الأدنى للقيمة في الموقع 4 في فصل الشتاء (26.7 ميكروجرام/لتر). وقد تم الحصول على سبعة مؤشرات للتنوع التي تشمل مؤشر مارجليف ، شانون - وينر ، بيلو ، فيشر ، مؤشر سيمبسون السائد ، مؤشر التنوع سيمبسون ومؤشر بيرجر بارك. وقد اظهرت النتائج ايضا ان درجة حرارة المياه والقلويات الكلية والكلوريدات والفوسفات هي أكثر العناصر فعالية التي قد تؤثر على التركيب النوعى للطحالب الدقيقة خلال المواسم المختلفة.