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Sensitivity of Phytolankton to the Wastewater Quality Discharging at Lake Manzala, Egypt

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Abstract

Lake Manzalla receives diverse types of wastewaters, loaded with various pollutants via drains. Management of aquatic ecosystem in the Lake requires accurate knowledge for the available resource. Understanding of water quality in the drains can introduce better practices to minimize its impact on the environments. This study focused on sensitivity of phytoplankton, density and composition, to physico-chemical characteristics of the wastewater in 5 of the main drains discharging into the Lake. A total of 163 phytoplankton taxa, belong to eight groups, were identified. Chlorophyceae was the most diverse class (48 sp.) followed by Cyanophyceae (38 sp.), Bacillariophyceae (35 sp.), Euglenophyceae (27 sp), Dinophyceae (6 sp.), Conjugatophyceae (6 sp.), Synurophyceae and Xanthophyceae 2 and 1 sp., respectively. Abundance and occurrence of some species were physically controlled and others were nutrient limiting. Cyanophyceae (53%) was the most abundant groups and predominated by *Microcystis aeruginosa*. Changes in water quality led to alterations in occurrence of phytoplankton that provides an important role in biomonitoring of pollutants, biological purification and bioindicator for the environmental changes. To avoid the dangerous impact of pollutants in the drains, it was suggested pretreatment, at least, must be done for wastewater before discharging into the lake and the mass production of microalgae produced can used in commercial purposes (biofuels or/and Non-fuel Applications).

Key words: Algae, Bioindicator, Pollution, Drains

INTRODUCTION:

Water is an essential resource for all life. Water resources face a host of serious threats caused by human activities, climatic changes, urban growth, and landscape changes. Freshwater is becoming scarcer, and having access to clean and safe drinking water is limited among countries (Abd El-Monem and Hussian 2015).

Lake Manzala is the largest lake in the northern region of Egypt, receives about 7500 million cubic meters annually of untreated industrial, domestic and agricultural wastewaters through several drains.Off the main drains are Bahr El-Baqer (domestic and industrial sewage), Hadous, Ramsis, El-Serw and Faraskour Drains (agricultural effluents) (Tayel, *et al.,* 2014). Drainage water contributes about 98% of the total annual inflow to Lake Manzala. The drains carry large amount of nutrients, especially from Bahr-El-Bakar, Ramsis and Hadous that are heavily contaminated by sewage and industrial wastes (Mustafa, *et al.,* 2015).45% of the total discharged water into the lake inflowing from Bahr El- Baqar drain (Stahl, *et al.,* 2009). This water is polluted with industrial and urban waste water, and it considered to be unsuitable for human use (Badawy and Wahaab, 1997), rich in organic carbon (Dheina, 2007), and needs specific treatment before reuse (Elewa, 2010).

Hadous Drain account over half of the lake water supply, whilst the rest comes from the other main drains. Hadous drain mostly receives agricultural waste(94.3%)including pesticides, fertilizers, industrial and runoff. In addition to sewage effluents supply the water bodies and sediment with huge quantities of inorganic anions and heavy metals (ECDG, 2002).The domestic diffuse sources are only 4% of the total discharge, contributes 94.7% of the organic load. The catchment area of Hadous, El-Serw, and Faraskour drains are contaminated and still susceptible to pollution from legal and illegal dumping of domestic and industrial wastewater (Ezzat, *et al.,* 2002).

The physico-chemical parameters are the most important principles in the identification of water quality in aquatic ecosystem. The maximum production of phytoplankton can be originated with the optimum conditions of physico-chemical variables (Ali, *et al.,* 2005).

Recently, microalgae are used 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).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). Its abundance and composition can be an excellent indicator and sensitivity to the environmental changes (Varadharajan and Soundarapandian, 2014).

Phytoplankton is responsible for a large part of the primary production and constituting a food chain basis. Their distribution and structure are strongly related to physical and chemical characteristics of the water bodies (Lopes, *et al.,* 2005). It is considered as a good indicator for trophic status of the aquatic ecosystem that changes with nutrient inflow. Ecologically, phytoplankton plays an important role in nutrient cycling and biological productivity in the aquatic system, linking a number of bottom-up and top-down processes (Reynolds, 1984), response to a wide range of pollutants, useful in providing early warning signals of deteriorating conditions and the potential causes of such conditions (Lacuna, *et al.,* 2012).

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). It is a very attractive tool to identify and demarcate areas of aquatic contamination, and represent the integrated value of relative biological availability of these chemicals (Phillips, 1980). 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). Many factors play an important role in determining phytoplankton species can survive, grow, be threatened or even become extinct in a particular lake (Basualto, *et al.,* 2006). Physico-chemical parameters and their effects on phytoplankton in water bodies are considered very important in designing management strategies and determine health status of the aquatic ecosystems (Edward and Ugwumba, 2010).

The objective of this study is to investigate interrelation between water quality and phytoplankton, composition and densities, inhabiting the aquatic ecosystems in four main drains discharging in Lake Manzala, and to examine the use of phytoplankton as bioindicator for pollution.

MATERIALS AND METHODS

Site location and description

Lake Manzala the largest natural lake in Egypt, located between 31 00-31 30 N and 31 45-32 22E longitude. It extends to 64.5 km in length, 49 km in width and 239 km shore line. Drainage water contributes about 98% of the total annual inflow to Lake Manzala. A total of 3.7 km^3 of fresh water (mostly from agricultural drainage) flow annually into Lake Manzala via five major drains, Old and New Bahr El-Baqer (domestic, agricultural and industrial sewage), Hadous, El-Serw and Faraskour (agricultural effluents) (Tayel, *et al.,* 2014) shown in Table (1).

Hadous Drain is the largest one, serving about 790000 feddans of agricultural lands, and contributes about 49% of the total inflow (Table 1). Old and New Bahr El-Baqer Drainsare considered as the most polluted water in Egypt (Abdel-Shafy and Aly, 2002). Those receive and carry the greatest part of wastewater (3 billion CM /year) into the lake, serving about 536000 feddans of agricultural area that forming about 25% of the total inflow (Hamed, *et al.,* 2013). El-Serw Drain serves about 68700 feddans and participating about 13% of the total inflow. Faraskour Drain serves about 20000 feddan constituting about 4% of the total inflow.

Sampling sits and preparation

Collection of water samples were performed seasonally from the five drains at Lake (Faraskour (site 1), El-Serw (site 2), Hadous (site 3), Old Bahr El-Baqer (site 4) and New Bahr El-Baqer (site 5) (Fig 2) using Ruttner sampler bottle (1.5 L capacity). Subsample was preserved in plastic bottles and stored in cold box for chemical analysis. The physical variables (water temperature, Conductivity and pH) were measured using a portable Hydro Lab. Equipment (model CRISON-Spain). Water Transparency was detected with Secchi disk readings. Water chemical analysis (NH_4, SiO_2, TP, NO_2 and HCO_3) were measured according to (APHA, 2012).

Phytoplankton Analysis

For quantitative and qualitative investigations of phytoplankton, 500 ml of the water samples preserved with 4% neutral formalin and Lugol's iodine solution. It was transferred in glass cylinder, extra Lugol's iodine solution was added to faint tea color, covered with aluminum foil and allowed for 5 days to settle (APHA, 2012). 90% of the supernatant fluid was siphoned off, sample volume was adjusted to fixed volume (50 ml) and transferred to a small plastic vial for microscopic examination.

Drop method was applied for counting and identification of phytoplankton species (APHA, 2012), triplicate sample (2 or 5µl) were taken and examined under inverted microscope ZEISS IM 4738, with magnification power 40 and 100x. Results of phytoplankton density were presented as number of cell per liter (cell 1^{-1}). The latest references were used for identification.

Phytoplankton biomass (Chlorophyll *a*) and Phaeophytin:

Phytoplankton biomass represented as Chlorophyll *a*(Chl *a*). A defined volume of water sample was filtered on glass microfiber filter (GF/F). filter with retained cells, containing Chl *a,* extracted in 90% acetone overnight at 4 ºC (Parsons *et al.,* 1984), prepared, measured spectrophotometry and calculated according APHA, (2012).to measure phaeophytin, the extract was acidified with 2 drop of 4N HCl and re-measured to calculate phaeophytin.

Table (1) Untreated drains water flow in Lake Manzala (Donia and Hussein, 2004 and Zahran *et al.,* 2015)

Drain	**Domestic point Sources m^3 /day**	**Industrial Point Sources m^3 /day**	**Domestic Diffuse source m^3 /day**	**Agricultural Diffuse source m^3 /day**	**Total m^3 /day**	**Inflow in Lake**
Faraskour	2490	0.0	13272	186758	202520	4%
El-Serw	7710	0.0	18769	508515	534994	13%
Hadous	80000	6135	207754	4836000	5129889	49%
New Bahr El-Baqar **Old Bahr El-Baqar**	184000	64268	122795	4521678	6548741	25%

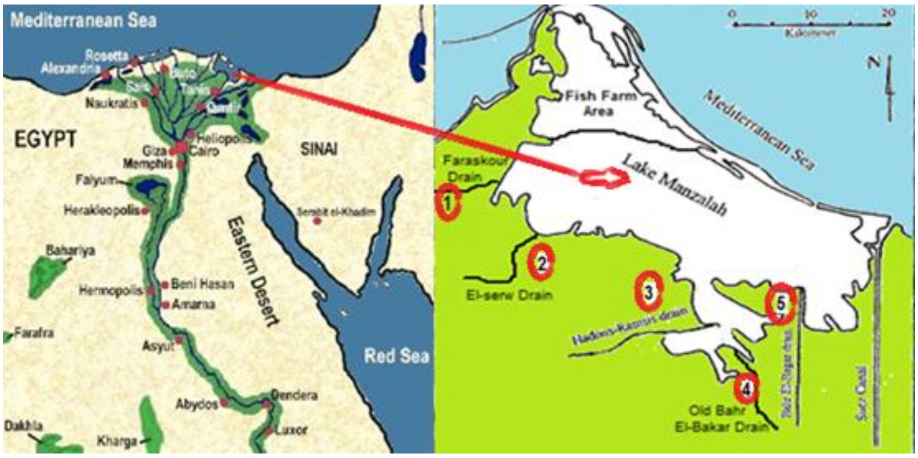

Fig (1): Map of the studied drains of Lake Manzala

Statistical analysis: Correlation Analysis was performed to assess the relationships between occurrence of the most common phytoplankton species, recorded in the drains, and other environmental factors. The recorded data were examined with principal component analysis (PCA) in order to show affecting of the most common species with the other abiotic variables, using XL Stat version 2015.

RESULTS AND DISSCUSSION

1. Phytoplankton abundance and distribution in drains:

Phytoplankton serves as sensitive indicators of environmental changes in the aquatic ecosystems as well as a biological sensor for detecting potentially toxic effects of some heavy metals (Durrieu, *et al.,* 2011), and plays a vital role in maintaining the balance of an aquatic ecosystem (Field,*et al.,* 2007). Physico-chemical measurements reflect water quality at a given time while biological assessment reflects conditions that have existed in a given environment over a long period of time (Odiete, *et al.,* 2003).

During the studied period, A total of 163 phytoplankton taxa, belonging to eight groups, were recorded in wastewaters of the drains. Chlorophyceae was the most diverse class (48 sp.), followed by Cyanophyceae (38 sp.), Bacillariophyceae (35 sp.), Euglenophyceae (27 sp), Dinophyceae (6 sp.), Conjugatophyceae (6 sp.), Synurophyceae and Xanthophyceae 2 and 1 sp., respectively.

Community structure of phytoplankton inhabiting wastewaters in the studied drains predominated with Cyanophyceae (53%) and Chlorophyceae (24%), as a result of richness with N and P content, in accordance with EL-Sheekh, *et al.,* (2010) and Deyab, *et al.,* (2002). Diatoms constituted about 20 % and Euglenophyceae 3 %, whereas Dinophyceae, Conjugatophyceae, Synurophyceae and Xanthophyceae were scarce.

In the present investigation, members of Cyanophyta were the most common species in the aquatic ecosystem in Lake Manzalla, and it was predominated with *Microcystis aeruginosa, Chroococcus minor* and *Gloeocapsapunctate*. Cyanobacteria are the most ancient of phytoplankton species, and they thus have a wide distribution and diverse dynamic that makes understanding their growth mechanics complicated (Davis *et al.,* 2009).

In a municipal waste water treatment, phytoplankton was mainly regulated by nutrients and the massive Cyanobacteria declined as the water quality improved which were well related to changes in algae diversity, dominance, abundance and biomass (Chindah *et al,* .2007).

Successful management of any resources requires accurate knowledge of the resource available. Phytoplankton abundance was clearly associated with some abiotic factors in the drains, such as pH, DO and SiO_2(r = 0.65, 0.67 and 0.55 respectively). The increase in those parameters enhanced the population densities of phytoplankton. Harris and Vinobaba (2012) stated that phytoplankton abundance and diversity were mainly affected by abiotic factors.

Seasonal variability of phytoplankton species compositions can be attributed to accumulative effect of the different environmental conditions. Several researchers informed on a number of algal species as water quality indicator (e.g. Tas and Gonulal, 2007). Drains were differing in the phytoplankton diversity along the year. Hadous drain was the richest one has 97 species that can be attributed to its nutrient rich. The relative high pollution state of its water was favorable for some phytoplankton species that coincided with it (EL-Sheekh, *et al.,* 2010). Phytoplankton diversity in New Bahr El- Baqar, Old Bahr El- Baqar and Faraskour Drains were lower than Hadous (83, 82 and 76 sp., respectively), while El-Serw Drain contained the least number of species (64 sp.).Low diversity in El-Serw drain may be linked to existence of pollutants fevered the aquatic life or/and reduce water clarity that limited the photosynthesis process (Harris and Vinobaba, 2012). In addition, phytoplankton species has different resource for nutrition requirements and responses to the physicochemical characteristics of the aquatic ecosystem, thus causing variations in the phytoplankton composition (Reynolds, 1984).

Our results showed that, the most abundant species of cyanophyceae was *Microcystis aeruginosa* that appeared in all drains along the year, Table (4). It represented about 44.8, 43.2, 6.4, 18.1 and 38.5% from the total of cyanophyceae at site 1, 2, 3, 4 and 5, respectively. *Microcystis aeruginosa* was live in high organic pollution condition (Onyema, 2013), used as the best single indicator of pollution (Nandan and Aher, 2005) and tolerance towards high concentration of nutrients (Çelekli and Külköylüoğlu, 2006).

Both Faraskour and El-Serw Drain have a domestic and agricultural waste (Zahran, *et al.,* 2015). Table (3) showed the least annual average of phytoplankton abundance were 3454 and 2928 x 10^4cell/l recorded in Faraskour and El-Serw Drain, with Chl *a* 45.3 and 30.4 µg/l, respectively), while the highest value was 21094 x 10^4cell/l recorded in Old Bahr El- Baqar Drain, with Chl *a* 163 µg/l(Table,2) The increasing of phytoplankton abundance may be attributed to high concentrations of organic wastes and high level of both N and P come with the agricultural and domestic sewage discharged in the drains (Deyab, *et al.,* 2002).

In Faraskour and El-Serw Drain conditions became optimal for the growth of the blue-greens with the population reaching its peak during winter season Table (3). Factors affecting on the most common phytoplankton species:

The Aquatic ecosystems consist of communities of living organisms and the environment they inhabit. Relationships between living organisms and their interactions with their environment are often complex and interdependent. Relations between the environmental variables and most common phytoplankton species were explored using PCA.

In Faraskour and El-Serw Drain, the most abundant phytoplankton species had linked to Cyanophyceae. *Microcystis aeruginosa* (44.8 and 43.2%), *Phormidium inundatum* (11.4 and 5.4%) and *Leptolyngbya tenuis* (5.5 and 3.9 %, respectively) were the most leading speciesthis class.

Microcystis aeruginosa abundance was more affected negatively with water temperature and pH (r=-0.9).In accordance Parrish (2014) reported that physical factors such as water temperature, sunlight, turbidity, salinity, and water velocitymay complement or surpass the role of nutrients in influencing the growth, toxicity, and distribution of *M. aeruginosa*. Itwas found to be controlled by relatively high temperature (Jewel, *et al.,* 2006).

Our results showed that the limiting growth factor for *Microcystis aeruginosa* was nitrogen that result agreed with (Baldia, *et al.,* 2007) who mentioned that *Microcystis* is a non-N fixing cyanobacterium; therefore it requires inorganic N to thrive. N may be just as influential, as P, in promoting *M. aeruginosa* (Davis *et al.,* 2009). It is usually found in polluted and wastewater (Abd El-Monem and Hussian 2015), otherwise it was reported as indicators of eutrophic waters (Peerapornpisal, *et al.,* 1999).

Phormidium inundatum was highly correlated with transparency and SiO_2 (r=0.7 and r= 0.8), and negatively with water temperature and pH (r=-0.5 and -0.7, respectively) while PO_4 was the limiting growth factor.

PCA showed that the occurrence of *Leptolyngbya tenuis* was more affected with transparency, DO and PO_4.Presence of high abundance from *Leptolyngbya tenuis* may be attributed to high load of domestic sewage and nutrient salts discharged into the drains (Khairy, *et al.,* 2015) and reported in mixture of sewage and agriculture wastewaters ((Abd El-Monem and Hussian 2015).

Appearance of the most common phytoplankton species in the different drains was detailed in table (4). Both Hadous, Old and New Bahr El- Baqar Drains have domestic, industrial and agricultural wastes (El-Sheekh, *et al.,* 2010 and Zahran,*et al.,* 2015). The most abundant species in Hadous, Old and New Bahr El- Baqar Drains were related to Cyanophyceae (*Chroococcus minor* represented 11.1, 20.6 and 11.6%, respectively) and Chlorophyceae (*Kirchneriella obese*8.2, 7.9and4.6%, respectively).

The vigorous growth of *Chroococcus minor* is correlated positively with increasing of phosphorus, pH and DO (r=0.8, 0.6 and 0.6, respectively) and negatively with nitrogen (r= -0.9) that refers to the limiting growth factor for *Chroococcus minor*is P.

Bacillariophyceae class was the third one dominated by *Aulacoseira granulate* represented about 1.7, 2.7, 9.4, 6.7 and 5.3% and *Lindavia ocellata*re presented 1.2, 4.4, 7.7, 3.1 and 2.6%at site 1, 2, 3, 4 and 5 drain, respectively. *Aulacoseira granulate* and *Lindavia ocellata* are considered a tolerant species for pollution (Bellinger and Sigee, 2010). Phosphorus was positively correlated to growth of both *A. granulata* and *Lindavia ocellata*.

The complexity of aquatic ecosystems and the linkages within them can make the effect of disturbances on them difficult to predict. These linkages mean that damage to one component of the ecosystem and can lead to impacts on other ecosystem components. Increasing our understanding of aquatic ecosystems can lead to better practices that minimize impacts on aquatic environments.

Much effort in water resource management is directed at optimizing the use of water and in minimizing the environmental impact of water use on the natural environment. Management of any aquatic ecosystem requires accurate for available knowledge, the uses to which it may be put, the competing demands for the resource, measures to and processes to evaluate the significance and worth of competing demands and mechanisms to translate policy decisions into actions on the ground.

Algae play an important role in controlling and biomonitoring of organic pollutants in aquatic ecosystems (Chekroun *et al.,* 2014). It have used in biological purification of wastewater, accumulate nutrients, heavy metals, pesticides, organic and inorganic toxic substances, and radioactive matters (Alp *et al.,* 2012).

It was suggested primary treatment plant, at least, most be designed to minimized ecological hazards of wastewater. Algae will be effective in natural treatment and the mass production produced can used in other commercial purposes (biofuels or/and Non-fuel Applications).

CONCLUSION AND RECOMMENDATIONS

Management of aquatic ecosystem in Lake Manzalla requires accurate knowledge for the available resource.Complexity of the aquatic ecosystems and the linkages within them can make the effect is difficult to predict. Understanding of aquatic ecosystems in the drains can lead to better practices to minimize impacts on the environments.

Phytoplankton play an important role in controlling and biomonitoring of pollutants, can used in biological purification of the wastewaters and sensitive indicators for the environmental changes in the aquatic ecosystems. Abundance and occurrence of some species were physically controlled and others were nutrient limiting and with certain environmental changes.

Much effort in water resource management is directed at optimizing the use of water and in minimizing its environmental impact. It was suggested primary treatment plant, at least, most be designed to minimized ecological hazards of wastewater. Algae will be effective in natural treatment and the mass production produced can used in other commercial purposes (biofuels or/and Non-fuel Applications).

Table (2): Annual average of physicochemical and biological parameters in the drains.

Parameters	Faraskour Drain	El-Serw Drain	Hadous Drain	Old Bahr El-Baqar Drain	New Bahr El-Baqar Drain
Water temperature (ºC)	24.1	22.2	23.6	23.8	24.3
Transparency (cm)	26	38	29	25	22
EC (mS/cm)	1	1.15	4.19	5.59	4.49
Salinity (‰)	1.06	0.88	2.29	2.86	2.28
TS (g/l)	1.09	1.07	2.93	3.77	3.18
pH	7.5	7.62	7.68	7.93	7.8
CO_3^{2-} (mg/l)	2.9	7.5	7.6	17.6	11.3
HCO_3^{1-} (mg/l)	189.8	199	310.6	282.5	306.3
DO (mg/l)	4	2.8	5.2	4.8	1
NH_4 (mg/l)	3.25	3.65	1.15	4.01	7.09
NO_2-N (µg/l)	89.6	147.6	57.1	107.2	68.8
NO_3-N (µg/l)	118.1	100.2	68	63.1	238.2
PO_4-P(µg/l)	194.3	243.3	311.5	351.2	596.8
TP (µg/l)	364.9	331.1	408	453.7	713.1
SiO_2-Si (mg/l)	5.4	5.2	8	9.7	8.4
Chl*a*(µg/l)	45.3	30.4	117.7	163.0	95.1
Pheophytin(µg/l)	83.4	34.9	275.1	343.0	236.9

Table (3): Seasonal distribution of phytoplankton abundance (No. x 10^4 cell/l) in the different drains

Classes / Site	Faraskour drain						
	Summer	Autumn	Winter	Spring	Annual Average	No. of species	% of class
Cyanophyceae	146	800	940	550	609	19	70.53
Chlorophyceae	21	170	170	175	134	28	15.52
Bacillariophyceae	37	100	130	115	95.5	17	11.06
Euglinophyceae	5	40	10	5	15	5	1.74
Dinophyceae	1	10	0	0	2.75	2	0.32
Conjugatophyceae	0	10	10	5	6.25	3	0.72
Synurophyceae	3	0	0	0	0.75	2	0.09
Xanthophyceae	1	0	0	0	0.25	1	0.03
Total crop	214	1130	1260	850	3454	77	

Classes / Site	El-Serw drain						
	Summer	Autumn	Winter	Spring	Annual Average	No. of species	% of class
Cyanophyceae	196	740	220	665	455.25	17	62.19
Chlorophyceae	5	100	40	260	101.25	18	13.83
Bacillariophyceae	14	120	130	375	159.75	19	21.82
Euglinophyceae	1	10	20	5	9	5	1.23
Dinophyceae	12	10	0	0	5.5	3	0.75
Conjugatophyceae	0	0	0	5	1.25	1	0.17
Synurophyceae	0	0	0	0	0	0	0
Xanthophyceae	0	0	0	0	0	0	0
Total crop	228	980	410	1310	2928	63	

Classes / Site	Hadous drain						
	Summer	Autumn	Winter	Spring	Annual Average	No. of species	% of class
Cyanophyceae	133	560	380	2000	768.25	25	31.87
Chlorophyceae	54	440	400	2300	798.5	32	33.13
Bacillariophyceae	35	290	780	1600	676.25	22	28.05
Euglinophyceae	0	150	50	400	150	16	6.22
Dinophyceae	0	10	0	50	15	1	0.62
Conjugatophyceae	0	10	0	0	2.5	1	0.1
Synurophyceae	0	0	0	0	0	0	0
Xanthophyceae	0	0	0	0	0	0	0
Total crop	222	1460	1610	6350	9642	97	

Classes / Site	Old Bahr El-Baqar drain						
	Summer	Autumn	Winter	Spring	Annual Average	No. of species	% of class
Cyanophyceae	418	1120	990	8550	2769.5	17	52.52
Chlorophyceae	206	760	390	4650	1501.5	32	28.47
Bacillariophyceae	122	250	460	2850	920.5	17	17.46
Euglinophyceae	6	100	0	200	76.5	13	1.45
Dinophyceae	11	10	0	0	5.25	2	0.1
Conjugatophyceae	1	0	0	0	0.25	1	0
Synurophyceae	0	0	0	0	0	0	0
Xanthophyceae	0	0	0	0	0	0	0
Total crop	764	2240	1840	16250	21094	82	

Classes / Site	New Bahr El-Baqar drain						
	Summer	Autumn	Winter	Spring	Annual Average	No. of species	% of class
Cyanophyceae	1640	1690	1830	4450	2402.5	23	61.41
Chlorophyceae	550	270	380	1500	675	29	17.25
Bacillariophyceae	400	290	490	1750	732.5	16	18.72
Euglinophyceae	30	50	10	250	85	12	2.17
Dinophyceae	0	10	0	0	2.5	1	0.06
Conjugatophyceae	0	0	10	50	15	2	0.38
Synurophyceae	0	0	0	0	0	0	0
Xanthophyceae	0	0	0	0	0	0	0
Total crop	2620	2310	2720	8000	15650	83	

Table (4): Occurrence and percentage appearance of the most common phytoplankton species in the drains

Drains / Most dominant sp.	Faraskour		El-Serw		Hadous		Old Bahr El-Baqar		New Bahr El-Baqar	
	Appearance	%	Appearance	%	Appearance	%	Appearance	%	Appearance	%
Chlorophyceae										
Ankistrodesmus fractus	+	25	+++	75	++++	100	++++	100	++++	100
Crucigenia tetrapedia	++	50	+	25	++++	100	++++	100	++++	100
Nephrocytium limneticum	+++	75	+	25	+++	75	++++	100	++++	100
Oocystis pusilla	+	25	++	50	+++	75	++	50	+++	75
Oocystis pyriformis	+++	75	++	50	++	50	+++	75	+	25
Selenastrum bibraianum	+	25	++	50	++++	100	++++	100	+++	75
Bacillariophyceae										
Actinoptychus octonarius	++++	100	+++	75	+++	75	++++	100	++++	100
Aulacoseira granulata	++++	100	+++	75	++++	100	++++	100	++++	100
Chroococcus minor	++++	100	+++	75	++++	100	++++	100	++++	100
Chroococcus minutus	++	50	+	25	++++	100	+++	75	+++	75
Cyclotella meneghiniana	++++	100	++++	100	+++	75	+++	75	++++	100
Lindavia ocellata	++	50	++	50	+++	75	++	50	++	50
Nitzschia acicularis	++	50	+++	75	++++	100	++++	100	++++	100
Nitzschia palea	++	50	+++	75	+	25	++	50	+++	75
Cyanophyceae										
Anabaena wisconsinensis	+++	75	++	50	++++	100	+++	75	+++	75
Anathece clathrata	+++	75	++	50	++	50	++	50	++	50
Gloeocapsa punctata	++	50	+	25	++++	100	++++	100	+++	75
Leptolyngbya tenuis	+++	75	+++	75	++	50	+++	75	+++	75
Merismopedia tenuissima	-	0	-	0	+++	75	++++	100	++++	100
Microcystis aeruginosa	++++	100	++++	100	++++	100	++++	100	++++	100
Phormidium inundatum	++++	100	++++	100	+++	75	++++	100	++++	100

(+) Detected in one season, (++) two seasons, (+++) three seasons and (++++) four seasons

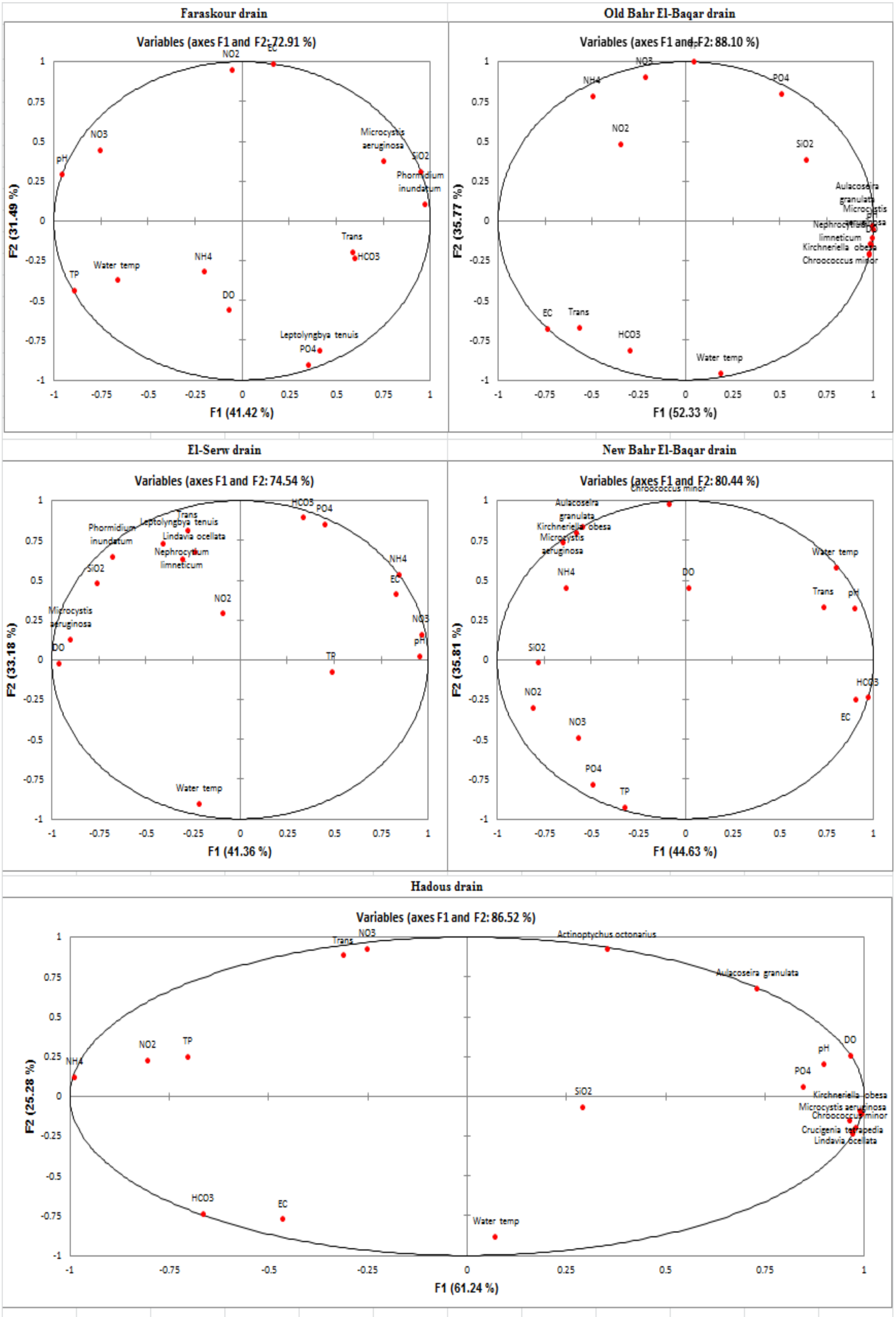

Fig (2): PCA betweenthe dominant phytoplankton specieswith some environmental factors at the drains.

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