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Ecological Evaluation on Zooplankton particularly the protozoan organisms at Lake Manzala, Egypt

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ABSTRACT

The present study was carried out in Lake Manzala to follow up the physico-chemical parameters, prevalence and biodiversity of the zooplankton particularly protozoan organisms. Organisms were sedimented by using cold centrifugation technique at 7^{o}C followed by examining and counting via Carl-Zeiss Jena transmitted-light inverted microscope. Protozoa represented the most common zooplankton where ciliates predominate flagellates which are followed by sarcodines. It was proved that the pollution level of this lake is much higher than those of the Nile branches which could be referred to the extensive illegal discharges of various pollutants from more than five provinces, those of oil pollutants derived from Mediterranean sea and sewage discharges. Comparing the present data with the previous records, it appears that a peculiar achievements was obtained at the moment, but still need more urbanization to have more progress from the ecological and economic points of view.

Keywords: Lake Manzala, Protozoa, Pollution, Zooplankton

INTRODUCTION

Lake Manzala is the largest coastal lake in Egypt which is a shallow brackish lake extending between the Damietta branch of the Nile and the Suez Canal with a maximum length of about 50 km along the Mediterranean coast (Ahmed *et al*., 2009). Simultaneously, it is connected to the sea from the north and Suez Canal from the east through small narrow inlets. This lake receives large amounts of partially treated sewage, irrigation, domestic, agricultural and industrial effluent wastes from urban centers such as Bahr El Baqar (190 Km in length and receiving more than six million cubic meters of wastewater from more than five provinces). This situation affects the fish productivity, species composition, eutrophication and biodiversity (Khairy *et al.*, 2016). At the same time, Lake Manzala is contaminated with variable quantities of aromatic hydrocarbons, nitrogenous, phosphorus and ammonium compounds (El morsi *et al*., 2017). However, the aim of the present study is to investigate the physicochemical and the biological parameters of water and their interactions in this Lake during 2018/2019.

Protozoa are characterized by their small size, high reproduction rates, semi-permeability of the plasma-membrane and consequently the close contact with the surrounding environment. Therefore, protistan organisms react more quickly to environmental changes than most of other eukaryotic individuals and thus serve as bioindicators of the water quality (Xu *et al*., 2009 and Gong *et al*., 2005).

Protozoo-plankton is considered as a key element in the food chain and can consume up to 100% of daily phytoplankton production (Irigoien *et al*.; 2005). Moreover, they participate in the carbon cycle and are fundamental part of the microbial loop (Azam *et al*., 1983). Protozoa are situated in one trophic level, allowing them to transfer energy (carbon and other nutrients) from lower trophic levels such as algae and bacteria to higher trophic ones as they are ingested by other organisms like metazoa (Medeiros, 2013). Protozoan grazing affect the abundance of bacteria in different aquatic ecosystems which removes dispersed bacteria resulting in higher transparency and lowering suspended organic loads in the output of the treated wastes. The presence of such bacterial populations allow the development of a microfauna consisting mainly of predator organisms such as protozoa and certain metazoan animals as rotifers, crustacean and insect larvae (Fried and Lemmer, 2003; Akpor *et al*., 2007).

MATERIALS AND METHODS

The present study was carried out at different sampling stations in Lake Manzala (Fig. 1). Stations were chosen to follow up the ecological parameters including physico-chemical parameters, prevalence and biodiversity of the zooplankton particularly protozoan organisms. Triple water samples were collected monthly at 30 cm depth of the water surface using a transparent perspex water sampler (1.2 L).

The hysico-chemical parameters were measured at the sampling sites. Water temperature, p^H, dissolved oxygen and EC were measured by using Cole-Parmer's oxygen, p^H and EC meter, while TDS, BOD, nitrates, phosphates, ammonia and organic matter were quantified by methods adopted by APHA (2017).

Microfauna with particular reference to protozoan organisms were sedimented by cold centrifugation technique at 7^oC in the presence of a thermocouple which is followed by examining and counting via Carl-Zeiss Jena transmitted-light inverted microscope (Galal, 1989). Protozoa were identified according to Bick (1972) and Patterson and Hedley (1992).

Statistical analyses of the data were carried out by applying Minitab (19) Statistical Package.

RESULTS AND DISCUSSION

The seasonal data of some physicochemical and biological parameters of Lake Manzala during a period extending between September 2018 and August 2019 was illustrated in table (1). Having a glance to figure (2), the seasonal average water temperature varied between 14 and 27 ^oC during winter and summer respectively. The pH values were found to be slightly alkaline throughout the studying period with a range of 7.3 to 7.8, while the electrical conductivity (EC) oscillated between the values of 2.8 and 11.8 mmhoS/cm during autumn and summer respectively. However, TDS values varied widely throughout the lake between 2.2 and 19.7gm/l., while those of the DO ranged between 2.4 and 11.3 mg/l During Autumn and Summer respectively. Simultaneously, ammonia, nitrates, phosphates and organic matter behaved similarly, where their minimal and maximal average values follow the same pattern as the previous parameters where the lowest levels were 10.2, 6.4, 8.1 and 45.12 mg/L, while the uppermost ones achieved 38.4, 23.1, 15.7 and 61.52 mg/L during autumn and summer respectively. On the contrary, BOD showed an opposite behaviour where their lowest and highest values were 5.1 mg/L on summer and 14.7 mg/L during Winter.

Regarding the numerical abundance of the major zooplankton groups in Lake Manzala, protozoa represented the most dominated type of zooplankton where ciliates predominate flagellates then sarcodines. The numerical densities of the total protozoa and their three differential super classes (Sarcodina, Mastigophora and Ciliophora) showed their lowest values on Winter (7.99, 0.32, 1.87,5.8 and 10^3 /L, while their highest ones were achieved during autumn for sarcodines and ciliates (0.64 and 7.9 10^3/L) beside those of flagellates and total protozoa which were obtained on summer (4.9 and 12.86 10^3/L). It was found in a pilot microscopical examination that average numerical total protozoan densities of 5492 organisms/L included in 54 genera belonging to 13 orders aggregated in 6 subclasses as shown in Table (3).

The average lowest and highest numerical densities of arthropod larvae were gained during Winter and Summer (22 and 42/L), while those of rotifers were achieved on Summer and Winter (56 and 123/L respectively).

Comparing the present data with those of Damietta branch of the Nile (Galal, 1999), it was proved that pH, DO, NO_3, PO_4 values are mostly higher in the latter branch except those of the summer season in case of the first two parameters (pH and DO), while those of NH_3 and OM showed an antagonistic behavior. The physicochemical parameters of Rosetta branch of the Nile (Galal *et al*., 2008; Galal, 2018)) are more or less higher than those of Damietta (Galal, 2009), but still less than those of Lake Manzala. This comparison indicated that the pollution level belonging to these three water bodies are different; those of the Nile branches were less polluted than Lake Manzala which could be referred to extensive illegal discharges of the various pollutants from more than five provinces as mentioned earlier in the latter water body (Lake Manzala).

It is well known that the aquatic floral growth and reproduction is a result of the utilization and assimilation of organic materials through the photosynthesis. Thus the aquatic flora and phytoplankton biomass increase by the uptake of available phosphorus and nitrogen from water. The relative importance of nitrogen and phosphorus to phytoplankton production was reported by Morales *et al*., 2001. In this respect, different ratios were suggested by many authors Chiaudini and Vighi (1974) , Forsberg and Ryding (1980). Therefore, according to El morsi *et al.* (2017), the nitrogen/phosphorus ratio has been calculated from lake Manzala and it was estimated to be within 2.28-10.6 on winter and 2.46-12.8 during summer. The most conservative ratio suggests that when N/P ratio is between 5 and 10, either nutrient could be limiting and if less than 5, nitrogen is the limiting for plant (phytoplankton) growth. The N/P ratio in Lake Manzala was below 5 at all the examined sampling stations of the present study indicating that nitrogen is the limiting nutrient which may favour green algal dominance.

It is worthy to mention that the excessive accumulation of nitrogen in surface water can cause an overgrowth of both phyto- and consequently zooplankton, leading to water quality degradation (eutrophication) which may deplete DO in natural water by microbial nitrification reactions. Also, high ratio of the unionized ammonia may develop high pH that is toxic to fish and other aquatic life (Environmental Protection Agency, 2001). Simultaneously, nitrate and nitrite constitute a public health concern, primarily related to methemoglobinemia and carcinogenesis (Vymazal, 2007). According to Barakat *et al*. (2012) and Kamel *et al*. (2015) Lake Manzala is contaminated with levels of organochlorines, although not higher than the maximum permissible level, and polycyclic aromatic hydrocarbons (PAHs) along the Egyptian Mediterranean coast in the seashore near that Lake (Azab *et al*., 2013 and El Nemr *et al*., 2007).
The presence of higher numerical densities of protozoa especially the bacterivorous types could be interpreted as a result of an elevation of the nutritive material with particular reference to the organic matter.

Both biotic and abiotic data of the present study were statistically examined through applying regression, correlation and time series analyses.

The significant relationships were summarized and illustrated in Tables (4_a and 4_b) and Figure (3). It was obvious from Table (4a) that the total protozoa, ciliates and sarcodines have significant regression coefficients with the same parameters (temperature, DO, BOD, NH3, NO3, PO_4 and OM), while those of flagellates and sarcodines represent significant regression relationships with two parameters only (Temp. and DO). On the other hand, Table (4b) showed that the total protozoan organisms were influenced by either both or separate rotifers and arthropod larvae through filter-feeding mechanism. The correlation analysis of the previously mentioned parameters indicated that both sarcodines and ciliates have no significant correlation relationships with any of the physicochemical parameters, while mastigophoreans showed positive values with all of the abiotic parameters apart from those of BOD. This statement proves that the ecosystem of this lake provide a case of conjugated food chains leading to a more or less balanced system (chemostat). It is necessary to mention that the ecological situation of this lake was too bad during a period extending between 1994 and 1999 (Unpublished data at Zoo. Dept., Fac. of Science, Menufia University), where the ecological parameters were as follows; BOD = 19.6 mg/l, NH3 = 52.9mg/l, OM = 103.1mg/l, DO = 1.2 mg/l, Total protozoa = 9.4 10^3 /l (sarcodins = 0.7, flagellates = 4.6, ciliates = 4.1 10^3/l). Accordingly, the Egyptian Government began to build up too many projects including removal of the deposits from the lake bottom, widening and increasing the lake depth, clearing the clogging of the connections between the lake and Mediterranean sea, establishing of an enormous Wastewater Treatment Plant to enhance the water quality of Bahr El-Baqar drainage canal before entering this lake since 2017. This will improve this lake extensively from economical, biological and nutritional points of view.

Table (1). Seasonal variations of biotic and abiotic parameters belonging to Lake Manzala, Egypt during 2018/2019.

Season / Factors	Autumn (Sept-Nov	Winter (Dec-Feb	Spring (Mar-May)	Summer (Jun-Aug)
Tem ^oC	22	14	20	27
P^H	7.3	7.4	7.6	7.7
EC mmohS/ cm	2.8	6.3	7.1	11.8
TDS gm/L	2.2	6.9	11.8	19.7
DO mg/l	2.4	7.2	8.4	11.3
BOD mg/l	13.7	14.7	11.9	5.1
NH_3 mg/l	10.2	16.9	27.1	38.4
NO_3 mg/l	6.4	10.0	18.7	23.1
PO_4 mg/l	8.1	8.6	11.8	15.7
OM mg/l	45.12	43.91	54.8	61.52
Sarc 10^3/L	0.64	0.32	0.49	0.54
Flag. 10^3/L	2.54	1.87	4.11	4.9
Cili.10^3/L	7.9	5.8	6.53	7.42
T. Prtz 10^3/L	11.08	7.99	11.13	12.86
Art. L No/L	31	22	29	42
Rotif No/L	91	123	83	56

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Table (3) Prevalence and Numerical abundance of the major protozoan groups including various organisms at Lake Manzala, Egypt during 2018/2019.

Phylum: Sarcomastigophora **Superclass: Sarcodina** **Class: Rhizopodea 79** ***Amoeba sp.*** ***Arcella sp.*** ***Difflugia sp.*** ***Pelomyxa sp.*** ***Centropyxis sp.*** **Class: Actinopodea 42** ***Actinophrys sp.*** ***Actinosphaerium sp.*** **Superclass : Mstigophora** **Class: Phytomastigophorea 583** ***Euglena sp.*** ***Peranema sp.*** ***Chilomonas sp.*** ***Cryptomonas sp.*** ***Ceratium sp.*** ***Chlamydomonas sp.*** ***Actinomonas sp*** ***Amphidinium sp*** ***Trachelomonas sp***	**Subclass 2: Vestibuliferea** **O: Colpodida** ***Colpoda sp.*** **O: Trichostomatida** , ***Plagiopyla sp.*** **Subclass 3: Suctoria** **O: Suctorida** ***Acineta sp.*** ***Podophrya sp*** ***Tokophrya sp.*** **Class 2: Oligohymenophorea 321** **O: Hymenostomatida** ***Cinetochilum sp.*** ***Colpidium sp.*** **O: Scuticociliatida** ***Cyclidium sp.*** ***Pleuronema sp.*** **O: Peritrichida** ***Carchesium sp.*** ***Cothurnia sp.*** ***Epistylis sp.*** ***Vaginicola sp.*** ***Opercularia sp.*** ***Vorticella sp.*** **O: Peniculinda** ***Paramecium sp.*** ***Urocentrum sp.*** ***Frontonia sp.*** ,	**Class 3:Polyhymenophora 1435** **Subclass: Spirotrichia** **O: Hypotrichida** ***Urostyla sp.*** ***Euplotes sp.*** Oxytricha sp. Tachysoma sp. **O:Heterotrichida** ***Stentor sp.*** ***Spirostomum sp.*** ***Metopus sp.*** **O: Oligotrichida** ***Halteria sp.*** ***Strombidium sp*** ***Codonella sp.*** --------------------------- **54 genera including 4592 organisms**
Superclass: Ciliophora **Class I: Kinetofragminophorea 2132** **Subclass 1: Gymnostomatia** **O:Prostomatida** ***Urotricha sp*** ***Coleps sp.*** ***Prorodon sp.*** **O: Pleurostomatida** ***Amphileptus sp.*** ***Litonotus sp.*** ***Loxophyllum sp.*** ***Hemiophrys sp.*** **O: Haptorida** ***Lacrymaria sp*** ***Spathidium sp.*** ***Dileptus sp.***		

Table (4a) Summary of the significant relationships between biotic and abiotic parameters in water samples at Lake Manzala during 2018/2019.

Relation between biotic & various abiotics.	Source	DF	MS	F	P
Total Protoz VS Temp., DO, BOD, NH3, NO3, PO4, OM	Regression	7	7.37	24.15	0.004
	Residual Error	4	0.31		
	Total	11			
Ciliates VS Temp., DO, BOD, NH3, NO3, PO4, OM	Regression	7	2.12	10.49	0.019
	Residual Error	4	0.20		
	Total	11			
T. Protz VS Temp., DO	Regression	2	15.32	6.23	0.020
	Residual Error	9	2.46		
	Total	11			
T. Protz VS Temp., DO, BOD	Regression	3	14.005	10.40	0.004
	Residual Error	8	1.35		
	Total	11			
T. Protz VS Temp., DO, BOD, NH3	Regression	4	11.64	13.11	0.002
	Residual Error	7	0.89		
	Total	11			
T. Protz VS Temp., DO, BOD, NH3, NO3	Regression	5	9.32	9.03	0.009
	Residual Error	6	1.03		
	Total	11			
T. Protz VS Temp., DO, BOD, NH3, NO3, PO4	Regression	6	7.78	6.36	0.030
	Residual Error	5	1.22		
	Total	11			
Sarcodina. VS Temp., DO, BOD, NH3, NO3, PO4, OM	Regression	7	0.031	11.92	0.015
	Residual Error	4	0.003		
	Total	11			
Sarcodina VS Temp., DO	Regression	2	0.069	6.87	0.015
	Residual Error	9	0.010		
	Total	11			
Flagellates VS Temp., DO	Regression	2	7.43	5.47	0.028
	Residual Error	9	1.36		
	Total	11			

Table (4b) Summary of the significant relationship between the major groups of Zooplankton at Lake Manzala during 2018/2019.

Relations between major planktonic organisms	Source	DF	MS	F	P
T. Protz VS Arth. Larvae & Rotifer	Regression Residual Error Total	2 9 11	22.16 0.94	23.58	0.000
T.Protz VS Arth. Larvae	Regression Residual Error Total	1 10 11	26.43 2.46	10.03	0.010
T. Protoz VS Rotifers	Regression Residual Error Total	7 4 11	43.89 0.89	49.32	0.000

Fig. (1). Map of Lake Manzala, Egypt.

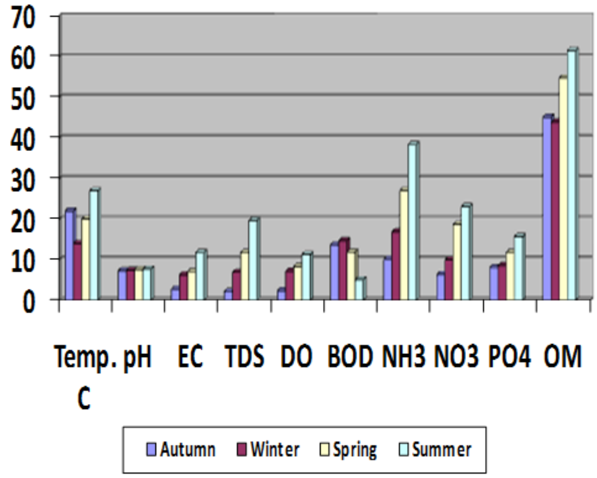

Fig. (2). Seasonal average values of certain physico-chemical parameters at sampling sites of Lake Manzala during 2018/2019.

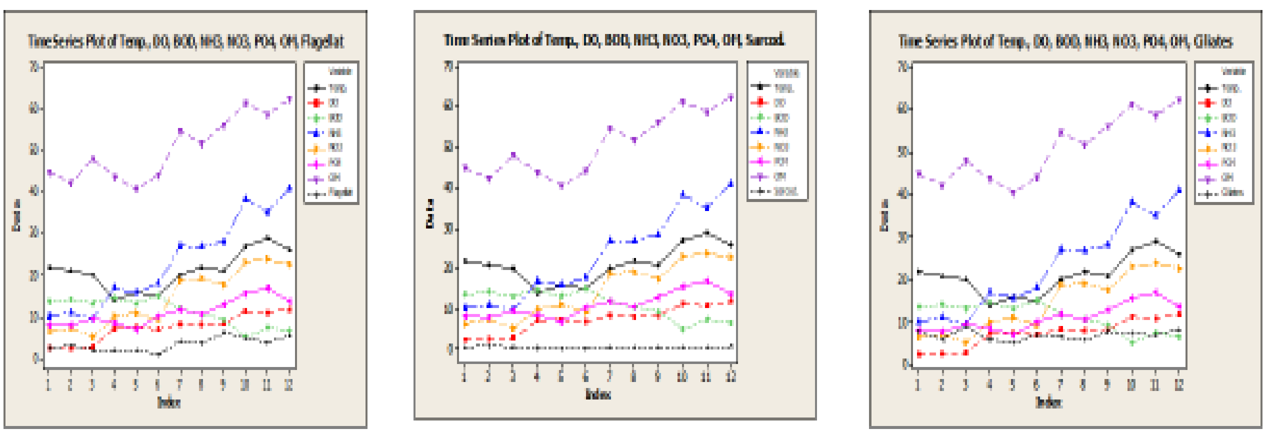

Fig. (3). Time Series analysis of monthly biotic and abiotic parameters of Lake Manzala, Egypt during 2018/2019.

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التقييم البيئى للهائمات الحيوانية خاصة الكائنات الأولية فى بحيرة المنزلة بمصر

منصور جلال
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المستخلص

أجريت هذه الدراسة على بحيرة المنزلة وذلك لتتبع الخواص الكيميائية والطبيعية لمياه هذه البحيرة وتأثيرها على الهوائم الحيوانية كماً وكيفاً. ولقد لوحظ أن الكائنات الأولية تسود الهوائم الأخرى خاصة الهدبية منها والتى تنتشر بدرجة أكبر من السوطيات واللحميات. وبالمقارنة مع دراسات سابقة على كل من فرعى النيل (رشيد ودمياط) اتضح أن بحيرة المنزلة أكثر تلوثاً وذلك لعدة أسباب منها الصرف الجائر وغير القانونى لمصرف بحر البقر والذى يعتبر مستودع لمياه الصرف الصحى لأكثر من خمس محافظات آخذين فى الاعتبار الصرف الصناعى والزراعى للمنطقة المحيطة. ولقد أدى هذا الى ارتفاع قيم المحتوى الكربونى وارتفاع املاح النترات والفوسفات والذى فاقم من قيم المتطلب الأكسجينى الحيوى مما اثر على تنوع وكثافة الهائمات ومنها الكائنات الأولية على وجه الخصوص والذى يؤثر بدوره على الثروة السمكية بالبحيرة نتيجة لتناقص مساحة البحيرة. إلا انه يتضح من المشاريع الحكومية التى أقيمت منذ عام 2014 للمحافظة على تلك البحيرة أن هناك اختلافاً كبيرا عن النتائج التى حصلنا عليها خلال الفترة الممتدة بين عامى 1994 و 1999 . إلا أن هذه البحيرة تحتاج لمزيد من الاهتمام والترشيد البيئى حتى تزدهر الأنشطة السمكية والزراعية والصناعية المرتبطة بها.