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Ecological aspects with new zooplankter record at Lake Nasser, Egypt

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Abstract: Due to the scarce in the limnological data about different khors of Lake Nasser, therefore, this study aims at contributing to a more complete evaluation of different ecological aspects of Kalabsha and Allaqi khors. To achieve this objective water and sediments samples were collected in autumn 2013 and analyzed to determine the physic-chemical variables, chlorophyll *a* as phytoplankton biomass and zooplankton communities, as well as sediments quality. The results showed that the mean values of the different physicochemical parameters are fairly increased in Allaqi khor than in Kalabsha khor. Dissolved oxygen was exhibited mean values closed to 8.0 mg/l, meaning that both khors waters are well oxygenated and it is considered as healthy water. The low value of electrical conductivity at both khors classified Lake Nasser to the first category of the African Lakes classification with low conductivity less than 600 µs/cm. N/P ratio ranged from 13 to 40, indicating potential control of algal growth by phosphorus. Zooplankton community at Kalabsha khor comprised 25 species belonging to 21 genera which dominated by Copepoda (43.24%) followed by Rotifera (31.60%) and finally by Cladocera (24.53%) On the other hand, Allaqi khor comprised of 24 species belonging to 21 genera and dominated by Rotifera (45.67%) followed by Copepoda (39.03%) and finally by Cladocera (14.79%). It is worth mentioning that a new record of rotifer, *Ptygura libera* (Myers 1834) was recorded for the first time in Lake Nasser khors and in Egypt Freshwater bodies. This species confirmed mesotrophic status of the lake. The obtained data showed a high similarity and homogeneity between the two khors. Rotifer was the greatest taxonomic group in the two khors and this pattern is common in tropical freshwater bodies. For sediments, the grain size distributions of bed sediments in Kalabsha and Allaqi khors revealed that the source of sedimentation in both khors is originate from shores not from the river sedimentation. The calculation of sediment enrichment factor (SEF) showed that the heavy metals in bed sediment at both khors are crustal origin, where all values of SEF are less than 1.0 for all heavy metals at all sites. Also, the calculated ecological risk factor at both khors was less than 40.0, indicating that all heavy metals were at low risk. Finally, long-term investigations must be addressed to various aspects in Lake Nasser khors.

Keywords: Lake Nasser, water quality indicator, trophic state, zooplankton, sediments and heavy metals.

1. Introduction

The construction of the Aswan High Dam in southern Egypt resulted in the creation of the longest man-made lake in the world. Lake Nasser (22° 31` to 23° 45` N and 31° 30` to 33° 15` E) extends in the hot and dry climate of the eastern Sahara for about 180 km in Sudan and 300 km in Egypt. One of the main features of Lake Nasser is the presence of side extensions, lagoons, locally named khors. The mean length of the khors increases downstream from the south to the north, owing to the northwardly declining ancient riverbed. These khors cover about 79% of the total lake surface area, while their volume is 86.4 km^3 water, representing 55% of total lake volume (Entz, 1976). All are U shaped in cross section. Kalabsha and Allaqi khors are wide, with a gentle slope and a sandy bottom, cover a considerable area and represent auxiliary semi-isolated lakes (Latif, 1984). The study of ecological aspects of Lake Nasser khors has received minor interest.

The structure and abundance of the zooplankton community in Lake Nasser khors and its spatial distribution are influenced by abiotic factors and interactions among species. Rotifers and cladocerans generally are relatively more abundant in tropical aquatic ecosystems (Matsumura- Tundisi 1999). Although zooplankton do not depend directly on nutrients to survive, and are affected by the quantity and quality of algae, bacteria and detritus in a reservoir, its trophic state may influence the richness, structure, body size and productivity of this community (Lathrop & Carpenter 1992).

Sediments provide habitat for many organisms and are an important component of aquatic ecosystems. Sediments also influence the environmental fate of many toxic and bio accumulative substances in aquatic ecosystems. Because sediments tend to integrate contaminant inputs over time, they represent potentially significant hazards to the health of aquatic organisms and to the overall health of aquatic ecosystems. Pollution of aquatic environment by heavy metals is a worldwide problem. Once heavy metals are introduced into water, they rapidly become associated with particulates and are incorporated in bottom sediments (Binning and Baird, 2001). The contamination of sediment with heavy metals, even in small concentration may lead to serious environmental problem (Loizidou *et al*., 1992). Due to the scarce in the limnological data about different khors of Lake Nasser, therefore, this study aims at contributing to a more complete evaluation of different ecological aspects such as physico-chemical characteristic of water and its zooplankton structure in addition to chlorophyll *a* as phytoplankton biomass as well as sediments quality along Kalabsha and Allaqi khors at Lake Nasser.

2. Materials and Methods:

All samples were carried out during Autumn 2013 at two large khors (Kalabsha and Allaqi) of Lake Nasser at km, 41 and 91 from Aswan High Dam (AHD), respectively. Five sampling sites were selected to represent Kalabsha khor (total length 47.2 km); while nine sampling stations were selected in Allaqi khor (total length 54.83 km) as shown in Fig. (1).

The water samples were collected and analyzed from fourteen sites along the two khors according to standard methods for examination of water and wastewater (APHA, 1992) in order to measure physicochemical and biological parameters. The physicochemical parameters such as water temperature, dissolved oxygen (DO), electric conductivity (EC), turbidity, pH and secchi depth were measured *in situ*, while total suspended matters (TSS), total alkalinity (TA), nitrate (NO_3), ortho phosphate (OP) and total phosphorus (TP) were measured in the lab. Chlorophyll *a* samples were obtained from a known volume of an integrated water sample taken from the euphotic zone and filtered through Whatman GF/F filter. The concentration of chlorophyll *a* was determined spectrophotometrically after overnight extraction in 90% acetone and calculated according to Marker *et al*. (1980) equations.

Zooplankton collection was carried out by vertical tows from 2m deep to the surface using a plankton net of 55µm mesh size. All samples were immediately fixed with 4% formalin and examined according to Yamamoto (1960), Ruttner-Kolisko (1974) and Patterson (2000).

Surficial sediment samples were collected (three samples at Kalabsha and five samples at Allaqi Khors) using a stainless steel Ponar grab sampler. These samples were transferred into polyethylene bags then stored at 4^oC to inhibit any biological activity. The samples were analyzed for determining pH value, electric conductivity (EC), nitrate (NO_3), organic matter (OM), phosphate (PO_4), calcium carbonate ($CaCO_3$) and heavy metals according to Hendershot, *et al.* (1993), Schnitzer (1982) and Binning and Baird (2001).

Data analysis:

a) Trophic State Index (TSI) Calculations:

Carlson's (1977) Trophic State Index (TSI) was used to combine measures of Secchi disc (SD), chlorophyll *a* (CHL *a*), and total phosphorous (TP) in a common numeric scale. The TSI values were calculated according to the following equations:

TSI (SD) = 60- 14.41ln SD (meters) TSI
(Chl *a*) = 9.81 ln CHLa (µg/l) +30.6 TSI
(TP) = 14.42 ln TP (µg/l) +4.15 where
ln = natural log

The index ranges is 0-100 with higher values indicating more eutrophic conditions. Three trophic state categories are used to describe lakes as oligotrophic (TSI<40), mesotrophic (TSI: 40-50), and eutrophic (TSI >50).

b) Limiting Nutrient measurement:

Calculating the N/P ratios from the data for nitrogen as nitrate and phosphorus as phosphate was suggested by (Forsberg and Ryding, 1980). If this ratio more than 10, phosphorus is the limiting nutrient, if the ratio is between 5 and10, either nutrient could be limiting and if it less than 5, nitrogen is the limiting for plant growth.

c) Canonical Correspondence Analysis (CCA)

Data of environmental factor and zooplankton were analyzed using Canonical Correspondence Analysis (CCA), Brodgar version 2.4.8 (Highland Statistics 2005) to determine relationships between environmental variables (physicochemical parameters) and the respective biotic components (zooplankters).

d) Sediment quality assessment

Sediment enrichment factor (SEF) was calculated by SEF = C_i-C_0/ C_0, where Ci is total concentration of each metal and C_0 is background level of metal. When SEF is less than 1.0, meaning the source of metal is crustal origin and if it more than 1.0, meaning that the source of metal is anthropogenic origin (Riba *et al.,* 2002).

Ecological risk (Er) was calculated by Er = Tr^i x C^i_f, where Tr^i: toxic response factor, C^i_f: contamination factor and toxic response factor for Cu & Pb=5, Cr=3 and Zn=1 (Hakanson, 1980). The metal classified as low risk if Er<40, Moderate risk 40≤Er <80, considerable risk 80≤ Er <160 High risk 160 ≤ Er <320 and Very high risk Er ≥320.

Another method of assessment is the comparison with guidelines according to Long, *et al.,* (1995) which use "Effect Range-Low" (ERL) and "Effect Range Medium" (ERM) values that suggested by National Oceanic and Atmospheric Administration (NOAA). If the metal is over ERL values but lower than ERM, then it means that the heavy metal pollution has reached a state of concern and that the pollution is classified as medium-contamination level. If the concentrations of metal is above ERM values, then it is categorized as heavily contaminated level.

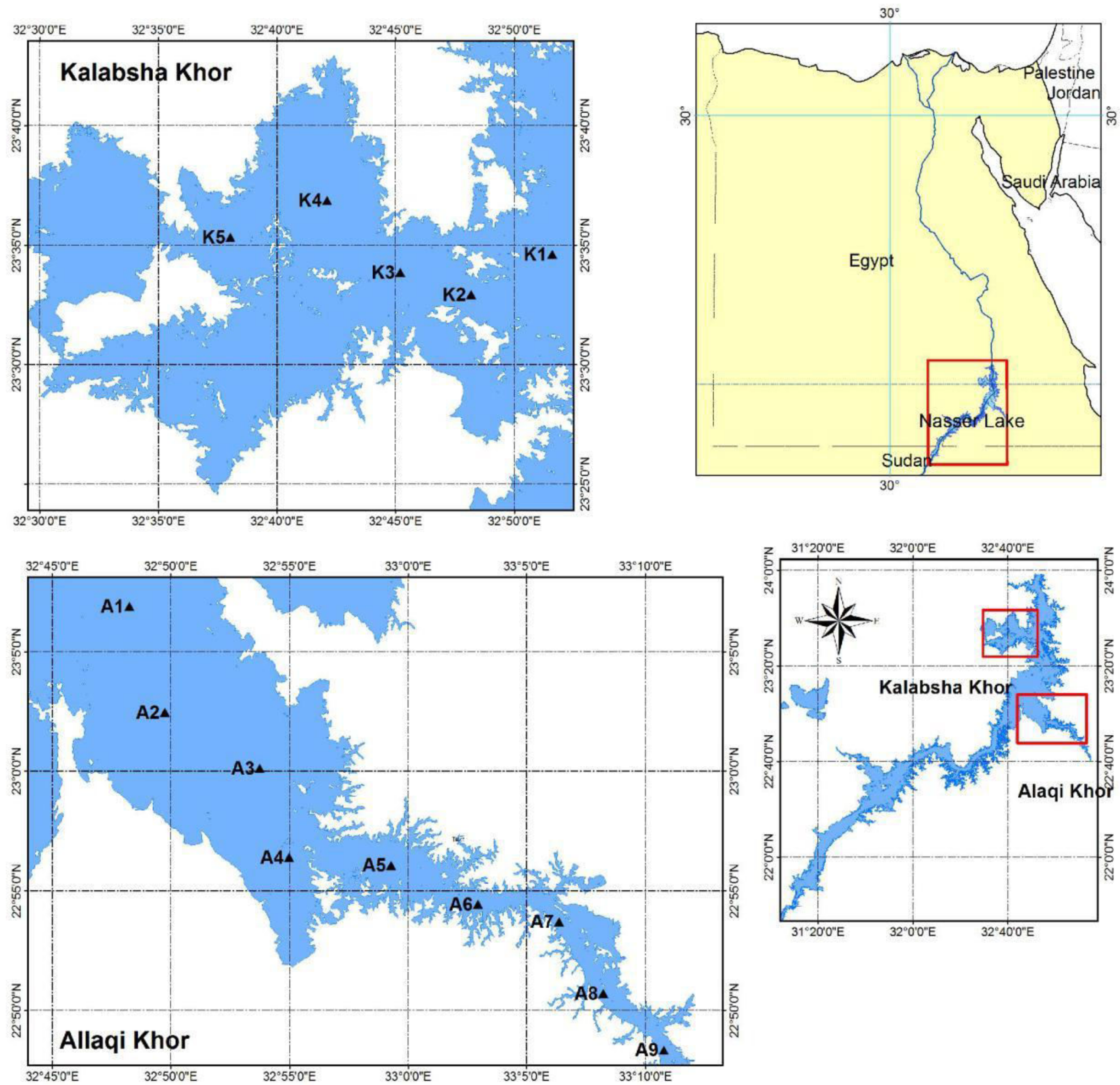

Fig. (1): Sampling sites along Kalabsha and Allaqi khors in Lake Nasser.

3. Results

Physicochemical Parameters

The results of the physicochemical parameters of Lake Nasser khors are shown in table 1. The **temperature of water** along Kalabsha khor ranged from 27 to 29^{o}C with an average of 27.88±0.8^{o}C while, it ranged from 28.1 to 29.6^{o}C with an average of 28.94±0.55^{o}C at Allaqi khor. The **pH** values in Kalabsha khor ranged from 7.74 to 8.15 with an average of 8.02±0.17 while it ranged from 7.03 to 8.22 with an average of 7.96±0.36 at Allaqi khor. The **dissolved oxygen (DO)** concentration ranged from 7.60 to 8.50 mg/l with an average of 8.16±0.37 mg/l and from 7.80 to 8.60mg/l with an average of

8.20±0.27mg/l at Kalabsha and Allaqi Khors, respectively. **Secchi disc transparency** values in Kalabsha khor ranged from 3.5 to 4.5m with an average of 4.10±0.42m; while in Allaqi khor, its values ranged from 3.0 to 4.0m with an average of 3.44±0.46m. The results of **turbidity** showed that its values in Kalabsha khor ranged from 0.80 to 3.42NTU with an average of 1.84±1.11NTU, where it ranged from 1.1 to 2.7NTU, with an average of 1.61±0.47 at Allaqi khor. **Total suspended solids (TSS)** values in Kalabsha khor ranged from 2.0 to 7.0 mg/l, with an average of 4.4±2.07mg/l, where its values ranged from 2.0 to 5.0 mg/l with an average of 3.33±1.00 mg/l at Allaqi khor. The results of **total alkalinity (TA)** showed that its values in Kalabsha khor ranged from 106.0 to 116.0mg/l with an average of 110.4±3.85mg/l, while in Allaqi khor, its values ranged from 102.0 to 110.0mg/l with an average of 105.1±2.85mg/l. The **electrical conductivity (EC)** in Kalabsha khor ranged from 237 to 246µS/cm with an average of 241.11±3.48µS/cm, while in Allaqi khor, its values ranged from 239 to 252µS/cm with an average of 244.40±5.22µS/cm. The concentrations of **ortho phosphate (Ortho-P)** in Kalabsha khor ranged from 0.03 to 0.05mg/l, with an average of 0.04±0.008mg/l, while in Allaqi khor, its values ranged from 0.023 to 0.06mg/l with an average of 0.04±0.014mg/l. On the other hand, Kalabsha khor recorded **total phosphorus (Total-P)** values ranged from 0.04 to 0.06mg/l, with an average of 0.05±0.010mg/l, where its values ranged from 0.04 to 0.09mg/l with an average of 0.06±0.0018mg/l at Allaqi khor. Kalabsha khor recorded **nitrate (NO_3)** values ranged from 0.7 to 1.0mg/l with an average of 0.84±0.11mg/l, where its values ranged from 0.8 to 1.2mg/l, with an average of 0.90±0.15mg/l at Allaqi khor. **Chlorophyll *a*** values in Kalabsha khor ranged from 5.87 to 8.04mg/m^3, with an average of 6.90±0.86mg/m^3; while in Allaqi khor, its values ranged from 5.36 to 10.45 mg/m^3, with an average of 7.51±2.19mg/m^3.

Table (1): Physicochemical characteristics along Kalabsha and Allaqi khors.

Site		Depth (m)	Temperature	pH	DO	EC	TA	Secchi Depth	TSS	Turbidity	Ortho-P	Total-P	NO_3	Chlorophyll a	Cu	TSI	N/P
Kalabsha	K1	43.0	27.3	7.74	7.6	239	108	3.5	7	3.42	0.030	0.040	1.0	5.87	0.11	49.08	33
	K2	39.4	27.8	7.97	8.4	240	110	4.0	6	2.57	0.040	0.050	0.8	7.18	0.12	50.17	20
	K3	16.6	29.0	8.09	8.0	245	106	4.0	4	1.21	0.030	0.040	0.9	6.21	0.10	48.63	30
	K4	26.0	28.3	8.13	8.3	246	112	4.5	3	1.18	0.040	0.060	0.8	7.18	0.10	50.49	20
	K5	5.5	27.0	8.15	8.5	252	116	4.5	2	0.80	0.050	0.060	0.7	8.04	0.11	50.85	14
Allaqi	A1	47.5	29.1	8.08	8.1	241	108	4.0	4	1.35	0.030	0.050	0.8	5.63	0.09	49.38	27
	A2	43.0	29.1	7.98	7.8	238	102	3.5	3	1.38	0.023	0.040	0.8	8.84	0.10	50.42	35
	A3	27.5	28.5	8.13	8.4	237	104	3.5	4	1.24	0.030	0.050	1.2	5.36	0.11	49.86	40
	A4	15.9	29.3	7.96	8.1	238	104	3.0	2	1.56	0.035	0.055	0.8	6.70	0.12	51.79	23
	A5	25.0	28.2	8.22	8.6	246	108	4.0	2	1.10	0.060	0.090	0.8	10.45	0.14	54.23	13
	A6	20.0	29.6	8.03	8.1	239	104	3.0	3	1.80	0.050	0.070	0.9	5.39	0.15	52.24	18
	A7	7.9	29.1	7.03	8.0	241	102	3.0	4	1.70	0.050	0.070	0.9	9.38	0.14	54.05	18
	A8	9.4	28.1	8.16	8.6	246	110	4.0	3	1.67	0.060	0.090	0.8	10.27	0.16	54.17	13
	A9	4.0	29.5	8.05	8.1	244	104	3.0	5	2.70	0.030	0.050	1.1	5.61	0.15	50.75	37

The heavy metals in water samples were recorded with values less than the detection limits for lead, chromium and cadmium in each of Kalabsha and Allaqi khors. Cupper concentration ranged from 0.10 to 0.12mg/l, with an average of 0.11±0.008 mg/l, where it ranged from 0.10 to 0.16mg/l with an average of 0.13±0.021mg/l at Allaqi khor.

Trophic state index (TSI) values in Kalabsha khor ranged from 48.63 to 50.86, with an average of 49.85, indicating Kalabsha khor as mesotrophic. On the other hand, in Allaqi khor, its values ranged from 49.38 to 54.23 with an average of 51.88, classifying this khor as slightly eutrophic, indicative of moderate primary productivity and nutrient conditions at both khors. Calculating the **limiting nutrient factor** (N/P) ratios revealed that their values in both khors ranged from 13 to 40, indicating that phosphorus is the limiting nutrient factor.

The above results of physicochemical parameters were comply with the permissible limits of Law 48/1982 and it Ministerial Decree 92/2013, except for cupper which violate the law (0.01 mg/l) at the two khors.

Zooplankton

Average zooplankton community at Kalabsha khor composed of 25 species belonging to 21 genera (standing crop 53167 org/m^3) and dominated by Copepoda (43.24%) followed by Rotifera (31.60%) and finally by Cladocera (24.53%), in addition to other forms which represented only 0.63% of total zooplankton count. On the other hand, at Allaqi khor it composed of 24 species belonging to 21 genera (standing crop 47018 org/m^3) and dominated by Rotifera (45.67%) followed by Copepoda (39.03%) and finally by Cladocera (14.79%), in addition to other forms which represented only 0.51% of total zooplankton count (Fig. 2 & Table 2).

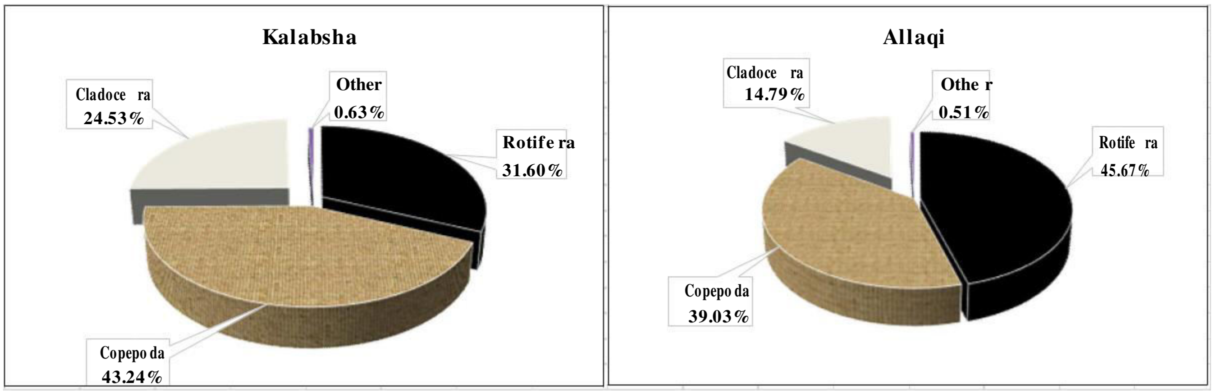

Fig. (2): Percentage occurrences of the main zooplankton groups at Kalabsha and Allaqi khors.

Table (2): the average number of the main groups (org/m^3) and their percentage to total zooplankton in Kalabsha and Allaqi khors.

Groups	No. of org./m^3		% to total zooplankton	
	Kalabsha	Allaqi	Kalabsha	Allaqi
Rotifera	16802	21472	31.6	45.67
Copepoda	22990	18352	43.24	39.03
Cladocera	13042	6956	24.53	14.79
Others	333	238	0.63	0.51
Grand Total	53167	47018	100	100

Rotifera community comprised 14 species belonging to 12 genera during this study in both khors. It was dominated by genus *Ptygura* which represented 60.62 & 43.72%, of the community followed by genus *Scaridium* (13.31% & 20.07) and then by genus *Keratella* (12.18 & 18.35%), in addition to other genera that represented collectively (13.88 & 17.86%) of total rotifers community in Kalabsha and Allaqi khors, respectively (Table 3). **Copepoda community** comprised three species contained in two orders (Cyclopoida and Calanoida), in addition to their juvenile stages (copepodite stages and nauplius larvae) of Copepoda group in both khors. Cyclopoida was the dominated order and it was represented by two species namely; *Thermocyclops neglectus* and *Mesocyclops ogunns*. They constituted 14.29 and 22.76% of total community in Kalabsha and Allaqikhors, respectively. While, Calanoida was represented by one species only namely; *Thermodiaptomus galebi*. They constituted 2.48 and 0.72% of total community in Kalabsha and Allaqi khors, respectively. The nauplius larvae and copepodite stages constitutes the majority of the total copepod and represented 40.35 & 36.17% for nauplius larvae and 32.71 & 50.52% for copepodite stages in Kalabsha and Allaqi khors, respectively (Table 3).

Cladocera community comprised seven species belonging to five genera in Kalabsha khor, while six species belonging to five genera were identified in Allaqi khor. Cladocera community was dominated by genus *Diaphanosoma*, constituting 60.95 & 83.65% of total Cladocera community, followed by genus *Bosmina* (31.03 & 8.37%) and genus *Ceriodaphnia* (6.20 & 5.70%) of total community in Kalabsha and Allaqi khors, respectively (Table. 3).

Species richness and diversity indices:

In the present study, species richness recorded 25 and 24 species at Kalabsha and Allaqi khors, respectively. Kalabsha had a richness value of 2.21, while Allaqi had 2.14. The diversity, similarity, community dominance indices and Evenness were nearly the same as shown in table 4.

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Table (3): Percentage occurrence of different taxa of zooplankton in each group at Kalabsha and Allaqi khors

Zooplankton groups	Kalabsha	Allaqi	Zooplankton groups	Kalabsha	Allaqi
Rotifera	**% Occurrance**	**% Occurrance**	**Copepoda**	**% Occurrance**	**% Occurrance**
Anuraeopsis fissa (Gosse)	2.27	1.48	*Thermodiaptomus galebi* (Barrois)	2.48	0.72
Ascomorpha ecaudis (Perty)	3.40	0.62	*Thermocyclops neglectus* (Sars)	1.45	4.03
Brachionus calyciflorus (Pallas)	1.13	1.35	*Mesocyclops ogunnus* (Onabamiro)	12.84	18.73
Brachionus patulus (Müller)	1.13	2.71	Copepodite stages	32.71	40.35
Collotheca sp.	0.57	0.74	Nauplius larvae	50.52	36.17
Conochillus unicornis (Rousslet)	0.28	2.09	**Subtotal**	100.00	100.00
Keratella cochlearis (Gosse)	5.67	2.83	**Cladocera**		
Keratella tropica (Apstein)	6.52	15.52	*Bosmina longirostris* (Müller)	31.02	8.36
Lecane bulla (Gosse)	1.98	5.17	*Ceriodaphnia cornuta* (Sars)	5.11	4.56
Macrochaetus serica (Thorpe)	0.28	0.00	*Ceriodaphnia dubia* (Richard)	1.09	1.14
Philodina sp.	1.42	1.97	*Daphnia longispina* (Müller)	0.36	1.14
Polyarthra vulgaris (Carlin)	0.00	0.37	*Daphnia barbata* (Weltner)	0.36	0.00
Ptygura libera (Myers)	60.62	43.72	*Diaphanosoma excisum* (Sars)	60.95	83.65
Scaridium longicaudum (Müller)	13.31	20.07	*Simocephalus vetulus* (Müller)	1.09	1.14
Trichocerca longiseta (Schrank)	1.42	1.35	**Subtotal**	100.00	100.00
Subtotal	100.00	100.00	**Turbellaria:**		
			Microdalyellia sp.	100	100.00

Table (4): Average diversity measures of zooplankton Kalabsha and Allaqi khors.

Item	Kalabsha	Allaqi
No. of species	25.00	24.00
Richness (R)	2.21	2.14
Diversity Index (H)	2.18	2.00
Similarity Index (S)	93.9	93.9
Dominance Index (D)	34.11	32.34
Evenness Index (E)	0.68	0.63

The diversity index of zooplankton was higher at both Kalabsha and Allaqi khors. The higher value of diversity index (H) indicated greater species diversity. The greater species diversity means larger food chain and more cases of inter-specific interactions and greater possibilities for negative feedback control that reduced oscillations and hence increases the stability of the community.

Canonical correspondence analysis (CCA)

CCA axes 1 and 2 explained 69.13 % of the variance in the species environment biplot. The most important factor that related with the two axes were total phosphorus, turbidity, chlorophyll a, ortho phosphorus, total alkalinity, water temperature and nitrate. *Scaridium longicaudum*, and nauplius larvae are aligned with axes 1, while copepodite stages and cladocera are aligned with axes 2. Copepoda are associated with phosphorus, while nauplius larvae are associated with environment rich in nitrate and alkalinity (Fig.3).

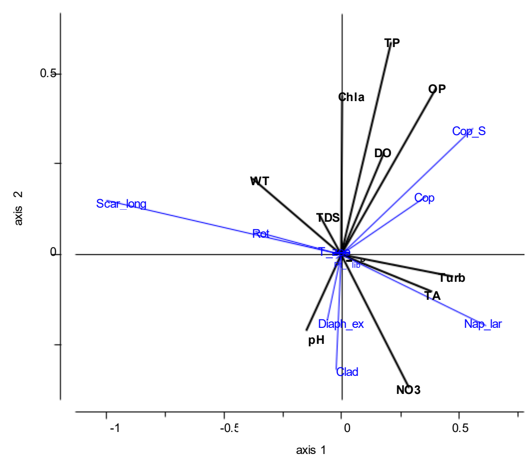

Fig. (3): CCA **Ordination diagram between 9 zooplankters;** *Ptygura libera* (Pt_lib), *Scaridium longicaudum* (Scar_long), total Rotifera (Rot), Copepodite stages (Cop_S), Nauplius larvae (Nap_lar), total copepods (Cop), *Diaphansoma excisum* (Diaph_ex), total Cladocera (Clad), and total zooplankton (T_zoo) **and 11 environmental variables;** water temperature (WT), pH, dissolved DO, Secchi depth (SD), turbidity (Turb), nitrate (NO_3), ortho phosphate (OP), total phosphorus (TP), total alkalinity (TA), TDS and chlorophyll *a* (Chla).

Sediment Quality

Tables (5) present the results of physicochemical parameters in bed sediments in Kalabsha and Allaqi khors at Lake Nasser. These results showed that **Grain size distribution** of bed sediment in both khors are classified as medium to fine sand, silty fine to medium sand and silty medium to fine sand except two samples at Kalabsha khor, which classified as pebble sized rock fragments. **pH** Value in Kalabsha khor ranged between 7.52 and 7.75, while it ranged between 7.41 and 7.80 in Allaqi khor. **Electrical Conductivity in** Kalabsha khor ranged between 2.73 and 10.95 ds/m, while it ranged between 2.68 and 4.00 ds/m at Allaqi khor. **Nitrate** concentrations in bed sediments of Kalabsha khor ranged between 4.2 and 4.7 mg/kg. However, it ranged between 3.9 and 6.1 mg/kg in Allaqi khor. The percentage of **organic matter** in bed sediments ranged from 0.73 to 1.71% and from 0.62 to 2.36% in Kalabsha and Allaqi khors, respectively. **Phosphate** concentrations in bottom sediments of Kalabsha khor, ranged between 0.48 and 0.49 mg/kg. However, it ranged between 0.22 and 0.28 mg/kg in Allaqi khor. The percentage of **calcium carbonate** in bed sediments of Kalabsha khor ranged from 7.9 to 15.5% and from 6.08 to 10.64% in Allaqi khor.

Table (5): Physicochemical characteristics in sediments for Kalabsha and Allaqi khors.

Site Name		pH	EC	OM	$CaCO_3$	NO_3	PO_4
		Value	ds/m	%	%	mg/kg	mg/kg
Kalabsha	**K1**	7.52	10.95	1.71	15.50	4.60	0.49
	K3	7.70	2.73	0.73	7.90	4.70	0.48
	K5	7.75	4.07	1.05	12.62	4.20	0.48
Allaqi	**A1**	7.76	2.68	0.62	9.27	6.10	0.25
	A3	7.41	4.00	1.89	10.64	5.20	0.23
	A5	7.69	3.99	1.68	10.64	4.70	0.22
	A7	7.80	2.73	1.88	7.14	3.90	0.24
	A9	7.69	3.95	2.36	6.08	5.00	0.28

For heavy metals, **Chromium (Cr)** concentrations ranged between 33 mg/kg and 40 mg/kg at Kalabshsa khor. However, its concentration ranged between 11 mg/kg and 45 mg/kg at Allaqi khor. Comparing the results with agriculture land use, we found that, all chromium concentrations were found within the standard limits (64 mg/kg). **Copper** (Cu) concentrations ranged between 41.7 mg/kg and 56.9 mg/kg at Kalabsha khor. However, its concentration ranged between 25.0 mg/kg and 62.7 mg/kg at Allaqi khor. It is worth to mention that, all sites along Allaqi khor were found within the permissible limits of agriculture land use target (63 mg/kg). **Zinc (Zn)** ranged between 11 mg/kg and 152 mg/kg at Kalabsha khor. However, it recorded values ranged between 38 mg/kg and 140 mg/kg at Allaqi khor. Comparing the results with agriculture land use, we found that, all zinc concentrations were found within the standard limits (200 mg/kg). **Lead (Pb)** ranged between 13 mg/kg and 47 mg/kg at Kalabsha khor, while the lead concentrations recorded values ranged between 6 mg/kg and 50 mg/kg at Allaqi khor. It is worth to mention that, all sites along Kalabsha and Allaqi khors were found within the permissible limits of agriculture land use target (70 mg/kg). Cadmium, arsenic and selenium are not detected in all sites at Kalabsha and Allaqi khors (Table 6).

Table (6): Concentrations of metals (g/kg) in bed sediments of Lake Nasser khors.

Site Name		Cr	Cu	Pb	Zn
Kalabsha	**K1**	38.0	56.9	47.0	152.0
	K3	33.0	41.7	13.0	10.6
	K5	40.0	54.9	14.0	62.0
Allaqi	**A1**	11.0	62.7	18.0	97.0
	A3	42.0	56.0	40.0	140.0
	A5	34.0	42.6	7.0	38.0
	A7	36.0	25.0	6.0	58.0
	A9	45.0	59.7	50.0	96.0

To assess the sediment in both khors, sediments quality indices and comparison with guidelines are applied. Sediment quality indices include sediment enrichment factor (SEF) and ecological risk factor (Er). The calculations of **SEF and Er** showed that Cr, Cu, Pb and Zn in bed sediment recorded values less than 1.0 and 40.0, respectively at the all sites in both khors (Table 7).

Table (7): Calculations of sediment enrichment factor and Ecological risk factor in bed sediment of Lake Nasser khors.

Site Name		Cr		Cu		Pb		Zn	
		SEF	Er	SEF	Er	SEF	Er	SEF	Er
Kalabsha	K1	-0.41	1.78	-0.10	4.52	-0.33	3.36	-0.24	0.76
	K3	-0.48	1.55	-0.34	3.31	-0.81	0.93	-0.95	0.05
	K5	-0.38	1.88	-0.13	4.36	-0.80	1.00	-0.69	0.31
Allaqi	A1	-0.83	0.52	-0.01	4.98	-0.74	1.29	-0.52	0.49
	A3	-0.34	1.97	-0.11	4.44	-0.43	2.86	-0.30	0.70
	A5	-0.47	1.59	-0.32	3.38	-0.90	0.50	-0.81	0.19
	A7	-0.44	1.69	-0.60	1.98	-0.91	0.43	-0.71	0.29
	A9	-0.30	2.11	-0.05	4.74	-0.29	3.57	-0.52	0.48

The comparison of metals concentration with effect range-low (ERL) and Effect range-median (ERM) showed that Zn, Pb and Cr concentrations are classified as no contamination, where the average values of these metals in both khors recorded values less than the ERL value, while Cu is classified as medium contamination where, the average Cu concentration recorded value between ERL and ERM (Table 8).

Table (8): Assessment of heavy metals in bed sediments at Lake Nasser khors.

Element		Cr	Cu	Pb	Zn
Guideline (mg/kg)	ERL	81	34	46.7	150
	ERM	370	270	218	410
Kalabsha (mg/kg)		37	51.2	24.7	74.9
Allaqi (mg/kg)		33.6	49.2	24.2	85.8
Contamination level		No contamination	Medium contamination	No contamination	No contamination

ERL: effect range-low, ERM: Effect range-median

4. Discussions

Lake Nasser khors form about 55% of the total Lake Nasser volume (Entz and Latif, 1974). Ecological status of water body in khors is different than those characterize the main channel. They have specific environmental conditions. Therefore, its local variations in the limnological characteristics are expected to be of considerable importance.

The above results showed that the mean values of the different physicochemical parameters are fairly increased in Allaqi khor than in Kalabsha khor. These factors play an important role in the distribution of zooplankton. Temperature is one of the most important factors, which affect the living organisms and their biological activities, either directly or indirectly. Generally, in this study, water temperature was negatively correlated with total zooplankton and their different groups and species. pH values were found always on the alkaline side at both khors. Reid (1961) concluded that the alkaline water is more productive than the acidic. Alkalinity and pH are often found as variables redacting the zooplankton community composition, based on data from a large number of different water bodies (Berzins & Pejler, 1987). Dissolved oxygen were exhibited mean values closed to 8.0mg/l, meaning that both khors waters are well oxygenated and it is considered as healthy water. According to Edmonson (1991), the concentration of dissolved oxygen in the lake waters gives an information about the pollution level and the producing rate of a lake. Turbidity in Lake Nasser is mainly caused by two factors: allochtonic inorganic silt and mud of riverine origin and autochtonic suspended organic matter (plankton and detritus) in the downstream area (Mageed and Heikal, 2006; Iskaros and El Dardir, 2010). The nihilist flow velocity in this zone of Lake Nasser mainly explains the low turbidity values in the two khors. The mean value of electrical conductivity at Lake Nasser khors was 244µs/cm. This value classified the lake khors to the first class of the African Lakes classification with low conductivity less than 600 µs/cm (Talling and Talling 1965). Nitrogen and phosphorus compound are considered essential nutrients for living organisms

(Ravindra *et al*., 2003). The slightly increase in phosphate and nitrate compounds in the two khors led to increase the chlorophyll *a* that represent phytoplankton biomass (Becher *et al*., 2000). High concentration of TP at Allaqi, which characterized by shallow depths at the end of the khor, led to shifting the trophic state from mesotrophic to eutrophic class (Schiemer *et al*., 2001). The positive relationship between chlorophyll *a* and phosphorus compounds (OP; r = 0.65, $P < 0.05$ and TP; r = 0.67, $P < 0.01$) showed the strong dependence of algal biomass for these nutrients (Smith & Shapiro, 1981), however the N/P ratio ranged from 13 to 40, indicating potential control of algal growth by phosphorus (Becher *et al*., 2000). This result coincided with the finding of Heikal (2010) which concluded that khors of Lake Nasser could be considered as potential pollution sources, so their continues monitoring is a must. The mean trophic state index at Allaqi khor (51.88) was fairly increased than that at Kalabsha khor (49.85), classifying Kalabsha as mesotrophic and Allaqi as eutrophic according to Carlson's (1977). Transparency in Kalabsha khor is recorded with higher value than in Allaqi khor. The decrease in transparency is mainly due to low suspended organic material (El-Shabrawy, 2009). The average value of chlorophyll *a* concentration was higher at Allaqi (7.51mg/m^3) than that at Kalabsha (6.9 mg/m^3). The increase of chlorophyll *a* at Allaqi is due to the rise in the phosphorus and nitrogen concentrations at Allaqi water. Secchi depth, as a general, indicator of chlorophyll *a* concentration has been reported to be negatively related to chlorophyll *a* concentration (Barica 1975). The positive function among the zooplankton component (Rotifers; r = 0.78, $P < 0.01$ and copepod; r = 0.58, $P<0.05$) in relation to chlorophyll *a* demonstrates dependence of zooplankton community on this resource.

In the context of the zooplankton, both khors showed highly similar values in species. The number of zooplankton species recovered in this study from Kalabsha khor was 25 belonging to 21 genera and that from Allaqi khor was 24 species belonging to 21 genera. Mageed and Heikal (2006) recorded 23 zooplankton species at Lake Nasser. Zooplankton count in the two khors is rich. The average standing crop recorded 53,167 and 47,018 ind/m^3 at Kalabsha and Allaqi khors, respectively. Samaan, (1971) found the standing crop at lake khors is 46,000 ind/m^3. Allaqi khor was dominated by rotifers, while Kalabsha khor was dominated by copepods. Several authors have associated the dominance of rotifers to the increase in the trophic conditions, due to their capability to ingest small feeding particles, such as bacteria and organic detritus, which are abundant in eutrophic ecosystems (Pace, 1986). On the other hand, in lentic waters, the reproductive rate of copepods compensates for loss of individuals by death and by downstream advection (Santos & Rocha, 2007). Rotifera was the group with greatest taxonomic taxa in the two khors. This pattern is common in tropical freshwaters such as lakes, reservoirs, rivers, or streams (Sampaio & Lopez, 2000). Domination of copepods in Kalabsha khor is coincided with the obtained results of El-Shabrawy and Dumont (2003) and El- Serafy *et al*., (2009). Green (1965) indicated that copepod-dominant lakes are mesotrophic in their characteristics.

It is worth mentioning that a new record of rotifer named *Ptygura libera* (Myers 1834) was recorded for the first time in Lake Nasser khors and in Egypt Freshwater bodies. This species confirmed mesotrophic status of the Lake. *Ptygura* is a genus of rotifers and it included in the family Flosculariidae. It is sessile type like most species of rotifers (i.e. it spend the main part of their lives attached to the stems of water plants, submerged tree rootlets, filaments of algae. etc.). It has a body and foot elongate, corona circular, lateral antennas, swimming backwards like many planktonic Flosculariidae and one protuberance present (Figs. 5 & 6). In our specimens, a transparent ampule-like tube, not mentioned by a Myers, surrounded the peduncle. This tube constructed of jelly and debris, appearance gelatinous and transparent. From this tube, the corona protrudes. Inside the tube, a developing egg can be spotted (Jersabek *et al*., 2003; Garcia and Elias 2004). *Ptygura libera* (Myers 1834) is a warm-stenotherm and reported from various areas in subtropical and tropical waters of North, Central and South America (Pourriot 1996; Koste 1978). It was observed in Montebello, Escondida, La Canada and Pojoj lakes in Chiapas, and La Esperanza and Donato Sinkholes in Quintana Roo and southeastern Mexico (Garcia and Elias 2004); in Pedro Beicht, Cachoeira das Graças, Jundiaí and Ponte Nova in the State of São Paulo in Brazil (Lucinda *et al*., 2004).

The diversity indices indicated that both khors have a well-balanced zooplankton community, indicating the dynamic nature of this aquatic ecosystem and more homogeneity in their composition (Shinde *et al*., 2012). Rotifera was the greatest taxonomic group (highly species richness) in the two khors. This result is similar to that obtained by Khalifa, *et al*. (2015).

For sediments of the two khors, the results of grain size distribution revealed that the source of sedimentation in Kalabsha and Allaqi khors is originate from the surrounding sand sheets and rocks drifted by the wind not from the river sedimentation. This is coincided with the results obtained by Iskaros and El Dardir (2010). The results of pH value indicate that the bottom sediment is slightly alkaline. Haiyan *et al*. (2013) reported that the heavy metals release rates increase in the acidic condition than in the alkaline conditions (i.e. as pH value decrease the release of heavy metals increase).

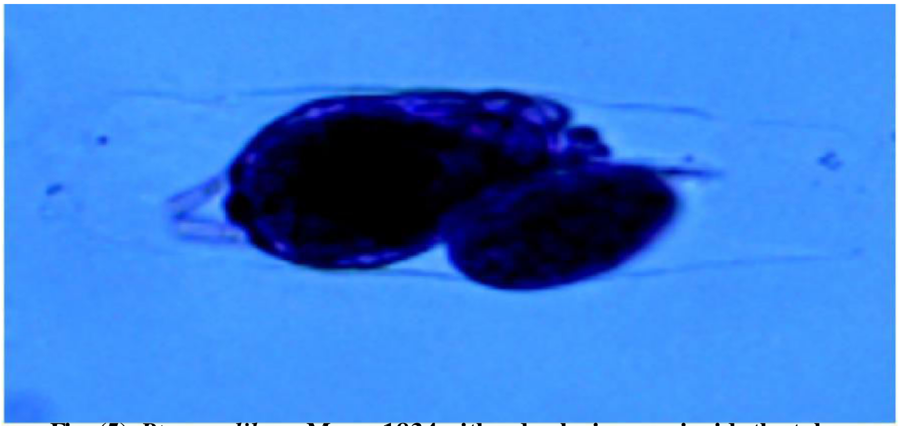

Fig. (5). ***Ptygura libera*** **Myers 1834 with a developing egg inside the tube**.

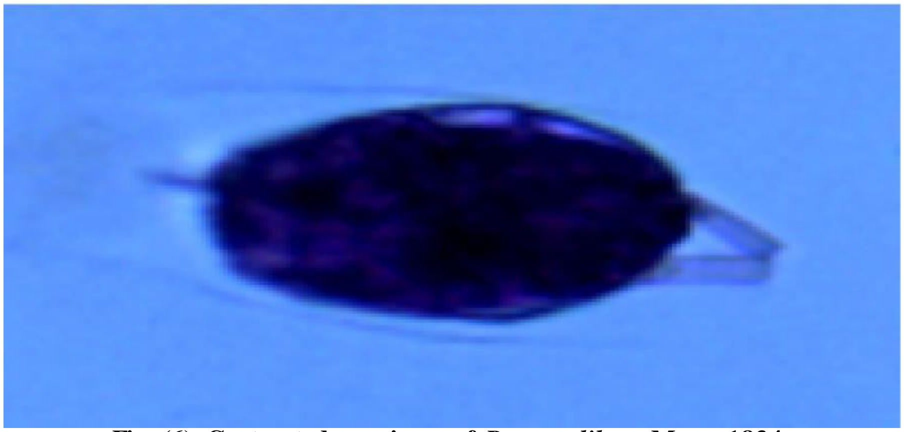

Fig. (6). Contracted specimen of ***Ptygura libera*** **Myers 1834.**

To assess the bed sediment in both khors, different sediment quality indices were applied including sediment enrichment factor (SEF) and ecological risk factor (Er). The calculations of SEF revealed that the heavy metals in bed sediment at the two khors are crustal origin (natural), where SEF is less than 1.0 at all sites(Riba *et al*., 2002). Also, calculations of Ecological risk factor recorded value less than 40, indicating that the sediment of the two khors posses heavy metals with low risk (Long *et al*., 1995). The comparison of metals concentration with ERL and ERM showed that Zn, Pb and Cr concentrations at each of the khors are classified as no contamination, while Cu is classified as medium contamination. The decrease of heavy metals concentrations in water may be related to the high level of DO and pH value. Based on SEF calculations, the metals in bed sediments are classified as natural source (chemically inert). Therefore, the release of metals from bed sediments is rarely occur. This was supported by Borg (1984), who cited that heavy metals in carbonate with low solubility as Pb are completely eliminated from the solution as result as $CaCO_3$ co-precipitation.

Conclusions

From this study, we can conclude that khors waters are well oxygenated and it is considered as healthy water. The phytoplankton biomass in Lake Nasser khors is mainly controlled by nutrients, especially phosphorus, which considered as potential control of algal growth at both khors. The calculated TSI suggested that Allaqi is an eutrophic and Kalabsha is a mesotrophic. Zooplankton in both khors showed highly similar values in species. Allaqi khor was dominated by rotifers, while Kalabsha khor was dominated by copepod. Rotifera was the main group with the greatest taxonomic taxa in both khors. It is worth mentioning that a new record of rotifera named *Ptygura libera* (Myers 1834) was recorded for the first time in Lake Nasser khors and in Egypt Freshwater bodies. This species confirmed mesotrophic status of the Lake. The diversity indices indicated that both khors have a well-balanced zooplankton community, indicating the dynamic nature of this aquatic ecosystem and more homogeneity in their composition.

For sediments, grain size distribution in Kalabsha and Allaqi khors revealed that the source of sedimentation is originated from shores not from the river sedimentation. The calculations of SEF revealed that the heavy metals in bed sediment at the two khors are natural origin. Also, calculations of Ecological risk factor recorded value less than 40, indicating that the sediment of the two khors posses heavy metals with low risk. Finally, long-term investigations must be addressed to various aspects in Lake Nasser khors.

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