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Using zooplankton in some environmental biotic indices to assess water quality of Lake Nasser, Egypt

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Abstract
The study used zooplankton as a tool of biotic elements to assess water quality of Lake Nasser and two of its main Khors (Wadi Abyad and Tushka) throughout different seasons in 2013. Species richness index (d), Wetland Zooplankton Index (WZI) and Saprobity index (S) were applied. The richness index values indicated that, the water quality of Lake Nasser is lower and may be polluted at some sites and time which didn't reflect the actual ecological status of the lake. Wetland Zooplankton Index scores revealed that water quality at the three localities increased in spring (good water) followed by winter, while it was moderate in summer and autumn when water level is high. Saprobiological analysis showed that, the main channel had the best water quality (good water) in spring, while Khor Wadi Abyad contained good water quality in summer, but Khor Tushka had moderate water quality during the study period. Wetland Zooplankton Index and Saprobity index somewhat give a good indication to assess water quality of Lake Nasser and some developments are needed according to the nature of the lake and their dominant zooplankton indicator species.

Keywords: Lake Nasser; Zooplankton; Biotic indices; Species richness index; Wetland Zooplankton Index; Saprobity index,

1. Introduction
Bio-monitoring and assessment of environmental changes using indicator organisms became a widely known and accepted method for water quality assessment in the European Union [1]. Species that have a predicted response to changes in a selected variable can serve as bio-indicators, reflecting the reactions of aquatic ecosystems to eutrophication, pH levels (acidification), salinity, and organic pollution [2]. Recently the ecologists trend to evaluated body water health by biotic elements, because the biotic factors affect and are affected by environmental condition, they can be used in monitoring the environmental changes and assess habitat degradation in a variety of geographic locations and ecosystem types. Several studies used fish [3], macro invertebrates [4, 5], diatoms [6] and periphyton [7] for this purpose.
Although zooplankton are small and rapidly reproducing organisms that response quickly to environmental changes and may be effective indicators of subtle alterations in water quality [8], only a few attempts have been made to use the zooplankton community to indicate quality of aquatic ecosystems [9-11]. Recently saprobic system was used to assess water quality by zooplankton independent [12, 13] on Ortendorfer and Hofrat list scores of indicator species [10]. Wetland Zooplankton Index (WZI) was designed to assessment water quality of great lakes in North America [14]. In Egypt, few studies were conducted to assess water quality by the biotic indices, bottom fauna was used to monitor Nile water health by Nile Biotic Pollution Index (NBPI) independent on United Kingdom Biological Monitoring Working Party (BMWP) biotic index [15]. Four diatom indices were applied to assess water quality of River Nile [16] and the study concluded that these indices unsuitable to assessment water quality of River Nile In the present work we compared between some biotic indices to assess water quality of Lake Nasser using zooplankton as a tool of these indices.

2. Material and methods
2.1. Site Description
Lake Nasser has an area of about 5248 km2, a mean depth of 21.5 – 25.5 m (maximum 90 m) and the maximum width is about 60 km, the average width is 8 km. Lake Nasser extends between 22º 31´to 23° 45´N and 31° 30´ to 33° 15´ E [17]. The reservoir is highly dendritic, with a number

of flooded side valleys, known as khors. The mean length of the khors increases downstream from the south to the north, owing to the northwardly declining ancient riverbed [18].

2.2. Sampling program

Seasonally sampling was performed from February 2013 to November 2013. Nine stations in the main channel of Lake Nasser (Fig.1) and six sampling sites from each of Khors Wadi Abyad and Tushka (Fig. 2-3) were studied. At main channel of Lake Nasser each station was represented by three sites (east, middle and west) except at stations 5 (middle), station 6 (middle and west) and station 9 (east and middle). In autumn only four samples were collected from sites 3 to 6 at khor Wadi Abyad.

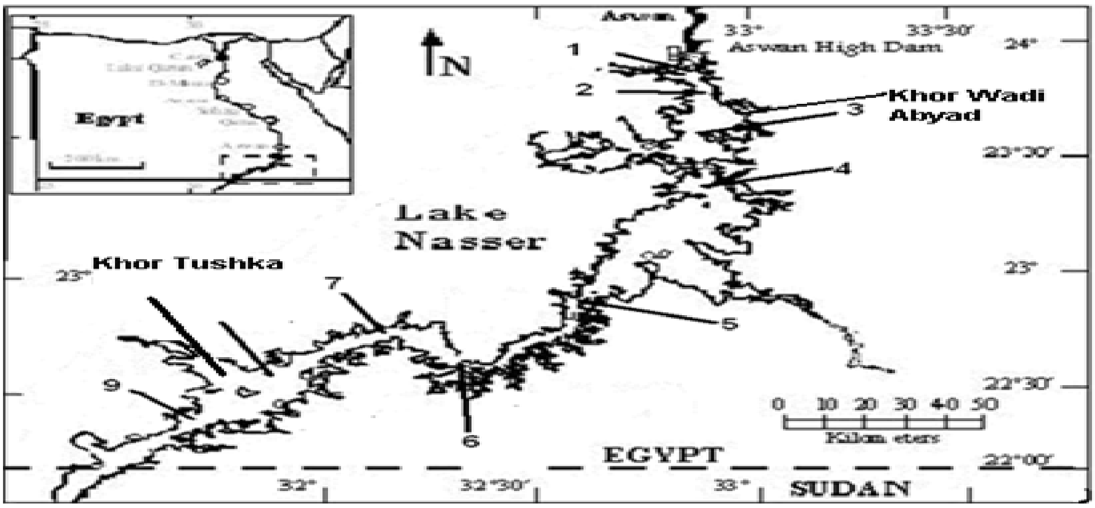

Fig 1: Map of Lake Nasser showing Khors Wadi Abyad, Tushka and the selected study sites at main channel.

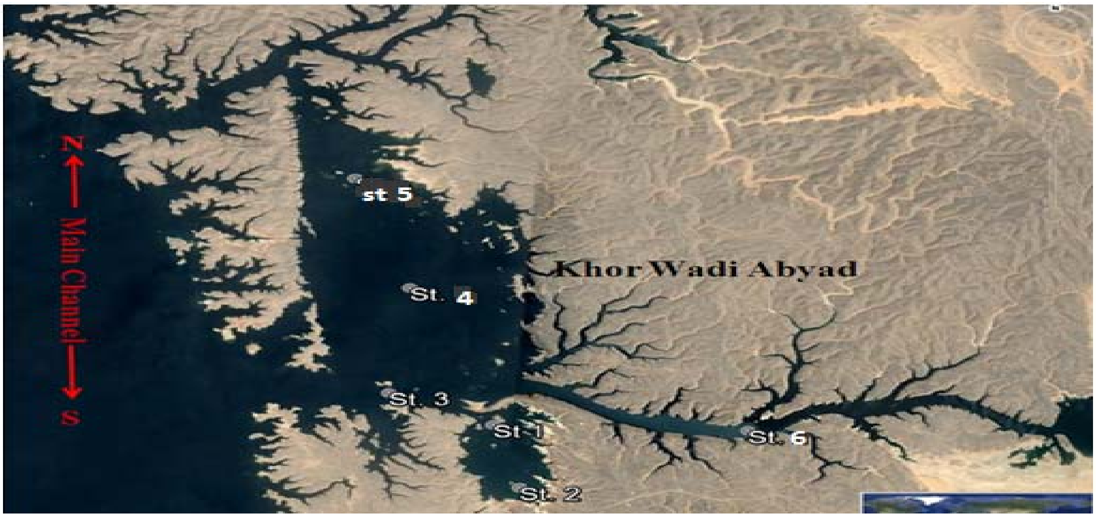

Fig 2: Map of Khor Wadi Abyad showing the selected sites. (Google earth)

Fig 3: Map of Khor Tushka showing the selected sites. (Google earth)

2.3. Chemical analysis
Physicochemical parameters including temperature, transparency, dissolved oxygen, pH and nutrient salts were estimated [19].

2.4. Zooplankton analysis
For zooplankton quantitative analysis 30 liters were taken from surface water at each sampling site by filtering through a zooplankton net of 55 µm mesh diameter. Collected samples were kept in plastic bottles with some lake water to which 4% formalin was added as a preservative. Samples were studied under the compound microscope and specimens identified at the species level when possible. Zooplankton numbers were expressed as number of organisms per cubic meter.

2.5. Data analysis
2.5.1. Species Richness Index (d)
One of the major components of species diversity is ‘Species richness’ or Margalef’s diversity index (d) [20] and is expressed by: $d = S-1 / \log N$ Where, (S) is the total number of species and (N) is the total number of individual. Species Richness Index commonly varies between 1 and 5, and larger the index indicates a more healthy body of water and when tends towards 1 pollution is thought to increase [21].

2.5.2. Wetland Zooplankton Index (WZI)
This index was calculated using weighted averages as the following equation [22, 6]: $WZI = \sum YiTiUi / \sum YiTi$
Where, Yi is the abundance or the presence of species i, Ti is the tolerance (1–3), Ui is the optimum (1–5). The index can therefore range from one (indicative low quality) to five (indicative of high-quality). The list scores of Ti and Ui for each indicator zooplankton species are calculated according to Lougheed and Chow-Fraser (2002) [14].

2.5.3. Saprobity Index (S)
The index of saprobity is calculated as a function of the indicator species numbers and their relative abundances:
$S= \Sigma sh/\Sigma h$ Where, S is Index of saprobity for zooplankton community; s is species-specific saprobity level and h is species abundance. Ecological characteristics of the indicator zooplankton species (s) are summed up in the database [10].
The relationship between the saprobity index and the classes of water quality identified on the basis of scales conducted [11] at table 1.

Table 1: Water quality classes according to Saprobic System [11].

Water quality Class	NH_3 mg/l	NO_2 mg/l	NO_3 mg/l	PO_4 mg/l	Saprobity Index
I- high	< 0.05	0	< 0.05	< 0.005	≤ 0.5
II- good	0.05-0.20	0.001-0.002	0.05-0.50	0.005-0.031	0.5 - 1.5
III- moderate	0.21-0.50	0.006- 0.020	0.51-1.5	0.031-0.100	1.6- 2.5
IV- poor	0.51-2.5	0.021-0.100	1.51-2.50	0.101-0.300	2.6-3.5
V- bad	>2.50	>0.100	>2.50	>0.300	> 3.5

3. Results
3.1. Physicochemical parameters
Physical and chemical parameters of main channel and the two Khors are shown in tables 2, 3 and 4. Temperature recorded the highest mean in summer season at the three studied localities. pH lie on alkaline side and it slightly fluctuated from season to other. Transparency means were increased in autumn at main channel, and attained its highest value in summer at Khor Wadi Abyad, while its maximum value at Khor Tushka was measured in winter. Dissolved oxygen reached its highest values in winter and autumn (cold seasons) during the study. Nutrient salts were fluctuated from seasons to other.

Table 2: Averages of physicochemical parameters of main channel in Lake Nasser

	Winter	Spring	Summer	Autumn
Temperature (°C)	19.6	28.3	29.6	24.4
pH	8.6	8.4	8.1	8.1
Transparency (cm)	320	230	271	350
DO (mg/l)	6.5	5.7	4.7	6.6
NO_2 (mg/l)	0.014	0.022	0.013	0.004
NO_3 (mg/l)	0.66	0.26	0.17	0.21
NH_3 (mg/l)	0.060	0.11	0.067	0.029
PO_4 (mg/l)	0.058	0.056	0.013	0.043

Table 3: Averages of physicochemical parameters in Khor Wadi Abyad

	Winter	Spring	Summer	Autumn
Temperature (°C)	20.4	27.9	30.1	24.35
pH	8.7	8.6	8.2	8.2
Transparency (cm)	287	234	358	353
DO (mg/l)	6.7	6	4.5	6
NO_2 (mg/l)	0.007	0.005	0.005	0.003
NO_3 (mg/l)	1.88	0.28	0.12	0.06
NH_3 (mg/l)	0.014	0.081	0.18	0.04
PO_4 (mg/l)	0.012	0.07	0.21	0.06

Table 4: Averages of physicochemical parameters in Khor Tushka

	Winter	Spring	Summer	Autumn
Temperature (°C)	19.1	30.6	30.8	19.2
pH	8.6	8.4	8.5	8.5
Transparency (cm)	256.7	185	200	211.5
DO (mg/l)	6.9	5.2	4.7	7.2
NO_2 (mg/l)	0.03	0.03	0.015	0.008
NO_3 (mg/l)	0.8	0.2	0.32	0.39
NH_3 (mg/l)	0.02	0.05	0.1	0.016
PO_4 (mg/l)	0.04	0.06	0.15	0.028

3.2. Zooplankton structure

The highest number of species (38) was detected at the main channel of Lake Nasser (4 Copepoda, 6 Cladocera, 24 Rotifera and 4 Protozoa), the number decreased to 31 species at Khor Tushka (3 Copepoda, 7 Cladocera, 17 Rotifera and 4 Protozoa) and the least number (24) was counted at Khor Wadi Abyad (3 Copepoda, 5 Cladocera, 13 Rotifera and 3 Protozoa). Copepoda was the most dominant group in the three localities, however, the greatest diversity was observed among Rotifera. *Thermodiaptomus galebi* recorded the highest number of adult copepods in the three localities. Cladocera was dominated by *Diaphanosoma mongolianum* in main channel and *Ceriodaphnia dubia* in Wadi Abyad, while Chydorus sphaericus was the most abundant in Tushka. *Keratella* was the main rotiferan in the main channel and Khor Tushka, but *Collotheca* was the dominant rotifer in Khor Wadi Abyad. The list of zooplankton taxa and averages at the three localities are shown in table (5).

Table 5: Averages (Individuals.m^{-3}) of zooplankton taxa at the three localities in Lake Nasser

Zooplankton taxa	Main channel	Khor Wadi Abyad	Khor Tushka
Protozoa			
Arcella dentate Ehrenberg, 1830	33	0	0
A. discoides Ehrenberg, 1843	0	0	14
Centropyxis aculeate (Ehrenberg, 1841)	163	42	21
Epistylis sp.	2240	1441	1556
Vorticella campanula Ehrenberg, 1831	40	106	248
Rotifera			
Ascomorpha ecaudis Perty, 1850	0	83	0
Asplanchna girodi de Guerne, 1888	117	0	354
Brachionus calyciflorus Pallas, 1766	81	42	958
B. caudatus Barrois and Daday, 1894	32	0	83
B. falcatus Zacharias1898	15	14	125
B. plicatilis Müller, 1786	213	0	125
B. patulus O. F. Muller, 1786	260	56	292
Cephalodella catellina (O. F. Muller, 1786)	4	28	0
Collotheca balatonica Varga, 1936	2067	7257	2188
Concholodies sp.	35	0	35
Conochilus hippocrepis (Schrank, 1803)	46	0	229
Epiphanous sp.	0	0	28
Euchlanis dilatata Ehrenberg 1832	7	28	0
Filinia opoliensis (Zacharias, 1898)	24	0	0
F. longiseta (Ehrenberg, 1834)	0	0	83
Hexarthra mira (Hudson, 1871)	4	97	167
Keratella tropica (Apstein, 1907)	1296	1319	1104
K. cochlearis (Gosse 1851)	1312	2708	3264
Lecan bulla (Gosse 1851)	76	181	125
L. luna (Müller, 1776)	11	0	0
Mytilina ventralis (Ehrenberg, 1830)	4	0	0
philodena sp.	22	0	0
Syncheta sp.	20	0	0
Trichocerca similis (Wierzejski, 1893)	5	0	0
T. longiseta (Schrank, 1802)	75	28	111
Trichocerca sp.	18	56	42
Tricotria tetractis (Ehrenberg, 1830)	4	0	0
Cladocera			
Alona quadrangularis (Müller, 1776)	25	0	150

Bosmina longirostris (O. F. Müller, 1785)	1560	4108	1569
Ceriodaphnia dubia Richard, 1895	1080	11150	403
Chydorus sphaericus (O. F. Mueller, 1785)	753	42	4215
Daphnia longispina (O.F. Müller, 1776)	581	1080	215
Diaphanosoma mongolianum Uéno, 1938	2750	2698	3235
Macrothrix spinosa King, 1853	0	0	21
Cladocera larvae	67	83	0
Copepoda			
Nauplius larvae	22955	16139	28118
Cyclopoid Copepodite	6644	4267	9188
Calanoid Copepodite	2172	2014	2924
Thermodiaptomus galebi (Barrois, 1891)	2467	3733	1090
Mesocyclops ogunnus Onabamiro, 1957	523	528	292
Thermocyclops neglectus (Sars G.O., 1909)	773	333	590
Harpacticoida sp.	5	0	0

3.3. Species Richness Index (d)

At the three studied localities, the highest value of richness index (1.72) was detected at eastern site of station 7 at main channel in summer (Fig. 4). While, the lowest one (0.22) was recorded at site 3 at Khor Tushka in spring. Regarding seasonal changes in species richness index the highest average value of 1.14 detected in autumn season at the main channel of Lake Nasser and in summer season at Wadi Abyad and Tushka with averages of 1.02 and 1.18 respectively (Fig. 5 and 6).

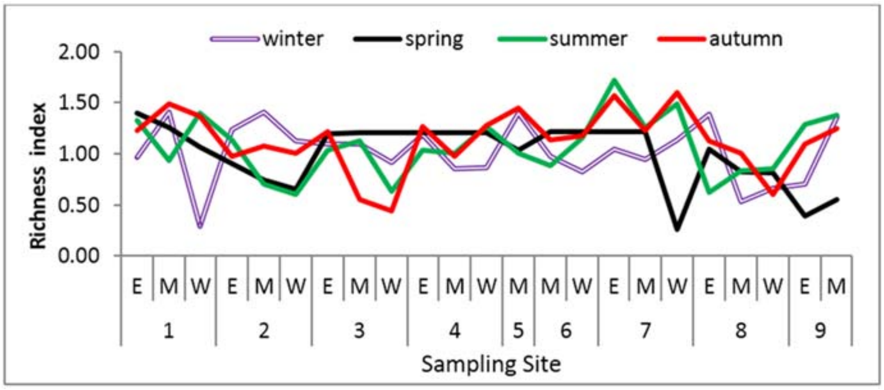

Fig 4: Seasonal changes of richness index values at the main channel of Lake Nasser.

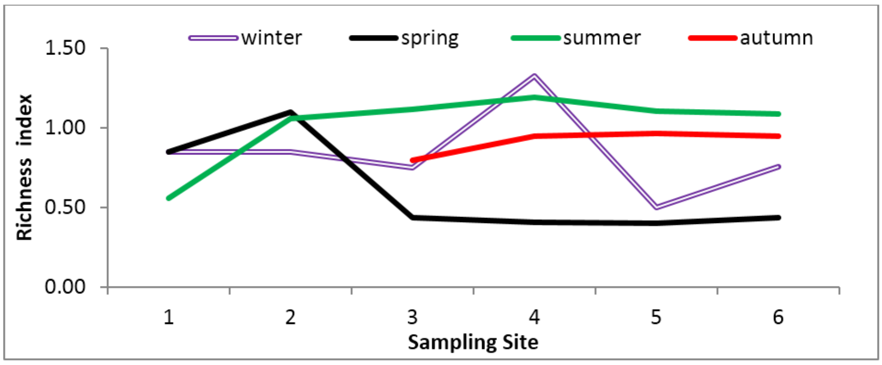

Fig 5: Seasonal changes of richness index values at Khor Wadi Abyad.

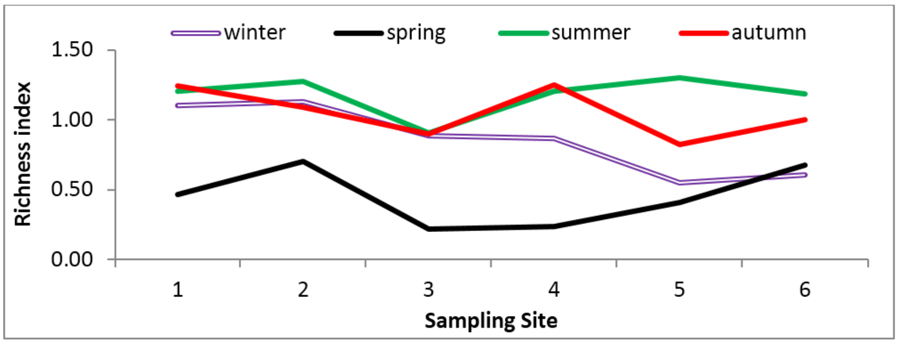

Fig 6: Seasonal changes of richness index values at Khor Tushka

3.4. Wetland Zooplankton Index (WZI)

In main channel of the lake, the WZI scores were ranged between 2 (low quality water) and 5 (high quality water). The good quality water was noticed in spring and autumn while moderate water quality was estimated in the other seasons (Table, 6). According to WZI scores, the best water quality was detected in Khor Wadi Abyad as it ranged between 3.5 and 5 (Table, 7). In Khor Tushka, WZI score showed the good water quality in spring season with average 4.3 and in summer it decreased to average of 3.1 which indicated moderate water quality (Table, 8).

Table 6: Seasonal changes of Wetland Zooplankton Index (WZI) scores at main channel of Lake Nasser.

Station	Site	winter	spring	summer	autumn
1	E	3.3	3.0	4.1	3.1
	M	3.7	4.0	3.7	3.6
	W	3.4	4.0	3.4	4.2
2	E	3.6	4.5	3.8	4.0
	M	3.4	4.6	4.0	3.8
	W	3.2	4.9	3.8	4.6
3	E	3.3	4.5	3.2	3.8
	M	3.6	4.5	4.1	4.5
	W	3.2	4.5	3.8	5.0
4	E	3.1	4.5	3.8	3.4
	M	3.5	4.5	3.2	3.3
	W	3.9	4.5	3.7	4.2
5	M	3.5	3.8	3.0	3.0
6	M	3.5	4.1	3.0	3.2
	W	3.2	4.3	2.9	3.1
7	E	3.3	4.2	3.2	3.1
	M	4.1	4.2	3.2	3.3
	W	3.7	5.0	3.1	3.2
8	E	3.3	3.7	2.9	3.8
	M	3.3	3.1	2.7	3.8
	W	3.1	3.5	2.9	4.1
9	E	3.5	3.0	3.0	3.7
	M	3.7	2.0	3.3	3.7
Average		3.4	4.0	3.4	3.7

Table 7: Seasonal changes of Wetland Zooplankton Index (WZI) scores at Khor Wadi Abyad.

Site	Winter	Spring	Summer	Autumn
1	3.9	3.8	3.9	-
2	3.8	3.8	4.3	-
3	3.5	5.0	3.5	3.8
4	3.9	5.0	3.7	3.5
5	4.5	4.9	3.6	3.8
6	3.9	4.6	4.1	3.5
Average	3.9	4.5	3.8	3.6

Table 8: Seasonal changes of Wetland Zooplankton Index (WZI) scores at Khor Tushka.

Site	Winter	Spring	Summer	Autumn
1	3.5	4.3	3.4	3.9
2	3.5	4.3	3.1	3.7
3	3.9	5.0	3.2	4.1
4	4.3	5.0	2.6	3.6
5	4.1	3.0	2.8	3.8
6	4.2	3.9	3.3	3.5
Average	3.9	4.3	3.1	3.7

3.5. Saprobity Index

Saprobity index average values were 2.11, 1.58 and 1.68 in winter, summer and autumn respectively, which means that the lake belong to class III water quality (moderate). The lowest value of index 1.52 was noticed in spring, so the lake water belongs to class II (good). In winter saprobity index sharply dropped at the western of site 2 and the western of site 1 (Fig.7). Regarding to saprobity index scores, the water quality of Khor Wadi Abyad belonging to moderate quality except in summer where a gradual improvement of water quality towards class II (good) as shown in figure 8. Saprobiological analysis showed that Khor Tushka had class III water quality with average score 1.75 during the study period (Fig. 9)

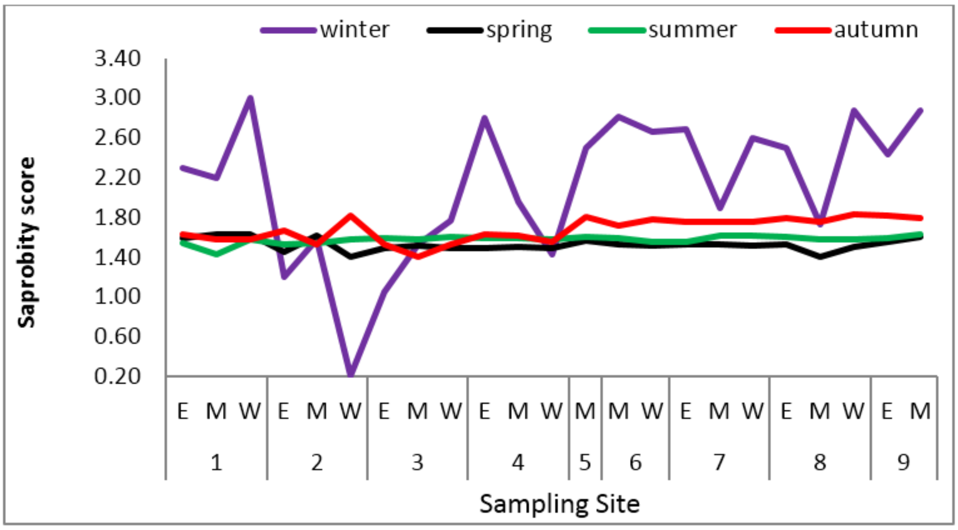

Fig 7: Seasonal changes of saprobity index scores at scores at main channel of Lake Nasser.

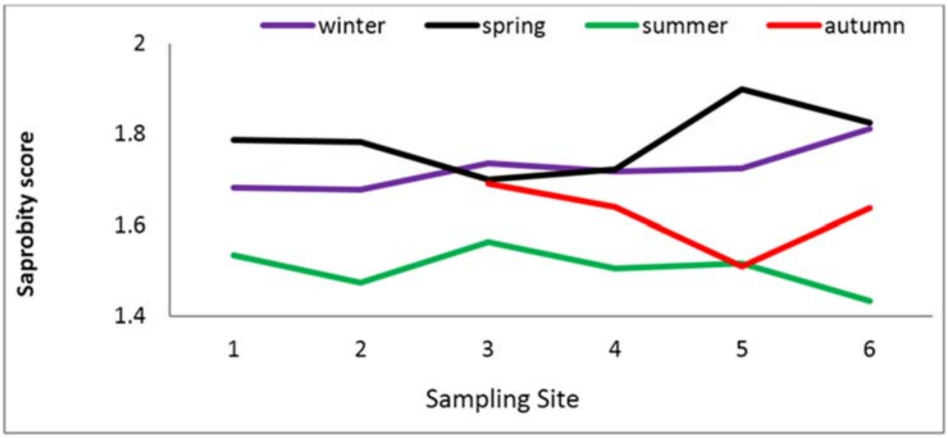

Fig 8: Seasonal changes of saprobity index scores at different sites of Khor Wadi Abyad.

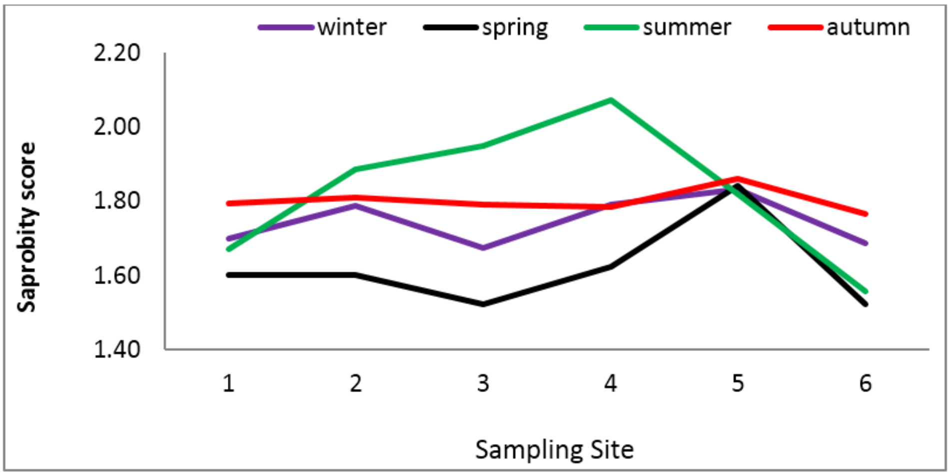

Fig 9: Seasonal changes of saprobity index scores at different sites of Khor Tushka.

4. Discussion

Zooplankton can be used as bioindicator of pollution and all environmental variations due to their quickly response to environmental changes and most species have short generation times (usually days to weeks). The variations of their spatial distribution based on different physical factors [23-25].In the present study, zooplankton community is composed of four main groups; Copepoda, Cladocera, Rotifera and Protozoa. These results are supported by the hypothesis that fresh water zooplankton comprise principally rotifers, cladocerans, copepods and protozoans [26, 27]. Copepod was the dominant group during this study and its nauplius was the abundant form in the three localities. The dominance of Copepods in Lake Nasser is due to the abundance of nauplius larvae which mainly feed on phytoplankton [28, 29].

The present chemical data according to chemical saprobity scores showed that, the water quality of Lake Nasser was fluctuated between moderate and good and reaching its best in summer at main channel while autumn season recorded the best water quality at the two Khors. The physico-chemical parameters of Lake Nasser were within safe limits for drinking and aquatic life survival [29].The drop in Lake Nasser water levels led to a decline in the water quality of the Lake and Khors from the order of good to medium [30].

The richness commonly index varies between 1 and 5, and larger the index indicates a more healthy body of water [21]. In the present study richness index values indicated that, Lake Nasser had water quality less than moderate and may be polluted at some sites and times as the highest value reached only 1.72 during the study period. These results didn't reflect the actual ecological status of the lake, where the chemical analysis in the present study and previous studies [30-33] , which confirmed that Lake Nasser has good or moderate water and it unpolluted in general. The results of richness index are confirmed by insignificant relation ($p > 0.05$) between different chemical parameters at the three studied localities. The unreasonable results of richness index with the community of zooplankton of Lake Nasser may be due to this index was applied in area different in nature as Santragachi Jheel which is one of the most important urban wetland of the District Howrah, W.B., India and has received various sewage waters from the nearby localities of the Howrah Township. Also, the abundance of rotifers compared to other groups in Santragachi Jheel, while copepods showed a numerical superiority over other groups of zooplankton in the present study. Wetland Zooplankton Index (WZI) designed to assess water quality of great lakes in North America [14]. The Water Quality Index (WQI) had insignificant linear relationship with WZI and unable to discern the pristine nature of wetlands in Georgian Bay, Lake Huron, where there is minimal human disturbance [34]. In the present study WZI scores revealed that, water quality of the three studied localities was increased in spring (good water) followed by winter, while it was moderate in summer and autumn when water level is high (pre-flood and flood seasons). These results reflect to some extend the actual ecological status of the lake which fluctuated between moderate and good water, However, WZI only showed significant relation with PO_4 in main channel ($p \leq 0.05$, $r^2 = 0.826$), NH_3 and PO_4 in Khor Tushka ($p \leq 0.05$, $r^2 = 0.410$ and 0.519), while WZI didn't showed relations with physicochemical parameters in Wadi Abyad. This variance may be due to the difference of dominated zooplankton indicator species, the difference of depth, vegetation, light penetration, nature of bottom, food items and predators of each locality. The index calculation may be lead to incorrect results when the dominant species are not included in it [35]. Also the regression results means that, WZI not accurate to assess water quality of the Lake especially Khor Wadi Abyad, although it give primary good indication according to chemical analysis of water at the three localities. Saprobiological analysis showed that, the main channel of Lake Nasser had the best water quality (good water) in spring while Wadi Abyad contained good water in summer, and Khor Tushka had class III (moderate) water quality during the study period. In general, the water in Lake Nasser not less than moderate quality according to saprobity index values. These results may be reflecting the actual ecological status of the lake, which coincided with the study, mentioned that, the various environmental parameters in different seasons and regions in Lake Nasser lie within the permissible range and it is a good quality for drinking, irrigation and fish culture purposes [33]. The regression analysis between saprobity index and chemical parameters appeared significant relation with NO_2, NH_3 in main channel ($p \leq 0.01$, $r^2 = 0.691$ and 0.892), NO_2 in Wadi Abyad ($p \leq 0.01$, $r^2 = 0.816$) and NH_3, PO_4 in Tushka ($p \leq 0.01$, $r^2 = 0.570$ and 0.711). Also, the regression results revealed that, saprobity index gave a primary good indication to water quality of the Lake but it is not accurate result; however it was better than WZI and richness index.

5. Conclusions

This study concludes that, Wetland Zooplankton Index and saprobity index somewhat give a good indication to assess water quality of Lake Nasser and there are some developments are needed according to the nature of the lake and their dominant zooplankton indicator species.

6. Acknowledgments

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7. References

1. Prygiel J, Coste M. The assessment of water quality in the Artois-Picardie water basin (France) by the use of diatom indices. Hydrobiologia 1993; 269(270)343-349.
2. Van Dam H, Mertens A, Sinkeldam J. A coded checklist and ecological indicator values of freshwater diatoms from The Netherlands. Netherlands Journal of Aquatic Ecology 1994; 28:117-133.
3. Minns CK, Cairns VW, Randall RG, Moore JE. An index of biotic integrity (IBI) for fish assemblages in the littoral zone of Great Lakes' Areas of Concern. Canadian Journal of Fisheries and Aquatic Sciences 1994; 51:1804–1822.
4. Lenat, DR. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water-quality ratings. Journal of North American Benthological Society 1993; 12:279–290.
5. Burton TM, Uzarski DG, Gathman JP, Genet JA, Keas BE, Stricker CA. Development of a preliminary invertebrate index of biotic integrity for Lake Huron coastal wetlands. Wetlands 1999; 19:869–882.
6. Kelly, MG, and Whitton BA. The trophic diatom index: a new index for monitoring eutrophication in rivers. Journal of Applied Phycology 1995; 7:433–444.
7. McCormick PV, Stevenson RJ. Periphyton as a tool for ecological assessment and management in the Florida Everglades. Journal of Phycology 1998; 34:726–733.
8. Schindler DW. Detecting ecosystem responses to anthropogenic stress. Canadian Journal of Fisheries and Aquatic Sciences 1987; 44 (1):6–25.
9. Gannon JE, Sternberger RS. Zooplankton (especially crustaceans and rotifers) as indicators of water quality. Transactions of the American Microscopical Society 1978; 97(1):16- 35.
10. Ortendorfer JL, Hofrat W. Wasser und Abwasser. Beiträge zur Gewasserforschung XII 1983, Band 26, Wien.
11. Sládeček V. System of water quality from the biological point of view. Arch. Biol. Beih. Ergeb. Limnol 1973; 7:1-218.
12. Dulić Z, Tutundžić V, Marković Z, Živić I. Monitoring water quality using zooplankton organisms as bioindicators at the dubica fish farm, Serbia. Arch. Biol. Sci., Belgrade 2006; 58 (4):245-248.
13. Dulić Z, Poleksic V, Raškovic B, Lakic N, Markovic Z, Živic I *et al.* Assessment of the water quality of aquatic resources using biological methods. Desalination and Water Treatment 2009; 11:264–274.
14. Lougheed VL, Chow-Fraser P. Development and use of a

zooplankton index of wetland quality in the Laurentian Great Lakes basin. Ecological Applications 2002; 12(2):474–486.
15. Fishar M R, Williams WP. The development of a Biotic Pollution Index for the River Nile in Egypt. Hydrobiologia 2008; 598:17–34.
16. Belal DMH. Epipelic diatoms as a tool for monitoring pollution in River Nile from Aswan to Cairo. M. Sc. Thesis. Fac. Sci. Zagazig Univ., Egypt, 2012, 109.
17. 17. El-Shabrawy GM. Lake Nasser–Nubia. In The Nile: Origin, environments, limnology and human use, H.J. Dumont (ed.) Springer Science + Business Media, 2009, 125 -156.
18. Entz, BAG. Morphometery of Lake Nasser. Project R.P.H, UNDP SF. FAO, 1973.
19. American Public Health Association (APHA). Standard methods of the examination of water and waste water. 19th Ed. New York, AWWA, WEF, 1995, 1015.
20. Margalef R. Information theory in Ecology. Gen. Syst 1958; 3:36-71.
21. Patra A, Santra KB, Manna C K. Ecology and diversity of zooplankton in relation to physico-chemical characteristics of water of Santragachi Jheel, West Bengal, Indian. Journal of Wet Ecology 2011; 5:20-39.
22. Zelinka M, Marvan P. Zur Prazisierung der biologischen Klassifikation des Reinheit fliessender Gewässer. Archive für Hydrobiologia 1961; 57:389–407.
23. Breitburg D L, Loher T, Pacey CA, Gerstein A. Varying Effects of Low Dissolved Oxygen on Trophic Interactions in an Estuarine Food Web. Ecologica Monographs 1997; 67(4):489-507.
24. Boesch DF, Brinsfield RB, Magnien R E. Chesapeake BayEutrophication: Scientific Understanding, Ecosystem Restoration, and Challenges for Agriculture Journal of Environment Qualit 2001; 30:303-320.
25. Epifanio CE, Garvine RW. Larval Transport on the Atlantic Continental Shelf of North America: a Review. Estuarine, Coastal and Shelf Science 2001; 52: 51-77.
26. Khalifa N. Study on the impact of industrial wastes at Helwan on River Nile zooplankton. Ph.D. Thesis. Zoo. Dept. Fac. Sci. Cairo Univ, 2000, 141.
27. Hegab M H. Effect of some environmental parameters on distribution of zooplankton and the relationship between them and food & feeding of some fish in Rosetta Branch of River Nile- Egypt. M. sci. Thesis, Fac. Sci., Al-Azhar Univ., Cairo, 2010, 243.
28. Iskaros IA, Bishai RM, Mokhtar FM. Comparative study on zooplankton in Aswan reservoir and River Nile at Aswan, Egypt. Egyptian Journal of Aquatic Research 2008; 34(2):260–284.
29. El-Enany HR. Ecological studies on planktonic and epiphytic microinvertebrates in Lake Nasser, Egypt. Ph. D. Thesis, Zool. Dept., Fac. Sci. Banha Univ., 2009, 311.
30. Heikal MT. Impact of Water Level Fluctuation on Water Quality and Trophic State of Lake Nasser and its Khors, Egypt. Egyptian Journal of Aquatic Biology & Fish 2010; 14 (1):75-86.
31. Sherief MK, Awadallah RM, Gross F. Trace elements in water samples from Lake Nasser Lake Nubia. Journal of Radioanalytical Chemistry 1980; 60(1):267-272.
32. Gharib S M, Abdel-Halim AM. Spatial variation of phytoplankton and some physico-chemical variables during the highest flood season in Lake Nasser (Egypt). Egyptian Journal of Aquatic Research 2006; 32(1):246-263.
33. Toufeek MA F, Korium MA. Physicochemical Characteristics of Water Quality in Lake Nasser Water. Global Journal of Environmental Research 2009; 3(3):141-148.
34. Seilheimer TS, Mahoney TP, Chow-Fraser. Comparative study of ecological indices for assessing human-induced disturbance in coastal wetlands of the Laurentian Great Lakes. Ecological Indicators 2009; 9:81–91.
35. Prygiel J, Coste M. “Progress in the use of diatoms for monitoring rivers in France”, In Prygiel, J., B. A. Whitton & J. Bakowska (eds). Use of Algee for Monitoring Rivers III. Douai, Agence de l’Eau Artois-Picardie, 1999, 165 – 179.