INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCE AND ENGINEERING (IJESE)
Vol. 1: 15-25
http://www.pvamu.edu/texged Prairie View A&M University, Texas, USA

Impact of Pollution on Invertebrates Biodiversity in the River Nile Associated With Dahab and El-Warrak Islands, Egypt.

Setaita H. Sleem and Montaser M. Hassan.
Zoology Department, Faculty of Science, Ain Shams University, Cairo, Egypt.

ARTICLE INFO

Article History
Received : Sept. 30, 2101
Accepted: Nov. 20, 2010
Available online: Jan., 2010

Keywords
Zooplankton
Benthos
River Nile
Biodiversity
Dahab and
El-Warrak islands

ABSTRACT

Dahab and El-Warrak are among 144 islands along the River Nile in Egypt declared as protected areas in 1998. Some parts of these islands are populated and many human activities are conducted, but other parts are still wild. The present study investigated the invertebrates biodiversity in two populated Nile islands namely Dahab and El-Warrak near Cairo. It indicated that the common water habitats of the populated parts of these islands are polluted compared to the unpopulated areas. Rotifer density increased in the highly populated stations as an indicator of organic pollution. The species diversity of both zooplankton and macrobenthos were studied and revealed that they slightly increased in unpopulated segments of the islands and decreased with increase of pollutants and loss of sensitive species infront of populated parts of both islands.

1. INTRODUCTION

Some 144 islands are scattered along the River Nile in Egypt and declared as Protected Area in 1998. Dahab and El-Warrak are two important sites of biodiversity and wilderness located around Cairo, Egypt. The latter is regarded as one of the most populated part of the River Nile. A dense fringe of swamp vegetation, mainly of *Phragmites* and *Typha*, surrounds most islands. Here abundant bird life, amphibians, fish and invertebrates can be found. Shallow mudflats and sandy shores often attract the largest numbers of wading birds and waterbirds. The islands and the associated habitats of the River represent one of the most important wintering grounds for waterbirds in Egypt today. They provide a vestige of what the wilderness of the River Nile, which ancient egyptians enjoyed, must have looked like. The islands are formed by alluvial deposits of the river and change their shape and size readily according to water level, erosion and deposition regimes of the River. Bare sandy or muddy banks come into existence seasonally depending on water level, which is lowest in winter. Many of these islands are inhabited and cultivated, but also natural vegetation still remains.

Zoology Department, Faculty of Science, Ain Shams University, Cairo, Egypt
ISSN 2156-7549
2156-7530

This article is a part of an environmental study on River Nile islands, supported by an environmental project from Ain Shams University, 2007-2008.

The importance of zooplankton and macrobenthic components in the trophic dynamics of freshwater ecosystems has long been recognized. These organisms, not only regulate the aquatic productivity by occupying intermediate position in the food chain, but also by indicating environmental status in a given time (Xie *et al.*, 2008). In addition, their diversity has assumed added importance during recent years due to the ability of certain species to indicate the deterioration in the water quality caused by pollution and eutrophication (Khan, 2003; Hassan, 2008). Zooplankton organisms contribute significantly to the recycling of nutrients and provide a food base for predatory invertebrates and vertebrates (Sautour and Castel, 1997; Bedir, 2004).

Accordingly, the disruption of the food chain in the ecosystem due to the degradation and loss of diversity, led to decrease of the number of fish at the top of the food web. Boulenger (1907) mentioned that Loat in his survey during 1899-1902, recorded 85 fish species inhabiting egyptian Nile waters, but Bishai and Khalil (1997) reported only 71 fish species; 22 species are common in the catch, while 49 are rare. Fishar *et al.* (2003) and Fishar & Williams (2006) showed that the River Nile from Aswan to Cairo shows evidence of reduced taxa richness and there are severe polluted points from industrial sources and from sewage drains and from human impacts at large cities.

Dahab and El-Warrak are highly populated and many human activities are conducted over there and a huge amount of sewage and drainage waters are discharged in the River affecting many aquatic organisms.

Therefore, the objective of this study is to reveal the impact of human activities in populated parts of Dahab and El-Warrak islands on the invertebrates biodiversity of the associated water habitats of the River Nile as compared to unpopulated parts.

2. MATERIALS AND METHODS

2.1. Sites of the Study

The present study dealt with two islands in the River Nile namely; Dahab and El-Warak at the Greater Cairo. In each island, two sites were selected, one represents the impact of human activities, while the other is not impacted by human activities (Fig. 1). These sites are supposed to represent different habitats of the Nile islands as indicated in Table (1).

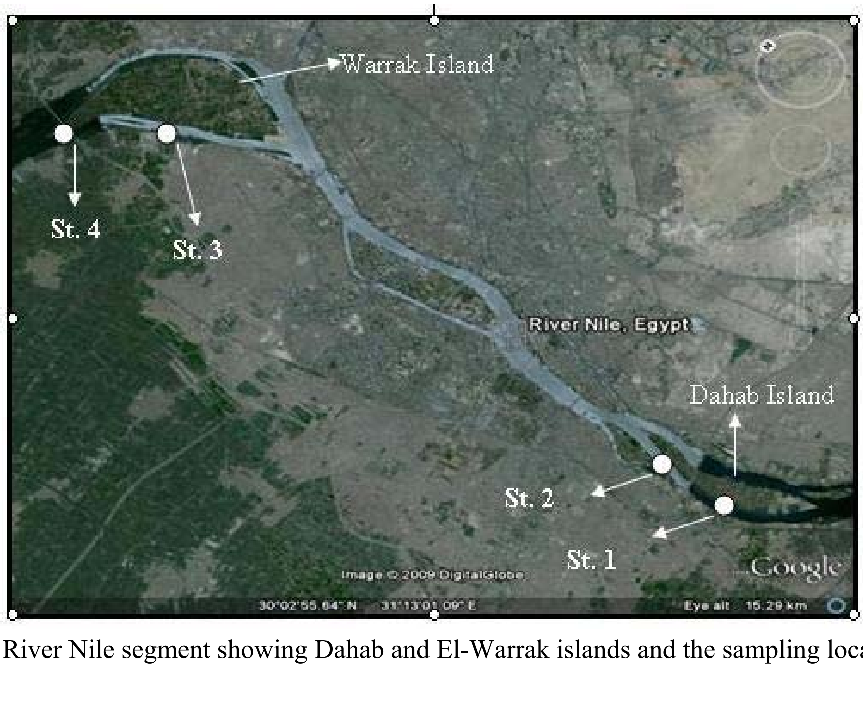

Fig.1: A map of a River Nile segment showing Dahab and El-Warrak islands and the sampling locations.

Table 1: The selected sites and their position in the River Nile during 2008.

St.	Name	Description	N	E
1	South Dahab Island	Unpopulated	7″ 30′ 29 º	56″ 47′ 31 º
2	North Dahab Island	Populated	13″ 19 3 º	6″ 87 31 º
3	South El-Warrak Island	Populated	20″ 47′ 30 º	30″ 54′ 31 º
4	North El-Warrak Island	Unpopulated	58″ 2′ 30 º	8″ 84′ 31 º

2.2. Samples Collection and Sampling Program

Samples were collected seasonally during 2008. Water samples were collected for measuring the ecological variables such as pH, salinity,…..etc. Zooplankton samples were collected from 50 liters of water using 55 µm mesh size plankton net. Samples were preserved in 5% neutral formaldehyde solution. Each sample was shaked well and then the content was poured into a standard 100 ml total volume cup after washing of the bottle with pure distilled water. One milliliter was dropped in a plastic counting grade with 2 mm sides height and then completed with pure distilled water for counting, using Carl Zeiss binocular stereomicroscope. This process was repeated three times. Zooplankton species were identified according to Koste (1978), Shiel and Koste (1992) and Smirnov (1996).

Macrobenthos samples were collected using Ekman grab sampler; its opening area is 225 cm^2. Three grabs samples were taken from each station from the upper layer of the bottom sediments. The sample was immediately washed to remove any adhering sediments or mud and sieved through 500 µm mesh diameter net and stored in polyethylene jars carrying the relevant date and mixed with 10% neutral formaldehyde solution. In the laboratory, the samples were washed and sieved again through 0.5 mm mesh diameter net. Benthic animals were sorted to their genera or species using a zoom stereo microscope. Each group was counted and weightd after putting them on filter paper for five minutes to remove excess water adhering to their bodies. Every species was kept in a glass bottle with 7% formalin for identification. The biomass of animals was expressed in gram fresh weight per square meter (GFW/m^2). All molluscan species have been weighed with shell. Additional animals samples were collected from macrophytes for detecting benthic species associated with them. Identification of the collected species were done according to Brinkhurst (1971), Ibrahim *et al.* (1999) and Ramadan *et al.* (2000).

2.3. Data treatment

Taxa similarity of zooplankton and bottom fauna was calculated between seasons and stations. Sorenson's index of similarity was used according to Wallwork (1976) as quantitative and used on presence or absence of species or taxa by the following equation

$$C_s = \frac{2W}{A+B}$$

Where C_s is the similarity coefficient, A + B is the sum of the quantitative measure of the two seasons or stations densities, and W is the sum of the shared (lesser) values of the two seasons or two sites.

Species diversity of zooplankton and bottom fauna was calculated and evaluated to assess the impact of pollution on the degradation of species diversity, food chains and eventually the ecosystem using a computer soft wear namely Primer 5 version 5.2.0. Primer-E Ltd (2001) licensed to academic single user.

3. RESULTS

3.1. Zooplankton Community Structure

Zooplankton standing crop in the studied area was comprised of five groups namely; Rotifera (101028.3 org/m^3), Cladocera (2137.67 org/m^3) Copepoda (1427.5 org/m^3), Protozoa (36833.3 org/m^3), and meroplankton (375 org/m^3) (Table 2). Rotifera was the most dominant group. It was represented by 71 % of the total zooplankton density followed by Protozoa 26 % (Fig. 2). *Keratella cochlearis* was the most dominant species (59045.83 org/m^3) followed by *Anuraeopsis fissa* (22666.67 org/m^3) *Brachionus calyciflorus* (6104.1 org/m^3) and *Keratella vulga* (3763.3 org/m^3).

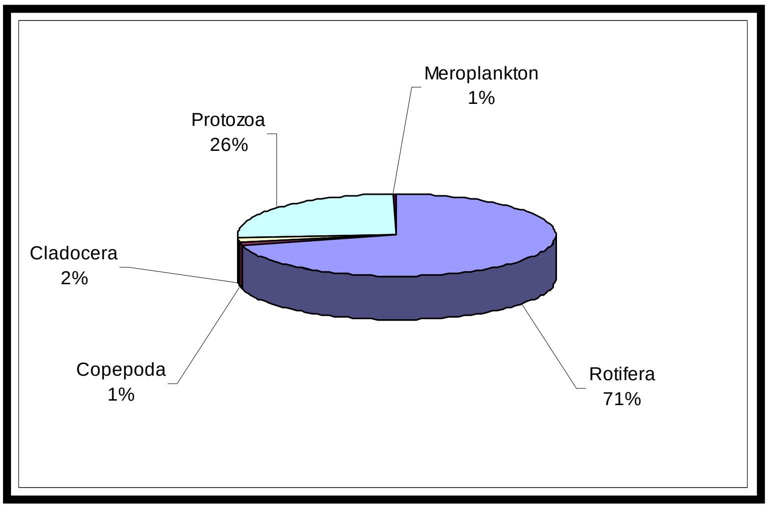

Fig. 2: Percentage of the population density of zooplankton groups in the studied area.

As shown in Table (2), zooplankton density increased from station 1 to station 3 and then slightly decreased in station 4. Station 3 recorded the highest total zooplankton density. The maximum rotifer density was found in station 3 followed by 4 however, the lowest density was in station 1.

Table 2: The population densities (org/m^3) of the different zooplankton groups in the four stations.

	1	2	3	4	Average
Protozoa	32667	23667	35667	55333	36833
Rotifera	66657	86950	144853	105653	101028
Copepoda	663	1887	1023	2137	1428
Cladocera	1747	2300	2250	2250	2137
Meroplankton	833	167	0	500	375
Total	102567	114970	183793	165873	141801

Table 3: The population densities (org/m^3) of the different zooplankton groups in the three seasons.

	Winter	Summer	Autumn	Average
Protozoa	109500	1000	0	36833
Rotifera	180172	47500	75412	101028
Copepoda	1915	992	1375	1428
Cladocera	3705	455	2250	2137
Meroplankton	250	0	875	375
Total	295542	49947	79912	141801

Winter season showed the highest density of Rotifera, Copepoda, Cladocera, and Protozoa (Table 3). Accordingly, zooplankton standing crop recorded the highest density during winter followed by autumn, while the minimum value was reported during summer.

3.2. Macrobenthos community structure:

Macrobenthic invertebrates in the present study were represented by three groups; Mollusca, Annelida and Arthropoda respectively, according to the population density and biomass (Figs. 3 and 4).

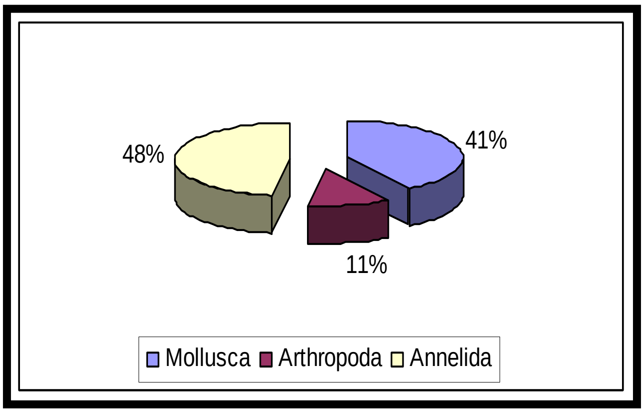

Fig. 3: The percentage of population density of macrobenthic fauna in the studied area.

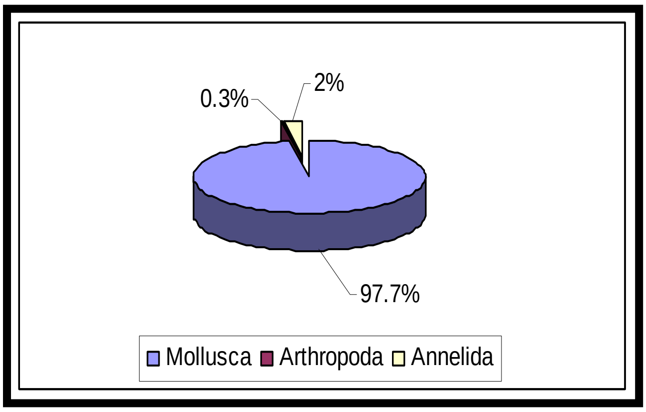

Fig 4: The percentage of biomass of macrobenthic fauna in the studied area.

The maximum population density was recorded in station 2 followed by station 4 (Table 4). The minimum population density was found in stations 1. The population densities of molluscs and arthropods reported the maximum values in station 2, however the minimum values were recorded in station 1.

Table 4: The biomass and population densities of the benthic invertebrate groups in the four stations.

	St1		St2		St3		St4		Average	
	BM	**PD**	**BM**	**PD**	**BM**	**PD**	**BM**	**PD**	**BM**	**PD**
Mollusca	24	107	1951	3993	620	847	2088	1612	1171	1640
Arthropoda	1	133	8	995	4	509	1	187	3	456
Annelida	15	1447	30	1344	15	955	59	3860	30	1901
Total	40	1687	1989	6332	639	2311	2147	5659	1204	3997

The population density of macrobenthos during the present study was low. The maximum population density was found during autumn followed by summer; however the minimum was during winter. The maximum molluscan density was during autumn but the minimum was in summer (Table 5).

Macrobenthos biomass is an important factor; the maximum biomass was recorded in autumn, but the minimum was during summer. Furthermore, the biomass of both mollusca and arthropods showed the maximum biomass in autumn and the minimum values during summer (Table 5).

Table 5: The biomass and population densities of the benthic invertebrate groups in the three seasons. The biomass is expressed as GFW/m^2 and density is expressed as org/m^2.

	Winter		Summer		Autumn		Average	
	BM	**Den**	**BM**	**Den**	**BM**	**Den**	**BM**	**Den**
Mollusca	84.7	310	45.425	280	3382.17	4329	1171	1640
Arthropoda	2.5875	345	0.3025	135	6.66	888	3	456
Annelida	0.305	140	0.3	680	88.8	4884	30	1901
Total	87.5925	795	46.0275	1095	3477.63	10101	1204	3997

3.3. Species Diversity:

3.3.1. Zooplankton:

Station 3 is one of the aquatic associated habitats of the populated areas of El-Warrak island; it displayed the highest number of zooplankton density and the lowest species number and species richness (Table 6). On the other hand, station 2 showed the highest number of species, Shannon Weaver (H`) and Brillouin indices of diversity. The species number of rotifers increased from 16 (in station 1) to 20 (Table 7) also the species richness and diversity indices increase. However, in site 4 some sensitive species started to increase and rotifer species started to decrease (Table 7).

Table 6: Species diversity of zooplankton in different stations during the period of the study.

	Sp. no.	Density	Rich.	Even.	Brillouin	H'(loge)
St1	24	102566	2.0	0.5	1.6	1.6
St2	29	114972	2.4	0.5	1.8	1.8
St3	23	183793	1.8	0.5	1.7	1.7
St4	26	165874	2.1	0.5	1.7	1.7

Table 7: Species number of different zooplankton groups in the four stations.

	Rot.	Cop.	Clad.	Prot.	Mero.	Total
St.1	16	3	3	1	1	24
St.2	20	3	4	1	1	29
St.3	18	2	2	1	0	23
St.4	18	3	3	1	1	26

Similarity indices and the dendrogram of the four sites using zooplankton data indicated that stations 1and 2 showed high similarity values to each other, and sites 3 and 4 too (Table 8; Fig. 5).

Table 8: Similarity matrix between different stations in zooplankton data.

	St1	St2	St3	St4
St1	0.0	0.0	0.0	0.0
St2	94.3	0.0	0.0	0.0
St3	71.6	77.0	0.0	0.0
St4	76.4	81.9	94.9	0.0

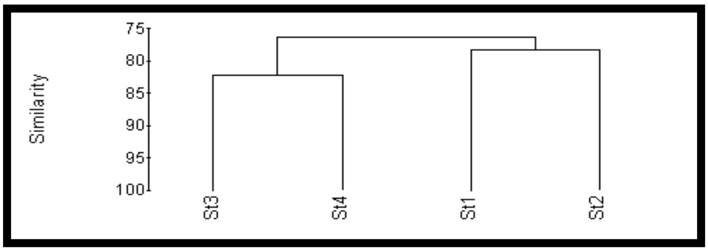

Fig.5: Dendrogram showing the similarity distance among the four sites in zooplankton data during the period of the study.

3.3.2.Macrobenthos:

Species number (S) and diversity indices of station 2 recorded the highest value among the other three stations (Table 9). On contrary, station 3 has the lowest species number and diversity indices. This is clear in Table (10) where species numbers of different benthos groups increased from station 1 to station 2 and decreased from station 2 to station 3.

Table 9: Species diversity of macrobenthos in different stations during the period of the study.

	S	N	Rich.	Even.	Brillouin	H'(log e)
St1	8	1686	0.94	0.32	0.66	0.67
St2	12	6331	1.26	0.65	1.61	1.61
St3	7	2310	0.77	0.74	1.43	1.44
St4	9	5659	0.93	0.46	1.02	1.02

Table 10: Species number of macrobenthos groups in the four stations during 2008.

	Molu.	Arth.	Ann.	Total
St.1	4	3	1	8
St.2	5	4	3	12
St.3	5	1	1	7
St.4	5	2	2	9
Average	5	3	2	9

Macrobenthic fauna is considered a good indicator for the biological and environmental status of the aquatic ecosystem. The similarity matrix (Table 11) and the dendrogram showed that stations 1 and 4 are more or less matched in benthic fauna and consequently in their properties, however stations 2 and 3 are approximated to each other in their structure.

Table 11: Similarity matrix between stations in macrobenthos data.

	St1	St2	St3	St4
St1	0.0	0.0	0.0	0.0
St2	44.2	0.0	0.0	0.0
St3	55.7	63.7	0.0	0.0
St4	49.3	49.7	465	0.0

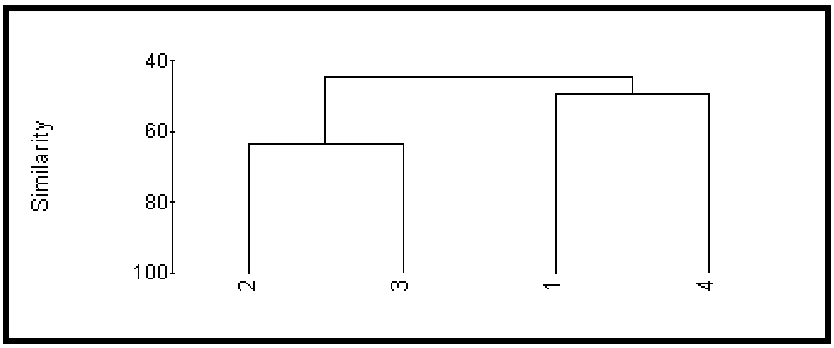

Fig. 6: Dendrogram showing the similarity distance among the four sites in macrobenthos data during the period of the study.

Table 12: Water characteristics of the different stations in Dahab and El-Warrak islands during 2008.

	1	2	3	4
Temp (°C)	20.45	20.6	21.4	21.15
EC (µS/cm)	349.5	377.5	368.5	356.5
TDS (mg/l)	184.5	179.5	180	173.5
pH	8.565	8.555	8.36	8.485
DO (mg/l)	7.9	8	8.75	8.9
BOD (mg/l)	4.75	5	6.95	6.15
COD (mg/l)	9.2	8.9	7.3	5.5
CO3 (mg/l)	0	0	0	0
HCO3 (mg/l)	130.5	140	134.5	129
Cl (mg/l)	29.75	31.9	30.75	25.45
SO4 (mg/l)	27.75	34.05	35.45	27.35
Ca (mg/l)	18.8	20.9	20.8	17.25
Mg (mg/l)	24.3	25.9	25.7	21.05
Na (mg/l)	19.8	23.25	30.8	28.9
K (mg/l)	7.9	7.95	10.8	10.3
NO2 (µg/l)	11	12.5	15.5	16.5
NO3 (µg/l)	69	66.5	150	134
NH3 (µg/l)	390	472.5	472.5	387
P04 (µg/l)	119	131	143.5	126.5
TP (µg/l)	361	419.5	421	367.5

After Khalil *et al.* (2008).

4. DISCUSSION

It is well documented that zooplankton density is one of the most important indicators in the aquatic ecosystems (El-Shabrawy and Khalifa, 2002 and Hassan, 2008). The previous authors concluded that zooplankton occupies a central position in the food web as they provide a food base for predatory invertebrates and vertebrates. In addition, these microorganisms help in nutrient recycling and accordingly they could reflect the status of the water quality.

The present study revealed that Rotifera and Protozoa respectively were the most dominant among the five groups comprising the zooplankton community in the studied area. These results agreed with those reported by Ramadan *et al.* (1998) and Khalifa (2000) who studied the Nile zooplankton at Helwan and reported that rotifers formed 85.3 % of the total zooplankton, followed by Protozoa. Mageed (2001) obtained similar results for the dominance of *Brachionus* and *keratella* over the rotifers. Furthermore, El-Shabrawy and Khalifa (2002) and Hassan (2008) indicated that increase or dominance of certain types of rotifers such as *Brachionus* and *keratella* is indicator for organic pollution. Additionally, Protozoa density and diversity increased as organic pollutants, such as nitrates and phosphates increased (Galal, 1999). This supported the increased species number of rotifers in the present study from 16 species to 20 (in station 1) and increased diversity indices in station 2 which is a human impacted area. This explains the increase in species richness and diversity indices. This may be due to the dilution effect caused by the clean water coming from station 1 that slightly enhances the water quality in station 2, allowing more organisms to grow and diverse. On the contrary, the decreased diversity indices in station 3 could be due to its polluted water and the water coming from station 2 impairs the water quality of station 3, decreasing the species diversity. Similar results were obtained by Ostfield and LoGiuice (2003) and Hassan (2008).

Similarity of stations (1, 2) and (3, 4) using zooplankton data in this work may be due to water movement that occurs in this direction and the mobility of zooplankton. On the other side, the dendrogram of similarity of stations using macrobenthos data revealed that stations 1 and 4 are similar, while stations 2 and 3 are similar. This may be due to the fact that, the bottom is the place where sedimentation of pollutants takes place. Similar results were reported by Ramadan *et al.* (2000).

The obtained results of seasonal variation in zooplankton density was supported by Ramadan *et al.* (1998) and El-Shabrawy and Khalifa (2002), where they found that zooplankton in Rosetta Nile branch reached its maximum density during winter and the minimum was during summer. They explained that zooplankton composition in rivers is quite different from that in lakes; since in rivers, zooplankton is dominated by rotifers with relatively few Cladocera and Copepoda and vise versa in lakes.

In the present investigation, zooplankton diversity was the minimum value in station 3 because it is already impacted by organic pollution (Table 12) (Khalil *et al.,* 2008) and it's also affected by the pollutants coming from station 3. These results were supported by Odum (1997), Abdel-Aziz and Dorgham (2002), Rakocevic-Nedovic and Hollert (2005) who stated that species diversity tends to be low in areas subjected to physico-chemical stresses. Additionally, Martin *et al.* (2000) found that anthropogenic activities strongly affect species diversity.

Benthic organisms provide indirect benefits to society as ecological stabilizers and through benthic-pelagic coupling, which contributes to sustained ecosystem services (McArthur *et al.,* 2010). There were only five molluscan species recorded in the studied area. This could be attributed to the pollution of this water and sediment. Sabae (1999) stated that Nile water is threatened by pollution through 37 main drains discharging municipal, agricultural and industrial wastes. Ramadan *et al.* (2002) reported that benthic meiofauna in the River Nile at Helwan region is very poor, and attributed the decline in its density to the impact of pollution. Additionally, El-Shimy and Obuid-Allah (1992) conducted a survey study on the freshwater invertebrates in the River Nile and found 15 molluscan species. Furthermore, Ramadan *et al.* (2000) reported 20 molluscan species in the River Nile between Esna and Delta Barrage. The present study showed that benthic arthropods are highly influenced by the accumulated pollution. The average species number in the present investigation was three; however the lowest number was recorded in station 3 which is considered as polluted area. Table (12) indicated that this station is more polluted due to the water current which carries the pollutants from station 2 to station 3. Furthermore, sediment is considered as a sink for all water pollutants (Hassan, 2008). Annelida is an important benthic group inhabiting River Nile. Fishar *et al.* (2003) recorded three species; and stated that annelids especially oligochaetes display the greatest diversity and have the greatest indicator value. In this investigation, the average species number was 2 and only one species was recorded in station 3. This may indicate the impact of human activities on the biodiversity of living organisms.

Biodiversity provides important functions to the aquatic ecosystem due to the function done by different species in the community. Therefore, the decreased species number in the studied habitats is considered as loss of biodiversity in polluted ecosystems that leads to loss of functional biodiversity. Ostfield and LoGiuice, (2003); Hassan, (2008); and Brandt and Ebbe, (2009) explained that loss of biodiversity leads to loss of ecosystem function which in turn leads to habitat destruction. This is attributed mainly to the uncontrolled growth of human population and activities (Maurer, 1996). Furthermore, Ramadan *et al.* (1998) and Hassan (2008) attributed the loss of biodiversity to the increased water pollution. McArthur *et al.* (2010) stated that benthic environments have been and will be impacted by human activities occurring over the last century. Benthic ecosystems have been negatively impacted by over-fishing, bottom trawling and dredging, pollution of water, aquaculture and introduced species and human induced climate change. The combination of these direct and indirect human impacts on the aquatic environment is inducing unprecedented changes in these ecosystems and further biodiversity losses are likely.

In conclusion, the present study revealed that the populated islands in the River Nile is one of the main reasons of increasing pollution and declining of biodiversity in this important ecosystem.

5. REFERENCES

Abdel-Aziz, N.E.M. and Dorgham, M.M. (2002). Response of copepods to variable environmental conditions in egyptian Mediterranean near shore water. Egypt. J. Aquat. Biol. and Fish., 6: 283-300.

Bedir, T.Z. (2004). Ecological Studies on Zooplankton and Macrobenthos of Lake Burullus. M. Sc., Ain Shams University, Cairo-Egypt.

Bishai, H.M. and Khalil, M.T. (1997). Feshwater fishes of Egypt. Publication of National Biodiversity Unit. EEAA, No. 9.

Boulenger, G.A. (1907). Zoology of Egypt. The fish of the Nile. Publ. for the egyptian government, Hugh Press, London.

Brandt, A. and Ebbe, B. (2009). Southern Oceandeep-sea biodiversity From patterns to processes. Deep-Sea Research, II (56): 1732-38.

Brinkhurst, R.O. (1971). A guide for the identificationof British aquatic Oligochaeta. Freshwater Biological Association, Scientific Publication number 22. 55pp.

El-Shabrawy, G.M. and Khalifa, N. (2002). Zooplankton abundance and community structure in the northern part and estuary of Rosetta Nile branch in relation to some environmental variables. Egypt. J. Aquat. Biol. and Fish., 6, 69-90.

El-Shimy, N.A. and Obuid-Allah, A. (1992). A survey of some freshwater invertebrates in the Nile at Assiut, Egypt. J. Egypt. Ger. Soc. Zool., 7: 363-376.

Fishar, M.R.A. and Williams, W.P. (2006). A feasibility study to monitor the macroinvertebrate diversity of the River Nile using three sampling methods. Hydrobiologia, 556: 137-147.

Fishar, M.R.A., Kamel, E.G., and Wissa, J.B. (2003). Effect of discharged water from Shoubra El-Khima electric power station into the River Nile (Egypt) on the aquatic annelids. J. Egypt. Acad. Environ. Develop., 4: 83-100.

Galal, M. (1999). Cilliate protozoans' diversity branch of the River Nile Between Kalubeya and Dakahleya provinces. Egypt. J. Aquat. Biol. and Fish., 3: 197-213.

Hassan, M.M. (2008). Ecological studies on zooplankton and macrobenthos of Lake Edku, Egypt. Ph D. thesis Ain Shams University, Faculty of Science, Zoology Dep., Cairo, Egypt.

Ibrahim, A.M., Bahnasawy, A.M., Mansy, M.H., and El-Fayomy, R.I. (1999). Distribution of heavy metals in the Damietta Nile estuary ecosystem. Egypt. J. Aquat. Biol. and Fish., 3: 369-397.

Khalifa, N. (2000) Astudy on the impact of industrial wastes at Helwan on River Nile zooplankton. Ph. D. Thesis, Fac. Sci. Zool. Dep., Cairo Univ.

Khalil, M.T., Fishar, M.R., El-Shabrawy, M.M. and Hassan, M.H. (2008). Environmental evaluation for some of the River Nile islands, and the impact of human activities on biodiversity of associated habitats of the river. Environmental project, Ain Shams University. 2007-2008.

Khan., R.A. (2003). Faunal Diversity of Zooplankton in Freshwater Wetlands of Southeastern West Bengal Zoological Survey. . In, pp. 107 p., plates,[Records of the Zoological Survey of India : Occasional Paper No. 204]. Kolkata of India.

Koste, W. (1978). Rotatoria die radertiere milleleuropas ein bestimmungswerk, . Begrundot Von Max Voigl., 1: 673-234.

Maurer, B.A. (1996). relating human population growth to the loss of biodiversity. Biodiversity Letters, 3(1): 1-5.

Martin, P., Haniffa, M.A. and Arunachalam, M. (2000). Abundance and diversity of macroinvertebrates and fish in the Tamiraparani River, South India. . Hydrobiologia, 430: 59-75.

McArthur, M.A., Brooke, B.P., Przeslawski, R., Ryan, D.A., Lucieer, V.L., Nichol, S., McCallum, A.W., Mellin, C., Cresswell, I.D. and Radke, L.C. (2010). On the use of abiotic surrogates to describe marine benthic biodiversity. Estuarine, Coastal and Shelf Science, in press, 1-12.

Ostfield, R.S. and LoGiuice, K. (2003). Biodiversity loss, and the erosion of an ecosystem service. Ecology, 84(6): 1421-27.

Odum, E.P. (1997). Ecology a bridge between science and society. Sinauer associates, Inc. Sunderland, Massachusetts, 01375 U.S.A.

Rakocevic-Nedovic, J. and Hollert, H. (2005). Phytoplankton community and chlorophyll a as trophic indices of Lake Skadar (Montenegro, Balkan). ESPR-Environ. sci and Pollut. Res., 12(3): 146-52.

Ramadan, S.E., El-Serehy, H.A., Farghaly, M.E., and El-Bassat, R.A. (1998). Zooplankton community in the Nile River, Egypt. Bull. Nat. Inst. of Oceanogr. and Fish., 24: 139-159.

Ramadan, S.E., Khirallah, A.M. and Abdel-Salam, K.M. (2000). Benthic communities in the Nile River, Egypt II-Mollusca. . Bull. Nat. Inst. of Oceanogr. and Fish., 26: 149-66.

Ramadan, S.E., Fishar, M.R., Hassan, S.H., Ebeid, A.A. and Gawad, S.S.A. (2002). Benthic community in the River Nile, Egypt III-Meiofauna at Helwan region.

Egypt. J. Aquat. Biol. and Fish., 6(1): 95-113.

Sabae, S.Z. (1999). Indicator bacteria for faecal pollution in the River Nile at Greater Cairo region. Egypt. J. Aquat. Biol. and Fish., 3: 85-94.

Sautour, B. and Castel, J. (1997). Importance of microzooplanktonic crustaceans in the costal food chain: Bay of Marennes-Oleron, France. Oceanologica Acta, 21: 105-112.

Shiel, R.J. and Koste, W. (1992). Rotifers from australian inland water. III: Trichocercidae. . Trans. R. Soc. Aust., 116: 1-37.

Smironov, N.N. (1996). Cladocera: the Chydorinae Anssayciinae (Chidoridae) of the world. , pp. 119pp. SPB Academic Publishing bv.

Wallwork, J.A. (1976). The distribution and diversity of soil fauna. Academic Press., London: 355 pp.

Xie, Z., Xiao, H., Tang, X., Lu, K., and Cai, H. (2008). Interactions between red tide microalgae and herbivorous zooplankton: Effects of two bloom-forming species on the rotifer *Brachionus plicatilis* (O. F. Muller). Hydrobiologia, 600: 237-245.