Effect of pollution on macrobenthic invertebrates in some localities along the River Nile at Great Cairo, Egypt.

Abd El-Halim A. Saad[1], Waheed M. Emam[1], Hesham R. A. Mola*[2] and Hadeel M. Omar[1]

1- Zoology department, Faculty of science, Ain Shams University, Cairo, Egypt.

2- National Institute of Oceanography and Fisheries (NIOF), El-Qanater.

*Corresponding author E-mail: hesham_reda06@yahoo.com

ABSTRACT

The impact of heavy metals on macrobenthic invertebrates in five stations along the River Nile at Great Cairo (from Helwan to El-Qanater El-Khiria) was studied during the period from May, 2013 to February, 2014. Physico-chemical characteristics and heavy metals (iron, manganese, zinc, copper and cadmium) were analyzed in water. The highest average number (2305 org./m^2) of macrobenthic invertebrates was recorded during spring, while the lowest (642 org./m^2) was recorded during summer. Annelida, Mollusca and Arthropoda were the most dominant groups being 62 %, 34 % and 4 % respectively. Twenty two species and taxa were recorded; Mollusca (13 species) and Annelida (7 species) Arthropoda (2 species).

All the heavy metal concentrations were within the permissible limits except at Helwan and Hawamdia due to the effect of discharged industrial wastes. The highest positive correlation was recorded between Arthropoda and iron & zinc, while iron recorded a negative correlation with Mollusca and Annelida. The principal component analysis (PCA) showed that the most dominant annelid *Limnodrilus* spp. had a positive correlation with cadmium and negative correlation with all other heavy metals. This indicates that this species can resist the high concentrations of cadmium.

Keywords: Macrobenthic invertebrates, heavy metals, River Nile.

INTRODUCTION

The River Nile is considered as one of the longest rivers in the world; it runs about 6,650 km through nine countries from Burundi to Egypt. The last 1,600 km of this journey goes through Egypt. The main part of water resources come from the Blue Nile in Ethiopia and the rest from the White Nile in Uganda (El Gohary, 1994). The River Nile is the artery of Egypt, as it provides more than 96% of the municipal, industrial and irrigation requirements of Egypt (Abdel-Satar, 2005).

Freshwater benthic macro-invertebrates include representatives of many oligochaetes, insects, crustaceans, gastropods and bivalves (Trop and Covich, 2001; Merritt *et al*., 2008). They contribute in many important ecological functions, such as decomposition, nutrient recycling, as well as an important role in aquatic food webs as both consumers and prey (Covich *et al*., 1999; Vanni, 2002; Moore, 2006). Macrobenthos are commonly used as bioindicators because they are typically less mobile than fish; therefore, they provide a more localized assessment of their response to stream conditions (Barbour *et al*., 1999). In addition, they provide a more accurate understanding of changing in aquatic conditions than chemical and microbiological data, which at least give short-term fluctuations (Ravera, 1998 & 2000). The use of benthic macro-invertebrates as environmental indicators is based on their ability to integrate changes in physical, chemical and ecological characteristics of their habitats over time and space (Milbrink, 1983). Odiete (1999) stated that the most popular biological method in assessment of freshwater bodies receiving domestic and industrial wastewaters is the use of macrobentic invertebtes. Moreover, the Water Framework Directive (WFD, 2006) demands the establishment of biomonitoring programmes for European aquatic ecosystems and includes macroinvertebrates as one of the biological elements to be monitored.

The present work aims to study the effect of some pollutants, especially heavy metals on the community composition, spatial distribution and seasonal variations of macrobenthic fauna with reference to some physico-chemical parameters in five stations along the River Nile at Great Cairo.

MATERIALS AND METHODS

A-Studied Area

The studied area in the River Nile was started from Helwan (Industrial area), El-Hawamdiya (Sugar factory), Rod El-Farage (Tourism activity), Shobra (Front of Electrical power Station) and El-Qanater El-Khiria (Front of water purification Station). The selected stations were showed in Table (1) and Fig (1).

Table 1: Latitudes, longitudes and average depths for the studied Stations.

Station	Name	Latitude	Longitude	Av.depth
1	Helwan	29°48'0"N	31°17'45"E	12m
2	El-Hawamdiya	29°52'31"N	31°17'3"E	8m
3	Rod El-Farage	30° 5'27 " N	31°14'1"E	15m
4	Shobra	30° 7'29"N	31°14'4" E	7m
5	El-Qanater El-Khiria	30°11'1"N	31° 8'20 "E	5m

Fig. 1: Map of River Nile at Great Cairo showing the selected stations during the study.

B-Collection and analysis of samples

Water and samples were collected-seasonally- from the selected stations in the River Nile during the period from May, 2013 to February, 2014. Some parameters were measured in the field (water temperature, pH, electrical conductivity and total solids) using multi-probe portable meter (Model CRISON-Spain.) and water transparency using secchi disc. All the chemical parameters and heavy metals were determined according to (APHA, 2005).

The bottom fauna was collected by the Ekman Grab bottom sampler. After collection the bottom fauna was washed thoroughly in a small hand net of bolting silk

(0.5 mm mesh size) and picked in and preserved immediately in 10 % neutral formalin solution in polyethylene jars. In the laboratory, samples were washed again. However, each species was counted separately. The bottom fauna was identified and sorted into groups and species according to Edmondson (1966), Brown, (1994 & 2001) and Bishai, *et al*. (2000).

C- Statistical analysis

Statistical analyses of Correlation coefficient (r value), p value, Principal component analysis (PCA) to correlate physico-chemical parameters, heavy metal in water, heavy metal in Sediment with the dominant macrobenthic invertebrates species and groups was carried out by XL STAT program, 2015.

RESULTS AND DISCUSSION

Physico-chemical parameters in water

Water temperature recorded its highest reading during summer (32.7°C) and the lowest during winter (18.5°C). The highest reading of transparency was recorded at El-Qanater El-Khiria Station during Autumn (120 cm) this might be due to settlement of sediment while the lowest reading was recorded at Helwan Station during summer and Winter (50 cm in June) which might be due to evaporation of water, which causes concentration of dissolved solids and increasing of temperature and production of plankton. Similar observations were recorded by Parveen & Mola (2013). The lowest values of pH (7.86 and 7.89) were recorded At El-Hawamdiya and Helwan station during summer. The relative decrease of pH values in these stations might be due to the effect of inflowing industrial wastewater and the highest value of pH (8.92) was recorded at Helwan during winter (Table 2).

Table 2: Physico-chemical parameters in water during the study.

Season	Station	Temp	Trans.	EC	PH	DO	BOD	COD	HCO_3	CO_3
Spring	1	27	75	396	8.5	9.6	6	11.5	160.1	4.5
	2	27.5	72	388	8.6	7	5.8	22.3	152	6
	3	28	65	385	804	9	5.6	17.5	153	0
	4	28.1	68	392	8.5	8.5	6.2	17.2	152	0
	5	26.5	85	382	8.3	8.8	4.8	12.5	150	2.1
Summer	1	31.1	50	346	7.89	9.2	4.4	8.5	190	4
	2	31.6	70	399	7.86	8.8	4.4	8.6	190	3
	3	31.7	40	358	8.01	8	6.4	8	190	0
	4	32.7	70	358	8.06	9	1.6	8.7	195	0
	5	31.8	95	341	8.17	9.5	1.6	8.3	190	3
Autumn	1	25.1	95	368	8.3	7.9	2.6	10.5	190	10.2
	2	25.5	96	372	8.4	7	4.8	8.1	182.1	8
	3	25.9	100	339	8.1	8	3.5	10	183.2	8
	4	25.2	110	344	8.3	9	3.2	9.4	182	14
	5	25	120	346	7.9	9.4	2.5	9.7	180	7
Winter	1	18.5	50	320	8.81	7.8	6.5	10	180	5
	2	19.2	70	325	8.92	7.8	5.9	9.4	172.5	7.5
	3	19.5	100	321	8.66	7	5.8	8.8	173	7
	4	19.7	65	328	8.83	7.8	6.1	9.5	172	8
	5	18.6	70	538	8.25	7.2	5	11	170	0

The lowest value of Dissolved Oxygen (DO) was recorded At El-Hawamdiya station during spring and autumn (7 mg/l). The relative decrease of DO values in this station might be due to the effect of inflowing wastewater from El-Hawamdiya factory which consuming the DO during the oxidation processes. Also, this might be attributed to the input of industrial wastes, as biochemical decomposition of organic matter leads to increasing ammonia and sulphids production during mineralization of organic matter which lead to enormous oxygen depletion. Similar observations were given by Emam (2006). The highest value of DO (9.6 mg/l) was recorded at Helwan during spring. This may be due to the abundance of phytoplankton which enriched water with oxygen during photosynthesis activity (Mola & Parveen, 2014). The highest value of Chemical oxygen demand (COD) was recorded at El-Hawamdiya during spring (22.3 mg/l) this might be due to the effect of inflowing organic wastewater from El-Hawamdiya factory.

The highest value of Electrical Conductivity (EC) was recorded at El-Qanater El-Khiria Station during winter (538 µmhohs/cm). This may attributed to the effect of Discharged washable water from El-Qanater Water Station. Bicarbonate concentrations observed its highest values during summer due to the effect of evaporation. The higher EC values were result from the concentration of soluble salts cations and anions (Ahmed, 2007) and the presence of inorganic wastes which contain high amount of organic and inorganic compounds (Gallab, 2000).

Heavy metals in water

Bioactive metals play an important role in metabolism, thus in physiology and pathology of fish. Metals like Zn, Cu, or Mn function as a cofactor in several enzyme systems (Bury *et al*., 2003) while Fe is directly involved with haemoglobin formation in fish blood. However, when in excessively high concentrations, these bioactive metals may pose serious threats to normal metabolic processes.

Five elements of heavy metals (iron, manganese, zinc, copper and cadmium) in water were analyzed during the present study (Table 3). Iron is the most abundant transition element, and probably the most well-known metal in biologic systems (Forstner and Wittmann, 1983). The highest concentration of Iron was observed at El-Qanatir El-Khiria (600 µgm/l) during winter and Shoubra during autumn (578 µgm/l). This may be due to the effect of discharged water from El-Qanater purification water and Shoubra Electrical Station.

Manganese is an essential trace element for microorganisms, plants and animals (CCREM, 1987) and can be bio concentrated up to 4 orders of magnitude, possibly to facilitate essential uses. It is present in natural waters in suspended form (similar to iron) although soluble forms may persist at low pH or low DO. Manganese, although it is an important trace element, it also sometimes exhibits toxicity (Burger and Gochfeld, 1995). Mn is a relatively non-toxic metal element and this is reflected by the absence of Mn in many toxicological assessments and by the lack of the relevant quality standards in China (Li and Thornton, 2001). The highest values of manganese were observed at El-Hawamdia during summer (190.4 µgm/l) and Helwan during spring (168.6 µgm/l) while it decreased sharply and reached to the lowest (12.6 µgm/l) at Shobra. This may be due to the effect of drainage water from Helwan Steel Company and El-Hawamdia Company.

Zinc is one of the most abundant essential trace elements in the human body. It is a constituent of all cells, and several enzymes depend upon it as a cofactor (Forstner and Wittmann, 1983). The highest values of zinc were observed at Shoubra during summer (134.2 µgm/l), autumn (120.8 µgm/l) and Helwan during autumn (128.6 µgm/l). Although, these 3 values higher than the permissible limits but all the other study, zinc recorded low values not increase over the permissible level (110 µgm/l). Similar observations stated by Haggag, *et al*. (1999) which recorded that the average concentration of zinc in water samples obtained from the River Nile at different locations were varied from 43 µgm/l and 1123 µgm/l. Cadmium recorded its maximum value (7.4 µgm/l) at El-Qanatir El-Khiria during winter. It is not recorded at the most studied stations during summer, autumn and winter. This might be due to it very low concentrations and under the instrument detection limit.

Copper is one of the more abundant transition metals and it can be acutely toxic to freshwater fish in high concentrations. Although but its compounds are used in fish culture and fisheries as algaecides (Svobodova *et al.*, 1993). The highest value of copper was observed at El-Hawamdia (13.8 µgm/l) during summer (µgm/l). This may be due to excessive use of Cu-based agrochemicals in the discharged water from El-Hawamdia Company. All copper values during study not exceeded than the safe limit. The permissible level of copper in water is 1 ppm according to WHO (1984) and USEPA (1986a). Chen *et al.* (1985) and Boyd, (1990) suggested a level of < 25 µg/l for no known adverse effects on aquaculture fish, while Post (1987) suggested < 14 µg/l for fish hatcheries.

Table 3: Heavy metals concentrations (µgm/l) in water at the selected stations.

Season	Station	Fe	Mn	Zn	Cu	Cd
Spring	1	256	168.6	86.2	1.8	2.6
	2	215	29.6	65.8	1.4	6.8
	3	213	64.4	79.0	0.4	3.6
	4	80	28.2	62.2	0.2	2.8
	5	271	36.2	67.2	10.6	0.0
Summer	1	143	13.8	48.8	0.6	0.0
	2	190	190.4	60.2	13.8	0.0
	3	119	9.8	48.0	5.0	0.0
	4	481	12.6	134.2	4.2	0.0
	5	131	8.0	84.6	5.0	0.0
Autumn	1	263	18.4	128.6	4.0	0.0
	2	141	13.4	84.8	2.8	0.0
	3	557	19.2	66.7	0.0	0.0
	4	578	38.4	120.8	1.6	0.0
	5	278	14.0	85.0	0.0	0.0
Winter	1	82	25.0	27.0	3.4	0.0
	2	146	67.6	27.2	0.0	0.0
	3	158	27.6	25.8	0.0	0.0
	4	169	22.2	27.0	0.0	3.2
	5	600	98.2	34.0	0.0	7.4

Macrobenthic Invertebrates

The maximum Average number (2305 Org./m^2) of macrobenthic invertebrates was recorded during spring while the lowest number (642 Org./m^2) was recorded at ad during summer (Figures 2&3). Annelida, Mollusca and Arthropoda were the most dominant groups in the lake during the study being 62 % (2515 Org./m^2), 34 % (1365 Org./m^2) and 4 % (158 Org./m^2) respectively. Abdelsalam and Tanida (2013) reported that the oligochets especially which affiliate to family Naididae are truly cosmopolitan and widely distributed among different habitats.

Twenty two species and taxa were recorded during the study. Mollusca (13 species) and Annelida (7 species) was recorded the highest number of species while phylum Arthropoda (2 species) was observed the lowest. The highest seasonal average number of Annelida was observed during spring (6085 org./m^2) while the lowest was observed during summer (625 org./m^2). Mollusca recorded its highest average number during winter (2665 Org./m^2) while the lowest was observed during spring (625 org./m^2). This may be due to increasing of *Melanoides turberculata* which recorded the highest average (2515 Org./m^2) and the lowest average (325 org./m^2) during the same seasons and formed 76.04 % of the total Mollusca (Table 4). The present study is agreed with Bendary (2013) and particularly agreed with Zaki (2008) who reported that the snail population was high in autumn and low in spring.

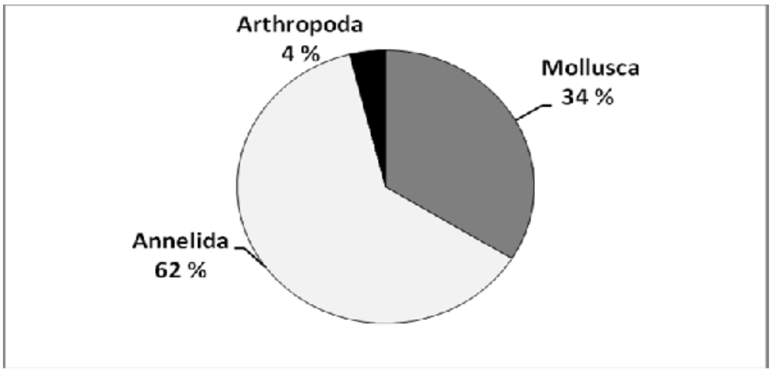

Fig. 2: Percentage frequency of the dominant Macrobenthic Invertebrate groups during the study.

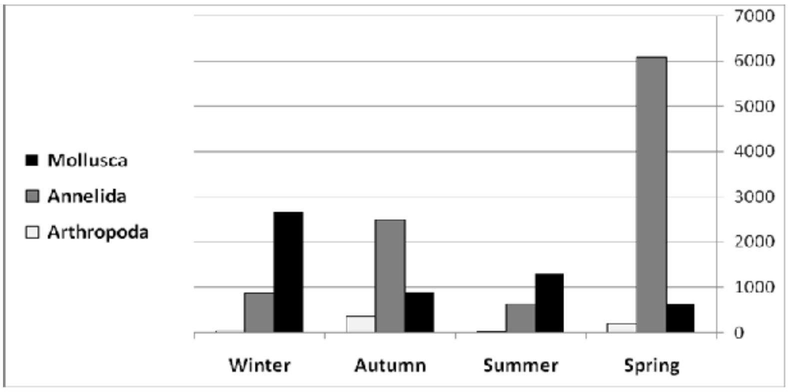

Fig. 3: Seasonal variations of macrobenthic groups during the study.

Limnodrilus spp. formed the most dominant species being 84.85% of the total Annelida with average of 2134 Org./m^2. The predominance of oligochaetes especially *Limnodrilus* spp. in water is possibly due to their ability to adapt to various habitats and to their tolerance to low oxygen content in anoxic conditions of the bottom sediment (Mola and Abdel Gawad 2014). *Branchiura sowerbyi, Limnodrilus hoffmeisteri,* and *L. udekemianus* considered the most dominant annelid species being 121, 96 and 148 org./m^2 respectively. Although *L. udekemianus* was recorded in four seasons, it is not considered as tolerant species; the variation of temperature was not determining factor for their distribution (Nassif, 2012). The present data was not coincided with Wisa (2012) who mentioned that *B. sowerbyi* was completely disappeared in many stations of River Nile.

The lowest average number of Arthropoda was recorded during summer (20 Org./m^2) while the highest one was observed during autumn (365 org./m^2). It was represented by Chironomus larvae and larva of Crptochironomus being 4 and 154 org./m^2 respectively. The disappearing of Chironomus larvae might attributed to high water temperature which leads to rapid metamorphosis from larval to pupal stages that in turn produces adult forms within a short duration. In contrast, the decrease during cold seasons of the year (autumn and winter) may inhibit or reduce the rate of development of by decreasing their metabolic activities (Bendary, 2013). El-Enany (2004) founded that chironomus larvae showed a positive correlation with heavy metals in water and sediment and can be used as indicator for organic pollution.

Table 4: Monthly variations of the most frequented species of macrobenthic invertebrates during the period from April, 2013 to February, 2014.

Group and specie	**Spring**	**Summe**	**Autumn**	**Winter**	**Average**
Bellamya unicolor	0	5	10	10	6
Bulinus truncatus	40	0	0	0	10
Caelatura sp.	25	20	85	0	33
Cleopatra bulimoides	15	10	25	5	14
Corbicula fluminalis	115	5	160	10	73
Gabiella seaariensis	25	185	105	105	105
Gyranulus ehrenbergi	10	0	0	0	3
Lanistes carinatus	25	50	35	0	28
Melanoides tuberculata	325	925	385	2515	1038
Mutela sp.	5	10	65	20	25
Psidium pirothi	10	0	0	0	3
Theodoxus niloticus	25	70	20	0	29
Valvata nilotica	5	0	0	0	1
Total mollusca	625	1280	890	2665	1365
Branchiura sowerbyi	170	195	95	25	121
Hellobddla sp.	0	0	0	20	5
Limnodrilus hoffmeisteri	80	45	50	210	96
L. udekemianus	240	55	150	145	148
Limnodrilus spp.	5580	330	2175	450	2134
Nais sp	0	0	0	10	3
Pristina sp.	15	0	15	5	9
Total Annelida	6085	625	2485	865	2515
Chironomus larvae	0	0	5	10	4
Larva of Crptochironomus	205	20	360	30	154
Total Arthropoda	205	20	365	40	158
Grand total	6915	1925	3740	3570	4038

Statistical analysis

Physico-chemical parameters and macrobenthic invertebrates

Principal component analysis (PCA) was conducted between physic-chemical parameters and macrobenthic invertebrates. The highest positive correlation between Arthropoda and *Melanoides tuberculata* being (r=0.99). The highest negative correlation was observed between chemical oxygen demand and bicarbonate (-0.79). Also, *Limnodrilus* spp. Showed a negative correlation (-0.45) with bicarbonate. Bicarbonate showed in the opposite side for the most dominant annelid species (Figure 4). The chemical oxygen demand (COD) showed a positive correlation with *Limnodrilus* spp. and Annelida being 0.62 and 0.61. Arthropod recorded a positive correlation with carbonate (0.60). This may be due to *Limnodrilus* spp. have the ability to adapt with organic pollution and to their tolerance to low oxygen content in anoxic conditions of the bottom sediment. This agreed with El-Enany (2004) and Mola & Abdel Gawad (2014).

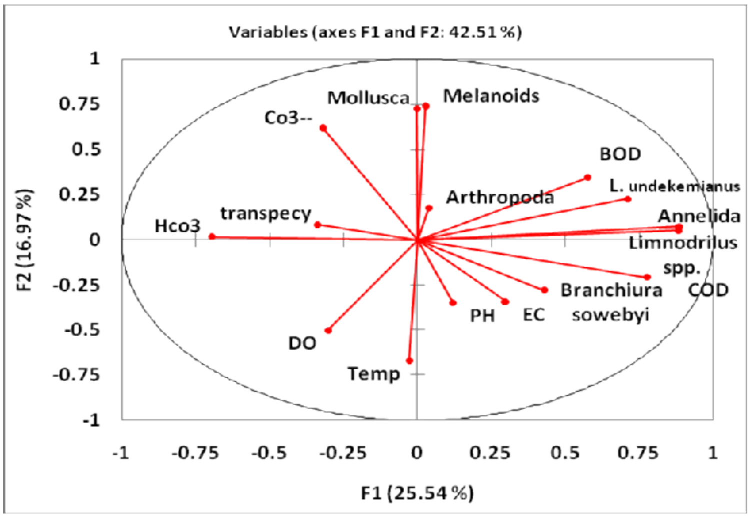

Fig. 4: Principal component analysis (PCA) was conducted for physico-chemical parameters and macrobenthic invertebrates.

Heavy metals and macrobenthic invertebrates

Principal component analysis (PCA) was conducted also between heavy metals and macrobenthic invertebrates and showed that the highest positive correlation between Arthropoda with iron and zinc being 0.36 and 0.46 respectively (Figure 5). The dominant arthropds (chironomus larvae) showed as a good indicator for pollution (Sharma *et al.*, 2015). In vice versa, Iron recorded a negative correlation with mollusca and annelid (0.25). The most dominant annelid *Limnodrilus* spp. showed a positive correlation with Cadmium (0.34) and negative and weak correlation with all the other heavy metals (iron, manganese, copper and zinc).

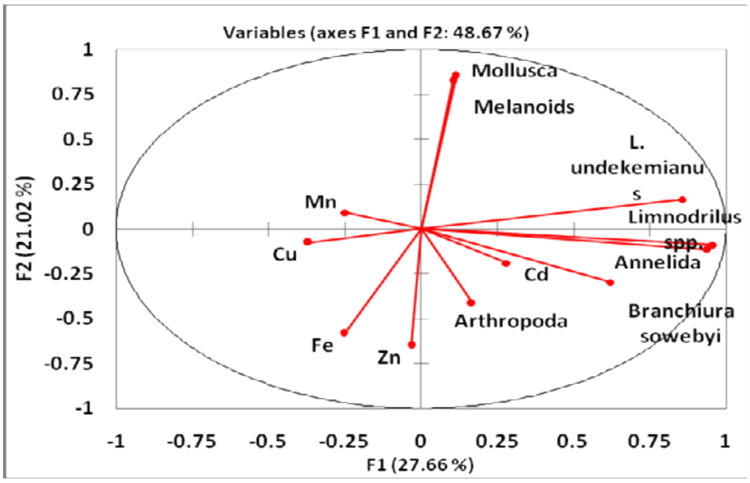

Fig. 5: Principal component analysis (PCA) was conducted for heavy metals parameters and macrobenthic invertebrates.

This observation agreed with Klerks and Bartholomew (1991) which reported that the oligochaete *Limnodrilus* spp. from the metal-polluted resistance to a combination of cadmium.

So, we can conclude that, the dominate of the oligochaets *Limnodrilus* spp. and the mollusks *Melanoides tuberculata* during all seasons indicates that these species can adapt with the difficult ecological conditions and can tolerate the high concentrations of organic matters and heavy metals especially at Helwan and El-Hawamdiya.

REFERENCES

Abdel-Satar, A.M. (2005). Water quality assessment of River Nile from Idfo to Cairo. Egyptian J. Aqua. Rese. 3 (2):200-223.

Abdelsalam, K.M. and Tanida, K. (2013). Diversity and spatio-temporal distribution of macro-invertebrates communities in spring flows of Tsuya Stream, Gifu prefecture, central Japan. Egyptian Journal of Aquatic Research, 39, 39-50.

APHA (American Public Health Association) (2005). Standard methods for examination of water and wastewater. 21st Edn. Standard Methods is a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF). Washington DC, USA.

Barbour, M.T.; Gerritsen, J.; Snyder, B.D. and Stribling, J.B. (1999). Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. Second edition. EPA 841-B-99-002. U.S. Environmental Protection Agency. Office of Water. Washington, District of Columbia, U.S.A. 339 pp.

Bendary, R.E.E. (2013). Ecological studies on macrobenthic invertebrates associated with macrophytes in River Nile, Egypt. M.Sc. Thesis, Zool. Dept. Fac.Sci.. Ain shams Univ., 207pp.

Bishai, H.M., Abdel Malek, S. A. and Khalil, M.T. (2000). Lake Nasser. Egyptian Environmental Affairs Agency (EEAA production). National Biodiversity Unit. No. 11.

Brown, D. S. (1994). Freshwater Snails of Africa and their Medical Importance (2nd edn.). Taylor & Francis, London, 609 pp.

Brown, K.M. (2001). Mollusca: Gastropoda. In: Thorp, J.H., Covich, A.P.(Eds)., Ecology and Classification of North American Freshwater Invertebrates. Academic press, pp. 297-329.

Burger, J. and Gochfeld, M. (1995). Growth and behavioral effects of early postnatal chromium and manganese exposure in herring gull (Larus argentatus) chicks. Pharmacology Biochemistry and Behavior 50, 607–612.

Bury N.R., Walker P.A., Glover C.N. (2003): Nutritive metal uptake in teleost fish. J. Exper. Biol. 206: 11.23.

Canadian Council of Resource and Environment Ministers (CCREM) (1987). Canadian water quality guidelines., Ontario.

Chen, J.C.; Ting, Y.Y.; Lin, H. and Lian, T.C. (1985). Heavy metal concentrations in sea water from grass prawn hatcheries and the coast of Taiwan. J. Wor. Maricul. Soc. 16, 316–332.

Covicch, A.P.; Palmer, M.A. and Crowl, T.A. (1999). The role of benthic invertebrate species influence energy flows and nutrient cycling. BioScience 49:119-127.

Edmondson, W.T. (1966). Freshwater Biology. 2nd Edn. John Wiley and Sons. Inc. New York & London.

El-Enany, H.R. (2004). Ecological studies on Lake Manzalah with special references to their water quality and sediment productivity. M.Sc. Thesis, Zool. Dept. Fac. Sci. Al Azhar Univ., 386pp.

El-Gohary, F. (1994). Comparative environmental risks in Cairo: Water pollution problems, in comparing environmental health risks in Cairo, Egypt, USAID & GOE, vol. 2, p.2.1.

Forstner, U and Wittmann, G.T.W. (1983). Metal pollution in the aquatic environment. Springer-Verlag, Berlin, pp. 30-61.

Forstner, U and Wittmann, G.T.W. (1983). Metal pollution in the aquatic environment. Springer-Verlag, Berlin, pp. 30-61.

Gomaa, M.N.E.; Abou-Arab, A.A.K.; Badawy, A. and Naguib, K. (1995). Distribution pattern of some heavy metals in Egyptian fish organs. Food chemistry. 53: 385 – 389.

Haggag, A.M.; Mohamed, A.S.M. and Khaled, H.Z. (1999). Seasonal effects of the industrial effluents on the Nile catfish (Clarias gariepinus). J. Egy. Germ. Soc. Zool. 28:365–252.

Klerks, P.L. and Bartholomew, P.R. (1991). Cadmium accumulation and detoxification in a Cd-resistant population of the oligochaete Limnodrilus hoffmeisteri. Aquatic Toxicology. 12 (2): 97-112.

Li, X. and Thornton, I. (2001). Chemical partitioning of trace and major elements in soils contaminated by mining and smelting activities. Appl. Geochem. 16: 1693 - 1706.

Merritt, R.W., Cummins, K.W. and Berg, M.B. (2008). An Introduction to the Aquatic Insects of North America. 4th Edition) Kendall Hunt Publishing. Dubuque, Iowa, U.S.A. 1158 pp.

Milbrink, G. (1983). An improved environmental index based on the relative abundance of Oligochaete species. Hydrobiologia, 102: 89-97.

Mola, H.R.A. and Abdel Gawad S. S. (2014). Spatio-temporal variations of macrobenthic fauna in Lake Nasser Khors, Egypt. (2014). Accepted paper. Egypt. J. Aqu. Res. 40: 415–423.

Mola H.R.A. and Parveen S. (2014). Effect of monsoon on zooplankton variations and environmental characteristics in a tropical fish pond at Aligarh, India. Egypt. J. Aquat. Biol. & Fish., Egypt. J. Aquat. Biol. & Fish., 18(3): 105-114.

Moor, J.W. (2006). Animal ecosystem engineers in streams. Bioscience, 56: 237-246.

Nassif, M. G. (2012). Ecological studies on invertebrates of Ismailia Canal, Egypt. M. Sc. Thesis, Fac. Sci., Ain Shams Univ., 167pp.

Odiete, W.O. (1999). Environmental physiology of animals and pollution. Diversified Resources, Lagos, Nigeria, pp: 220-246.

Parveen S. and H.R. Mola (2013). Comparison of physico-chemical parameters and zooplankton species diversity of two perennial ponds in Aligarh, India. J. Environ. biol., 34(4):709-716.

Ravera, O. (1998). Utility and limits of biological and chemical monitoring of the aquatic environment. Annal. Dichim., 88: 909-913.

Ravera, O. (2000). Ecological monitoring Tailormade III. International workshop on Information for Sustainable Water Management, pp: 157-167.

Sharma, k.k.; Kour, S. and Antal, N. (2015). Diversity of zooplankton and macrobenthic invertebrates of two perennial ponds in Jammu Region. J. Glob. Biosc., 4(2): 1383-1393.

Svobodova, Z.; Lloyd, R.; Machova, J. and Vykusova, B. (1993). Water quality and fish health. EIFAC technical paper no 54, FAO, Rome.

United States Environmental Protection Agency (USEPA) (1986). Quality criteria for water. US Department of Commerce, National Technical Information Service, US Environmental Protection Agency, Springfield, Virginia. PB87-226759, EPA 440/5 86-001.

United States Environmental Protection Agency (USEPA) (1993). Code of federal regulations. Part 131: Water quality standards. Protection of environment. Parts 100-49. U.S. Government Printing Office, Washington, DC.

Vanni. M.J. (2002). Nutrient cycling by animals in freshwater ecosystems. Ann. Rev. Ecol. Syst., 33:341-370.

Water Framewoke Directive (WFD) (2003). DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000: establishing a framework for Community action in the field of water policy. Official J. Europ. Comm.

Wissa, J. B. (2012). Ecological Studies on Benthic Invertebrates as Indecators of Organic Pollution in El-Rahawy Region, Giza, at River Nile, Egypt. Ph.D. Thesis, Fac. Sci., Ain Shams Univ., 249pp.

WHO (1993). Evaluation of certain food additives and contaminants. Technical Report Series, 1993, Number 837. World Health Organization, Geneva.

Zaki, H. Y. M. (2008). Survey on snail populations at Abis district, Egypt. M. Sc. Thesis, Dep. of Parasitology, Faculty of Vet. Med., Alexandria Uni., 94 pp.

ARABIC SUMMARY

تأثير التلوث على لافقاريات القاع الكبيرة فى بعض الأماكن فى نهر النيل بالقاهرة الكبرى، مصر.

عبد الحليم عبده سعد[١] – وحيد محمود إمام[١] – هشام عبد المولى[٢] - هديل محمد عمر[١]

١- قسم علم الحيوان ، كلية العلوم ، جامعة عين شمس، القاهرة، مصر.

٢- المعهد القومى لعلوم البحار والمصايد، القناطر الخيرية، مصر.

تم خلال هذا البحث دراسة تأثير العناصر الثقيلة على اللافقاريات القاعية الكبيرة فى خمس محطات من حلوان حتى القناطر الخيرية خلال الفترة من مايو ٢٠١٣ حتى فبراير ٢٠١٤. تم تحليل الخصائص الفيزوكيميائية للمياه وخمس عناصر ثقيلة خلال الدراسة وهى الحديد والمنجنيز والزنك والنحاس والكادميوم. وقد سجل أعلى متوسط لعدد اللافقاريات القاعية الكبيرة (٢٣٠٥ كائن/م^{٢}) فى موسم الربيع، بينما سجل أقل متوسط للعدد خلال موسم الصيف (٦٤٢ كائن /م^{٢}). وأظهرت الحلقيات والرخويات ومفصليات الارجل أكثر المجموعات تواجداً مسجلة ٦٢% و ٣٤% و٤% على التوالى. وقد سجل ٢٢ نوعاً من لافقاريات القاع خلال الدراسة؛ ٢٣ نوعاً منها للرخويات و ٧ أنواع للحلقيات ونوعان لمفصليات الأرجل.

وقد أظهرت نتائج تحاليل العناصر الثقيلة خلال الدراسة أنها تقع فى الحدود المسموح بها فيما عدا بعض المحطات التى تقع تحت تأثير الصرف الصناعى وخاصة محطتى حلوان والحوامدية. وقد سجلت أعلى علاقة إرتباط خلال الدراسة بين مفصليات الأرجل وعنصرى الحديد والزنك فيما سجلت علاقة علاقة عكسية بين كلا من الرخويات والحلقيات. وقد أظهر التحليل الاحصائى متعدد الاوجة (PCA) أن أكثر أنواع الحلقيات انتشار من نوع الليمنودرلاس قد سجلت علاقة طردية مع الكادميوم وعلاقة عكسية مع باقى العناصر الثقيلة وهذا يدل على أن هذه الانواع لها مقاومة لتركيزات الكادميوم العالية.