

STUDIES ON THE EFFECT OF POLLUTION ON LAKE MANZALA ECOSYSTEM IN PORT-SAID, DAMIETTA AND DAKAHLIA GOVERNORATES, EGYPT

By

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Abstract

This work studied how pollution impacts the ecosystem of Lake Manzala by determination of physicochemical parameters, studying biodiversity of aquatic plants and macroinvertebrates, and determining bioaccumulation of Pb, Cu, Cd & Zn in some major organisms, *Biomphalaria alexandrina* and *Melanooides tuberculata* snails and *Oreochromis niloticus* fish. The more near to Mediterranean Sea and to the industrial area, Port-Said and Damietta sites showed higher dissolved oxygen and conductivity than Dakahlia sites. Distribution percentage of *Eichhornia crassipes* is high among Port-Said and Dakahlia sites of 100 and 88 %, respectively, while *Lemna giba* is the most abundant among Damietta sites of 60%. The maximum macroinvertebrate taxa richness was obtained at Gammalya, Dakahlia of 16 species while the maximum abundance was registered at Annanya, Damietta of 591 organisms. Gastropoda are the most distributed organisms in Lake Manzala followed by Hemiptera and Plecoptera then shrimps and scud. All the medically important snails, *B. alexandrina*, *B. truncatus* and *L. natalensis* were recorded in Dakahlia, but only *B. alexandrina* was in Damietta and Port-Said sites. The collected water samples from Damietta sites showed the highest significant Cu & Cd concentration while Port-Said samples showed the highest Pb concentration and Dakahlia showed the highest Zn concentration. The metals concentrations were higher in snail tissue and in fish liver, kidney and most of muscle samples as compared in surface water. The higher metal bioaccumulation was determined in snails collected from sites showed higher water metals concentrations. Fish muscle showed the least residues than liver and kidney for all the measured metals. Pb and Cd were more accumulated in kidneys, Cu was more accumulated in liver and Zn was accumulated in all examined fish parts in descending order as follows Kidney >liver > muscle.

Key words: Lake Manzala, *Biomphalaria alexandrina* snails, Nile tilapia *Oreochromis niloticus*, heavy metals (Cu, Cd, Pb and Zn).

Introduction

The ecological damage of the aquatic environment are mainly related to anthropogenic factors as well as the presence of hazardous, infections and parasitizing agents (Silveira-Cohignya *et al.*, 2004). Aquatic biota, sediments, and water samples may be used for pollution-monitoring purposes (Porte and Albaiges, 1993). Recently several investigators study the impact of chemical characteristics of water on fresh water macroinvertebrates (Buss and Borges, 2008; Sola *et al.*, 2004; Stone *et al.*, 2008; Van Damme *et al.*, 2008). Also, Muncaster *et al.* (1990) recommended that whereas water contaminant levels are usually below detection limits

therefore, living organisms should also be used to monitor environmental contamination, since they may reflect the contamination history of a particular location because they have been exposed during their entire lifetime and are capable of accumulating these toxic substances in their lipid tissue fractions. Metal bioaccumulation can be of importance from the public health point of view, especially when a human consumes the accumulators. The benthic gastropods in wetlands have an especially close relationship with the sediments that comprises their habitat and feeding site. Gastropods in turn are used as food source by birds and fish, which in turn make them accessible for hu-

man consumption through food chain and eventually pose great health risk (Altindag and Yigit, 2005). Lake Manzala is considered one of the most important lakes in Egypt. It is exposed to high levels of pollutants from industrial, domestic and agricultural resources (Badawy and Wahaab, 1997; Abdel-Baky *et al.*, 1998b; Ibrahim *et al.*, 1999b). Ali (2008) reported that Lake Manzala receives about 4000 million cubic meters of untreated industrial, domestic and agricultural drainage water, discharged annually into the lake through several drains: Bahr El-Bakar Drains (domestic and industrial sewage), Hadous, Ramsis, El-Serw and Faraskour Drains (agricultural effluents). These drains maintained high heavy metals levels which exceed than the allowed maximum concentration reported by World Health Organization, which might cause a public health problem (Abdel-Satar, 2001). Also, Bishai and Yossef (1977) reported that drains inlet to Lake Manzala gradually transformed, with time, its brackish environment to eutrophic fresh water that can be breeding sites for many freshwater organisms including snails that transmit schistosomiasis, *Biomphalaria alexandrina* and *Bulinus truncatus* and fascioliasis, *Lymnaea* species. In Egypt, schistosomiasis is not only a prime health problem, but it is also an economic one, as it affects people at the early age diminishing their productivity and exerting a serious socioeconomic problem (El-Baz *et al.*, 2003). Also, fascioliasis in Egypt is highly enzootic affecting cattle, sheep, donkeys, goats and buffaloes and estimating severe negative economic impact (Mazyad and El-Nemr, 2002; Awad *et al.*, 2004; Morsy *et al.*, 2005; Haridy *et al.*, 2006). In addition, human fascioliasis constitutes a significant health problem, as the estimated number of people infected with fascioliasis in Egypt is 830,000 cases (Aseeb *et al.*, 2002), while population at risk is considered to be 27 million (WHO, 2007).

The objective of the present study was to study how pollution impacts an ecosystem

of Lake Manzala, through determining physicochemical parameters, studying biodiversity and distribution of aquatic plants, macroinvertebrates and medically important snails and determining bioaccumulation of Pb, Cu, Cd and Zn in some major organisms.

Materials and Methods

This study was carried out in 14 different sites in Lake Manzala in three governorates; Port Said (5 sites), Dakahlia (6 sites) and Damietta (3 sites) in North Delta, Egypt (Fig. 1).

Samples collection: A survey of the water banks was carried out in the sites from May 2013 to end of May 2014 utilizing a motorized boat, from which live samples of macroinvertebrates including snails were collected and their water ecological conditions were recorded (e.g. temperature and conductivity measured in the selected watercourses by temperature conductivity meter (HANNA instrument, HI 9635). Also, Hydrogen ion concentration (pH) measured by pH-meter (HI 8543). Dissolved oxygen was measured by oxygen meter (HANNA HI 9146). From each site samples resemble all of macrophyte species were collected. In the lab the macrophytes were sorted and identified according to Madsen (1994). Macroinvertebrate organisms clinging to aquatic vegetation or free swimming were collected using the kick and shuffle method by 500 μm mesh D-Form dip net (Robinson, 2004 and Takougang *et al.*, 2008) and the collected samples from each site were placed in separate plastic aquaria then transferred to the laboratory, where they were sorted out, taxonomically identified to the lowest possible taxonomic level (Hauer and Lamberti, 1996; Leska, 1998; Bouchard, 2004) then number of each taxon were calculated. Taxa Richness (TR) equals the total number of taxa represented within the sample. Fish samples were collected with the help of professional local fishermen. Also, water samples were collected in 1 liter polyethylene bottles from sites under study, to determine the concentra-

ations of Pb, Cu, Zn & Cd.

Accumulation of heavy metals: Snails were dissected within 12 hr of collection and the whole body tissues were removed and fish were dissected to get muscle, liver, kidney within one hour. The dissected tissues dried at about 80°C in an electric oven. After complete drying the tissues were pulverized in clean dry mortar and stored separately by labeling the specimen with date and species name. Samples of whole fish were dried at 105°C for a period of 36hr then powdered. One gram of each dried tissues was transferred to clean screw capped glass bottle and digested with 10 ml of solution HNO₃-

HClO₄ (4:1 v/v) (FAO, 1983). Initial digestion was conducted for four hours at room temperature, followed by heating at 40-45°C for one hour in water bath, then raised to 70°C until the end of digestion. After cooling at room temperature the digest was diluted to 25ml with deionized water and filtered in volumetric flask to determine the concentrations of the examined heavy metals. In the Environmental Research laboratory, Theodor Bilharz Research Institute the specimen of snails, fish and water were analyzed for the levels of cadmium, lead, zinc and copper using, Avanta Atomic Absorption Spectrophotometer.



Fig. 1: Sites of Lake Manzala in Port-Said, Damietta and Dakahlia Governorates. Port-Said sites: 1: Bahr El-Bakar, 2: Kobry El-Lansh, 3: El-Khandk, 4: El-Treek El-Dawly and 5: El-Temsah; Dakahlia sites 6: El-Dela, 7: Ibn-Salam, 8: Matarya, 9: Nasayma, 10 Deshda and 11 Gammalya & Damietta sites 12 Anannya, 13: Sayyala and 14: Izbet El-Borg.

Statistical analysis: One-way ANOVA and Duncan multiple range test were used to evaluate the significant difference in the concentration of different studied metals with respect to different sites. A probability at level of 0.05 or less was considered significant (Bailey, 1981). Standard errors were also estimated. Data were carried out using Instate software computer program, VERSION 5.03 (Graph pad, USA) and IBMPC compatible computer.

Results

In physicochemical parameters (Fig. 2),

temperature ranged between 21°C and 31°C, higher values were recorded in Sayyala, Damietta during spring season. The lowest temperature (21°C) was in El-Temsah, Port-Said and Ibn-Salam, Dakahlia during autumn. Port-Said and Damietta sites have higher dissolved oxygen concentration with maximum concentration of 12.5 & 12.1mg/l in El-Temsah and Syala sites, respectively while lowest value of 2.6mg/l was obtained in Matarya, Dakahlia. Conductivity varied between 1800 to 270µmhos/cm. Low-er conductivity values were obtained at Ga-

mmalya, Dakahlia, but the highest value was obtained at El-Temsah, Port-Said. Most sites of Damietta have intermediate values with maximum value of 11000 μ mhos/cm in

Ananya site. Hydrogen ion concentration values increased from 7.1 at Kobry El-Lansh, Port-Said to 8.2 at Nasayma, Dakahlia to 8.6 at Sayyala, Damietta.

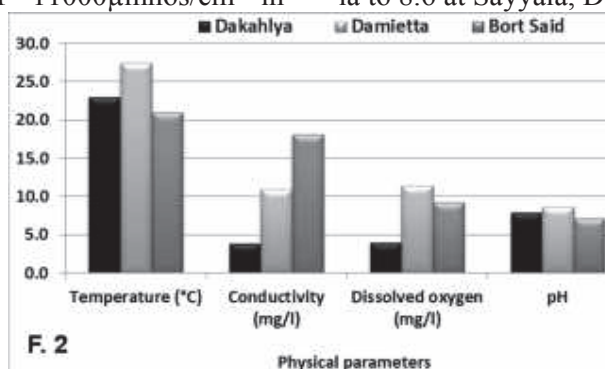


Fig. 2: One year survey means of physicochemical parameters at sites in Lake Manzala in three governorates.

The chemical parameters (Tab. 1) showed that the Pb, Cu and Cd concentration in all Port-Said and Damietta sites exceeded the higher limit that was determined by of EPA (2011) with while only Deshda among Dakahlia sites exceeded the higher limit for Cu and Cd.

Statistical analysis revealed that the concentration of the chemical parameters in Damietta sites was the higher, significantly, than the other tested governorates. Lead increased significantly at $p < 0.001$ in Sayyala than Kobry El-Lansh, Bahr El Bakar, Ezbet El-Borg & Ananya and at $p < 0.01$ than El-

Khankad and at $p < 0.05$ than EL_Tareek El-Dawly. Copper was significantly increased in Ezbet El-Borg than Bahr El Bakr, Deshda, Matereya at $p < 0.001$, while it increased at $p < 0.05$ in Sayyala than Gammalya and Ananya. Also, the concentration of zinc was increased significantly in Sayyala than El-Khankad, Bahr El Bakar, E;-Tareek El-Dawly, Ezbet El-Borg, Gammalya and Ananya ($p < 0.01$). In addition, cadmium recorded significant increase ($p < 0.001$) in Ezbet El-Borg than Sayyala, El-Khankad, Bahr El Bakar, El-Tareek El-Dawly, Gammalya, Bahr El Bakr and Ananya

Table 1: Concentrations (M \pm SE) of Pb, Cu, Zn and Cd; and their folds over national level of concern (CL); in water samples collected at different sites in three governorates (Gov.) at Lake Manzala over one year.

Gov.	Sites	Pb (ppb)	Folds M/CL	Cu (ppb)	Folds M/CL	Zn (ppm)	Folds M/CL	Cd (ppb)	Folds M/CL
Port-Said	El-Khandak	114.0 \pm 31.4	1.8	16.4 \pm 21.2	1.3	0.5 \pm 0.2	4.2	10.4 \pm 10.6	5.2
	El-Tareek El-Dawly	110.00	1.7	98.61	7.6	0.06	0.5	3.99	2.0
	Kobry El-Lansh	100.47 \pm 40.61	1.6	156.18 \pm 261.68	12.0	0.28 \pm 0.07	2.3	5.38 \pm 5.24	2.7
	Bahr El-Baar	73.67 \pm 45.39	1.2	28.73 \pm 14.35	2.2	0.32 \pm 0.17	2.7	5.23 \pm 5.42	2.6
Port-Said		99.54 \pm 18.15	1.6	74.98 \pm 65.12	5.8	0.29 \pm 0.14	2.4	6.25 \pm 2.84	3.1
Dakahlia	Deshda	50.84 \pm 48.40	0.8	26.63 \pm 6.17	2.0	0.33 \pm 0.25	2.8	6.83 \pm 3.81	3.4
	Gammalya	8.75	0.1	6.31	0.5	0.84	7.0	2.87	1.4
	Matarya	39.22 \pm 15.25	0.6	6.88 \pm 1.156	0.5	0.19 \pm 0.02	1.6	1.77 \pm 1.99	0.9
Dakahlia		32.94 \pm 21.74	0.5	13.27 \pm 11.57	1.0	0.45 \pm 0.34	3.8	3.82 \pm 2.66	1.9
Damietta	Ananya	88.05 \pm 93.86	1.4	106.69 \pm 140.27	8.2	0.36 \pm 0.05	3.0	4.35 \pm 5.03	2.2
	Sayyala	191.50 \pm 2.12	3.0	207.70 \pm 227.12	16.0	0.63 \pm 0.39	5.3	9.69 \pm 0.04	4.8
	Ezbet El-Borg	70.13	1.1	315.30 \pm 0	24.3	0.32	2.7	306.60 \pm 0	153.3
Damietta		116.56 \pm 65.52	1.9	209.90 \pm 104.32	16.1	0.44 \pm 0.17	3.6	106.88 \pm 172.98	53.4
Lake Manzala		84.66 \pm 49.98	1.3	96.943 \pm 103.26	7.5	0.38 \pm 0.22	3.2	35.71 \pm 95.22	17.9
PL		65 ppb		13 ppb		120 ppm		2 ppb	

PL: permissible limits according to EPA (2011), All values = means (M) \pm standard error (SE); with different letters; statistically significant extremely significant at *** $p < 0.001$ level; ** $P < 0.01$ highly significant and * $p < 0.05$ significant.

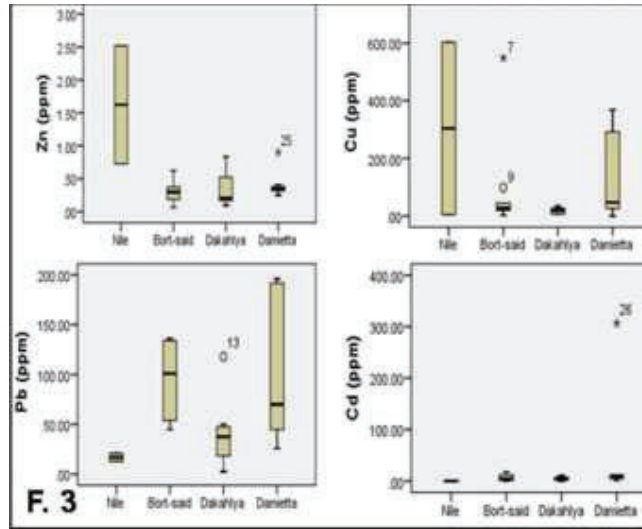


Fig. 3: Box plots of the heavy metals Zn, Cd, Cu and Pb according to the Port-Said, Dakalia and Damietta. Box represents interquartile range; top and bottom of box respectively 25th & 75th percentile, Line across box median, Circles represent outliers.

Aquatic plants: Aquatic plants survey of Lake Manzala showed a total of seven species, *Eichhornia crassipes*, *Ceratophyllum demersum*, *Jussiaea repens*, *Lemna giba*, *Pistia stratiotes*, *Phragmites* and Bermuda grass. *E. crassipes* is the most abundant in Lake Manzala followed by *Phragmites* and

C. demersum then *L. giba* and *P. stratiotes* while *J. repens* and Bermuda grass showed a limited distribution (Fig 4). *E. crassipes* is the most abundant among Port-Said and Dakahlia site of 100 and 88% distribution percentage, respectively, followed by *L. giba* among Damietta sites of 60%.

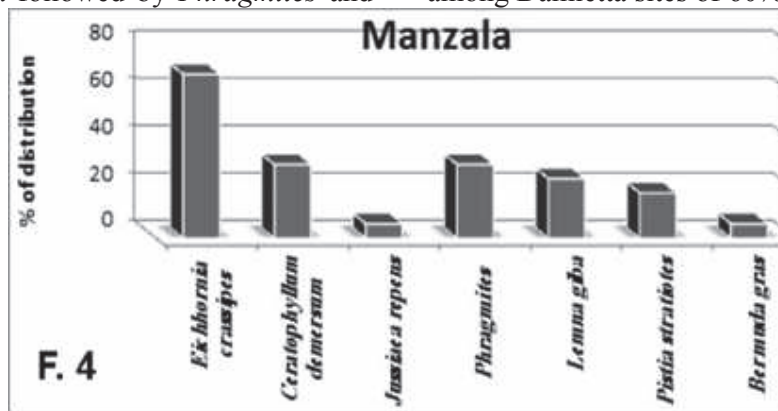


Fig.4: Distribution of aquatic plant species at Lake Manzala.

The macroinvertebrate and freshwater snail distribution patterns (Tab. 2 & Fig. 5), showed total number of living organisms captured was 1410 with taxa richness of 20. Macroinvertebrates were identified as gastropoda, 829 (60.04%), Shrimp, 246 (17.52%), Scud, 154 (10.97%), Hemiptera, 78 (5.56%), Plecoptera, 77 (5.48%), Damselfly and Maggot larvae, each 5 (0.36) and Dragon fly and Crayfish, each 1 (0.07%).

Gastropoda are the most distributed organisms in Lake Manzala followed by Hemiptera and Plecoptera then shrimps and scud. Each of crayfish, Damselfly, Dragon fly and magot larvae showed limited distribution. The maximum macroinvertebrates taxa richness was determined in Gammalya, Dakahlia (16 species), while the maximum abundance was recorded at Annanya, Damietta of 591 organisms (20 species). Gastropoda

was the most distributed in Dakahlia and Damietta, while shrimps and Hemiptera is the most distributed in Port-Said followed by Gastropoda. Total number of organisms captured was 843 with taxa richness of 10, resulting in an average snail density of 39.476snails/site. The maximum snail taxa richness was obtained at Gammalya, Dakahlia of 9 species while the maximum abundance was obtained at Annanya, Damietta of 240 snails, (table 2 & fig. 4). Snails were identified as *Planorbis planorbis*, 290 (34.40%), *Biomphalaria alexandrina*, 254 (30.13%), *Physa acuta*, 216 (25.62%), *Melanoides tuberculata*, 51 (6.05%), *Lymnaea natalensis*, 10 (1.19%), *Lanistes carinatus*, 7 (0.83%), *Cleopatra bulimoides*, 6 (0.71%), *Bulinus truncatus*, 5 (0.59%), *Bellamyia unicolor*, 3 (0.36%) and *Helisoma duryi*, 1 (0.12). *B. alexandrina* and *P. planorbis* are the most distributed in Lake Manzala fol-

lowed by *P. acuta*, *C. bulimoides*, *L. natalensis* and *M. tuberculata* then *B. truncatus* and *L. carinatus*. Each of *B. unicolor* and *H. duryi* showed limited distribution in the lake. *C. bulimoides*, *P. planorbis* and *B. alexandrina* are the most distributed in Dakalya, *P. planorbis* is the most distributed in Damietta and each of *P. planorbis*, *B. alexandrina* and *P. acuta* are the most distributed in Port-Said.

The medically important snails' distribution (Fig. 6), were *B. alexandrina*, *B. truncatus* and *L. natalensis* were recorded in Dakahlia while *B. alexandrina* only was recorded in Damietta and Port-Said sites. Active transmitting sites were recorded for *S. mansoni* in El-Khandak, Port-Said and Nasayma, Dakahlia with natural infection of 7 & 6%, respectively in collected *B. alexandrina*.

Table 2: Regional distribution of total snails and macroinvertebrates at different governorates at Lake Manzala.

Governorates Biospecimens		Dakahlia				Damietta		Port Said				% in total sample
		Nasayma	Matarya	Gammalya	IbnSalam	Sayyala	Ananya	El-Tareek Al-Dawly	Kobry El-Lansh	Kaar El-Bahr	El-Khandak	
Snail Species	<i>L. carinatus</i>		2	5								0.83
	<i>C. bulimoides</i>	2	2	2								0.71
	<i>P. planorbis</i>	50	10	20		10	40		60	100	14	34.40
	<i>B. alexandrina</i>	50	50	50				10	30	50	14	30.13
	<i>B. truncatus</i>		3	2								0.59
	<i>L. natalensis</i>	2	1	7								1.19
	<i>P. acuta</i>	10					200		1	5		25.62
	<i>H. duryi</i>			1								0.12
	<i>M. tuberculata</i>			50						1		6.05
	<i>B. unicolor</i>			2	1							0.36
Snail taxa richness		5	6	9	1	1	2	1	3	4	1	10
Macro-invertebrate Taxa	Gastropoda	114	68	139	1	10	240	10	91	156	14	60.04
	Cryfish			1								0.07
	Scud		10	50			94					10.97
	Shrimp		15	10			221					17.52
	Hemiptera	7		20		11			10	30		5.56
	Plecoptera	15		20		1	31		10			0.07
	Dragon fly			1								1.99
	Dameslfly			5								3.42
	Maggot larvae						5					0.36
Total number of collected macro-invertebrates		136	93	246	1	22	591	10	111	186	14	1411
Macro-invertebrate taxa richness		7	8	16	1	3	6	1	5	5	1	20

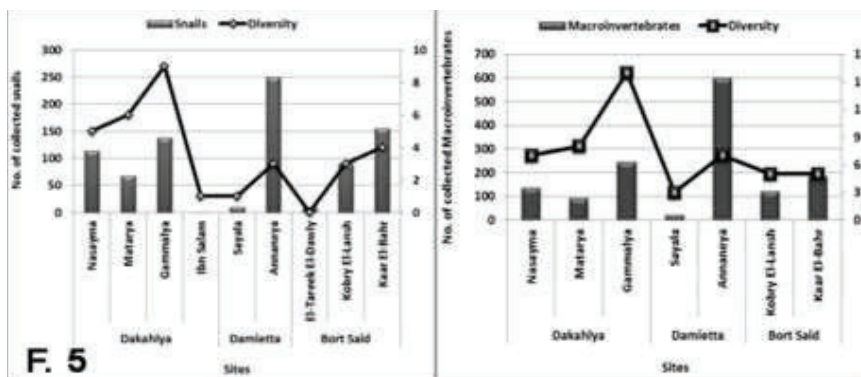


Fig. 5: Taxa richness and Diversity of macroinvertebrates & freshwater snails in Lake Manzala in 3 governorates

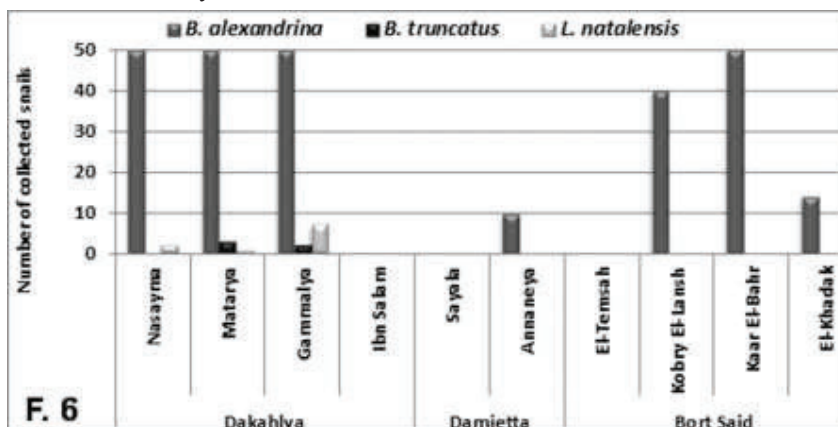


Fig. 6: Distribution and abundance of medically important snail within Lake Manzala sites of governorates.

Bioaccumulation of heavy metals in snails and fish samples: Levels of the heavy metals lead (Pb), copper (Cu), zinc (Zn) and cadmium (Cd) were determined in water surface of Lake Manzala, besides whole soft body tissues of both freshwater snail species (*B. alexandrina* & *M. tuberculata*), also they measured in different organs of fish *Oreochromis niloticus* (muscle, liver and kidney). Results of Pb, Cu, Zn and Cd bioaccumulation levels in *Biomphalaria* and *Melanoides* snails are explored in (Fig. 7), it was highest in compared to its level in surface water. The studied snails collected from Kobry El-Lansh and Port-Said governorate showed highest bioaccumulation of all metals. These results were co-parallel with the highest level of Pb, Cu & Cd in water samples collected from same study sites whereas the highest Zn level was observed in Gammalya site followed Kobry El-Lansh site. When the capacity of bioaccumulation are compared between *Biomphalaria* and *Melanoides* (Fig.8)

the metal concentration values exhibited that *B. alexandrina* have greater capacity for Pb, Cd and Zn accumulation, while *M. tuberculata* has greater capacity for Cu accumulation.

The accumulation of heavy metals in studied fish organs (liver, kidney and muscle samples) showed higher concentrations than surface water (Fig. 9). Pb & Cd is more accumulated in kidneys and Cu is more accumulated in liver while Zn is accumulated in all examined fish parts in descending order: Kidney > liver > muscle. Kidneys of fish samples collected from Dakahlia (Matarya) showed the highest accumulation of Pb, Cd and Zn than other sites of Lake Manzala, while liver of fish samples collected from Kobry El-Lansh showed the highest accumulation of Cu and Zn. Also, results showed that in contrast to snails, the highest accumulation in fish tissue was not co-parallel with highest level in water samples in the same study sites

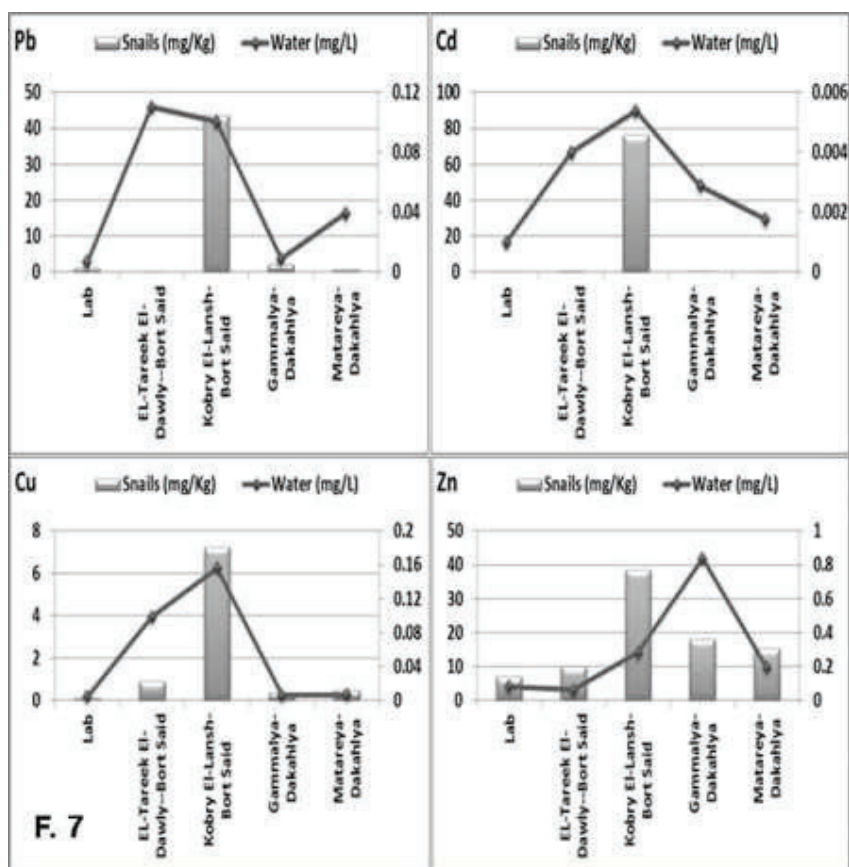


Fig. 7: Levels of cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) in water samples and their residues in tissue of *B. alexandrina* and *M. tuberculata* collected from sites of Lake Manzala in Port-Said, Dakahlia and Damietta governorates and laboratory reared ones.

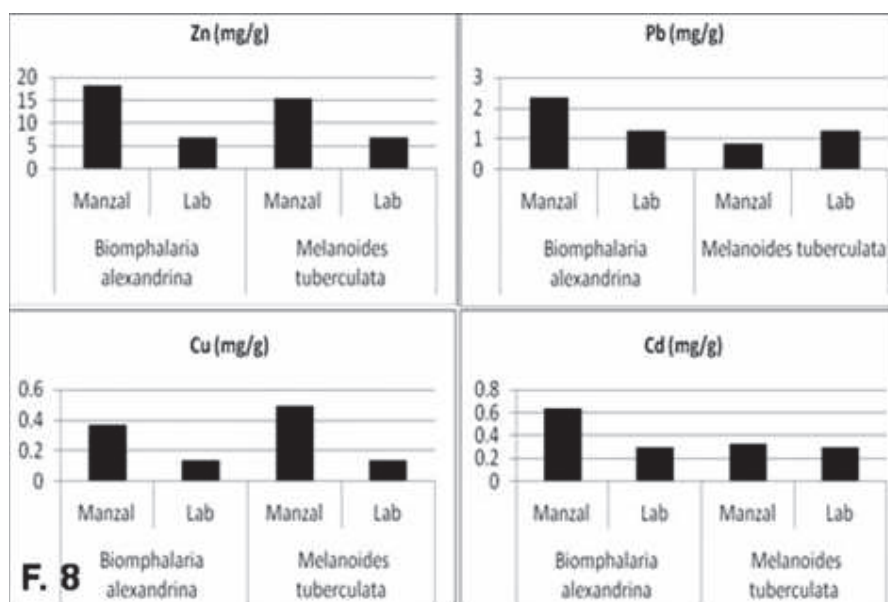


Fig.8: Residues of Cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) in laboratory breeding snails, *B. alexandrina* and *M. tuberculata* and those collected from Lake Manzala in Dakahlia Governorate.

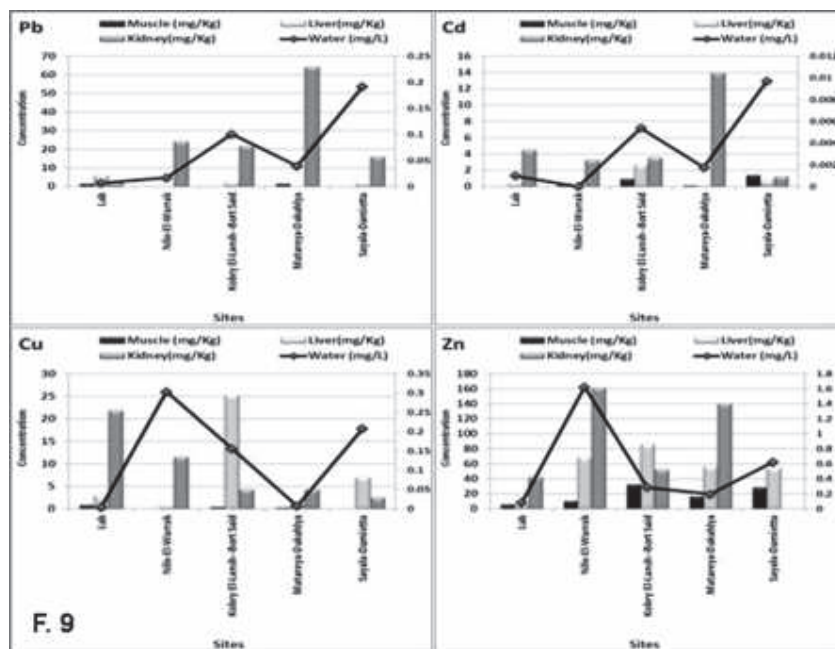


Fig. 9: Levels of cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) in water samples and their residues in muscle, liver and kidney of *Oreochromis niloticus* fish samples (Family: *Cichlidae*) and laboratory reared ones.

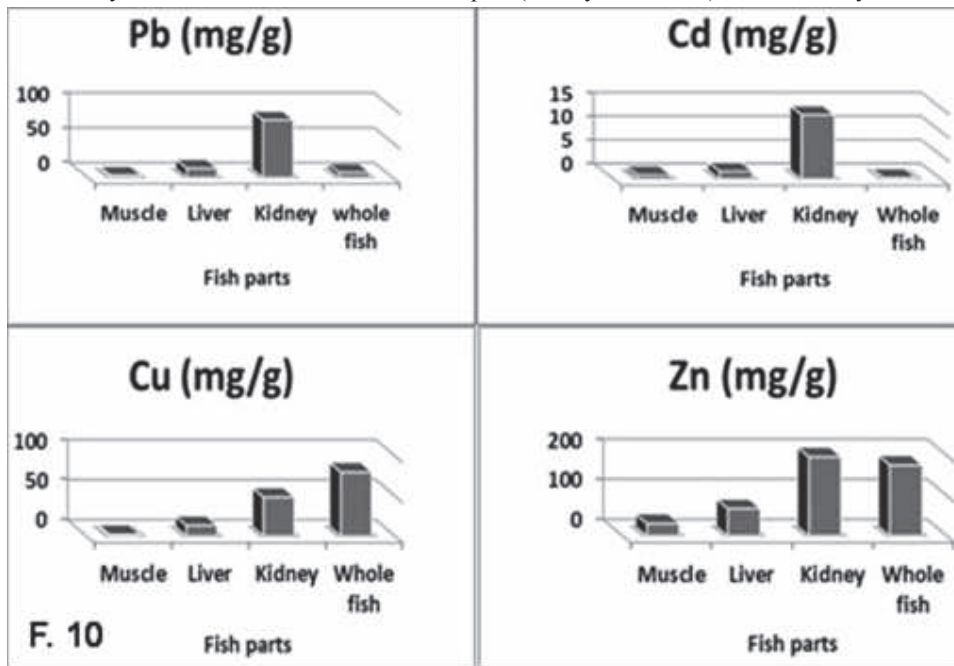


Fig. 10: Accumulation pattern of Cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) in different fish parts; muscle, liver, kidney and whole fish; determined in *O. niloticus* fish samples collected from Lake Manzala.

Concentrations (Fig. 10) of Pb, Cd, Cu and Zn in the different examined fish tissues. Metal accumulated in the following orders: kidney> liver>whole fish>muscle for Pb, kidney>liver>muscle>whole fish for Cd, whole fish>kidney>liver>muscle for Cu and

kidney>whole fish> liver>muscle for Zn, the kidney and liver were the target organs in accumulation of heavy metals. The tissues of *O. niloticus* accumulated more heavy metals and the highest values were recorded in the tissues of fish from Dakahlia (Matarya site).

Discussion

The present study concerned to address pollution impact on the ecosystem of Lake Manzala. It was noticed through the results of physico-chemical parameters that Lake Manzala sites in Damietta and Port-Said shared higher levels of dissolved oxygen, conductivity and heavy metals (Pb, Cd and Cu) than Dakahlia sites, which showed higher level of Zn. This could be related to Damietta and Port-Said sites were more near to Mediterranean Sea, where water exchange takes place between the lake and sea across Strait El Gamil. Also, both Damietta and Port-Said sites are adjacent to industrial areas that adversely affect their water quality. On the other hand, Dakahlia sites more suffered from some point sources of pollution represented by some drains providing their habitat with the highest taxa richness of freshwater organisms including the three medically important snails, *Biomphalaria*, *Bulinus* and *Lymnaea*. Sites of Dakahlia and Port-Said, especially in the southern part, shared the active transmission of *S. mansoni* and the high distribution of the aquatic plant, *E. crassipes*. The recorded temperature in the present study ranged from 21-31°C that explained the abundance of gastropoda that tolerated to a wide range of temperature. This agreed with El-Emam and Roushdy (1981) who demonstrated that the optimum temperature for these mollusca lied between 22°C to 26°C.

The present study recorded higher natural infection among collected *Biomphalaria* compared to other studies in watercourses reflected high risk of schistosomiasis transmission in the lake where people considering as safe water and where traditional methods of snail control couldn't be applied. El-Homossany (2006) showed that natural snail infection can occur in Nile especially in sites where fishing and agricultural activities, but mostly by low ratio, for *B. alexandrina* and *B. truncatus* snails (0.71% and 0.29, respectively). Also, El-Khayat *et al.*, (2005) indicated that the natural infection among field

B. alexandrina snails collected from different localities was low (1.1). Haristone (1973) concluded that low percentage of natural infection is the rule (1-2%), however high percentage (3.3-7.5) may be recorded in summer period suggestion that the proportion of snails infected with schistosome at any time depends upon complex interaction of different factors. Manzala sites in the three governorates shared the inhabiting of *Biomphalaria* where it was associated with *E. crassipes* in Dakahlia and Port-Said sites and with *L. giba* in Damietta sites. *Biomphalaria* is the only among medically important snails that could tolerated the higher levels of heavy metals that recorded in Port-Said and Damietta governorates suggesting its higher resistance to pollution impacts and environmental stressors. This suggestion was reinforced by El-Khayat *et al.* (2011a) found that *B. alexandrina* was significantly found to live under the highest level of Pb, Cd, Cu, Na, K and Ca concentrations than the other snail species ($p < 0.01$). Also, El-Khayat *et al.* (2011b) studied the habitat characteristics for different freshwater snail species biologically through macroinvertebrate information and determined that *B. alexandrina* was the more distributed in sites that evaluated as very poor sites (23% of their sites were evaluated as very polluted sites). Mahmoud (2001) commented that the adverse effects of water pollution on snail biology were modified by biotic factors including food supplies, aquatic plants, behavioral and physiological adaptation.

The present data of water analysis explored that all the measured heavy metals in Damietta and Port-Said sites and Zn and Cd in certain Dakahlia sites exceeded the limits determined EPA (2011). Also, the average of the four metals along the lake in the three studied governorates exceeded the recommended limits, this exhibited that Lake Manzala is polluted lake. This agrees with the demonstration that Lake Manzala receives huge amounts of sewage, industrial and agricultural wastes via Bahr El-Bakar

drain, which collects these pollutants from different districts through its way from Cairo (Badawy and Wahaab, 1997; Abdel-Baky *et al.*, 1998a, b; Ibrahim *et al.*, 1999a; Bahnasawy, 2001; Bahnasawy *et.al.*, 2009; Khalil and Faragallah, 2008). Moreover, Ali (2008) concluded that heavy metals discharged into the lake create a serious environmental problems, where the level of iron, manganese, lead and cadmium are exceeded the universal guidelines for water quality established by Environmental protection Agency.

In the present study, the concentration of the four measured metals was higher in *Biomphalaria* and *Melanoides* tissues as compared to surface water. These results coincided with the highest levels of Pb, Cu & Cd in water samples. This is in agreement with Mahmoud and Abu Taleb (2013) who studied the relationship between accumulations of Cd, Cu and Pb in tissues of snails *C. bulimoides*, *H. duryi*, *B. truncatus*, *B. alexandrina*, *P. acuta*, *B. unicolor* and *T. niloticus* and its concentrations in water. They showed that the accumulations of Cd, Cu and Pb in the tissues of snails were directly proportional with concentrations of these elements in the water from which these snails were harbored.

Heavy metals are known to be accumulated in fish tissues, reaching concentrations of up to 20000 fold higher than surrounding water environment (Popek *et al.*, 2006). The present heavy metals accumulation pattern in different fish tissues of *O. niloticus* demonstrated that Pb and Cd are most accumulated in kidney, Cu is most accumulated in liver while Zn is accumulated in all examined parts with maximum accumulation in kidney. Western Australian Food and Drink Regulations recommended a level of 40mg/kg Zn for human consumption (Marks *et al.*, 1980). Accordingly, the concentrations of Zn in the muscles of the studied fish are still below the permissible level. Also, the concentrations of Cu in the muscles of the studied fish are still below the permissible level for Cu (30mg/kg) recommended by the Na-

tional Health and Medical Research Council (Marks *et al.*, 1980). Kotze *et al.* (1999) and Canli and Atli, (2003) interpreted that the difference in the levels of accumulation in different organs tissue of fish can be attributed primarily to the differences in the physiological role of each organ. Also, regulatory ability, behavior and feeding habits are other factors that influence the accumulation differences in different organs. This is confirmed by the findings of Abdel-Moneim *et al.*, (1994) who reported that, target organs, such as the liver and gills, are metabolically active tissues and accumulate heavy metals in higher levels, as shown in many species of fish, *Mugil cephalus* in the Mediterranean Sea, *Clarias gariepinus* and *Labeo umbratus* from Olifants River, South Africa (Coetzee *et al.*, 2002) and *Tilapia zilli* from River Nile (Hamed, 1998). The present highest accumulation of Cu in fish liver was interpreted by El-Shahawi and Yousuf (1998) and Abdel-Baky (2001) who stated that the high accumulation of Cu in the liver could be attributed to the specific metabolic processes and enzyme catalyzed reaction involving Cu taking place in the liver. Also, the sulfur legends in the liver have a great tendency to co-ordinate with Cu *via* oxygen carboxylate amino group nitrogen and/or sulfur of the mercapto group in the metallothionein protein which is in the highest concentration in the liver. Also, the present least bioaccumulation for all the measured metals in fish muscles was confirmed; Zaghoul *et al.*, (2007) who studied heavy metals (Cu, Pb, Zn and Mn) accumulation in some selected vital organs (gills, liver, kidney and muscle) of the Nile tilapia; *O. niloticus* collected from the different sites along El-Burullus Lake and declared that the lowest concentrations of the studied heavy metals accumulated in muscle. Also, Bahnasawy *et al.* (2009) found that muscles contained the lowest levels of heavy metals in the examined fish *M. cephalus* and *L. ramada*. Soltan *et al.* (2005) and Fernandes *et al.* (2008) found that Cu exhibited its highest

levels in the liver and the lowest values in the muscles. Furthermore, many authors reported that muscle was not an active tissue in accumulating heavy metals (Ibrahim *et al*, 1999a, b; Canli and Atli, 2003; Karadede *et al*, 2004; Yilmaz, 2005; Chouba *et al*, 2007).

Conclusion

The outcome results proved that the concentrations of metals in the studied fish tissues were dependent upon the target organ as well as the type of metal. Generally, the studied metals were more concentrated in the non-edible parts of the fish than the edible muscles. Zn, Cu, Pb and Cd concentrations in the muscles were within the maximum permissible limit. It is clear that the tissues of snails accumulated more metals than fish *O. niloticus*. Thus, Public Health and Agricultural Authorities must keep into consideration the heavy metals in fishes and their impact on human health and economy.

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