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Full Length Research Paper

Distributions of metals (cadmium, lead, iron, manganese, zinc and copper) in water, aquatic plant and fish

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Abstract

The River Nile is the principal fresh water resource, supplying Egypt with about 98 percent of its fresh water (Abu-Zeid, 2003 and Ali et al., 2008). Pollution in the River Nile's main stem, drains and canals has increased in the last few decades (NWRC, 2000). Concentrations of cadmium (Cd), lead (Pb), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were measured in water, Ceratophillyum demersum (C. demersum) aquatic plant, and the muscle, gill, liver, blood and kidney of Claries lazera fish (C. lazera) collected from nine sampling stations (districts), Beni Suef, Elfashn, Beba, Somosta, Ehnasia, Elwasta and Naser, along El Ebrahimia canal and two districts located at the east bank of the Nile (Bayed El-Arab and Sanor) in the province of Beni Suef, Egypt during 2009-2010 using Solar Atomic Absorption spectrometer M6.The results reveal that the studied metals were detected in all the examined samples. In water, Pb had the highest concentration among the metals detected in Elfashn, Beba, Naser, Elwasta, Somosta, Bayed El-Arab and Sanor; Mn presented the highest concentration in Ehnasia, while Fe had the highest concentration in Beni Suef. The concentrations of Pb, Fe, and Mn were above the maximum permitted limits in all the districts. Cd concentration was above the permitted limit, except in Somosta and Naser, while Zn and Cu concentrations were below the permitted limits in the nine districts. The metal levels in water were compared with national and international water quality guidelines, and with the literature values reported for rivers and streams. Comparisons were made of the metal concentrations in water and aquatic plants with those in the catfish tissues obtained from water. The metal concentrations found in the C. demersum aquatic plant samples taken in the nine studied districts were distributed in this order; Mn > Zn > Cu >Pb >Fe > Cd. and were higher than the water. In fish, metals accumulated in the various examined tissues at several levels, but the metal concentrations in muscles (edible part) were below the metal levels in the other organs (nonedible) in the fish samples. The concentrations of Cd, Pb and Fe in fish tissues were above the international standard, while the concentrations of Mn, Zn and Cu were below this standard. The high concentrations of these metals in water, aquatic plants and fish in El Ebrahimia canal may be the result of both anthropogenic activities producing industrial, agricultural and domestic waste and accidental pollution incidents.

Keywords: Heavy Metals, Aquatic environment, Nile River

INTRODUCTION

Water Pollution is considered to be one of the most dangerous hazards affecting Egypt. Pollution in the Nile River System (main stem Nile, drains and canals) has increased in the past few decades because of increases in population; several new irrigated agriculture projects, and other activities along the Nile. As the program to expand irrigated agriculture moves forward, the dilution capacity of the Nile River system will diminish at the same time that the growth in industrial capacity is likely to increase the volume of pollutants discharged to the Nile.

The pollution of surface water in Beni Suef constitutes a great hazard to all biological systems. The principle pollutants of water in the governorate are heavy metals especially cadmium, lead, iron, manganese, zinc and copper (EEAA, 2008).

Heavy metals are among the many chemical compounds regarded as harmful and present in atmospheric air, soil and water. Human release more of the metals by burning fossil fuels and discharging industrial, agriculture and domestic wastes. The main threats to human health from heavy metals are associated with exposure to cadmium and lead. Although several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed countries, though emissions have declined in most developed countries over the last 100 years (Brodkin et al., 2007; Järup, 2003 and Senze et al., 2009).

Aquatic plants are known in accumulating metals from their environment and affect metal fluxes (Kara, 2005). Aquatic plants absorb heavy metals from the water and can accumulate high amounts of heavy metals. In such way, they reflect the toxicity of the water environment, and may serve as a tool for the biomonitoring of contaminated water (Ravera, 2001; Zurayk et al. 2001 and Cardwell et al., 2002). Fish is one of our most valuable sources of protein food. Worldwide, people obtain about 25% of their animal protein from fish and shellfish. The protein found in fish is of high biological value, which means that fish can be used as the sole source of protein in the diet. Aquatic system become contaminated with heavy metals released from domestic, industrial, mining and agricultural effluents which are continuously discharged into it (Chouba et al., 2007 and Tulonen et al., 2006). Many fish species are among the top consumers of trophic pyramids in aquatic ecosystem. In consequence, they are endangered by diet-borne pollutants (e.g heavy metals) transferred along the food chain (Khalil et al., 2008).

The aim of this work was to estimate the distribution of some metals in different compartments of the aquatic environment in the River Nile and El Ebrahimia canal throughout the province of Beni Suef, Egypt. For this purpose, concentrations of Cd, Pb, Fe, Mn, Zn and Cu were measured in surface water, Ceratophyllum demersum aquatic plant and muscles, gills, liver, blood and kidney of Claries lazera fish. The analysis of this metals in previously digested samples were carried out by Atomic Absorption Spectroscopy (AAS) M6.

MATERIALS AND METHODS

Sampling sites

Nine sampling sites, Beni Suef, Elfashn, Somosta, Beba, Elwasta, Ehnasia and Naser of El Ebrahimia canal and two districts located at the east bank of the Nile (Bayed El-Arab and Sanor) in Beni Suef province.

Sampling and sample preparation

A total of 162 samples of surface water, aquatic plant (C. demersum) and of catfish species (Claries lazera) (fifty four sample of each) were collected from El Ebrahimia canal along seven districts Beni Suef, Elfashn, Somosta, Beba, Elwasta, Ehnasia and Naser and two districts located at the east bank of the Nile (Bayed El-Arab and Sanor) of Beni Suef province (18 of each district) during one year in the period 2009-2010. Water were taken using 0.5 liter bottles pre-cleaned with polyethylene and acidified with 5 ml of concentrated HNo_3 and stored approximately at refrigerator. The water samples digested by using equal volumes of a mixture of nitric and perchloric acids. All digested samples were (pH) adjusted and volumetrically recorded Chau et al., (1979). C. demersum samples were packed in labeled clean plastic bags in deep freezer (-20 ºC) for chemical analysis. Plant samples were digested according to the method described by Chapman and Pratt, (1982) using an acid mixture of 750 ml of concentrated nitric acid, 150 ml of concentrated sulfuric acid and 300 ml of 60-62% perchloric acid. A total of thirty five catfish (Claries lazera) were collected with nets by professional fishermen. The samples were brought to the laboratory on the same day. The body length of the fish was ranged from 35-40 cm and the body weight was ranged from 500-600 gm. Two ml of blood using the tail cutting method, approximately 2 g of the epaxial muscle on the dorsal surface of the fish, the entire liver, two gill racers, and 2 gm of kidney from each sample were dissected, washed with distilled water, dried in filter paper, weighed, packed in polyethylene bags and kept at −20°C until analysis for metals concentrations determination. Samples were digested using mixture of nitric acid and perchloric acid according to method applied by Agemain et al., (1980) while blood samples was digested according to method applied by Zilva, (1973).

Samples Analysis

The metal analyses of the previous digested samples (Cd, Pb, Fe, Mn, Zn and Cu) were carried out using Atomic Absorption Spectroscopy M6, Thermo scientific 2009 according to Robinson and Dekker, (1990). The concentrations of heavy metals are expressed as mg/kg wet weight of tissues. The absorption wavelength values were 228.8 nm for Cd; 0.5 nm for Pb; 228.8 nm for Fe; 279.5 nm for Mn; 213.9 nm for Zn and 488 nm for Cu.

Statistical procedures

Statistical analyses were performed using the statistical

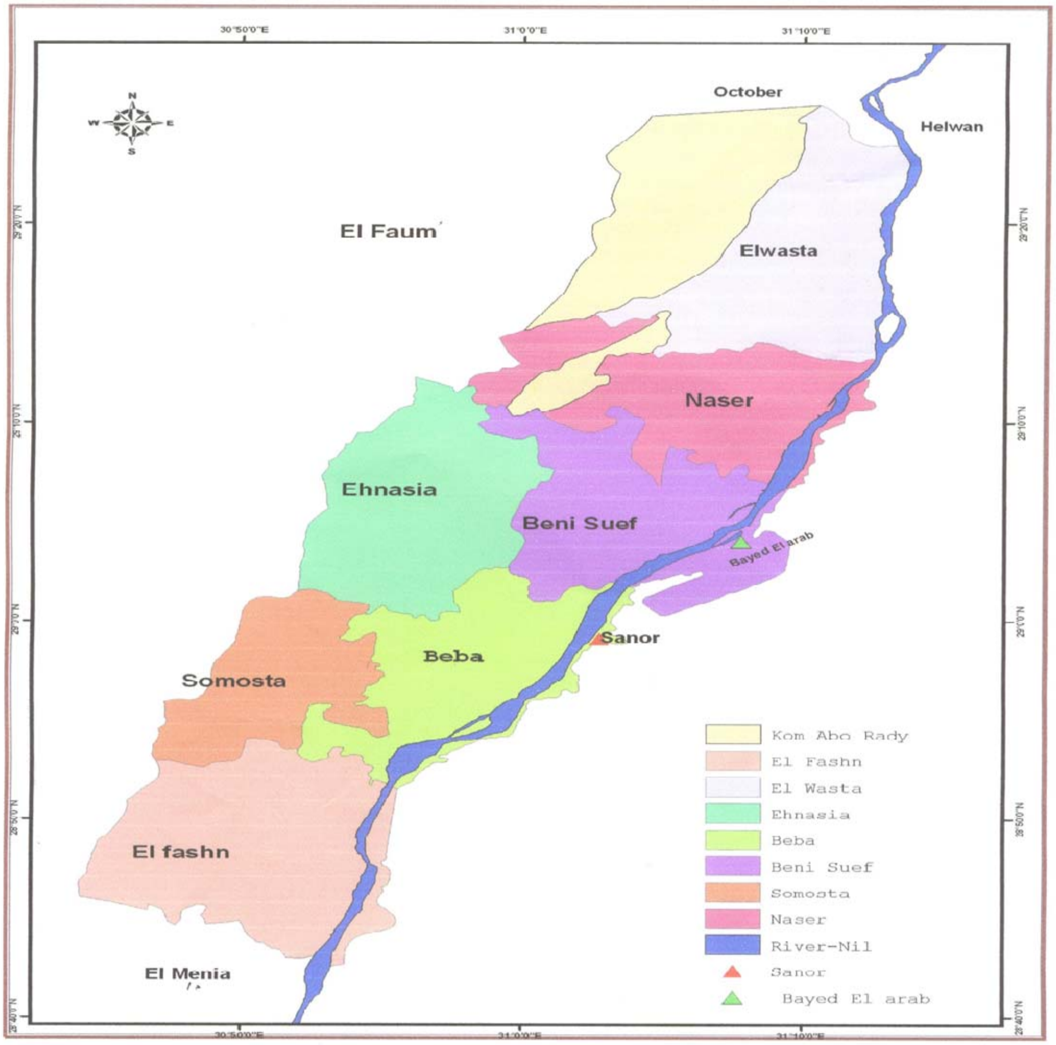

Figure 1: Map of Beni Suef governorate districts

Soft ware package Graph Pad in Stat Version 2. The 0.05 level of probability was used as the criterion for significance.

DISCUSSION

Metal concentrations in water

Metal concentrations (Cd, Pb, Fe, Mn, Zn and Cu) in water samples are represented in Table 1.and Figure. 2. Pb has the highest concentration among the detected metals in Elfashn, Beba, Ehnasia, Elwasta, Naser, Sanor and Bayed El-Arab while in Beni Suef Fe has the highest concentration and Mn has the highest concentration in Somosta. In order of metals concentrations in different sites of El Ebrahimia canal and Nile River, concentration of metals in water follow the order of. In Beni Suef were Fe > Pb > Mn > Cd > Zn > Cu; In El Fashn were Pb > Fe > Mn > Cd > Cu > Zn, In Beba were Pb > Fe > Cd > Zn > Mn > Cu, in Somosta were Pb > Mn > Fe > Cu > Zn > Cd in Ehnasia were Mn > Pb > Fe > Cu > Zn > Cd, in Elwasta were Pb > Mn > Fe > Cd > Zn > Cu, in Naser were Pb > Fe > Zn > Cu > Mn > Cd, in Bayed El-Arab were Pb > Zn > Cu > Fe > Mn > Cd and in Sanor Pb > Mn > Fe > Zn > Cu > Cd.

The highest concentration of Cd was in Beni Suef, Elwasta, Elfashn, Bayed El-Arab, Beba, Ehnasia, Somosta Naser and Sanor (0.029 ± 0.0006; 0.029± 0.0006; 0.025 ± 0.002; 0.020 ± 0.003; 0.017 ± 0.002; 0.014 ± 0.001; 0.010 ± 0.004, 0.006±0.002 and 0.004±0.001 ppm respectively).

Cd concentrations were above the recommended limit (0.01 mg/l) adopted by (EOS, 1993); (WHO, 1993) and (U.S.EPA, 1998) except in Naser, Somosta and Sanor sites were below the level. Metals concentrations were

Table 1. Metal concentrations (ppm) in surface water samples collected from different districts of El Ebrahimia canal and Nile River in Beni Suef Governorate

Districts	Cd	Pb	Fe	Mn	Zn	Cu
Beni Suef	0.029 ± 0.0006	0.254 ± 0.086	0.293 ± 0.130	0.196 ± 0.093	0.019 ± 0.001	0.018±0.0007
Elfashn	0.025 ± 0.002	0.247 ± 0.120	0.182 ± 0.006	0.089 ± 0.054	0.008 ± 0.004	0.015±0.0003
Beba	0.017 ± 0.002	0.379 ± 0.024	0.050 ± 0.002	0.016 ± 0.006	0.017 ± 0.0004	0.015±0.0005
Somosta	0.010 ± 0.004	0.422 ± 0.131	0.048 ± 0.001	0.053 ± 0.025	0.015 ± 0.0003	0.018±0.0007
Ehnasia	0.014 ± 0.001	0.433 ± 0.046	0.307 ± 0.005	0.725 ± 0.132	0.019 ± 0.004	0.026± 0.0004
Elwasta	0.029 ±0.0006	0.710 ± 0.023	0.090 ± 0.003	0.461 ± 0.037	0.028 ± 0.008	0.014±0.0005
Naser	0.006 ± 0.002	0.889 ± 0.102	0.145 ± 0.026	0.01± 0.003	0.017 ± 0.0005	0.015±0.0008
Bayed El-Arab	0.020±0.003	1.127± 0.129	0.049±0.0007	0.040±0.013	0.164±0.032	0.057±0.0002
Sanor	0.004±0.001	0.725± 0.052	0.103±0.090	0.268±0.156	0.015±0.0005	0.017±0.0008
References						
WHO, 1993	0.01 ppm	0.01 mg/L	0.01 mg/l	0.01 ppm	4 mg/l	2 mg/l
US-EPA, 1998	0.01 ppm	0.05 ppm	0.30 mg/l	0.10 mg/l	0.30 mg/l	0.05 mg/l
EOS, 1993	0.01 mg/l	0.1 mg/l	0.3 mg/l	--	5 mg/l	1 mg/l
CCME (2005) for irrigation water	5.1 (ug/l)	200 (ug/l)	5000 (ug/l)	200 (ug/l)	1000-5000 (ug/l)	-
CCME (2005) Livestock water	80 (ug/l)	100 (ug/l)	--	--	50000 (ug/l)	-

Data expressed as Mean ± S.E and N=5.

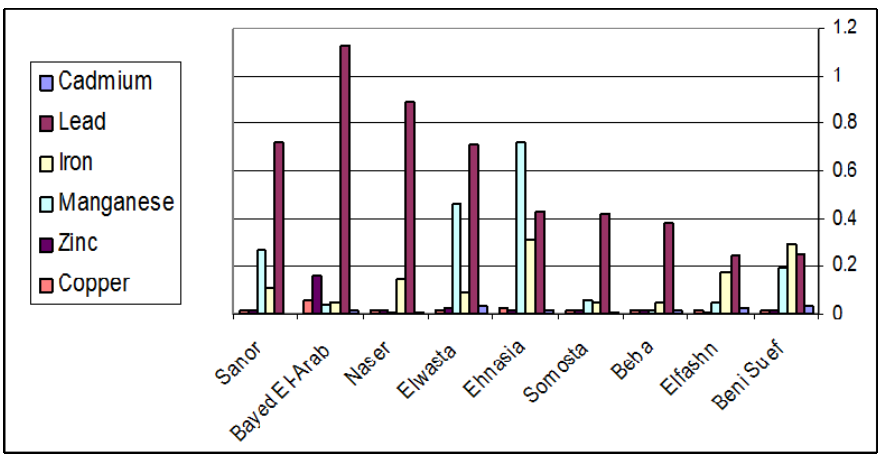

Figure 2: Metal concentrations (ppm) in water samples collected from Beni Suef Governorate districts.

below the limits adopted for irrigation water and livestock water by CCME, 2005 (5.1 and 80 ug/l respectively), thus toxic effects for Cd may be observed. Our results were above concentrations of Cd in water from River Nile in Aswan, Assiut and Beni-Suef regions (0.011 ± 0.005, 0.011 ± 0.01 and 0.013 ± 0.007 mg/L respectively) (Salem et al. 2001); in surface water samples collected from Elfashn, Beba, Beni Suef, Somosta, Naser and Ehnasia districts (0.07±0.002, 0.091±0.0019, 0.107±0.036, 0.0879±0.014, 0.086±0.019 and 0.089±0.0034 ppm respectively) (Abdou et al., 2003) and from selected khors of Lake Naser (Fatma, 2008) but were below the results obtained in water from Hawamdia (Nile), Kafer-El-Zayat (Nile) (Khallaf et al., 1994).

The highest concentration of Pb was in Bayed El-Arab, Naser, Sanor, Elwasta, Ehnasia, Somosta, Beba, Beni Suef and El fashn (1.127 ± 0.129; 0.889 ± 0.102; 0.725 ± 0.052; 0.710 ± 0.023; 0.433 ± 0.046; 0.422 ± 0.131; 0.379 ± 0.024; 0.254 ± 0.086 and 0.247 ± 0.120 ppm respectively). Pb mean values were relatively above the recommended limit (0.01 mg/l) by WHO, (1993) and above the maximum permissible limit (0.05 mg/L) which is the highest contaminant level recommended by the National Interim Primary Drinking Water Regulations (U.S.EPA, 1998) but it was below the limits adopted by CCME, 2005 for irrigation water and livestock water (200 and 100 ug/l) respectively. Abdou et al., (2003) found that lead levels in water samples were 0.07±0.002, 0.091±0.0019, 0.107±0.036, 0.0879± 0.014, 0.086±0.019, 0.089±0.0034 ppm (mg/liter) in El-fashn, Beba, Beni-Suef, Somosta, Naser and Ehnasia districts, respectively. Our results were below the results of Pb concentrations in samples of water collected from Nile in Hawamdia and Kafer-El-Zayat (3.43 and 2.89 mg/l respectively) and from Nile River in Assiut governorate (1.940, 0.810, 0.810, 0.314, and 0.790 ppm) (Khallaf et al., 1994 and Abd El-Nasser et al., 1996) and higher than the results of Pb concentration in water samples collected from lake Naser (Rashed, 2001 and Fatma, 2008).

The highest concentration of Fe was in Ehnasia, Beni Suef, Elfashn, Naser, Sanor, Elwasta, Beba, Bayed El-Arab and Somosta (0.307 ± 0.005; 0.293 ± 0.130; 0.182 ± 0.006; 0.145 ± 0.026; 0.103 ± 0.090; 0.090 ± 0.003; 0.050 ± 0.002; 0.049 ± 0.0007 and 0.048 ± 0.001 ppm respectively). Increase in Fe levels above the international standards (0.01 mg/l) (WHO, 1993) but below the limits (0.10 mg/l) adopted (U.S.EPA, 1998) and (EOS, 1993) except in Ehnasia, Beni Suef, Elfashn, Naser, Sanor were above the limit. Ali and Soltan, (1999) investigated Fe concentrations in River Nile water at four main stations, Aswan (at south), Mansoura, Damieta and Ras-El-Bar (at North) and the results were 0.30, 0.29, 0.38 and 0.08 mg/l respectively. The concentrations of Fe in water from selected khors of lake Naser (ElRamla, Kalabsha, Korosko, and Toushka) are 0.789, 0.441, 0.603, and 1.225 ppm respectively (Fatma, 2008).

The highest concentration of Mn was in Ehnasia, Elwasta, Sanor, Beni Suef, Elfashn, Somosta, Bayed El-Arab, Beba, and Naser (0.725 ± 0.132; 0.461 ± 0.037; 0.268 ± 0.156; 0.196 ± 0.093; 0.089 ± 0.054; 0.053 ± 0.025; 0.040 ± 0.013; 0.016 ± 0.006 and 0.01± 0.003 ppm respectively). Increase in Mn levels above the international standards (0.01 mg/l) adopted by (WHO, 1993) and (0.10 mg/l) adopted by U.S.EPA, (1998) except in Naser but was below the international level (200 ug/l) for irrigation water adopted by CCME, (2005). Mn concentrations in River Nile water at four main stations, Aswan (at south), Mansoura, Damieta and Ras-El-Bar (at North) are 0.36, 0.042, 0.092 and 0.08 mg/l respectively (Ali and Soltan, 1999). The Mn concentration found in the river Gomti water was in the range: (0.0038-0.0.0973 mg/L) (Singh et al., 2005). Tupwongse et al., (2007) determined Mn in lake water in northern Thailand in concentrations ranged from 40-382 microg L.

The highest concentration of Zn was in Bayed El-Arab, Elwasta, Ehnasia, Beni Suef, Beba, Naser, Somosta, Sanor and Elfashn (0.164 ± 0.032; 0.028 ± 0.008; 0.019 ± 0.004; 0.019 ± 0.001; 0.017 ± 0.0004; 0.017 ± 0.0005; 0.015 ± 0.0003; 0.015 ± 0.0005 and 0.008 ± 0.004 ppm respectively). Concentration of Zn was below the national standards (5 mg/l) adopted by (EOS, 1993) and below international standards (4 mg/l and 0.30 mg/l) adopted by (WHO, 1993 and U.S.EPA, 1998) in all districts along Elibrahimia canal and Nile River in Beni Suef governorate. Also it was below the international standards (1000-5000 ug/l and 50000 ug/l) adopted by CCME, 2005 for irrigation water and livestock water respectively. Zinc concentrations in River Nile water at four main stations, Aswan (at south), Mansoura, Damieta and Ras-El-Bar (at North) are 0.095, 0.137, 0.448, 0.128 mg/l respectively (Ali and Soltan, 1999). Zinc concentrations in different samples of water from Hawamdia (Nile), Kafer-El-Zayat (Nile), Abbassa (Farm), Barseik (Farm) are 0.13, 0.16, 0.16, and 0.24 mg/l respectively (Khallaf et al., 1994).

The highest concentration of Cu was in Bayed El-Arab, Ehnasia, Somosta , Beni Suef, Sanor, Beba, Elfashn, Naser and Elwasta (0.057 ± 0.0002; 0.026 ± 0.0004; 0.018 ± 0.0007; 0.018 ± 0.0007; 0.017 ± 0.0008; 0.015 ± 0.0005; 0.015 ± 0.0003; 0.015 ± 0.0008 and 0.014 ± 0.0005 ppm respectively). Concentration of Zn was below the national standards (1 mg/l) adopted by (EOS, 1993) and below international standards (2 mg/l and 0.05 mg/l) adopted by (WHO, 1993 and U.S.EPA, 1998) in all districts along Elibrahimia canal and Nile River in Beni Suef governorate except in Bayed El-Arab was above the international standards adopted by U.S.EPA, 1998 (0.05 mg/l). This results supported by the results of Mansour and Sidky, (2003) who stated that copper concentrations were determined in Lake Qarun and Wadi El-Rayan wet land (Egypt) and in same way, surface water samples collected from Lake Burullus, Egypt were showed Cu levels (Diab et al., 2006) and the mean concentrations of Cu in 90 water samples collected from six different sites of El-Manzala lake, Egypt was 1.28 ppm respectively (Ahmed and Hussein, 2004).

Metals concentrations in plant

Macrophytes concentrate great amount of metals and are consequently useful indicators of local pollution (Ramadan, 2003 and Magdalena Senze et al., 2009). One of the economic and rapid methods for elements removal is displacement of metals by biosorption. Ceratophyllum demersum (C. demersum) can be used for refining wastewater Foroughi et al., (2010).

The analysis of C. demersum samples in Beni Suef Governorate Table, 2 and Figure.3, revealed that the distribution of metal concentration was in the order of Mn > Cu > Zn > Pb >Fe > Cd in the districts of Beni Suef Governorate. The concentrations of metals in plants were above its level in water which indicates accumulation.

The highest concentration of cadmium was in C. demersum collected from Beni Suef, Ehnasia, Naser, Beba, Sanor, Elwasta, Bayed El-Arab, Elfashn and from Somosta (1.095 ± 0.019; 0.986 ± 0.068; 0.896 ± 0.041; 0.751 ± 0.028; 0.655 ± 0.056; 0.511 ± 0.066; 0.355 ± 0.073; 0.245 ± 0.068 and 0.121 ± 0.004) respectively. High concentrations of Cd were recorded in water and C. demersum plant grown up in lakes and canals in Serbia and Poland (Kastori, 1997; Szymanowska et al., 1999

Table 2. Metal concentrations (ppm) in aquatic plant samples (Ceratophillyum demersum) collected from different districts of El Ebrahimia canal and Nile River in Beni Suef Governorate

Districts	Cd	Pb	Fe	Mn	Zn	Cu
Beni Suef	1.095 ± 0.019	3.107 ± 0.878	1.670 ± 0.026	209.240 ± 0.136	16.934 ± 0.406	20.243±1.370
El fashn	0.245 ± 0.068	6.307 ± 0.325	22.255 ± 1.429	209.438 ± 0.021	19.726 ± 0.971	15.828±2.208
Beba	0.751 ± 0.028	3.235 ± 0.296	1.472 ± 0.063	208.756 ± 0.112	18.114 ± 0.299	20.640±1.158
Somosta	0.121 ± 0.004	21.431 ± 0.988	5.768 ± 1.946	209.639 ± 0.033	18.173 ± 0.212	19.525±0.700
Ehnasia	0.986 ± 0.068	6.032 ± 0.437	1.439 ± 0.022	209.358 ± 0.058	19.095 ± 0.709	22.311± 0.352
Elwasta	0.511 ± 0.066	7.549 ± 0.275	1.553 ± 0.030	209.221 ± 0.060	17.424 ± 0.711	21.180±1.092
Naser	0.896 ± 0.041	2.214 ± 0.120	1.657 ± 0.025	209.182 ± 0.072	17.503 ± 0.622	20.589±0.764
Bayed El-Arab	0.355±0.073	6.202± 0.600	3.364±0.199	209.489±0.058	17.454±0.100	13.427±0.553
Sanor	0.655±0.056	1.219 ± 0.085	2.689±0.060	209.369±0.044	18.266±0.366	11.21±0.088
References						
CCME, 1996	0.1 – 0.2 mg/kg	--	--	--	--	--
WHO, 2003	--	--	20-15 mg/l	--	--	--

Data expressed as Mean ± S.E and N=5.

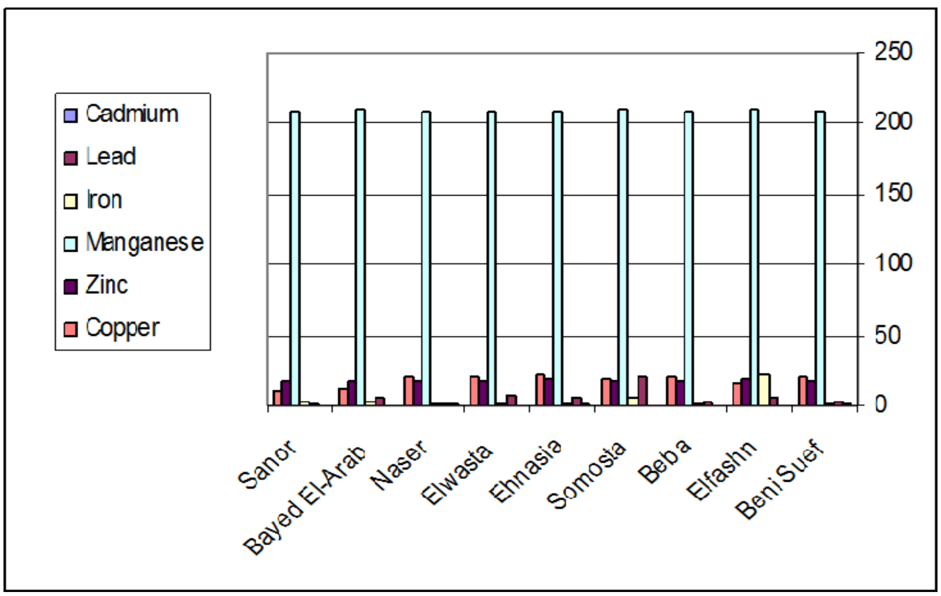

Figure 3: Metal concentrations (ppm) in C. demersum samples collected from Beni Suef Governorate districts.

and Pajevi et al., 2001).

The highest concentration of lead was in C. demersum collected from Somosta, El wasta, El- fashn, Bayed El-Arab, Ehnasia, Beba, Beni Suef, Naser and Sanor (21.431 ± 0.988; 7.549 ± 0.275, 6.307 ± 0.325; 6.202 ± 0.600; 6.032 ± 0.437; 3.235 ± 0.296; 3.107 ± 0.878; 2.214 ± 0.120 and 1.219 ± 0.085) respectively. Ali and Soltan, (1999) investigated the concentrations of lead River Nile ceratophyllum demersum aquatic plant at four main stations, Aswan (at south), Mansoura, Damieta and Ras-El-Bar (at North) and he found the that the concentration of lead are 7.1, 55.7, 38.2 and 1.20 mg/kg respectively. Concentrations of lead in tissue of Ceratophyllum demersum from locality Melenci (which is located on canal Banatska Palanka - Novi Be č ej after flowing of Kikinda canal and before flowing of Stari and Plovni Begej) and locality Lazarevo (downstream from Melenci, after flowing of Stari and Plovni Begej) are on localities Vlajkovac (23,0 μg/g) (Pajevi et al., 2001).

The highest concentration of Fe was in C. demersum collected from El- fashn, Somosta, Bayed El-Arab, Sanor, Beni Suef, Naser, El wasta, Beba and Ehnasia (22.255 ± 1.429; 5.768 ± 1.946; 3.364 ± 0.199; 2.689 ± 0.060; 1.670 ± 0.026; 1.657 ± 0.025; 1.553 ± 0.030; 1.472 ± 0.063 and 1.439 ± 0.022 respectively). Fe concentrations in River Nile C. demersum at four main stations, Aswan, Mansoura, Damieta and Ras-El-Bar are 5527, 4520, 2200 and 380 mg/kg respectively. The increase of Fe concentration in aquatic plants from Aswan is mainly due to the great quantity of hematite (Fe_2O_3) that fall into the Nile during shipping process (Ali and Soltan, 1999). Concentrations of Fe in C. demersum in different canals I Serbia were determined by Kastori, (1997) and Pajevi et al., (2001).

The highest concentration of Mn was in C. demersum collected from Somosta, Bayed El-Arab, El- fashn, Sanor, Ehnasia, Beni Suef., El wasta, Naser and Beba (209.639 ± 0.033; 209.489 ± 0.058; 209.438 ± 0.021; 209.369 ± 0.044; 209.358 ± 0.058; 209.240 ± 0.136; 209.221 ± 0.060; 209.182 ± 0.072 and 208.756 ± 0.112 ppm respectively). Concentrations of manganese in C. demersum from locality Melenci (which is located on canal Banatska Palanka - Novi Be č ej after flowing of Kikinda canal and before flowing of Stari and Plovni Begej) and locality Lazarevo (downstream from Melenci, after flowing of Stari and Plovni Begej) are on localities Novi (12561 µg/g) and Vlajkovac (6985.3 µg/g) and to much lower in locality Hetin (961,0 µg/g), it could be concluded that there is increased chemical contamination of water flow of the Canal, because there have been noticed higher concentrations of mentioned pollutants in plant samples from Lazarevo (Pajevi et al., 2001). Various aquatic plant species are known to accumulate heavy metals through the process of bioaccumulation. World's most troublesome aquatic weed water hyacinth (Eichhornia crassipes) has been studied for its tendency to bio-accumulate and bio-magnify the heavy metal contaminants present in water bodies. The chemical investigation of plant parts has shown that it accumulates heavy metals like manganese (Mn) to a large extent. The Mn tends to show greater affinity towards bioaccumulation. The higher concentration of metal in the aquatic weed signifies the biomagnifications that lead to filtration of metallic ions from polluted water. The concept that E. crassipes can be used as a natural aquatic treatment system in the uptake of heavy metals is explored (Tiwari et al., 2007).

The highest concentration of Zn was in C. demersum collected from El- fashn, Ehnasia, Sanor, Somosta, Beba, Naser, Bayed El-Arab, El wasta and Beni Suef (19.726 ± 0.971; 19.095 ± 0.709; 18.266 ± 0.366; 18.173 ± 0.212; 18.114 ± 0.299; 17.503 ± 0.622; 17.454 ± 0.100; 17.424 ± 0.711 and 16.934 ± 0.406 ppm respectively). The concentrations of zinc in macrophytes collected from various stations of east and west Edku lake are 7.76, 4.43, 15.8 and 11.49, 9.66, 8.66, 13.55, 10.48 mg/kg in E.crassipes, 4.43, 8.75, 11.83, 11.8 and 11.65, 11.07, 15.46, 16.15, 13.58 in potamogeton, and 11.7, 10.97 and 12.32, 12.59, 11.3, 12.9 in ceratophylum demersum (Laila and Abbas, 2005). Concentrations of Zn were determined in biota collected from the Eastern Harbour and El-Mex Bay in the Mediterranean Sea, Egypt. The levels of Zn in the macroalgae, Ulva lactuca, Enteromorpha compressa (green algae) and Jania rubens (red algae), recorded high concentrations and the two species of bivalves, Donax trunculus and Paphia textile, showed different amounts of zinc in their tissue. The levels of Zn accumulated in the Saurida undosquamis, Siganus rivulatus, Lithognathus mormyrus and Sphyraena sphyraena fish samples (Abdallah and Abdallah, 2008).

The highest concentration of Cu was in C. demersum collected from El- fashn, Ehnasia, Somosta, Beba, Naser, El wasta, Beni Suef, Bayed El-Arab and Sanor (19.726 ± 0.971; 19.095 ± 0.709; 18.173 ± 0.212; 18.114 ± 0.299; 17.503 ± 0.622; 17.424 ± 0.711; 16.934 ± 0.406; 13.427 ± 0.553 and 11.21 ± 0.088 ppm respectively). The concentrations of Cu collected in C. demersum at four main stations, Aswan (at south), Mansoura, Damieta and Ras-El-Bar (at North) were 69.5, 63.3, 169 and 118 mg/kg respectively (Ali and Soltan, 1999). In the same manner, Cu levels were determined in Ceratophyllum demersum samples collected from four selected stations on the Habbaniya lake, middle of Iraq during 1997 (Al-Saadi et al., 2002).

Metal contents in tissues of fish

Metal concentrations in muscles, gills, liver, blood and kidney of C. lazera fish samples collected from different sites were measured from 35 specimens. Average metal concentrations in different tissues are shown in Table 3 and Figures 4-8 shows that the detected levels of metal were higher than the metal level in water which may be due to accumulation. Kock et al., (1995) found extremely high concentrations of Cd and Pb in the kidney of Arctic char from alpine lakes in spite of low metal concentrations in the water. Kalfakakon and Akrida-Demertai, (2000) demonstrate that metal concentrations in fish are higher than in water, which indicates the bio-accumulation in the trophic chain of Ioannina Lake ecosystem (Pamvotis, Greece).

There was difference in accumulation of trace metals in various organs of C. lazera fish collected from El Ebrahimia canal from different seven sites. Comparing mean concentration of metals was recorded in different tissues showed the following accumulation ranking: liver > Gills > kidney > blood > muscles. The difference in the accumulation of trace metals in various organs of fishes may be attributed to the quantity present in the water, sediment and plankton, age and type of the fish and presence of ligands in the tissues having an affinity to the metal and/or to the role of the tissue in the detoxification process (Adhikari, et al., 2009).

Table 3: Metal concentrations (ppm) in different organs of catfish (Claries lazera) samples collected from different districts of El Ebrahimia canal and Nile River in Beni Suef Governorate

Districts	Fish organs	Cd	Pb	Fe	Mn	Zn	Cu
	Muscle	0.48 ± 0.15	2.36 ± 0.105	66.016 ± 0.770	0.728 ± 0.078	4.146 ± 0.495	0.536±0.004
	Gills	0.17± 0.100	4.319 ± 0.095	41.886 ± 0.993	11.915 ± 0.337	4.56 ± 0.293	1.305± 0.007
Beni Suef	Liver	0.89 ± 0.038	3.743 ± 0.206	61.315 ± 1.137	1.701 ± 0.093	13.989 ± 3.253	15.772± 2.897
	Blood	0.49 ± 0.051	0.414 ± 0.031	147.383 ± 1.412	1.346 ± 0.175	0.083 ± 0.072	0.697± 0.029
	Kidney	0.77± 0.105	1.705 ± 0.180	143.90 3± 0.482	1.331 ± 0.213	7.526 ± 0.394	3.241± 0.579
	Muscle	0.29 ± 0.118	1.48 ± 0.095	4.11± 0.685	1.205 ± 0.397	6.325 ± 1.518	0.911± 0.139
	Gills	0.09 ± 0.042	8.636 ± 0.229	66.378 ± 0.208	10.446 ± 0.383	0.345 ± 0.205	1.281± 0.069
Elfashn	Liver	1.08 ± 0.024	8.273 ± 0.302	170.370 ± 2.190	1.593 ± 0.122	12.998 ± 0.258	30.105±4.800
	Blood	0.35 ± 0.019	0.547 ± 0.078	142.304 ± 0.600	0.521 ± 0.069	0.025 ± 0.008	0.512±0.070
	Kidney	1.585 ± 0.020	1.68 ± 0.117	4.493 ± 0.164	1.308 ± 0.234	9.353 ± 0.270	3.506±0.154
	Muscle	0.611 ± 0.121	2.336 ± 0.095	40.996 ± 1.427	1.67 ± 0.155	10.441 ± 0.719	0.768±0.039
	Gills	0.176 ± 0.055	6.192 ± 0.220	14.061 ± 1.428	4.955 ± 0.121	1.305 ± 0.782	1.015± 0.173
Beba	Liver	0.148 ± 0.013	8.375 ± 0.532	59.588 ± 0.496	0.748± 0.156	10.825 ± 0.451	15.635±3.057
	Blood	0.224 ± 0.059	0.529 ± 0.079	187.654 ± 0.213	0.451 ± 0.063	0.016 ± 0.004	0.655±0.076
	Kidney	2.136 ± 0.058	1.838± 0.119	5.508 ± 0.131	1.187 ± 0.252	11.083 ± 0.308	3.518±0.164
	Muscle	0.621 ± 0.104	2.26 ± 0.110	88.016 ± 0.336	1.116 ± 0.643	7.419 ± 1.226	1.965±0.415
	Gills	0.087 ± 0.022	8.977 ± 0.212	5.468 ± 0.505	9.1 ± 0.412	8.05 ±0 0.16	1.484±0.116
Somosta	Liver	0.728 ± 0.055	7.101 ± 0.401	207.711 ± 1.624	1.235± 0.062	15.128 ± 0.339	27.31± 0.842
	Blood	0.613 ± 0.069	0.438 ± 0.047	131.232 ± 0.612	0.562 ± 0.203	00.252 ± 0.220	0.415±0.037
	Kidney	1.463 ± 0.153	1.996± 0.435	3.726 ± 0.151	1.815 ± 0.367	10.453 ± 0.243	2.865±0.113
	Muscle	0.263 ± 0.045	2.698 ± 0.072	58.368 ± 0.164	0.883 ± 0.121	6.08 ± 0.113	1.225±0.080
	Gills	0.695 ± 0.202	4.576 ± 0.139	29.753 ± 1.266	8.005 ± 0.312	5.746 ± 0.594	0.97±0.140
Ehnasia	Liver	0.751 ± 0.070	5.576 ± 0.284	95.33 ± 1.374	1.661 ± 0.072	13.491 ± 1.234	37.578±2.416
	Blood	0.398 ± 0.047	0.364 ± 0. 061	152.886 ± 0.909	0.556 ± 0.043	0.051 ± 0.026	0.561±0.056
	Kidney	1.033 ± 0.103	1.6 ± 0.110	8.203 ± 0.542	1.061 ± 0.306	8.698 ± 0.691	2.876± 0.124
	Muscle	0.52 ± 0.210	3.43 ± 0.110	2.748 ± 0.500	0.83±0.092	3.293 ± 1.447	0.665 ±0.092
	Gills	0.716± 0.148	4.93 ± 0.235	41.091± 0.687	16.236± 0.600	5.678± 1.987	1.595±0.181
Elwasta	Liver	0.376 ± 0.001	8.832 ± 0.230	177.643 ± 0.093	1.665 ± 0.169	18.606 ± 1.177	17.188 ± 4.259
	Blood	0.611 ± 0.037	0.666 ± 0.066	150.877 ± 0.517	0.662 ± 0.119	6.834 ± 0.126	1.225 ±0.030
	Kidney	0.288 ±0.058	0.33± 0.205	39.046± 0.491	1.538± 0.281	6.181 ± 0.488	2.88±0.587
	Muscle	0.031 ± 0.006	2.808 ± 0.105	53.783± 0.859	0.731± 0.201	9.475± 0.396	0.626±0.094
	Gills	0.383± 0.143	4.607 ± 0.124	40.071± 0.241	8.288 ± 0.877	2.568 ± 0.087	1.621 ±0.068
Naser	Liver	0.735 ± 0.018	9.585 ± 0.126	53.783± 0.859	1.786± 0.158	12.845± 1.372	22.576±1.103
	Blood	0.475 ± 0.020	0.382 ± 0.139	136.659± 0.790	2.244± 0.069	1.147 ± 0.386	0.629 ±0.042
	Kidney	0.421-0.512	0.160-0.639	135.22-137.95	2.110-2.431	0.378-1.594	0.546-0.685
	Muscle	0.96±0.023	2.553 ± 0.213	69.938±0.864	1.41±0.114	6.083±0.271	0.763±0.116
Bayed El-arab	Gills	0.919±0.531	8.091 ± 0.414	4.468±0.150	4.878±0.649	8.653±0.183	1.363±0.264
	Liver	1.266±0.081	7.235 ± 0.264	277.821±1.472	1.306±0.179	15.111±0.484	25.446±1.245
	Blood	0.193±0.027	0.598±0.043	125.290±1.194	0.48±0.081	5.036±0.733	0.501±0.023
	Kidney	1.355±0.065	1.203 ± 0.073	3.181±0.004	1.604±0.178	9.6±0.322	3.875±0.176
	Muscle	0.061 ± 0.013	1.92 ± 0.090	61.041 ± 1.243	0.968 ± 0.148	3.615 ± 0.484	0.958 ± 0.094
	Gills	2.291 ± 0.087	8.233 ± 0.413	91.49 ± 2.415	3.633 ± 0.686	12.318± 0.068	1.34± 0.085
Sanor	Liver	0.845 ± 0.040	5.961± 0.194	86.105 ± 0.305	1.408 ± 0.156	11.891± 0.692	36.241± 6.681
	Blood	0.192 ± 0.022	0.701 ± 0.010	126.469 ± 0.211	0.512 ± 0.056	4.941 ± 0.301	0.422 ± 0.015
	Kidney	1.962 ± 0.054	3.59 ± 0.134	3.01± 0.041	1.635 ± 0.472	10.201± 0.452	4.813± 0.458
References							
WHO, 2003		--	--	20-15 mg/l	2-9 ug/g	40 mg/kg	--
FAO/WHO, 1999		0.1 µg/g	0.2 µg/g	43 µg/g	2-9 ug/g	60 µg/g	3 µ.g/g
EOS, 1993		0.5 µg/g	2 µg/g	30 µg/g	--	40 µg/g	20 µg/g

Data expressed as Mean ± S.E and N=5.

Concentrations of metals (Cd, Pb, Fe, Mn, Zn and Cu) in tissues of Claries lazera fish of El Ebrahimia canal of Beni Suef, El-fashn, Beba, Somosta, Ehnasia, El-wasta, Naser, Bayed El-arab and Sanor districts were above the permissible limit reported by Food Agriculture Organization/World Health Organization (FAO/WHO), (1999) and Egyptian Organization for Standardization, (1993). Iron recorded the highest content while the Cd recorded the lowest amount in comparable with other metals in all districts. So health hazards could be encountered through the consumption of Catfish in El Ebrahimia canal in Beni Suef, El-fashn, Beba, Somosta, Ehnasia, El-wasta, Naser districts and Nile River of Bayed El-arab and Sanor districts. Catfish can serve as a biomonitor for industrial pollution with heavy metals in Beni Suef Governorate.

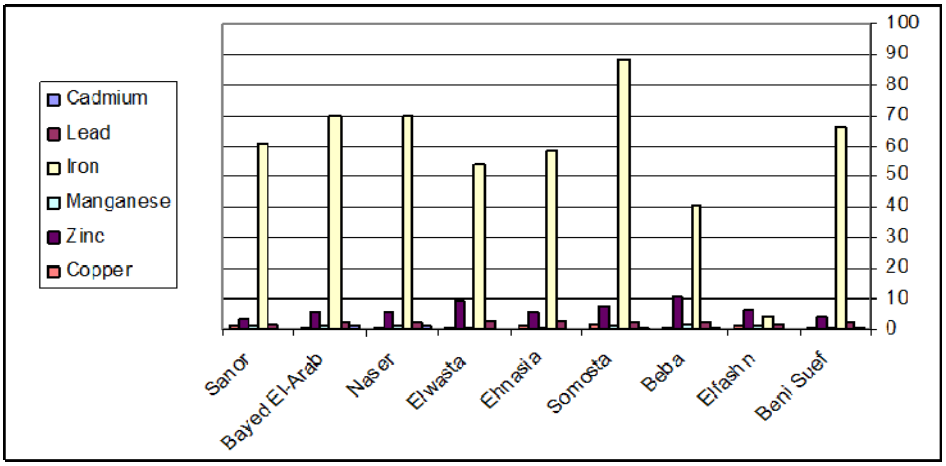

Figure 4: Metal concentrations (ppm) in muscles of Claries lazera fish samples collected from Beni Suef Governorate districts.

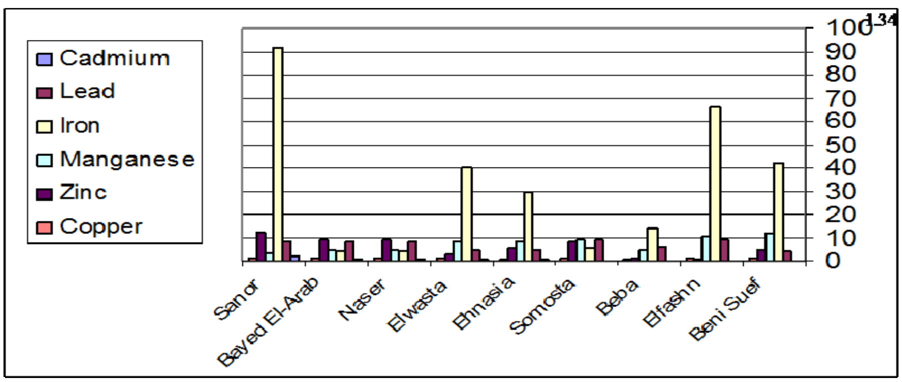

Figure 5: Metal concentrations (ppm) in gills of Claries lazera fish samples collected from Beni Suef Governorate districts.

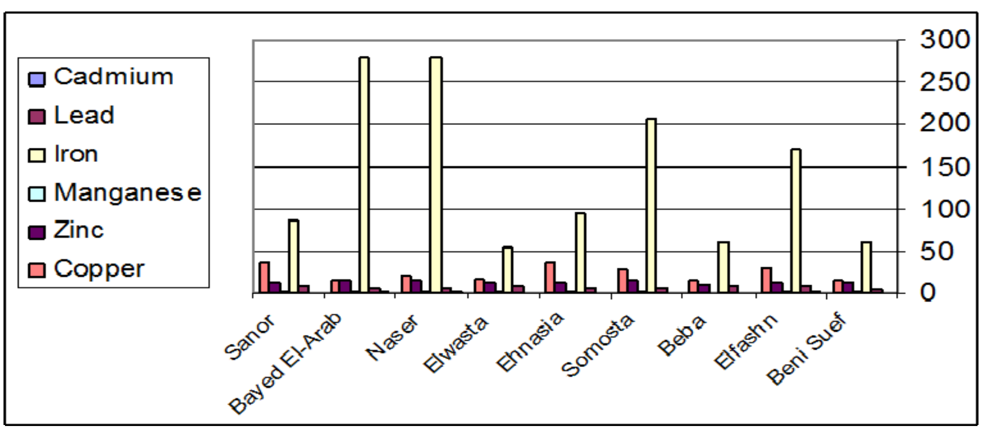

Figure 6: Metal concentrations (ppm) in liver of Claries lazera fish samples collected from Beni Suef Governorate districts.

In order of concentrations of metals in muscles of C. lazera fish collected from different sampling sites, it follows the order of: Fe > Zn > Pb > Mn > Cu > Cd in Beni Suef; Zn > Fe > Pb > Mn > Cu > Cd in Elfashn; Fe > Zn

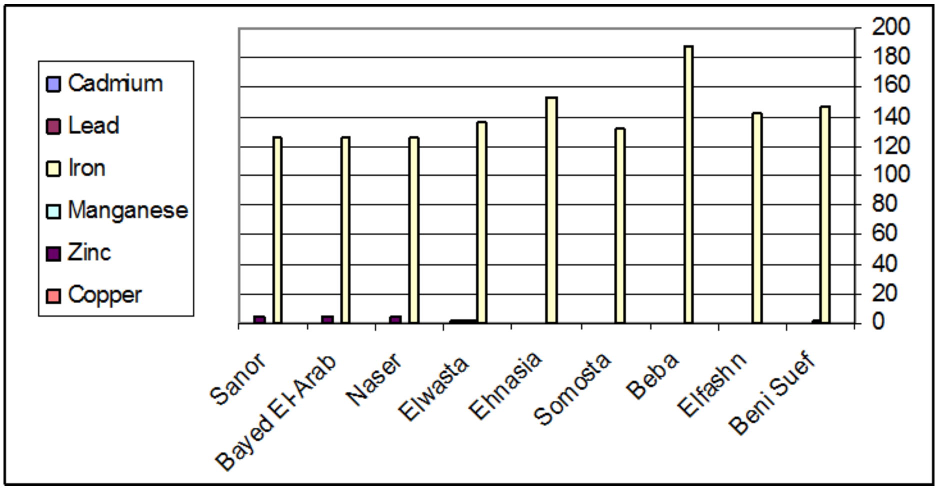

Figure 7: Metal concentrations (ppm) in blood of Claries lazera fish samples collected from Beni Suef Governorate districts.

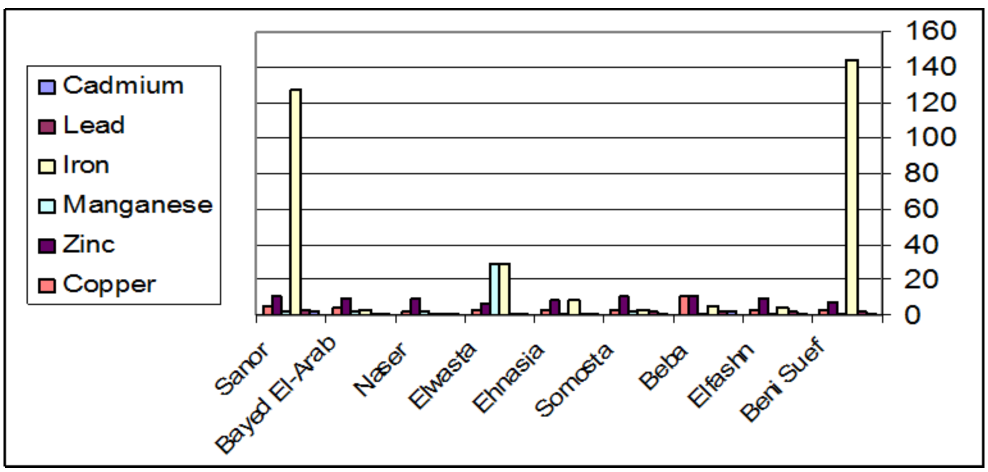

Figure 8: Metal concentrations (ppm) in kidney of Claries lazera fish samples collected from Beni Suef Governorate districts.

> Pb > Mn > Cu > Cd in Beba; Fe > Pb > Zn > Cu > Mn > Cd in Somosta; Fe > Zn > Pb > Cu > Mn > Cd in Ehnasia; Fe > Zn > Pb > Mn > Cu > Cd in Elwasta and Fe > Zn > Pb > Mn > Cd > Cu in Naser. Jastrzebska et al., (2009) reported that the culture site and culture condition exerted significant influence on levels of macro- and microelements in freshwater fish. The difference in the behavior of metals in fish muscles in different sampling sites may be due to the metal concentration in ecosystem and also geological nature of the place. Concentration of metals in fish tissues may be due to the direct contact with water and sediment and indirect exposure through the food chain (Aida et al., 2007).

Comparing mean concentration of Cd in muscle samples collected from different sampling sites, showed the following accumulation ranking: Bayed El-arab > Somosta > Beba > Elwasta > Beni Suef > Elfashn > Ehnasia > Sanor > Naser (0.96± 0.023, 0.621 ± 0.104, 0.611 ± 0.121, 0.52± 0.210, 0.48 ± 0.15, 0.29 ± 0.1180, 0.263 ± 0.045, 0.061 ± 0.013 and 0.031 ± 0.006 ppm respectively).The level of Cd in muscle samples were higher than the WHO and EOS limits in fish tissues safe consumption (Gulfraz et al., 2001) and EOS, (1993). Cd values in our study were higher than the results reported in tissue of fish collected from River Nile in Hawamdia and Kafer-El-Zayat and Qena (Khallaf et al., 1994 and Hussein et al., 2006), approximately equal to results reported by Seddek et al., (1996) from Nile in Assiut Governorate and lower than the results reported by Fatma, (2008) and Saeed and Shaker, (2008) for samples collected from lake Naser and River Nile northern Delta lakes (Edku, Borollus and Manzalla). Cadmium values was found in 20 % of fish samples collected from seven rivers in North of Luxembourg exceeded the threshold of about 10-50 ng g (wet wt) recommended for human health. (Boscher et al., 2010).

Pb showed the following accumulation ranking: Elwasta > Ehnasia > Bayed El-arab > Naser > Beni Suef > Beba > Somosta > Sanor > Elfashn (3.43 ± 0.110, 2.698 ± 0.072; 2.553 ± 0.213; 2.553 ± 0.213; 2.36 ± 0.105; 2.336 ± 0.095; 2.26 ± 0.110; 1.92 ± 0.090 and 1.48 ± 0.095 ppm respectively). The reported values were higher than the limit adopted by the WHO for cadmium (0.05 ppm) in fish tissues safe consumption (Gulfraz et al., 2001) and above the permissible level adopted by the Egyptian Organization for Standardization and above the mean concentrations (mg/kg) fresh weight of lead (0.02) for fish in a total diet study for metals and other elements conducted by the U.K. Ministry of Agriculture, Fisheries and Food (MAFF, 1997 b). Pb values were higher than the results reported for tissue of fish collected from Nile in Hawamdia; Wadi el Rayan lakes- Egypt and from Nile in Qena province (Khallaf et al., 1994; Abdou, 2005 and Hussein et al., 2006) and lower than those reported from River Nile northern Delta lakes and lake Naser (Saeed and Shaker, 2008 and Fatma, 2008).

Fe concentration in muscles showed the following accumulation ranking: Somosta > Bayed El-arab > Naser > Beni Suef > Sanor > Ehnasia > Beba > Elfashn > Elwasta (88.016 ± 0.336; 69.938 ± 0.864; 53.783 ± 0.859; 66.016 ± 0.770; 61.041 ± 1.243; 58.368 ± 0.164; 40.996 ± 1.427; 4.11± 0.685; and 2.748 ± 0.500 ppm respectively). Fe concentrations were higher than the international standards (15-20 mg/l) adopted by WHO, 2003 and the level adopted by Egyptian Organization of Standardization (30 mg/l) (EOS, 2003) except in Elfashn and Elwasta districts. Our results were lower than that of Concentration of Fe in Tilapia nilotica from Nasser lake (Rashed, 2001 and Fatma, 2008) and higher than that of Aegean and Mediterranean seas of Turkey (Tepe, 2008 and Türkmen et al., 2009).

Mn concentration in muscles showed the following accumulation ranking: Beba > Bayed El-arab > Beni Suef > Elfashn > Somosta Sanor > Ehnasia > Elwasta > Naser (1.67 ± 0.155; 1.41 ± 0.114; 0.728 ± 0.078; 1.205 ± 0.397; 1.116 ± 0.643; 0.968 ± 0.148; 0.883 ± 0.121; 0.731 ± 0.201 and 1.41 ± 0.114 ppm respectively). Our results were below the international standard of WHO (WHO, 2003). Our results were below the results of Mn concentrations in tissues of fish collected from River Nile in Assiut and from northern Delta lakes (Seddek et al., 1996 and Saeed and Shaker, 2008) and higher than Slovak fish species (Chub-Leuciscus cephalus, Common carp-Cyprinus carpio, Prussian carp-Carassius gibelio, Roach-Rutilus rutilus, and Wels catfish-Silurus glanis) (Andreji et al., 2006). Zn concentration in muscles showed the following accumulation ranking: Beba > Naser > Somosta > Elfashn > Bayed El-arab > Ehnasia > Beni Suef > Sanor > Elwasta (10.441 ± 0.719; 9.475 ± 0.396; 7.419 ± 1.226; 6.325 ± 1.518; 6.083 ±0.271; 6.08 ± 0.113 and 4.146 ± 0.495; 3.615 ± 0.484 and 3.293 ± 1.447 ppm respectively). Zn concentrations not above the WHO and EOS standards. Our results were below Zn concentrations in tissues of fish collected from Lake Qarun and River Nile northern Delta lakes (Edku, Borollus and Manzalla) (Saeed and Shaker, 2008) and above, different samples of catfish from Hawamdia (Nile), Kafer-El-Zayat (Nile), Abbassa (Farm), Barseik (Farm) are 2.09, 1.32, 1.17, and 0.46 µg/g respectively (Khallaf et al., 1994).

Cu concentration in muscles showed the following accumulation ranking: Somosta > Ehnasia > Sanor > Elfashn > Beba > Bayed El-arab > Elwasta > Naser > Beni Suef (1.965 ± 0.415; 1.225 ± 0.080; 0.958 ± 0.094; 0.911 ± 0.139; 0.768 ± 0.039; 0.763 ± 0.116; 0.665 ± 0.092; 0.626 ± 0.094 and 0.536 ± 0.004 ppm respectively). Cu concentrations not above the WHO and EOS standards. The median and range values of Cu in 9 samples of Claries lazera collected from El-Mahmodia Canal, were 2.12 and (1.05-3.5) (Lasheen, 1987). In the same manner, the copper levels in samples of catfish collected from 5 sites of lake Manzalah (Egypt) showed ranges of: 4.37±0.58, 3.91±0.62, 6.16±0.61, 3.66±0.53 and 4.13±1.16 µg/g respectively (Amaal and Yasser, 2009).

CONCLUSION

The high concentrations of the metals reported in this study are evident in the water, aquatic plant and fish samples taken from El Ebrahimia canal, which contains high levels of trace metals.

An increased concentration of some metals in water above the national and international limits may have health risk to several rural communities that rely on the canal as source of domestic water.

Accumulation of high concentrations of metals in the fish tissues collected from the different districts lead to a high mortality rate, and cause many biochemical and histological alterations in surviving fish, which rendering surviving fish unfit for human consumption.

High concentrations of these trace metals may results from agricultural sources, which is the main activity in the vicinity of the Beni Suef Governorate, and other anthropogenic activities that produce industrial, transport and domestic waste, as well as accidental pollution incidents.

Apart from natural mineralogical sources, other manganese and zinc sources result from the use of these elements as additives for macronutrient fertilizers used on agricultural crops deficient in these elements.

More research should be done to discover the possible sources and the quantitative distribution of the different heavy metals in the Beni Suef Governorate surface waters.

A system to monitor heavy metals in water, plant and fish tissues is necessary as they are an environmental risk for human and fish health.

We can concluded that there is an environmental exposure to Cd, Pb, Fe, Mn, Zn and Cu in water and aquatic plant as macro environment and in the microenvironment of the Catfish due to the domestic, agricultural and industrial wastes, either partially or without treatment are being discharged into surface water. So we recommend the consumers should be eating the muscles of catfish due to contain low levels of metals and disposal of the viscera, head and tail parts of catfish due to contain high concentrations of metal and be considered unfit for the consumers.

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