JOURNAL OF VETERINARY MEDICAL RESEARCH 2016, 23 (2): 218 - 233

Journal homepage:
http://www.bsu.edu.eg/bsujournals/JVMR.aspx

Online ISSN: 2357-0520 Print ISSN: 2357-0512

Original Research Article

Assessing the impact of discharged effluents on water quality and food safety in Beni-Suef Governorate

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ABSTRACT

The objective of this study was to evaluate the impacts of discharged waste effluent into water sources on heavy metals content in water, sediment and fish. A pilot study was carried out during the period from (March to May 2014). Samples were collected from water, sediment and fish (Oreochromis niloticus) from five fish farms and River Nile in Beni-Suef governorate to estimate Lead, Cadmium, Zinc and Copper. The results revealed a significant increase in Pb and Cd in water, sediment and fish samples collected from fish farms and these metals were within the permissible limits in River Nile samples. Zn and Cu in all samples of water and muscle of (farms and River Nile) were lower than permissible limits of WHO. The results of this study indicate that high levels of some heavy metals present in fish collected from the fish farms in Beni-Suef governorate are not accepted as food for human purposes.

ARTICLE INFO

Article history:

Received 11/2016

Accepted 12/2016

Online 12/2016

Keywords:

discharged effluents, water quality, food safety Beni-Suef Governorate

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1. Introduction:

The pollution of the surface water in the province of Beni- Suef is a major hazard to all biological systems, and that the principle water pollutants in the governorate are heavy metals, especially lead, manganese, cadmium and iron **(EEAA, 2008).** Pollution in the River Nile's main stem, drains and canals has increased in the last few decades. The River Nile receives wastewater discharges from 124 sources points between Aswan and El-kanater Barrage, of which 67 are agricultural drains and the rest are industrial sources **(National Water Research Center, 2000).**

The pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years, because they are indestructible and most of them have toxic effects on organisms **(MacFarlane and Burchett, 2000)**. Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems **(Censi et al. 2006).**

Fish is a good bio-indicator because it is easy to be obtained in large quantity, potential to accumulate metals, long lifespan, optimum size for analysis and easy to be sampled **(Batvari et al. 2007**). In fish, which is often at the higher level of the aquatic food chain, substantial amounts of metals may accumulate in their soft and hard tissues **(Mansour and Sidky, 2002).**

2. Materials and methods:

2.1. Area of study:

Beni Suef is one of the governorates of Egypt. It is located in the centre of the country. The capital of the governorate is the city of Beni Suef, located about 120 km south of Cairo on the west bank of the Nile River. The total size of Beni Suef governorate is 10954 m^2, it consider of 0.7% from the total size of Egypt **(EEAA, 2008).** Areas in Beni Suef governorate are included in this study (Abo-salh island, Abo-seleem, El-fashn, Ehnasia 1-2 and River Nile) (Fig 1).

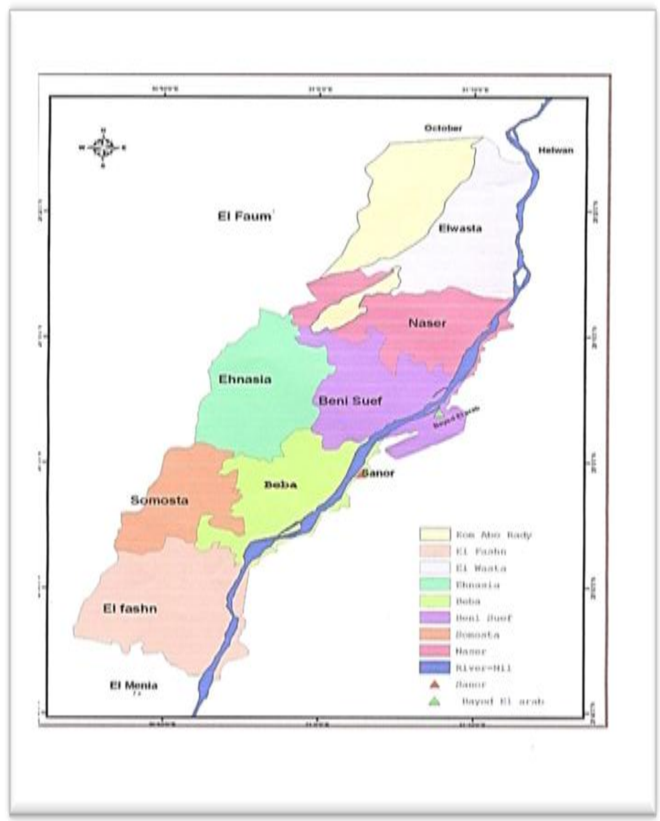


Fig. (1) Location of the province and the farms

2.2. Sampling:

Water, sediment and fish samples (Oreochromis niloticus) were collected in this study during the period from March to May 2014 one time in year from five fish farms (Abo-salh island, Abo-seleem, El-fashn, Ehnasia 1and 2) and River Nile. The sampling bottles were preconditioned with 5% nitric acid and later rinsed thoroughly with distilled deionized water. At each sampling site, the glass sampling bottles were rinsed at least three times before sampling was done **(Öztürk et al. 2009)**.

2.2.1. Water:

Sixty surface water samples were collected from the six studied areas, (ten samples from each area) water samples were taken at a distance of 10 cm from the surface water and of 100 ml volume. Each water sample was taken in clean washed glass containers. All water samples were shaken well before heavy metals levels determination.

2.2.2. Sediment:

Sixty Fish pond sediment samples were collected from the surface down (ten sample from each area) at depth of 10 cm at ten different locations, and these samples were pooled together. Sediment samples were sealed in polyethylene bags and kept cold on ice box during transportation to the laboratory **(Ping Zhuang et al. 2013)**. All sediment samples were mixed well before heavy metal levels determination**.**

2.2.2. Fish:

A total of sixty samples of Oreochromis niloticus (ten from each area) were collected with nets by local fishermen. The mean length and weight of the fish were 250.6±12.4 mm and 200.6±50.15 g for. All fish samples were kept at -20°C until analysis **(Öztürk et al. 2009)**.

2.3. Preparation of samples:

2.3.1. Water samples:

100 ml of water samples were measured, 10 ml of aqua regia (HNO3 (Loba Chemie PVT Ltd) and HCl- (Analar from Rankem) in the ratio of 3:1) and 1 ml of perchloric acid added in a culture test tube. Incubated at 80°C in a water bath, after total digestion and subsequent cooling. Solution was diluted to 50ml and analyzed for heavy metals. **(AOAC, 1990).**

2.3.2. Sediment samples:

Each frozen sediment samples was thawed separately and sub-sampled for dry weight determination at 105^{o}C. The other portion of the samples was freeze-dried. Finely crushed and homogenized using mortar and pestle. About 0.5g of the homogenized sample was digested in 10 ml aqua regia -HNO3 (Loba Chemie PVT Ltd) and HCl- (Analar from Rankem) in the ratio of 3:1 and 1 ml perchloric acid (Loba Chemie PVT Ltd) in a culture test tube. Incubated at 80°C in a water bath, after total digestion and subsequent cooling, the solution was diluted to 50 ml. Analyzed for heavy metals in a closed system by atomic absorption spectrophotometry **(AOAC, 1990).**

2.3.3. Fish samples:

Muscles samples were digested according to method applied by

(Agemain et al., 1980) as follows: weighed portion of each sample (1 g) was put into a kjeldahl flask containing 5 ml of conc. nitric acid and 1 ml perchloric acid (80%). A blank of 10 ml digestion mixture was prepared in a second Teflon beaker. The mixture was heated until the solution become colourless. The samples were diluted to 50 ml with Bi-distilled water.

The detection and estimation of these heavy metals were carried out by Atomic Absorption Spectrometry (AAS) (Perkin Elmer 2380) of department of Forensic Medicine and Toxicology in Faculty of Veterinary Medicine, Beni-Suef University and Animal Health Research Institute, Dokki, Giza, Egypt.

Statistical Analysis:-

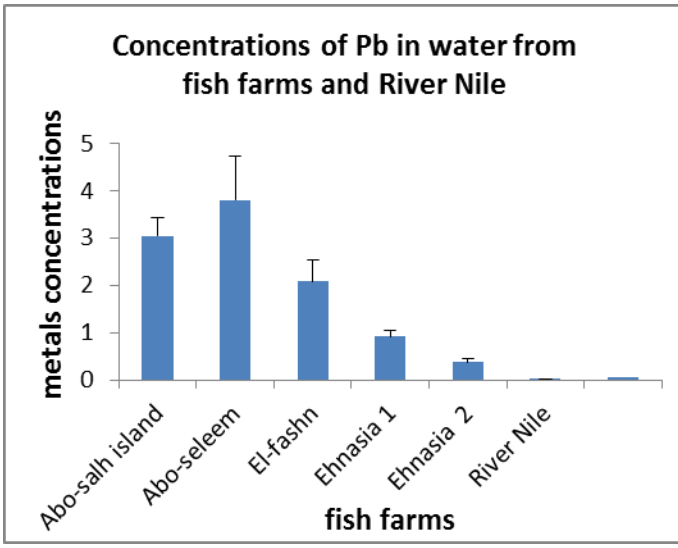
Statistical analysis was done using SPSS. (16.0). Results were evaluated statistically significant by a two-tailed p value < 0.05. Furthermore, the data are shown as mean ± standard error.

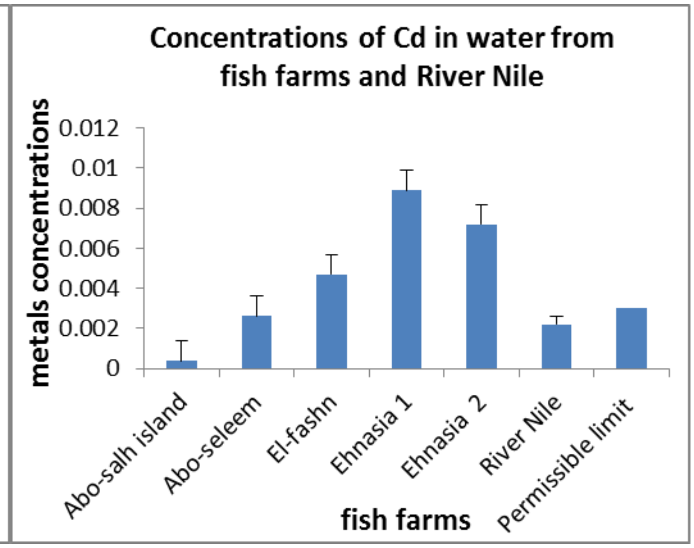
3. Results:

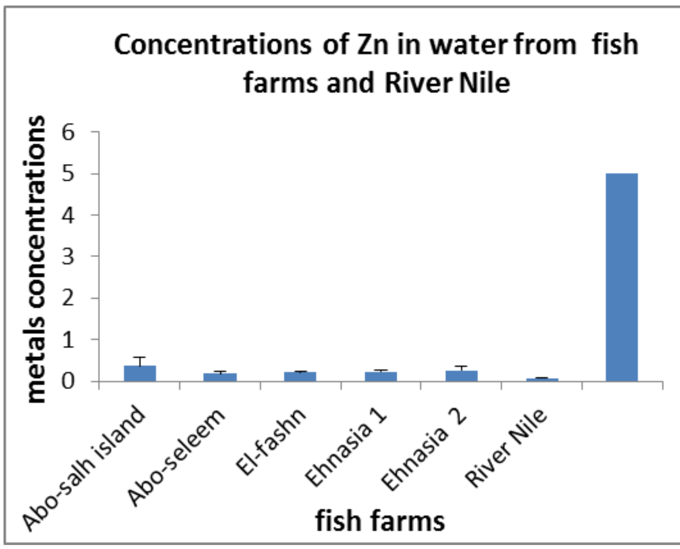
Table (1): Heavy metals concentration (ppm) in water samples from fish farms and River Nile (mean± S.E).

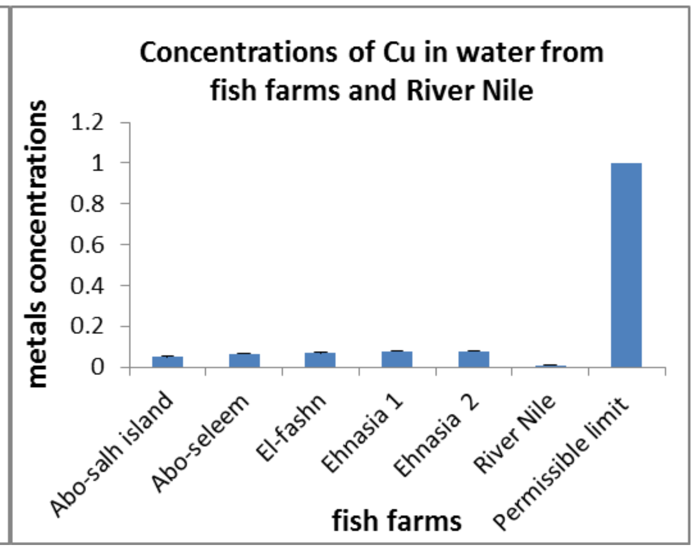
	Fish farms					River Nile	Permissible limit* (ppm)
	1	2	3	4	5		
pb	3.048±0.368 [a]	3.804±0.925 [a]	2.079±0.462 [a]	0.915±0.140	0.370±0.075	0.001±0.0001	0.05
Cd	0.004±0.001	0.003±0.001	0.005±0.001	0.009±0.001 [a]	0.007±0.001 [a]	0.002±0.0004	0.003
Zn	0.363±0.194 [a]	0.179±0.041 [a]	0.202±0.025 [a]	0.231±0.038 [a]	0.263±0.078 [a]	0.070±0.007 [a]	5
Cu	0.050±0.004 [a]	0.065±0.004 [a]	0.069±0.001 [a]	0.076±0.004 [a]	0.078±0.003 [a]	0.007±0.0004 [a]	1

- Data expressed as mean ± S.E. (n= 10 replicates)
- ([a]) Significantly different from permissible limit by One-way ANOVA at p≤0.05.
- 1 (Abo-salh island), 2 (Abo-seleem), 3 (El-fashn), 4 (Ehnasia 1), 5 (Ehnasia 2)
***WHO (2003).**









The concentration of metals (Pb, Cd, Zn and Cu ppm) in water from fish farms and River Nile were illustrated in Table (1).

Results in the current study indicate that Pb concentration is significantly increased in farms 1, 2 and 3 when compared with permissible limit. Also the highest mean values of Pb are found in farm 2 > farm 1 > farm 3 > farm 4> farm 5 > River Nile respectively.

Significant increase in Cd concentration is observed in (farm 4 and 5) in comparison with permissible limit. Cd concentrations in fresh water are found in farm 4> farm 5> farm 3> farm 1> farm 2> River Nile respectively.

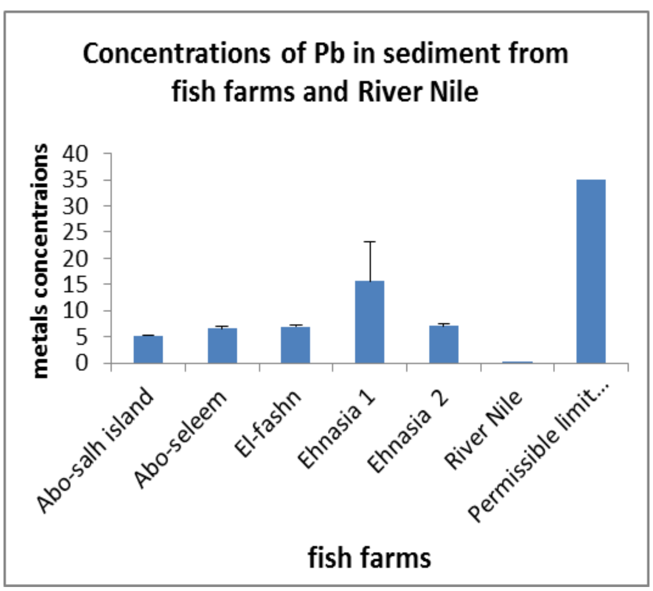
Also, our results show significant difference in Zn concentration of all water samples compared to permissible limit. Zn concentrations in fresh water are found in farm 1> farm 5> farm 4> farm 3> farm 2> River Nile respectively.

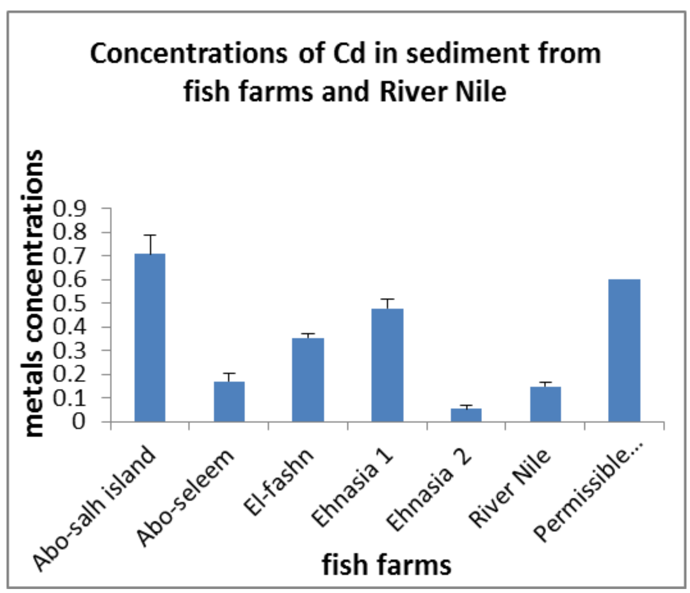
There are significant differences in the mean values of Cu of all fresh water samples in comparison with the permissible limit. Cu concentrations in fresh water in farm 5 > farm 4> farm 3 > farm 2 > farm 1 > River Nile respectively.

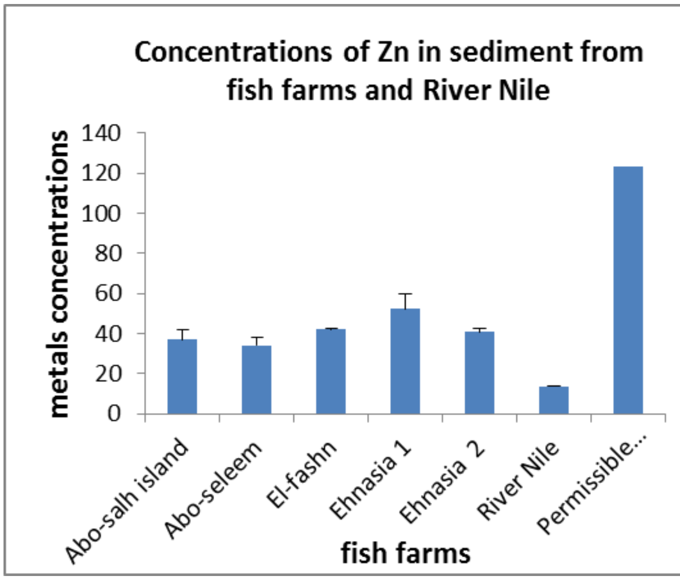
Table (2): Heavy metals concentration (mg/kg) in sediment samples from fish farms and River Nile (mean± S.E).

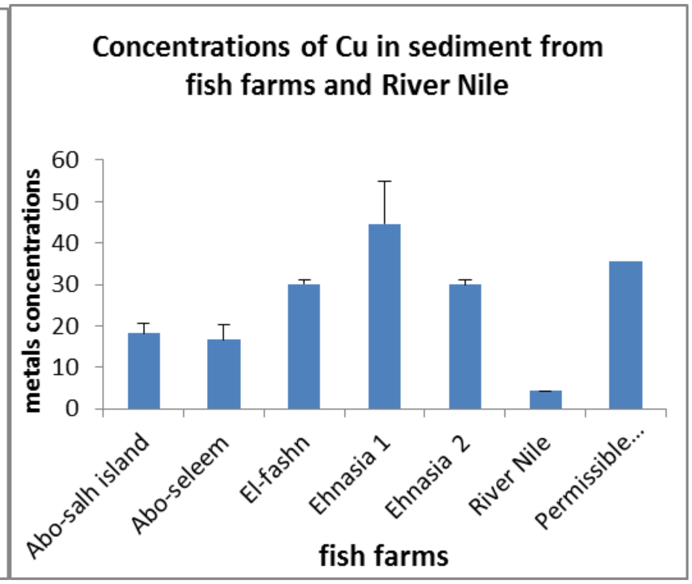
	Fish farms					River Nile	Permissible limit* (mg/kg)
	1	2	3	4	5		
Pb	5.188±0.196 [a]	6.543±0.412 [a]	6.987±0.141[a]	15.572±7.47 [a]	7.091±0.287 [a]	0.015±0.009 [a]	35
Cd	0.708±0.079	0.168±0.033 [a]	0.354±0.015[a]	0.476±0.042 [a]	0.052±0.015 [a]	0.147±0.016 [a]	0.6
Zn	37.010±4.796[a]	34.195±3.75 [a]	42.15±0.67 [a]	52.27±7.787 [a]	40.951±1.50[a]	13.590±0.370 [a]	123
Cu	18.171±2.559[a]	16.735±3.629 [a]	30.06±0.973	44.607±10.22	29.887±1.268	4.297±0.073 [a]	35.7

- Data expressed as mean ± S.E. (n=10 replicates)
- ([a]) Significantly different from permissible limit by One-way ANOVA at $p \leq 0.05$.
- 1 (Abo-salh island), 2 (Abo-seleem), 3 (El-fashn), 4 (Ehnasia 1), 5 (Ehnasia 2)
***Canadian Council of Ministers of the Environment (2012).**









The obtained data in table (2) revealed the concentration of metals (Pb, Cd, Zn and Cu mg/kg) in sediment from fish farms and River Nile.

Significant increase in Pb concentration is observed in all sediment samples in comparison with permissible limit. Our results revealed that; the highest mean values of Pb were found in farm 4> farm 5> farm 3> farm 2 > farm 1 > River Nile respectively.

Results in the current study indicate that cd concentration is significantly increased in (farm 2, farm 3, farm 4, farm 5 and River Nile) when compared with permissible limit. Cd concentrations in sediment samples are as the following; farm 1 > farm 4> farm 3> farm 2> River Nile> farm 5 respectively.

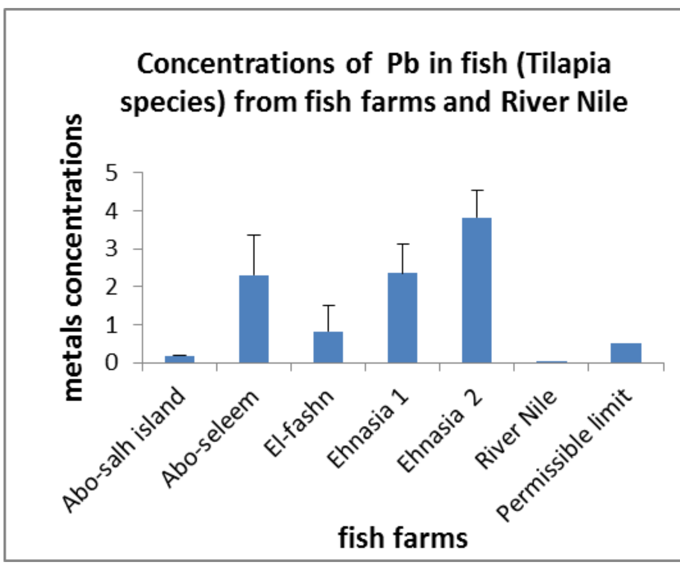
Also, our results show significant difference in Zn concentration of all farms and River Nile compared to permissible limit. Zn concentrations in fish musculature in farm 4> farm 3> farm 5> farm 1 > farm 2> River Nile respectively.

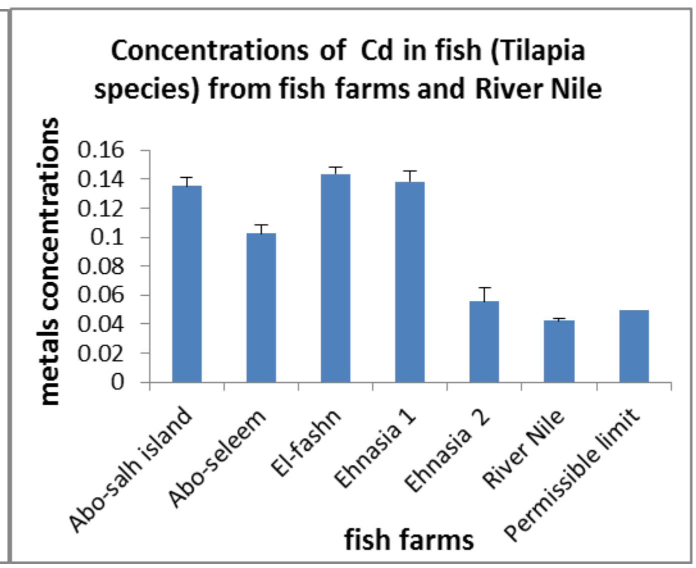
There are significant differences among the mean values of Cu from (farm 1, farm 2 and River Nile) compared to the permissible limit. Cu concentrations in sediment samples are in this order farm 4> farm 3> farm 5> farm 1 > farm 2> River Nile respectively.

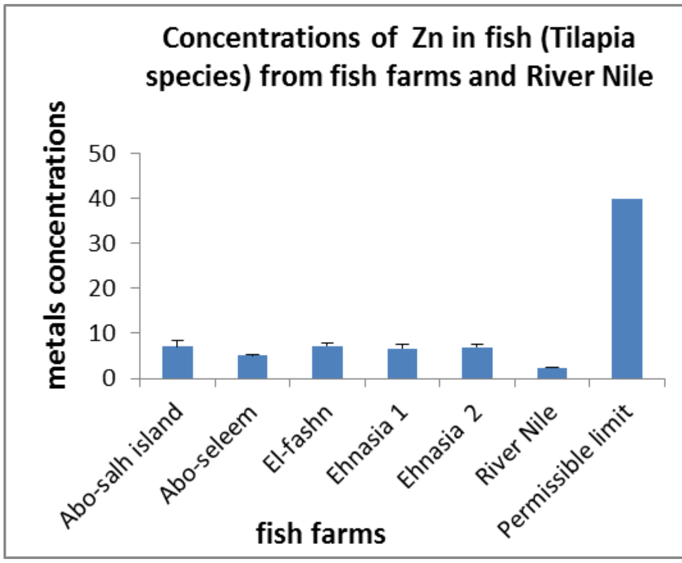
Table (3): Heavy metals concentration (ppm) in fish samples from fish farms and River Nile (mean± S.E).

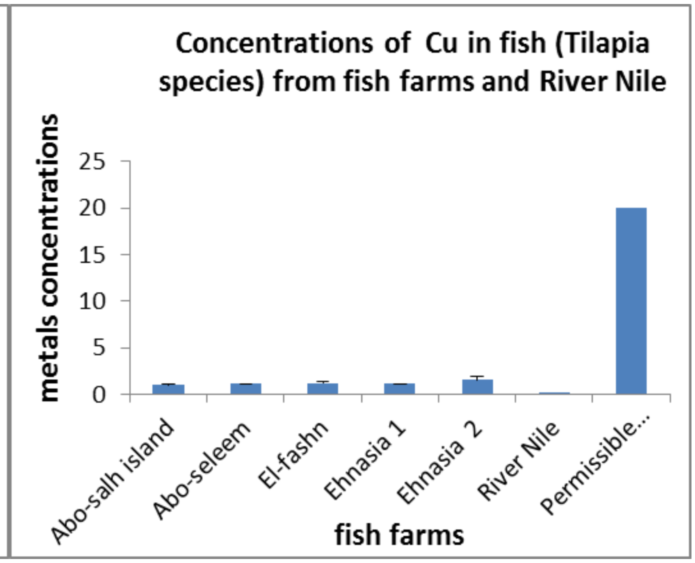
	Fish farms					River Nile	Permissible limit* (ppm)
	1	2	3	4	5		
pb	0.179±0.005	2.301±1.046	0.814±0.692	2.347±0.789	3.826±0.715 [a]	0.004±0.0003	0.5
Cd	0.135±0.006 [a]	0.102±0.006 [a]	0.143±0.004 [a]	0.138±0.007 [a]	0.055±0.009	0.042±0.001	0.05
Zn	7.074±1.282 [a]	5.023±0.341 [a]	7.274±0.451 [a]	6.606±1.076 [a]	6.905±0.746 [a]	2.333±0.116 [a]	40
Cu	1.009±0.036 [a]	1.084±0.050 [a]	1.214±0.092 [a]	1.094±0.017 [a]	1.529±0.321 [a]	0.036±0.002 [a]	20

- Data expressed as mean ± S.E. (n=10 replicates)
- ([a]) Significantly different from permissible limit by One-way ANOVA at p≤0.05.
- 1 (Abo-salh island), 2 (Abo-seleem), 3 (El-fashn), 4 (Ehnasia 1), 5 (Ehnasia 2)
***WHO (2000), Zn permissible limit acc. to: WHO (1993).**









The concentrations of metals (Pb, Cd, Zn and Cu ppm) in the dry tissues of muscle Tilapia were summarized in Table (3).

Results in the current study indicate that Pb concentration is significantly increased in farm 5 when compared with permissible limit. Also the highest mean values of Pb are found in farm 5> farm 4> farm 2 > farm 3> farm 1 > River Nile respectively.

Significant increase in Cd concentration is observed in (farm 1, farm 2, farm 3 and farm 4) in comparison with permissible limit. Cd concentrations in fish musculature are as the following; in farm 3> farm 4> farm 1> farm 2> farm 5> River Nile respectively.

Also, our results show significant difference in Zn concentration of all farms compared to permissible limit. Zn concentrations in fish are in this order farm 3> farm 1> farm 4> farm 5> farm 2> River Nile respectively.

Cu concentrations in fish musculature are as the following; farm 5> farm 3> farm 4> farm 2> farm 1> River Nile respectively. There are significant differences among the mean values of Cu from all collected fish samples compared to the permissible limit.

4. Discussion:

In the recent years, more toxic compounds were detected in aquatic ecosystem **(Khare and Singh, 2002).** Fishing is one of the most important industries and seafood is consumed by a large segment of Egyptian population. However, fish population can be effected by a large range of the environmentally persistent heavy metals **(Soliman, 2006).**

4.1. Heavy metals in Water:

In our study the Pb concentrations in water at the five farms were higher than the permissible limits (0.05 ppm) which is recommended by **WHO (2003)**. These results are higher than **Fatma (2008)** results who reported that Pb concentration at khor Toushka was (0.0488-0.1064 mg/l). Also, the study which obtained by **(Elmaci et al. 2007)** reported that higher Pb levels were found in Lake Uluabat in Turkey (0.03 mg/L) **(Mason, 2002)** recorded that the high levels of Pb in water can be attributed to industrial and agricultural discharge.

The results in the current study show that, the concentrations of Cd in water in El-fashn, Ehnasia 1 and Ehnasia 2 farms were higher than **WHO (2003)** limits (0.003 ppm). According to **(El-Kattan and Nahla, 2008)** cadmium levels in water statistically, Mubark district was significantly higher than Sadat city and Shebin El-Kom regions (0.090, 0.070, 0.050 ppm, respectively). Also the other study in Lake Uluabat in Turkey showed higher Cd levels (0.04 mg/L) **(Elmaci et al. 2007).** These results reflect that the anthropogenic influences rather than natural environment of the water may be the main reasons **(Wasim Aktar et al. 2008**) where Cd is present as an impurity in several products, including phosphate fertilizers and detergents.

The values of Zn accumulation in the present study in water samples were lower than the permissible limits (5 ppm) according to **WHO (2003)**. **Authman (2008)** carried out a study on the heavy metals in Sabal drainage and found that the concentrations of Zn was (0.67 mg/l).our results are in agreement with **El-Araby (2006)** who stated that the average concentrations of heavy metals in different locations in El-Moheet drain are within the permissible range according to **Egyptian law**. Zn levels in the analyzed water samples of Lake Lapland in Finland reported by **(Mannio et al. 1995)** showed higher Zn levels (1.84 mg/L).

Cu concentrations in the current study show that all results of water samples are within permissible limit (1 ppm) according to **WHO (2003)**. The high levels of Cu reported by **Authman (2008)** who carried out a study on the heavy metals in Sabal drainage and found that the concentrations of Cu was (0.18 mg/l) this result was higher than the permissible limits of the Egyptian law. **Ali and Abdel-Satar (2005)** attributed the increase of metal concentrations in the water during hot seasons (spring and summer) to the release of heavy metals from the sediment to the overlying water under the effect of both high temperature and a fermentation process resulting from the decomposition of organic matter.

4.2. Heavy metals in Sediment:

The concentrations of Pb in all sediment samples in this study were lower than the permissible limits (35 ppm) which is recommended by **Canadian Council of Ministers of the Environment (2012)** but the concentrations of Pb in sediment samples are higher than concentrations of Pb in musculature samples and water samples. The elevated levels of lead that observed in the present study are comparable to those reported earlier by **Kishe and Machiwa (2003)** who reported lead levels of (30.7±5.6) in sediments of Mwanza gulf of lake Victoria, Tanzania. Unlike **Hounkpatin et al. (2012)** in a similar study reported slightly lower levels of lead (26.80 ± 0.57 ppm).When comparing our study with another study by **(Chouba et al. 2002)** who found lead concentrations in sediments of Tunisian lagoons are generally lower than (30 µg g^{-1}**).** It could be attributed to the geological environment surrounding lagoon, fishing activities and sewage discharges. Domestic and industrial effluents are the major sources of the observed high level of Pb are mainly precipitated as soluble oxide **(Abdo, 2004).**

Only Abo-Salh Island in our study has higher level of cd than permissible limits of **Canadian Council of Ministers of the Environment (2012)** which is **(**0.6 ppm). These results agree with **(Nguyen et al. 2005)** who reported levels of cd (0.1–0.7 µg/g dry wt) in sediment of Lake Balaton in Central Europe. Also analyzed sediment samples of Lake Hannah (Canada) showed Cd levels (1-2.7 µg/g dry wt) **(Pyle et al. 2005).**

Our study appeared that Zn Levels are lower in all sediment samples than the permissible limits (123 ppm) which reported by **Canadian Council of Ministers of the Environment (2012)**. Comparing the heavy metals levels in sediments with other areas of the world, it is found that similar high levels of Zn (13–150 µg/g dry wt) were reported in sediment of Lake Balaton in Central Europe **(Nguyen et al. 2005)**. Furthermore, very high levels of Zn (148.0 µg/g dry wt) were recorded in sediments of Lake Hannah (Canada) **(Pyle et al. 2005).**

Cu concentration which measured in our study in Ehnasia 1 farm is (44.607±10.221 $mgkg^{-1}$) and that higher than the permissible limits (35.7 ppm) according to **Canadian Council of Ministers of the Environment (2012)**.

This variation in the farms sediment was reflected on the metals distribution. This comply with **Franc et al. (2005)** who mentioned that sediments contain more sand and lower values of organic matter exhibit low metals enrichment. Also, the concentrations of heavy metals in sediment increase as the amount of organic material increase **(Tsai et al. 2003)**. He also mentioned that the pollutant concentrations in sediments increased with decreasing the particle size in sediments.

By comparing the accumulation of heavy metals in water and sediments, it can be concluded that the heavy metals are highly accumulated in sediments than water, since the sediments act as reservoir for all contaminants and dead organic matter descending from the ecosystem above. Similar findings were reported by other authors **(Nguyena et al. 2005).**

4.3. Heavy metals in Fish:

In our study the Pb Concentrations in fish muscles in farms were higher than the permissible limit (0.5 ppm) which is recommended by **WHO (2000)**. These results in agreement with **Elghobashy et al. (2001)** who recorded that Pb concentration was increased in fish muscle of Lake Borollus. Compared study reported that lead concentrations in fish from Sadat district were significantly higher (1.685 ppm) than those in Mubarak district (0.970 ppm) and finally in Shebin El-Kom city (0.456 ppm) **(El-Kattan and Nahla, 2008).** Our results are nearly higher than those observed by **Marouf and Dawoud (2006)**. They indicated that pb levels was ranged from

(0.42 to 0.74 ppm). The high lead level may be attributed to the collection of water and fish from contaminated water in areas near to industrial discharges exposed to high way motor car effluents, untreated industrial discharges (steel and iron factories in Sadat and Mubark district), agricultural discharge (super phosphate fertilizers) and sewage effluents **(Ward et al. 1978 and El-Nabawi et al. 1987).**

In this study Concentrations of Cd in fish muscles were higher than the permissible limit (0.05 ppm) which is recommended by **WHO (2000)**.When comparing our study with **Moustafa et al. (2011)** who found that the concentration values for Cd were (0.9–1.9 mg kg^{-1}) and similar results which were reported by **Celik and Oehlenschlager (2007)**, where the cadmium levels varied from (0.1 to 0.8 ppm) Found that our results are lower than them results. In Egypt, most of fish farms are depending on agriculture drainage water mixed with industrial, herbicides and the phosphate fertilizers which are considered the main source of Cd in the environment **(Osman et al. 2009).**

The values of Zn accumulation in the present study in fish samples appear to be lower than permissible limits (40 ppm**)** according to **WHO (1993)**. **Celik and Oehlenschlager (2005)** reported that zinc level was (9.73µg/g). Also, according to **Celik and Oehlenschlager (2004)**, zinc level was (8.6 µg/g). Zinc contents in our results are similar to findings reported by **Aucoin et al. (1999)** who mentioned that Zn concentration was ranged from (4.62–14.6 mg kg^{-1}) in different fish species. The low concentrations are probably related to it is essential element and the high pH values, which also seems to influence the concentration of these metals in natural unpolluted water **(Tawfiq, 1998).**

In our study the concentration of Cu was lower than the permissible limits (20 ppm) which is recommended by **WHO (2000)**. The copper values in this study are similar to the values of **Bahnasawy et al. (2009)** (3.8–5.2 mg kg^{-1}). These results are in agreement with those obtained by **El-Naggar et al.** (**2009**) who mentioned that values for Cu were (18–55 mg kg^{-1}) and added that this increase is anticipated to industrial, drainage and sewage effluents. **Mohamed et al. (2012)** reported that the elevation of copper accumulation in Abu-Rawash Area might be due to industrial and sewage wastes.

Conclusion:

Results revealed a high level of both Pb and cd in water and fish samples in farms higher than River Nile samples. While concentrations of Cu and Zn in all samples were found within the permissible limits in farms and River according to WHO. These results indicated that fish collected from the fish farms in Beni-Suef governorate may affect their quality and food safety reverse fish collected from River Nile are safe for human consumption. The exposure to toxic elements could be minimized by regular control of their presence in food and feed.

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الملخص العربي:

تقييم أثر الملوثات على جودة المياه وسلامة الأغذية في محافظة بني سويف

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الهدف من هذه الدراسة هو تقييم التاثير السام لبقايا بعض المعادن الثقيلة علي البيئة المائية في (جزيرة ابو صالح ، مزرعة ابو سليم ، مزرعة الفشن ، مزرعة اهناسيا ١ ، مزرعة اهناسيا ٢ ، نهر النيل) في محافظة بني سويف. وقد جمعت العينات في شهر مارس – مايو ٢٠١٤ لتقدير نسبة الرصاص ،الكادميوم ،الزنك والنحاس وقد جمعت عينات من الماء و الرواسب الطينية و الاسماك من الخمس مزارع ونهر النيل. وقد كانت النتائج كالاتي :- كانت نسبة الرصاص والكادميوم في المزارع اعلي من الحد المسموح به من منظمة الصحة العاليمة في عينات الاسماك والماء اما العينات التي جمعت من النيل كانت النسبة خلال الحد المسموح به . اما بالنسبة للزنك والنحاس في عينات الاسماك والمياه في المزارع والنيل فقد كانت اقل من الحد المسموح به. وبالنسبة الي عينات الرواسب الطينبية في المزارع والنيل ايضا كانت في خلال الحد المسموح به من المجلس الكندي لوزارة البيئة. هذه النتائج تشير الي ان ارتفاع بعض المعادن في عينات الاسماك والماء المجمعة من بعض المزارع في محافظة بني سويف ليست مناسبة للاستهلاك الادمي.