E-ISSN: 1116 - 3089 P-ISSN: 3026-9784
MPRI-JOMDR | INTERNATIONAL JOURNAL OF ORGANIC & MEDICINAL DEV. RESEARCH, VOL. 03 NO. 3 JANUARY, 2024

DETERMINATION OF HEAVY METAL CONCENTRATIONS IN FISH (*Electrophorus electricus*) FROM IBOM RIVER IN IKONO LOCAL GOVERNMENT AREA

EDITI ETIM PAUL; IMAOBONG MFON ESSEN; ENOBONG JEREMIAH EFFIONG; & MFONISO SATURDAY AKPAITAM

Department of Science Technology, Akwa Ibom State Polytechnic, Ikot Osurua, Akwa Ibom State, Nigeria.

editipaul035@gmail.com

Abstract

This research work was conducted to assess the concentration of five difference heavy metal concentrations in Electric eel (Electrophorus electricus), collected from Ibom River in Ikono Local Government Area of Akwa Ibom State, Nigeria, using Atomic Absorption Spectrophotometer (AAS) method. The five different heavy metals analyzed were Chromium (Cr), Cadmium (Cd), Lead (Pb), Copper (Cu) and Zinc (Zn). The results of the analysis shown that the concentrations of heavy metals in Electric eel were in their decreasing order Zn 3.144mg/kg ± 0.010 > Cu 2.125mg/kg ± 0.035 > Cr 0.504mg/kg ± 0.006 > Cd 0.196mg/kg ± 0.009 > Pb 0.027mg/kg ± 0.005 were detected. The concentration of heavy metals recorded in the fish sample also indicated a certain degree of bio-accumulation. The concentrations of all metals in the fish sample were below the National

Keywords: Heavy Metals, Concentration, Electric Eel (*Electrophorus electricus*)

EDITOR-IN-CHIEF
Prof. A.S. Hossein [Saskatchewan]

Aquatic Resources Research and Development Agency (NARRDA, 2015) recommended limits except copper (Cu) and chromium (Cr) which were higher than the recommended limits. The bio-accumulation factor of heavy metals such as copper (Cu) and chromium (Cr) in Electric eel (fish) are high beyond the tolerable level, which indicated that as far as these metals are concerned, the fish is unfit for human consumption, due to harmful effects of copper (Cu) to human body such as kidney damage, inhibit urine production and anemia cause by rupture of red blood cells (hemolytic anemia) which can cause death. Also, excess amount of chromium (Cr) can cause harmful effect to human system such as kidney damage, upper abnormal pain, nose irritation and damage according to Agency for Toxic Substances and Disease Registry (ATSDR, 2012). Consequently, close monitoring of metals pollution and the consumption of the Electric eel of Ibom River is recommended with a view to minimizing the risk of health of the population that depend on the river for water and fish supply.

INTRODUCTION

Fishes are one of the most widely distributed organisms in the aquatic environment and considered as one of the main protein sources of food for human. Freshwater fishes are similar to sea water fishers which play an important role in determining resident's diet (Ahmad *et al.,* 2009).

Heavy metals are an important group of chemical pollutants, whereby food is the main route for entry into body, some heavy metals irreversibly are bound to human body tissues, examples cadmium to kidneys and lead to bones. Fish constitute a major source of heavy metals in food. High level of metals in environment may lead to an excessive accumulation which cause problem to human, animal and plants (Allah *et al.,* 2017).

Fish has been found to be excellent indicator for the heavy metal contamination level in aquatic system because it occupies different food chain levels. A major concern and attention about the health effects people due to consumption of foodstuff contaminated with metals were paid. Heavy metals occur in the environment both as a result of natural processes as well as contaminants from

human being activities. Some heavy metals are known as potentially toxic include arsenic, lead, aluminum and cadmium, others are essential such as nickel, zinc and chromium (Arora *et al.,* 2008).

Heavy metals have positive and negative effect on human health and surroundings. The accumulation of heavy metals in fish has been extensively studied and well documented. However, the research has been generally focused on the muscle tissue, while the distribution pattern among other tissues, such as liver and gills have been mainly neglected. Furthermore, the contaminants also concentrate in some of the organs of fish and can cause lethal and a range of sub lethal effects. It was known that active metabolite body parts such as liver, gill and kidney concentrate more on an amount of heavy metal than other parts like muscle (Davies, 2009).

Heavy Metal Concentrations in Water Samples (Ibom River)

The concentration of heavy metal in metal from variety of water sources is becoming a matter of global concern. Though effects of chemical contamination of drinking water are not felt on short-term bases, their accumulation over a long period in the body has significant health effects. Water contamination by heavy metals in some areas is practically inevitable due to natural process (weathering of rocks) and anthropogenic activities (industrial, agricultural and domestic effluents. Rivers passing along urban centres are used for irrigation of the crops grown on their banks. Waters of such rivers have often been reported to be polluted by heavy metals and most of these waters are contaminated with heavy metals through industrial effluents, sewage and sludge, and vehicular emission (Etesin and Benson, 2017). Fishes grown in such water, therefore, are likely to be contaminated with heavy metals and unsafe for consumption. Industrial or municipal wastewater is mostly used for irrigation of crops mainly in periurban ecosystem. This is because waste water is easily available coupled with disposal problems scarcity of fresh water (Emami *et al.,* 2015).

Effect of Heavy Metals on Fish and Environment

Growth of fish larvae and juveniles is very fast. Many environmental factors influence growth: temperature, accessible alimentary base and presence of

toxicants. Under optimum conditions, at appropriate temperature and at sufficient quantities of food, the fish increase in both body length and mass (Mance and Yates, 2019). On the other hand, in the water polluted with toxicants, e.g heavy metals, fish growth may be inhibited. Inhibition of growth is one of the most distinct symptoms of toxic action of metals on fish larvae. Therefore, fish body length and mass are indicators of environmental conditions (Goldhaber, 2013). Aquatic organisms, such as fish, accumulate pollutants directly from contaminated water and indirectly through the food chain. Application of chemical fertilizers containing trace of heavy metals causes contamination of fish with these metals. The effects of pesticides either organophosphorus or chlorinated pesticides have been extensively studied and confirmed in fish. The impact of toxic materials on the integrity and functioning of Deoxyribonucleic Acid (DNA) has been investigated in many organisms under field condition (Jadhav *et al.,* 2010). Several biomarkers have been utilized as tools for detection of exposure to genotoxic pollutants. Such biomarkers include presence of DNA adducts, chromosomal aberrations, Deoxyribonucleic Acid (DNA) strand breaks and micronuclei measurements. In fish, erythrocytes are mainly used as sentinel markers of exposure to dangerous for fish juveniles and may considerably reduce the size of size populations or even cause extinction of entire fish population in polluted reservoirs. The data of many authors indicate that heavy metals reduce survival and growth of fish larvae. They also cause behavioural anomalies (such as impaired locomotors performance resulting in increased susceptibility to predators) or structural damages (mainly vertebral deformities).

According to Yilmaz *et al.,* (2017). Exposure of heavy metals to the marine environment result in the slowed of development in the growth rate, and reduced survival. Due to the toxicant copper cause inhibited skeletal ossification, while lead caused scoliosis.

Hazardous Effect of Heavy Metal Concentrations of Fish on Human Health

Heavy metals can pollute the environment through many routes. Because of their stability, they may penetrate environmental compartments, in some cases, many years after the initial deposition pollution of the soil and water systems may also

arise from the weathering of disposed product (Bolger *et al.,* 2012). Heavy metal accumulations in fishes from natural and artificial sources and subsequent consequences represent important environmental pollution problems. Food safety issues and potential adverse health risks make this one of the most serious environmental concerns (Bhagure and Miragane, 2011).

Some heavy metals such as copper, zinc, manganese, cobalt and molybdenum act as micronutrients for the growth of fishes when present in trace quantities, whereas others such as cadmium, arsenic and chromium acts as carcinogens. Mercury and lead are associated with the development of abnormalities in children which can cause renal prostate and ovarian cancer by taking excess cadmium into a body system (Emami *et al.,*2015). Generally, at the biochemical levels, the toxic effects caused by excess concentrations of heavy metals include competition for sites with essential metabolites, replacement of essential ions, reactions with -SH groups, damage to cell membranes and reactions with the phosphate's groups (Fagr *et al.,* 2010).

Sources of Heavy Metal in Contaminated Soil and Water

Heavy metals occur naturally in the soil environment from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace (<1000mg/kg) and rarely toxic. Due to the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of natural and urban environments may accumulate one or more of the heavy metals above defined background values high enough to cause risk to human health, plants, animals, ecosystems, or other media. The heavy metals essentially become contaminants in the soil environments because; their rates of generation through man-made cycles are more rapid relative to natural ones, they become transferred from mines to random environmental locations where higher potentials of direct exposure occur, the concentrations of the metals in discarded products are relatively high compared to those in the receiving environment, and the chemical form (species) in which a metal is found in the receiving environment system may render it more bioavailable (Allah *et al.,* 2017).

It is projected that the anthropogenic emission into the atmosphere, for several heavy metals, is one-to-three orders of magnitude higher than natural fluxes. Heavy metals in the soil from anthropogenic sources tend to be more mobile, hence bioavailable than pedogenic, or lithogenic ones. Metal-nearing solids at contaminated sites can originate from a wide variety of anthropogenic sources in the form of metal mine tailings, disposal of high metal wastes in improperly protected landfills, leaded gasoline and lead-based paints, land application of fertilizer, animal manures, biosolids (sewage sludge), compost, pesticides, coal combustion residues, petrochemicals, and atmospheric deposition are discussed hereunder (Yilmaz *et al.,* 2017).

MATERIALS AND METHODS

Materials, reagents used for analysis were;

Beakers 250ml capacity

Volumetric flask 100ml capacity

Hot plate

Weighing balance

Digestion flask

Perchloric acid

Nitric acid

Collection of Sample for Analysis

This fish sample *Electrophorus electricus* was collected from Ibom River in Nkwot Nung Imo Village in Ikono Local Government Area of Akwa Ibom State. Some quantity of flesh water alongside with the fish sample were brought to the laboratory with the help of a custard pail. The sample washed with clean water and cut with knife into pieces and dried on the oven for about two days. The muscle of the sample was grained with the used of mortar and pestle. The grained sample was stored in an airtight container and labeled properly. Hence, the required quantities were scooped out for heavy metals determination.

Procedure for Digestion (Wet Digestion)

About 1.0g of fish sample *Electrophorus electricus* weighed into a conical flask. 10mls of Hydrochloric acid (HCl) and 20mls of Nitric acid were added and digested

at 130^{0}C in a fume cupboard until the solution appeared colourless with a slight, increase in temperature. Digestion was completed, when fume of hydrochloric acid (HCl) appeared and silica became white. It was taken to dryness and the flask allowed to cool sufficiently to avoid splattering before about 50mls of distilled water was added and filtered with Whatman filter paper, and excess distilled water was added to make up to 100mls of calibration mark.

Preparation of Standard Solution

Zinc (Zn)

A stock solution containing 1000mg/ml of zinc ion was prepared by dissolving 1.0g of zinc ribbon in 10ml of concentrated HCl. The solution was evaporated almost to dryness and salt re-dissolved in 1000ml of de-ionized water; standard solutions of concentrated 0.0, 0.5, 1.0 and 1.5ppm were prepared from this stock solution.

Copper (Cu)

A stock solution 1000mg/ml of Cu^{2+} ions was prepared by dissolving 2.682.g of $CuCl_2$ H_2O in de-ionized water and finally diluted to 1000mg/ml, standard solutions of concentrated 0.0, 0.5, 1.0 and 2.0ppm were prepared from this stock solution.

Iron (Fe)

A stock solution containing 1000mg/ml of Fe^{3+} was prepared from 1.0g of pure ion wire. The wire was dissolved in 100ml concentrated HNO_3, boiled on water bath and diluted the 100ml with distilled water. From this stock solution, standard solution of concentrated 0.0, 0.5, 1.0, 2.0 and 4.0ppm were prepared.

Manganese (Mn)

A stock solution containing 1000mg/ml of manganese ions was prepared from 1.5g of manganese (IV) oxide by dissolving the salt on 10ml of concentrated HCl. The solution was diluted to 1000ml from which standard solutions of concentrated 0.0 – 0.2ppm were prepared.

Determination of heavy metals by Associated of Official Analytical Chemist (A.O.A.C, 2020). The digest was used for the determination of heavy metals concentration using Atomic Absorption Spectrophotometer (AAS).

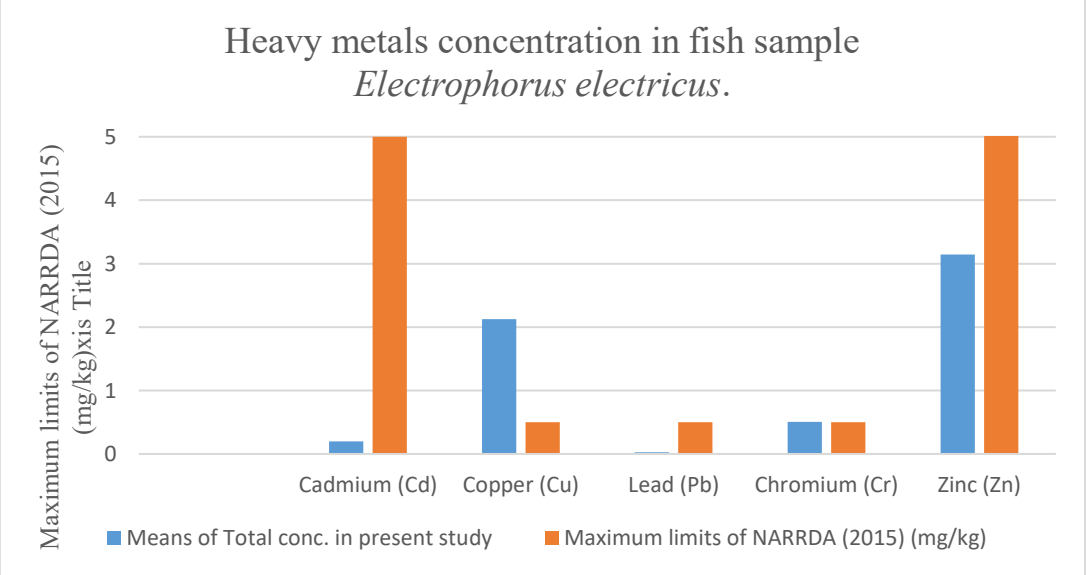
RESULTS

The results of heavy metals concentration in fish sample are presented in table 1 below;

Table 1: Heavy metals concentration in fish sample *Electrophorus electricus*.

Heavy metals	Means of Total conc. in present study (mg/kg)	Maximum limits of NARRDA (2015) (mg/kg)
Cadmium (Cd)	0.196 ± 0.009	5.00
Copper (Cu)	2.125 ± 0.035	0.50
Lead (Pb)	0.027 ± 0.005	0.50
Chromium (Cr)	0.504 ± 0.006	0.50
Zinc (Zn)	3.144 ± 0.010	50.00

National Aquatic Resources Research and Development Agency (NARRDA).



In the result above, it was observed that generally, in fish sample cadmium (Cd) recorded the highest concentration of metals among the two matrices at station2

EDITOR-IN-CHIEF
Prof. A.S. Hossein [Saskatchewan]

(0.0202mg/kg) and its least valve at station1 (0.0190mg/kg) with the overall mean value of 0.196mg/kg ± 0.009.

The highest concentration of metal in copper (Cu) had recorded in fish sample in the two matrices at station1 (2.150mg/kg) and its least value at station2 (2.100mg/kg) with the overall mean value of 2.125mg/kg ± 0.035.

Lead (Pb) had its highest value of (0.030mg/kg) of metal concentration in fish sample in two station matrices at station2 and its least value at station1 (0.023mg/kg) with the overall mean value of 0.027mg/kg ± 0.005.

The concentration of chromium (Cr) metal in fish sample is highest in the two matrices at station2 (0.508mg/kg) and its least value at station1 (0.500mg/kg) with the overall mean value of 0.504mg/kg ± 0.006.

The zinc (Zn) recorded the highest concentration of metal among the two matrices at station2 (3.154mg/kg) and its least value at station1 (3.133mg/kg) also, with the overall mean value of 3.144mg/kg ± 0.010.

DISCUSSION

In the recent time, Ibom River has been subjected to a lot of anthropogenic pollutants capable of impairing the health status of the river. This study revealed that all the heavy metals analyzed were found in fish sample. However, among all the metals analyzed, Zinc (Zn) was observed to have the highest concentrations of metal in the entire fish sample. It is observed that zinc has higher value than the recommended limits value of National Aquatic Resources Research and Development Agency (NARRDA, 2015), in fish sample except that of cadmium (Cd) and lead (Pb) which are lower than the recommended limits.

Based on the results obtained in the analysis of this study, zinc has the highest value of metals that range between (3.133mg/kg - 3.154mg/kg) with the mean value of (3.144mg/kg ± 0.010), in comparism to the permissible limit of 50.00mg/kg recommended by National Aquatic Resources Research and Development Agency (NARRDA, 2015) in fish food, it observed that the value of zinc is lower than that of the permissible limit. The highest value of zinc in this researched work might be due to human activities and vehicle movement that occur in the environment.

Human activities such the use of chemicals and zinc base fertilizer by farmers and spent engine oil waste and petrochemicals around the environment.

Copper (Cu) is one of the metals, which are essential to human health. Its presence in the aquatic environment may be due to accumulation of domestic and agricultural wastes. Copper combines with certain protein to produce enzymes that act as catalyst to help in the body functions and it's also necessary for the synthesis of hemoglobin (Zyadah, 2007). Since the copper (Cu) level (2.100mg/kg - 2.150mg/kg) with the mean value of (2.125mg/kg ± 0.035) recorded in this study is greater than 0.50mg/kg, which is the permissible limits of (NARRDA, 2015). The fish gotten from Ibom River cannot be consumed because of the poisoning content from this metal. However, very high intake of copper (Cu) can cause adverse health effects for most living organisms such as cancer, kidney damage, inhibit urine production and anemia cause by rupture of red blood cells (hemolytic anemia) which can cause death according to Agency for Toxic Substances and Disease Registry (ATSDR, 2012).

The chromium (Cr) in this case although certain products are disposed off on soil, some has assistance for agriculture and forestry. In addition, various are possibly dangerous due to their constituents of this metals, or poisonous organic mixtures and are sometimes, if ever, supplied to land. Some others are actually little in plant nutrients or have no soil conditioning effect (Okoronkwo, 2019). The chromium (Cr) levels (0.500mg/kg – 0.508mg/kg) with the mean value of (0.504mg/kg ± 0.006) recorded in this study were greater when compared to (NARRDA, 2015) maximum permissible limits of 0.50mg/kg in fish food. Thus, consumption of fish from Ibom River can cause harmful effect to human system such as kidney damage, upper abnormal pain, nose irritation and damage in the system of living organisms according to Agency for Toxic Substances and Disease Registry (ATSDR, 2012).

Cadmium (Cd) like any other substance could be absorbed through the gills and has been known to cause damage to fish gills. In man, cadmium poisoning could lead to anaemia, renal damage, bone disorder and cancer of the lungs (Okoronkwo, 2019). The cadmium (Cd) levels (0.190mg/kg – 0.0202mg/kg) with the mean value of (0.196mg/kg ± 0.009) recorded in this study were lower, when

compared to (NARRDA, 2015) maximum permissible limit of 5.00mg/kg in food food. Thus, consumption of fish sample from Ibom River could not pose any cadmium induced health hazard.

Lead (Pb) level recorded in this study is due to its relatively toxicity which can be probably due to contamination of the river by the activities of car wash operators and automobiles repair workshop located in the area. In this study, lead levels (0.023mg/kg – 0.030mg/kg) with the mean value of (0.027mg/kg ± 0.005) were below the recommended limit of 0.50mg/kg for fish food. Lead (Pb) and cadmium (Cd) are toxic elements which have no significant biological functions and show their carcinogenic effects on aquatic biota and human, even at low exposures. Lead (Pb) exposure is known to cause muscle-skeletal, renal, ocular neurological, immunological, reproductive and developmental effects (ATSDR, 2012).

CONCLUSION

Heavy metals in aquatic environments are derived from natural sources (soil formation), non-point sources, transportation, domestic waste, urban run-off, agricultural and industrial activities. A lot of other anthropogenic activities as observed around Ibom River could also contribute significantly to the pollution of this water body.

The results of this finding present a valuable baseline data in the heavy metals in the fish sample from Ibom River in Ikono Local Government Area of Akwa Ibom State, Nigeria. It was observed that the concentrations of heavy metals recorded in the sample were below the (NARRDA, 2015) recommended limit, except chromium (Cr) and copper (Cu). However, the fact that some level of bio-accumulations was found in the fish sample from Ibom River is a cause for constant monitoring of the water because the surrounding villagers depend on the water downstream for domestic and agricultural purposes.

Recommendation

The concentration of heavy metals in Electric eel (fish) in this study showed trace amounts of heavy metals, mainly from anthropogenic input from the villagers. The levels of metals accumulation in fish sample in this study area has constitutes

health hazards to aquatic life and man. But it is necessary to monitor the usage of that River by appropriate agencies by adhering strictly to the rules guiding its safety.

Government must ensure safe disposal of agricultural, domestic sewage and industrial effluents and recycled where possible to avoid these metals and other contaminants from going into that River. It is heavily recommended that, location of automobile workshops, dumping of domestic sewage and other activities that are attribute to the unsafe use of that River should be discouraged, while regular assessment of that River to see its cleanness and proper maintenance should be encouraged.

REFERENCES

Allah, A. T., Wanas, M. Q. & Thompson, S. N. (2017). Effects of heavy metals on survival and growth of GASTROPODA. *Journal of Moll. Study,* 63(1), 79-86.

Ahmad, A. K., Shuhami-Othm, A. N. & Ali, M. M. (2009). A temporal study of selected metals concentration in fishes of lake Chini, peninsula Malaysia Malay. *Journal for Analytical Science,* 13(4), 100 – 106.

Arora, M., Kiran, B., Rani, S., Rani, A., Kaur, B. & Mittal, N. (2008). Heavy metal accumulation in vegetables irrigated with water from difference sources. *Food Chemistry,* 88(3), 811 – 815.

Bhagure, G. R. & Mirgane, S. R. (2011). Heavy metal concentrations in groundwater and soils of Thane Region of Maharashtra, India. *Environmental Monitoring and Assessment,* 24(2), 643 – 652.

Bolger, M., Carrington, C., Larsen, J. C. & Petersen, B. (2012). Safety evaluation of certain food additives and contaminations, WHO Food Additive Series, pp. 212 – 273.

Davies, B. E. (2009). "Lead heavy metals in soils". London: Blackie Academic & Professional, pp. 206 – 223.

Emami-Khansari, F., Ghazi-Khansari, M. & Abdollahi, M. (2015). Heavy metals content of canned tuna fish. *Food Chemistry,* 99(3), 293 – 296.

Etesin, M. U. & Benson, N. U. (2017), Cadmium, Copper, Lead and Zinc tissue levels in bonga shad *Ethmalosa fimbriata* and Tilapia *Tilpia guineensis* caught from Imo River, Nigeria. *Am. Journal Food Technology,* 2(1), 48 – 54.

Fagr, K. A., Saber, A. E., Farag, A. S. & Wagdy, K. B. (2010). Effect of water pollution on expression of immune response genes of solea aegyptiaca in lake qurun. *African Journal of Biotechnology,* 7(10), 1418 – 1425.

Goldhaber, S. B. (2013). Trace element risk assessment: essentially vs. toxicity. *Regulatory Toxicology and Pharmacology,* 77(2), 232 – 242.

Jadhav, J. P., Kalyani, D. C., Telke, A. A., Phugare, S. S. & Govindwar, S. P. (2010). Evaluation of the efficacy of a bacterial consortium for the removal of colour, reduction of heavy metals, and toxicity from textile dye effluent. Bioresources Technology, 109(4), 165 – 173.

Mance, G. & Yates, J. (2019). Proposed environmental quality standards for list II substance in water zinc, *Journal for Technical Report TR,* 209(1), 34 – 36.

National Aquatic Resources research and Development Agency (NARRDA, 2015). Guidelines for aquatic quality. Recommendations NARRDA Geneva, p. 130.

Okoronkwo, I. P. (2009). Heavy metals content in water and fish of River Niger at Yelwa-Yayri. M.Sc. thesis. University of Benin, Benin City, Nigeria. p. 88.

Yilmaz, F., Ozdemir, A., Demirak, E. & Tuna, A. (2017). Heavy metal levels in two fish species *Leucistscus cephalu* and *Lepomis gibbosus. Journals for Food Chem.*, 100(4), 830 – 835.

Zyadah, M. A. (2007). Accumulation of some heavy metals in Tilapia Zilli organs from lake Manzalah, Egypt. *Turk. Journal zool.,* 23(3), 365 – 372.