Available online@www.actasatech.com

Journal of Life &Physical Sciences

*acta*SATECH 10 (1):61-66(2018)

Assessment of heavy and trace metal contents of internal organs of tilapia *(Oreochromis niloticus)* and catfish *(Clarias gariepinus)* obtained from Dandaru fish pond, Ibadan Oyo State

***Abiona, O.O., Awojide, S.H., Odesanmi, O.R. and Ajayi, S.I.**

Department of Pure & Applied Chemistry,
Faculty of Basic and Applied Sciences,
College of Science, Engineering and Technology,
Osun State University, P.M.B.4494, Osogbo, Nigeria

Corresponding Author <oludapobiona@yahoo.com >

Abstract

This study was designed to investigate the concentration of heavy and trace metals in the gills, liver and kidney of Oreochromis niloticus and Clarias gariepinus obtained from Dandaru, a fish pond at Ibadan Oyo state. The samples were digested using the method described by AOAC, 2005 while the concentration of heavy and trace metals were determined using Atomic Absorption Spectrometer (AAS). The result obtained from the heavy and trace metal analysis of the gill, liver and kidney of O. niloticus from Dandaru pond showed that the value of lead which is a heavy metal ranged from 0.06 to 0.10 µg/g while in C. gariepinus it ranged from 0.06 to 0.90 µg/g. The result obtained showed that the values of the heavy and trace metals determined in the gill, liver and kidney of O. niloticus and C. gariepinus obtained in dandaru pond was higher than values obtained in the control samples, with the exception of mercury which was not detected at all. The highest concentration of metals determined in Dandaru pond was found in the kidney of O. niloticus and C. gariepinus. The result also revealed that the values of manganese, iron, and lead exceeded the WHO permissible limit in Fish. This study clearly showed an implication of heavy metal bioaccumulations occasioned by direct pond pollution in the gills, liver and kidney of the samples, therefore, adequate monitoring of the pond is highly recommended while adequate information, education and training should be introduced to control further pollution.

Keywords: Heavy metals; fish; pollution; dandaru pond and trace metals

Introduction

Contamination and accumulation of an aquatic ecosystem by toxic metals has long been major environmental problem and is still growing at an alarming rate. Past episodes of trace metal contamination of the aquatic environment have increased the awareness about its toxicity (Martin-Draz *et al*., 2005).

Worldwide, fish products represent only up to 10% of human diet. However, they are the main uptake routes of metals into the human body (Ruelas-Inzunza *et al.*, 2010). In addition, fish are a useful bio indicator for the determination of metal pollution in aquatic ecosystems (Ahmad and Shuhaimu-Othman, 2010). The concentrations of trace elements in fish organs are determined primarily by the level of pollution in their environment, notably in water and foods (Farkas *et al*., 2003).

Most researches have been conducted to assess the level of trace metals in fish tissue, such as in liver, kidney, stomach, skin, gill, bone, muscles and spleen (Pagenkopf and Neuman, 1974; Cogun and Kargin, 2004; Olmedo *et al*., 2013; Sylvester and Tariwari, 2016 and Health, 1991).

The distribution of metals varies between fish species, depending on age, development status and other physiological factors (Kagi and Schaffer, 1998). Heavy metals may enter marine environment from a variety of natural and anthropogenic sources (Kennish, 2001). Walker *et al.* (2001) reported that the six factors, which contribute to the movement and distribution of heavy metals, are polarity and water solubility, partition coefficient, vapour pressure, partition between different compartment of the environment and molecular stability and recalcitrant molecules.

In Nigeria, water bodies have being found to be sources of exploitation for industrial, domestic, agricultural and urban uses (Fafioye *et al*., 2017). In some locations waste from hospitals environments are discharged without treatment (Abah and Ohiman, 2011). Many water bodies have being subjected to these activities which makes it necessary to monitor heavy and trace metals in waters where aquatic animals are harvested for consumption, as consequences of the activities could be hazardous to man through food consumption

In this study, we examined the concentrations of heavy metals in the gills, liver and kidney of two different fish species Tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) obtained from Dandaru fish pond at Orita Mefa, Ibadan, Oyo State owned by the government of Oyo State, Nigeria. It is expected that results will give an insight to the pollution status of the pond and possibly ascertain the danger inherent in effluent from University College Hospital, Ibadan.

Materials and method

Study area

Materials and methods

Study area

This investigation was carried out at Dandaru fish pond located at Orita mefa in Ibadan, Oyo State Nigeria. Dandaru is an open fish pond located within the vicinity of a Teaching Hospital, Ibadan, Oyo State which continuously receives untreated effluents and hospital wastes containing high content of various heavy metals.

Sample collection

Two commercially important and commonly consumed marine fish species were used in this study, *O. niloticus* and *C. gariepinius* obtained from the polluted fish pond in Orita Mefa Ibadan, Oyo State All fish samples were harvested from two different points latitude 7^0 24^1 16N, longitude 3^0 53E and 205m above sea level of the polluted pond by two local fishermen. The physical characteristic of the fish where assessed. The total length that is the maximum length of the fish with the mouth closed and the tail fin pinched together were measured. An electronic weighting scale was used to weigh each of the individual mass of each fish. The weight was measured in grams (g).

Harvested fish samples were then packed and placed in clean plastic buckets and transported to the laboratory. Fish sample were sorted and transferred for storage in the laboratory freezer at -20^{o}C to reduce biological deterioration prior to analysis.

The control samples for each of the fish species where bought at a local market alive and whole placed in plastic buckets and transferred to the laboratory. Samples where sorted and stored in the laboratory freezer at -20^{o}C to reduce biological deterioration prior to the analysis.

Sample preparation

Fish samples were defrosted and de-scaled. The de-scaled fish Samples were then rinsed with distilled water and placed on a polypropylene dissection board for dissection. Isolation of the following internal organ as test samples gills, livers and kidneys. Cares were taken during dissection of the internal organs to prevent any injuries and metal contamination of the organ samples by using stainless dissecting kits. The isolated internal organs were then oven-dried at 180^{o}C for 4 hours to allow it reach a constant weight.

Digestion of fish samples

Solid sample (1.0 g) was weighed into the pre cleaned borosilcate 250 mL capacity beaker for digestion, mixture of the hydrochloric acid and nitric in ratio 3:1 (10 mL) was added into weighed sampled in the beaker.

The samples with the digestion solution were placed on the hot plate for digestion in the fume cupboard at a temperature of 100^0c for two hours. The beaker and its contents after the digestion were allowed to cool; another 20 mL of the digesting solution was allowed to cool to room temperature. The mixture was filtered into 250 mL volumetric capacity borosilicate container. The filtrate was made up to the mark with distilled water. The same procedure was followed for the digestion of the different fish organs.

Standard solution of each sample, Manganese (Mn), Cobalt (Co), Zinc (Zn), Iron (Fe), Lead (Pb) and Mercury (Hg) were prepared according to Sc 2000 manufacturer procedure for AAS. The determination of Mn, Co, Zn, Fe, Pb and Hg were made directly on each final solution using Perkin-Elmer Analyst 300 Atomic Absorption Spectroscopy (AAS).

Statistical analysis
Data collected were subjected to One-way Analysis of Variance (ANOVA), and were used to assess whether metal parameters varied significantly between organs. Possibilities less than 0.05 were considered statistically significant.

Results
Table 1 and 2 shows the result of the heavy and trace metal analysis found in the various organs of *O. niloticus* found in dandaru pond, Ibadan. The result of the metals ranged as follows: Mn (2.12–5.13 µg/g), Co (3.65–5.74 µg/g), Zn (0.22–0.75 µg/g), Fe (37.90–63.30 µg/g), Pb (0.06–0.10 µg/g) and Hg (not detected) while results obtained for *O. niloticus* used as control samples were: Mn (0.16–0.16 µg/g), Co (0.04–0.31 µg/g), Zn (0.10–0.14 µg/g), Fe (32.8–55.50 µg/g), Pb and Hg were not detected in any of the organs. The results revealed that the kidney had the highest concentration accumulation of the metals. The result obtained for heavy metal analysis of the gill, liver and kidney of *C. gariepinus* from Dandaru pond ranges as follows: Mn (0.50–1.39), Co (0.28–3.54), Zn (0.20–0.69), Fe (30.50–57.30), Pb (0.06–0.90) and Hg which was not detected. The results obtained for *C. gariepinus* used as control samples were: Mn (0.09–0.13), Co (0.08–0.27), Zn (0.10–0.13), Fe (15.00–48.29), Pb and Hg was not detected.

Table 1: Heavy metals analysis in the different organs of *O. niloticus* from Dandaru pond.

	Metals (µg/g)					
Internal organs	Mn	Co	Zn	Fe	Pb	Hg
Gill	$2.12±0.89^a$	$3.65±0.71^a$	$0.22±0.11^a$	$37.9±1.54^a$	$0.10±0.01^a$	ND
Liver	$4.23±0.56^b$	$4.50±0.88^b$	$0.48±0.22^b$	$53.4±1.30^b$	$0.08±0.01^a$	ND
Kidney	$5.13±0.12^b$	$5.74±0.99^c$	$0.75±0.21^b$	$63.3±1.28^b$	$0.06±0.01^a$	HD

The result shows the mean ± SD of three replicates. Data within a row followed by the same letter are not significantly different at P < 0.05.

TABLE 2: Heavy metals analysis in the different organs of *O. niloticus* in the controlled sample.

	Metals (µg/g)					
Internal organs	Mn	Co	Zn	Fe	Pb	Hg
Gills	$0.16±0.13^a$	$0.20±0.12^a$	$0.10±0.02^a$	$32.8±1.63^a$	ND	ND
Liver	$0.16±0.14^a$	$0.31±0.02^a$	$0.12±0.02^a$	$40.3±1.09^b$	ND	ND
Kidney	$0.16±0.10^a$	$0.04±0.01^c$	$0.14±0.13^a$	$55.5±1.21^c$	ND	ND

The result shows the mean ± SD of three replicates. Data within a row followed by the same letter are not significantly different at P < 0.05.

TABLE 3: Heavy metals analysis in the different organs of *C. gariepinus* from Dandaru pond.

	Metals (µg/g)					
Internal organs	Mn	Co	Zn	Fe	Pb	Hg
Liver	$0.50±0.18^a$	$2.72±0.11^c$	$0.20±0.01^a$	$30.50±0.72^a$	$0.90±0.01^c$	ND
Gills	$1.12±0.01^b$	$0.28±0.06^a$	$0.28±0.06^a$	$42.5±1.04^b$	$0.06±0.01^a$	ND
Kidney	$1.39±0.08^b$	$3.54±0.90^d$	$0.69±0.01^b$	$57.3±1.25^c$	$0.06±0.01^a$	ND

The result shows the mean ± SD of three replicates. Data within a row followed by the same letter are not significantly different at P < 0.05.

TABLE 4: Heavy metals analysis in the different organs of *C. gariepinus* in the controlled sample.

	Metals (µg/g)					
Internal organs	Mn	Co	Zn	Fe	Pb	Hg
Liver	$0.13±0.01^{b}$	$0.27±0.08^{c}$	$0.11±0.01^{a}$	$15.0±0.84^{a}$	ND	ND
Gills	$0.09±0.01^{a}$	$0.08±0.01^{a}$	$0.10±0.01^{a}$	$26.4±1.00^{b}$	ND	ND
Kidney	ND	ND	$0.13±0.10^{a}$	$48.29±1.15^{c}$	ND	ND

The result shows the mean ± SD of three replicates. Data within a row followed by the same letter are not significantly different at P < 0.05.

Disscussion

In aquatic ecosystems heavy metals are taken up through different tissues of the fish at different levels (Dural *et al*., 2006; Yilmaz *et al*., 2007). Various biotic and abiotic factors control metal bioaccumulation in fish tissues such as feeding habits, life style, fish age, gender, body mass, and physiologic conditions, as well as water temperature, pH value, and dissolved oxygen concentration (Kamaruzzaman *et al*., 2010; Fernandes *et al*., 2007).

The two fish species *C. gariepinus* and *O. niloticus* analyzed for heavy metals accumulation showed that *O. niloticus* accumulated more of the heavy and trace metals compared to *C. gariepinus*. The reason for the higher concentration of heavy metals accumulation in the *O. niloticus* could be attributed to the difference in feeding habit. *O. niloticus* is a bottom feeder and as such, feeds on bottom sediment containing higher concentration of metals than that of overlying water (Adeniyi and Yusuf, 2007), and this might have contributed to the accumulation of these metals in *O. niloticus*.

Mn is known to be an essential element in animals. Severe skeletal and reproductive abnormalities have being associated with the deficiency of Mn in mammals. Mn was detected in all the fish samples analysed form the polluted pond. The highest value of Mn was detected in the kidney of *O. niloticus* (5.13 µg/g) while the lowest was found in the liver of *C. gariepinus* (0.50 µg/g). For the control sample of both *O. niloticus* and *C. gariepinus* the values ranged from 0.09 to 0.16 µg/g which were lower than the values detected in fish from polluted pond. In all of the organs of fish analysed except the liver of *C. gariepinus* the values obtained were higher than the World Health Organization (WHO) limits of 0.50 µg/g. This could pose a threat to fish due to long time exposure. The same trend was reported by Joseph *et al*. (2012), where all organs had Mn values higher than the permissible limits.

Zn, an essential element, is one of the most common heavy metal pollutants and at higher concentrations, it produce adverse effects in fish by structural damages, which affects the growth, improvement and survival of fish (Afshan *et al*., 2014). The highest value of Zn in the organs of the fishes from the polluted pond is found in the kidney of *O. niloticus* (5.74 µg/g) while the lowest value of Zn was found in the gills of *C. gariepinus* (0.28 µg/g). The values detected from the control samples of both fishes where quite lower compared to those of the polluted ponds. The value of Zn in all the organs of both fishes was lower than the W.H.O limits of 5.0 µg/g. The high values obtained for *O. niloticus* may be attributed to the scales on its body which definitely plays a significant role in the accumulation of the metals. This result is in agreement with the findings of Mastan (2014).

The concentration of Fe in the organs of *O. niloticus* and *C. gariepinus* in the polluted pond ranged from 30.50 to 63.3 µg/g. the highest concentration was recorded in the kidney of *O. niloticus* and even the lowest value of Fe exceeded the WHO limit of 0.30 µg/g in the organs of both fishes from the polluted pond. The high concentration of Fe could be majorly associated with the bio-accumulation of this metal from the effluent coming directly from the hospital and also to pollutions arising from an evident natural abundance of this metal in the environment of the open dandaru pond (Olowu *et al.*, 2009). Fe is required in the diet for the prevention of anaemia which is common in low income earners.

Pb is a toxic heavy metal, it was detected in all the organs of the control sample, the highest value of Pb in the organs of fishes from the polluted pond was 0.10 µg/g detected in the gills of *O. niloticus*. Pb was not detected in the organs of the control sample. The values of Pb in the various organs of *O. niloticus* and *C. gariepinus* were above the WHO limit of 0.01 µg/g. This findigs on the highest concentrations of Pb in the gills of *O. niloticus* is in agreement with the findings by Joseph *et al*. (2012), which reported that the highest concentration of lead was detected in the gills of *O. niloticus.*

Conclusion

This study has shown that Dandaru pond is heavily polluted such as to increase heavy metal accumulation in internal organs of fish. The kidney was observed to be more vulnerable in accumulating the metals than liver and gills of the two species of fish used in the study. *O. niloticus* internal organs had the highest metal concentrations than those of *C. gariepinus* giving us an indication of a higher rate of bioaccumulation in *O. niloticus*. In view of possible bio-magnification of these heavy metals in humans who heavily rely on fish consumption, it is recommended that every industry should have a properly designed and regulated effluent treatment plant for waste disposal.

Reference

Abah S.O. and Ohimain E.L. (2010): Assessment of dumpsite rehabilitation potential using the integrated risk based approach: a case of Eneka, Nigeria. *World App. Sci. J.*, 8(4): 436-442.

Adeniyi, A.A. and Yusuf, K.A. (2007): Determination of heavy metals in fish tissues, water and bottom sediments from Epe and Badagry Lagoons, Lagos, Nigeria. *Environ. Monitor. Assess.*, 37: 451-458.

Afshan, S., Ali, S., Ameen, U.S., Farid, M., Bharwana, S.A., Hannan, F. and Ahmad, R. (2014): Effect of Different Heavy Metal Pollution on Fish. *Res. J. Chem. Environ. Sci.*, 2(1): 74-79.

Ahmad, A.K. and M. Shuhaimi-Othman (2010): Heavy metal concentrations in sediments and fishes from Lake Chini, Pahang, Malaysia. *J. Biol. Sci.*, 10: 93–100.

Cogun, H.Y. and Kargin, F. (2004): Effects of Ph on the mortality an Accumulation of copper in tissue of *Oreochromis niloticus*. *Chemosphere*, 55: 277-282.

Dural, M., Lugal Göksu, M.Z., Özak, A.A. and Derici, B. (2006). Bioaccumulation of some heavy metals in different tissues of *Dicentrarchus Labrax* L, 1758, *Sparus Aurata* L, 1758 and *Mugil Cephalus* L, 1758 from the ÇamlIk lagoon of the eastern cost of Mediterranean (Turkey). *Environ. Monitor. Assess.*, 118(1–3): 65–74.

Fafioye, O.O., Oladunjoye, R.Y., Bamidele, T.T. and Ige, T.A (2017): Determination of heavy metal levels in *Oreochromis niloticus* and *Chrysichthys nigrodigitatus* from Ogun River, Nigeria. *Int. J. Fish. Aqua.*, 9(8): 86-91.

Farkas, A., Salanki, J. and Speeziar A. (2003): Age and size specific patterns of heavy metals in the organs of frsh water fish *Abramisbrama L.* populating low-contaminated site. *Water Res.*, 37: 959–964.

Fernandes, C., Fontaínhas-Fernandes. A., Peixoto, F. and Salgado, M.A. (2007): Bioaccumulation of heavy metals in *Liza saliens* from the Esmoriz-Paramos coastal lagoon, Portugal. *Ecotoxicol. Environ. Saf.*, 66 (3): 426–431.

Health, A.G. (1991): Water Pollution and Fish Physiology. Lewis Publishers, Boca Raton, Florida ,USA, 359pp.

Joseph C.A., Saiwa M., Bashir S.Y. and Victor O.O. (2012): Bioaccumulation of heavy metals in fish samples from river Benue in Vinikilang, Adamawa State, Nigeria. *Am. J. Anal. Chem.*, 3:727-736.

Kagi, J.H. and Schaffer, A. (1998): Biochemistry of metallothionein. *Biochemistry*, 27: 8509–8515.

Kamaruzzaman, B.Y., Ong, M.C. and Rina, S.Z. (2010): Concentration of Zn, Cu and Pb in some selected marine fishes of the Pahang coastal waters, Malaysia. *The Am. J. Appl. Sci.*, 27(3): 309–314.

Kennish, A.J. (2001): The effects of aluminum and other metals on amphibians. *Environ. Pollut.*, 71: 305-328.

Martin–Diaz, M.I., Villena-Lincoln A., Bamber, S., Blasco, J. and Delvalls, T. (2005): An integrated approach using bioaccumulation and biomarker measurements in female shore crab (*Carcinusmaenas*). Chemoshpere: 58: 615 – 626.

Mastan, S.A. (2014): Heavy metals concentration in various tissues of two freshwater fishes, *Labeo rohita* and *Channa striatus*. *Afr. J. Environ. Sci. Technol.*, 8 (2): 166-170.

Nussey, G., Van Vuren, J.H.J. and Du Preez, H.H. (2000): Bioaccumulation of chromium, manganese, nickel and lead in the tissue of the *Moggel*, *Labeoumbratus* (Cyprinidae) from Witbank Dam, Mpumalanga. *Water SA*, 26(2): 269-284.

Olowu, R.A., Ayejuyo, O.O., Adewuyi, G.O., Adejoro, I.A., Denloye, A.A.B., Babatunde, A.O. and Ogundajo, A. (2010): Determination of heavy metals in fish tissues, water and sediment from Epe and Badagry Lagoons, Lagos, Nigeria. *J. Chem.*, 7(1): 215–221.

Olmedo, P., Pla, A., Hernandez, A.F., Barbier, F., Ayouni, L. and Gil, F. (2013): Determination of toxic elements (mercury, cadmium, lead, tin and arsenic) in fish and shellfish samples. Risk assessment for the consumers. *Environ Int.*, 59: 63-72.

Pagenkopf and Neuman. (1974): Analysis of some heavy metals in the riverine water, sediment and fish from river Ganges at Allahabad. *Environ. Monit. Assess*., 157: 449-458.

Philips, S.A. (1990): Metallothionein and metals levels in cytosol of liver, kidney and brain in relation to growth parameters of *Mullussur muletus* and *Liza aurata*. from the eastern Adriatic Sea. *Water Res.*, 37(13): 3253-3262.

Ruelas-Inzunza, J., Paez-Osuna, F. and Garcia-Flores, D. (2010): Essential (Cu) and non-essential (Cd and Pb) metals in ichthyfauna from the costs of Sinaloa State (SE Gulf of California). *Environ. Monit. Assess.*, 162: 251–263.

Sylvester, C.I. and Tariwari, C.N.A. (2016): Heavy metal concentration in fishes from surface water in Nigeria: Potential sourses of pollutant and mitigation measures. *J. Biochem. Res.*, 5(4): 31-47.

Valente, R. and Strobel, C.J. (1993): Environmental Monitoring and Assessment Program Estuaries: 1993 Virginian Province Quality Assurance Project Plan. U.S. EPA, NHEER L-AED, Narragansett, RI. Pp. 23.

Walker, K.A (2001): Monitoring of environmental heavy metals in fish from Nasser Lake. *Environ. Int.*, 27: 27-33.

Yilmaz, F., Özdemir, N., Demirak, A. and Tuna, A.L. (2007): Heavy metal levels in two fish species *Leuciscus cephalus* and *Lepomis gibbosus* . *Food Chem.*, 100(2): 830–835.