AJEHS
African Journal of Environmental
Health Sciences
Volume 1, [1], November, 2014
pp 51-56

Seasonal and Habitat Variation in Heavy Metal Concentration in Selected Fishponds and their Feeder Streams in Osun State

O.T. Aladesanmi
Institute of Ecology and
Environmental Studies
Obafemi Awolowo University, Ile-Ife
Email: ttaladesanmi@gmail.com;
titiakinsiku@yahoo.com

R.T. Ilesanmi
Department of Crop Science and
Production
Obafemi Awolowo University, Ile-Ife

Corresponding Author:
O.T. Aladesanmi, as above

Keywords:
Heavy Metals, Fish ponds,
Rainy Season, Dry Season

Abstract

The presence of heavy metals in the environment could constitute hazard to public health. Hence the present study determined heavy metal (Pb, Co, Cr, Cu, Cd, Ni, Fe, Mn, Zn) concentrations in three selected earthen fish ponds and their feeder streams in Osun state, south-west, Nigeria in rainy and dry seasons of 2011 and 2012. The analysis was carried out using an atomic absorption spectrophotometer (AAS). The result revealed that most heavy metals were higher in the dry season than in the rainy season. In addition, high level of the metals was generally recorded in the feeder streams than in the pond which confirms the stream as potential source of heavy metal pollution to the fish ponds. A significantly ($p=0.05$) higher concentration of Zn was observed in Ilesha pond than in the stream water. On the other hand, Ni concentration in Osogbo and Yakoyo stream was significantly higher than in the pond water.

Introduction

The significance of environmental factors to the health and well-being of human populations' is increasingly apparent, hence the need for immediate attention by the society. Consequently, the management of our environment and the control of discharge of waste products from anthropogenic activities is of high interest to researchers, regulatory bodies, environmental advisory agencies and policy-makers all over the world. Rapid urbanization, industrialization and population growth have been the major causes of stress on the environment leading to problems like human health problems, eutrophication and fish death, coral reef destruction, biodiversity loss, ozone layer depletion and climatic changes (Sadiq, 2002; Bay *et al.*, 2003). Determination of adverse effects of various elements upon human health and the ecosystem has been gaining momentum recently, especially on scientific, social

and emotional ground. Consequently, the management of our environment and the control of anthropogenic activities is of high interest to researchers, regulatory bodies, environmental advisory agencies and policy-makers all over the world (Sadiq, 2002; Bay *et al*., 2003; Ogundiran and Afolabi, 2008).

The pollution of aquatic environment with heavy metal has been a worldwide problem during the recent years because they are indestructible and most of them have toxic effect on organism (MacFarlane and Burchette, 2000). Water is one of the important natural resources useful for developmental purposes in both urban and rural areas. Agricultural wastes such as pesticides, fungicides and fertilizers, human and animal feces, seepage from pit latrines and septic tanks, refuse dump, industrial, domestic and municipal wastes released into water bodies are often responsible for surface water contamination. Bremen *et al.* (2001) observed that most surface water resources accessible to household in rural areas are subjected to chemical and biological contaminations which may come from animals, septic tanks, storms water run-off. Contaminated water is associated with health risks.

Among environmental pollutants, metals are of particular concern due to their toxic effect and ability to bioaccumulate in aquatic ecosystems (Censi *et al*., 2006); body tissues and organs (Babalola, *et al*., 2009). Heavy metals including both essential and non essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms (Storelli *et al*.,2005). The heavy metals investigated in this study have been implicated for various human health problems even at trace levels. Pb is ingested by humans when Pb-containing foods and drinks are consumed. Water bodies are easily contaminated with Pb-laden effluents and this gets into aquatic organisms and then to man, Pb has no known essentials function in animals and is a well known toxic metal that damages the liver, kidneys, brain, central nervous and reproductive systems (Lovei and Levy, 2000) of man and aquatic organisms causing all kinds if diseases. Pb and Cd are classified as carcinogens (USEPA 1999).

Other metals, investigated in this study, were Ni, Cr, Zn and Cu, each of which has been reported for various health problems being non-biodegradable and with the possibility of accumulation in the food web. This study is conducted on water from three selected earthen fish ponds and their feeder streams with a view to identify and characterize the levels of heavy metals (Fe,Cu, Mn, Pb, Cd, Co, Cr, Ni and Zn) in the water and establish the pollution status of the fish ponds.

Materials and Methods

The study covered three towns in Osun State. A purposive sampling method was used to select the study area. The ponds of interest were earthen fish ponds with inflow from surrounding natural streams. The streams selected are Arula in Osogbo, Yah in Ilesha and Awuru in Yakoyo. There are various anthropogenic activities around the stream and fish ponds like waste disposal, sewage as well as agricultural practices which may result in deterioration of water quality rendering serious environmental problems posing threat on human beings and sustaining aquatic organism. Water samples were collected following the standard procedure described by Kegley and Andrews (1987), Ademoroti (1996) and the APHA (1998). Heavy metal lead (Pb), chromium (Cr), zinc (Zn), nickel (Ni), cadmium (Cd), copper (Cu), Iron (Fe), Cobalt (Co), Mercury (Hg), Manganese (Mn), determination was carried out with the use of Atomic Absorption Spectrometer. The instrument was be calibrated with analytical grade metal Standard Stock Solution. Controls included water samples from fresh water and deionized water. The data was subjected to statistical analysis using analysis of variance. Only variables with p-values = 0.05 were considered significant.

Results and Discussion

Effect of Habitat Variation on Heavy Metal Concentrations

The potential toxicity of metals in water may have detrimental effects on biochemical processes of aquatic organisms (Jonsson, 2009) especially fish which serves as a source of protein which is deficient in Nigerian diet (Areola, 2007). Metal concentrations in water at different ponds and streams are illustrated in Table (1-.3). Metal concentrations in water were found in the following order: Fe > Ni > Zn > Mn > Co > Cu > Cr>Pb in Ilesha pond water and this was slightly different from the sequence observed in Yah stream water (Fe > Ni > Zn > Mn > Cu > Cr> Co >Pb). Osogbo pond water recorded heavy metal concentration in the order of Fe > Ni > Mn > Zn > Co > Cu > Cr>Pb while Arula stream recorded a sequence of Fe > Zn > Ni > Mn > Cu > Co > Cr>Pb. In addition, heavy metal concentrations recorded in Yakoyo pond water was in the order of Fe > Zn > Mn > Ni > Co > Cu > Cr>Pb while Ewuru stream water recorded the concentration in the order Fe > Zn > Ni > Mn > Cu > Co > Cr>Pb which was similar to the trend observed in Arula stream water. Variations in the order of dominance of these metals could be as a result of the different anthropogenic activities going on in the surrounding of individual water body.

Table 1: Heavy Metal concentration in Ilesha Fish Pond and Yah Stream

Metals	Pond Water (µg/L)	Stream Water (µg/L)	P value
Pb	3.15±0.03	3.70±0.13	0.09
Cr	8.69±0.97	9.97±1.06	0.06
Co	9.78±1.05	6.66±0.51	1.12
Zn	68.57±6.25	41.67±3.44	0.05*
Ni	85.35±8.19	87.86±9.14	0.98
Mn	15.85±6.22	14.34±1.58	0.002
Fe	495.16±71.83	414.50±79.64	0.37
Cu	9.72±0.98	11.15±1.24	0.11
Cd	ND	ND	

*Significant (p<0.05); ** Highly significant (p<0.01); ***: Very Highly significant (p<0.001)
S.E.M: Standard error of mean, ND: Not detected

Table 2: Heavy Metal concentration in Osogbo Fish pond and Arula Stream

Metals	Pond Water (µg/L)	Stream Water (µg/L)	P value
Pb	1.87±0.13	2.37±0.19	0.09
Cr	2.94±0.27	3.60±0.76	0.01
Co	10.12±1.05	9.52±0.59	0.11
Zn	59.21±6.06	67.08±4.94	0.22
Ni	19.89±2.19	47.69±7.04	0.05*
Mn	19.90±6.70	30.98±2.03	0.01**
Fe	66.47±5.63	90.51±39.49	0.47
Cu	9.62±1.03	11.09±1.24	0.34
Cd	ND	ND	

*Significant (p<0.05); ** Highly significant (p<0.01); ***: Very Highly significant (p<0.001)
S.E.M: Standard error of mean, ND: Not detected

Table 3: Heavy Metal concentration in Yakoyo Fish pond Ewuru/Rara Stream

Metals	Pond Water (µg/L)	Stream Water (µg/L)	P value
Pb	2.71±0.12	1.52±0.21	0.07
Cr	3.89±0.62	2.65±0.41	0.12
Co	10.64±0.55	9.00±1.09	1.92
Zn	68.82±4.38	57.48±6.62	0.05
Ni	31.94±5.09	35.64±4.14	0.05*
Mn	33.24±2.26	17.64±6.47	0.78
Fe	96.86±7.62	60.12±5.39	0.001***
Cu	11.19±1.27	9.52±6.13	0.001***
Cd	BDL	BDL	0.07

*Significant (p<0.05); ** Highly significant (p<0.01); ***: Very Highly significant (p<0.001)

Table 4: Seasonal Variation in the Water Quality of Yah stream and associated Fish pond at Ilesha

Metals (µg/L)	Dry season	Rainy season	P value
Pb	3.79±0.11	3.05±0.06	0.47
Cr	9.92±1.06	8.75±0.96	0.48
Co	10.41±1.01	6.01±0.55	0.05*
Zn	52.96±5.07	57.28±4.62	0.23
Ni	91.18±9.04	82.025±8.29	0.05*
Mn	19.75±1.71	10.44±6.08	0.05*
Fe	474.14±84.66	435.52±66.81	0.02*
Cu	10.88±1.00	9.98±1.22	0.31
Cd	ND	ND	

*Significant (p<0.05); ** Highly significant (p<0.01); ***: Very Highly significant (p<0.001)
S.E.M: Standard error of mean, ND: Not detected

However, Fe had the highest concentration in all the samples. Okoye, (1991a) and Asuquo *et al*, (1999), Olaifa, *et al*., (2004) also reported the dominance of Fe in their study. The concentrations of the essential metals (Fe, Zn, Ni, Mn) were generally higher than the non-essential metals in the water samples in the three locations. This supports the report of Zn concentration in Yah stream was significantly ($p<0.05$) lower than in the recorded value in the associated fish pond in Ilesha. In Osogbo, significance ($p<0.05$) differences were observed in the concentrations of Zn, Mn and Fe, while the concentrations of Ni and Mn in Ewuru stream were significantly ($p<0.05$) higher than the recorded values in the associated fish pond in Yakoyo.

Effect of Seasonal Variation on Heavy Metal Concentrations

Heavy metal concentrations were generally higher in the dry season than in rainy season as reported by Basyigit and Tekin-Ozan, (2013). Literature has also explained that heavy metals concentration in the sediment samples are usually higher in dry season compared to those of the rainy season. This may be as a result of slow current of water in dry season giving room for the particles to settle down. Metal concentrations in water samples from Yah, Arula and Ewuru streams and their associated fish ponds are shown in Tables 4-6. Concentrations of Co, Ni, Mn and Fe in Ilesha water samples were significantly ($p<0.05$) lower in the rainy season than in the dry season. Similarly, seasonal variations significantly affected the concentrations of Co, Zn, Ni, Fe, and Cu in Osogbo water samples.

Table 5: Seasonal Variation of the Water Quality of Arula Stream and Associated Fish Pond at Osogbo

Metals (µg/L)	Dry season	Rainy season	P value
Pb	2.42±0.05	1.19±0.46	0.19
Cr	3.32±0.08	1.15±0.28	0.06
Co	9.93±0.57	5.83±1.08	0.05*
Zn	47,43±4.28	4.29±2.72	0.001***
Ni	89.48±8.94	39.77±7.48	0.01*
Mn	11.33±1.20	5.97±1.19	0.21
Fe	172.17±11.85	32.30±21.06	0.01**
Cu	58.39±5.65	1.39±1.05	0.001***
Cd	ND	ND	

*Significant ($p<0.05$); ** Highly significant ($p<0.01$); ***: Very Highly significant ($p<0.001$)
S.E.M: Standard error of mean, ND: Not detected

Table 6: Seasonal Variation of the Physicochemical water quality of Ewuru/Rara Stream and associated Fish Pond at Yakoyo

Metals (µg/L)	Dry season	Rainy season	P value
Pb	2.71±0.12	1.52±0.21	0.07
Cr	3.89±0.62	2.65±0.41	0.12
Co	10.64±0.55	9.00±1.09	1.92
Zn	68.82±4.38	57.48±6.62	0.05*
Ni	31.94±5.09	35.64±4.14	0.78
Mn	33.24±2.26	17.64±6.47	0.001***
Fe	98.86±7.62	60.12±5.39	0.001***
Cu	11.19±1.27	9.52±6.13	0.07
Cd	ND	ND	

*Significant ($p<0.05$); ** Highly significant ($p<0.01$); ***: Very Highly significant ($p<0.001$)
S.E.M: Standard error of mean, ND: Not detected

In addition, the concentrations of Zn, Mn and Fe, were significantly ($p<0.05$) higher in the dry season than in the rainy season as reported by Basyigit and Tekin-Ozan, (2013). Tables 7 and 8 the EPA (2002), WHO (2003) and SON (2007) standards for surface water. Although study revealed that the heavy metals of interest found in measurable quantities are still within recommended limits. Efforts should however be concentrated on ensuring that these concentrations are not exceeded.

Table 7: Comparison of Heavy Metal Contents in Ilesha, Osogbo and Yakoyo Pond and Stream Water with Water Quality Guidelines (mg/L)

Heavy metal	WHO (2003)	EPA (2002)	SON (2007)	ILESA		OSOGBO		YAKOYO	
				POND	STREAM	POND	STREAM	POND	STREAM
Pb	0.05	0.05	0.01	0.0032	0.0037	0.0021	0.00577	0.00187	0.0024
Cr	0.05	0.05	-	0.0086 9	0.0099	0.0028	0.0392	0.0029	0.0036
Ni	0.02	-	0.02	0.085	0.087	0.084	0.087	0.019	0.048
Mn	0.5	0.02	0.20	0.0159	0.0014	0.011	0.0119	0.020	0.031
Cd	0.01	0.01	0.005	ND	ND	ND	ND	ND	ND

Table 8: Comparison of Heavy Metal Contents in Ilesha, Osogbo and Yakoyo Pond and Stream water with Water Quality Guidelines (μg/L) in both Dry and Rainy Seasons

Metal	WHO (1993)	EPA (2002)	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season
Pb	≤0.010	0.05	0.00334	0.003	0.0024	0.0012	0.0027	0.0015
Cr	-	0.05	0.009	0.0088	0.0033	0.0012	0.0039	0.0027
Ni	1.500	-	0.091	0.082	0.0895	0.0398	0.032	0.036
Mn	-	0.02	0.020	0.010	0.0113	0.0060	0.033	0.018
Cd	≤0.010	0.01	ND	ND	ND	ND	ND	ND

Conclusion

Water quality study is essential for setting base line conditions and standards. Against these standards results of further studies can be evaluated. The persistence and toxicity of heavy metals in man and aquatic ecosystem calls for the constant monitoring of the incidence of these metals in the environment. This study summarizes the seasonal and habitat variation in the concentration of some heavy metal in three fish ponds and their feeder streams in Osun state. The result showed that most investigated heavy metals were within WHO, EPA and SON recommended limits, however, these concentrations should not be exceeded.

References

Ademoroti, C.M.A. (1996), Standard method for water and effluent analysis Limited Ibadan, Nigeria, Fludex Press.

American Public Health Association APHA (1998). Standard Methods for the Examination of Water and Wastewater, 15th ed. Washington, DC 20005, APHA, 1015 Fifteenth St. N.W.

Areola, F. O. (2007). Fish marketing and export potentials of fish and fisheries products of Nigeria. A paper presented at the educative and informative aqua-cultural workshop and aqua-exhibitions tagged: sustainable fisheries livelihood: management and food security in Nigeria. On 23rd February.

Babalola, O. O., Okonji, R. E., Atoyebi, J. O., Sennuga, T.F., Raimi, M.M., Ejim-Eze, E. E., Adeniran, O. A., Akinsiku, O. T., Areola, J.O. and Odebunmi, S. O. (2009) Distribution of Lead in Some Selected Organs and Tissues of Albino Rats Exposed to Acute Lead Toxicity. *Available online at* *http://www.academicjournals.org/SRE* *ISSN 1992-2248* © 2010 Academic Journals; Vol. 5(9), pp. 845-848.

Basiyigit, B. and Tekin-Ozan, S. (2013) Concentrations of some heavy Metals in Water, Sediment and Tissue of Pikeperch (Sander lucioperca) from Karatas Lake related to Physiochemical Parameters, Fish Size and Season. Pollut. Jour. Environ. Stu. Vol 22(3) Pp 633-644.

Bay, S. M.., Zeng, E. Y., Lorenson, T. D., Tran, K. and Alexander, C. (2003). Temporal and spatial distributions of contaminants in sediments of Santa Monica Bay, California. *Mar. Env. Res.,* 56 (1-2), 255 – 276.

Censi, P., Spoto, S. E., Saiano, F., Sprovieri, M. and Mazzola, S. (2006). Heavy Metals in Coastal Water System: A Case Study from North Western Gulf of Thailand. Chemosphere, 64: 1167-1176.

EPA (Environmental Protection Agency), (2002). Risk Assessment: Technical background information. RBG table. Available online from http://www.epa.gov./reg3hwmd/risk.

Jonsson, C. M., Paraíba, L. C And Aoyama, H. (2009) Algae Acid Phosphatase Affected By Ten Metals And Enzymatic Parameters Determination in Presence of Mercury and Copper Pesticidas: R. Ecotoxicol. E Meio Ambiente, Curitiba, V. 19, P. 1-10, Jan./Dez. 2009.

Kegley and Andrews (1987). *The Chemistry of Water. Env. Sci. Tech.*, 21, 749.

Lovei, M. A and Levy, B.S. (2000). Lead exposure and health in central Eastern Europe. Evidence from Hungary, Poland and Bulgaria. World Bank, Washington D.C.

Okoye, B.C.O. (1991a). Nutrients and selected chemical Analysis in the Lagos Lagoon surface waters. *International Journal of Environmental Studies*, 38 pp131-136.

Macfarlane, G.B and Burchett, M.D. (2000). Cellular distribution of Cu, Pb and Zn in the Grey Mangroove Avicemmia marina (Forsk). *Vierh Aquatic Botanic*, 68: 45 – 49.

Storelli, M.M., Storelli, A., D'ddaabbo, R., Morano, C., Bruno, R and Marcotrigiano, G.O. (2005). Trace Elements in loggerhead turtles (*Caretta caretta*) from the Eastern Mediterranean; Overview and Evaluation. *Environmental Pollution*, 135: 163 – 170.

Ogundiran, O.O. and Afolabi, T. A. (2008). Assessment of the physicochemical parameters and heavy metals' toxicity of leachates from municipal solid waste open dumpsite. *Int. J. Env. Sci. Tech.*, 5 (2), 243-250.

Olaifa, F. E., Olaifa, A. K. and Onwude, T. E. (2004). Lethal and sublethal effects of copper to the African catfish *(Clarias gariepinus). Afri. J. Biomed. Res.* 7: 65-70.

Sadiq, M. (2002). Metal contamination in sediments from a desalination plant effluent outfall area. *Sci. Total Env.,* 287 (1), 37–44.

Standard Organisation of Nigeria SON (2007) Nigerian Standard for Drinking Water Quality. Nigerian Industrial Standard NIS 554: 2007.

United States Environmental Protection agency USEPA. (1986). Quality Criteria for Water. EPA 440/5-86-001. May 1986. Office of water regulations and standards. Washington DC., USA.

World Health Organisation (1993). Revision of WHO Guidelines for Water Quality. WHO Geneva.