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Comparative Assessment of the Concentration of Heavy Metals in Concrete and Earthen Fish Ponds in South – East, Nigeria

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Abstract:
Comparative assessment of the concentration of heavy metals in concrete and earthen fish ponds was carried out in south – east, Nigeria. Water samples using column sampling bottles were collected from 15 randomly selected concrete and earthen fish farms at different locations in Anambra, Enugu and Imo States for 6 months (3 months each in the dry and the wet season) for analysis. The specific locations of the farms were obtained using Global Positioning System (GPS) model extrex (FERMIN). The heavy metals analyzed using Atomic Absorption Spectrophometer (AAS) with Buck Scientific Model 210 VGP, were copper (Cu), zinc (Zn), arsenic (AS), chromium (Cr), iron (Fe), manganese (Mn), lead (Pb) and mercury (Hg). The main objectives of the study were to screen the ponds for presence of heavy metals and compare their concentrations in the two set of farms. Multivariate statistical method was employed using independent t-test to analyze the results. The results showed presence of heavy metals in varying amount in both concrete and earthen ponds with significant differences ($p < 0.05$) inthe mean values of Cu, As, Cr, Fe, Mn, Pb and Hg between the concrete and earthen pondsin dry and wet season. However, there was no significant difference ($p > 0.05$) in the values of Zn, Cr and Fe between the two seasons. Their mean values (ppm) ranged from, 0.11 ± 0.08 (dry season) and 0.00 ± 0.00 (wet season) Hg respectively to 2.34 ± 1.48 (dry season) and 1.27 ± 0.20 (wet season) Pb.The concentrations of all the metals in concrete and earthen fish ponds across the states were above the normal natural background of these metals. The detection of heavy metals well above the optimal levels and permissible limits in both concrete and earthen fish ponds suggests environmental pollution and underscores the need to periodically monitor our fish rearing environment for possible remediation. This study suggests a further research to determine the levels of these heavy metals concentration in fish ponds.

1. Introduction

Global population demand for aquatic food products is increasing. According to a report, more than one-fourth of all animal protein consumed by man is aquatic in origin of which aquaculture contributes substantial percentages (Anonymous, 1990). The increasing demand for aquaculture products has been attributed to a number of factors such as the rapid population growth, the dwindling supplies of fish from capture fisheries; and the increasing demand for some essential first class protein found to have positive effects on human health and exclusively found in fish (Woo, 1995; Hohn, 1999 and Carper 1988). According to the United Nations (UN) Nigeria's population of over 170 million people may exceed 210 million by 220 and the demand for fish protein is expected to grow by another 700,000 metric tons over the same period. FAO figures show that Nigeria's current fish consumption is 7.5 kilos per person against global fish consumption which has risen to 20 kilos per person, implying that the country's current consumption shortfall per person is still large, at 11.2 kilos per person (Fisheries Maestro, 2014).It is projected that by 2030, the estimated addition of 2 billion people to the world population will mean that aquaculture will need to produce nearly double the current output of 48 million tones to maintain current per capita consumption levels. It is obvious that the demand for fish product will continue to increase which cannot be met by supplies from capture fisheries. Aquaculture production in Low Income Food Deficient Countries(LIFDCs) including Nigeria need to be increased significantly if the fish – demand gap is to be met. In 2011, Nigeria occupied the 46th position in FAO World Aquaculture Production ranking (FAO, 2011).

In Nigeria, according to a report (FAO, 2003), fish farm presently cover an estimated 60,000Ha of the country and produce some 25000 to 30,000 Mt of fish per year, this is less than 0.5 Mt/ha/year. This shows that the yield per unit area is very low compared to what is obtained elsewhere like China where the average yield is as high as 3-3.8mt/ha/year (Fei, 1989). If aquaculture yield is to significantly increased and the quality of what is being produced assured, adequate knowledge of the environmental status is a sine qua non.

Evidences are fast emerging that water quality parameters of fish farm rearing units and pond raised-fish, like any other facets of human enterprise, are being impacted negatively by anthropogenic activities such as urban and industrial waste (toxic-pollutants, pathogens, heavy metal, plastic additives and stress from unsuitable aquaculture conditions).The safety of aquaculture products is therefore drawing global attention (Buras, 1993). Most studies dealing with the concentration of heavy metals focused mainly on rivers/lake fisheries, although cultured –based fisheries are more vulnerable to all the negative impacts of environmental pollution than open water system (Arun, 2002).Thus, less has been studied on the effects of pollution on aquaculture. The need to screen fish ponds for presence of heavy metals informed this study.

Monisha et al (2014) identified various sources of heavy metals to include soil erosion, natural weathering of the earth's crust, mining , industrial effluent, urban runoff, sewage discharge, insect or disease control agents applied to crops.Fair fax County Newsletter, 2012 has earlier reported that Zinc, Copper, and lead are three of the most common heavy metals released from road travel; accounting for at least 90% of the total metals in road run off .The report further identified the metals and their common sources:

Metals	Sources
Lead	- Leaded gasoline, tire wear, lubricating oil and grease.
Zinc	- Tire wear, motor oil, grease, brake emissions, corrosion of galvanized parts.
Iron	- Auto body rust, engine parts
Copper	- Bearing wear, engine parts, and brake emissions.
Cadmium	- Tire wear, fuel burning, batteries
Chromium	- Air conditioning coolants, engine parts, brake emissions.
Aluminum	- Auto body corrosion

Human activities have also been implicated in the elevated levels of Lead, Cadmium, Mercury and Zinc in freshwater (Meybeck *et al*; 1989). Seasonal variation in heavy metal concentrations has been reported. Wright *et al* (1984) reported higher concentration of iron, copper and manganese during rainy season than dry season while Idowu (2004) however, recorded a high value of copper in dry season.

2. Materials and Methods

2.1. Sample Collection

Water samples from 15 randomly selected farms from Anambra, Enugu, and Imo states were collected for six months (three months each in dry and wet season) for analysis. Five farms each were selected from three senatorial zone of the state to reflect the geographical spread using purposive sampling. Water samples were collected from concrete and earthen fishponds to compare. Water samples obtained from all the sites in dry and wet seasons were transported to Project Development Institute (PRODA) laboratory where the analysis was conducted using the atomic absorption spectrophometer (AAS) with Buck Scientific Model 210 VGP. The metals analyzed were Cu, Zn, As, Cr, Fe, Mn, Pb, and Hg.

2.2. Statistical Analysis

Data generated from this research were analyzed using **independent t-test at 0.05 and 0.01 levels of significant** to compare the different in metal concentrations between the two set of farms.

3. Results

The heavy metals detected in varying amount were Cu, Zn, As, Cr, Fe, Mn, Pb and Hg. The pooled mean values of the metals for concrete fish ponds and earthen fish ponds are shown in Table 1.

Parameters	Concrete fish ponds	Earthen fish ponds
Cu	0.33 ± 0.17	0.30 ± 0.59
Zn	0.67 ± 0.31	1.20 ± 0.79
As	1.36 ± 0.64	1.30 ± 0.93
Cr	0.72 ± 0.55	0.90 ± 0.82
Fe	0.43 ± 0.10	0.50 ± 0.66
Mn	0.51 ± 0.37	0.40 ± 0.47
Pb	2.00 ± 0.70	1.60 ± 0.85
Hg	0.08 ± 0.06	0.10 ± 0.43

Table 1: Mean concentrations (ppm) of heavy metals in concrete and earthen fish ponds

Table 2 shows Independent values of compared sample (t- test) between concrete and earthen fish ponds while Table 3 shows results of independent t-test for comparing mean values of detected heavy metals in concrete and earthen fish ponds within dry and wet seasons. The mean values of all the heavy metals (Cu, Zn, As, Cr, Fe, Mn, Pb and Hg) investigated in this study showed no significant ($p > 0.05$) difference between the concrete and earthen pond either within the dry and the wet season, although their values were higher in the dry season than wet season except for Zn and Cr that were higher in the wet season (Table 3). Their mean values (ppm) ranged from Hg, 0.11 ± 0.08 (dry season) and 0.00 ± 0.00 (wet season) respectively to Pb, 2.34 ± 1.48 (dry season) and 1.27 ± 0.20 (wet season).

Parameters	Dry Season		Wet Season	
	Concrete	Earthen	Concrete	Earthen
Cu	0.76±0.69[a]	0.60±0.37[a]	0.16±0.14[a]	0.11±0.08[a]
Zn	0.67±0.57[a]	0.56±0.35[a]	1.56±0.56[a]	0.96±0.65[a]
As	1.60±1.17[a]	1.61±1.16[a]	0.88±0.95[a]	0.98±0.88[a]
Cr	0.38±0.41[a]	0.40±0.40[a]	1.40±0.55[a]	1.05±0.93[a]
Fe	0.67±0.47[a]	0.67±0.87[a]	0.32±0.07[a]	0.34±0.05[a]
Mn	0.92±0.75[a]	1.16±0.72[a]	0.09±0.09[a]	0.15±0.14[a]
Pb	2.34±1.48[a]	2.9714±1.87[a]	1.27±0.20[a]	0.95±0.60[a]
Hg	0.11±0.08[a]	0.16±0.05[a]	0.0029±0.00[a]	0.01±0.02[a]

Table 2: Mean values (ppm) of detected heavy metals in concrete and earthen fish ponds compared within dry and wet season's respectively

Mean values for each type of farm followed by different superscripts are significantly different

Parameters	Dry Season	Wet Season
	Concrete	Earthen
Cu	0.76±0.69[a]	0.11±0.08[b]
Zn	0.67±0.57[a]	0.96±0.64[a]
As	1.60±1.17[b]	0.98±0.88[a]
Cr	0.38±0.41[a]	1.05±0.93[a]
Fe	0.68±0.47[a]	0.33±0.04[a]
Mn	0.92±0.75[a]	0.15±0.14[b]
Pb	2.34±1.48[a]	0.95±0.60[b]
Hg	0.11±0.08[a]	0.01±0.02[b]

Table 3: Mean values (ppm) of detected heavy metals in concrete and earthen fish ponds compared between dry and wet seasons

Mean values for each type of farm followed by different superscripts are significantly different

However, there were significant ($p < 0.05$) differences in the mean values of Cu, As, Mn, Pb, and Hg of concrete and earthen fish ponds between the dry season and the wet season (Table 3). The concentration of all the heavy metals was generally higher in the dry season period both for concrete and earthen ponds but values were not significantly different ($p > 0.05$) between the two set of farms. On the average the levels of heavy metal accumulation were higher in earthen fish ponds.

4. Discussions

The concentrations of heavy metals (biological trace elements) in concrete fish farms and earthen fish farms were relatively high and above normal natural background of these metals. This underscores the need to periodically investigate our fish rearing environment. The presence of heavy metals in concrete fish farms hitherto considered free from pollution equally highlights the fact that pollution could affect concrete fish farms as well.

This study measurements suggest that the presence of heavy metals such as Cu, Zn, Cr, Fe, Mn, and some of which are essential for life at trace levels are well above permissible concentrations making them a significant threat to ecosystems and a problem for those who rely on these waters for fish production. In addition, mercury, arsenic and lead were all present at much higher levels than acceptable concentrations. Food chain contamination by heavy metals has become an important issue according to (Pravin *et al;* 2011) partly because of potential accumulation in biosystems through contaminated water. Recent finding according to Brian (2013) indicates that even at extremely low levels copper will disrupt the sense of smell of fish thus preventing them from detecting predators or recognizing their eggs. Copper has been specifically identified to decrease neurons response and ability to avoid predators.

The levels of heavy metals concentrations in concrete fish farms and earthen fish farms were not significantly different when compared within the season but there were significant difference in the mean values of all the metals between dry and wet season in earthen fish farms. The values were higher in the dry season than in the wet season except for Zn and Cr. The difference in concentration of metals between dry and wet seasons reflects the sources of the metals into the environment and precipitation. Due to high evaporation during the dry season, metals are highly concentrated and therefore more detectable. However, in the case of Zn and Cr that were more abundant in wet season, it may be due to their source. Fair fax CountyVirginia (2012) indicates that the sources of Zn and Cr into the aquatic environment are predominantly road run-off and erosion of chromium containing rocks. This accounts for the high values of these metals in the environment during wet season. Vicki (2010) gave the optimal levels of Zn (< 0.005mg/l), arsenic (<0.004mg/l), Fe (< 0.1mg/l), Pb (<0.02mg/l), and Hg (0.0002mg/l) for freshwater fish as against the values of Zn (0.67mg/l), AS (1.6mg/l), Fe (0.68mg/l), Pb (2.97mg/l) and Hg (0.16mg/l) obtained in this study. Comparatively these values were higher and therefore above optimal levels. The present study indicates the concentration of Pb 2.97mg/l, found higher than FAO/WHO recommended value of 0.05mgl and US, FPA 1.7mg/l for sea food (Prabal *et al.* (2011). Ikechukwu *et al.* (2008) in a case study of Owerri-municipal heavy metal concentrations in urban wells obtained concentration levels of Cu, Fe, Pb, and Zn similar to this investigation but it was considered to be below WHO limits for drinking water. Opeolu *et al*. (2008) also studied the mobility profile of heavy metals in selected automobile workshops in Anambra State, Nigeria and reported levels of 0.94 mg/l (Pb), 0.26 mg/l (Zn), 1.12mg/l (Cu) and 0.07 mg/l (Cr) which varied from the present study. Also, the values obtained for Zn, Fe, Pb, Cu and Mn by Atama (2009) for Anambra River which is a lotic environment was lower than the figures obtained in this study which was conducted in lentic environment. These variations may be due to the differences in environmental factors and the fact that heavy metals in soil are likely to be more concentrated and easily detected than heavy metals in liquid medium.

The adverse effects of heavy metals on aquatic and human lives are well known.Fish loose sense of smell in polluted water and consequently this affects their feeding ability (Brian, 2013).In humans acute or chronic exposure to heavy metals can lead to various disorders such as cancer and can also result in excessive damage due to oxidative stress induced by free radical formation (Monisha et al, 2014). The knowledge of heavy metal concentrations in water is very important with respect to management, human consumption of these aquaculture products and to determine the useful monitor and remediation of the most polluted area (Pravin *et al.* (2011). The present sites of these investigation demands regular monitoring of metals status for effective management. Fish farm rearing unit demands regular monitoring of physico-chemical parameters and heavy metals status for effective management. Therefore, fish farmers should be encouraged to possess basic water quality kits to monitor basic water quality parameters of their ponds periodically.

Government should establish a regulatory body which will control aquaculture production and ensure that fish farmers are licensed in line with the international best practices.

Principles of Hazard Analysis of Critical Control Point (HACCP) should be strictly adhered to in fish farm site location and production processes, so that our aquaculture product can go to the international market.

The use of vascular plants that possess abilities to absorb these metals via their roots in ponds contaminated with pollutants can help to remedy such environment.

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