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Determination of accumulated heavy metals in benthic invertebrates found in Ajiwa Dam, Katsina State, Northern Nigeria

[*1]Kankia H. I. and [2]Abdulhamid Y.

[1]Department of Biochemistry, Umaru Musa Yar'adua University, Katsina, Nigeria
[2]Department of Biology,Umaru Musa Yar'adua University, Katsina, Nigeria

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ABSTRACT

The aim of this study was to investigate the level of Pb, Zn, Cu, Fe and Cd concentrations in various aquatic invertebrate species; Two classes of invertebrate were caught and identified {i.e. three (3) Mullusc: Bivalvia, Turbonilla and Monodonta while the other class are (2) Arthropods:Dysticus and lethocerus americana.} from the Ajiwa Dam at the three (3) Sampling stations using atomic Absorption Spectrophotometry (AAS) method. The result obtained showed that Fe had the highest concentration with average of 0.212mg/g and Pb which has the lowest concentration with 0.051mg/g. The study revealed the accumulation of Zn, Fe, Cu, Cd and Pb by aquatic invertebrates from Ajiwa Dam. The concentration of metals are Fe>Cu>Zn>Cd>Pb while their mean values were 0.04032mg/g, 0.0122mg/g, 0.02266mg/g, 0.0110mg/g and 0.0092mg/g respectively.

Keywords: Accumulation, Heavy metals, Benthic invertebrates, Ajiwa Dam, Katsina, Nigeria.

INTRODUCTION

Increase industrialization, population growth, and complete disregard for environmental health have led to global environmental pollution. The release of pollutants into the environment may occur accidentally or due to anthropogenic activities which ultimately results in soil, water, and air pollution, leading to many health hazards. From the galaxy of chemicals, heavy metals are among the major environmental pollutants that enter into the food chain. The flow of chemicals through the lower constituents of the food chain to different tropic levels imparts risk to the ecosystem, as chemicals tend to bioaccumulate and can be transferred from one food chain to another. Pollutants have been detected in various food chains where the results are usually detrimental to microorganisms, plants, animals, and humans alike [1,2].

Heavy metals accumulate in the body, building up in fat cells, bones, glands, and hair, and inevitably lead to a dizzying array of symptoms and chronic diseases. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis. In addition, allergies to heavy metals are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer [3-5]. The pollution by heavy metals is covert, persistent and irreversible that not only degrades the quality of the atmosphere, water bodies, and food crops, but also threatens the health and well-being of animals and human beings by way of the food chain. For example, Pb is a non-essential element to the human body, and excessive intake of the metal can damage the nervous, skeletal, circulatory, enzymatic, endocrine, and immune systems of those exposed to it. Moreover, high exposure to Cd can have adverse effects such as lung cancer, pulmonary adenocarcinomas, prostatic proliferative lesions, bone fractures, kidney dysfunction, and hypertension, while the chronic effects of As consist of dermal lesions, peripheral neuropathy, skin cancer, and peripheral vascular disease [6].

Toxic metals comprise a group of minerals that have no known function in the body and, infact, are harmful. Today mankind is exposed to the highest levels of these metals in recorded history. This is due to their industrial use, the unrestricted burning of coal, natural gas, and petroleum and incineration of waste material worldwide. Toxic metals are now everywhere and affect everyone on earth. They have become a major cause of illness, aging and even genetic defects [7]. Toxicity is the accumulation of substances into the body of living organisms that cause harm to the system. A substance therefore only become toxic when it reaches and exceeds a “threshold close” or to organisms that absorbs it [8]

Over the last few decades, there has been growing interest in determining heavy metal levels in the marine environment and attention was drawn to the measurement of contamination levels in public food supplied, particularly fish. Although heavy metal is a loosely defined term, it is widely recognized and usually applied to the wide spread contaminants of terrestrial and fresh water ecosystems [1].There are actually about 35 metals that are needed to be aware of because of occupational or residential exposure; 23 of these are the heavy elements or “heavy metals”: Sb, As, Bi, Cd, Ce, Cr, Co, Cu, Ga, Au, Fe, Pb, Mn, Hg, Ni, Pt, Ag, Te, Tl, Sn, U, V, and Zn generally refer to metals and metalloids having densities greater than 5 g/cm^3) [2]. Interestingly, small amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity [9-12]

Aquatic animals bioaccumulate heavy metals in considerable amount in tissues over a long time and the dependence of the populace in this area on this water body for domestic water supply and its aquatic organisms as source of protein makes it imperative to assess the level of heavy metals in this aquatic ecosystem in view of the health implications that cut across the food strata. Living organisms require trace amount of some heavy metals, such as Co, Cu, Fe, Mn, Mb, V and Zn. Fe for example prevent anaemia while Zn is a core factor for over 100 enzymes reaction. Because they may be needed in small quantity, metals such as mercury, lead and cadmium has no known vital or beneficial effect on organisms and accumulation over time in the body of mammals can cause serious health effect [13-23].

The metals under study can be classified based on toxicity. Toxic metal can be defined as those metals that have harmful effect on living organisms and the environment as a whole. Toxic metals may occur as ions in liquid waste or as metallic salt in solid wastes. A metal is considered to be toxic if small or high concentration of the metal is capable of producing serious harm or death to plants, animals, and humans. The study of toxic materials is called toxicology. Some examples of toxic metals include; Cd, Zn, Pb, and Cu [1-23]. In sub-saharan Africa, urban and pre-urban food production has been identified as an important resource for meeting the challenges of rapidly growing cities, and the positive aspects of such production have been well documented in the literature. However, health and environmental concerns are associated with urban and pre-urban agriculture (UPA)**.** Empirical evidence from the city of Katsina and Kano in northern Nigeria suggest that there is currently much reason for concern as industrial and domestic toxins are reaching dangerously high levels. As soil and water channels become increasingly polluted, the sustainability of urban and pre-urban food production is questioned. Since the health implications of long-term exposure of toxins are unclear, it is suggested that coordinated longitudinal research involving urban planners, agricultural scientists and health specialist is urgently needed. Rapid and unorganized industrialization and urbanization have contributed to the elevated levels of heavy metals in the urban environment of the developing countries such as china, India and Nigeria [24].

MATERIALS AND METHODS

STUDY AREA

The experimental site was the Ajiwa Dam and water works including the irrigated fadamas up the course of river Tagwai to makurda in Katsina state Nigeria. It is part of Tagwai downstream irrigated land within which the largest fadama acrage of Katsina state are found. The study area lies within latitude 12^{o} 30| -13^{o} 00| North longitude 7^{o} 30|-8^{o} 00 East in the sudan savanna ecological zone of Nigeria characterized by rainy season (May –October) and dry period (November-April). Annual rainfall varies between 600mm to 800mm while the annual temperature range is between 25^{o}-40^{o} with a relative humidity of 20-40^{o} between June and August. The mean annual evapotranspiration is 1618 mm, the elevation of the site is about 518m above the sea level. The Dam has a plant capacity of 50000km per day, catchment area of 1678km with 12meters height and spillway of 60meters, lift pump of 1040km\hr. capacity. The Dam was commission in 1975 for the purpose of providing water for consumption, irrigational purposes, fishing site as well for recreational and wildlife conservation. Neighboring villages apart from Ajiwa include Masabu, Kunturu, Watsa, Danku and so on all in Batagarawa Local Government area Katsina State, Nigeria

SAMPLING STATION

Three sampling station were selected during this study as station A (Watsa), station B (Masabu) and station C (Kanya Uban Daba) water inflows. All samples were analyzed for Pb, Zn, Cu, Fe, and Cd in accordance with standard techniques.

SAMPLE COLLECTION

Fresh water invertebrates were collected by using nets and hooks then separated by suspending the organisms found and repeatedly decanting it through the net that retain some benthos. Five species were collected and identified as *Bivalvia spp, Turbonilla spp, monodonta spp, Dysticus spp and lethocerus Americana*. The samples were collected randomly using nets, hooks and hands from three identified sites or stations. They were then kept and taken in the clean plastic container into the laboratory. Samples were stored under room temperature in an open environment until further treatment.
The benthic organisms were then identified using a magnifying glass, books of determination, guide to aquatic invertebrate manual coupled with the assistance of some of the zoologist of the Department of Biology, Umaru Musa Yar`adua University, Katsina for the identification of each species.

SAMPLE PRE-TREATMENT

Five different samples of the species of organisms caught at all the station were then separated individually. Then the complete bodies of each species were used during this study then each sample was washed with distilled water and then dried between temperatures of 1050C in an oven. The dried samples were grounded into powder using ceramic motar and pestle. All the materials and samples was washed using deionized water.

DIGESTION PROCEDURE

Wet digestion method was used in this study in which 1g of the oven dried samples (powdered) were weighted and put in to 100cm3 beaker. 1cm3 perchloric acid were added to each sample and then followed by adding 5cm3 of nitric acid and 1cm3 sulphuric acids and swirled gently to ensure complete mixing of the sample, then digested on hot plate at moderate temperature of 600C first until a yellow straw solution was obtained then the temperature was raised to 1200C until there was complete dissolution of the samples. 50cm3 of distilled deionized water was then added until complete evaporation of the acid. Then solutions were then cooled and filtered using acid washed paper (whatman1) in to 50cm3 volumetric flask and diluted to the mark with distilled deionized water. The samples were analyzed using atomic absorption spectrophotometry (AAS).

RESULTS

The results of the analysis of heavy metals were obtained from the AAS machine. Absorbance was calculated into mg/g using the standard given by the machine. The concentration of the heavy metals in the aquatic species found at the various sampling sites in Ajiwa Dam is presented in table 1

Table 2 shows the mean metal concentrations, grand mean, standard deviation and coefficient of variation percent of dry weight of five aquatic invertebrate species from three different sampling sites of Ajiwa Dam, Ajiwa, Katsina state.

Fe shows the highest concentration in the sample of benthos of all species with (0.04032mg/g)) and Pb had the lowest concentration of (0.00924mg/g**).** The order of concentration were Fe >Cu

> Zn >Cd >Pb> while their grand mean values were 0.04032 mg/g, 0.0122 mg/g, 0.01166 mg/g, 0.011 mg/g and 0.00924 mg/g respectively.

Table 1: Heavy metals concentration in mg/g in aquatic invertebrate species at the various Sampling site in the Dam

Benthos (Species)	Cd	Pb	Zn	Cu	Fe
Site A					
1.Bivalvia	0.010	0.009	0.009	0.014	0.012
2.Turbonilla	0.005	0.014	0.009	0.014	0.019
3.Monodonta	0.015	0.007	0.007	0.005	0.025
4.*Dysticus*	0.020	0.007	0.009	0.005	0.170
5.Lethocerus	0.005	0.013	0.013	0.009	0.019
Site B					
1.Bivalvia	0.010	0.007	0.005	0.014	0.015
2.Turbonilla	0.010	0.009	0.009	0.014	0.015
3.Monodonta	0.010	0.011	0.011	0.009	0.170
4.*Dysticus*	0.015	0.009	0.050	0.014	0.025
5.Lethocerus	0.005	0.007	0.007	0.018	0.025
Site C					
1.Bivalvia	0.015	0.009	0.007	0.014	0.012
2.Turbonilla	0.010	0.014	0.007	0.014	0.025
3.Monodonta	0.010	0.009	0.013	0.009	0.027
4.*Dysticus*	0.015	0.007	0.007	0.014	0.021
5.Lethocerus	0.010	0.011	0.011	0.018	0.025

TABLE 2: Mean concentration of Heavy Metals in mg/g of dry weight of five Invertebrate Species at three different sampling sites on Ajiwa Dam, Katsina

Benthos (Species)	Cd	Pb	Zn	Cu	Fe
1.Bivalvia	0.0117	0.0083	0.007	0.014	0.013
2.Turbonilla	0.0083	0.0123	0.008	0.014	0.0196
3.Monodonta	0.0116	0.009	0.010	0.007	0.074
4.*Dysticus*	0.0167	0.0076	0.022	0.011	0.072
5.Lethocerus	0.0067	0.009	0.0113	0.015	0.023
GM	0.011	0.00924	0.01166	0.0122	0.04032
SD	0.0039	0.001806	0.006019	0.003271	0.030057
CV%	35.46	19.55	51.62	26.81	74.50

Grand mean GM, Standard deviation SD, Coefficient of variation CV

DISCUSSION

Observation from this study shows that there were little variationsin mean concentration of heavy metals in all the species investigated between Zinc (Zn), Lead (Pb) and Cadmium (Cd) and higher variation between Iron (Fe) and copper (Cu). This could be connected with the sources of these metals to the Dam [24]. Their work reported seasonal differences in element concentration throughout the year. This could be associated with natural variation of trace metal in aquatic environment. This has to be monitored continuously for year [24].

The mean concentration of metals were low (Fe 0.04032mg/g, Cu 0.0122mg/g, Zn 0.01166, Cd 0.011, and Pb 0.00924) in the species. This indicate that the species found accumulating low heavy metals, accumulation take place when concentration in the organisms is higher than the concentration in water [2, 14, 16]. These metals were in the order of Fe> Cu> Zn >Cd>Pb. The high level of such trace metals or heavy metals in benthos observed in this study agrees with the findings of [14-16]. The concentration of Fe being highest in such species also agrees with result of the report of heavy metals in aquatic species conducted by [22]. The value of Zn recorded is lower than the ones obtained from the results of the report of heavy metals in water, sediment and fishes from river Nasarawa [24]. Zn is widely used for making paints, dyes, rubber, wood, preservatives and through wares and tears; Zn from this sources is discharged into the environment. The Mean level of Fe, Cu, Zn Cd and Pb determined were above the safety standards and health criteria established by World Health Organization (WHO), Food and Drugs Administration (FDA) and United Environmental Protection Agency (USEPA) [24] except for zinc and copper which is within the range recommended by other regulatory bodies. The level of zinc in such species is however within the range recommended by EPA [24].

Fe though high above WHO safety standard, it is still safe because it has benefits to organisms though in very high concentration leads to conjunctivis, chroiditis and retinitis if it is in contact and remains in the tissue but Cd is a toxic metal and has no metabolic benefits to human and aquatic biota [22, 24]. Its presence in any compartment of the aquatic ecosystem indicates contamination. Concentrations of metals were low in contrast to higher when compared to other polluted and water quality form human consumption [23, 24]. According to the federal Ministry of environment the maximum allowable limits for metals in aquatic life should not exceed their unit depending on the metals, for chromium 0.002µg/L, Zinc 2.0µg/L and Lead 1.7µg/L, excess of essential metals like copper, zinc, manganese and cobalt are toxic. Lead is associated with mental retardations, premature, loss of teeth and others [24].

The high level of these metals in water and aquatic invertebrate species are as a result of the runoffs during the rainy season from agricultural fields and the dumping of domestic wastes in the water body at different points along the length of the stream as they are known to contain heavy metals such as As, Cd, Co, Cu, Fe, Hg, Mn, Pb, Ni, and Zn which will eventually end up in this aquatic ecosystem.It is also reported that heavy metal are taken up and accumulated by invertebrates with tissues and body concentration usually higher in a wet basis than concentrate seawater [15-18].

Studies on pollution monitoring in fresh water lakes environment has been reported using different indicator species. In this study, essential metals were accumulated in amounts higher than non-essential metals (Zn, Pb,).this order suggests that benthos species accumulate heavy metals according to their biological importance.Zn and Cu are biologically essential and play important role as co-factors in more than 100 enzymatic processes [1, 18, 22].

Several studies reported that the levels of trace metals in the organism both in respective and irrespective of the benthos, liver were higher than the result obtained for bone and muscle. The higher level of trace metals in their body physiologically is their liver and relative tissues may be attributed to higher coordination of metallothionein protein with metals [16, 22,23,25-27]. According to their investigations, the liver is the principal organ responsible for the detoxification, transportation and storage of the toxic substances and it is an active site of pathological effects induced by contamination so that the organism may accumulate such metals. Once inside the water they directly contact with water and sediments pollutant that may be present in water [16, 22, 23, 25-27].

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CONCLUSION

This research has presented data on the levels of heavy metals in various aquatic invertebrate species at the three sites from Ajiwa Dam, Batagarawa, Katsina State, Nigeria. The finding indicates that aquatic organisms accumulate varied heavy metals depending concentrations, which also depends on the levels of pollutants. Although the results obtained does not show any form of danger posed to consumers of sea foods and water effects from this dam but the possibility of deleterious effects after long period cannot be ruled out. This is as a result of the fact that this water body serves as the receptor for domestic wastes as well as runoff from agricultural lands where phosphate fertilizers and other agrochemicals are frequently used. There is therefore the need for continual assessment of the level of pollution of this dam with metals from the mentioned sources in order to reduce the level of pollution.

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