Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.6, No.8, 2016

Assessment of Heavy Metal Contamination of River Gora Kaduna, Nigeria

*N.E.L Egbe and K.C Ahunanya

Department of Biological Sciences, Nigerian Defence Academy, P.M.B. 2109, Kaduna, Nigeria

Abstract

The concentration of four heavy metals viz. Lead (Pb), Manganese (Mn), Copper (Cu) and Zinc (Zn) in water and sediment samples obtained from the banks of River Gora where industrial and domestic effluents are discharged were determined. The study was performed during wet season (August) at two different sampling points. The result of this investigation shows that the sediments accumulated higher elements than the water. Lead concentration of water and sediment samples taken from point A were 0.84 mg/l and 320 mg/l respectively compared to point B of 0.00 mg/l and 47.62 mg/l. Levels of lead in the water samples from point A exceeded the acceptable limits by the World Health Organisation (WHO). The results point to the need for rational planning of pollution control strategies, so as to keep check on release of toxic heavy metals.

Keywords Heavy metals, Water pollution, Toxicity, River Gora, Kaduna, Nigeria

1. Introduction

Monitoring and assessment of water pollution has become a very critical area of study because of direct implications of water pollution on aquatic life, animals and human beings. The contamination of surface water by heavy metals is a serious ecological problem as some of the heavy metals like Cadmium (Cd) and Pb are toxic even at low concentrations, are non-degradable and bio-accumulate through food chain. Though some heavy metals such as (Iron) Fe, Cu, and Zn are essential micronutrients, they can be toxic to living organisms at higher concentrations (Kar *et al*., 2009; Nair *et al*., 2010). In aquatic environments, some heavy metal such as lead, mercury and cadmium are concentrated through the trophic system especially in the kidney and liver of various mammals (Dempster and Manning, 1994). Inputs of these toxic heavy metals to the environment can result from natural inputs from the erosion of rocks, volcanic activity and forest fires. Heavy metals are also frequent waste products of anthropogenic activities and their emission often results in the contamination of the surrounding environment (Lee and Stuebing, 1990). Mining, manufacturing industries and agricultural activities are main sources of heavy metals that pollute the soil, water and air in Nigeria. The excessive increase in the level of heavy metals in water bodies is due to wrong and misappropriate disposal of heavy metals in contaminated sludge water.

Acid rain resulting from dissolved hydrogen sulphide, sulphur dioxide and oxides of nitrogen has contributed to alterations of soil and freshwater acidity. As a consequence there is an increase in the bioavailability of many heavy metals to fresh water species (Sprenger and McIntosh, 1989). Under certain environmental conditions, metals may accumulate to toxic proportions and can cause ecological damage (Freedman, 1989). Prevalence of chronic ailments such as heart and kidney diseases, skin cancer and anaemia has been reported in people living for more than five years in areas polluted by heavy metals. Inhalation of arsenic has been directly associated with lung and skin cancer. Phytotoxic effects of elevated levels of heavy metals in soils cause poor vegetation establishment that makes the soils prone to erosion. The 2004 World congress on Environmental Health highlighted that environmental metal poisoning is becoming a major public health burden in African countries due to rapid globalization and industrialization (Carnie, 2004). The concentration of life threatening metals such as Lead (Pb), Arsenic (As), Mercury (Hg) and Zinc (Zn) has been found to be increasing in water, soil, and air in several African countries (Carnie, 2004). Neurotoxic effects of exposure to low levels found in the environment includes reduced or poor educational attainment, poor classroom behaviour, anaemia, high blood pressure and some cellular changes whose significance are yet to be fully understood.

Heavy metal pollution of riverine and other aquatic systems may affect man directly or through his supplies of water, agricultural and other biological products; his physical objects or possessions or his opportunities for recreation and appreciation of nature. The preservation of aquatic resources for ecosystem and human health and well-being is a paramount concern worldwide and it has become evident that approaches to managing aquatic resources must be undertaken within the ecosystem dynamics in order that their exploitation for human uses

remains sustainable (Nakamura *et al* ., 2006).

Water bodies especially rivers are frequently used for monitoring heavy metal pollution in urban areas. This is so because the industrial activities in and around an area may influence the level of heavy metal, hence the analytical data obtained from such analysis can serve as measures of pollution in the area under study. In this study, we report heavy metal (Pb, Mn, Cu and Zn) concentrations in the water and sediment samples in River Gora during the wet season month of the year.

2. Materials and method

2.1 Study area

The study was conducted in River Gora, which is a tributary of River Kaduna in Kaduna town during the wet season in August, 2010. Kaduna is a capital city in Northern Nigeria and the town with the second largest concentration of industries in the region. River Gora receives effluents predominantly from International Beer and Beverages Industries (IBBI), sun glasses industry, flour mill and glass industry. The River serves as drainage for urban surface runoff, as a source of irrigation water for farmlands along its banks and for domestic uses by locals that live along the course of the River. In the farmland area, high nutrient runoff from the various agricultural practices washes into the river as well as livestock manure, pesticides and human waste.

2.2 Sample collection and pre-treatment

Two sampling stations were established along the profile in the course of the research, site A and site B. Water sample was collected in 1l water bottle, previously rinsed with distilled water, and preserved at $4^{o}C$ in the refrigerator. Sediment samples were scooped from a depth of about 20 cm into plastic containers using a spatula. They were air-dried for three days until totally dry and then passed through a 2 mm sieve. Drying the materials protects the sediment sample from decomposition and also ensures a constant reference value.

2,3 Laboratory analysis

Analysis of water sample was done with 1-2% HNO_3 using a DR/400U atomic absorption spectrophotometer (AAS) (HACH, USA). This gives the total accumulation of various metals in the water sample.

Heavy metals readily form complexes with organic constituents; therefore it is necessary to destroy the organic matter by digestion with strong acids.

5 g each of the sediment sample was digested with 100 ml of 20% HNO_3 in a conical flask, boiled gently for 10-15 min and filtered while still warm to avoid precipitation of the metals. The filtrate was made up to 100 ml using distilled water. Allowed to cool and analysed using 1-2% HNO_3. The analysis was carried out using AAS according to the method of AOAC (2005).

The hydrogen ion concentration (P^H) of each sample was also determined.

3. Results

The average P^H of the water samples from sites A and B was 7.05 and 6.4 respectively, while that of the sediment was 7.30 and 7.10 from sites A and B respectively.

The heavy metal concentration in water and sediment samples obtained from the two sampling points is shown in Table 1 and Table 2 respectively.

Heavy metal concentrations (mgl^{-1}) showed variations. The concentration of heavy metal was observed to be higher in water and sediment samples collected from site A (the point of effluent discharge) than the samples from site B (a distance of about 1 Km downstream). The mean levels of Zn, Cu, Pb and Mn for site A for water samples were 0.3 mgl^{-1}, 0.02 mgl^{-1}, 0.82 mgl^{-1} and 0.27 mgl^{-1} respectively, and for site B, 0.19 mgl^{-1}, 0.01 mgl^{-1}, 0.0 mgl^{-1} and 0.25 mgl^{-1}. For the sediment samples, mean concentrations of Zn, Cu, Pb and Mn from site A were 49.6 mgl^{-1}, 17.25 mgl^{-1}, 320 mgl^{-1}, and 26.52 mgl^{-1} respectively, and for site B 26.5 mgl^{-1}, 4.28 mgl^{-1}, 30.08 mgl^{-1} and 6.5 mgl^{-1}.

Sediment accumulated much more levels of heavy metals than the water samples as shown in Table 2 and Figure 2 relative to Table 1 and Figure 1.

4. Discussion

The levels of lead observed in the stream have drawn our attention, mainly due to the toxic effects of lead on

plants and animals, including humans. Ecological and toxicological effects of lead and its compounds in the environment have been reviewed extensively (Demayo *et al*., 1982; Mudge G.P, 1983; De Michele S.J, 1984 and Lansdow and Yule, 1986). Lead is ubiquitous and is a characteristic trace constituent in rocks, soils water, plants, animals and air. Pb is an accumulative metabolic poison. Most of the chemical forms of lead can be incorporated into the body by inhalation, ingestion, dermal absorption and placental transfer to the foetus. High levels of exposure may cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system and acute or chronic damage to the nervous system. The mean concentration of lead in site A for the sampling month was 0.82 mg/ml. Comparing these figures with the International guideline for drinking water by WHO shows that lead in the water sample is above the acceptable condition and this could pose a threat to humans that utilize this water for drinking and for other domestic purposes. Livestock and plants watered with the polluted water could also accumulate these toxic metals in their tissues and these could ultimately affect humans that feed on them. As was previously shown by Emere *et al*., 2015, plants grown near Ungwan Dosa Stream in Kaduna accumulated Zn in their leaves. Lead concentration in the sediment sample was found to be 320 mgl^{-1} in site A, much less concentration of lead was obtained from site B. This recorded high levels of lead in both the water and sediment samples calls for stricter regulation of effluent discharged from the industries.

Sediment samples accumulated higher concentration of all the metals sampled compared to water samples. This could be because both the plant and animal remains finally end up decomposing in the sediments and particulate materials settle in the sediment thereby adding to the load of accumulated heavy metals in sediments. This is in accordance with the findings of Bubiez *et al*., (1982).

The levels of the Zn, Cu and Mn in both the water and sediment samples for both sampling sites were observed to be within the International guidelines for heavy metals in water and sediments.

The observed higher levels of the heavy metal in site A relative to site B indicate improper treatment of effluents by the industries that discharge their effluents into River Gora.

Table 1. Concentration of heavy metals in water samples obtained from site A and site B for the sampling month.

Metal (mg^{-1})	Site A			Site B		
	1	2	Ẍ	1	2	Ẍ
Zinc	0.308	0.32	0.31	0.10	0.28	0.19
Copper	0.00	0.045	0.02	0.00	0.02	0.01
Lead	0.80	0.84	0.82	0.00	0.00	0.00
Manganese	0.25	0.3	0.27	0.00	0.50	0.25

Table 2. Concentration of heavy metals in sediment samples obtained from site A and site B for the sampling month

Metal (mg^{-1})	Site A			Site B		
	1	2	Ẍ	1	2	Ẍ
Zinc	46.20	53.00	49.6	21.02	31.99	26.5
Copper	17.50	17.00	17.25	4.00	4.560	4.28
Lead	320	320	320	12.55	47.62	30.08
Manganese	25	28.05	26.52	5.34	7.67	6.50

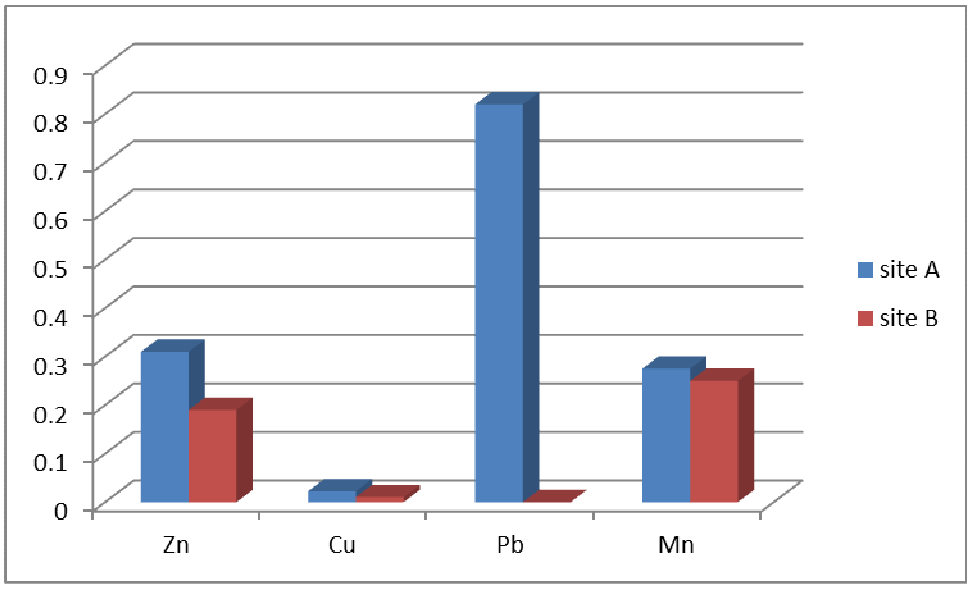

Figure 1. Mean Concentration of heavy metals in water samples obtained from site A and site B.

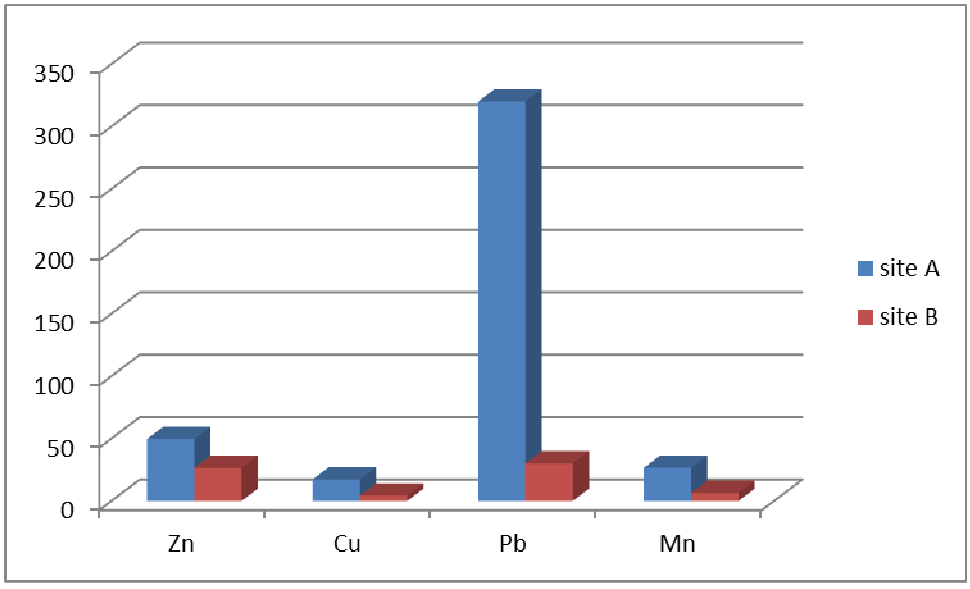

Figure 2. Mean concentration of heavy metals in sediment samples obtained from site A and site B.

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