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Heavy metals evaluation of Madna Stream' sediment in Kubokun village of Abuja Metropolis

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ABSTRACT

This research work was conducted to assess the concentration of heavy metals namely: Co, Cu, Cd, Fe, Mn, Pb and Ni. The concentration of Cadmium, Copper, Cobalt, Iron, Lead and Nickel were determined in sediments of Madna stream, Kubokun village, Abuja using ten different sites 200m apart. The elemental determination was carried out using wet digestion with concentrated HNO_3 *and HCl and analysis with atomic absorption spectrometer. The concentration of heavy metals follow the trend Fe > Co > Ni > Pb > Cu > Cd. For essential element it is Fe > Co > Cu, while the non essential elements has the trend, Ni > Pb > Cd. Result of the analyses show that the concentrations of all the heavy metals determined except for copper were above the WHO maximum acceptable concentration. Thus, indicating the tendency of pollution from both anthropogenic and natural sources. The level of Pd correlates positively with Co and Fe. Cu correlates negatively with Ni and Co. There is statistical significance in the level of Fe in the sediment compared to Pb, and that in Ni compared to Cu.*

Keywords: Anthropogenic, Heavy metals, Elemental determination, Kubokun

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INTRODUCTION

Environmental pollution is one of the major problems posing threat to the existence of man and other living organisms in this 21st century, pushing man and other living organisms to the verge of extinction. The ecosystem (biotic and abiotic factors) has been devastated as a result of the extensive industrial and agricultural activities of man. The increased exploration, production and consumption of this earth raw materials (fossil fuel, minerals) coupled with rapid growth of world population over the past 100 years has caused the increase of heavy metals in our environment [7]. The following: arsenic, cadmium, chromium, copper, iron, lead, mercury and nickel are regarded as the most common heavy metal pollutants according to the UNEP (United Nations Environmental Program) [4, 5].

Heavy metal pollutants are predominantly transported in association with suspended particulate accumulated with heavy metals and organic pollutants in low turbulent river, leading to the formation of highly polluted river bottom sediments in industrialized areas. The association of pollutants with sediment particles will be dependent on the area as well as the characteristics of the chemical portion interacting with the sediments [1]. Metals are introduced into aquatic systems as a result of the weathering of rocks, from volcanic eruptions and from a variety of human activities involving the mining, processing or use of metals and ore that contain metal pollutants [1]. The most common heavy metal pollutants ware arsenic, cadmium, chromium, copper, iron, lead, mercury, and nickel. There are different sources of pollutants: point source (localized pollution), where pollutant comes from a single, identifiable source. Another pollutant source is no point source, where pollutants come from dispersed (and often difficult to identify) sources. There are only a few examples of localized metal pollution, like the natural weathering of ore bodies and little metal particles coming from coal burning plants via smokes stacks in air, water and soils around the factory [3].The most common metal pollution of fresh water comes from mining companies. They usually use an acid mine drainage system to release heavy metals from ores, because metals are very soluble in an acid solution. After the drainage process, they disperse the acid solution in the ground water, containing high levels of metals [8].

Metals released from water as the pH falls can become locked up in bottom sediments, where they remain for years. Streams coming from draining mining areas are often very acidic and contain high concentrations of dissolved metals with little aquatic life. Both localized and dispersed metal pollution cause environmental damage because metals are non-biodegradable. Unlike some organic pesticides, metals cannot be broken down into less harmful component in the environment [6].Metals easily leach into water systems, since the ionic form of a metal is more toxic because it can form toxic compounds with other ions. Electron transfer reactions that are connected with oxygen can lead to the production of toxic ox-radicals, a toxicity mechanism now known to be of considerable importance in both animals and plants. Some ox-radicals such as superoxide anions (O^{2-}) and the hydroxyl radical (OH^-), can cause serious cellular damage [6].

The ambient environment for aquatic organisms is usually water or sediments. With inorganic chemicals, the extent of long-term bioaccumulation depends on the rate of excretion. Toxic chemicals can be stored into tissues of species, especially fat tissues. Bioaccumulation of cadmium in animal is high compared to most other metals, as it is assimilated rapidly and excreted slowly. Also, the sensitivity of individuals of a particular species to a pollutant may be influenced by factors such as sex, age or size. In general, the concentrations of metals in invertebrates, is inversely related to their body mass. In fish, the embryonic and larval stages are usually the most sensitive to pollutants [3]. Benthic organisms are likely to be the most directly affected by metal concentrations in the sediments, because the benthos is the ultimate repository of the particular materials that are washed into aquatic systems [2].

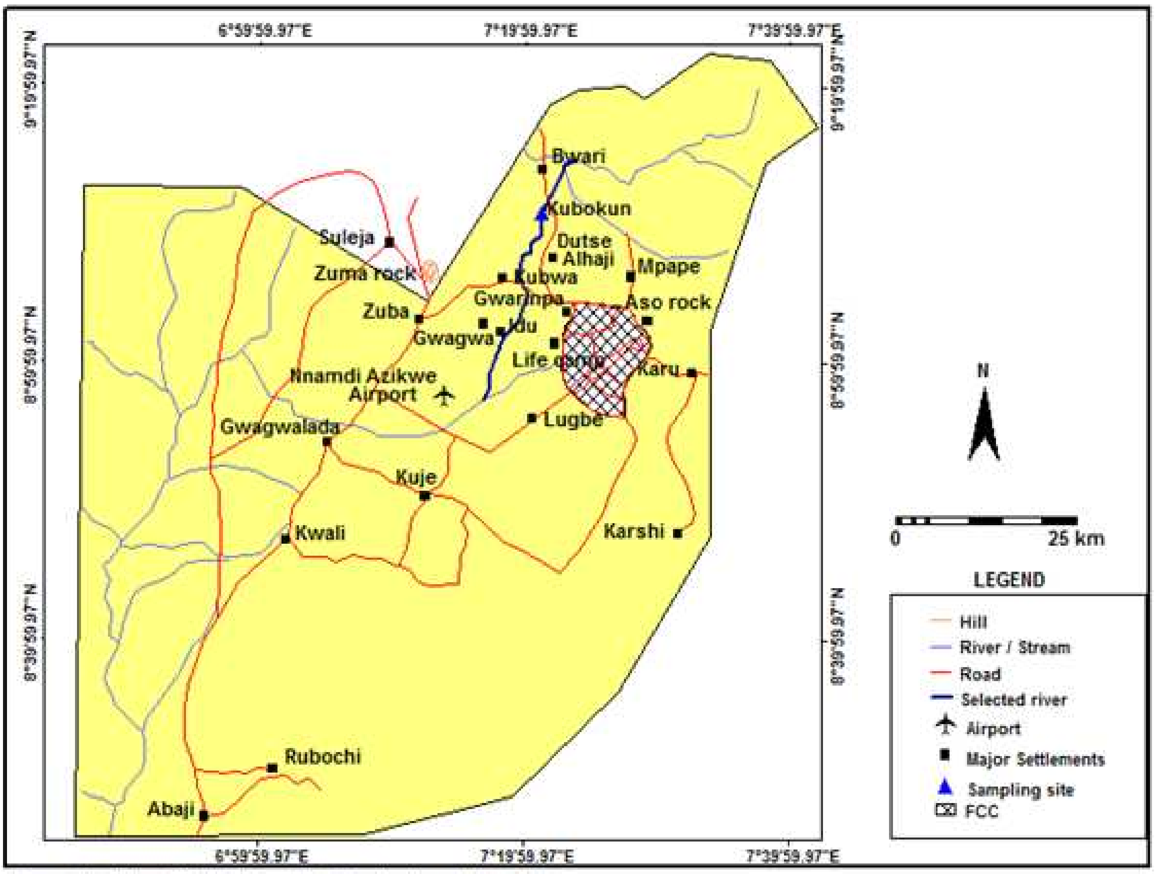
MATERIALS AND METHODS

Collection of sample

Sediment samples of about 220 g from each point were collected using clean hand trowel from ten different points (marked S_1-S_{10}) at every 200 m interval from the Madna stream into 450 ml plastic container. The collection was done downstream, with the sediment sample being preserved at $4^o{}_C$ before analyses. All laboratory wares used were first soaked in dilute nitric acid (2%) overnight; they were repeatedly rinsed with distilled water and dried in an oven before use. The containers used were sterilized (pretreated with dilute HNO_3 (2%) and rinsed with distilled water). The sample collected properly covered to avoid contamination.

Sediment digestion

The wet sediment was homogenized in its container, an aliquot was freeze dried and homogenized to a fine powder. Approximately 0.5g of powdered sediment was weighed into a beaker and 10 ml of aqua regia (HNO_3: HCl in 1 : 3) added. The vessel was heated on a hot plate for 2 hrs, with swirling, repositioning, and rinsing of beaker wall (if necessary) at 1hr with distilled water. Samples were transferred into centrifuge tubes and diluted to final volume of 30 ml with distilled water. They were spin in centrifuge to settle particles before filtering and filtrate transferred to a poly ethylene. The elemental analysis of the digest was carried out using atomic absorption spectroscopy at Multi-user purpose laboratory, Ahmadu Bello University Zaria.



Source: Adapted and Modified from Administrative Map of Abuja FCT.

Figure 1: Map of Abuja Metropolis showing the Madna Stream (the Blue arrow)

RESULTS AND DISCUSSION

Figure 2 Summarizes the concentration of each of the metal ions in the sediment of the different sites

The mean concentration of the metals from the studied sites determine in Madna stream of Kubokun Village has the trend: Fe > Co > Ni > Pb >Cu > Cd. The mean concentration of metals ranged between 0.026- 72.81 mg/l for the essential element we have Fe > Co > Cu, while for the non essential we have Ni > Pb > Cd.

Table 2 shows the correlation coefficient (r = -0.2745, 0.06419, -0.3560, 0.1207, -0.2830) of cadmium with other metals. With decrease in cadmium (r= -0.2745, -0.3560, -0.2930) there is high presence or increase in cobalt (P = 0.4427), iron (P = 0.3127) and lead (P = 0.4282) with no significant difference recorded. It also shows that with increase in cadmium (r = 0.06419, 0.1207) there is increase in the presence of copper (P = 0.8602) and nickel (P = 0.7909) with no significant difference at $P > 0.05$. The correlation coefficient (r = -0.2745, -0.4693) of cobalt as recorded in Table 2 shows that with decrease in cobalt there is increase in presence of cadmium (P = 0.4427) and copper (P = 0.1712) with no significant difference at $P > 0.05$. While increase in cobalt (r =0.2225, 0.4381, 0.7278) also allows the increase of iron (P = 0.5366) nickel (P = 0.2054) and lead (P = 0.0170) with significant difference only reflecting in lead at $P \leq 0.05$. As recorded in Appendix III, copper correlation coefficient (r = 0.0642) shows that copper increases with increase in cadmium (P = 0.8602) only, with no significant difference at $P > 0.05$. While it decreases (r = -0.4693, -0.0102, -0.6517, -0.3053) with increase in the presence of cobalt (P = 0.1712), iron (P = 0.9776), nickel (P = 0.0412) and lead (P = 0.3909) with only nickel showing significant difference at $P \leq 0.05$. Table 2 shows that iron (r = 0.2225, 0.2627, 0.6760) increases with increase in cobalt (P = 0.5366), nickel (P = 0.4634) and lead (P = 0.0319) with only lead showing significant difference at $P \leq 0.05$. It decreases (r = -0.3560, -0.0102) with increase in cadmium (P = 0.3127) and copper (P = 0.9776) with no significant difference at $P > 0.05$.

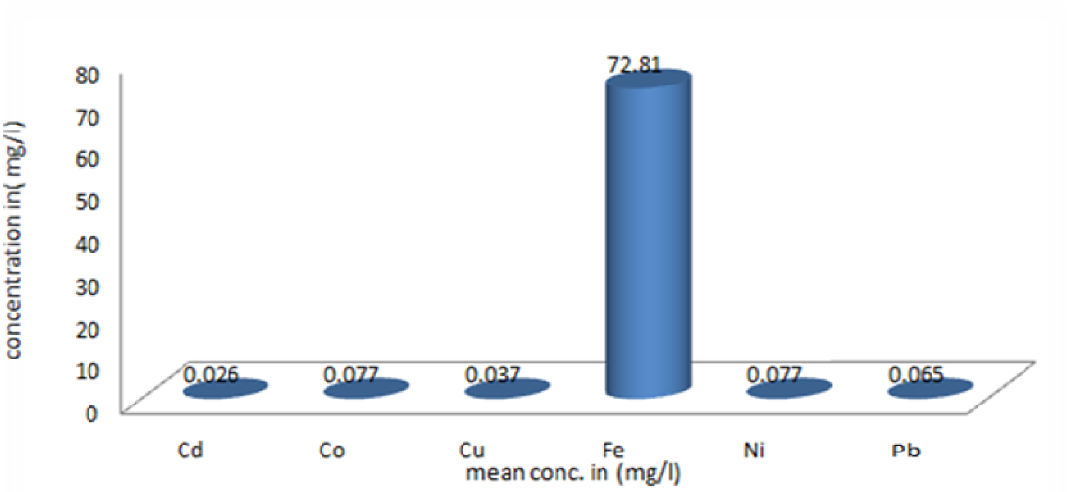


Figure 2: The Mean Concentration of each Metal in the ten sites.

Table 1: Statistical parameters of the studied metals (MAC: maximum acceptable concentration).

Elements	Mean	SD	Variance	WHO (MAC)
Cd	0.026	0.016	0.00024	0.003
Co	0.077	0.036	0.0013	
Cu	0.037	0.022	0.00050	2
Fe	72.81	25.95	673.49	0.3-0.5
Ni	0.077	0.038	0.0015	0.07
Pb	0.065	0.042	0.0017	0.01

Table 2: Correlation Coefficient and Significant Difference of Heavy metals (mg/l) in sediments of Madna stream, Abuja

Correlations	Cd	Co	Cu	Fe	Ni	Pb
Correlation Coeff. Level of Sign. Diff. No of Observation Cd	1 10	-0.2745 0.4427 10	0.06419 0.8602 10	-0.3560 0.3127 10	0.12017 0.7909 10	-0.2830 0.4282 10
Correlation Coeff. Level of Sign. Diff. No of Observation Co	-0.2745 0.4427 10	1 10	-0.4693 0.1712 10	0.2225 0.5366 10	0.4381 0.2054 10	0.7278 0.0170 10
Correlation Coeff. Level of Sign. Diff. No of Observation Cu	0.0642 0.8602 10	-0.4693 0.1712 10	1 10	-0.0102 0.9776 10	-0.6517 0.0412 10	-0.3053 0.3909 10
Correlation Coeff. Level of sign. Diff. No of observation Fe	-0.3560 0.3127 10	0.2225 0.5366 10	-0.0102 0.9776 10	1 10	0.2627 0.4634 10	0.6760 0.0319 10
Correlation Coeff. Level of Sign. Diff. No of Observation Ni	0.1202 0.7409 10	0.4381 0.2054 10	-0.6517 0.0412 10	0.2627 0.4634 10	1 10	0.3970 0.2560 10
Correlation Coeff. Level of Sign. Diff. No of observation Pb	-0.2830 0.4282 10	0.7278 0.0170 10	-0.3053 0.3909 10	0.6760 0.03190 10	0.3970 0.2560 10	1 10

As recorded in **Table 2**, nickel has a correlation coefficient of (r = -0.6517) this shows that decrease in nickel only result to increase in copper (P = 0.0412) only, with statistical significant difference at $P \leq 0.05$.The increase of nickel (r = 0.1202, 0.4381, 0.2627, 0.3970) also increases the presence of cadmium (P = 0.7409), cobalt (P = 0.2054), iron (P = 0.4634) and lead (P = 0.2560) with no significant difference being recorded. However lead decreases (r = -0.2830,-3053) with increase in cadmium (0.4282) and copper (0.3039), with no significant difference at P > 0.05. It increases (r = 0.7278, 0.6760, 0.3970) with increase in cobalt (P = 0.0170), iron (P = 0.03190) and nickel (P = 0.2560) with significant different only reflecting in cobalt and iron only at P ≤ 0.05.

CONCLUSION

This research work that investigates Madna stream for metal levels in the sediment showed that the stream is polluted by heavy metals. The majority of the sections analyzed revealed concentration of Cd, Co, Cu, Fe, Ni and Pb being slightly higher than maximum acceptable concentration of heavy metals in sediment from aquatic system by WHO, except for iron which was far higher, while copper recorded lesser concentration than the maximum acceptable concentration. The concentration of iron was far higher than the maximum acceptable concentration in aquatic system than the concentration of other metals in the analysed sediment from the stream. Though iron is an essential metal which is needed by the body at a certain concentration, in which excess can cause iron overload. The people of Kubokun village who depend on the water for drinking and irrigation of their crops are likely to suffer from symptoms caused by iron overload. Such as gene mutation, heart disease, liver problems and diabetes.

The villagers are not prone to health problem relating to copper poison, but should be concerned with health problems related to copper deficiency such as immune system dysfunction, brittle bones (in children), Oedema (swelling), high cholesterol levels, poorly pigmented skin, Anaemia etc (F.D.A, 2000).

The total levels of heavy metals in the sediment studied follow the trend: Fe > Co > Ni >Pb > Cu > Cd. For the essential elements, this is: Fe > Co > Cu, while the non essential elements, follow the ranking: Ni >Pd > Cd. The major source of pollution of the Madna stream, apart from using cadmium batteries, fertilizer, gasoline etc, could be from other communities from which the Madna stream takes it source or flows through. The natural activities in the communities could also be a contributing factor.

It can be concluded that the sediment of Madna stream is polluted with some heavy metals which could constitute health and environmental concern. Therefore water from this stream need to be periodically monitored to ascertain its suitability for drinking and irrigation purposes.

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