Determination of Heavy Metals in Water, Fish and Soil Samples from Antau River in Keffi, Nasarawa State, Nigeria: A Case Study of Antau River in Keffi, Nasarawa North Central Nigeria

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Abstract: ***Water satisfies domestic, industrial as well as agricultural purposes hence the need to monitor the level of water pollution. In this work, the concentration of heavy metals in water, fish (Tillapia zilli and Claria gariepinus) and soil samples collected from both downstream and upstream were determined using Atomic Absorption Spectrophotometer method. Heavy metals detected include: Pb, Zn, Cd, As, Fe, Ni, Cr, Co and Mn. The level of Zn was found to be higher in water (± 0.80 mg/L) and fish (± 31.9 mg/kg) while Pb concentration was found to be higher in soil samples (± 3.76 mg/kg) compared to other metals. Of all the three samples namely: water, fish and soil, soil has the highest concentration of heavy metals followed by fish and water. The concentration values of Pb, Ni, Cr and Mn were found to be higher in all the three samples and are above the acceptable limits specified by World Health Organization (W.H.O), while Zn, Cu and Fe were found with the W.H.O limits, thus confirming conclusively that the river is heavy polluted with the presence of heavy metals.***

Keywords: Atomic Absorption Spectrophotometer, Heavy Metals, Pollution

1. Introduction

It is essential to monitor the level of water pollution not only for health reasons but also for industrial and agricultural purposes. Human activities to a large extent have continued to deny people access to improved water supply. Heavy metals are known as metallic elements with high molecular weight or specific gravity which produces toxicity by forming complexes or ligands with organic compounds and active site enzymes. At high concentration, they are dangerous because they bioaccumulate faster in living things such as fish than they are broken down [1]. These metals are present in human and animal waste and can enter environment if wastes are released without treatment. The challenge however is the application of suitable technology for the control of organic micro-pollutants and heavy metals. This research work will not only enlighten public as well as manufacturing industries on the pollution potentials and hazards of heavy metals in water and soil but will also sensitize on appropriate pollution control measures.

2. Literature Review

Metals are introduced into water bodies through oil spillage, sewage effluents, auto emission, industrial activities such as mining, canning, electroplating, rock weathering etc. [2], [3] [4]. Metals after entering water bodies may be precipitated, suspended in water or may be taken up by fauna and flora and eventually accumulate in marine organisms consumed by human beings [5]. Pollution has been defined as the introduction to the environment substances which are liable to cause hazard to human health, living resources and aquatic ecosystem [6]. Various categories of pollutants are known to pollute water environment but those of heavy metals are non-biodegradable hence accumulate in the body system causing serious health challenges. It is well known that mineral element are necessary for life as some of them like Fe, Zn, Cu etc. are essential nutrients required small amounts for enzymatic biochemical activities [7], [8], some other minerals such as Cd, Hg are potential poisons not even required in small amount but have valuable industrial applications with resultant effect on the environment if not controlled [9] [10]. Virtually all metals are toxic if the exposure level is sufficiently high to exceed the tolerance level [11]. Industrial waste may contaminate environment or endanger public health if discharged directly into water bodies resulting in increase in temperature of the water, thereby causing death of aquatic life. Some heavy metals may accumulate in marine organism resulting in food poisoning. About 80% of all diseases and more than one third of all deaths in developing countries are caused by contaminated water [12] cited by [13]. It has been confirmed that with adequate supplies of safe drinking water, the incidence of some illness and death could drop by as much as 75% [14] cited by [13]. The presence of heavy metals in soil is as a result of hazardous waste, spent catalyst or coke dust, tank bottom and sludge treatment processes [15] cited by [16]. The intense consumption of refined petroleum products in Nigeria has put pressure on petroleum depots and companies thus becoming major sources air, water and soil pollution [16].

3. Materials and Method

The research is a case study of Antau river in Keffi, Nasarawa State (North-Central, Nigeria). The various samples (water, fish and soil) used for the analysis of heavy metals were collected from the river. Water sample was collected at various locations along the flowing river

using a clean plastic container rinsed with deionized water. The fresh fish samples collected from the river were *Tilapia zili* and *Claria gariepinus*. The fish samples were collected at the upstream and downstream of the flowing river using locally made wire net of 2.5 mm diameter. Soil samples were collected from different points with the use of soil sampler.

3.1 Water Samples Preparation

5 cm^3 of concentrated nitric acid (HNO_3) was added to 250 $cm^3$of water samples in 500 cm^3 beaker. The solution was evaporated to near dryness on hot plate. After cooling, another concentrated nitric acid was added with the beaker covered with water glass. Gentle heating continued until digestion was completed. The concentration was filtered and transferred to 50 cm^3 standard flask and diluted to mark with distilled water.

3.2 Fish Samples Preparation

The whole fish was dried in an electric oven at 70-80^{0}C for three days. The fish samples were pulverized using clean mortal and pistil to produce it powdered form. A homogenized 2 g of the grounded fish was weighed in analytical balance and ashed in a furnace at 550^{0}C. The samples were put in flask and 10 ml each of concentrated HNO_3 and HCl were added. The samples were digested for 2-3 hours, filtered into 100 cm^3 standard volumetric flask and made to mark with distilled water.

3.3 Soil Samples Preparation

Air dried soil samples was sieved using 200 mm mesh. 5g of the soil was weighed into 100 ml conical flask and was digested with 10 ml of concentrated HNO_3 and 2 ml HCl and the content was filtered into 100 ml standard flask and made to mark with distilled water.

3.4 Heavy Metal Detection

The digested samples water, soil and fish were analysed for heavy metals such as: Fe, Ni, Pb, Zn, Cr, Co, Cu, As, Mn and Cd by Bulk 210 model Atomic Absorption Spectrophotometer. Standards were prepared using salts of the metals. The instrument was instrument was switched on and the relevant hollow cathode lamp and wave length fixed for each metals. Air-acetylene flame was employed. The standard for each metal were then sprayed into flame as well as the samples and the corresponding absorbance values were taken. Both standards and samples were read under the same conditions.

4. Results

Table 1.0: Concentration of metals in mg/L for water samples

	Heavy metals									
	Fe	Ni	Pb	Zn	Cr	Co	Cu	As	Mn	Cd
Down stream	0.20	0.30	0.10	1.30	0.13	0.0014	0.01	ND	0.24	ND
Upstream	0.10	0.50	0.10	0.30	0.20	0.002	0.01	ND	0.16	ND
Average Concentration	± 0.15	± 0.40	± 0.10	± 0.80	± 0.17	± 0.008	± 0.01	ND	± 0.20	ND
% Concentration	8.16	21.76	5.44	43.53	9.25	0.44	0.54	ND	0.44	10.83

4.1 ND-Not Detected

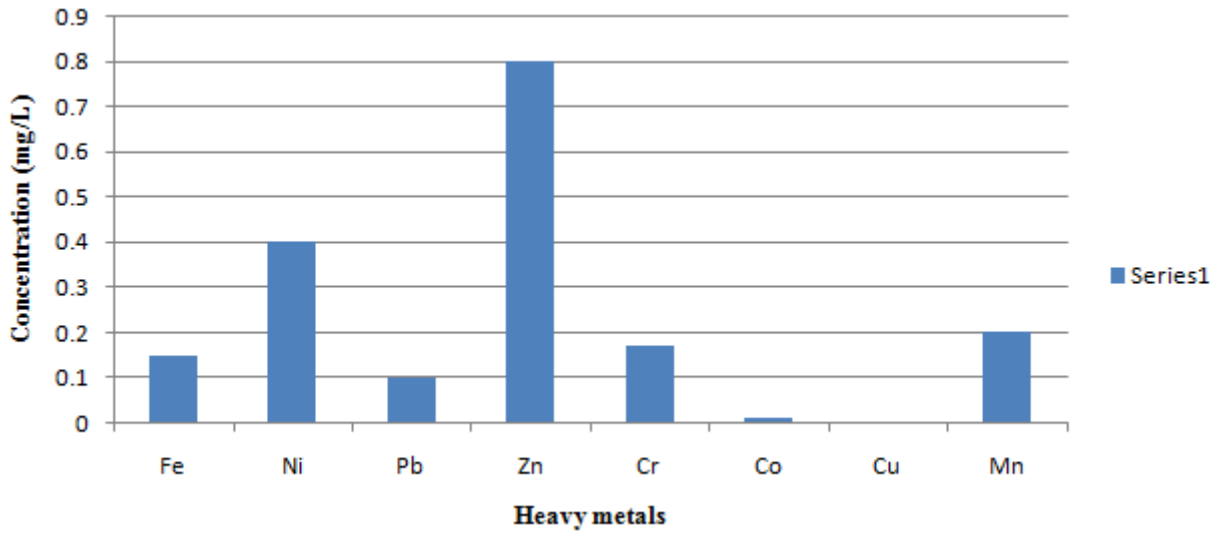

Figure 1.0: Concentration of metals in mg/L for water samples

Table 2.0 a: Concentration of metals in mg/kg for fish samples (*Tillapia zilli*)

	Heavy metals									
	Fe	Ni	Pb	Zn	Cr	Co	Cu	As	Mn	Cd
Down stream	0.60	1.55	0.12	33.20	0.50	0.10	0.14	ND	3.30	ND
Upstream	0.20	1.25	0.08	30.60	0.30	0.10	0.06	ND	1.30	ND
Average Concentration	± 0.40	± 1.40	± 0.10	± 31.90	± 0.40	± 0.10	± 0.10	ND	± 2.30	ND
% Concentration	0.11	3.83	0.27	87.16	1.10	1.10	0.27	ND	6.28	ND

4.2 ND-Not Detected

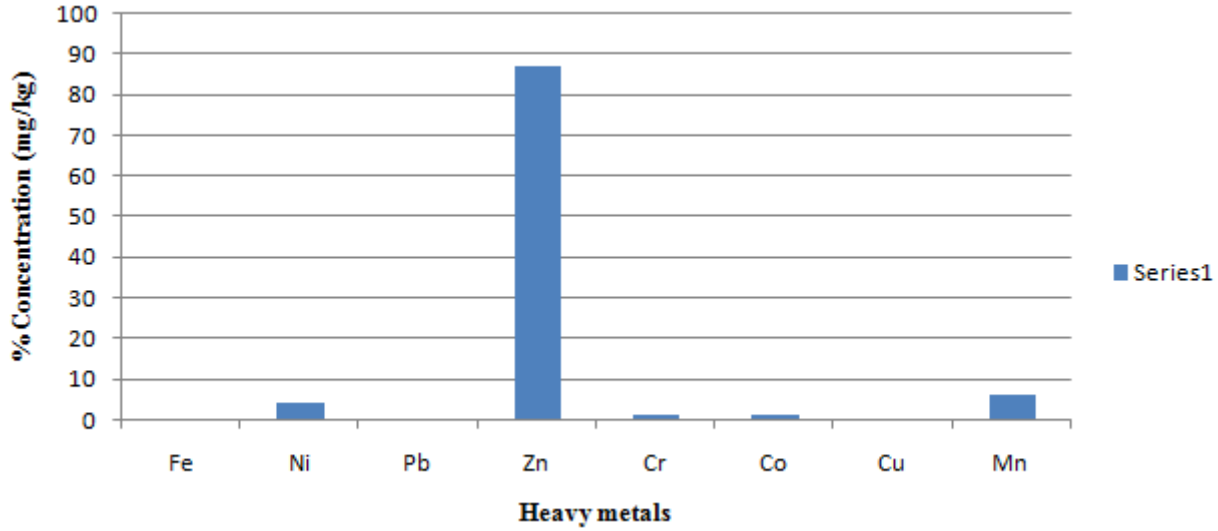

Figure 2.0a: Concentration of metals in mg/kg for fish samples (*Tillapia zilli*)

Table 2.0 b: Concentration of metals in mg/kg for fish samples (*Claria gariepinus*)

	Heavy metals									
	Fe	Ni	Pb	Zn	Cr	Co	Cu	As	Mn	Cd
Down stream	0.23	1.32	0.28	5.20	0.15	0.25	0.18	ND	7.10	ND
Upstream	0.17	1.24	0.12	4.20	0.50	0.15	0.02	ND	5.30	ND
Average Concentration	± 0.20	± 1.28	± 0.20	± 4.70	± 0.33	± 0.20	± 0.10	ND	± 6.20	ND
% Concentration	1.51	9.69	1.51	35.58	2.50	1.51	0.76	ND	46.93	ND

4.3 ND – Not Detected

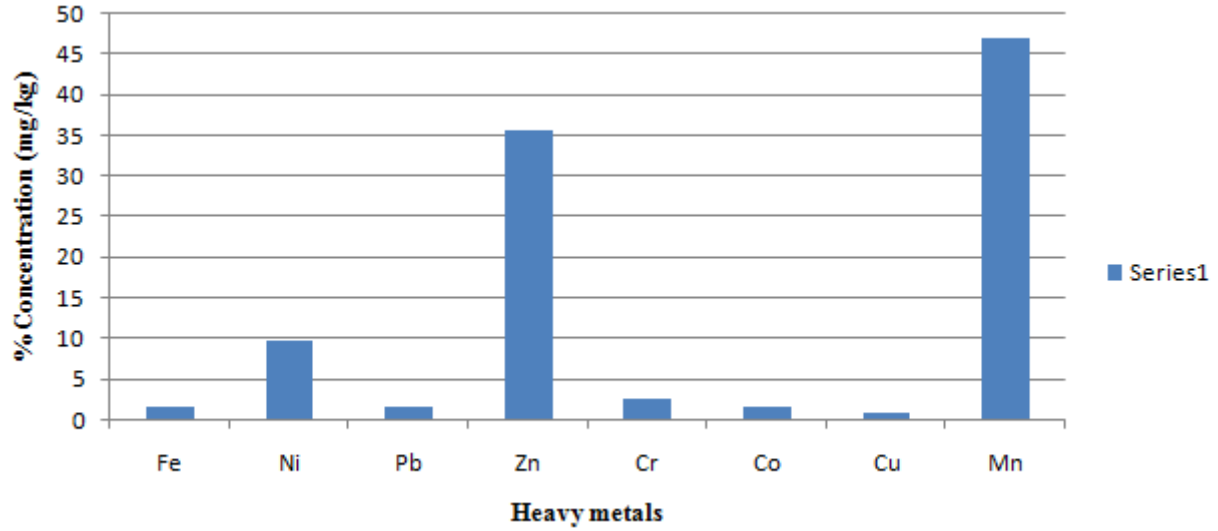

Figure 2.0 b: Concentration of metals in mg/kg for fish samples (*Claria gariepinus*)

Table 3.0: Concentration of metals in mg/kg for soil samples

	Heavy metals									
	Fe	Ni	Pb	Zn	Cr	Co	Cu	As	Mn	Cd
Down stream	0.32	2.60	4.12	3.22	1.26	0.80	0.52	ND	0.62	ND
Upstream	0.28	1.50	3.40	2.15	1.22	0.60	0.40	ND	0.52	ND
Average Concentration	± 0.30	± 2.05	± 3.76	± 2.69	± 1.24	± 0.70	± 0.46	ND	± 0.57	ND
% Concentration	2.55	17.42	31.95	22.85	10.54	5.95	3.91	ND	4.84	ND

4.4 ND – Not Detected

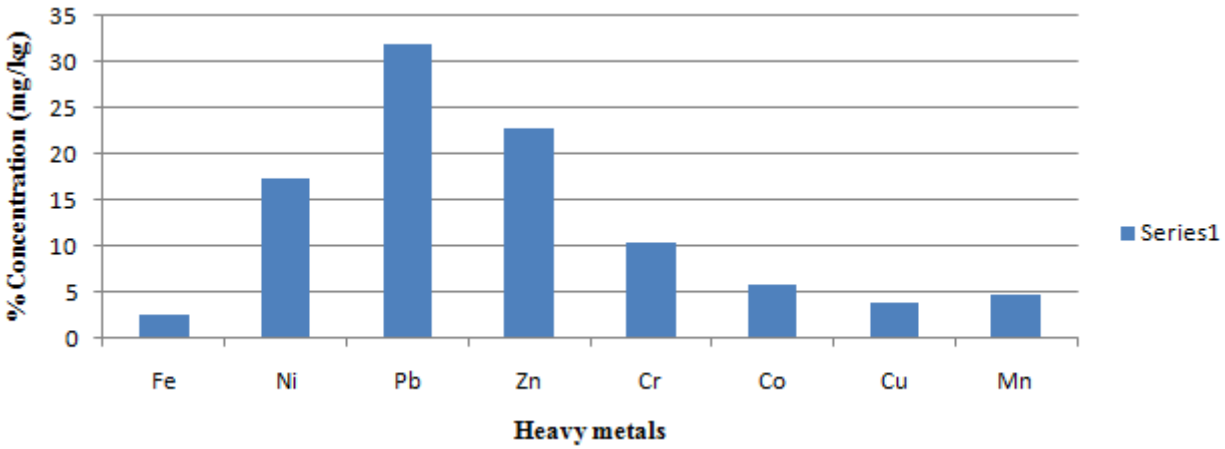

Figure 3.0: Concentration of metals in mg/kg for soil samples

Table 4.0: Average Concentration of metals in water, fish and soil samples

Samples	*Heavy metals*									
	Fe	Ni	Pb	Zn	Cr	Co	Cu	As	Mn	Cd
Water	0.15	0.40	0.10	0.80	0.17	0.008	0.01	ND	0.20	ND
*Fish (**Tillapia zilli**)*	0.40	1.40	0.10	31.90	0.40	0.10	0.10	ND	2.30	ND
*Fish (**Claria gariepinus**)*	0.20	1.28	0.20	4.70	0.33	0.20	0.10	ND	6.20	ND
Soil	0.30	2.05	3.76	2.69	1.24	0.70	0.46	ND	0.57	ND

4.5 ND – Not Detected

Table 5.0: Acceptable limit for heavy metals (mg/kg)

Fe	*Ni*	*Pb*	*Zn*	*Cr*	*Cu*	*As*	*Mn*	*Cd*
0.30	0.10	0.05	5.00	0.05	1.00	0.01	0.10	0.005

Source: [17]

5. Discussion of Results

Results from analysis have shown that these heavy metals: Fe, Ni, Pb, Zn, Cr, Co, Cu and Mn were all present in all the three samples analyzed while the concentration of As and Cd were below the detection level of the instrument. This is an indication that Antau River is highly contaminated with heavy metals.

Furthermore, from table and figure 1.0, 2.0 a, 2.0 b and 3.0, the average concentration of metals are highest in soil sediments followed by fish samples and least in water samples. Similar observation has been reported in the determination of heavy metals in fish associated with water and soil sediment from fish pond [18]. High concentration of metals in soil sediments compared to fish and water samples suggests that the soil acts like a sink for some of these metals besides anything that dissolves in water is deposited in the soil. In addition, some of these metals are naturally present in the soil, thus, high concentration of these heavy metals present in the soil is justified, Nasarawa State being a solid mineral producing state. The concentration of heavy metals in fish is higher than that of water (from table and figure 1.0, 2.0 a and 2.0 b). This is as a result of accumulation of these metals in the fish and when consumed it may lead to food poisoning or other health related challenges such as: decreased fertility, spontaneous abortion, low birth weight, cancer, mental retardation, brain damage, tumour, decreased haemoglobin level, neurological and gastrointestinal disorder death [17] [19] [20]. Emission of lead into the atmosphere as a result of indiscriminate disposal of acid-storage batteries, motor vehicle emission, paints and pigments, photography, dying etc is partly responsible for

the high level of Pb in the soil as shown in Fig. 3.0 compared to the W. H. O standard.

6. Conclusion

The pollution level of Antau River in Keffi, Nasarawa State of Nigeria was determined. The percentage concentration of heavy metals is highest in the soil followed by fish and least in water samples. The river is mostly polluted by Ni, Pb, Cr and Mn. From the analysis of the result obtained and the potential dangers associated with consumption of these heavy metals, it can be concluded that Antau River is not fit for consumption. Unfortunately, many house hold depend on it for consumption and other domestic purposes without treatment hence likely to be affected by the epidemics of water pollution by heavy metals.

7. Recommendations

In order to ensure access to improved water supply by this community and people living in water ways, it is suggested that more dams should be constructed, water supply and distribution should be decentralized in various communities, Water Corporation should expand piped water network close to homes, hence they must ensure ceaseless flow of water from pipes, regular maintenance of the system and quick response to leakages. In addition, people living along water ways should be sensitized of the possible danger and health risk associated with the use of untreated water with a view of discouraging discharge of sewage and other industrial, agricultural or domestic waste into water ways. Strict laws must be passed to control water pollution by individual and companies. Sewages should be processed, treated and converted to biodegradable substances or useful fertilizers in sewage plants. Technologies now exist for controlling many types of pollutants; therefore treatment technologies must be chosen accordingly to control organic micro-pollutants and heavy metals. The application of knowledge of fluid mechanics will enhance water sustainability and also help in solving challenges relating to type of flow, determination of parameters like pressure, speed, density, volume and other flow parameters that will ensure safe flow rate of liquid so as to prevent spills while ensuring even distribution of improved water.

The Federal Environmental Protection Agency (FEPA) should ensure strict compliance with appropriate pollution control measures, sewage and effluents discharge guidelines as well as prompt response to cleaning up of oil spills. Crude oil storage vessels, oil pipes must be developed with satisfactory rigidity and strength to prevent accidental oil spills.

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