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Article

Concentrations of Heavy Metals in Soil Samples within Mkpanak in Ibeno Coastal Area of Akwa Ibom State, Nigeria

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Abstract: This work is aimed at investigating the concentrations of some heavy metals in soil samples within Mkpanak in Ibeno Coastal Area of Akwa Ibom State, Nigeria. Six heavy metals (Fe, Ni, Zn, Pb, Cd and V) were analyzed using atomic absorption spectrophotometer. The average concentrations of Cd, Zn, Ni, V, Pb and Fe in the soil samples in mg/kg were 1.12 ± 1.27, 30.49 ± 2.18, 8.78 ± 5.20, 8.41 ± 4.49, 21.16 ± 20.10, and 396.35 ± 261.71 respectively. The mean concentration of Fe in the soil samples was quite high and exceeded the critical toxicity level. The pollution implications of these heavy metals together with their associated health hazards on animals, humans and economic crops have been discussed based on the results, national and international standards as well as available literature. Recommendations on possible ways of monitoring and controlling the introduction and distribution of these metals into the environment and soil have been made.

Keywords: environment; heavy metals; pollution; soil; lead; cadmium; iron; zinc.

1. Introduction

Soil is a crucial component of rural and urban environments, and in both places land management is the key to soil quality. Human endeavours such as technology, industrialization, agriculture, transportation, education, construction, trade, commerce, as well as nutrition have rendered the whole environmental system "a throwaway society". This is true because indiscriminate disposal of wastes coupled with increasing world population and urbanization have combine to worsen the situation day in day out. Mining, manufacturing, and the use of synthetic products (e.g. pesticides, paints, batteries, industrial waste, and land application of industrial or domestic sludge) can result in heavy metal contamination of urban and agricultural soils. Heavy metals also occur naturally, but rarely at toxic levels. Potentially contaminated soils may occur at old landfill sites (particularly those that accepted industrial wastes), old orchards that used insecticides containing arsenic as an active ingredient, fields that had past applications of waste water or municipal sludge, areas in or around mining waste piles and tailings, industrial areas where chemicals may have been dumped on the ground, or in areas

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downwind from industrial sites [1].

The extent of soil pollution by heavy metals and base metal ions some of which are soil micronutrients is very alarming. It has been observed that the larger the urban area, the lower the quality of the environment. In terms of environmental contamination, and specifically metals pollution of the soil, Ademoroti [2] while correlating the total metal content of vegetables and of the soils where they are grown, discovered that the environment is significantly polluted by cadmium, lead and nickel. The correlation between cadmium, lead, and nickel content in the soils and vegetables (grown in them) shows that there is a positive linear correlation. Onyeka [3] observed that the major cause of land pollution in Onitsha is solid waste. Akpan [4] in his study compared the result of the analysis of soil extracted from Uyo municipality with WHO (World Health Organization) and FAO (Food and Agricultural Organization) standards and admitted that the soils from the all the sources investigated were polluted because of waste dumped on the land. Akaeze [5], from the analysis of soil samples from Uyo town, disclosed that heavy metals such as lead, copper and iron are present in the soil and that these may also contaminate soil water which constitutes the major sources of drinking water.

Apart from the contamination of soil and agricultural land by other elements, lead alone has a poisoning effect. According to Akaeze [5] the toxicity of lead could lead to encephalopathy, renal effect, and hematological effect. The World Health Organization had confirmed the effects of lead intake, including abortion, infant mortality, malformation of foetus, genetic mutilation, retarded growth, intoxication, depression of respiration and chromosomal aberrations.

Excess heavy metal accumulation in soils is toxic to humans and other animals. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer. The most common problem causing cationic metals (metallic elements whose forms in soil are positively charged cations e.g., Pb^{2+}) are mercury, cadmium, lead, nickel, copper, zinc, chromium, and manganese. The most common anionic compounds (elements whose forms in soil are combined with oxygen and are negatively charged e.g., MoO_4^{2-}) are arsenic, molybdenum, selenium, and boron.

The soil is a very important resource to man as it constitutes the medium on which plants grow and the platform on which industrialization takes place. Yet the soil is often polluted by flared industrial gases, land reclamation, agricultural and industrial activities. This study was aimed at determining the levels of some heavy metals in the soil around Mkpanak in Ibeno Local Government Area of Akwa Ibom State, Nigeria in order to provide information on the pollution status of the study area.

2. Materials and Methods

2.1. Study Area

Ibeno people who are predominantly fishermen and traders are believed to have migrated from the Andoni land in Rivers state of Nigeria in early 17th century. The community covers about 18 sq kilometers and the population is made up of people from four clans: Mkpanak, Ukpenekang, Iwuochang and Okorutip. Mkpanak is located along the bank of Qua Iboe estuary which is in a tropically humid climatic region characterized by distinct dry and wet seasons. The wet season, which sometimes begins in March or April, is always characterized by heavy storms of short duration. The dry season which normally lasts 3 - 5 months is comparatively short beginning in November and extending to February. The mean annual rainfall ranges from 2,000 to 3,200 mm for the study area. The mean annual temperature in the study area is fairly constant and

averages about 28 °C. Relative humidity is comparatively uniform over the area with mean value of 80% for October and 60% for dry season. It varies depending on the heaviness of the rains.

2.2. Sample Collection

The method of sample collection and pre-treatment of soil samples prior to analysis were according to the Standard Methods [6]. Soil sampling was carried out by collecting portions of soil using a soil auger of length 15 cm at each of the ten locations [6]. The samples were put into polyethylene bags, labeled and taken to the laboratory for pre-treatment and analysis.

2.3. Sample Treatment and Analysis

All soil samples were air-dried at ambient laboratory temperature and later ground using mortar and pestle before sieving through 1 - 2 mm mesh and stored for chemical analysis. Each soil sample (2 g) was placed in a Teflon beaker and digested using a mixture of concentrated nitric acid (10 cm^3) and concentrated perchloric acid (5 cm^3). This was allowed to cool before leaching the residue with 5 cm^3 of 20% HNO_3. Digested samples were filtered and made up to 50 cm^3 with deionized water. A blank determination was carried out but without the sample. Solutions of the samples were then taken and aspirated into atomic absorption spectrophotometer (Unicam Solaar, model 969). A calibration graph was plotted for each element using measured absorbance and the corresponding concentration. The calibration curve was then used to determine the concentrations of the metal.

3. Results and Discussion

The concentrations of six heavy metals (Pb, Cd, Zn, Ni, Fe and V) in soil samples from Mkpanak in Ibeno area are presented in Table 1. Similarly, the ranges, means, standards deviations as well as the coefficients of variation of these elements in soil samples are respectively shown in Tables 2.

As shown in Table 2, the analysis of soil for determining heavy metal concentrations showed that the mean concentrations of each of the heavy metals analyzed was within the critical limits except for Fe which was quiet high and exceeded the critical toxicity level. Several standards have been employed in comparing the levels of the heavy metals in soil samples vis-à-vis their toxicity implications [7-9]. Accordingly the levels of heavy metals at the different sample locations is considered deficient, if they are lower than the standard limiting range or as contaminant if their levels exceed standard limiting values. In the soil samples, the trend of mean concentrations was Fe > Zn > Pb > Ni > V > Cd (Table 2).

Table 1. Heavy metal concentrations in soil samples from Ibeno

Samples	Cd (mg/kg)	Zn (mg/kg)	Ni (mg/kg)	V (mg/kg)	Pb (mg/kg)	Fe (mg/kg)
LOC-1	0.24	31.60	11.38	14.17	19.01	518.20
LOC-2	0.92	44.00	6.46	9.39	37.62	128.37
LOC-3	0.03	10.18	13.14	4.78	7.80	590.40
LOC-4	0.77	22.05	3.08	4.32	20.13	524.70
LOC-5	2.51	40.30	13.37	10.36	15.00	182.36
LOC-6	0.90	18.53	5.52	5.90	10.30	463.40
LOC-7	4.17	11.52	18.93	17.41	72.28	932.00
LOC-8	0.38	42.40	4.02	4.93	6.91	338.50
LOC-9	0.59	33.30	7.75	8.22	13.48	170.71
LOC-10	0.64	51.04	4.12	4.60	6.40	111.82

Table 2. Means, ranges, standard deviations and coefficients of variation of metal levels of soil samples from Mkpanak, Ibeno

Metal	Range (mg/kg)	Mean (x)	SD	CV(%)
Cd	0.03-4.17	1.12	±1.27	113.39
Zn	10.18-51.04	30.49	±2.18	7.10
Ni	3.08-18.93	8.78	±5.20	59.23
V	4.32-17.41	8.41	±4.49	53.39
Pb	6.4-72.28	21.16	±20.10	94.99
Fe	111.82-935	396.35	±261.71	66.03

The results obtained from the study area showed that Cd had a mean concentration of 1.12 mg/kg in soil samples. When compared to typical natural levels (0.01 - 3.0 mg/kg) in soils [7], the mean concentration of 1.12 mg/kg in soil samples was high and exceeded the lower limit of 0.01 mg/kg. There is need to prevent this trend since there is a high tendency of heavy metals to accumulate in the environment. Cadmium is a heavy metal naturally present in soil at concentrations of slightly more than 1 mg/kg. It is highly toxic to most organisms, having toxicity 2 - 20 times higher than many other heavy metals. Cadmium content in soil has been dramatically increased from anthropogenic sources including smelters and agricultural applications of fertilizer and sewage sludge. Cadmium in soil can be bioavailable for plant uptake and subsequent human uptake, thus cadmium in the environment poses a significant health risk. When present at elevated concentration in soil, cadmium is readily available for uptake in a range of crops; there is a clear association between the cadmium concentration in soil and in the plant grown on that soil [10].

The results obtained from the study area showed that Pb in the soil samples had a mean concentration of 21.16 mg/kg with the concentration in LOC-7 being much higher than those in other soil samples. This may have been due to lead discharged from the battery of cars in the mechanic workshop very close to this location as well as gasoline, engine oil and used containers carried by runoff into this location. When compared with the background level (200 mg/kg) and the typical concentration in a non-polluted soil (2 - 200 mg/kg) [8], the mean concentration of 21.16 mg/kg in the soil sample is low. Lead content in soil varies in a very wide range. The