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Determination of Heavy Metals (Fe, Mn, Zn, Pb, Cd, Ni, & Cu) in Soils around Industrial Area in Jos Metropolis of Plateau State, Nigeria

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ABSTRACT

Heavy metal pollution is a serious problem associated with areas of intensive industrial activities. A study was carried out on some heavy metals Heavy (Fe, Mn, Zn, Pb, Cd, Ni, &Cu) on the quality of soil in the vicinity of the industrial areas of Jos Plateau Sate to determine the levels of pollution. These areas include; Jos Steel Rolling Mills (JSRM), Ray field Jos, National Metallurgical Development Centre (NMDC), Nigerian Mining Corporation (NMC) and NASCO Food. Soils samples were collected and analyzed for pH, values, organic matter contents, carbon contents and the total metal concentrations for the above metals using Atomic Absorption Spectroscopy (AAS). The results of the analysis showed relatively high concentrations of Fe, Cd, and Ni with concentrations range of 0.227±0.062ppm, to 5.367±0.091ppm.The samples from JSRM and NASCO food recorded a high concentration of Mn with a value of 0.221±0.121 and 0.612±0.126ppm respectively. But for Zn, Ni, and Cu, showed relatively low concentrations. Comparing the results with the WHO standard showed that Pb, Fe, Cd, and Ni were above the WHO values. High concentrations of these elements in the soils could lead to a toxicity in agricultural products which may affect human activity. This problem could be remediated by government legislations and phytoremediations, a method of reclamation of soils contaminated with toxic metals by using hyperaccumulator plants.

INTRODUCTION

Pollution is the introduction of substances or energy by man into the environment that is liable to cause hazard to human health, harm to living organisms or any ecological systems, damage to structures and

amenities or interference with legitimate use of the environment. Heavy metals pollution is a serious problem associated with areas of intensive industry. These metals along with other pollutants are discharged to the environments through industrial activities, automobile exhaust, heavy duty electrical power generators, refuge burning and pesticide use in agriculture etc (Yousufzai, *Durdana, Ishaq, Farooq and Ishuretullah.* 2000). There has been an increasing concern regarding the accumulations of these heavy toxic metals in both public health and natural ecosystem.

The bio-accumulation of heavy metals presents is a problem both from the stand point of how the metal migrate into the environment and how the metals can be effectively removed from the contaminated sites (Gardea, Polette, Arteaga, Bibb and Gonzalez*/* 2010). Heavy metals have great significance due to their tendency to accumulate in the vital human organ over a prolonged period of time, injury to vegetable caused by these metals have been well recognized because of the many botanical and chemical investigation during the past hundred years, (Yousufzai*, Durdana, Ishaq, Farooq and Ishuretullah* 2000). Unlike many substances, metals are not biodegradable and thus can accumulate in the environment. Many studies have indicated that the accumulations of heavy metal in the soils have had adverse effect on the growth and development of a wide variety of plant species. Although low concentration of some heavy metals such as copper and zinc have been found to be responsible for metabolic disturbance and growth inhibition in plants (Geardea Polette, Arteaga, Bibb and Gonzalez*/* 2010). Other studies have demonstrated that the uptake of such metals as lead, Nickel and cadmium can damage the integrity of the cell in certain plants.

The disposition of industrial waste, mining activities, incidental accumulates, atmospheric deposits, agricultural chemicals etc are examples of some pollutants with heavy metals. (Marta, Emiliano and Raul, 2010).

Soil pollution is the malfunction of soil as an environmental component following its contamination with certain compounds particularly as a result of human activities; (Saller and Kesj, 1991).The mobile forms of these heavy metals constitute a risk as the metals leach into the groundwater that could later be used for human consumption. Soil pH and other factors such as the preservation of competing ligands, the ionic strength of the soil solutions and the simultaneous presence of competing metals are known to significantly affect sorption process. Also, the leaching potential through the soil profile and the absorption of heavy metals differ in the different soil horizons due to texture composition in different solid horizons hence toxicity of heavy metal is related to their existing species speciation of the metals (Marta, Emiliano and Raul, 2008).

In order to avoid the accumulation of the metals and their movement within soil profiles different remediation techniques have been developed. Presently, a number of researchers are investigating the manner in which plants absorbs heavy metals ions and are conducting experiments with these plants to see if they can be used to alleviate the metal contamination problems. The solution, a technique known as phytoremediation holds this promise of being feasible and effective. A method capable of immobilizing mobile form of metal like biosolids are adequate in addition to the phytoremediation which is based on the absorption of heavy metal by different plants species, a method for reclamation of soils contaminated with metals by using hyper accumulators plants (Riffat, Syed and Ishfaq. 2010, Gardea, Polette, Arteaga,Bibb and Gonzalezl 2010, and Marta, Emiliano and Raul, 2008).

The objective of this study is to determine the levels of concentrations of heavy metal in the various industrial areas within Jos Metropolis using Atomic Absorption Spectroscopy (AAS) to ascertain their pollution effect on the environment. It also to determine possible remediation of

the effect of these metals through government legislation and phytoremediation processes.

METHODOLOGY

Procedure

Sample Collection

Soils samples were collected from four different locations in Jos and environs (2010) where industrial activities are extremely high. The soil samples were collected with rubber spoons at 15cm depth around the industrial areas used for dry seasons farming. About 50g of the soil sample were collected with the shovel at each sampling point into a clean polythene bags, sealed and labeled to avoid a mix-up of difference samples in these locations.

Sample Preparation and Analysis

The wet acid digestion method was employed, where 0.2g of finely ground soil sample into a digestion tube and a mixture of Nitric acid (HNO_3), Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4) in the ratio 5:3:1 respectively were added.

The Standard method of analysis was used for determination, of Ash content, soil pH value in distilled water, soil pH in 0.01$CaCl_2$ organic carbon. The atomic absorption spectrophotometric (AAS) measurements were taken using a model Unicam 969. Wavelength used for analysis of Fe, Zn, Pb, Cd, Cu, and Mn, were 248.5 nm, 217.0 nm, 213 nm, 217.0 nm, 228.5 nm, 232.0 nm, 328.0 nm and 279 .5 nm respectively. Samples were read three times and standard deviation was computed in the range of analysis and a correlation coefficient for calibration curve of 0.98 or greater was obtained. The instrument was periodically checked with known standards. Data analysis of the experiment was performed in triplicate for each set of a given data. Standard statistical methods – confidence limit, (a method that shows how confidence the sample mean is a true major of the population mean) were used for determining the

mean value and standard deviations. Confidence intervals of 95% were calculated for each set of sample to determine error margin.

RESULTS AND DISCUSSION

The various tables 1 and 2 shows the results for the physiochemical properties of soils and the concentrations of heavy metals around industrial areas of Jos metropolis

Table 1: Some Physiochemical Properties of Soils around Industrial Areas of Jos

Properties Assessed	Samples/ Location A	B	C	D
Ash content	93.0 ± 0.30	94.80 ± 0.60	92.80 ± 0.04	88.10± 0.70
pH of soil in H_2O	4.45 ± 0.02	5.00 ± 0.65	6.24 ±	0.02 4.37 ± 0.04
pH of soil in $CaCl_2$	4.60 ± 0.04	5.20 ± 0.03	5.83 ± 0.02	4.98 ± 0.01
Organic Matter	7.00± 0.02	5.20 ± 0.03	7.20 ± 0.04	12.00± 0.02
% Organic Carbon	4.06 ± 0.01	3.02 ± 0.03	4.18 ± 0.00	6.96 ± 0.02

Source - Laboratory

Key:

A = Jos Steel Rolling Mill Jos (JSRM)

B = National Metallurgical Development Centre (N. M .D. C.) Jos.

C = Nigerian Mining Cooperation (N.M.C) Jos

D = Nasco Food Jos.

TABLE 2: Concentrations of Heavy Metals (mg/kg) at 15m Depth around Industrial Areas of Jos Metropolis

	Metals						
Sample	Fe	Mn	Zn	Pb	Cd	Ni	Cu
A	2.635 ± 0.305	0.221 ± 0.120	0.430 ± 0.011	0.221 ± 0.201	0.321 ±0.006	0.111 ± 0.006	0.225 ± 0.069
B	3.530 ±0.305	0.028 ±0.020	0.039 ±0.002	0.388 ±0.15	0.271 ±0.019	0.111 ±0.006	0.225 ± 0.009
C	5.367 ±0.090	0.034 ±0.009	0.028 ±0.003	0.357 ±0.381	0.473 ±0.010	0.082 ±0.079	0.226 ±0.025
D	2.597 ±0.076	0.612 ±0.126	0.029 ±0.003	0.428 ±0.432	0.737 ±0.062	0.082 ±0.066	0.226 ±0.120
WHO	0.30	0.50	3.00	0.01	0.003	0.02	2.00

WHO/FAO standard for heavy metals, 2007 guideline

DISCUSSION

The result from Table 1, showed a high percent of ash content for all the samples, ranged from 88.10 to 94.80 with the highest value at location in MNDC. This indicates a low organic matter content of the soil in the sampling sites. The pH values in water according to the result range from 4.37 to 6.24 with the highest at location in NMC while sample in NASCO FOOD has the lowest. Also pH value of soil in $CaCl_2$ range from 4.60 to 5.83 with the highest and lowest at JSRM and NNC respectively. This shows that sample in JSRM and in NASCO FOOD showed significance acidity level compared to the other areas therefore the soil is acidic. Hence pH plays a major role in the properties of the soil. pH is known to have significant effect on sorption process and leaching potential through the soil profile (Marta, Emiliano and Raul, 2008).

The organic matter range from 5.00 to 12.00 with the highest and lowest in NASCO FOOD and NMDC respectively. This showed that Nasco has more organic matter in the soil and this may be due the industrial and human activities. Same researchers have reported that

organic matter plays a significant role in the availability and mobility of heavy metals in soil. Also, humified organic matter are involved in the formation of soluble complexes with Cu and Zn while Cr (iv) could be reduced to Cr (iii) which relatively immobilized in the presence of organic matter. The value of the percentage organic carbon ranged from 3.02 to 6.96 with highest in NASCO FOOD, the reason may be associated with high level of industrial discharge from the company into the environment and consequently the soil.

In Table 2, the results of the AAS analysis of the soil sample showed the presence of various heavy metals. The results indicate that the concentration of Fe range from 2.597 mg/kg to 5.367mg/kg with a highest in NMC. The results showed Mn concentration ranged from 0.028 to 0.162 mg/kg with the highest value in NASCO FOOD, this could be due to the high industrial waste around the area (Farmaki and Thomadis, 2008). The values of the Ni, Cu and Zn showed a low concentration in all the samples. This may be due to the types of raw material being used at the industrial sites. It has been reported that metal availability and bioaccumulation is governed by several environmental factors such as pH, organic chelators humic substances, the presence of other metals, anions, ionic strength, temperature, salinity, high intensity, oxygen level and other prevailing electrochemical function (Kara, 2005). Pb content ranged from 0.221 to 0.428 mg/kg with the highest in NASCO FOOD, this could be due to the types of materials at industrial sites. Pb was generally low in all the location, and could be accredited to the low solubility of Pb in soil as other researchers have reported (Marta, Emiliano and Raul, 2008). The Zn sample ranged from 0.029 to 0.048 mg/kg with a highest at location A (JSRM) and the lowest at all location in NASCO FOOD, while Cu content ranged 0.225 to 0.336 mg/kg. This may be due to bioaccumulation of the metals in the soil. When Cu and Zn were compared in terms of concentration, Zn has more bioaccumulated than

Cu contrary to a report that the concentration of Cu accumulate more effectively than Zn.

Cd ranged from 0.271 to 0.737 mg/kg with a highest at location in NASCO FOOD, this could be due to the bioaccumulation as a result of human and industrial activities. Other works showed that precipitation and surface hydrolysis are likely to be the most mechanism for Cd immobilization in the soil, while Carbonate phosphate, amorphous oxides and the OH^- groups of clay minerals seriously influence Cd mobility (Kara, 2005). Fe, Cd and Pb were above the WHO Standard when compared; hence these metals were considered toxic due to segmented accumulation in the soil therefore making agricultural products unsaved for consumption.

CONCLUSION AND RECOMMENDATIONS

The present study had indicated that the quantities of soil especially around the industrial areas or premises were affected by high level of waste discharge around the area. High level of iron concentrations were recorded more in each sample. Sewage sludge from industrial sites contains high concentration of elements such as Mn, Pb, Cd, Cu and Cr.

Soil contaminations can be achieved in several ways, physically, chemically and biologically and the result confirmed pollution due to extensive anthropogenic activities (construction work intensive agricultural activity, operation of new industrial units and high industrial works), consequently legislation as well as remediation by the use of phytoremediation plants such as votivex grass. This grass is recommended in soil contaminated with high level of Pb and Cd as has been reported that it could reduce the concentrations of Pb and Cd in soil by 38-60% and 35-42% respectively of the heavy metals accumulate.

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