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The impact of man's activities on the heavy metals levels in soils in Wuse District, Abuja, Nigeria

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ABSTRACT

Levels of heavy metals in soils from Wuse District, Abuja were determined using atomic absorption spectrometry (AAS) in order to assess the impact of human activities on soil as well as the atmosphere in the Federal Capital Territory. The pH of the soil samples collected were found to be in the range 6.34-8.67. Concentrations of Pb, Ni, and Cd were determined in 15 different sites in Wuse District classified as high and low traffic density areas. The concentrations were measured by A.A.S. The study focuses on the levels of Pb, Ni, and Cd in order to assess the impact of man`s activities in the environment by using soil as indicator. Most of the soil samples analyzed showed pH=7 and only a few samples were tending towards alkaline pH. The metal levels obtained were 180 ± 62.56 ppm for Pb; 9.22 ± 4.0 ppm for Ni and 0.26 ± 0.02 ppm for Cd respectively. Pb showed significant correlation to high vehicle traffic density. The levels of metal contents obtained using atomic absorption spectrometry varied accordingly: cluster I; ranged from 119 to 141 ppm with mean values 129 ± 90 ppm for Pb; 0.23 to 0.40 ppm with mean values 0.3 ± 0.6 ppm for Cd and 6.3 to 21.3 ppm with mean values 7.7 ± 6.8 ppm for Ni. Cluster II; ranged from 128 to 184 ppm with mean values 165 ± 25.7 ppm for Pb; 0.13 to 0.25 ppm with mean values 0.18 ± 0.05 ppm for Cd and 5.25 to 9.75 ppm with mean values 7.7 ± 2.97 ppm for Ni. Cluster III; ranged from 150 to 241 ppm with mean values 207 ± 23.8 ppm for Pb; 0.22 to 0.33 ppm with mean values 0.24 ± 0.06 ppm for Cd and 3.25 to 13.90 ppm with mean values 8.09 ± 3.76 ppm for Ni respectively. The results of the study area reveals that the levels of metals obtained in both high and low traffic areas are linked to man`s activities in the area. Though, the metal status are not yet high. In conclusion therefore, are considered comparatively safe and may not be a cause of concern for environmental pollution. But increase in man`s activities could pose a significant health risk to humans in the near future in Abuja, being the fastest growing cities in Africa.

Keywords: Heavy metals, atmosphere, Wuse, Federal Capital Territory.

INTRODUCTION

Metal deposition into the soil along the roadside can arise from natural or man-made sources which will eventually lead to an increase in the levels of metals in the environment. Essentially, metal deposition in the environment can come from discharge of waste products resulting from industrial, commercial or domestic activities [1]. Natural sources of metals in the environment are weathering of parent material as well as soil erosion [2].

The major sources of heavy metals (Cu, Pb, Cr, Cd and Zn) deposition in the atmosphere are traffic, domestic heating and long range transport [3]. Pollutants resulting from these activities can attain high levels in the environment that may discomfort or harm man and his environment. Alongside air, water and the biota the soil is of central significance in ecosystem research as it is the place where many kinds of interactions take place between minerals, air, water and the living environment.

Soil is a geochemical sink for metal pollutants and buffer controlling the transport of elements into the atmosphere, aquatic ecosystem and plants [4]. The contamination of roadside soils of Botswana by Al, Co, Cu, Fe, Pb, Mn, Ni and Zn with high Pb contents in soil, has been attributed to vehicular emissions [5]. Since the movement of Nigerian Federal capital from Lagos to Abuja in 1991, there has been a rapid urbanization with a corresponding high population leading to high density of vehicles plying the roads.

These activities also result in high vehicular in high emissions into the environment. Though, very little attention has been paid to the possibility of environmental contamination from other metals than lead contamination whose major source is automobile. In this regard, this research work was carried out to determine the concentration of heavy metals in this region as a result of man's activities. AAS was employed in determining Pb, Cd, and Ni in fifteen soil samples collected from strategic point around Abuja city. This investigation presents an attempt to assess the level of these heavy metal contaminants arising mainly from vehicular emissions. Emphasis is placed on the need for new study. For instance, grass could bioconcentrate the heavy metal in a level many times than found in the soil and as such could be a source of contamination to grazing animals. It will be interesting to know if there will be seasonal fluctuations in the level of impact of heavy metal releases on the soil, and the effect of the potentially toxic element on the local fisheries.

MATERIALS AND METHODS

Sample collection

Soil samples were collected along the road in Wuse District Abuja. The samples were collected from fifteen different sites as shown Table 1.

Traffic density was also determined to study the volume of traffic in these locations. Soil sampling was carried out during the working days between the hours of 10-14. Sampling of soil was within 5 m from the motor way and top 5 cm layer. This procedure was carried out in the dry season in the month of April. These samples were collected into new polyethene sacks. This soil samples were oven dried at 60 ^{o}C for 1 hr and stored in polyethene bags to avoid contamination from extraneous materials. The samples were ground in a porcelain mortar and sieved through a nylon sieve of 2 mm size. The sieved particles samples were stored in polyethene bags and used for the analysis.

Digestion of Samples

1.0 g of sieved soil sample was accurately weighed into an evaporating dish, followed by the addition of 10 mL of 14 M HNO_3 acid. The mixture was heated in a water bath, evaporated to dryness and allowed to cool. This procedure was repeated with another 10 mL of 14 M HNO_3 acid followed by the addition of 10 mL of 12 M HCl acid. The digested soil sample was then warmed in some M HCl to redissolve the metal salts. The mixture was finally filtered and the filtrate obtained made up to 25 mL. This was used for the analysis of metal contents in soil.

Table 1: Description of sample sites

Sample codes	Description of Sample Sites
WZ5TJ	Wuse Zone 5, Traffic Junction beside modern market
JBRA	Julius Berger Round-about
WZ4JT	Wuse Zone 4, Traffic Junction
SHTWE	Sheraton Hotels and Tower Express way
WZ5MJ	Wuse Zone 5, Maitama Traffic Junction
MAIFS	Maitama Federal Secretariat
WZ3FS	Wuse Zone 3, Filling Station opposite zone 4
CUTHQ	Custom Headquarters, Abuja Street
WUNWM	Wuse New market incinerator
WUAMS	Wuse automobile mechanic shop
WAAYR	Wuse 4, Azikiwe/Sani Abacha/Yar'adu'a Roundabout
WU2AC	Wuse II, Aminu Kano crescent Traffic Junction
NITWU	Nitel Wuse
CENTM	Central mosque Abuja
WU2BP	Wuse II, Banex Plaza

Table 2: observed Traffic density in some selected sites
A: High Traffic Density Areas

Sites	Traffic Density/h
Wuse Zone 5, Maitama Traffic Junction	2,000
Wuse Zone Azikiwe/Abacha/Yar'adu'a	1,555
Wuse Zone 4, Nitel	1,500
Central Mosque	2,000
Wuse Zone 3, Filling Station	1,600
Wuse II, Banex Plaza	1,200
Wuse II Aminu Kano crescent Traffic Junction	1,200

B: Low Traffic Density Areas

Sites	Traffic Density/h
Berger Roundabout	500
Wuse Zone 4, Traffic Junction	900
Maitama Federal Secretariat	-
Sheraton Hotels & Tower Express	700
Customs Headquarters	500
Wuse market incinerator	-
Automobile mechanic shop Wuse market	-

Determination of pH of Soil Samples

The pH of each soil sample collected was determined by occasionally mixing one part of soil with two parts of distilled water over a period of 30 minutes to allow soil-water to approach an equilibrium condition and the pH of the soil-water suspension was determined using a pH meter Model AGB-72, Manufactured by Rapides Instrument United Kingdom. The pH values obtained are shown in Table 3.

Table 3: Observed pH levels in the soil samples

Sample	Average **pH** Values
WZ5JT	6.57
JBRA	6.34
WZ4TJ	6.36
SHTWE	6.35
MZ5MJ	6.68
MAIFS	6.68
WZ3FS	6.86
CUTHQ	6.79
WUNWM	8.66
WUAMS	8.67
WAAYR	6.14
WU2BP	7.84
WU2AC	7.44
NITWU	7.99
CENTM	6.7

Atomic Absorption Spectrometry

Atomic Absorption Spectrometry (A.A.S) was employed in the determination of the elemental composition of the samples. Atomic Absorption Spectrophotometer model PYE Unicam SP was employed in the determination.

Cluster Analysis of Elemental Data

Clustering Analysis technique was employed to establish the relationship among the samples based on the similarity in their elemental concentrations. There are several clustering techniques but the choice in this work is the Ward's technique which commences with the number of clusters equal to the number of sample and fuses these together until only one cluster remains. The criteria for linking clusters is minimization of error sum of squares (SS), i.e

i.e

□ □ □(Lij-Lijcc)^2

Cluster (c) Samples (i) element (j)

Where

Lij (c) = mean value of j for cluster (c) to which (i) is assigned.

The first summation (over elements) gives squared distance of each sample from its cluster centre, the second sums are all sample in each cluster, and the third sums are all clusters. A major disadvantage of Ward's method and all other hierarchical clustering methods, is that once a sample has been assigned to a cluster, it remains frozen in that cluster position. Results of Ward's method are usually presented in dendrograms.

RESULTS AND DISCUSSION

The results for pH measurements of the soil samples are as displayed in Table 3.

The pH values of soil samples collected ranged from 6.34-8.67. This shows that most of the samples were neutral and only a few samples were tending towards alkaline. For instance, sample WUAMS, cluster which the analysis showed to be an outlier, showed slight alkaline pH of 8.67. This could be due to the discharge of wastes from a mechanical workshop located in the area and the resultant oxidation activities.

Result of Cluster Analysis Technique

The result of the cluster analysis using ward's method are conveniently presented by means of a tree diagram called dendrogram shown in figure 1, the samples have broaden up into tree separate clusters (groups). The only sample which fell out in the process is WUAMS. It is an outlier, which means its concentration for Pb, Ni and Cd are not close to the rest of the soil sample.

Table 4: Metal Concentration in ppm, Wuse District Abuja

Sample	Pb	Cd	Ni
WZ5TJ	235	0.33	13.88
JBRA	34.13	0.33	10.7
WZ4TJ	131	0.4	10.69
SHTWE	122.5	0.3	6.25
WZ5MJ	41.13	0.3	8.37
MAIFS	40.63	0.23	21.75
WZ3FS	182.5	0.25	5.25
CUTHQ	18.75	0.3	10.75
WUNWM	28.75	0.13	9.75
WUAMS	66.25	0.17	7.38
WAAYR	93.13	0.2	11.82
WU2BP	172.5	0.2	3.25
WU2AC	150	0.2	4.82
NITWU	84.13	0.17	8.15
CENTM	200	0.2	6.38

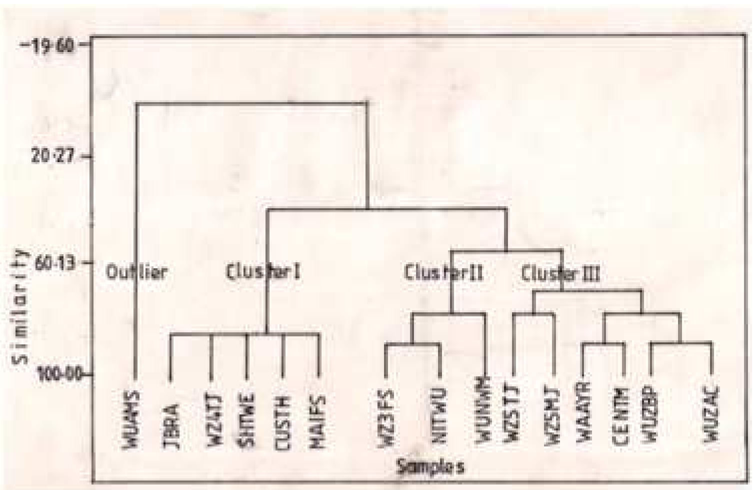

Figure 1. Dendrogram derived from hierarchical cluster analysis of the Soil Samples.

The characteristic of samples in each cluster are as follow:

Cluster I

Lead (Pb)

The Pb content of the sample in cluster I ranged from 119 to 141 ppm with a mean value of 129 ±5.90 ppm. Cluster (I) constitutes the highest number of samples. These samples were those that were collected from low traffic density area and showing higher Pb value than the background value in soils. The background value of Pb in soil is normally less than 20 ppm [6]. This suggests that the soil in this area is already polluted by Pb. This high Pb is apparently caused by the high vehicular releases. High Pb content of roadside soils has been attributed to vehicular emissions [7]. It has been shown that leaded gasoline (petrol) contributes to Pb levels in roadside soils [8, 9]. It has been reported that the gasoline (petrol) marketed in Nigeria contained about 520 mg/l Pb content which is higher than that in some industrially developed nations [10].

Cadmium (Cd)

The cadmium contents for the set of values in cluster I ranged from 0.23 to 0.40 ppm, with mean values of 0.3 (Cd) is a component of tyre wastes its content in the soil samples was found to be low and this could be due to the fact that, it occurs in the area of soil sample are close to the roadside. Tyre wastes ranked sevenths in the listing of sixteen major sources of atmospheric emission of Cd [11]. The sources of Cd and Zn have been attributed to metal processing/impurities in Zn-based oil and rubber additives from tyre wear [12]. Sample WZ4TJ, had high Cd content of 0.40 ppm. This sample was collected from roads and roundabouts were there was high traffic. There are similarities between the values obtained for the various samples in cluster (I), and these values were within the background cadmium (Cd) levels in world soils [13]. Cadmium has also been reported in some motor oils according to [14]. Cd contents 0.1-3.1 ppm have been reported in Northern Nigeria [15]. Waste incineration is also an important source of atmospheric cadmium as reported by [10]. Incineration of tyres and other municipal wastes is a common practice in the federal capital territory. Other activities like vulcanizing, smelting and metallurgical operations are also sources.

Nickel (Ni)

Nickel contents of soil sample in cluster (I) ranged from 6.3 to 21.3 ppm, with mean of 7.7±6.8 ppm. Soil sample MAIFS, had the highest Ni content compared to all other samples in clusters II and III. High Ni content could be linked to vehicular releases. Ni content of roadside soils is associated to traffic related sources such as corrosion of metallic parts, concrete materials, re-entrained dust from roads and tear and wear of tyres and engine parts [8]. High levels of Ni and Zn in roadside soils have been reported [12]. Most vehicles are equipped with nickel containing reduction catalysts and are known to release Ni in the form of Nickel carbonyl into the roadside environment [14]. Municipal incinerators and combustion of oil in the open are known to be major contributors of roadside Nickel (Ni)

Table 5: Range (R) and mean (X) of elemental concentrations in cluster I

	Pb (ppm)		Cd (ppm)		Ni (ppm)	
Sample code	Range(R)	Mean(X)	Range (R)	Mean (X)	Range (R)	Mean (X)
JBRA WZ4TJ SHTWE CUTHQ MAIFS	119-141	129 ±5.0	0.23-0.40	0.31± 0.06	6.3-21.30	7.7 ± 6.06

Table 6. Range (R) and mean (X) of elemental concentrations in cluster II

	Pb (ppm)		Cd (ppm)		Ni (ppm)	
Sample Code	Range (R)	Mean (X)	Range (R)	Mean (X)	Range (R)	Mean (X)
WZ3FS NITWU WUNWM	128-184	165±25.7	0.13-0.25	0.18±0.05	5.25-9.75	7.7± 2.97

Table 7. Range (R) and mean (X) of elemental concentrations in cluster III

	Pb (ppm)		Cd (ppm)		Ni (ppm)	
Sample Code	Range (R)	Mean (X)	Range (R)	Mean (X)	Range (R)	Mean (X)
WZ5TJ MAAYR CENM WU2BP WU2AC	150-241	207±23.8	0.22-0.33	0.24±0.06	3.25-13.90	8.09±3.76

CONCLUSION

The high levels of Pb obtained in this study implied that it was as a result of vehicular exhausts. This conforms to Pb levels reported for other parts of Nigeria and some other countries which were mainly due to combustion of gasoline (petrol). This is because the gasoline marketed in Nigeria has lead content of about 520 mg/l which is higher than that in some industrialized countries. The levels of other metals studied are not yet high enough to be harmful to man and his environment.

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