Variation in heavy metal contents on roadside soils along a major express way in South east Nigeria

[1] Mbah C N , [2]M A N Anikwe

[1]Department of Soil and Environmental Management.
Ebonyi State University, P.M.B, 053, Abakaliki – Nigeria.
[2]Department of Agronomy and Ecological Management.
Enugu State University of Science and Technology, Enugu – Nigeria
cnmbah10@yahoo.com

Abstract: Pollution of natural environment due to release of heavy metals from various sources is a widespread problem through out the world. The study investigated heavy metal concentration on roadside along a major expressway in south eastern Nigeria. Fifteen air dried surface soil samples were collected from 50cm – 1m (point A) and fifteen from 100m (point B) away from the roadside along a road with a distance of 170 km. Heavy metals were found in both points with highest concentration at 50cm – 1m (point A). Mean values 5205.11(Fe), 247.97(Cu), 74.11(Zn) 100.19(Pb) and 18.8(Cd) mgkg-^{1} were recorded at 50cm – 1m while means values at 100m away from the roadside for Fe, Cu, Zn, Pb and Cd were 4890, 217.86, 64.08, 87.13 and 3.05 mgkg-^{1}, respectively. Variability of heavy metals ranged between 7 – 56% and 14 – 70% at 50cm – 1m and 100m, away from the road, respectively. At 50cm – 1m and 100m, Pb and Cd showed high variability with highest variability (70%) observed in Pb at 100m away from roadside. Results from the study showed that the studied soil contains higher levels of heavy metals nearer the roadside and constitute health risk to human and animal health when plants – based food stuff grown along the area is consumed. [New York Science Journal. 2010;3(10):103-107]. (ISSN: 1554-0200).

Keywords: Automobile waste; Heavy metal; Expressway; Pollution; Toxicity.

1. Introduction

Heavy metals enter the environment as a result of both natural and anthropogenic activities (Ojanuja, *et al*., 1996, He *et al.*, 2004). Naturally heavy metals occur in soils, usually at a relatively low concentration, as a result of the weathering and other pedogenic processes acting on the rock fragments on which the rock develops – soil parent materials (Alloway, 1996). Anthropogenic sources of heavy metals for soils include commercial fertilizers, liming materials, agrochemicals and other materials used as soil amendment, irrigation waters and atmospheric decompositions (Senesi *et al.*, 1999). The waste products from vehicles that ply highways contain some heavy metals inform of smokes. Emissions from exhaust pipes of automobile engine and contacts between different metallic objects in machines contain such heavy metals as lead (Pb), Zinc(Zn), Iron(Fe), Copper (Cu) and Cadnium (Cd) and are major sources of pollution among soils (Turer and Maynard, 2003). The contaminants from automobile either accumulates on the soil surface or are moved down to deeper layers and eventually may change the soil physicochemical properties directly or indirectly. Nriagu (1993) observed that soils in the eastern region of Nigeria have been polluted by a wide range of sources with Pb, Cd, As, Hg, and other heavy metals. Therefore, there exists the need for more researches on the sources of heavy metal enrichment of the soils of this region regarded as the food belt of Nigeria.

Most commonly heavy metals do not degrade naturally and accumulation of high concentration in soils can be toxic to plants, humans and other living organisms in the surrounding environment. This study was aimed at assessing the variation in heavy metal content of roadside soils along a major expressway (Abakaliki – Enugu – Okigwe) in south east Nigeria and to determine whether heavy metals accumulate at ecotoxological levels or not at the roadside or far from the roadside.

2. Material and methods

2.1 The project environment.

The study was carried out along Abakaliki – Enugu – Okigwe expressway south eastern Nigeria. **Abakaliki** (Ebonyi State) falls within longitude 8^0 3^1E and latitude 6^0 25^1N in the derived savannah region of the southeast agro-ecological zone of Nigeria. Geologically, the area is underlain by sedimentary rocks derived from marine deposits of the crutaceous and tertiary periods. The soil belongs to the order ultisol and is classified as Typic-Haplustult (FDALR.1985).

Enugu (Enugu State) lies between latitude 06^0 25^1 N and latitude 07^0 15^1 E. The soil is lateritic, of sandy loam textural class and classified as Typic Haplustult (FDALR, 1985).

Okigwe (Imo State) is bounded by latitude 04^o 4^1 and 08^o 15^1N and longitude 06^o 40^1 and 08^o 15^1E. The predominant parent material underlying Imo State from which most of the soils are formed are the coastal plain sands popularly known as "Acid soil" (Orajaka, 1975). The soil is classified as Plinthic Tropudult/Plinthic Acrisol (FDALR, 1985).

The project area (Abakaliki – Enugu – Okigwe) is within the humid tropics. The area is characterized by high temperature and high rainfall. The rainfall pattern is bimodal between April and October, while the dry season is between November and March. The mean temperature ranges between 24^oC – 27^oC while relative humidity is between 60 – 80% (ENADEP, 1993). The farming system is primarily the slash – and – burn method. Coupled with intensive use of the land and the absence of any definite management system, the productivity of the soil has been adversely affected. The rapid depletion of plant nutrients (<2.0 according to Enwezor, *et al.*, 1990) and poor physical conditions (Mbah, *et al*., 2004) constitute strong limitations to crop production in the area.

2.2 Soil sampling and data collection

This study was conducted with air dried 2mm-sieved surface soil samples (0-20cm) collected from roadside along Abakaliki – Enugu – Okigwe expressway. Surface soil was used since Elbassam (1977) and Mohr (1979) reported that maximum contamination of heavy metals takes place in top layers of soil.

Thirty samples were collected from the study area at a distance of 10km apart along the road transect covering a distance of 170 km. Fifteen of the (thirty) samples were collected from a distance of 50cm – 1m(point A) away from the roadside with the rest fifteen samples were from a distance of 100m (point B)away from the roadside .Soil samples 12 – 15 (Tables 1 and 2) were collected from sites under cashew plantation for over 30 years while other sample were under cassava alone or mixed crops. Sample B6 and B9 (Table 2) were collected from industrial waste dumpsite while B2 was from slope on erosion site.

2.3 Laboratory analysis and methods

The heavy metals (cu, zn, fe, pb, and cd**)** content of the soil samples were extracted using the wet-acid digestion method.

Digestion of soil sample for heavy metals was carried out with a mixture of Conc. $HCL0_4$ and HNO_3 at a ratio of 2:1 and heavy metals were extracted using 0.5m HCL (Lacatusu, 2002). The heavy metals concentrations in the supernatant were determined using Atomic Absorption spectrophotometer meter Alpha 4 model.

2.4 Statistical analysis

Mean and co-efficient of variation (CV%) were used to determine the variation in heavy metal contents along point A (50cm – 1m) and B (100m) from the roadside. Variability was ranked as follows: little variation (Cv % < 20), moderate variation (cv % = 20 – 50) and High Variation (Cv % > 50) according to Aweto (1982).

3 Results

Heavy metals (Fe, Cu, Zn, Pb and Cd) content at 50cm – 1m (point A) and 100m (point B) from the road side are shown in Tables 1 and 2, respectively. The tables show higher mean values of heavy metals in Table 1 (50cm – 1m) compared to Table 2 (100m). Mean values of Fe, Cu, Zn, Pb and Cd were 5205.11, 247.97, 100.19, 74.11 and 9.83 $mgkg^{-1}$ respectively at point A (50cm -1m) while 4890(Fe), 217.86(Cu), 64.08(Zn), 87.13(Pb) and 3.05(Cd) $mgkg^{-1}$ where obtained at point B (100m). However, observed values of Cu and pb at B6, pb at B8 and pb, zn, fe and cu at B9 values were higher than those at points A6, A8 and A9, respectively. Generally, results showed that as distance from the roadside increase heavy metal content of the soil decrease.

3.1 Agronomic implications

The concern over heavy metal pollution of soils is based on many reasons. First as a result of human activity heavy metals may accumulate in the soil environment to a point where their levels are toxic to plants. Second their off-site movement either to surface water or to ground water has the potential for contamination of drinking water resources. Thirdly heavy metal might accumulate in the food-chain and affect the health of people who eat food grown on metal contaminated soils. Soil heavy metal contents varies with the distance from the roadside .Variability of heavy metals ranged between 7 -56% at 50cm – 1m and 14 – 70% at 100m from the roadside. Heavy metals varied at both distances with highest variation (70%) observed in pb at 100m from the roadside.

Table 1: Heavy metal concentration on point A (50cm- 1m) away from the roadside ($mgkg^{-1}$)

Sampling points	Fe	Cu	Zn	Pb	Cd
1	5204.7	217.5	69.0	78.8	140
2	4816.6	224.8	72.0	49.5	4.6
3	5592.5	277.3	78.3	94.6	09.0
4	5617.8	248.3	71.0	189.2	10.1
5	5525	250.9	73.0	97.3	12.3
6	5190.8	266.4	75.0	35.6	16.7
7	5696.7	326.3	81.0	236.5	5.1
8	5562.2	193.6	78.0	4.9	8.3
9	4707.8	145.0	61.0	119.4	8.0
10	4958.9	232.0	70.0	78.8	8.0
11	4613.3	200.0	75.3	113.2	12.7
12	5011.6	227.3	80.1	99.9	6.3
13	5213.5	258.1	87.3	87.3	21.2
14	4902.1	270.0	70.4	97.6	09.3
15	5461.2	282.1	76.4	120.3	6.8
Mean	5205.11	247.97	74.11	100.19	9.83
CV %	7	17	8	56	51

Table 2: Heavy metal concentration on point B (100m) away from the roadside ($mgkg^{-1}$)

Sampling Points	Fe	Cu	Zn	Pb	Cd
1	4837.8	217.5	63.0	65.4	1.2
2	4888.9	199.4	61.0	97.3	1.1
3	5079.2	237.4	71.0	78.8	1.2
4	5125.8	224.8	70.0	65.4	1.4
5	5255.8	179.4	50.0	49.5	3.2
6	5020.3	299.0	50.0	189.5	1.6
7	5506.3	255.6	81.0	81.4	4.4
8	5488.3	250.1	70.0	81.3	6.0
9	5046.7	221.1	69.0	205.0	8.1
10	4940	241.1	61.0	61.5	4.8
11	4533.2	168.9	51.0	46.5	3.2
12	4902.1	169.72	65.2	70.2	1.5
13	4112.0	190.7	70.1	66.4	2.3
14	4008.2	200.7	61.2	78.2	2.4
15	4611.3	213.0	68	91.2	3.4
Mean	4890.0	217.86	64.08	87.13	3.05
CV %	17	16	14	53	70

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4. Discussion

The higher level of heavy metals observed at 50cm – 1m away from the roadside could be attributed in part to heavy metal emission from vehicle exhaust in particulate form which are forced to settle under gravity closer to the road edge or due to non-point contamination sources most commonly vehicle exhaust and wear of vehicle parts. Studies by Hay- Garth and Jones (1992) showed decreasing heavy metal concentration with increasing distance from the road. Similarly, Nicholas and Egar (1976) reported that vehicle introduce a number of metals into the atmosphere adjacent to road way. The higher levels of some of the heavy metal observed at points B6, B8 and B9 relative to points A6,A8 and A9 could be as a result of impact of municipal wastes, erosion deposition and industrial activities. In a related study, Gray and Biddleton (1980) showed that municipal composts contained high levels of some trace elements (Cu, Zn, Pb and Cd) and that soil heavy metal content decreases as the distance from the roadside increases except where additional sources occur.

Many soil properties including soil P^H exchangeable properties and base saturation are influenced by soil heavy metal contents. At low P^H, solubility and percolation of heavy metals into deeper horizons of the pedon are increased. However, He, *et al.*, (2004) observed that heavy metal mobility into soils depends on a lot of factors including soil concentration, soil properties, metal property and environmental factors. Similarly microbial decomposition of organic matter added to a soil may result in the release of organic compounds that may complex with and dissolve heavy metals and hence increase the availability of these metals to plants and possibly the amounts that reach ground water.

High level of heavy metals in soils means that agricultural soils are contaminated by atmospheric depositions. Several authors haves shown a relationship between atmospheric element deposition and elevated heavy metal concentration in plants and top soils, Larseen, (1992). Heavy metal uptake by plants grown in polluted soils has been studied at a considerable extent. All findings have shown that elevated levels of metals in soil may lead to increased uptakes by plants. Alloway and Davies (1971) and Grant and Dobbs (1977) observed that plants grown on soils possessing enhanced metal concentration have increased metal ion content. Amusan, *et al.*, (1999) studied heavy metal uptake by plants and found that pb uptake by water leaf (*talinum traingulare*) and okra (*Abelmoschus esculentus*) increased by 200% and 733% in leaves and by 126% on the fruit of Okra relative to the control. However, hyper-accumulating plants have been found to accumulate heavy metals at levels above critical levels (Brady and Weil, 1999) while incase of zn and cu, Miller and Mcfee (1983) reported that their toxicity manifest in plants before accumulating to levels that will affect human and animals. The uptake of these heavy metals by plants results in bioaccumulation of these elements which according to Alloway (1996) and Kabata-pendias and Pendias (1984) cause a serious risk to human health when plant – based food stuff are consumed.

4.1 **Conclusion**

Results of the study showed elevated heavy metal concentration at 50-1m from the roadside. The observed heavy metal contents at point A(50cm-1m) and point B (100m) are within the normal range in soils (Table 3).However, critical limits (range of values which toxicity is considered possible) which vary according to heavy metals have been set by researchers (Table 3).Results of the study showed that the mean concentration of the studied heavy metal are above the critical limits at 50cm – 1m(point A) except zn while at 100m cu alone was observed to be above the critical limits. Results from the study showed that agricultural soil nearer roadside contains higher levels of heavy metals and constitute health risk to human and animal health when plants – based food stuff grown along the area consumed.

Table 3: Normal and critical limits of heavy metals in soil ($mgkg^{-1}$)

Heavy metal	Normal range	Critical Limits
Pb	2 – 300	100 – 400
Zn	1 – 900	90 – 400
Cu	2 – 250	60 – 125
Cd	0.01 – 20	4 – 8
Fe	-	-

Normal range = Bowen (1979), critical range = Kabata – pendias and Pendias (1984).

Acknowledgement:

The authors are grateful to the Laboratory Staff of Departmental of Soil Science, University of Nigeria, Nsukka – Nigeria

Correspondence to:
Dr Mbah Charles N
[1]Department of Soil and Environmental Management. Ebonyi State University, P.M.B, 053, Abakaliki – Nigeria

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9/10/2010

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