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Research Article

ASSESSMENT OF HEAVY METALS IN ROADSIDE SURFACE SOIL AND VEGETATION ALONG MUBI – MICHIKA MAJOR ROAD IN ADAMAWA STATE, NIGERIA

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Abstract

The study of heavy metals in environmental niches is essential, especially with their potential toxicity to human life. To identify the levels of heavy metals in roadside environment, samples of roadside soils and vegetation were collected from ten (10) towns along the Mubi - Michika major road which include Mubi, Mararaba, Dzakwa, Hildi, Uba, Kudzum, Dilchim, Bazza, Watu and Michika. Subsequently, the concentrations of heavy metals particularly Cu, Pb, Cr, Fe and Cd in the samples were analyzed using atomic absorption spectrophotometer (AAS). The result revealed that Cu, Pb, Cr, Fe, and Cd were present in the soil, at the mean concentration ranged of Cu (0.20±0.01 to 1.16±0.20%), Cd (0.04±0.03 to 0.13±0.05%), Zn (6.30±0.01 to 13.90±0.23%), Pb (1.32±0.03 to 5.63±0.04%), Fe (12.00±0.20 to 32.92±0.42%), and Cr (0.04±0.02 to 0.09±0.03%). The concentrations of the heavy metals in plant leaves samples ranged from Cu (0.01±0.03 to 0.93±0.01%), Cd (0.01±0.03 to 0.09±0.02%), Zn (2.40±0.03% to 7.10+0.14%), Pb (0.26±0.01 to 2.16±0.01%), Fe (5.10±0.01 to 15.00±0.14%) and Cr (0.01±0.03 to 0.03±0.13%). The Pb concentrations in both soil and plant leaves were found to be in excess of FAO/WHO recommended limits. While the levels of the other heavy metals in both soil and plants leaves were found to be within the FAO/WHO recommended limits. The high level of Pb indicates potential health risk for human through the food chain. From the study, the heavy metals pollutant in roadside soil and vegetation along Mubi-Michika roadside villages might originate from common anthropogenic source and high rate of human activities such as automobile emission.

Key words: Heavy Metals; Roadside; surface soils; vegetation; Mubi–Michika

Introduction

Human activities have dramatically changed the composition and organization of soils and plant (Okunola *et al.,* 2008). Heavy metal concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities and waste disposal methods (Uwah *et al.,* 2009). Contamination and subsequent pollution of the environment by heavy metals have become global concern due to their sources, widespread distribution and multiple effects on the ecosystem (Uwah *et al.,* 2011).

Industrial and Urban wastes, agricultural application and also mining activities resulted in an increased concentration of heavy metals in both soil and plants (Yusuf *et al.,* 2002). Heavy metals pollute both soil and plant and so it is necessary to examine the state of the polluted soil and plants and establish, what influence, heavy metals have on both. Heavy metals have great significance due to their toxicity and accumulative behaviour and are not biodegradable (Egboh *et al.,* 2002)

Surface soil may act as carries and possible sources of pollution, since the mobility of these metals is such that remain in upper layers without regards to type of soil. Moreover, these metals are not permanently fixed and can be released by change in climatic or environmental conditions such as rainfall and soil pH (Ajibola and Oziegis, 2005).

The main sources of roadside contaminants are the deposition of aerosol particles which are adhesive in nature (Okunola *et al.,* 2007). In the urban environment, these particles originate mainly from road traffic, welding, emission from industries construction activities and flaking of paints (Radojavice and Bashkin, 1999). Some of the heavy metals such as Zn, Se, Cu, and Fe are essential to maintain the metabolism of the body. However, at high concentration, they lead to poisoning. The exposure of such substance in the roadside is mainly by ingestion (Shinggu *et al.,* 2007).

The main aim of this research work is to assess the levels of heavy metals in roadside soil and vegetation and to enlightened people living along Mubi – Michika roadside environment about the hazards and implications of farming near the road. This was carried out by analyzing spectrophotometrically the levels of the metals in the plants and soil samples.

Materials and Methods

Study Area

Mubi region geographically is located in the North Eastern part of Nigeria in Adamawa State. It lies between Latitude 9°31′N and 11°15′N and Longitude 13°15′Eand 13°45′ E (Adebayo, 2004).

Analytical reagent (AnalaR) grade chemicals and distilled water were used throughout the study. All glassware and plastic containers used in this work were washed with detergent solution followed by 20% (v/v) nitric acid and then rinsed with tap water and finally with distilled water.

Sampling and Sample Treatment

Ten towns along Mubi – Michika major road were selected for soil and fresh plant leaf samplings, this road was chosen for study because it have the heaviest traffic, these towns include Mubi, Mararaba, Dzakwa, Hildi, Uba, Kudzum, Dilchim, Bazza, Watu and Michika. Samples of surface soil and fresh plant leaves (*Sida Acuta Burm,* commonly known as broom weed) were randomly collected from the vicinity of the sampled areas in the months of December, 2010 and January, 2011 according to Okonkwo and Maribe (2004). The samples were collected at interval of five kilometers apart and at three meters distance from the road.

Fresh leaves of *sida acuta Burm* were randomly taken from the vicinity of the sampled area where soil samples were collected, using a clean stainless steel pair of scissors (Okonkwo and Maribe, 2004), placed in a paper bags, labeled and taken to the laboratory for pre-treatment and analysis.

Surface soil samples at 3 meters distance from each road were collected with the aid of stainless steel spoon washed with soap and rinsed with distilled water after each sampling (Okunola *et al.,* 2008). Ten sub samples of 20g each were collected from each side of the road at a sampling site. The sub samples for each sampling location were then placed in cellophane bags (Bamgbose *et al.,* 2000). The composite samples of each site, was obtained by bulking procedure to standardize the samples. A conning and quartering method was applied repeatedly to reduce the sample volume (Jeffery *et al.,* 1989). Representative sample collected from each site sample was then labeled and taken to the laboratory for processing/pr-treatment and analysis. The soil sampling spots was cleared of debris before sampling (Chimuka *et al.,* 2005).

Samples Digestion

Soil samples from each site was homogenized and air dried in a circulating air in the oven at 30°C to a constant weight and was sieved through 0.2 mm. 2g of the powdered soil sample was placed in 100cm³ Tall – form beaker (Okunola *et al.,* 2008). 10cm³ of 1:1 nitric acid and water was added to it and boiled gently on a hot plate until the volume was reduced to near dryness and then cool. 10cm³ of distilled water was added to it and then boiled gently again until the volume was approximately 5cm³. The suspension was allowed to cool and filter through a whatman No. 540 filter paper, the beaker and filter paper was washed with small portions of distilled water until a volume of about 25cm³ was obtained. The filtrate was transferred into a 50cm³ graduated flasks and made up to the mark with distilled water (Jeffery *et al.,* 1989). The quantification of the metallic content of the digested samples was carried out by atomic absorption spectrophotometer (AAS).

Plant leaves samples were properly rinsed with distilled water to remove any attached soil particles. It was cut into smaller portions then placed in a large clean crucible and oven dried at 105°C for 12 h until they were brittle and crisp (Uwah *et al.*, 2011). The dried plant leaves samples were ground into fine powder using clean acid wash mortar and pestle and then sieved through 0.2mm sieve (Okunola *et al.,* 2008). 1g of powdered leave sample was placed into 100cm³ beaker. A mixture of 5cm³ of concentrated trioxonitrate(iv) acid (HNO₃) and 3cm³ of hydrogen peroxide (H₂O₂) was added, this was digested on low heat using hot plate until the content was about 2cm³, the digest was allowed to cool, filtered into 50cm³ standard flask using whatman No. 540 filter paper and make up to the mark with more distilled water. Triplicate digestion of each sample was carried out together with blank digested without the plant sample (Jeffery *et al.,* 1989).

Statistical Analysis

All analysis was performed in triplicates. Results were in form of means ± SD. Statistical significance was established using one way Analysis of Variance (ANOVA).

Results and Discussion

The concentrations of various heavy metals in roadside surface soils and vegetation along Mubi- Michika major road are presented in Tables 1 and 2, respectively. Generally, the results showed that for most of the soils samples, the concentration of Cu, Zn, Pb, Fe, and Cr are higher than in the Plant Leaves samples. In the present investigation, the level of copper (Cu) in the samples studied ranged from 0.20 ± 0.01 to $1.16 \pm 0.20\%$ in soil and 0.01 ± 0.03 to $0.93 \pm 0.01\%$ in plant leaf respectively. The maximum concentration of Cu ($1.16 \pm 0.20\%$) in soil was recorded along Mubi road while the maximum concentration ($0.93 \pm 0.01\%$) in leaf samples was recorded along Michika road. The least concentration in soil and leaf samples (($0.20 \pm 0.01\%$ and $0.01 \pm 0.03\%$) respectively were both registered along Dilchim road. The Mubi road serves as one of the major roads with associated ancillary vehicle workshops located along it. The level of copper in Mubi and Michika soil samples exceeds the FAO/WHO limit. These were also significantly higher than values reported elsewhere (Rashad and Shalaly, 2007; Abechi *et al.,* 2010). The presence of Cu in roadside soil is attributable to smelting, battery and soldering works.

Table 1: Heavy metal concentrations in studied roadside surface soil samples (% dry weight basis).

Sample	Cu	Cd	Zn	Pb	Fe	Cr
Mubi	1.16 ± 0.20	0.13 ± 0.05	13.90 ± 0.23	5.63 ± 0.04	32.92 ± 0.42	0.09 ± 0.03
Mararaba	0.63 ± 0.02	0.07 ± 0.02	10.20 ± 0.01	5.00 ± 0.02	30.00 ± 0.31	0.04 ± 0.02
Dzakwa	0.36 ± 0.01	0.04 ± 0.02	7.30 ± 0.02	1.69 ± 0.01	13.20 ± 28	ND
Hildi	0.27 ± 0.01	ND	7.00 ± 0.04	1.32 ± 0.03	12.30 ± 0.11	ND
Uba	0.62 ± 0.01	0.10 ± 0.03	11.30 ± 0.01	5.17 ± 0.01	28.30 ± 0.28	0.50 ± 0.02
Kudzum	0.25 ± 0.01	ND	6.90 ± 0.01	ND	12.30 ± 0.32	ND
Dilchim	0.20 ± 0.01	ND	6.30 ± 0.01	ND	12.00 ± 0.20	ND
Bazza	0.42 ± 0.01	0.06 ± 0.02	9.80 ± 0.01	4.95 ± 0.03	27.90 ± 0.25	0.06 ± 0.01
Watu	0.38 ± 0.02	0.04 ± 0.03	7.60 ± 0.01	1.73 ± 0.03	12.80 ± 0.23	ND
Michika	0.98 ± 0.01	0.10 ± 0.03	12.10 ± 0.03	5.33 ± 0.04	31.10 ± 0.13	0.07 ± 0.02
Range	0.27±0.01-1.16±0.02	0.04±0.02-0.13±0.05	7.00±0.04-13.90±0.23	1.32±0.03-5.63±0.04	12.30±0.11-32.92±0.42 0-40	0.04±0.02-0.09±0.03
FAO/WHO	0-0.8	0-0.15	0-15	0-0.15		0-0.40

All values represent meant ± standard deviation of triplicate determination
Key: ND = Not Detected.

Table 2: Heavy metal concentrations in studied roadside plant leaf samples (% dry weight basis).

Sample	Cu	Cd	Zn	Pb	Fe	Cr
MubiMararaba	0.66 ± 0.02	0.02 ± 0.01	7.10 ± 0.14	2.16 ± 0.01	15.00 ± 0.14	0.03 ± 0.13
Dzakwa	0.23 ± 0.03	0.09 ± 0.02	3.00 ± 011	1.72 ± 0.01	13.95 ± 0.23	0.01 ± 0.01
Hildi	0.15 ± 0.02	ND	3.00 ± 0.11	0.26 ± 0.01	5.20 ± 0.01	ND
Uba	0.18 ± 0.01	0.01±0.03	2.90 ± 0.04	0.32 ± 0.01	5.60 ± 0.02	ND
Kudzum	0.35 ± 0.01	0.02± 0.01	4.60 ± 0.13	2.00 ± 0.03	11.50 ± 0.02	0.02 ± 0.01
Dilchim	0.25 ± 0.01	ND	2.90 ± 0.04	ND	5.40 ± 0.01	ND
Bazza	0.01 ± 0.03	ND	2.40 ± 0.03	ND	5.10 ± 0.01	ND
Watu	0.21 ± 0.03	0.07 ± 0.02	3.10 ± 0.10	1.95 ± 0.03	5.30 ± 0.01	0.01 ± 0.03
Michika	0.19 ± 0.01	0.01 ± 0.03	2.90 ± 0.04	0.46 ± 0.01	5.20 ± 0.01	ND
Range	0.93 ± 0.01	0.02 ± 0.03	5.30 ± 0.04	2.01 ± 0.01	14.80 ± 0.23	0.02± 0.01
	0.01 ± 0.03-	0.01 ± 0.03-	2.40 ± 0.03-	0.26 ± 0.01-	5.10 ± 0.01-	0.01 ± 0.03-
FAO/WHO	0.93 ± 0.01	0.09 ± 0.02	7.10 ± 0.14	2.16 ± 0.01	15.00 ± 0.14	0.03 ± 0.13
	0-0.70	0-0.12	0-13	0–0.12	0-30	0-0.02

All values represent meant ± standard deviation of triplicate determination
Key: ND = Not Detected.

The concentrations of Cadmium in soil and plant samples ranged from $0.04 \pm 0.03\%$ to $0.13 \pm 0.05\%$ and $0.01 \pm 0.03\%$ to $0.09 \pm 0.02\%$ respectively. The maximum concentration ($0.13 \pm 0.05\%$ in soil and $0.09 \pm 0.02\%$ in plant leaf was recorded in Mubi and Mararaba respectively. Cadmium (Cd) was not detected in Dzakwa, Kudzum and Dilchim. However, the recorded values in both the plant and soil samples fall within the permissible limit of the FAO/WHO (2001) standards. Cadmium presence in the soil dusts results from industrial works such as battery and other electrical works. Soils in this study exhibited lower levels of contamination than 0.75 µg/g (Jaradat and Momani, 1999), 2.11 µg/g (Amusan *et al.*, 2003), 5.15 to 5.79 µg/g (Abechi*et al.,* 2010) and 0.88 µg/g (Bai*et al.,* 2008). In absence of any major industry in the sampling sites, the levels of Cd could be due to lubricating oils and/or old tires that are frequently used on the rough surfaces of the roads which increase the wearing of tires.

Among all metals, Zinc (Zn) is the least toxic and an essential element in the human diet as it is required to maintain the proper functions of the immune system. The concentration of Zinc (Zn) in soil and plant leaf samples ranged from 6.30 ± 0.01 to $13.90 \pm 0.23\%$ and $2.40 \pm 0.03\%$ to $7.10 \pm 0.14\%$ respectively. These values fall within the safe limit recommended by FAO/WHO (2001). The highest concentrations in soil and plant leaf samples ($13.90 \pm 0.23\%$ and $7.10 \pm 0.14\%$) respectively was obtained in Mubi, while the least ($6.30 \pm 0.01\%$ and $2.40 \pm 0.03\%$) in soil and plant leaf respectively was found in Dilchim. These values are high compared with many other studies (Abechi *et al.,* 2010, Jaradat and Momani, 1999; Bai *et al.,* 2008). Since no major industry exists in the study areas such as smelting operations, we may assume that the primary sources of Zn are probably the attrition of motor vehicle tire rubber exacerbated by poor road surfaces, and the lubricating oils in which Zn is found as part of many additives such as zinc dithiophosphates. Also, the mobility of the metal depends on soil pH and also depends on the organic matter and granulometric composition of the soil. Acidic pH makes easier the solubilization of the Zn compounds, although the soils in this study are generally slightly alkaline. An indication that Zn and other metals remain in soils for a longer period.

In the present study, lead (Pb) levels in soil and plant samples varies from $1.32 \pm 0.03\%$ to $5.63 \pm 0.04\%$ and $0.26 \pm 0.01\%$ to $2.16 \pm 0.01\%$ respectively. Pb content was found high in Mubi soil and plant leaf ($5.63 \pm 0.04\%$ and $2.16\pm 0.01\%$ respectively) (high traffic volume), while the lower value ($1.32 \pm 0.03\%$) was found in Hildi soil and Dzakwa plant leaf ($0.26 \pm 0.01\%$). The concentration of Pb in both the soil and plant leaf samples in most of the study areas exceeded the FAO/WHO standard limits. However, Pb was not detected in Kudzum and Dilchim. The high level of Pb in the study areas is a source of worry; this might be

attributed to the heavy traffic volume and excessive application of fertilizer in this area which may account for the high level of lead. The high mean value of the concentrations attested to the overall high level of contaminations of this metal in the roadside environments. This is in agreement with the report of (Ekere and Ukoha, 2013; Rashad and Shalaly, 2007; Ayodele and Gaya, 2003). The high concentrations of lead observed could also be attributed to lead particle from gasoline combustion which consequently settles on roadside soils and vegetations. The case of Mubi being more predominant could be attributed to the heavy traffic volume of the route. Conversely, Dzakwa and Hildi have the least concentration values of Pb ($0.26 \pm 0.01\%$ and$1.32 \pm 0.03\%$ respectively) and this could be expected, because of the least volume of vehicles recorded on the road. Though, the high mean soil lead level confirms that the roadside environment is generally lead enriched despite a relatively low traffic volume compared to other studies (Ekere and Ukoha, 2013). Lead enters soil through the actions of electrical smelting and soldering workers. Lead is noted as toxin and it has adverse effects on humans and animals (Ekere and Ukoha, 2013).

Fe is not a toxic metal because it serves as a micronutrient, the results discussed. Since the metal is the predominant metal available in all sites. The concentration of iron (Fe) content was found highest in Mubi soil ($32.92 \pm 0.42\%$) and plant ($15.00 \pm 0.14\%$) respectively, while the lowest concentration was recorded in Dilchim soil ($12.00 \pm 0.20\%$) and plant leaf samples ($5.10 \pm 0.01\%$) respectively. The iron (Fe) content ranged from 12.00 ± 0.20 to $32.92 \pm 0.42\%$ in soil and 5.10 ± 0.01 to $15.00 \pm 0.14\%$ in leaf samples respectively. However, the values of iron in both soil and leaf samples falls within the recommended permissible limit of the WHO/FAO standard value. In the present investigation, the value of Fe was found much higher in Mubi, which is significant due to iron-rich soil of the area (Kumar, *et al.,* 2007).

The chromium content in soil and plants samples ranged from 0.04 ± 0.01 to $0.09 \pm 0.03\%$ and 0.01 ± 0.03 to 0.03 ± 0.13 respectively. Chromium was not detected in Dzakwa, Hildi, Kudzum, Dilchim and Watu.The highest value $0.09 \pm 0.03\%$ of Cr was detected in Mubi. The concentrations of chromium in all the sampling sites fall within the WHO/FAO standard. This was also similar to Venkateswaran, *et al.,* (2007) where no Cr was detected in the first three fractions.

According to Venkateswaran *et al.,* (2007), the leaching of Cr to the environment from these samples may not occur readily, Cr (VI) is a highly toxic metal that has been linked to cancer in humans following prolonged inhalation, and is toxic to plants at relatively low concentrations (Achi *et al.,* 2011).Thus the trend of concentration of various heavy metals in studied soil and leaf samples are as follows: Fe > Zn >Pb> Cu > Cd >Cr respectively.

Conclusion

The result of this study generally revealed the presence of all metals with exception of Cr that was not present in some study areas. The concentrations of the metals in the soils and the plant leaf are in the order of Fe > Zn >Pb> Cu > Cd > Cr respectively. The level of Pb at the moment is high compared to other studies in Nigeria. Hence, possible accumulation in the soil and transfer to plants growing along the edge of the highway could occur as a result of continual usage of the road by automobile. This can also lead to accumulation of the metal in the tissues of organisms that feed on the plant and other plants growing along the highway. This can be transferred to other consumers in the food chain (Akinola and Adedeji, 2007). The level of contamination was more pronounced in the soil than in the plant. However, economic plants should not be cultivated along roads with heavy traffic especially along the roadsides so as to avoid heavy metal toxicity in man and animals through food chain. Proper biomonitoring of the environment should be done as often as possible so as to enlighten the general public on the dangers of heavy metal pollution. Generally, the study indicated possible soil pollution in this environment by activities carried out within these areas.

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