Research Article

Assessment of Heavy Metals Accumulation in Shrubs And herbs along some Selected Roads in Mubi, Nigeria

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Abstract

This study assessed the accumulation of heavy metals in shrubs and herbs along Mubi Mararaba Road (MMRR), Mubi Maiha Road (MMR), Adamawa State University Second Gate (ADSU2G) road and Adamawa State University Ecological Garden (ADSUEG) in Mubi. The fresh leaves samples of the herbs and shrubs in these aforementioned locations were collected at a distance between 0-100 m and 100-200 m away from the road. After identification, the samples were air dried at room temperature and were pulverized into fine powder using wooden pestle and mortar. Analyses of heavy metals were carried out using standard procedures. The investigation revealed varied concentrations of the heavy metals such as Cadmium (Cd), Copper (Cu), Zinc (Zn), Iron (Fe) and Lead (Pb) in both the herbs and shrubs; with those obtained at a distance between 0-100 having higher concentration of most of the metals. The study therefore, concluded that, the concentrations of Cd, Zn, Pb, Fe and Cu at the study areas which were within the ranges of 0.16-0.42 mg/kg, 2.75-7.82 mg/kg, 0.12-0.53 mg/kg, 24.13-69.52 mg/kg and 3.21-9.16 mg/kg respectively in both the herbs and shrubs were within the allowable limit for plants; and

the concentrations of these metals were dependent upon distance of the plants from road.

Keywords: Heavy metals; Concentration; Plants; Roadsides

1. Introduction

Environmental pollutants have continued to be a matter of great concern and challenge being faced by all nations globally. These pollutants could be naturally occurring compounds or foreign matter which when in contact with the environment result to adverse changes [1]. Among all the pollutants, heavy metals have received much attention by the environmental chemists due to their toxic nature. Cadmium (Cd), Zinc (Zn), Copper (Cu), Lead (Pb), Iron (Fe) and Arsenic (As) are some of the heavy metals [2]. Some of these metals originate from tyres, engine oil consumption, brake wear and road surface material [3]; and some from anthropogenic activities such as: mining, combustions, vehicular emissions and agro-chemicals [4]. Although, some of these heavy metals are essential for some important processes in many living organisms, including humans [5, 6], however, they are generally toxic when their concentrations exceed certain thresholds.

Plants growing along vehicular roads are exposed to high level of heavy metals pollution. They absorbed these metals through their roots and vascular system. Contaminations by heavy metals could alter the chemical compositions of plants and thus, seriously affecting the quality and efficacy of the natural products produced by plants especially plants that are of medicinal importance [7]. High concentrations of these metals in the plant could also affect the ability of the plant to produce chlorophyll, increase the plant oxidative stress and weaken stomata resistance [8]. Consumption of plants containing heavy metals especially when they are present in higher quantity could posed a great health risk; as some of these metals (Pb, Cd, Zn and Cu) are responsible for certain diseases that have lethal effect on humans [9]. Plants growing in environment contaminated by heavy metals are more affected by the metals than other organisms. Several researchers reported the presence of heavy metals in plants [10, 11]. However, different plant species differ in their strategies to resist pollution, especially of heavy metals.

In the northern part of Nigeria, especially along the major roads linking Mubi to other towns and villages within and outside Mubi North and South local government areas of Adamawa State, Nigeria, farmers are fond of planting crops very close to the roads. This exposed crops to vehicular emissions and other sources of heavy metal pollutants, thus resulting in the accumulation of heavy metals in their tissues. This study, therefore, would help provide information on the level at which plants especially shrubs and herbs situated along vehicular roads could accumulate heavy metals so as to advise the farmers and those who use shrubs and herbs for food and medicinal purposes in that region and elsewhere appropriately.

2. Materials and Methods

2.1 Study area

The study was carried out in Mubi, a commercial centre of Adamawa State, Nigeria. It has so many networks of roads linking the main town to many other villages and local government areas such as Maiha, Michika and Hong. The major road networks in Mubi include: Mubi to Mararaba road, Mubi to Maiha road and Mubi to Bazza road. These roads,

especially Mubi/Mararaba road usually have very high density of traffic, and farmers during farming season plant their crops very close to the busy roads. Mubi lies within latitude 10^0 16'52"N of the equator and longitude $13^0$16'48"E of the prime median. It falls within the Sudan Savanna vegetation zone of Nigeria; and the annual rainfall is about 1088 mm and has an average annual temperature of 26^0C. The land area of Adamawa State University, Mubi campus is 1.039 km^2 and its perimeter is 4.73 km (Figure 1).

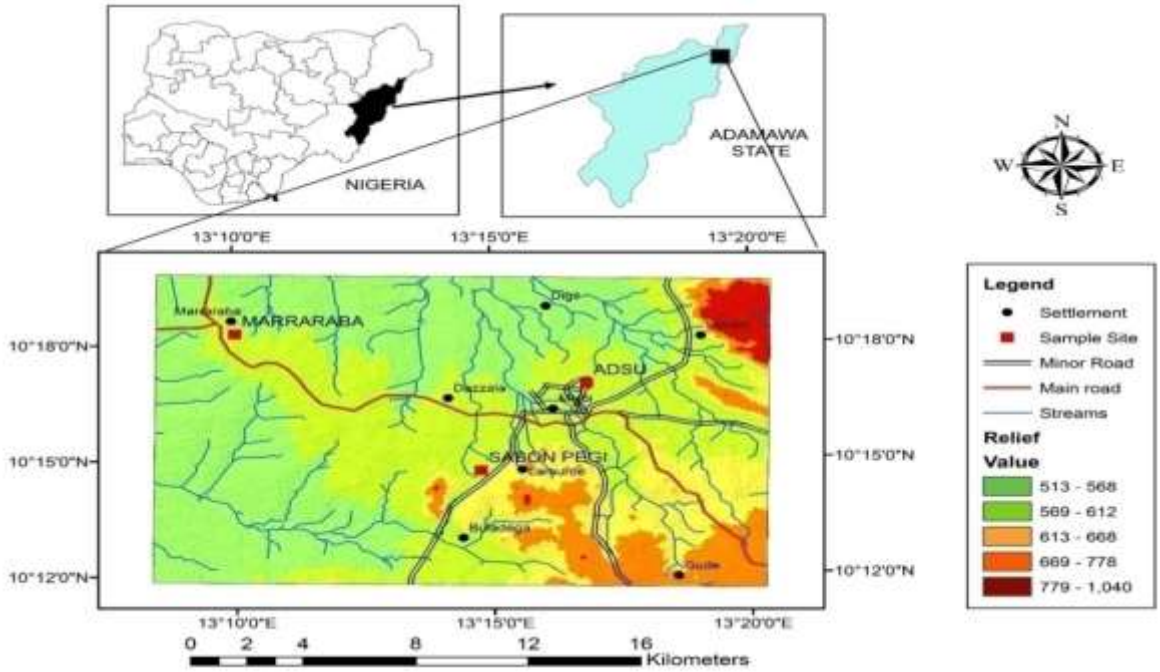

Figure 1: Map of Adamawa showing study area.

2.2 Sample collections

Samples of the roadsides herbs were collected from four different locations, these include: MMRR, MMR, ADSU2G and ADSUEG. The fourth location served as a control. In each of the sampling locations, the samplings were made between a distances of 0–100 m and 100–200 m away from the roadsides. The samples were collected and placed into a well labeled polythene bag.

2.3 Identification and preparation of plant samples for heavy metals assessment

The herbs and shrubs samples collected were taken to the herbarium unit of the department of Botany, Adamawa State University, Mubi for Identification. The leaves of herb and shrub samples collected were first washed using a running tap water so as to wash off dirt after which they were shade dried at room temperature. Thereafter, the leaves samples were then pulverized into a very fine powder and stored in a black polythene bag pending heavy metals analysis.

2.4 Analysis of heavy metals

Sieved sample (0.5 g) was accurately weighed into 100 cm^3 beaker and a mixture of 5 cm^3 concentrated

nitric acid and 2 cm^3 perchloric acid was added and digested on low heat hot plate until the content was about 2 cm^3.The digest was allowed to cool, filtered into 50 cm^3 standard flask using 0.45 um millipore filter kit. The beaker was rinsed with small portions of distilled water and then filter into the flask. Triplicate digestion of each sample was carried out together with blank digest without the plant sample. Heavy metal quantization was carried out by Atomic Absorption Spectrophotometer (AAS).

3. Results

3.1 Analysis of heavy metals accumulation in shrubs along some selected roads in Mubi

The heavy metals such as: Cd (0.42 mg/kg), Zn (7.75 mg/kg), Pb (0.37 mg/kg), Fe (63.05 mg/kg) and Cu (9.1 mg/kg) of *Cassia obtusifolia* obtained at a distance between 0-100 m, along Mubi Mararaba road (MMRR) was significantly (at $p<0.05$) the highest compared to the Cd (0.28 mg/kg), Zn (4.75 mg/kg), Pb (0.23 mg/kg), Fe (55.16 mg/kg) and Cu (6.76 mg/kg) of *C. obtusifolia* obtained between 100-200 m along the same locaton (MMRR). Similar observations were made for the Cd (0.39 mg/kg), Zn (7.82 mg/kg), Fe (69.52 mg/kg) and Cu (8.34 mg/kg) and Cd (4.85 mg/kg), Pb (0.26 mg/kg) and Fe (53.96 mg/kg) of *C. obtusifolia* and *Waltheria indica* respectively, obtained along Mubi/Maiha road (MMR) and Adamawa State University second gate road (ADSU2G) at the same distance (0-100 m). However, the Pb (0.32 and 0.20 mg/kg) content of the *C. obtusifolia* obtained from these distances (0-100 and 100-200 m) did not differ significantly. The same incidence were observed for the Cd (0.27 and 0.25 mg/kg) and Cu (6.25 and 6.00 mg/kg) of *W. Indica* obtained also at the distances of 0-100m and 100-200 m respectively. The heavy metals content: Cd (0.21 mg/kg), Zn (2.87 mg/kg), Pb (0.16 mg/kg), Fe (43.63 mg/kg) and Cu (5.13 mg/kg), of plant sample (*Guiera senegalensis*) from the control location [Adamawa State University Ecological Garden (ADSUEG)] were all lower than those of the shrubs samples obtained from the roadsides (Table 1).

3.2 Analysis of heavy metals accumulation in herbs along some selected roads in Mubi

The Cd content of *Gomphrena celosoides* (0.35 and 0.31 mg/kg), *Melochia corchorifolius* (0.23 and 0.16 mg.kg), *Bidens pilosa* (0.26 and 0.20 mg/kg) and *Mitracarpus villosus* (0.16 mg/kg) obtained at distances between 0-100 and 100-200 m at MMRR, MMR, ADSU2G and ADSUEG respectively, were not significantly different. Similar observation was made for the Pb content, 0.29 and 0.27 mg/kg (MMRR), 0.19 and 0.12 mg/kg (MMR), 0.20 and 0.15 mg/kg (ADSU2G) at distances between 0-100 and 100-200 m respectively, except for the herb sample from ADSUEG (0.53 mg/kg) which was significantly the highest. The Zn and Fe contents of herbs, *G. celosoides* (6.16 and 68.66 mg/kg), *M. corchorifolius* (4.12 and 0.19 mg/kg) and *B. pilosa* (4.59 and 45.75 mg/kg) from MMRR, MMR and ADSU2G sampling locations respectively at distances between 0-100 m were significantly the highest compared to those at distance between 100-200 m and that of the control location (2.78 and 37.13 mg/kg). The Cu content of *M. corchorifolius* (5.32 mg/kg) and *B. pilosa* (5.63 mg/kg) from MMR and ADSU2G respectively at distance between 0-100 m were significantly the highest in comparism to herbs at other distance (100-200 m) and sampling locations (MMRR and ADSUEG) (Table 2).

3.3 Comparism of heavy metals accumulation of herbs and shrubs from the same sampling location at different distances

The Cd (0.42 mg/kg), Zn (7.76 mg/kg), Pb (0.37 mg/kg) and Cu (9.16 mg/kg) of shrub (*C. obtusifolia*) from MMRR sampling location at 0-100 m were significantly the highest compared to those of herb (*G. celosoides*) at all distances and shrub (*C. obtusifolia*) at 100-200 m. However, the Fe content (68.05 mg/kg) of *G. celosoides*, at the same sampling distance (0-100 m) was significantly the highest compared to those at other distances. The significantly lowest content of these heavy metals especially Zn (4.75 mg/kg), Pb (0.23 mg/kg) and Fe (55.16 mg/kg) were observed at distance between 100-200 m in *C. obtusifolia* (Table 3). The Zn (4.85 mg/kg), Pb (0.26 mg/kg) and Cu (6.25 mg/kg) contents of *Waltheria indica* from ADSU2G at distance between 0-100 m were significantly the highest compared to Zn (3.65 mg/kg), Pb (0.15 mg/kg) and Cu (5.00 mg/kg) of *B. pilosa*, which were the lowest significantly at distance between 100-200 m. However, the Cd and Fe contents of the *B. pilosa* at 0-100 m and all shrubs from 0-100 m and 100-200 m respectively were significantly similar but different from those of *B. pilosa* at 100-200 m which were significantly the lowest (Table 3).

The Cd (0.39 mg/kg), Zn (7.82 m/kg), Pb (0.32 mg/kg), Fe 69.52 mg/kg) and Cu (8.34 mg/kg) contents of shrub (*C. obtusifolia*) from MMR sampling location at 0-100 m were significantly the highest in comparism to the Cd (0.16 mg/kg), Zn (2.75 mg/kg), Pb (0.12 mg/kg), Fe (24.13 mg/kg) and Cu (3.21 mg/kg) contents of herb (*M. corchorifolius*) at 100-200 m from the same sampling location (MMR) which were significantly the lowest (Table 3).

In ADSUEG (control) sampling location, the Cd (0.21 mg/kg), Fe (43.63 mg/kg) and Cu (5.13 mg/kg) contents of shrub (*G. senegalensis*) were significantly the highest compared to the Cd (0.16 mg/kg), Fe (37.13 mg/kg) and Cu (4.16 mg/kg) content of the herb (*M. villosus*) which were the lowest. The Zn (2.78 and 2.87 mg/kg) content of both the herb (*M. villosus*) and shrub (*G. senegalensis*) respectively, were not significantly different. However, the Pb content of *M. villossus* (0.53 mg/kg) was significantly the highest compared to that of *G. senegalensis* (0.16 mg/kg) at $p<0.05$ (Table 3).

3.4 Comparism of the heavy metals accumulation of herbs and shrubs from all sampling locations at different distances

In comparism of the heavy metals content of roadside shrubs and herbs from all sampling locations (MMRR, MMR, ADSU2G AND ADSUEG) and at different sampling distances (0-100 and 100-200 m), it was observed that, the Cd (0.42 mg/kg) content of *C. obtusifolia* at 0-100 m from MMRR was significantly the highest followed by that of *C. obtusifolia* (0.39 mg/kg) from MMR at the same sampling distance (0-100 m). The significantly lowest Cd content were the ones of *M. villosus* (0.16 mg/kg) and *M. corchorifolia* (0.16 mg/kg) all at 100-200 m from ADSUEG and MMR sampling locations respectively. The Zn (7.82 mg/kg) and Pb (0.53 mg/kg) contents of *C. obtusifolia* at 0-100 m and *M. villosus* from MMR and ADSUEG respectively were the highest significantly whereas the Zn (2.75 mg/kg), Fe (24.13 mg/kg), Cu (3.21 mg/kg) and Pb (0.12 mg/kg) contents of *M. corchorifolia* at 100-200 m all from MMR were the lowest. However, the Fe (69.52 mg/kg) content of *C. obtusifolia* at 0-100 m still from same location (MMR) was the highest significantly,

but not different from that of *G. celosoides* at 0-100 m from MMRR. The Cu (9.16 mg/kg) at 0-100 m from MMRR was the highest, but also not significantly different from that of *C. obtusifolia* (8.33 mg/kg) also at 0-100 m from MMR (Table 4).

Location	Plant Sample	Distance (m)	Heavy Metals (mg/kg)				
			Cd	Zn	Pb	Fe	Cu
MMRR	CO	0-100	0.42±0.01*	7.75±0.00*	0.37±0.00*	63.05±0.00*	9.16±0.06*
MMRR	CO	100-200	0.28±0.01	4.75±0.00	0.23±0.01	55.16±0.01	6.76±0.01
MMR	CO	0-100	0.39±0.01*	7.82±0.01*	0.32±0.00	69.52±0.01*	8.34±0.01*
MMR	CO	100-200	0.23±0.01	6.55±0.00	0.20±0.00	43.79±0.01	5.53±0.01
ADSU2G	WI	0-100	0.27±0.03	4.85±0.03*	0.26±0.01*	53.96±0.01*	6.25±0.07
ADSU2G	WI	100-200	0.25±0.01	4.55±0.06	0.22±0.01	45.62±0.01	6.00±0.07
ADSUEG	GS	CONTROL	0.21±0.01	2.87±0.01	0.16±0.01	43.63±0.01	5.13±0.02

Means along the column of plants from the same sampling location without a superscript asterisk (*) are not statistically significantly different at $p<0.05$.

Key: MMRR= Mubi Mararaba Road; MMR= Mubi Maiha Road; ADSU2G= Adamawa State University Second Gate; ADSUEG= Adamawa State University Ecological Garden; CO=*Cassia obtusifolia*; WI=*Waltheria indica*; GS=*Guiera senegalensis*; Cd= Cadmium; Zn= Zinc; Pb= Lead; Fe= Iron; Cu= Copper.

Table 1: Analysis of heavy metals accumulation in shrubs along some selected roads in Mubi.

Location	Plant Sample	Distance (m)	Heavy Metals (mg/kg)				
			Cd	Zn	Pb	Fe	Cu
MMRR	GC	0-100	0.35±0.01	6.16±0.01*	0.29±001	68.66±0.01*	8.15±0.01
MMRR	GC	100-200	0.31±0.01	5.82±0.01	0.27±0.01	62.15±0.00	6.75±0.01
MMR	MC	0-100	0.23±0.01	4.12±0.00*	0.19±0.01	42.16±0.01*	5.32±0.02*
MMR	MC	100-200	0.16±0.01	2.75±0.00	0.12±0.00	24.13±0.01	3.21±0.01
ADSU2G	BP	0-100	0.26±0.1	4.59±0.01*	0.20±0.03	45.75±0.03*	5.63±0.01*
ADSU2G	BP	100-200	0.20±0.00	3.65±0.03	0.15±0.01	33.85±7.06	5.00±0.07
ADSUEG	MV	CONTROL	0.16±0.01	2.78±0.02	0.53±0.01*	37.13±0.01	4.16±0.03

Means along the column of plants collected from the same location without a superscript asterisk (*) are not statistically significantly different at $p<0.05$.

Key: MMRR= Mubi Mararaba Road; MMR= Mubi Maiha Road; ADSU2G= Adamawa State University Second Gate; ADSUEG= Adamawa State University Ecological Garden; MV=*Mitracarpus villosus*; GC=*Gomphrena celosoides*; MC=*Melochia corchorifolius*; BP=*Biden pilosa* ; Cd= Cadmium; Zn= Zinc; Pb= Lead; Fe= Iron; Cu= Copper.

Table 2: Analysis of heavy metals accumulation in herbs along some selected roads in Mubi.

Location	Plant Sample	Distance (m)	Heavy Metals (mg/kg)				
			Cd	Zn	Pb	Fe	Cu
MMRR	**GC**	**0-100**	0.35±0.01^{b}	6.16±0.01^{b}	0.29±0.01^{b}	68.66±0.01^{a}	8.15±0.01^{b}
MMRR	**GC**	**100-200**	0.31±0.01^{b}	5.82±0.01^{c}	0.27±0.01^{b}	62.15±0.00^{c}	6.75±0.01^{c}
MMRR	**CO**	**0-100**	0.42±0.01^{a}	7.76±0.01^{a}	0.37±0.01^{a}	63.05±0.01^{b}	9.16±0.05^{a}
MMRR	**CO**	**100-200**	0.28±0.01^{c}	4.75±0.01^{d}	0.23±0.01^{c}	55.16±0.01^{d}	6.76±0.01^{c}
ADSU2G	**BP**	**0-100**	0.26±0.01^{a}	4.59±0.01^{b}	0.20±0.03^{c}	45.75±0.03^{a}	5.63±0.01^{c}
ADSU2G	**BP**	**100-200**	0.20±0.00^{b}	3.65±0.03^{c}	0.15±0.01^{d}	33.85±0.06^{b}	5.00±0.07^{d}
ADSU2G	**WI**	**0-100**	0.27±0.02^{a}	4.85±0.02^{a}	0.26±0.01^{a}	53.96±0.01^{a}	6.25±0.01^{a}
ADSU2G	**WI**	**100-200**	0.25±0.01^{a}	4.55±0.02^{b}	0.26±0.01^{b}	53.96±0.01^{a}	6.25±0.01^{b}
MMR	**CO**	**0-100**	0.39±0.01^{a}	7.82±0.01^{a}	0.32±0.00^{a}	69.52±0.01^{a}	8.34±0.01^{a}
MMR	**CO**	**100-200**	0.23±0.01^{b}	6.55±0.00^{b}	0.20±0.00^{b}	43.79±0.01^{b}	5.53±0.01^{b}
MMR	**MC**	**0-100**	0.23±0.01^{b}	4.12±0.00^{c}	0.19±0.01^{c}	42.16±0.01^{c}	5.32±0.69^{c}
MMR	**MC**	**100-200**	0.16±0.01^{c}	2.75±0.00^{d}	0.12±0.00^{d}	24.13±0.01^{d}	3.12±0.01^{d}
ADSUEG	**MV**	**CONTROL**	0.16±0.01^{b}	2.78±0.02^{a}	0.53±0.01^{a}	37.13±0.01^{b}	4.16±0.03^{b}
ADSUEG	**GS**	**CONTROL**	0.21±0.01^{a}	2.87±0.01^{a}	0.16±0.01^{b}	43.63±0.01^{a}	5.13±0.02^{a}

Means with the same superscript letter(s) along the column are not statistically significantly different at $p<0.05$.

Key: MMRR= Mubi Mararaba Road; MMR= Mubi Maiha Road; ADSU2G= Adamawa State University Second Gate; ADSUEG= Adamawa State University Ecological Garden; CO=*Cassia obtusifolia*; WI=*Waltheria indica*; MV=*Mitracarpus villosus*; GS=*Guiera senegalensis*; GC=*Gomphrena celosoides*; MC=*Melochia corchorifolius*; BP=*Bidens Pilosa*; Cd= Cadmium; Zn= Zinc; Pb= Lead; Fe= Iron; Cu= Copper.

Table 3: Comparism of heavy metals accumulation of herbs and shrubs from the same sampling location at different distances.

Location	Plant Sample	Distance(m)	Heavy Metals (mg/kg)				
			Cd	Zn	Pb	Fe	Cu
MMRR	GC	0-100	0.35^{c}	6.16^{d}	0.29^{d}	68.66^{a}	8.15^{b}
MMRR	GC	100-200	0.31^{d}	5.82^{e}	0.27^{e}	62.15^{b}	6.75^{c}
MMRR	CO	0-100	0.42^{a}	7.76^{b}	0.37^{b}	63.05^{b}	9.16^{a}
MMRR	CO	100-200	0.28^{de}	4.75^{g}	0.23^{g}	55.16^{c}	6.76^{c}
ADSUEG	MV	CONTROL	0.16^{k}	2.78^{c}	0.53^{a}	37.13^{e}	4.16^{k}
ADSUEG	GS	CONTROL	0.21^{ij}	2.87^{k}	0.16^{j}	43.63^{d}	5.13^{i}
MMR	CO	0-100	0.39^{b}	7.82^{a}	0.32^{c}	69.52^{a}	8.33^{a}
MMR	CO	100-200	0.23^{ghi}	6.55^{c}	0.20^{h}	43.79^{d}	5.52^{g}
MMR	MC	0-100	0.23^{hij}	4.12^{i}	0.19^{i}	42.16^{d}	5.32^{h}
MMR	MC	100-200	0.16^{k}	2.75^{l}	0.12^{k}	24.13^{f}	3.21^{l}
ADSU2G	WI	0-100	0.27^{ef}	4.85^{f}	0.26^{f}	53.96^{c}	6.25^{d}
ADSU2G	WI	100-200	0.25^{fgh}	4.55^{h}	0.22^{g}	45.62^{d}	6.00^{e}
ADSU2G	BP	0-100	0.26^{efg}	4.59^{h}	0.20^{h}	45.75^{d}	5.63^{f}
ADSU2G	BP	100-200	0.20^{j}	3.65^{j}	0.15^{j}	33.85^{e}	5.00^{j}
SE±			0.01	0.01	0.01	0.01	0.01

Means with the same superscript letter(s) along the column are not statistically significantly different at $p<0.05$.

Key: MMRR= Mubi Mararaba Road; MMR= Mubi Maiha Road; ADSU2G= Adamawa State University Second Gate; ADSUEG= Adamawa State University Ecological Garden; CO=*Cassia obtusifolia*; WI=*Waltheria indica*; MV=*Mitracarpus villosus*; GS=*Guiera senegalensis*; GC=*Gomphrena celosoides*; MC=*Melochia corchorifolius*; BL=*Bidens Pilosa*; Cd= Cadmium; Zn= Zinc; Pb= Lead; Fe= Iron; Cu= Copper.

Table 4: Comparism of the heavy metals accumulation of herbs and shrubs from all sampling locations at different distances.

4. Discussion

Analysis of heavy metals content of shrub samples collected along roadsides of MMRR, MMR, ADSU2G and ADSUEG based on their distances from road showed variation in their contents of heavy metals such as Cd, Zn, Pb, Fe and Cu. Shrubs (*C. occidentalis* and *W. indica*) obtained along the roadsides from all sampling locations between 0-100 m from the roadsides had significantly higher content of all the heavy metals than those of shrubs collected between 100-200 m. The higher content of these heavy metals in shrubs obtained between 0-100 m might be attributed to their nearness to roadsides as soil and plants close to roads are the major recipient of large amount of heavy metals from vehicular emissions [12, 13]. Emission from vehicles contain heavy metals that could accumulate in roadside plants [14]. The heavy metals content of shrub (*G. senegalensis*) from the control location (ADSU ecological garden) were significantly the lowest compared to those of shrubs from roadsides. This justify the reports that concentrations of heavy metals

in plants are closer to roads than sites away from roads [15]. The concentrations of these heavy metals in shrubs obtained from roadsides, which varied between 0.23 to 0.42 mg/kg (Cd), 4.55 to 7.82 mg/kg (Zn), 0.20 to 0.37 mg/kg (Pb), 43.79 to 69.52 mg/kg (Fe) and 5.53 to 9.16 mg/kg (Cu) from all sampling distances (0-100 m and 100-200 m) and locations were all within the allowable limit of 20, 2, 100 and 10 mg/kg for Zn, Pb, Fe and Cu respectively in plants. Concentration of heavy metals that are within the allowable limit for plants was similarly reported by Alexander (2015) in the leaves sample of Sida acuta obtained along Mubi/Mararaba and Mararaba/Michika roads. Contrary findings were, however, reported by [9, 11]. When they observed higher concentrations of Cu, Fe, Zn and Pb that ranges between 11.8 to 15.5 µg/g, 167.4-181.4 µg/g, 42.9-88.5 µg/g and 4.86 – 8.94 µg/g respectively, which were far above the thresholds for plants. Contradiction in the concentrations of heavy metals in plants reported in this study and those of [9, 11], could be due to differences in distances from roads from which these plants samples were collected, availability of these metals in soils of sampling locations [16] , type of plant species analyzed for presence of heavy metals [17] and density of traffic along the sampling locations [18].

Similar observations were made for the heavy metals content of herbs (*G.celosoides*, *M. corchorifoliu*s, *B. pilosa* and *M. villosus*) from the same sampling locations where those shrubs were collected. Virtually all the heavy metals where significantly higher in herbs (*G.celosoides*, *M. corchorifolius* and *B. linn*) obtained between 0-100 m from the roads. Unlike in shrubs (*C. occidentalis* and *W. indica*) obtained between 0-100 m, the Cd content of herbs (*G.celosoides*, *M. corchorifolius* and *B. pilosa*) in that same locations and distance were higher, but not significantly different from those of herbs (*G.celosoides*, *M. corchorifolius* and *B. pilosa*) collected between 100-200 m. The Pb content of herb from control location was significantly higher than those of herbs from all sampling locations and distances. This might be due to differences in species.

Comparism of the effect of distance from roadsides on heavy metals content of roadside herbs and shrubs obtained from the same location showed that, shrub (*C. occidentalis*) collected from MMRR, the most busiest road in the study area, significantly had the highest concentrations of all the heavy metals analysed (Cd, Zn, Pb and Cu) except Fe at distance between 0-100 m compared to those of the herb (*G. celosoides*) at the same distance. The same was observed for *C. occidentalis* and *M. corchorifolius* both at the same distance (0-100 m) and location (MMR). The heavy metals content of *G. senegalensis* from the control location (ADSUEG) were also mostly observed to be significantly higher than those of *M. villosus*. This could be a justification of the reports that concentration of heavy metals differ for different plant species collected from the same location [19].

Comparism of the heavy metals content of herbs and shrubs from all sampling locations showed that, MMRR sampling location had higher contents of most of the heavy metals which include: Cd (0.42 mg/kg), Fe (68.66 mg/kg) and Cu (9.16 mg/kg) than other sampling locations (MMR, ADSUEG and ADSU2G). MMR had significantly higher content of Zn (7.82 mg/kg) and Cu (8.33 mg/kg), which was significantly similar to that of MMRR. The higher

content of most of these heavy metals in herb and shrub from MMRR might be attributed to the fact that they were exposed to higher concentration of vehicular emissions than those in other locations; as MMRR is the most busiest vehicular road in the study area with heavy traffic.

5. Conclusion

From the findings of this study, the researchers concluded the following:

Herbs and Shrubs along Mubi/Mararaba road had higher concentration of Cd, Fe and Cu. The concentrations of heavy metals such as: Cd, Zn, Cu, Fe and Pb in herbs and shrubs along Mubi/Mararaba, Mubi/Maiha, ADSU second gate roads and ADSU ecological garden are within the allowable limit for plants. Concentrations of heavy metals in herbs and shrubs along vehicular roads are dependent upon the distance from roadsides. Accumulation of heavy metals in plants from the same sampling location and distance are determined by the type and kind of plant species.

Conflicts of Interest

The authors declared no conflicts of interest.

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