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Evaluation of Chemical Properties and Heavy Metals Status of Fluted Pumpkin (*Telfairia occidentalis*) in a Soil along Build up Traffic Road, Port Harcourt, Nigeria

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The study was conducted along University of Port Harcourt - Choba, heavily built traffic road, to evaluate the impact of vehicular activities on heavy metals lead (Pb), Cadmium (Cd) and Zinc (Zn) on soil and Fluted Pumpkin. Three traverses of 50 meters apart were cut along University of Port Harcourt - Choba major road, composite soil samples collected from each of the traverse cuts at distances of (0-5) and 15 meters while the control samples were collected from 100 meters away at a depth of 0-15 and 15-30 cm respectively. Plant tissue samples (roots, stems and shoots) of *Telfaria occidentalis* were collected from each of the traverses, while control plant sample was taken at 100 meters away from the road. A total of 18 composite soil samples and four plant samples were collected. All the samples were analyzed for Pb, Cd and Zn using Atomic Absorption Spectrophotometer (AAS). Result of the study showed that the content of Pb in plant tissue was significantly (P<0.05) higher in traverse 1 over control and exceeded the maximum permissible limit of 0.3mg/kg Pb in vegetable while in traverses 2 and 3, the concentration of Pb falls within the maximum permissible limit. Uptake of Zn in the plant tissue were significantly (P<0.05) higher than control in all the traverse and was within the maximum permissible limit of 99.4mg/kg Zn. Cadmium was not detected in traverse 2 and control but the value recorded in traverse 1 falls within the maximum permissible level of 0.2mg/kg Cd. The study revealed that the three heavy metals in soil samples significantly (P<0.05) increased over the control samples in all the traverses sampled. The concentrations of all the metals decrease with increase in distance from the road. Soil samples collected at 0-5 meters distance away from the traffic area had higher concentrations than the samples collected at 15- and 100-meters distances from the road side. The study also revealed that the concentrations of the three heavy metals decreased with increase in soil depth. Soil chemical properties investigated were significantly higher in samples in direct proximity to roadside than the control.

INTRODUCTION

Heavy metals are naturally present in soils; though geological and anthropogenic activities increase their concentration to amounts that are harmful to plants, animals and micro-organisms. Those commonly found in contaminated sites are lead (Pb), chromium (Cr), Arsenic (As), Zinc (Zn), cadmium (Cd), Copper (Cu), nickel (Ni) and Mercury (Hg) (GWRTAC, 1997). Most of these metals do not undergo microbial or chemical degradation (Kirpichtchikova et al., 2006). Once introduced into the soil, they persist for a long time (Andiano, 2003) though changes may occur in their form (speciation) and bioavailability.

Heavy metal contamination in soil pose major risks and hazard to humans and the entire ecosystem through direct ingestion or contact with contaminated soil, food chain (soil-plant-human or soil-plant-animal-human), and drinking or taking up contaminated ground water. They exhibit toxic effects on soil biota by affecting some microbial processes and at same time accumulate along food chain posing great threat to animal and human health (Anjali mandal and Jaya Lakkakula, 2022).

A major source of heavy metal contamination of soil is air-bone as it emits metals into the atmosphere depositing it on nearby road side soils due to automobile traffic (Panichaypichet et al., 2007). Lead, Zinc, Cadmium and Copper are the major metal pollutants at the road side environment as the metals are released from fuel burning, wear out of tires, leakage of oils, corrosion of batteries and metallic parts such as radiators (Dolan et al., 2006).

The most common heavy metals found at contaminated sites in order of abundance are Pb, Cr. As, Zn, Cd, Cu and Hg (USEPA, 1996). The major sources of heavy metals in soils as reported by Azeez et al., (2011) are abandoned industrial activities, improper waste dumping, industrial discharge, intensive use of agrochemicals and automobile emission. Highway traffic also generates heavy metal and particulate matter through vehicular and tire-pavement abrasion mechanisms.

Studies have also revealed that heavy metal pollution is generally concentrated in the first few meters to tens of meters on either side of the road pavement and sharply decreases with distance from the road (Olajiri and Ayodele, 1997, Blok, 2005). Heavy metals tend to accumulate within the top 30cm of soil despite decade of exposure from automobile traffic (Teutsch et al.,2001, Turer et al.,2001). Tillage operations or soil disturbance may affect its penetration into the soil (Panichayachet et al., 2007).

Heavy metal emission from vehicles consists of fuel consumption, engine oil consumption, tire wear and road abrasion (Winther, 2010, Wilckle et al., 1998, Marcus and Mcbratney, 1996). Engine oil consumption is responsible for the largest emission for Cd, Tire wear contributes to Zn, while brake wear is the major source of Cu and Pb (Winther, 2010).

Plant uptake of heavy metals and subsequent accumulation along food chain is one of the major threats to human and animal health (Sprynskyy et al., 2007); absorption through plant roots is their main route. These metals become toxic when they are not metabolized by the body and accumulate in the tissues (Sobha et al., 2007).

Study revealed that heavy metal contents found in vegetables were higher in areas of high traffic routes within Calabar metropolis of Cross Rivers State of Nigeria (Akpan et al., 2015). Port Harcourt in the South–South of Nigeria has very high human population growth and inadequate arable land for farming, hence most farmers, cultivate their crops (including vegetables) on farms along the traffic road exposing the crops to heavy metal contaminants.
The study therefore, evaluated the status of heavy metals in soil planted to *Telfaria occidentalis* and some soil chemical properties along Uniport-Choba road of South - South region of Nigeria.

MATERIALS AND METHODS

Study Area

The study area is situated at Uniport-Choba University of Port Harcourt road in Obio/Akpor Local Government Area of Rivers State, Nigeria. The site is located at Latitude 4˚53' N and Longitude 6˚54'E with an elevation of 18m above sea level (FAO, 1984).

Climate

The annual temperature varies from minimum of 22^{0}C to an average maximum of 31^{0}C (FDRD, 1981), the relative humidity (RH), between 35 to 90% depending on the particular period of the year. The mean annual rainfall ranges from 3000-4500mm (FAO, 1984), bimodal in nature with peaks in June and September with a period of low precipitation in August (known as August break). The rainy season is from April to October while November to March is dry season. The study area falls within the humid tropics where the climate is seasonally damp, typical of South- South Nigeria.

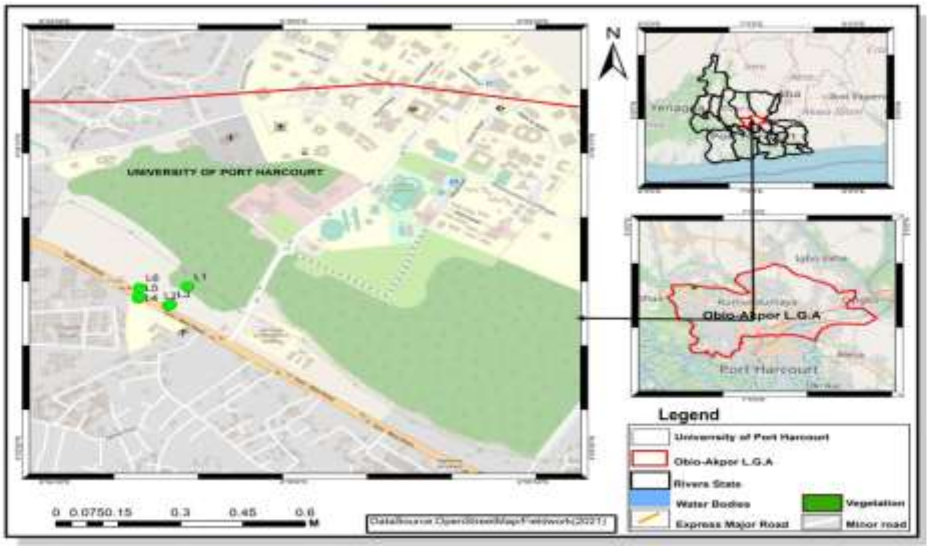

Fig 1: Map of the study area
Source: Open Street Map/Fieldwork (2021)

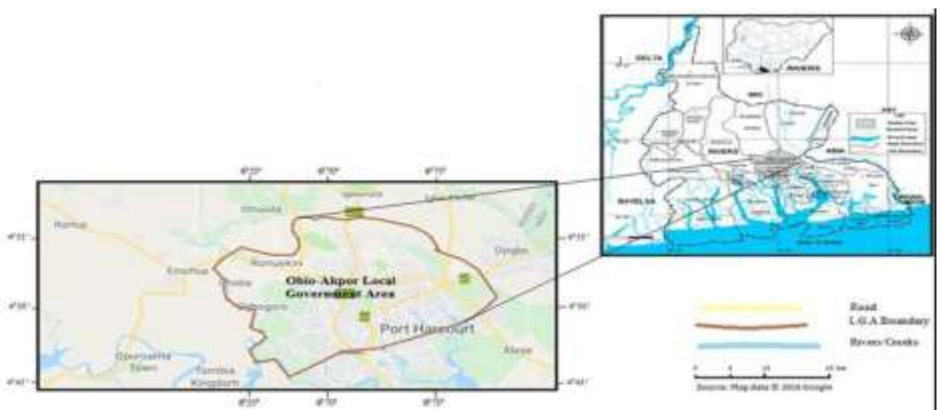

Fig 2: Map of the Local Government of Study Area; Source: Google

Collection of Soil and Plant Samples

Soil samples were collected along heavily built traffic of University of Port Harcourt Choba, East-West road with traverse cuts of 50 meters apart. Composite soil samples were collected in each of the cut transverses with auger tool at a distance of 0-5m and 15m at 0-15 and 15-30cm depths. Control soil sample (0) was taken 100m away at same depths. A total of 18 composite samples were collected. The samples were placed in polythene bags, labeled and transported to the laboratory for air drying, sieving and analyses. Also, plant samples (root, stem and shoot) of Fluted Pumpkin (*Telfairia occidentalis*) were taken at the same distances as with the soil samples along the transverses and the 100 meters distance as (control). Heavy metals analyzed were Lead, Zinc and Cadmium.

Preparation of soil and plant samples for Laboratory Analysis

The soil samples were crushed with hands and spread on flat surface to air dry at room temperature in the laboratory. They were later pulverized with mortar and pestle, sieved through 2mm mesh screen and stored in labeled polythene bags for laboratory analysis. The plant tissue samples (root, stem and shoot) were washed cleaned in running water and air-dried at room temperature in the laboratory. The samples were ashed and taken to the laboratory for heavy metal analysis.

Soil and Plant Laboratory Analysis

The following heavy metals: Lead, Zinc and Cadmium were extracted by wet digestion method of Benton, (2001), while the Atomic Absorption Spectrophotometer (AAS) was used for elemental reading. The soil chemical parameters investigated were Total organic carbon by wet oxidation method according to Nelson and Sommers, (1986), Available phosphorus determined using Bray-2 method by Jones, (1998). Total Nitrogen by micro Kjeldahl digestion method (Simmone et al., 1994), soil pH by Mclean, 1982) while exchangeable cations (Ca, Mg and K) by ammonium acetate leaching method.

Data collected were subjected to a comparison of means using Analysis of variance (ANOVA) at 5% level of significance and treatment means were separated using LSD at P<0.05.

RESULT AND DISCUSSION

Effect of distance on heavy metals concentration in plant futed pumpkin *(Telfaria occidentalis)*.

The result of heavy metals concentration (Lead, Cadmium and Zinc) on plants (*Telfairia occidentalis*) is as presented in Figure 1. The result revealed that the three heavy metals (Pb, Zn and Cd) investigated were significantly higher (Probability level) in the three traverse cuts than control in the plant tissues along Uniport-Choba road. The result showed that the content of Pb was 0.204mg/kg in control sample as against 1.215mg/kg in (Transverse 1), 0.003mg/kg in (traverse 2) and 0.100mg/kg in (traverse 3).

The significant increase in Pb content observed in traverse cuts one (1.215mg/kg) over the control could be attributed to atmospheric deposits by automobile traffic. This observation tallies with the findings of (Panichaypichet et al., 2007).

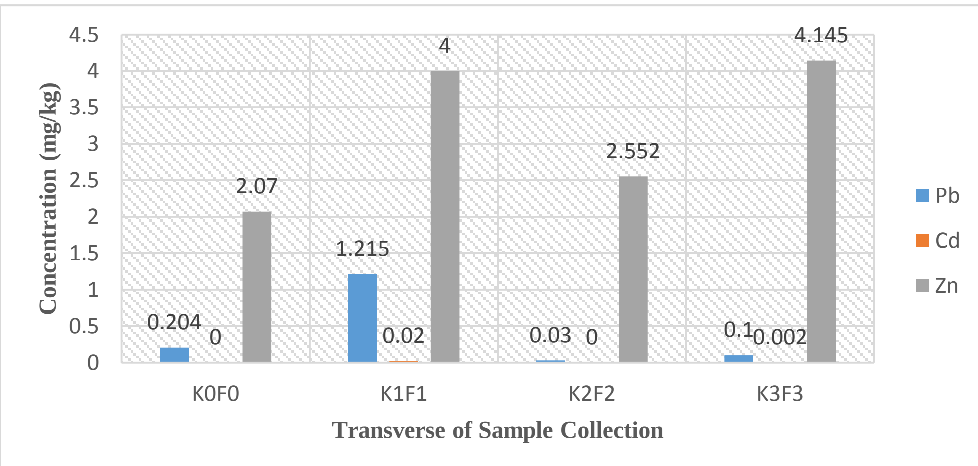

Figure 3: Heavy metal concentration in Fluted pumpkin (Telfairia occidentalis) along Uniport-Choba road.
Pb- Lead, Cd- Cadmium, Zn- Zinc; K0FO-control, K1FI- Transverse 1, K2F2-Transverse 2, K3F3-Transverse 3.

The low values of Pb in plants tissues in all the traverse cuts may also be as a result of the low content of Pb recorded from the soil; which agrees with the findings of Echem, (2014) who reported that low content of Pb in plants may be due to absorption of soil Pb by plants. This also corroborated with the work of Nwoko et al., (2014) who inferred that *telfaria occidentalis* has the ability to absorb Pb from the soil.

The low Pb content found in the plant tissues may have inhibited the plant metabolisms, which is in line with the findings of Bhahacharpya et al., (2008) who inferred that even a very low Pb content may affects some vital plant process such as photosynthesis, mitosis and water absorption with toxic symptoms of green leaves, wilting of older leaves, stunted foliage and brown short leaves. The Pb concentration was below the permissible limit of 2mg/kg in plant according to (WHO/FAO, 1989).

The study also showed that Cadmium increased from 0.00mg/kg in the control sample and traverse 2 to 0.020mg/kg in traverse 1 at the 0-5 meters distance away from the road side. Since no Cd was detectable in control sample, the cadmium observed in traverse 1 along the traffic road could be attributed to deposition through any of these sources; including fuel burning, wear of tires, oil leakage and corrosion of batteries. This agreed with the findings of Dolan et al., (2006) who reported that Cu and Zn are the major metal pollutants in road side environment, released due to fuel burning, wear of tires, leakage of oils, corrosion of batteries and metallic parts such as radiators. USEPA, (1996) reported that Pb, Cr, As, Zn, Cd, Cu, Hg are the most common heavy metals found at contaminated sites in order of abundance.

Uptake of zinc in the plant tissues ranged from 2.07mg/kg in the control to 4.145mg/kg in traverse three. The results showed that the content of zinc in the traverses was significantly (P<0.05) higher than that of the control sample with traverse three having the highest content of zinc. The significant increase in zinc in the plant tissue harvested from the traverses over the control sample could possibly be due to emission from vehicular activities such as engine oil consumption, brake wear and road abrasion as reported previously by Winther, (2010) and Wickle et al., (1998).

Winther, (2010) implicated engine oil consumption as the highest contributor of Cd emission and Tire wear emits more of Zinc while brake wear contributes most of the Cu and Zn.

Table 1: Effects of heavy traffic build up on heavy metals status in soils along the roadside

Transverse	Distance (m)	Lead (Pb) mg/kg	Cadmium (Cd) mg/kg	Zinc (Zn) mg/kg
1	0	3.04±1.35^{d}	0.00±0.00^{c}	5.36±3.81^{d}
	5	9.80±0.183^{b}	0.30±0.10^{a}	52.8±23.51^{b}
	15	7.17±0.35^{bc}	0.09±0.01^{b}	30.01±14.54^{c}
2	0	5.57±1.80^{c}	0.00±0.00^{c}	8.98±3.81^{cd}
	5	9.20±61.83^{b}	0.07±0.09^{b}	42.21±0.67^{bc}
	15	6.89±6.81^{c}	0.01±0.00^{c}	21.26±0.33^{c}
3	0	6.65±1.83^{c}	0.015±0.00^{c}	10.22±3.81^{cd}
	5	13.56±6.59^{a}	0.06±0.084^{b}	64.15±4.86^{a}
	15	8.85±1.85^{b}	0.04±0.080^{b}	30.43±0.84^{bc}

Values with a,b,c means with the same letter are not significantly (p<0.05) different while those with a,b,c means with different letters are significantly different (p>0.05).The 0 represent control sample taken 100m away from the roadside.

Results of the study on heavy metals (Pb, Cd and Zn) in soil are as presented in table 1 above. The result revealed that the three heavy metals investigated from the three traverse cuts soil samples were significantly (P<0.05) higher than the control implying that the effect of vehicular activities may have being responsible for the increase in heavy metal contents in the soil around heavily built up road traffic area.
Panichayapichet et al., (2007) reported that heavy metals can be emitted into the atmosphere and then deposited on nearby road side due to automobile traffic through air borne pollution and that these heavy metal increases with increase in volume of traffic (Fergusson and Simmonds, 1983).

The concentration of the three heavy metals studied decrease with increase in distance from the road in all the traverse cuts. This is in line with the field investigation studies of (Blok, 2005; Olajiri and Ayodele, 1997) that heavy metal pollution is generally concentrated in the first few to tens of meters on either side of the road pavement and sharply decreases with distance from the road.

Soil samples collected from high impacted zone (0-5 meters) away from the traffic area have higher concentration (9.80±1.83^{b}) for Pb, 0.30±0.10^{a}) for Cd and 52.84±2.51^{ab}) for Zn than the samples collected at 15 meters and 100 meters distance from the road side traffic in traverse one; similar trend were also observed in traverses two and three. This corroborates with the findings of Warren and Birch, (1987) who reported that the distribution of metals on road side soils is strongly but inversely correlated with increase in the distance from the road.

The concentration of lead (Pb) and Zinc (Zn) were found to be relatively higher in traverse cuts three than those of traverse one and two. This perhaps could possibly be attributed to the fact that traverse cut three was closer to an area previously used for motor mechanic workshop, which may have led to more emission of Pb from petrol combustion while Zn could be from worn out tires and lubrication oils.

USEPA, (1996), infers that Pb is a major source of soil pollution evolving from aerial emission from combustion of petrol containing tetraethyl lead in urban areas and those adjacent to major roads while zinc may be added to soils adjacent to roads from tires and lubricant oils in the soil samples investigated.
Cadmium had the lowest concentration in all the traverse cuts and was not detected from most of the soil investigated.

Depth of Soil and Heavy Metal Built up along Uniport-Choba Road

The study showed that the concentration of the three heavy metals investigated decreased with increase in the depth of the soil (0-15 and 15-30cm) as presented in table 2. Studies have shown that heavy metals tend to accumulate within the top 30cm of soil (Teutsch et al, 2001; Turer et al., 2001). However; this study was limited to 0-15 and 15-30cm depths only.

The three heavy metals studied from the soil were within the permissible levels with the exception of Pb which was below the permissible limit of (85mg/kg) in soils according to (WHO, 1996).

Table 2: Effect of Depth on heavy metals concentration along Uniport-Choba road

Traverse cuts	Distance (meters)	Depth (cm)	Pb (mg/kg)	Mean (mg/kg)	Cd	Mean	Zn	Mean
1	0(control)	0-15	3.18		0.00		2.52	
		15-30	2.95	3.04	0.00	0.00	2.20	2.36mg/kg
	5 meters	0-15	10.20		0.35		57.20	
		15-30	9.40	9.80	0.25	0.30	49.48	52.84
	15	0-15	7.38		0.096		31.98	
		15-30	6.96	7.17	0.084	0.09	28.94	30.46
2	0(control)	0-15	6.05		0.00		9.39	
		15-30	5.09	5.57	0.00	0.00	8.57	8.98
	5	0-15	9.61		0.08		46.37	
		15-30	8.79	9.20	0.06	0.07	38.05	42.21
	15	0-15	7.41		0.01		23.36	
		15-30	6.37	6.89	0-00	0.01	19.15	21.26
3	0(control)	0-15	7.09		0.02		10.8	
		15-30	6.21	6.65	0.01	0.015	9.64	10.22
	5	0-15	14.32		0.07		68.35	
		15-30	12.8	13.56	0.05	0.06	59.95	64.15
	15	0-15	9.38		0.04		34.54	
		15-30	8.32	8.85	0.03	0.035	26.32	30.43

Effect of Traffic build-up on Some Chemical Properties of Soil along Choba Uniport Road

The results of traffic build up on the soil chemical properties of soil are as presented in table 3 The values of percent total organic carbon, available phosphorus was significantly (probability level) higher in soil samples collected close to the road sides (0-5m) than those distant (15m) and 100m (control) samples in the three locations investigated. The result however, agreed with the report of Sun-Jeong et al., (2010) and Lee et al., (2015) who reported higher values of these nutrients in samples collected with greater proximity to the road side than those very distant from the road.

The generally low phosphorus content observed in the study area especially at distance away from the road could be due to the strongly acidic nature of the soil which may have played active role in phosphorus fixation. Available phosphorus in the samples studied decreases with increase in distance from the traffic built up. Generally, the concentration of P was low, but within the critical limit as reported by Bobbink et al., (2002).

The soil pH ranges from strongly acidic to neutral (pH 4.10 – 7.0).The higher values - slightly acidic to neutral were recorded in samples collected with proximity to the traffic road as against the lower values (strongly) acidic observed at distance away from the road 100m (control). This observation corroborated the findings of Chris Munyati and Oratile Menwe, (2017) and Maja Radziemska and Joans Fronczyk, (2015). Similar trend was observed in the three traverse cuts investigated.

Results of soil samples also showed a significantly increase in soil Exchangeable cations (Ca, Mg and K) on samples collected *close* to the road side (0-5m) than those of control samples. There was consistent decrease in the contents of these elements as the distance increases away from the road. There is variation in the contents of percent total nitrogen, however percent total nitrogen is slightly higher in the high impacted areas (0-5m) than the interior distance in all the traverse cuts though not significant.

Table 4: Effect of distance on Chemical properties in the soil collected from heavy traffic built up road

Transverse	Distance (m)	PO_4 mg/kg	pH in KCl	TOC (%)	N_2 (%)	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)
1	0	7.20 ± 1.56^{c}	4.15 ± 0.21^{c}	4.14 ± 1.48^{c}	0.12 ± 0.07^{c}	3.75 ± 2.46^{c}	1.53 ± 0.09^{c}	0.51 ± 0.30^{c}
	5	10.68 ± 1.04^{bc}	6.38 ± 0.07^{ab}	6.24 ± 0.08^{a}	0.25±0.02a	12.24 ± 1.8^{ab}	2.55 ± 0.71^{ab}	0.85 ± 0.04^{a}
	15	8.15 ± 0.72^{c}	5.70 ± 0.07^{b}	5.05 ± 1.27^{b}	0.22 ± 0.04^{a}	8.05 ± 4.02^{b}	1.87 ± 0.47^{b}	0.78 ± 0.33^{b}
2	0	9.66 ± 1.56^{bc}	4.10 ± 0.21^{c}	4.45 ± 1.48^{c}	0.13 ± 0.07^{c}	3.21 ± 2.46^{c}	1.40 ± 0.09^{c}	0.61 ± 0.30^{c}
	5	12.48 ± 2.56^{b}	6.50 ± 0.01^{ab}	6.15 ± 0.42^{a}	0.20 ± 0.03^{a}	14.0 ± 0.50^{a}	3.06 ± 0.06^{a}	0.83 ± 0.71^{a}
	15	10.50 ± 6.19^{bc}	5.50 ± 0.14^{b}	5.38 ± 0.30^{b}	0.165 ± 0.02^{b}	7.85 ± 2.70^{b}	2.01 ± 1.7^{b}	0.65 ± 0.37^{b}
3	0	8.55 ± 1.56^{c}	4.15 ± 0.21^{c}	4.55 ± 1.10^{c}	0.12 ± 0.07^{c}	$3.50.0 \pm 2.2^{c}$	1.48 ± 0.09^{c}	0.51 ± 0.30^{c}
	5	18.25 ± 1.51^{a}	7.00 ± 0.28^{a}	6.43 ± 0.20^{a}	0.22 ± 0.01^{a}	13.60 ± 5.30^{a}	3.2 ± 1.15^{a}	0.82 ± 0.44^{a}
	15	14.10 ± 0.025^{ab}	5.60 ± 0.57^{b}	5.60 ± 0.04^{b}	0.20 ± 0.03^{a}	8.05 ± 7.21^{b}	1.38 ± 0.11^{c}	0.45 ± 0.39^{c}

Values with a,b,c means with the same letter are not significantly ($p<0.05$) different while those with a,b,c means with different letters are significantly ($p>0.05$) different

CONCLUSION AND RECOMMENDATION

The study revealed that the three heavy metals studied were present at a higher concentration in soil and plants at direct proximity of roadside at high traffic build up than samples at distance away, though within the permissible limit.

Due to the persistent of these heavy metals in an environment, cultivation of edible crops should be avoided at roadside close proximity to heavy traffic build up areas to prevent contamination of both the food chain and underground water table.

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