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IMPACT OF VEHICULAR TRAFFIC ON CONCENTRATIONS OF SELECTED HEAVY METALS IN *CASSAVA TUBERS* HARVESTED FROM ROADSIDE IN OWERRI, NIGERIA

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Abstract: *Cassava tubers and soil samples on which they were cultivated were collected at 10m, 15m and 20m from two sections of roadsides of Owerri-Aba expressway. Samples from section 1 were analyzed for the presence of lead (Pb), cadmium (Cd), copper (Cu) and manganese (Mn) while those from section 2 were analyzed for lead, zinc (Zn), chromium (Cr), cadmium and nickel (Ni) using atomic absorption spectrophotometer (AAS). Results obtained showed that at section 1, the concentrations of heavy metals in cassava samples were in the range (0.0-13.5mg/kg) Pb, (0.0-0.5mg/kg) Mn, (1.5-16mg/kg) Cu and (0.05-0.4mg/kg) Cd. At section 2, they ranged from 3.22-5.48mg/kg (Pb), 8.70-14.18mg/kg (Zn), 0.0-0.16mg/kg (Cr), 1.70-2.12mg/kg (Ni) and 0.03-0.22mg/kg (Cd). Similarly, in soil samples from section 1, the concentrations were (0.0-25mg/kg) Pb, (0.5-4.5mg/kg) Mn, (0.0-10mg/kg) Cu and (0.1-0.55mg/kg) Cd, while those from section 2 were (7.4-9.6mg/kg) Pb, (9.5-15.5mg/kg) Zn, (0.2-0.7mg/kg) Cr, (3.1-4.8mg/kg) Ni and (0.3-0.5mg/kg) Cd. In both samples from section 1, as well as only soil samples from section 2, the average concentrations of heavy metals studied decreased from 10 to 20m from the roadsides, except for Pb. Moreover, at section 1, the order of concentration of heavy metals is Pd>Cu>Mn>Cd for both soil and cassava tuber samples but Zn>Pb>Ni>Cr>Cd in samples from section 2. Only Pb in cassava tubers harvested at most of the locations in the two sections far exceeded the 2.0 mg/kg maximum permissible limit (MPL) set by WHO/FAO. Furthermore, result of bioaccumulation factor showed that the cassava samples moderately bioaccumulated the heavy metals.*

Keywords: *Vehicular traffic, heavy metals, cassava tubers, food safety, roadsides*

1. Introduction

Vehicular traffic constitutes a major nonpoint source of environmental pollution with its emissions polluting nearby air, land and water bodies [1]. Studies have shown that fumes from exhausts of automobile account for about 80% of air pollution due to heavy metals in Nigeria [2], [3]. In addition, mechanical abrasions of vehicular components including alloys, wires, tyres, oil and brake pads release some metals like cadmium, zinc, lead, iron and copper into roadside soil and plants [4]. Thus, there is an increasing concentration of heavy metals in urban roadside soils and plant samples due mostly to higher traffic [5]. Soil is considered major reservoir or sink for metal contaminants in automobile emissions [1].

Some heavy metals like Cu, Co, Mn, Ni, V, Mo, Fe and Zn are essentially required in minute quantities by organisms for normal metabolic activities. For instance, Cu and Zn are known cofactors or activators of some enzymes [6]. However, when in excess, these elements may become harmful to organisms with associated neurological and cardiovascular impairments. Other heavy metals like Cd, Pb, Hg are toxic with no beneficial effects to organisms.

Heavy metal pollution is of very serious public health concern due to their persistence, toxicity and non-biodegradability in the environment [7], [8]. These heavy metals may be found in the atmosphere in particulate form and can be transferred to land or water surfaces by wind, precipitation and occult deposition [9]. Plants exposed to these heavy metals may absorb them through the leaves and roots [10].

Cassava (*Manihot esculenta* Crantz) is a major staple food and feedstock in the world [11]. Over 2 billion people worldwide, with about 700 million in tropical and sub-tropical regions depend on cassava tubers for the provision of carbohydrates and energy [12]. In fact, cassava is the fourth staple crops, following rice, sugar, and corn. The global output of cassava is about 183 million tons a year [13].

Studies have indicated increasing presence of harmful levels of heavy metals such as cadmium, nickel, manganese, chromium, zinc, mercury, lead and iron in cassava and its associated products [14], [15]. This calls for an increasing public health concern and monitoring to avert the harmful effects on plants, animals and humans which share the same food chain [8].

2. Materials and methods

Study area

The samples used in this study were collected from randomly selected farms on Aba-Owerri expressway, Imo State, Nigeria. The GPS locations are 159428N, 512590E; 159333N, 513089E; 158814N, 514161E.

Collection of samples

The cassava **(***Manihot esculenta*) tubers were harvested and samples of soil on which they were growing collected from three cassava farms cultivated over a year ago along Aba -Owerri expressway in Imo state, Nigeria. At each of the six locations studied, both cassava tubers and soil samples were collected at three distances of 10m, 15m and 20m from the roadside respectively. Soil samples were collected using well cleaned soil auger at depths of 0.30m. The samples were properly labeled and sent to the laboratory for further processing. Both soil and cassava samples from section 1 were analyzed for Cadmium (Cd), Copper (Cu), Manganese (Mn) and Lead (Pb) while those from section 2 were analyzed for Cadmium (Cd), Nickel (Ni), Chromium (Cr) Zinc (Zn) and Lead (Pb).

Sample preparation and analysis for heavy metals

The collected cassava tubers were carefully peeled, pelletized, sun dried, pounded and then packaged in clean containers fitted with lids. As described by Akinyele and Shokunbi [16] with modifications, "wet digestion of samples was performed using mixtures of acids; HNO_3:HCl (3:1). Twenty millilitres of the acid mixture was used for each 1 g sample digested. Each mixture was heated up to 150 °C for 2½ h on the heating digestion block. Then the acid digest was allowed to cool and filtered into a 25 mL volumetric flask, using Whatman No 1 filter paper and made up to mark with de-ionized water.

This way, organic matter was destroyed in the sample and a high concentration of the sample was achieved. The blank digests and spiked samples were similarly processed. The concentrations of Pb, Cd, Mn, Cr, Zn and Cu, depending on the section involved, were obtained using the atomic absorption spectroscopy (AAS)."

Also, the modified method described by Akinyele and Shokunbi [16] was adopted in processing and analyzing soil samples. "One gram of each dried sample was weighed into a porcelain crucible and dry-ashed in a muffle furnace by stepwise increase of temperature up to 500 °C within 1 h and then leaving to ash at this temperature for additional 12 h. The residue was dissolved in 1 M nitric acid, filtered into a 25 mL volumetric flask using Whatman No 1 filter paper and made up to mark with the nitric acid (1 M). The blank digests was similarly processed. The concentrations of Pb, Cd, Mn, Cr, Zn and Cu, depending on the section involved, were obtained using the atomic absorption spectroscopy (AAS)."

3. Results and discussion

The concentrations of all the selected heavy metals studied were expectedly higher in soil samples than in cassava samples. The results further revealed that at section 1, the heavy metals concentrations ranged from 0.0 to 13.5 mg/kg, 0.0 to 0.5 mg/kg, 1.5 to 16mg/kg and 0.05 to 0.4mg/kg for lead, manganese, copper and cadmium in cassava samples respectively. Similarly, at section 2, the concentrations ranged from 3.22 to 5.48mg/kg, 8.70 to 14.18mg/kg, 0.0 to 0.16mg/kg, 1.70 to 2.12mg/kg and 0.03 to 0.22mg/kg for Pb, Zn, Cr, Ni and Cd in cassava samples respectively. These findings are similar to the results reported by Kalagbor *et al* [17], but lower than the reports of Osakwe and Okolie [1], Ogundele *et al* [18].

In soil samples from section 1, the concentrations were however, 0.0 to 25 mg/kg, 0.5 to 4.5 mg/kg, 0.0 to 10mg/kg and 0.1 to 0.55mg/kg for lead, manganese, copper and cadmium in soils samples respectively. The concentrations were 7.4 to 9.6mg/kg, 9.5 to 15.5mg/kg, 0.2 to 0.7mg/kg, 3.1 to 4.8mg/kg and 0.3 to 0.5mg/kg for Pb, Zn, Cr, Ni and Cd respectively for soil samples in section 2. The results of this study lend credence to those reported by Rahman and Zaim [19], but lower than the concentrations reported by Ogundele *et al* [18], Asdeo [20], Mbong *et al* [21], Yahya *et al* [22].

It was also found that the concentrations of Pb in the cassava tubers harvested at most of the locations in the two sections far exceeded the 2.0 mg/kg maximum permissible limit (MPL) set by WHO [23], WHO/FAO [24], Ahmad *et al* [25]. However, this corresponds to the results reported by Kalagbor *et al* [17], Ogundele *et al* [18]. Such excessive concentration of Pb in cassava tuber samples studied poses great risk to vulnerable populations including children [26]. Conversely, the concentrations of chromium in all the cassava tuber samples were well below the 20mg/kg by WHO [23], WHO/FAO [24] at all the locations studied.

Similarly, the concentrations of cadmium in all the tubers from the two sections studied were below the 0.5mg/kg limit by WHO [23], WHO/FAO [24]. Also, the concentrations of copper in the cassava tuber samples were far below 30mg/kg MPL by WHO [23], Sauerbeck [27]. The concentrations of manganese in the tubers studied were far below the 55.5mg/kg MPL of WHO. Moreover, the concentrations of zinc were found to fall below 60mg/kg MPL of WHO [23]. The concentrations of nickel were well below the 10mg/kg MPL set by WHO [23]. Kalagbor *et al* [17] have earlier reported that the concentrations of most heavy metals in cassava samples studied were below the MPL.

For soil samples from both sections studied, the concentrations of the heavy metals were quite below the MPL of 2-300mg/kg, 20-100mg/kg, 140mg/kg, 3.0 mg/kg set by FEPA [28], EU [29], 35mg/kg by Ogundele *et al* [18], 30.8-219.23mg/kg and 2-100mg/kg by Mbong *et al* [21] for Pd, Mn, Cu, Cd, Ni, Zn and Cr.

The low concentrations of most of the heavy metals studied are clear evidence of low industrialization and limited anthropogenic activities in Imo State, Nigeria [30].

Distribution of heavy metals in cassava tubers on roadside

The average concentrations of heavy metals studied decreased from 10 to 20m distance away from the roadside at both sections, except for Pb. This is corroborated by the results reported by Yan *et al* [31]. These results are shown in figures 1 and 2 respectively. At section 1, the order of concentration of the heavy metals is Pd>Cu>Mn>Cd for both soil and cassava tuber samples. At section 2, it was Zn>Pb>Ni>Cr>Cd for both soil and cassava tuber samples. These orders are related to the findings of Osakwe and Okolie [1] except for Pb, but differ from the reports of Mbong *et al* [21] and Yan *et al* [31]. The higher concentrations of Zn and Pb in the soil samples, compared to other heavy metals studied could be due to the use of Zn in manufacture of brake linings owing to its heat conducting properties. It may be released onto the road due to mechanical abrasion of vehicular parts like tyres, cables as well as from engine oil combustion [32-34].

Similarly, the high concentration of lead could be attributable to anthropogenic activities which include fuel combustion, vehicular emissions, use in electronic devices, and a constituent of lead-acid batteries in car and tyres which release it to the soil through corrosion [18].

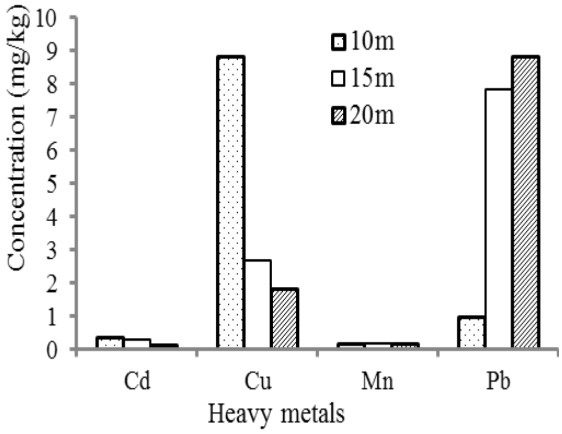

Fig. 1: Average concentrations of heavy metals in cassava tubers harvested at various distances away from the roadside at section 1.

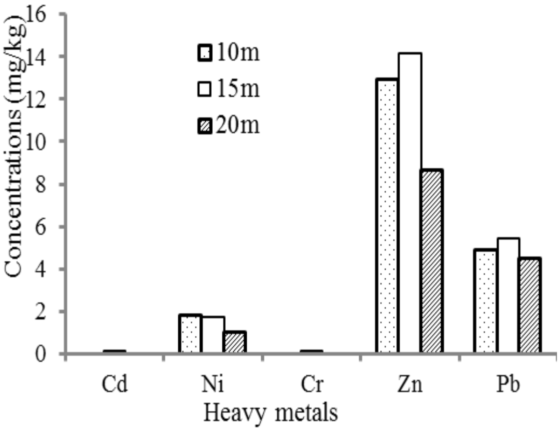

Fig. 2: Average concentrations of heavy metals in cassava tubers harvested at various distances away from the roadside at section 2.

Distribution of heavy metals in soil on roadside

At section 1, the concentrations of the heavy metals in the soil increased from 10 m to 20m away from the roadside, except for lead. Conversely, at section 2, the concentrations for all the heavy metals decreased with distance away from the roadside, except for lead. These are shown in figure 3 and 4 respectively.

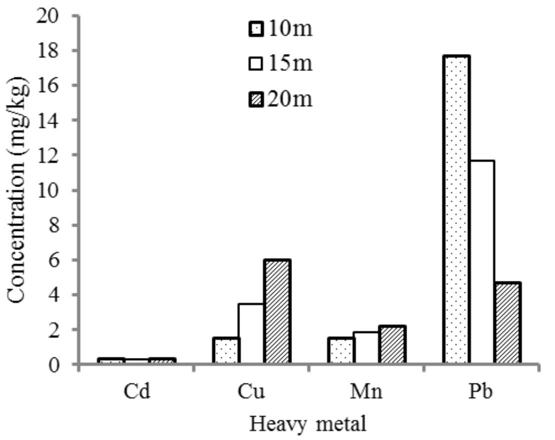

Fig.3: Average concentrations of heavy metals in soil samples collected at various distances away from the roadside, at section 1.

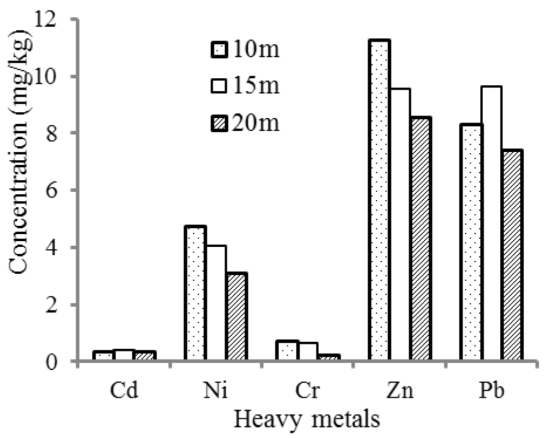

Fig. 4: Average concentrations of heavy metals in soil samples collected at various distances away from the roadside, at section 2.

Heavy Metal Bioaccumulation Factor (BAF)

Heavy metal bioaccumulation factor is a measure of the rate of uptake of each jeavy metal by plants. Values above 1 indicates that the plant is a hyperaccumulator of heavy metals. When it is below 1, then the plant moderately bioaccumulated the heavy metal. This is of great importance because heavy metals at excessive concentrations have harmful effects to both plants and animals when ingested. Also, plants can serve as indicators to accessible fraction of metals [22]. This was computed using the equation 1;

$$BAF = \frac{Conc\ of\ heavy\ metal\ in\ plant\ sample}{Conc\ of\ heavy\ metal\ in\ soil\ sample} \quad (1)$$

Table 1

Bioaccumulation factors for cassava samples in section 1.

Distance (m)	Cd	Cu	Mn	Pb
10	1.22	1.89	0.11	0.06
15	1.00	0.76	0.09	0.67
20	0.38	0.30	0.08	1.89

Table 2

Bioaccumulation factors for cassava samples in section 2

Distance (m)	Cd	Ni	Cr	Zn	Pb
10	0.24	0.40	0.04	1.2	0.60
15	0.31	0.43	0.20	1.50	0.57
20	0.52	0.34	0.42	1.0	0.62

The results shown in tables 1 and 2 indicate that cassava tubers did not hyperbioaccumulate heavy metals at most of the locations studied except for Cd at secton 1 and Zinc at section 2. These are related to the results reported by Yahya *et al* [22], Yan *et al* [31], Opaluwa *et al* [35]. Thus, the metals studied were moderately bioaccumulated in the cassava tuber samples (0.01-1.0) [1].

4. Conclusion

The results obtained revealed the presence of lead, cadmium, nickel, manganese, zinc, chromium and copper in most of the soil and cassava samples studied. The trands exhibited by the concentrations of heavy metals are Pd>Cu>Mn>Cd and Zn>Pb>Ni>Cr>Cd for both soil and cassava tuber samples from sections 1 and 2 respectively.

Moreover, the concentrations of all the heavy metals studied were below maximum permissible limits set by FAO/WHO, except for the concentration of lead in cassava tuber in both sections.

Similar to the results obtained from soil samples of section 2, the concentrations of heavy metals in cassava tuber of both sections also decreased with increasing distance 10 to 20m away from the roadside. However, it increased with increasing the distance from roadside. The results showed that cassava cultivated on roadsides of Owerri-Aba expressway were moderately bioaccumulating heavy metals.

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