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Research Article

An Assessment on the Effect of Heavy Metals Accumulation in *Sorghum bicolor* L., *Arachis hypogea* L. and *Vigna unguiculata* L. Grown Along Gusau-Sokoto Major Road

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Abstract— The pollution of soils by chemicals that contain heavy metals from automobile sources is an important environmental issue. Due to this important issue, a research was conducted to Assess the Effect of Heavy Metal Accumulation in Plants along Heavy Traffic Roads in Zamfara State, Nigeria. In this research, some selected edible plants (Sorghum, Cowpea, Groundnut/Peanut) were collected from five different locations along Gusau – Sokoto road as treatment samples. At the same time three plants were collected from Jaurin Rogo, Gusau as control samples. The plants samples after digestion were prepared and analyzed six metals (ZN, Cd, Pb, Cr, Ni, & Cu) by using Atomic Absorption Spectroscopy (AAS) and the results when compared with WHO/FAO (1996) threshold limits of heavy metals in plants, were found to be above permissible limits for two heavy metals (Cd & Cr) in all plant samples. The research findings unveiled the risk associated with planting and rearing besides major traffic roads of the country and recommended proper monitoring of the planting sites and cash crops such as cotton should be planted instead.

Keywords— Heavy metals, crops, roadsides, pollution, plants and traffic.

1. Introduction

One of the most urgent issue for agriculture is global food security, therefore evaluating soil quality and agricultural activities will help in making better food and quality environment [1].

Heavy metals accumulation in agricultural soils has given consideration worldwide due to its injurious effects in soil's ecological functions. Heavy metals are ingested through food grains and injured human beings [2].

Farmers usually plants their crops near roadsides, especially those living along major roads (i.e., linear settlement). Roadside soils and plants are assumed to accumulate considerable number of toxic metals particularly from automobile emissions and other toxic materials [3]. Therefore, assessing the effects of heavy metals in the environment is of great importance.

Soils pollution of is usually caused by chemicals that contain heavy metals from vehicles and other automobile sources and become an important environmental issue. These metals are released during different activities of the road transport such as component wear, combustion, metals' corrosion and fluid leakage. Pb, Cd, Cu, and Zn are the major pollutants of the major roads and are released from burning of fuel, oil spilling, car accidents and batteries corrosion etc. [4].

Health problems such as spread of diseases, like typhoid and cholera, some of which are largely seen as diseases caused by contaminated water were connected with environmental pollution [5]. Though some noninfectious diseases (NIDs) such as cancer and asthma, or several defects evident at birth among infants are brought about due to environmental pollution [5].

The most important assessment parameters for food quality assurance now is toxic metal contamination in food. Exceedence of certain threshold limits could lead to common harmful health effects considering their (heavy metals) tendency for poor biodegradability, accumulation over time, and long biological half-lives [6].

In the North Western part of Nigeria, especially Sokoto, Kebbi and Zamfara, there is no regular environmental

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assessment and monitoring. Therefore, the region can be considered as virgin with regard to environmental studies. Most vehicles in the region are old (especially Lorries), which may lead to leakage from their fuel tanks and engines [3,7]. In addition, wrecked cars and scrap metals are often seen along Gusau – Sokoto road. Moreover, there are a lot of accidents due to poor roads which may lead to oil spill and may end up in the farms nearby.

The aim of the research was to assess the accumulation of metals in crops (*Sorghum bicolor* L., *Arachis hypogea* L. and *Vigna unguiculata* L.**)** grown along major roads of Gusau – Sokoto. The specific objectives were to compare the analyzed metals with the WHO [8] permissible limits in plants.

2. Related Work

Automobile vehicles become the major means of transport in most of the major cities of the world. despite easing the transportation, automobile emissions, oil spilling, wearing of tyres and other pollutants emitted from them causes harm to man, his domestic animals and plants.

Uka *et al.* [9] investigated the effects of heavy metal accumulation on photosynthetic pigment of roadside trees in Kumasi, Ghana. In their results it revealed that photosynthetic pigments of polluted trees are reduced when compared with the control. Mafuyai *et al.* [10] also in their research on contamination of heavy metal in dust along major traffic roads of Jos (Plateau), Nigeria. Their findings revealed that, the concentration of metals in the dust (soil) was decreasing as they move few meters away of from the roadside. Ogbonna *et al.* [11] conducted a similar research on the accumulation of lead (Pb) and Nickel (Ni) on the leaves of roadside edible trees of Umuahia, Nigeria. The result of their study revealed that, there is high concentration of heavy metals in the leaves of the tree samples. Altaf *et al.* [12] also conducted a research on heavy metals accumulation on roadside wild plant. The results of their study revealed that, lead (Pb) was above threshold level.

Similarly, Saheed *et al.* [13] conducted a research on the effects of air pollution on the leaves structure of family Euphorbiaceae in South-western Nigeria. It was discovered in their results that, air pollution affects growth (such as number of leaves, petiole length and leave area) of the affected plants. Edegbai and Agbo [14] conducted a research on the effects of vehicle emission on roadside plants (weeds). The findings of their study concluded that, the effects of the emission decrease as they move meters away from the main road. Sivanesan *et al.* [15] performed a review on the impact of automobile pollution accumulated by roadside plants. In their review, they discussed on the potentiality of some plant species for phytoremediation.

Most of the studies conducted were not from Northwestern Nigeria, and some of the researchers focused on morphology of the leaves, accumulation of metals in the soil, some concentrated on one plant family only, some focused on wild plants, while others focused on plants with phytoremediation potentials. There is little or no research on the effect of the accumulated heavy metals by roadside plants on animals (man included). In order to fill the gap left by the researchers, this research was conducted to assessed the effect of heavy metals accumulation by roadsides plants of Northwestern Nigeria.

3. Experimental Method

3.1 Study Area

This study was conducted in Zamfara State, Nigeria. Zamfara, is a state in Northwestern Nigeria, and is bordering Sokoto, Kebbi, Niger and Katsina States. According to Zamfara Information Technology Development Agency [16], Zamfara has an area of 38,418 km^2 and an estimated population of 5.83m. the people of Zamfara state engaged in different crop production, livestock and fish rearing in large numbers with agricultural activities going on in the state it was give a slogan "Farming is our Pride" [16, 17].

3.2 Collection of Samples

The plant samples (*Sorghum bicolor* L., *Arachis hypogea* L., & *Vigna unguiculata* L.) were collected (in three replicates) from five locations along Gusau – Sokoto road, the plant samples were put into a brown envelops. All the plants samples were labeled appropriately and taken to Biology Laboratory in Zamfara State College of Education, Maru for further preparation.

Table 1: Sample Locations and Their Coordinates

S/N	Name of Sample Location	Latitude	Longitude	Town
1	FERMA, Gusau	12.208368 °	6.635165 °	Gusau
2	Kwanar Gandun Kiyawa	12.232062°	6.613675 °	Gusau
3	Kwanar Furfuri	12.24894 °	6.49509 °	Bungudu
4	Kwanar Nahuche	12.27708 °	6.57362 °	Bungudu
5	Kwanar Road Nigeria, Maru	12.302695 °	6.427773°	Maru
6	Jaurin Rogo	12.189286 °	6.708865 °	Gusau

Source: field work, 2023

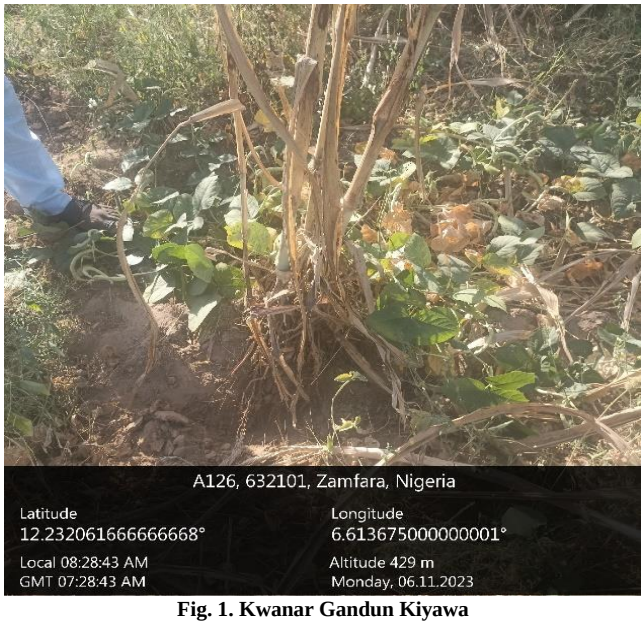

Fig. 1. Kwanar Gandun Kiyawa

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Fig. 2. Kwanar Furfuri

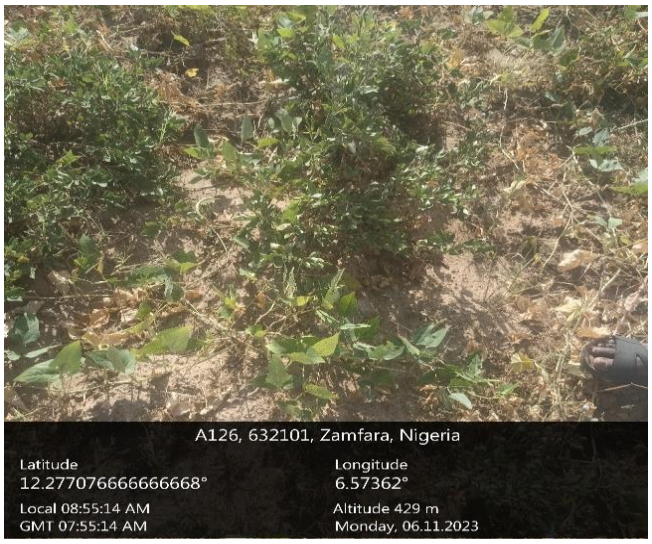

Fig. 3. Kwanar Nahuche

Fig. 4. Kwanar Road Nigeria

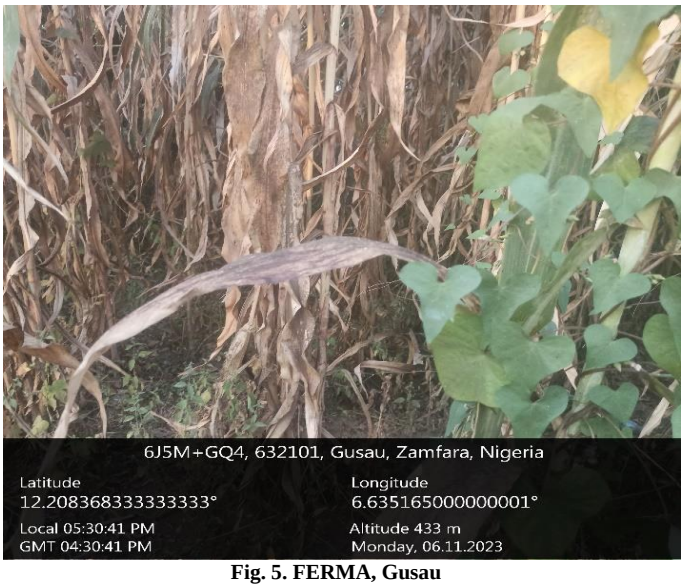

Fig. 5. FERMA, Gusau

Fig. 6. Jaurin Rogo

3.3 Preparation and Digestion of Plants Samples

Plant samples (leaves) were dried in an oven at 100°C for about 24 hours and blended to fineness for easy digestion with an electrical blender and then sieved through a 2mm mesh sieve for easy digestion. 5ml of 4:1 mixture of concentration HNO_3 and $HClO_4$ was added to 1g of weighed plants with an analytical weighing balance. It was heated at a temperature of 105°C for 1 hour to dryness. Then allowed to cool and made up to the mark of 50ml volumetric flask with 1M HNO_3. The solutions were centrifuged (30min) then transferred into sampling bottles for analysis [4,18].

3.4 Heavy Metal Analysis

The concentration of these heavy metals (Ni, Zn, Cd, Cu, Mn, Pb and As) in the plants samples were analysed using Atomic Absorption Spectrophotometer (AAS).

3.5 Statistical Analysis

All the data compiled in this study was analyzed using Statistical Package for Social Science (SPSS) Version 21 and the results obtained were presented in tables, and expressed as mean and standard deviation.

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4. Results and Discussion

The result of the study is presented in tables (2-4) below and the concentration of heavy metals found in the plants were categorized (1 plant per table). Explanation for each table followed immediately after the table.

Table 2: Concentration of heavy metals in Sorghum (*Sorghum bicolor* L.)

	Metals (Mean ± standard deviation in mg/kg)					
Location	**Zn**	**Cd**	**Cu**	**Ni**	**Cr**	**Pb**
FERMA, Gusau	25.88 ± 2.36	1.54 ± 0.06	1.44 ± 3.38	1.21 ± 0.05	1.87 ± 0.23	0.08 ± 0.03
Kwanar G/ Kyw	24.13 ± 3.92	0.76 ± 0.04	1.51 ± 1.83	0.30 ± 0.55	1.71 ± 0.46	NF
Kwanar Furfuri	22.22 ± 3.12	0.98 ± 0.05	1.51 ± 1.22	0.10 ± 0.32	1.31 ± 0.26	NF
Kwanar Nahuche	22.82 ± 2.16	1.76 ± 0.07	4.51 ± 2.21	0.30 ± 0.45	1.68 ± 0.43	0.12 ± 0.04
Kwanar R/ Nig.	28.26 ± 3.26	1.94 ± 0.05	4.23 ± 2.13	1.10 ± 0.22	1.73 ± 0.45	0.05 ± 0.02
Jaurin Rogo	18.97 ± 0.21	0.22 ± 0.69	1.70 ± 0.61	0.10 ± 0.10	0.70 ± 0.25	NF
FAO/WHO	**50**	**0.2**	**10**	**67**	**1.3**	**0.3**

Key: FAO = Food and Agricultural Organization, WHO = World Health Organization Threshold Limits of Metals in plants. NF = Not Found.

Table 2 presented the concentrations heavy metals (Zn, Cd, Cu, Ni, Cr & Pb) analyzed in sorghum (*Sorghum bicolor* L.) grown close to the major roads of Gusau – Sokoto at different locations and the mean metal concentrations accumulated by sorghum varies according to location.

The order of accumulation in Table 2 is as follows, Kwanar Road Nigeria, Maru: Zn (28.26 ± 3.26) > Cu (4.23 ± 2.13) > Cd (1.94 ± 0.05) > Cr (1.73 ± 0.45) > Ni (1.10 ± 0.22) > Pb (0.05 ± 0.02), FERMA, Gusau: Zn (25.88 ± 2.36) > Cr (1.87 ± 0.23) > Cd (1.54 ± 0.06) > Cu (1.44 ± 3.38) > Ni (0.30 ± 0.55) > Pb (0.08 ± 0.03), Kwanar Gandun Kiyawa: Zn (24.13 ± 3.92) > Cr (1.71 ± 0.46) > Cu (1.51 ± 1.83) > Cd (0.76 ± 0.04) > Ni (1.21 ± 0.05) > Pb (which was not detected), Kwanar Nahuche: Zn (22.82 ± 2.16) > Cu (4.51 ± 2.21) > Cd (1.76 ± 0.07) > Cr (1.68 ± 0.43) > Ni (0.30 ± 0.45) > Pb (0.12 ± 0.04), Kwanar Furfuri: Zn (22.22 ± 3.12) > Cu (1.51 ± 1.22) > Cr (1.31 ± 0.26) > Cd (0.98 ± 0.05) > Ni (0.10 ± 0.32) > Pb (which was not found). Jaurin Rogo (Control site): Zn (18.97 ± 0.21) > Cu (1.70 ± 0.61) > Cr (0.70 ± 0.25) > Cd (0.22 ± 0.69) > Ni (0.10 ± 0.10) > Pb (which was not found). As observed from the Table, Chromium (Cr) and Cadmium (Cd) exceeds the threshold limits sets by WHO [16] respectively in all the samples.

Table 3: Concentration of heavy metals (Mg/Kg) in Cowpea (*Vigna unguiculata* L.)

Metals (mg/kg)						
Location	**Zn**	**Cd**	**Cu**	**Ni**	**Cr**	**Pb**
Kwanar G/ Kyw	22.13 ± 2.33	0.26 ± 0.14	0.41 ± 1.12	0.30 ± 0.55	1.1 ± 0.40	NF
Kwanar Nahuche	28.82 ± 2.26	0.71 ± 0.17	1.21 ± 1.51	4.35 ± 1.12	1.60 ± 0.43	0.07 ± 0.03
Kwanar R/Nig.	31.16 ± 3.52	0.94 ± 0.65	1.03 ± 1.13	1.10 ± 0.22	1.73 ± 0.45	NF
FAO/WHO	**50**	**0.2**	**10**	**67**	**1.3**	**0.3**

Key: FAO = Food and Agricultural Organization, WHO = World Health Organization Threshold Limits of Metals in plants. NF = Not Found.

Table 3 presented the concentrations heavy metals (Zn, Cd, Cu, Ni, Cr & Pb) analyzed in cowpea (*Vigna unguiculata* L.) grown close to the major roads of Gusau – Sokoto at different locations and the mean metal concentrations accumulated by cowpea varies according to location.

The order of accumulation in Table 3 is as follows, Kwanar Road Nigeria, Maru: Zn (31.16 ± 3.52) > Cr (1.73 ± 0.45) > Ni (1.10 ± 0.22) > Cu (1.03 ± 1.13) > Cd (0.94 ± 0.65) > Pb (which was not found), Kwanar Nahuche: Zn (28.82 ± 2.26) > Ni (4.35 ± 1.12) > Cr (1.60 ± 0.43) > Cu (1.21 ± 1.51) > Cd (0.71 ± 0.17) > Pb (0.07 ± 0.03), Kwanar Gandun Kiyawa: Zn (22.13 ± 2.33) > Cr (1.1 ± 0.40) > Cu (0.41 ± 1.12) > Ni (0.30 ± 0.55) > Cd (0.26 ± 0.14) > Pb (which was not detected). As observed from the Table, Chromium (Cr) and Cadmium (Cd) exceeds the threshold limits sets by WHO [16] respectively in all the samples except in Kwanar Gandun Kiyawa where Cr (1.1 ± 0.40) is below the threshold (1.3mg/kg).

Table 4: Concentration of heavy metals (Mg/Kg) in Groundnut (*Arachis hypogea* L.)

	Metals (mg/kg)					
Location	**Zn**	**Cd**	**Cu**	**Ni**	**Cr**	**Pb**
Kwanar Nahuche	27.71 ± 2.26	0.51 ± 0.15	2.22 ± 1.62	4.23 ± 1.11	1.40 ± 0.24	0.08 ± 0.04
Kwanar R/Nig.	29.03 ± 2.82	0.34 ± 0.55	1.01 ± 1.10	3.20 ± 0.23	1.30 ± 0.37	0.02 ± 0.06
FAO/WHO	**50**	**0.2**	**10**	**67**	**1.3**	**0.3**

Key: FAO = Food and Agricultural Organization, WHO = World Health Organization Threshold Limits of Metals in plants.

Table 3 presented the concentrations heavy metals (Zn, Cd, Cu, Ni, Cr & Pb) analyzed in groundnut (*Arachis hypogea* L.) grown close to the major roads of Gusau – Sokoto at different locations and the mean metal concentrations accumulated by cowpea varies according to location.

The order of accumulation in Table 4 is as follows, Kwanar Road Nigeria, Maru: Zn (29.03 ± 2.82) > Ni (3.20 ± 0.23) > Cr (1.30 ± 0.37) > Cu (1.01 ± 1.10) > Cd 0.34 ± 0.55) > Pb (0.02 ± 0.06) and Kwanar Nahuche: Zn (27.71 ± 2.26) > Ni (4.23 ± 1.11) > Cu (2.22 ± 1.62) > Cr (1.40 ± 0.24) > Cd (0.51 ± 0.15) > Pb (0.08 ± 0.04). As observed from the Table, Chromium (Cr) and Cadmium (Cd) exceeds the threshold limits sets by WHO [16] respectively in all the samples except in Kwanar Road Nigeria, Maru where Cr (1.30 ± 0.37) is exactly 1.3mg/kg.

Discussion

The findings of this study revealed that all the crops (*Sorghum bicolor* L., *Arachis hypogea* L. and *Vigna unguiculata* L.) under investigation accumulates metals in them but only cadmium and chromium were above threshold limits of 0.2mg/kg and 1.3mg/kg set by WHO [8]. The treatment group (roadside plants) when compared with control group (Sorghum of Jaurin Rogo) found to accumulates much higher heavy metals. This is in accordance with the findings of the following researchers who investigated the accumulation of metals by roadside's plants. Ogundele *et al.* [4]. found in all the plants samples they analyzed heavy metals (Zn, Cd, Cr, Cu, Ni Pb) beyond permissible limits. Morelli *et al.* [19]. also found in bark of

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trees at the roadside Cu and Pb concentrations above the permissible limit for commercial and industrial use. Swaileh *et al.* [3]. also found roadside's plants accumulated heavy metals concentrations (Pb and Cd) in leaves nearly twice those of the control (Cd: 0.86 ± 0.10, Pb: 2.21 ± 0.24), while in stem are Cd (0.73 ± 0.31), Pb (1.57 ± 0.32) which were all exceeded the permissible limits of 0.02mg/kg for Cadmium (Cd) and 0.3mg/kg for Lead (Pb).

Similarly, some researchers investigated the soils around roadsides and their findings are as follows. Sürücü *et al.* [20]. found 162.86mg/kg of Cr, 3.99mg/kg of Cd in soils 15m away from roadside of Sulaimani-Mergapan road in Iraq, both which exceeded the threshold limits of heavy metals in agricultural soils. Mmolawa *et al.* [21] in Botswana, found Pb and Ni in soils above permissible limits. Acar and Özkul [22], found Cr and Ni in roadside's soil all above permissible limits. Agbaje *et al.* [23] found Cd in the soil beyond threshold level.

5. Conclusion and Future Scope

This study concluded that plants and soils around major traffic roads of Gusau – Sokoto of Zamfara State, Nigeria accumulates heavy metals in them, but not exceeded the threshold limits except for Cadmium (Cd) and Chromium (Cr) which were found above threshold limits set by WHO [8] in all the plant types (cowpea, peanut and sorghum). Therefore, regular monitoring and analyzing of the soils close to roadsides should be done by the farmers and the government in general. This study recommends planting of cash crops (instead of edible) that can absorb and accumulates heavy metals in them to avoid completely consumption of the crops by human and domestic animals.
Further work should be performed especially around Northwestern states of Nigeria, in order to categorize the sources of contamination, and to characterize different plant species with potentials for phytoremediation in highly traffic impacted roads.

Data Availability
The data supporting the findings of this research can be available on request via email talktoshagams@gmail.com

Conflict of interest
The authors declare no conflict of interest.

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Author's Contribution
Study design, writing and editing of manuscript, samples collection, Nura Muhammad Ahmad and Attahiru Muhammad Shagamu; Data analysis and interpretation, Attahiru Muhammad Shagamu; Sample preparations, Attahiru Muhammad Shagamu and Mubarak Aminu; All under Supervision of Keta, J. N. and Singh, D. All the authors have read and approved the final version of the manuscript.

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