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Assessment of Selected Heavy Metal Level in Soil and Maize (*Zea mays*) Plant within the Vicinity of Auto Mechanic Workshops in Gwagwalada, Abuja, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors EBA and HZO designed and supervised the research work. Author CBO performed the experiment, analyzed the data and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Assessment of heavy metals in the environment is an important tool to evaluate the risk of toxic metals to humans. In order to achieve this, soil and plant samples were collected within the vicinities of auto mechanic workshops in Gwagwalada area council at five (5) sites used as the study areas and a control site. The soil and plant samples were analysed for five heavy metals (Cd, Cu, Ni, Pb and Zn) using Atomic Absorption Spectrophotometry. The range of mean heavy metal concentration of the Auto mechanic soils were: Cd: 15.73 - 35.89 mg/kg, Cu: 112.05 - 170.42 mg/kg, Ni: 58.25 - 136.48 mg/kg, Pb: 105.59 - 316.57 mg/kg, Zn: 116.16 - 349.49 mg/kg while the range of mean heavy metal concentration in plants at the experimental sites was: Cd: 1.75 - 10.56 mg/kg, Cu: 25.38 - 79.42 mg/kg, Ni: 28.93 - 47.98 mg/kg, Pb: 5.48 - 33.48 mg/kg, Zn: 35.61 mg/kg - 111.54 mg/kg. The study indicated that consumption of plants grown on these sites could pose health hazard to man.

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1. INTRODUCTION

Soil is a natural body consisting of layers of mineral constituents of variable thickness, which differ from the parent materials in their morphological, physical, chemical and mineralogical characteristics [1]. It is composed of particles of broken rocks that have been altered by physical, chemical and environmental processes of weathering and erosion and is a mixture of minerals or organic constituents that are in solid, gaseous and aqueous states [2].

Man's activity in the environment has led to the pollution of soil mainly by chemical contaminants. The presence of heavy metals in soil can affect the quality of food, groundwater, micro-organisms activity, plant growth and so on [3]. When contaminated soils are later abandoned and then used for agricultural purposes such as farming, animal breeding and herding, plants take in these metals in the process, for the fact that they are not bio-degradable (cannot be broken down into smaller parts by bacteria), they can have adverse effect on plants. These heavy metals have toxic effect on living organisms in the soil when permissible concentration levels are exceeded [3]. Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals and atmospheric deposition [4].

Heavy metal is a general term used to describe a group of metals and metalloids with an atomic density greater than 5.0 g/cm^3 [5]. These elements occur naturally in soils and rocks at various ranges of concentrations as well as in ground and surface water bodies and sediments [6]. Due to the pollution associated with heavy metal concentration at elevated levels, there is need to ascertain the level heavy metals in this environment. Hence, this study is intended to serve as a basis for future investigation of activities leading to temporary changes in concentration of heavy metals from automobile mechanic workshops soils in Gwagwalada since no known work of this kind has been done in this area.

2. MATERIALS AND METHODS

2.1 Study Areas

Gwagwalada is one of the largest area councils in the F.C.T. It lies within latitude 8º 56ˈ to 8º 29ˈ N and longitude 7º 5ˈ to 7º 31ˈ E. It was created on the 15th of October, 1984 and has an official population figure of 158,618 at the 2006 Census. Its average annual temperature is about 27.2℃ and an annual rainfall of about 1650 mm [7]. It has an area of about 1069.589 square kilometers and falls within the Guinea savannah vegetation. Due to the vast growing population in the area, people engage in wide range of the use of automobile vehicles for commuting hence this necessitates the demand for mechanic workshops. The soils around these mechanic workshops are considered to be contaminated by heavy metals from substances like motor oils, grease, discarded battery electrodes and electrolytes, machine parts and scraps at various stages of corrosion, old tyres, cables and so on. This tends to pose a high risk of pollution of the farmlands leading to insufficient soil aeration, low crop yield and reduced crop quality.

2.2 Sample Collection

Soil and plant samples were collected within the vicinities of auto mechanic workshops in five (5) study sites: Dagiri (DG) and Kutunku (KT) study sites each occupying an estimated area of 30m x 10 m, Gwako (GK) study site, an estimated area of 25 m x 8 m while Gwagwalada central (GC) and Zuba (ZB) study sites each occupying an estimated area of 40 m x 20 m. A control site (non-contaminated site) which was about 1km distance where no activities involving disposal of metal containing materials was selected.

The five mechanic workshops were each divided into four (4) quadrants. Soil samples were taken from the soils of each quadrant at 0 – 15 cm depth and were mixed properly to give a composite sample mixture. The maize plants *(Zea mays*) were collected from a nearby farmland within 5 m to 10 m of each mechanic workshop. The plants were carefully uprooted and then bagged in a labeled polythene bag and then taken to the laboratory. The soils were collected from each site with the aid of clean stainless steel spoon which was washed and rinsed with distilled

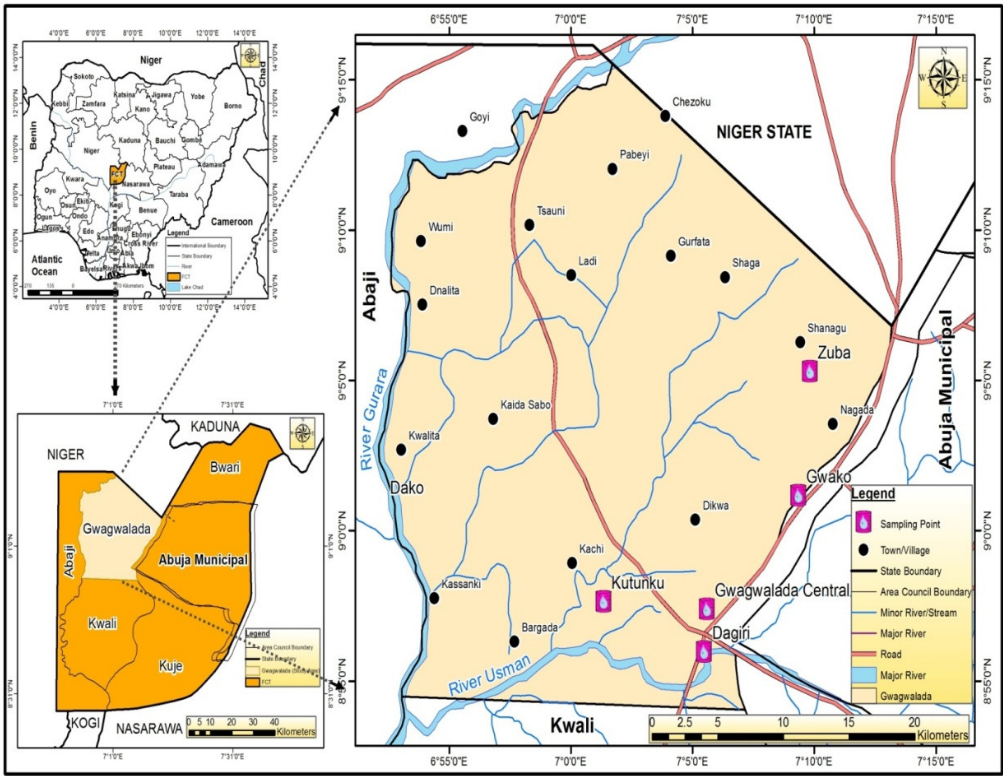

Fig. 1. Map of Gwagwalada showing study sites

water after each sampling. A total of six soil and plant samples (one from each site) were collected.

2.3 Sample Pre-treatment

Soil samples from each site were homogenized in mortar, air dried at 30℃ overnight and then passed through a 2 mm sieve. The sieved soils were placed in polythene bags prior to analysis [8].

Plant samples were properly rinsed with tap water and then with distilled water to remove any attached soil particles. They were then cut into smaller portions and placed in large clean crucibles, and then oven dried at 100℃ for 48 hrs. The dried plant samples were then ground into fine particles and were placed in polythene bags prior to analysis [8].

2.4 Heavy Metal Analysis

2.4.1 Soil samples

One gram of each soil sample was digested in Teflon cups with 30 ml aqua-regia (HCl: HNO_3, 3:1) on a thermostat hot-plate at 150℃ according to [9]. After, about 2 hours of digestion, the Teflon cup with its content was removed from the hot-plate to simmer. Then, 5 ml HF was added and heated further for 30 min. The Teflon cup with the content was allowed to cool down to room temperature and was filtered, After which the filtrate was quantitatively transferred into 50 ml volumetric flask and made up to mark with distilled-deionized water. Triplicate digestion of each sample was carried out together with the blank. Cd, Cu, Pb, Ni, and Zn concentrations were determined using atomic absorption spectrophotometer (AAS).

2.4.2 Plant (*Zea mays*) samples

Dried maize samples (0.5 g each) were weighed into 100 ml beaker, a mixture of 5 ml concentrated HNO_3 and 2 ml $HClO_4$ were added and digested according to [10] at low heat using hot plate until the content was about 2 ml. The digest was allowed to cool and then filtered into 50 ml standard flask. The beaker was then rinsed with small portions of distilled-deionized water and filtered into the flask. Triplicate digestion of each sample was carried out together with the blank. Concentrations of Cd, Cu, Pb, Ni, and Zn were spectrophotometrically determined using AAS.

2.4.3 Quality assurance

Validation of the technique was conducted on the digested plant and soil samples. This was done by spiking the pre-digested samples with multi-element standard solution (5 mg/L of Cd, Cu, Ni, Pb and Zn) as reported by [10]. The digest was run on atomic absorption spectrometry equipment and the concentrations of metals in the spiked and unspiked samples were used to calculate the percentage recovery in order to validate the method.

The validity of the extraction procedure, the precision and accuracy of the atomic absorption spectrophotometer was tested by spiking experiments. The results of the percentage recoveries on the digested soil and plant samples are presented in Table 1. The percentage recoveries for the soil samples varied between 85.26% - 96.83% while for the plant samples, the percentage recoveries varied between 81.63% - 92.08%. From the results, acceptable recoveries were obtained in all cases which validated the efficiency of the AAS.

Table 1. Percentage recovery of heavy metals in soil and plant samples

Metals	Soil samples (%)	Plant samples (%)
Cd	94.83	91.28
Cu	91.13	85.94
Ni	85.26	81.63
Pb	88.71	89.38
Zn	96.83	92.08

3. RESULTS AND DISCUSSION

3.1 Total Heavy Metal Concentration

3.1.1 Mean Cd concentrations in soil of the workshops and control site

The mean level of Cd in the workshop soils within the study areas ranged from 15.73 mg/kg (GC) to 35.89 mg/kg (DG) with the control site having values of 2.12 mg/kg. Fig. 2 showed that the soil cadmium contents were significantly lower in the control site compared to the study areas. Cadmium concentrations in the workshop soils were above the standard limits (3 mg/kg) set by [11]. The high concentration of cadmium at the study areas could be attributed to lubricating oils, vehicle wheels and metal alloys used for hardening of engine parts.

3.1.2 Mean Cu concentrations in soil of the workshops and control site

Copper had relatively high values ranging from 112.05 mg/kg (KT) to 170.42 mg/kg (ZB) with the control site recording 50.62 mg/kg. The exceptionally high value in ZB could be attributed to automobile wastes containing electrical and electronic parts, such as copper wires, electrodes and copper pipes and alloys from corroding vehicle scraps which have littered the vicinity for a long time, with the metals released from the corrosion gradually leaching into the soil [12]. These levels of Cu recorded in this study were similar to those recorded by [13] but were however lower than those by [14]. Copper concentration in most workshops sites were above standard limits (140 mg/kg) set by [11].

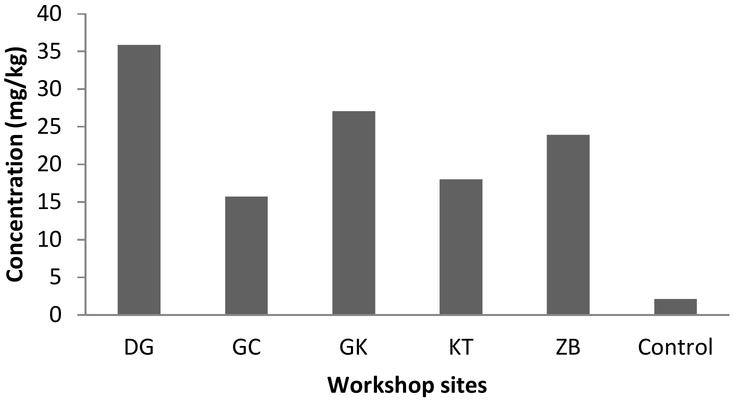

Fig. 2. Mean Cd Concentrations in the workshop soils

3.1.3 Mean Ni concentrations in soil of the workshops and control

Nickel concentration ranged from 58.25 mg/kg (GK) to 136.48 mg/kg (GC) with the control site recording 23.35 mg/kg**.** Nickel concentration in the auto mechanic soils were generally above standard limits (75 mg/kg) set by [11] thus implying high contamination of the metal in the soil. This could be attributed to the disposal of spent automobile batteries from the nearby auto-battery chargers and various paint wastes which have contributed to the contamination of the soil samples [15].

The concentration range reported in this study was higher than concentration range values reported by [16] in a similar study. The mean nickel values in the control site were seen to be the lower than those in the studied areas.

3.1.4 Mean Pb concentrations in soil of workshops and the control site

Lead had relatively high values ranging from 105.59 mg/kg (KT) to 316.57 mg/kg (ZB) with the control site having values of 53.55 mg/kg. Lead concentration in most of the study areas were generally above the standard limits (300 mg/kg) set by [11]. The exceptionally high value in the study areas could easily be attributed to the activities in the auto mechanic clusters. It is possible that these high levels of Pb is elevated by the amount of waste oil, presence of automobile liquid emissions and expired motor batteries indiscriminately dumped by battery chargers and auto mechanics in the study area.

These levels of Pb recorded in this study are similar to those recorded by [17] in their study on

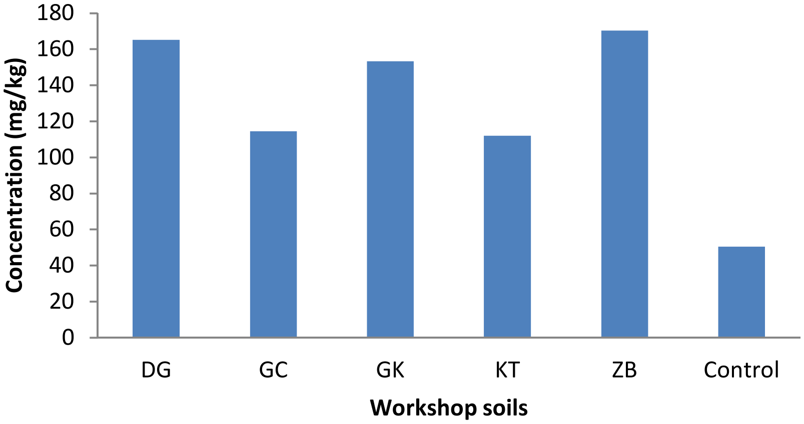

Fig. 3. Mean Cu Concentrations in the workshop soils

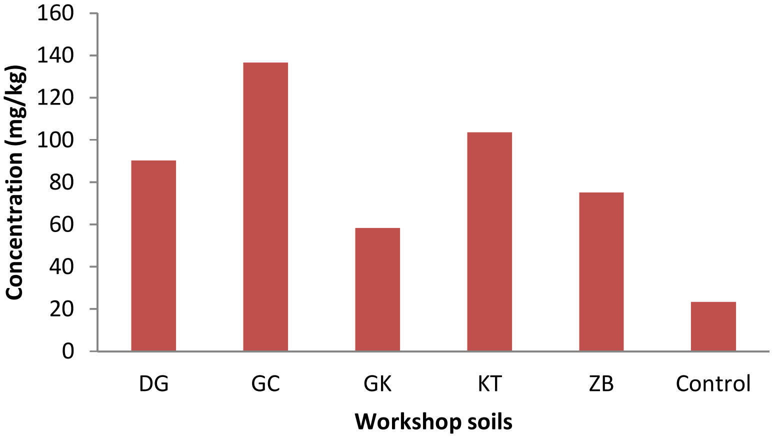

Fig. 4. Mean Ni Concentrations in the workshop soils

heavy metal analysis of soil samples. Values by [18] were lower than those reported in this study. However, concentration range by [13] was higher than the concentration range reported in this study.

3.1.5 Mean Zn concentrations in soil of workshops and the control site

The mean level of Zinc in the auto mechanic soils within the study areas ranged from 116.16 mg/kg (KT) to 349.49 mg/kg (ZB). This was considerably higher than the control site which recorded 59.49 mg/kg. Zinc exhibited higher levels of contamination than those of the other metals studied. Zinc in form of zinc oxide is a component of paint, so the high zinc levels in the soils of the study areas could be as a result of the activities of the spray painter and also vehicle body paints. Zinc is also a component of automobile exhaust and part of additives to lubricating oils [19] and so its high concentration could also be attributed to these.

Levels of Zn recorded in this study were lower than values reported by [12] but were higher than values reported by [18]. Zinc concentration in most workshops soils were above the standard limits (300 mg/kg) set by [11].

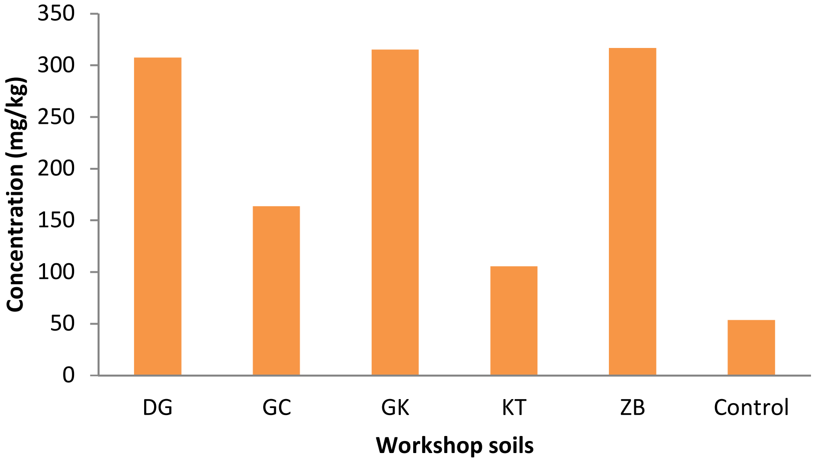

Fig. 5. Mean Pb Concentrations in the workshop soils

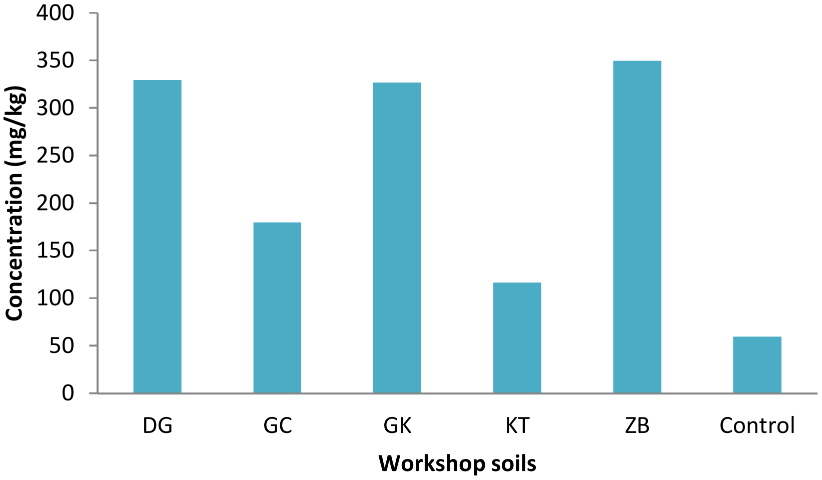

Fig. 6. Mean Zn Concentrations in the workshop soils

3.1.6 Total heavy metal concentration in plant samples (mg/kg)

Figs. 7-11 showed the total metal concentrations of Cd, Cu, Ni, Pb and Zn in the maize plants. The heavy metal concentrations in the maize plants were found to be lower than that of the soil. Also, the metal contents in the plant samples at the study areas were higher than those of the control site.

Cadmium concentration in the plants ranged from 1.75 mg/kg (KT) to 10.56 mg/kg (DG). Its concentrations in the plants were above the standard limit of 0.2 mg/kg set by [20]. The levels of cadmium recorded in this study were much higher than values reported by [21]. It was however much lower in the range of values reported by [22]. Toxic effects of cadmium on maize plants include reduced shoot growth and inhibition of root growth [23].

Copper concentrations in the plants at the study sites was highest at ZB (79.42 mg/kg) and lowest at KT (25.38 mg/kg). Its concentrations in the plants at most study sites were generally below the standard limit of 73.3 mg/kg set by [20]. Results obtained from this study were lower than values reported by [24], but were higher than the values reported by [9]. High toxicity of Copper in plants tends to lead to a reduction in the root growth, seed growth and biomasss and could eventually lead to the plant mortality [25].

Nickel concentrations in the plants at the study sites was highest at GC (47.98 mg/kg) and lowest at ZB (28.93 mg/kg). Results obtained from this study were higher than the values reported by [26]. Its concentrations in the plants were below the standard limit of 67.90 mg/kg set by [20]. High toxicity of Nickel in plants tends to lead to a decrease in the chlorophyll content, stomata conductance, decreased enzyme activity and reduction in plant nutrient acquisition [27].

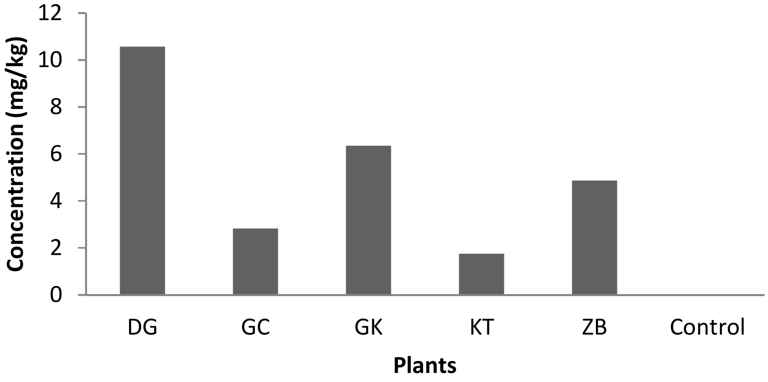

Fig. 7. Mean Cd Concentrations in *Zea mays*

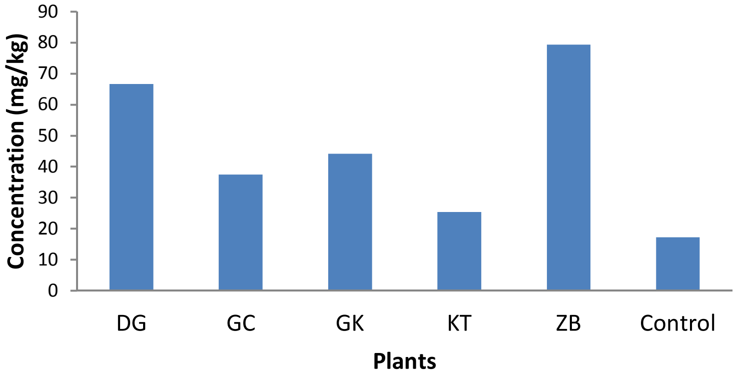

Fig. 8. Mean Cu Concentrations in *Zea mays*

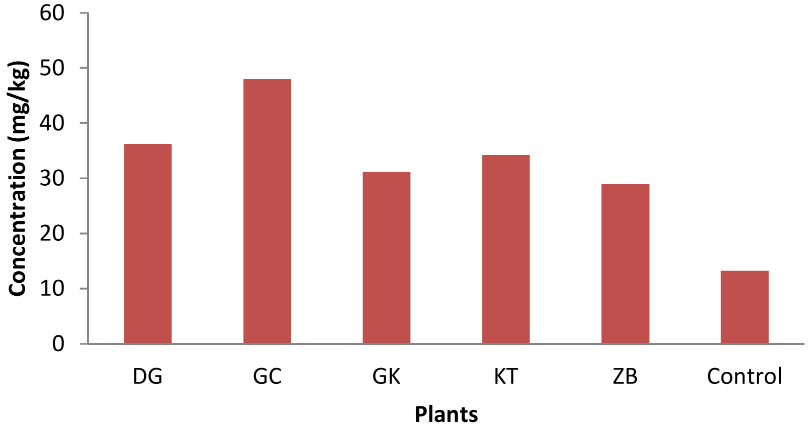

Fig. 9. Mean Ni Concentrations in *Zea mays*

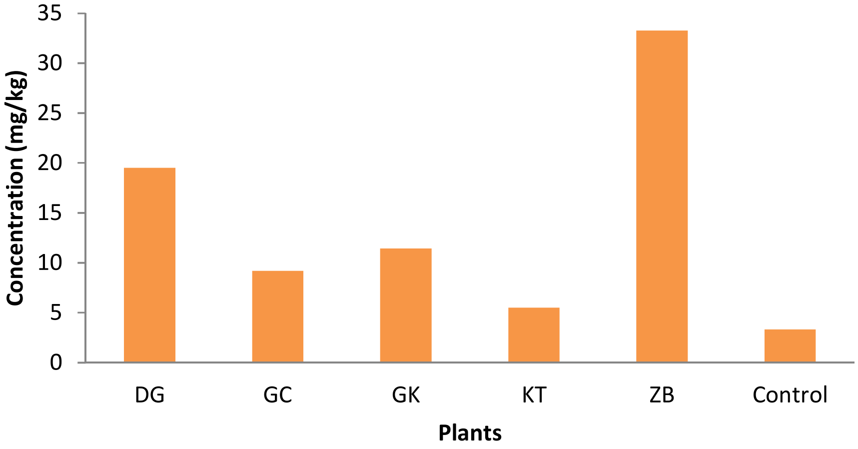

Fig. 10. Mean Pb Concentrations in *Zea mays*

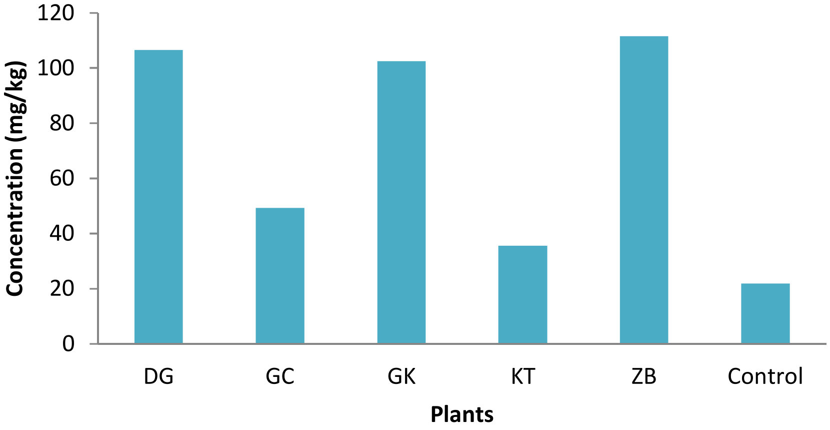

Fig. 11. Mean Zn Concentrations in *Zea mays*

Lead concentration in the plants ranged from 5.48 mg/kg (KT) to 33.28 mg/kg (ZB). Its concentrations in the plants were above the standard limit of 0.3 mg/kg set by [26]. The levels of Lead recorded in this study were much higher than values reported by [28]. It was however much lower than the range of values reported by [29]. Toxic effects of lead on maize plants include reduction in germination percentage; suppressed growth; reduced plant biomass and a decrease in plant protein content [30].

Zinc concentrations in the plants at the study sites were highest at ZB (111.54 mg/kg) and lowest at KT (35.61 mg/kg), but its concentrations at the study sites were generally higher than the control site value which recorded 21.79 mg/kg. Its concentrations in the plants at most study sites were generally above the standard limit of 99.40 mg/kg set by [20]. The range of results obtained from this study was lower than values reported by [31]. High toxicity of zinc in plants tends to lead to an alteration in structure of the chloroplast, decrease in plant nutrient content and reduced efficiency of photosynthetic energy conversion [32].

4. CONCLUSION

The results obtained from this study have shown that soil and plants sampled within the vicinity of auto mechanic workshops in Gwagwalada had higher heavy metals relative to the control site. This was due to the activities within these areas that generated waste, ranging from spent oil to metal waste which contaminated the soils with heavy metals. Results of the heavy metals in the soils of the experimental sites indicated that the concentration of the metals were generally above the European Commission (1986) recommended limits for these metals in soil with few exceptions. For plants; results also showed that the concentration of Cd, Pb and Zn at the experimental sites were higher with few exceptions than the FAO/WHO (2001) recommended limits. This could imply indirect health hazard to man through the food chain.

5. RECOMMENDATION

In view of these findings, there is need to monitor more closely the environment under review and put in place appropriate checks to preserve the health of communities within the vicinity of the auto mechanic workshops. Further studies on the level of these heavy metals should be carried out to ascertain long-term effects of anthropogenic impact, particularly as the effects of heavy metals are bioaccumulative and pose great dangers to the health of humans, plants and animals. Regulating safe farming distances is necessary to minimize toxicity of farm products and enlightenment should be done on the inherent risk of farming close in order to avoid the ingestion of the heavy metals studied.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Birland WP. Soil and geomorphology 3rd edition, Oxford University press, New York. 1999;301-334.
2. Chesworth Encyclopedia of soil science springer, xxiv, Dordrecht, Netherland. 2008;1011-1015.
   ISBN: 1402039948
3. Antoaneta E, Alina B, Georgescu, L. Determination of heavy metals in soils using XRF Technique. Romanian Journal of Physics. 2009;55(7-8):815-820.
4. Wuana RA, Okieimen FE. Heavy metals in contaminated soils: A review of sources, chemistry, risks and best available strategies for remediation. African Journal of Environmental Science and Technology. 2011;7(5):249–258.
5. Duffus JH. Heavy metals-A meaningless term. Pure and Applied Chemistry. 2002; 74:793-807.
6. Hutton M, Symon C. The quantities of cadmium, lead, mercury and arsenic entering the UK. Environment from human activities. Science of the Total Environment. 1986;57:129-150.
7. Balogun O. The federal capital territory of Nigeria: A geography of its development. University of Ibadan Press Limitedp; 2001.
8. Nuonom L, Yemefack M, Techienkwa M. Njomgang R. Impact of natural fallow duration on Cameron. Nigerian Journal of Soil Research. 2000;3:52-57.
9. Ogunfowokan AO, Oyekunle JAO, Dorosinmi LM, Akinjokun AI, Gabriel OD. Speciation study of lead and manganese in roadside dusts from major roads in Ile-Ife, South Western Nigeria. Journal of Chemistry and Ecology. 2009;25(6): 405-415.

10. Awofolu OR. A survey of trace metals in vegetation, soil and lower animals along some selected major roads in Metropolitan City of Lagos. Environmental Monitoring and Assessment. 2005;105:431-447.
11. European Commission (EC). European Commission office for official publications of the European Communities, Luxembourg, Council Directive 66/27/EEC on the protection of environment and in particular of soil, when sewage sludge is used in agriculture; 1986.
12. Nwachukwu MA, Feng H, Alinnor J. Trace metal Deposition in soil from auto-mechanic village to urban residential areas in Owerri, Nigeria. Proceedings of Environmental Science. 2011;4:310-322.
13. Aloysius AP, Sha'Ato R, Offem JO. Contributions of automobile mechanic sites to heavy metals in soil: A case study of North Bank mechanic village Makurdi, Benue State, Central Nigeria. Journal of environmental Chemistry and Ecotoxicology. 2013;3(3):2337-2347.
14. Okoro AC, Chukwuma GO, Chukwuma EC, Nwachukwu PC, Ezeh KA. Investigating the effects of selected heavy metals on topsoil at the vicinities of two automobile mechanic villages, Owerri Municipal, Nigeria. The International Journal of Engineering and Science. 2013; 2(11):19-26.
15. Udousoro II, Umoren IU, Asuquo EO. Survey of some heavy metal concentrations in selected soils in South Eastern parts of Nigeria. World Journal of Applied Science and Technology. 2010; 2(2):139-141.
16. Luter L, Akaahan TJ, Attah S. Heavy metals in soils of auto-mechanic shops and refuse dumpsites in Makurdi, Nigeria. Journal of Applied Science and Environmental Management. 2011;15(1): 207-210.
17. Oguntimehin I, Ipinmoroti KO. Profile of heavy metals from automobile workshops in Akure, Nigeria. Journal of Environmental Science and Technology. 2008;1(7): 19-26.
18. Adewole MB, Uchegbu LU. Properties of soils and plants uptake within the vicinity of selected automobile workshops in Ile-Ife Southwestern Nigeria. Ethiopian Journal of Environmental Studies and Management. 2013;(3):31-35.
19. Adriano DC. Trace elements in the terrestrial environment, Springer-Verlag, 2nd ed. N.Y. 2001;324.
20. FAO/WHO. Food additives and contaminants. Joint FAO/WHO food standards program; ALINORM 01/12A: 1-289; 2001.
21. Okunola OJ, Uzairu A, Ndukwe G. Levels of trace metals in soil and vegetation along major and minor roads in metropolitan city of Kaduna, Nigeria. African Journal of Biotechnology. 2007;6(14):1703-1709.
22. Abdallah SA, Uzairu A, Kagbu JA, Okunola OJ. Assessment of heavy metals bioaccumulation by *Eleusine indica* from refuse dumpsites in Kaduna Metropolis, Nigeria. Journal of Environmental Chemistry and Ecotoxicology. 2012;4(9): 153-160.
23. Wang AS, Angle JS, Chaney RL, Delorme TA, Reeves RD. Soil pH effects on uptake of Cd and Zn by Thlaspi caerulescens. Plant and Soil. 2007;281(2):325–337.
24. Amusan AA, Ige DV, Olawale R. Characteristics of soils and crop uptake of metals in municipal waste dumpsites in Nigeria. Journal of Human Ecology. 2005; 17:167-171.
25. Sheldon R, Menzies NW. The effect of copper toxicity on the growth and root morphology of Rhodes grass (*Chloris gayana* Knuth.) in resin buffered solution culture, Plant and Soil. 2005;278(2): 341–349.
26. Omono C, Matthews A, Kakulu S. Investigation of heavy metal levels in roadside agricultural soil and plant samples in Adogo, Nigeria. Academia Journal of Environmental Sciences. 2012; 1(2):031-035.
27. Sheoran IS, Singal HR, Singh R. Effect of cadmium and nickel on photosynthesis and the enzymes of the photosynthetic carbon reduction cycle in pigeon pea (*Cajanus cajan* L.) Photosynthesis Research. 1990; 23(3):345–351.
28. Uwah EI, Ndahi NP, Abdulrahman FI, Ogugbuaja VO. Heavy metal levels in spinach (*Amaranthus caudatus*) and lettuce (*Lactuca sativa*) grown in Maiduguri, Nigeria. Journal of Environmental Chemistry and Ecotoxicology. 2011;3(10):264-271.
29. Abii TA. Levels of heavy metals (Cr, Pb, Cd) available for plants within abandoned

mechanic workshops in Umuahia Metropolis. Research Journal of Chemical Sciences. 2012;2(2):79-82.

30. Hussain A, Abbas N, Arshad F. Effects of diverse doses of lead (Pb) on different growth attributes of *Zea mays*. Agricultural Sciences. 2013;4(5):262–265.
31. Audu AA, Lawal AO. Variation in contents of plants in vegetable garden sites in Kano Metropolis. Journal of Applied Science and Enviromental Management. 2008;10(2): 105-109.
32. Bonnet M, Camares O, Veisseire P. Effects of zinc and influence of Acremonium lolii on growth parameters, chlorophyll a fluorescence and antioxidant enzyme activities of ryegrass (*Lolium perenne* L. cvApollo). Journal of Experimental Botany. 2000;51:(346): 945-953.

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