Assessment of heavy metal pollution on some edible crop trees from vehicular movements on road side within University of Port Harcourt

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The heavy metal from five selected tree plants [*Mangifera indica* (L.), *Elaeis guineensis*(Jacq.), *Prunus dulcis* (Mill), *Citrus sinenesis* (L) and *Psidium gujava* (L.)] in the University of Port Harcourt were analysed for its content in the leaves and soil. The leaves of edible trees and soil far from the major roads were used as a control. The digestion method was used for analysis of heavy metals and the heavy metals in soil were analysed by atomic absorption spectrophotometer with spectra AA 650. The results obtained indicate that concentration of Lead was between 12.85-35.57 and 10.57-25.17 mg/kg for soil and leaves across sampled sites. Nickel ranged between 0.00-28.87 and 0.00-0.02 mg/kg for soil and leaves respectively. Copper was between 2.27-13.69 and 1.33-10.58 mg/kg for soil and leaves. Zinc had a ranged of 2.40- 17.53 and 2.40-9.33 mg/kg for soil and leaves. Aluminium presented a range of 0.04-0.93 and 0.04-0.67 mg/kg for soil and leaves across sampled sites. Lead showed significant presence as compared to other sampled metals in both soil and leaves in all plants across locations, Ni showed presence in Choba and Delta Parks for orange, almond and oil palm plants and absence in other sites (University Park and UPTH); with noticeable absence in mango and guava across the four sampled locations. The concentrations of Pb and Zn in the leaves of sampled plants exceeded the recommended intake considered suitable for humans while the concentrations of Cu, Ni and Al were within the range for human consumption. However, heavy metal concentrations were higher in sampled locations compared with the control as a result of exhaust from automobiles as the main source of these heavy metals pollution in plants and soil. Hence, edible crops like those from this study should not be planted along major roads to avoid pollution by heavy metals from vehicular movement.

Key words: Heavy metal pollution, trees, soil, road side, vehicular movement.

INTRODUCTION

Man has become capable of altering his physical environment to suit change with earth's surface at much faster rate than many natural process (Bhatia, 2006). One major problem the world is facing today is environmental pollution. This is the release of harmful or unfavorable materials into the environment through natural or anthropogenic which are man-made sources. It helps in altering physical, chemical and biological conditions of the environment. Pollution is the release in excess of allowable limits of foreign substance within environment (Anyanwu et al., 2014). Pollution arises from different sources like improper solid waste disposal, which is generated from human activities, crude oil pollution, heavy metal pollution etc. Pollution includes the point of sources which are emission, wastes and solid release from industries, vehicle tiredness and metals from heat up and mining, non-point bases such as soluble salts (natural and artificial), practice of insecticides and pesticides, discarding of industrialized and civic wastes in agriculture, and unnecessary use of fertilizer (Nriagu, 1996). Heavy metals are natural components on earth crust. They enter human body through food, drinking water and air

(Helmemstine, 2014). Some heavy metals are released from atmospheric depositions from industries, urban effluents, traffic emissions and waste incinerators (Maryan et al., 2015; Ozuzu et al., 2020). Heavy metal happens naturally in ecosystem with large variations in concentration. Their pollutants are Cd, Cr, Cu, Hg, Pb and Zn. Metals such as Zn, Cu, Mn, Ni, and Co are micronutrients needed for plant development while for biological function, we have Cd, Pb and Hg (Duffus, 2002). Heavy metals identified in most polluted environment contain As, Cu, Cd, Pb, Cr, Ni, Hg and Zn. Heavy metals like Pb, Zn with Cu are released in the environment through lead in petrol, industrial effluents, leaching of metal ions from soil into lakes and rivers by acid rain, roadways and automobiles which there after lead to environmental pollution. On road surface, most heavy metals become bound to the surface of dust or soluble (dissolved). Plant accumulates heavy metals from its roots that affect food chain. These metals are released through diverse processes of road transport combustion, component wear, fluid leak and corrosion of metals. Knowing that the world is like an industrial village, activities of some industry release heavy metals in air, soil and water. These heavy metals locate soil and are absorbed by plants growing on that soil. Most heavy metals have effect on plants and man growth. Studies affirm that heavy metals have been proven to disturb development or even cause death when present at levels higher than organism can tolerate, which depends on organism and species. The outcome of heavy metal depends on excessive toxic release of substances in the environment and plant species affected. This study focused on assessing heavy metal contents in some edible plant species seen along the road side within the University of Port Harcourt parks.

METHODOLOGY

The design adopted was randomized complete block design. This design is appropriate for getting data based on random sampling carried out within four locations within University of Port Harcourt namely University Park / Abuja park, Delta Park, Choba Park and University of Port Harcourt Teaching Hospital (UPTH) and a pristine environment in Omuoko community in Aluu, in Ikwerre LGA of Rivers state as control sites where there was no presence of any form of air, soil or water pollutions.

Sampling site description

The samplings were carried out within the University of Port Harcourt Rivers on geographical coordinates: Latitude 4°54'0"N, Longitude 6°54'0"E, and 6°55'30"E. The area experience two distinct seasons- rainy season (monthly mean temperature of 29.09°C) and dry season (monthly mean temperature of 31.97°C) (Figure 1). The annual rainfall is put at 2400 mm centimeters and it rains from April to October while the dry season starts from November and ends March. The climate condition of the area is characterized by temperature, high rainfall, and high relative humidity (Weather statistics for Port Harcourt, Rivers State (Nigeria).

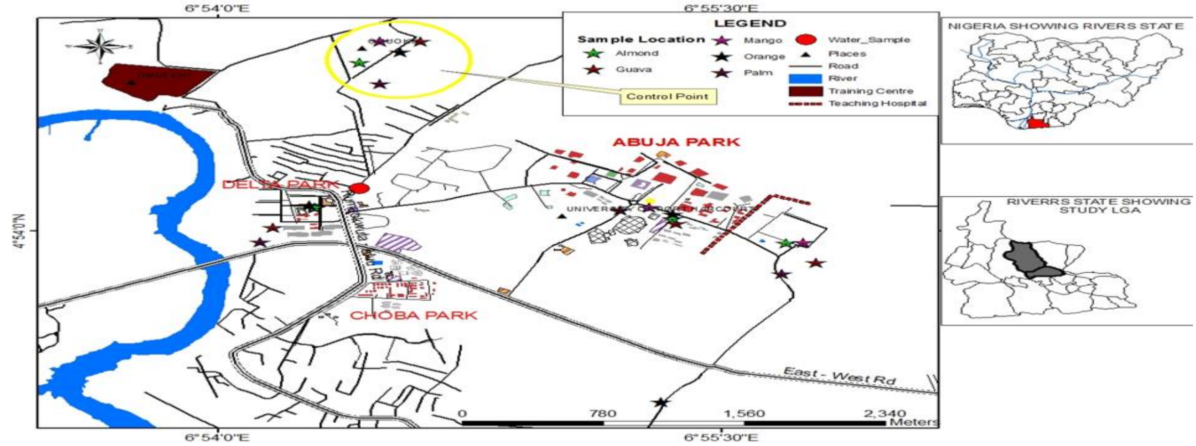

Figure 1. Map of University of Port Harcourt showing various sample sites.

The leaves of *Mangiferia indica*, *Elaeis guineensis*, *Prunus dulcis*, *Citrus sinensis*, and *Psidum /guajava* and soils around the roots of plants were collected at 0-15 cm depth from the various.University Parks. UPTH and Omuoko in Aluu which served as control sites were collected with aid of stainless spoon, washed with soap and rinsed with water after sampling (Awofolu, 2005). Soil and leaves were collected and placed in cellophane bag (Bamgbose et al., 2000) labeled and taken to laboratory for pre-treatment analysis. Soil sampling spots were cleared of debris before sampling (Chimuka et al., 2005). Fresh leaves of the five plants species were randomly collected at the various sampling sites close to the major roads and sampled soils were taken from base of plant species using clean stainless steel scissors (Okonkwo and Maribe, 2004) put in paper bags, labeled and taken to laboratory for pre-treatment analysis.

Sample preparation/wet digestion for plants and soil samples

Plant samples were properly rinsed with distilled water to remove attached soil particles, cut in smaller portions, then placed in clean crucible and was oven dried at 100°C for 48 h. The dried plant samples were ground in fine elements using fresh acid, washed mortar and pestle. The method according to Awofolu (2005) was used in the digestion of plant sample. 0.5 g of sieved leaf samples were weighed in 100 ml beaker, a mixture of 5 ml concentrated trioxonitrate (iv) acid (2 ml per chloric acid) was added and digested on low heat using hot plate content about 2 ml. The digestion was allowed to cool and filtered in 50 ml standard flask of 0.45 um Millipore fitter kit. Beaker was rinsed with minor portions of double water and filters in flask. Triplicate digestion of sample was carried out with blank digest without plant sample. Quantitation of metallic content of digested samples was carried out with flame atomic interest spectrophotometry model AA650. Soil samples collected were homogenised and air-dried in circulating air in oven at 35°C to constant weight and passed 2 mm sieve. 5 g of soil samples were placed in 100 ml beaker. 3 ml 30% hydrogen peroxide was included following previous describe method by Sharidah (1999) and this was left for 60 min until vigorous reaction stopped. 75 ml of 0.5 m solution of Hcl was added and the content was heated at low heat on hot plate for 2 h. The digestion was then filtered into 50 ml standard flask in triplicate; digestion of sample was done together with blank and quantitation of metallic content of digested samples was carried out with flame atomic absorption spectrophotometry model AA650. Heavy metals analsyed included lead, nickel, copper, zinc and aluminum.

Statistical analysis

The data collected was analyzed using Analysis of variance (ANOVA). From Microsoft excel Office, mean were separated using least significant difference (LSD) at 5% level of probability using SPSS 2014 Version.

RESULTS AND DISCUSSION

Heavy metal content on leaves of orange plant in study area

The results showed that the investigated heavy metals (lead, nickel, copper, zinc and Aluminum) were present in all sampled locations (Delta Park, Choba Park, Abuja Park, UPTH and a Control site). These heavy metals were observed to be significantly high in all the sampled locations especially lead, followed by Zinc and Nickel (Figure 2).

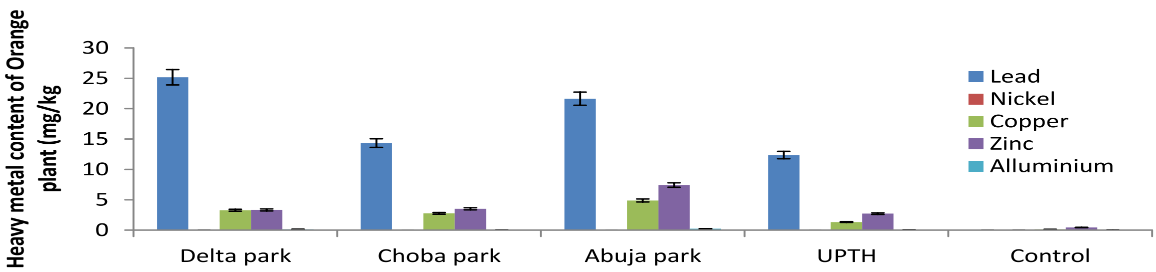

Figure. 2 Heavy metal content of leaves of orange plant within different sampled sites.

Heavy metals in leaves of almond tree in different sampled sites

Results showed that the investigated heavy metals (lead, nickel, copper, zinc and aluminum) were present in all sampled locations in significantly high quantity, especially lead, zinc and copper but was lowest in the control site. No significant difference was found between Nickel and aluminum and between zinc and copper in all the sampled sites at $p \leq 0.05$ (Figure 3).

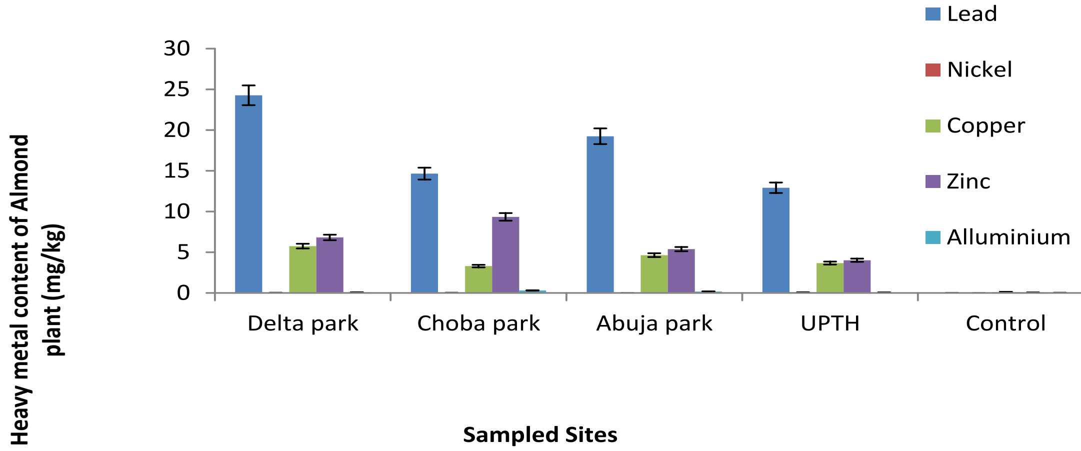

Figure 3. Heavy metals in leaves of almond tree in different sampled sites.

Heavy metals content in leaves of oil palm plant in different sampled sites

Results showed that the investigated heavy metals especially Lead, Zinc and Copper with Nickel as least, were present in the leaves of the oil palm tree in all sampled locations and control site. The control site recorded the least of all the investigated heavy metals. There was no significant difference ($p \leq 0.05$) between nickel and aluminum and between zinc and copper 129. in all sampled sites (Figure 4).

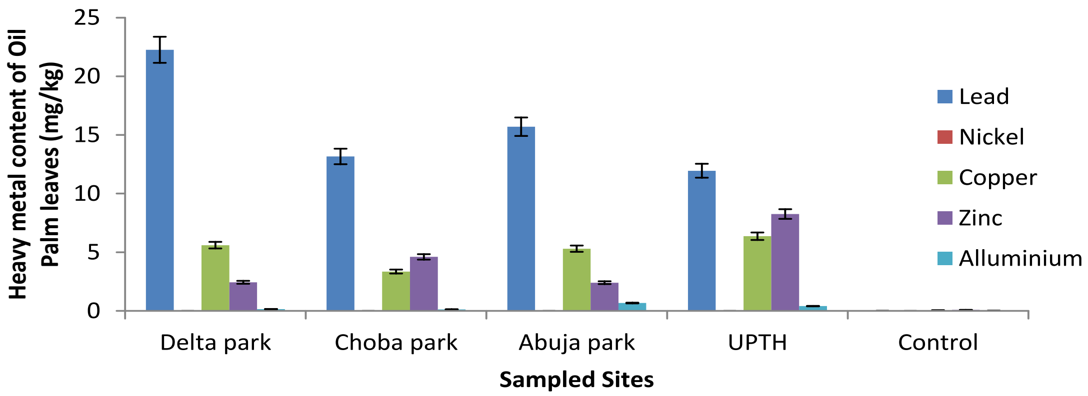

Figure 4. Heavy metals content in leaves of oil palm plant in different sampled sites heavy metals in leaves of mango plant in different sampled sites.

Results showed that the investigated heavy metals especially lead, zinc and copper with nickel as the lowest were present in the leaves of the mango plant in all sampled locations and control site. The control site recorded the least of all the investigated heavy metals. No significant difference ($p \leq 0.05$) was between nickel and Aluminum and between zinc and copper in all the sampled sites (Figure 5).

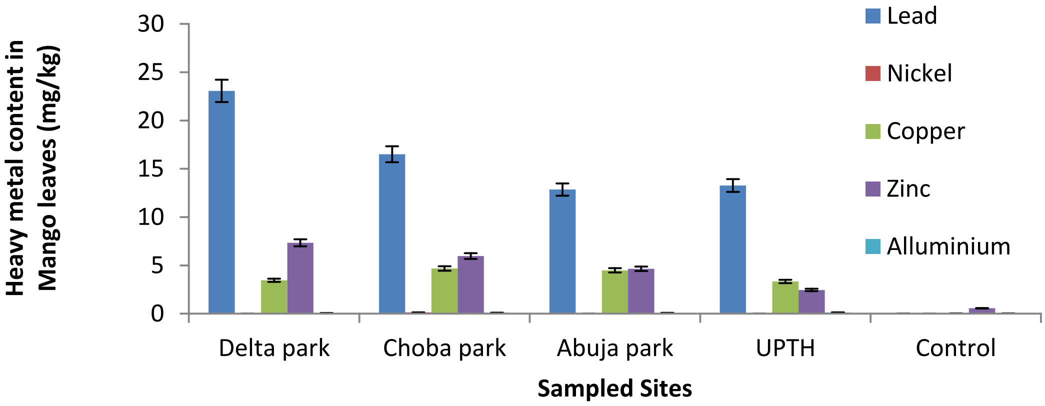

Figure 5. Heavy metals in leaves of mango plant in different sampled sites.

Heavy metals in leaves of guava plant in different sampled locations

The results show that the investigated heavy metals especially lead, zinc and copper with nickel as least, were present in the leaves of the guava plant in all the sampled locations and control site. The control site recorded the least of all the investigated heavy metals. There was no significant difference ($p \leq 0.05$) between nickel and aluminum in all the sampled sites. Zinc was significantly different from copper in all the sampled sites (Figure 6).

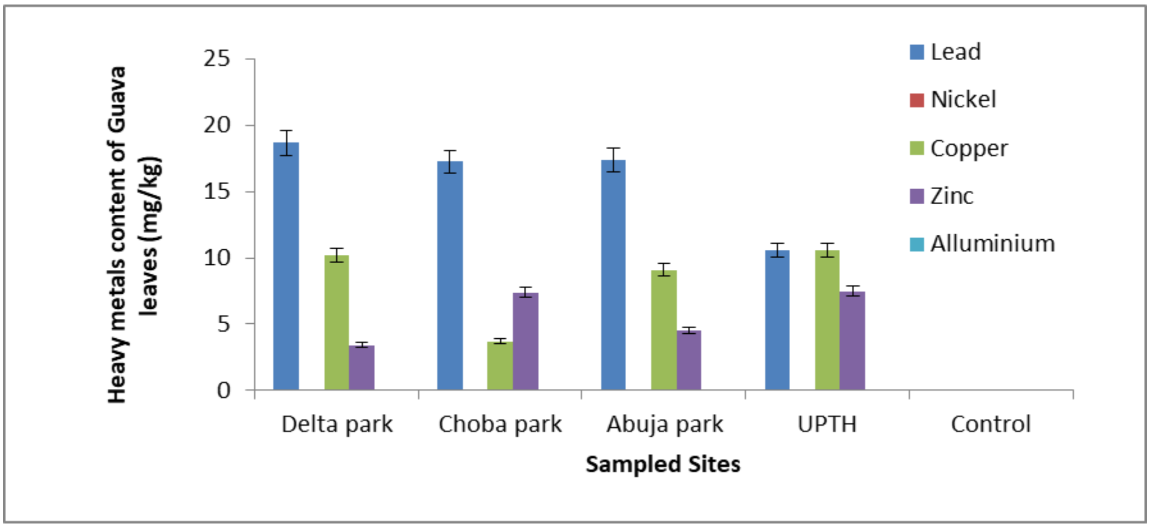

Figure. 6. Heavy Metals in Leaves of Guava Plant in Different Sampled Sites

Heavy metal content in soils surrounding the plants

Heavy metal content of soil around the orange plant in the different sampled site

Results showed that lead was significantly higher in the soils surrounding the orange plant in all the sites except the control sites which had the least lead content followed by Zinc and Copper. Nickel was observed to be significantly lower. The control site had the lowest of all the heavy metals analyzed. No significant difference ($p \leq 0.05$) was observed between the lead content in Delta Park, UPTH and Choba Park, and between the Nickel content in the soil sampled at Choba Park, Abuja Park, UPTH and the Control Site (Figure 7).

Heavy metal content of soil around the sweet almond plant in the sampled sites

Results show that lead was significantly higher in the soils surrounding the almond plant in all the locations except the control location which had

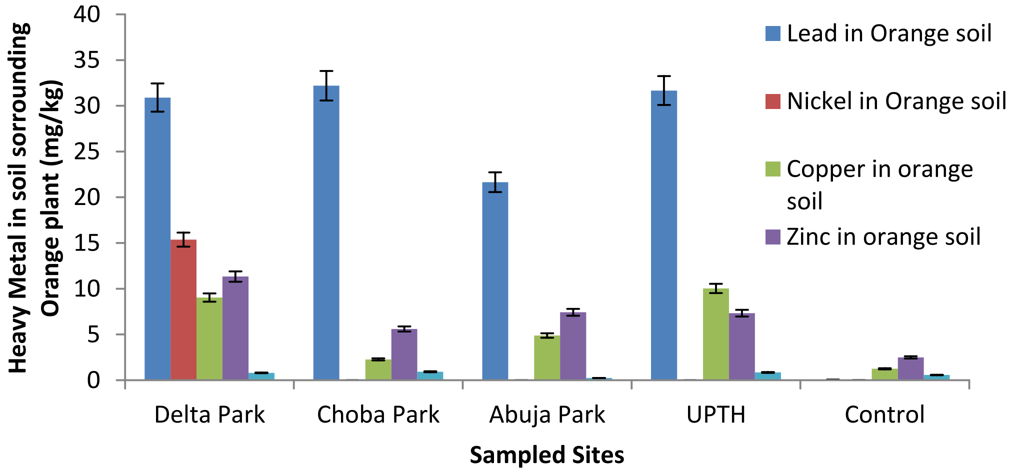

Figure 7. Heavy Metal Content of Soil around the Orange Plant in the Sampled Sites.

the least lead content, followed by Zinc and Copper. Nickel was observed to be significantly lower. The control site had the lowest of all the heavy metals analyzed. No significant difference ($P \leq 0.05$) was observed in the lead content of the soil surrounding the almond plant in all the sampled locations except in the control location which had significantly low content of lead. The same was observed with all the investigated heavy metals (Figure 8).

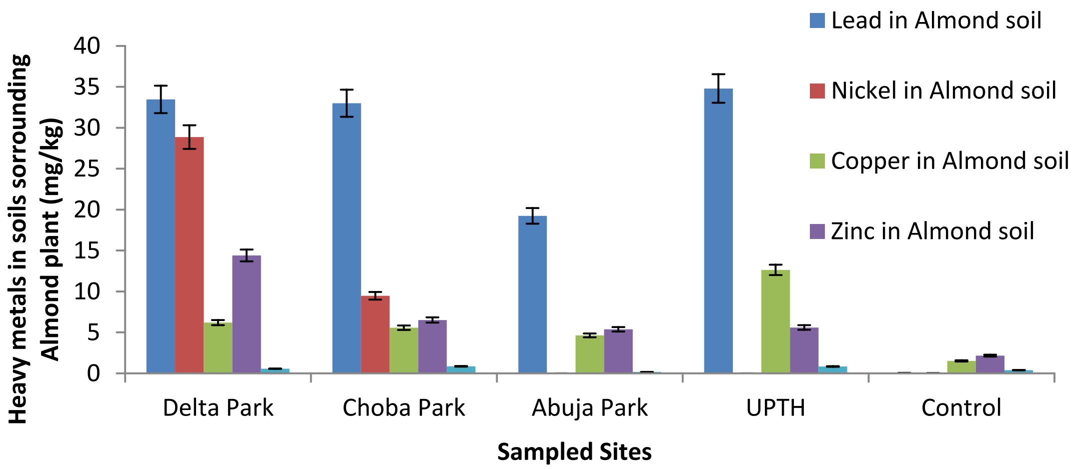

Figure 8. Heavy metal content of soil around the almond plant in the sampled sites.

Heavy metal content of soil around the oil palm plant in the different sampled sites

Results showed that lead was significantly ($P \leq 0.05$) higher in the soils surrounding the oil palm plant in all the sites except in the control location which had the least lead content, followed by zinc and copper. Nickel was observed to be significantly lower and there was no significant difference in nickel in all the sampled locations except for Choba Park. Although, the control site had the lowest of all heavy metals analysed, there were significant differences ($P \leq 0.05$) in the heavy metals analyzed between the control site and the sampled locations and there was no significant difference in the aluminum content of the soil surrounding the oil palm plant in all the sampled locations except in the control locations (Figure 9).

Heavy metal content of soil around the mango plant in the different sampled sites

Results show that lead was significantly higher in the soils surrounding the mango plant in all the sampled locations except the control sites which

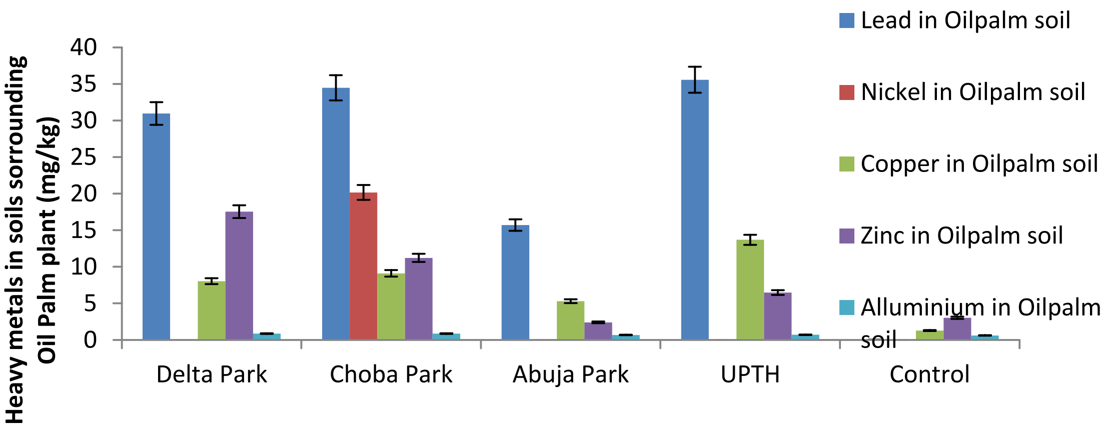

Figure 9. Heavy metal content of soil around the oil palm plant in the sampled sites.

had the least lead content. There was significant difference (P≤ 0.05) in the aluminum content of the soil surrounding the mango plant in all the sampled locations except for Choba and Delta Park (Figure 10).

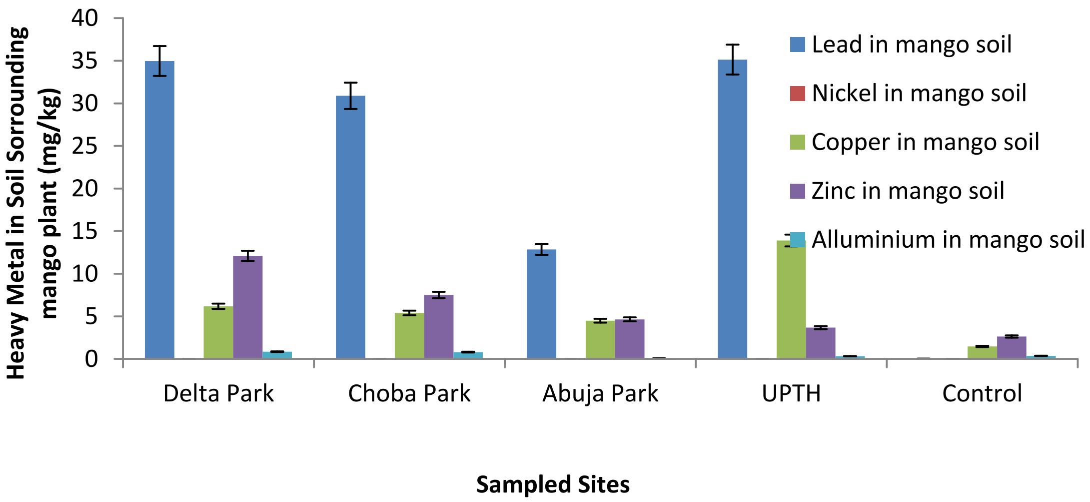

Figure 10. Heavy metal content of soil around the mango plant in the sampled sites.

Heavy metal content of soil around the guava plant in the different sampled sites

Results show that lead was significantly higher in the soils surrounding the guava plant in all sampled sites except the control sites which had the least lead content (Figure 11). The same trend was observed for all the investigated heavy metals with the control site having the least except for the case of nickel where nickel was observed to be significantly lower in the soils surrounding the plant in all the.sampled sites. There was no significant difference in lead in all the sampled sites except for the control site. There was no significant difference (P≤ 0.05) in the aluminum and nickel content of the soil surrounding the mango plant in all the sampled locations except for Abuja Park.

The higher mean content of these metals as observed in the sampled sites could be because these plants were found along the road with great exposure to vehicular emission. Many researchers have also observed higher heavy metal contents in plants located along major roads, which agrees with the result of this study in which the concentration of the heavy metals analyzed

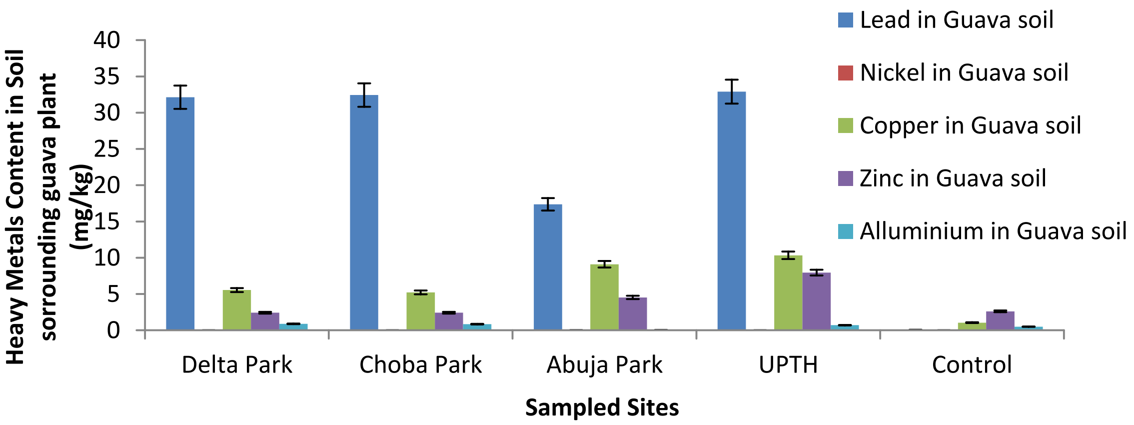

Figure 11. Heavy metal content of soil around the guava plant in the different sampled sites.

decreased with increase in distances from the main roads especially the control site which had no presence of cars. This increase of heavy metal especially lead (Pb) in the leaves could be inferred from the higher quantities of Pb seen in the samples as compared to the control which might be that this heavy metal was absorbed by the plant from vehicular emission and increase in traffic density since no factory is located in the sampling sites. This is in line with the report of Atayese et al. (2009) and Verma et al. (2013) who stated that there was a direct relationship between increased levels of heavy metals in plants and traffic density. This is also because lead is a major contaminant posing significant environmental problems (Shen et al., 2002) and is an accumulative protoplasmic poison (Verma et al., 2013). All the leaves of the sampled plants especially mango and orange exhibited higher levels of lead suggesting its ability to accumulate lead in comparison to oil palm plant and is considered as tolerant species This is in line with the study of Sahar and El – Khawas (2011) who showed that *Mangifera indica* accumulate higher levels of lead. Also, the higher quantities of Lead observed in the sampled sites could also be through absorption of this heavy metal from the soil since vegetation growing on soils with high concentrations of heavy metals has a tendency of absorbing the heavy metals through its rooting system and transporting them to other parts of the plants like leaves, flowers and fruits. This is so because higher quantities of lead were also observed in the soil surrounding the all sampled plants except in the control site.

Plant samples of mango, orange, guava, oil palm and almond leaves had Pb concentrations exceeding the WHO limit of 2 mg/kg reported for medicinal plants (Ghosh et al., 2009; WHO, 1996). The values are also higher than that of control (which ranges from 0.01-0.1). This variation might be attributed to high traffic density in the sampling locations. The result is similar to that of Jaya (2009) who reported that the concentration of heavy metals, lead and cadmium in raw mangoes (leaves) were beyond the permissible levels given by WHO for human consumption (WHO, 1996). The results of this study when compared with the WHO standard lower limits of Pb (0.3 mg/kg) indicate that the mango trees and the other plants sampled along the roads were contaminated with heavy metals except for those in the control site. The Pb contents of the plants in the control site of this study are lower when compared to the WHO (1996) safe limit of 0.3 mg/kg. The study showed that, in the plant, Pb contents are within the permissible limit. Thus, the Pb level in the leafy parts of the plants in the control site examined seems not to be alarming except in a case of excessive consumption.

Zinc was the second most dominant heavy metal observed in the study. Zinc has been considered as an essential element as it is a component of various enzymes (Woolhouse, 1983). The control plants revealed lesser concentrations of zinc. The increase in levels of zinc in plants at the sample site is because of the increased traffic density (Ogbonna and Ogbonna 2011; Sahar, 2011). The zinc levels observed in all the plants in the sampled sites were significantly ($P \leq 0.05$) higher than those observed in the control site. The plants used with higher levels of zinc accumulation are considered as zinc pollution indicators along busy roadways. This range of heavy metals are among the wide range of heavy metals found in fossil fuel which are either emitted into the environment as particles during combustion or may itself be transported in air and contaminate soil (Yahaya et al., 2010). This is in line with the report of WHO (2004) that combustion and traffic are among the sources of heavy metals in the environment. The increase in copper content in plants grown in the sample site as compared to those at the control site is attributed to increased traffic density. Increased copper levels in plant leaves subjected to vehicular pollution are well reported (Sahar, 2011; Adamsab et al., 2012). The Cu level in guava leaves were significantly ($P \leq 0.05$) higher than those in all the other plants used. By virtue of high copper content, guava plant could be regarded as copper pollution indicators. Also, the concentration of copper in the plant samples was within the daily dietary intake of 2–3 mg/kg and also within the WHO limit for medicinal plants. Nickel and Aluminum in the sampled locations were within the permissible limits of the WHO hence not considered harmful for consumption.

Heavy metal content in soil

The concentration of the heavy metals in the soil were in the order of Pb>Cu > Zn > Ni >Al with Ni showing significant presence in Choba and Delta parks for Orange, almond and oil palm food crops. Ni was absence in Abuja park and UPTH. The concentration of these heavy metals in the sampled sites were significantly ($P \leq 0.05$) higher than in the control site. The high concentrations of Pb observed in the sample soil as compared to the control could probably have been contributed by deposition of atmospheric Pb emitted from vehicles and industrial point sources, which could be carried over very long distances, as well as the application of lead containing pesticides on the land. This is in line with the study carried out by Cheng and Hu (2010). High values of Cu in the sample sites when compared to the controls might be due to corrosion of metallic car parts (Al-Khashman, 2004; Al-Khashman and Shawabkeh, 2006). The prevalence of Zn, though the least toxic among all heavy metals (Ladipo and Doherty, 2011) in the study area is indicative of the significance of zinc in the ecosystems. Also, the traffic situation in the study area could be regarded as a source of zinc in the roadside dust. Wear and corrosion of vehicle parts (brakes, tyres, radiators, body, and engine parts) might also be one of the potential sources of Zn in roadside dust. Zn values in the soil samples from the sample sites were found to be higher than in the control sites. Opaluwa et al. (2012) noted that the spread of these metals over a large span of land and the continuous usage of these farmlands for growing crops could lead to bioaccumulation, hence the need for reduction in the concentration of the metals. In comparison to international standard for permissible level of heavy metals in soil as recommended by World Health Organization (WHO, 1996), the concentration of lead, copper, zinc, nickel, and aluminum in the sampled sites are below the permissible level (Table 1). Hence, the level of pollution of these areas is still minimal. Plants grow by absorbing nutrients from the soil and their ability to do so depend on the nature of the oil, its location, combination of sand, silt, clay, and organic matter.

Table 1. WHO permissible limits for heavy metals in plant and soil.

Element	Target value of soil (mg/kg)	Permissible value of plant (mg/kg)
Cd	0.8	0.02
Zn	50	0.60
Cu	36	10
Cr	100	1.30
Pb	85	2
Ni	35	10

Source: WHO (1996) Permissible limits of heavy metals in soil and plants (Geneva: World Health Organization), Switzerland.

Usually metals preferentially concentrate in the leaves next to its roots and then the stem. Large number of factors control metal accumulation and bioavailability associated with soil and climatic conditions, plant genotype and agronomic management, including: active/passive transfer processes, sequestration and speciation, the type of plant root system and the response of plants to elements in relation to seasonal cycles. This study presents the same pattern. There was higher metal accumulation in the soil than in the leaves. Results of analysis of variance (ANOVA) show significant variations in the levels of heavy metals within the leaves of the plants used from the four sampled locations and the control site. This variation may be due to the fact that different plants contain different proportion of heavy metals, depending upon age of plant and other environmental factors, as can be observed amongst various treatments.

Conclusion

Heavy mental associated with vehicular movement affect ecosystem. It has been proven to disturb development or even cause death when present at levels higher than the organism can tolerate, which depends on organism and species. Studies have shown that lead, copper and zinc are heavy metal that affects road side vegetation. In this study, all sampled soils and leaves contained Pb, Zn, Cu, Ni and Al. Heavy metal in sampled leaves where in the other Pb>Zn>Cu>Al>Ni while for soil it was Pb>Cu>Zn>Ni>Al. The heavy metal uptake by sampled sites are in the order Delta park>UPTH>Choba park>Abuja for soil and for leaves Delta park>Choba park>Abuja park>UPTH respectively.

The concentrations of Pb and Zn in the leaves of sampled plants exceeded the WHO recommended tolerable intake considered suitable for humans while the concentrations of Cu, Ni and Al were within the normal range for human consumption. Also, the metals concentrations in the soils show that these heavy metals were below permissible levels (WHO standard). It can also be concluded that the uptake efficiency of these heavy metals under study are in the order of mango > orange > oil palm > guava > almond. For better efficient clean-up especially where an area is polluted with heavy metals such as the ones in this study, mango, orange and oil palm with higher levels of lead, copper, and zinc was considered as a multi metal indicator and can be used to monitor and ameliorate heavy metal pollution in the urban localities while if an equal proportion all many heavy metals is evident then it will be better to use mango as a phytoremediation plant.

However, the mean concentration of the heavy metals was lower than the permissible limits set by European union standard (2000), but care must be taken to maintain a low level of heavy metal concentration on roadside dust as these metals are bio-accumulative and the dust can travel to long distance to human residence. There should be extensive awareness campaign on the need for enhanced fuel quality and the emplacement of emission standards to reduce the impact of vehicle emissions. The government should come up with vehicle inspection and maintenance facilities in order to ensure the roadworthiness of vehicles and impound vehicles that violate emission standards in the country.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Adamsab, M.P., HinaKousar, Nuthan Kumar, D., and Sujith, V.S., (2012). Assessment of certain heavy metals (iron, manganese, zinc and copper) in Shivamogga, Machenahalli, Bhadravathi and Tammadihalli forest of Karnataka, India. *World Journal of Science and Technology*, 2(11): 32-35.

Al-Khashman, O. A. (2004). Heavy metal distribution in dust, street dust and soil from the work place in Karak Industrial Estate, Jordan. *Atmospheric Environment, 38*: 6803-6812.

Al-Khashman, O. and Shawabkeh, R. (2006). Metal Distribution in Soils around the Cemetery in Southern. Jordan. *Environmental Pollution, 140*: 387-394.

Anyanwu, D.I., Awi-Waadu, G.D.B., Tanee, F.B.G. and Ochekwu, E.B. (2014). Fundamental Principles of Ecology. M and J Grand Orbit Communication Ltd, Port Harcourt.

Atayese, M.O., Eigbadon, A.I., Oluwa, K.A., Adesodun J.K., (2009). Heavy metal contamination of *Amaranthus*grown along major highways in Lagos. *African Crop Science Journal*, 16:225-235.

Awofolu O.R. (2005). A survey of trace metals in vegetation, soil and lower animal along some selected major roads in metropolitan city of Lagos. Environ Monit Assess. Jun; 105(1-3):431-47.

Bamgbose, O., Arowolo, T.O.A and Odukoya, O (2000). Earthworm as a Bio-indicators of Metal Pollution Dumpsite of Abeokuta. Nigeria. Rev.Biol. Trop. V. 48n.J. San. Jose.

Bhatia, S.C. (2006). *Environmental chemistry.* Satish Kumar Jain for CBS Publisher and Distributors, India.

Chimuka L, Mugwedi R, Moboladisoro BH, and Odiyo OJ (2005). Metals in environmental media*:* A study of trace and platinum group metals in Thohoyandou, South Africa. Water SA.**31**(4): 581-588.

Duffus J. H. (2002). Heavy metals -A meaningless terms from International Union of Pure and Applied Chemistry. Pure Appl.Chem. , **74** (5):793-807.

European Union (2000). Heavy metals in wastes. European Commission on Environment.

Ghosh, A. K. M., Zaidi, H., and Attique, A. (2009). Effect of air pollution on the foliar organs of *Callistemon citrinus*Stapf. *J. Sci Res.* 2: 207-209.

Ghosh, A. K. M., Zaidi, H., and Attique, A. 2009. Effect of air pollution on the foliar organs of *Callistemon citrinus*Stapf. *J. Sci Res.* 2: 207-209.

Helmenstine, A.M (2014). Heavy metals definition.chemistry.about.com/…/chemistry glossary/… heavy metal definition.html.

Jaya, D.S. (2009). Assessment of heavy metal contamination in the evergreen tree *Mangifera indica* L. and soils near National Highway-47 in Thiruvananthapuram District, Keral *Toxicology International* 16(1): 43—47.

Ladipo, M. K. and Doherty, V. F. (2011). “Heavy metal levels in vegetables from selected markets in Lagos, Nigeria”. *African Journal of Food Science and Technology.* 2(1): 18-21.

Maryan, M.R., Soheilm S., Hoda, K. and Rezvan, S. (2015). Natural and Anthropogenic Source of Heavy Metals Pollution in the Soil Samples of an Industrial Complex; a Case Study. *Iranian Journal of Toxicology*. 9 (29): 1336-1341.

Nriagu J.O (1996). Heavy metals in the environment: An Overview. *Journal of an Environmental Biology* 26: 301-313.

Okonkwo, O.J and Maribe F. (2004). Assessment of Lead Exposure in Thohoyandou, South Africa. The Environmentalist. **24**:171-178.

Ogbonna, I.L.P., and Ogbonna, C.P., (2011). Heavy Metal Content in Soil and Medicinal Plants in High Traffic Urban Area. *Pakistan Journal of Nutrition,* 10 (7): 618-624.

Opaluwa, O.D., Aremu, M.O., Ogbo, L.O., Abiola, K.A., Odiba, I.E., Abubakar, M.M., and Nweze, N.O (2012). Heavy metal concentrations in soils, plantleaves and crops grown around dump sites in LafiaMetropolis,Nasarawa State, Nigeria. *Advances in Applied Science Research*,2012,3 (2):780-784.

Ozuzu, S. A., Ochekwu, E. B. and Ndukwu, B. C. (2020): Epiphytic *platycerium andinum* baker growing around generator houses: a bioaccumulator for heavy metals.*global scientific journal*: 8 (5): 1191 - 1203 may 2020, online: issn 2320-9186 www.globalscientificjournal.com

Sahar A., and El – Khawas, (2011). Certain medicinal plants as biomonitors to roadside automotive pollution. *Journal of Food, Agriculture & Environment*, 9(1):593-598.

Sharidah, M.M.A (1999). Heavy Metal in Mangrove Sediments of the United Arab Emirates Shorelines. (Arabian Gulf). Water, Air and Soil Pollutant. **116**:523-534

Shen Z.G., Li X.D., Wang C.C., Chen H.M., and Chua H,(2002). Lead phytoextraction from contaminated soilwith high-biomass plant species, *J. Environ. Qual.*, 31: 1893-1900.

SPSS (2014). Statistical package for Social Sciences version 14

Verma, D.K., Gupta, A.P. and Dhakeray, R., (2013). Bioindicators: A Comparative Study on Uptake and Accumulation of Heavy Metals in Some Plant's Leaves of M.G. Road, Agra City, India. *International Journal of Environmental Pollution and Solutions*, 2:37-53.

Woolhouse, H.W., (1983). Toxicity and tolerance in the responses of plants to metals. Encyclopedia of Plant Physiology, Physiological Plant Ecology III, New Series. Springer - Verlag, Berlin, Heidelberg, New York, pp 245-302.

WHO (1996). Permissible limits of heavy metals in soil and plants (Geneva: World Health Organization), Switzerland.

WHO (2004). Task group on environmental health criteria for arsenic and Arsenic Compounds 18, World Health Organization, Geneva, Switzerland.

Yahaya, M.I., G.C. Ezeh, Y.F. Musa and S.Y. Mohammad, (2010). Analysis of heavy metals concentration in roadsides soil in Yauri, Nigeria. *Afr. J. Pure Applied Chem*., 4:22-30