Journal of Research in Forestry, Wildlife & Environment Vol. 9(1) March, 2017
http://www.ajol.info/index.php/jrfwe

jfewr ©2017 - jfewr Publications
E-mail:jfewr@yahoo.com
ISBN: 2141 – 1778
Adereti et al., 2017

ASSESSMENT OF HEAVY METAL CONCENTRATION IN SOIL AND LEAVES OF TREE SPECIES AROUND A SCRAP METAL RECYCLING FACTORY IN ILE-IFE, OSUN STATE, NIGERIA

Adereti K.F[1], Awotoye O.O[1], Adebola S. I[1], and Akinpelu B.A[2]
[1]Institute of Ecology and Environmental Studies, [2]Department of Biochemistry
Obafemi Awolowo University Ile-Ife, Nigeria

Corresponding Author: +2348074499623; kehindefrancisca@gmail.com

ABSTRACT

The gaseous emissions from scrap metal recycling factory could cause pollution to the environment if the concentrations are substantial and not properly controlled. This study determined the concentration of some heavy metals (Iron, Copper, Lead and Cadmium) in the leaves of selected tree species and soils around the scrap metal recycling factory in Ile-Ife, Osun state, Nigeria. The heavy metals were analysed, using the Buck Atomic Absorption Spectrophotometer. Samples for analysis were taken from the leaves and soil underneath Newbouldia laevis, Trema orientalis, Tectona grandis, Alstonia boonei, Bridelia micrantha and Senna siamea, trees. The results showed that the mean concentration of Pb and Fe (mg/kg) in the soil underneath these tree species were greater in the dry season than the wet season except in the soil underneath Alstonia boonei that showed no relative change in Pb concentration. The Pb content in the leaves of all the tree species was higher in the wet season relative to dry season, with Tectona grandis having the highest Pb concentration (90.2 mg/kg) in the wet season. However, the concentration of Fe in both wet and dry season was greater than the concentration of other heavy metals analysed in all the tree species. The soil under Tectona grandis was observed to accumulate more Cu (19.3 mg/kg) in the dry season than the other tree species. The study revealed increase in accumulation of heavy metals in the soil during the dry season and the leaves of the studied tree species during the wet season. Tree species whose heavy metal content exceeded permissible levels should be encouraged around metal polluted sites due to their high tolerance for heavy metal concentration.

Keywords: Concentration, heavy metals, wet and dry season, recycling factory, tree species.

INTRODUCTION

Accumulation of heavy metals may vary from plant to plan tand from one soil location to another due to relativity of anthropogenic activities (Singhand Agrawal, 2010). Some human activities had been reported to increase the concentration of heavy metals in terrestrial systems to levels that are harmful to both plants and animals in the environment. Such activities include mining and smelting of metals, burning of fossil fuels, use of fertilizers and pesticides in agriculture, production of batteries and other metal products in industries, sewage sludge, and municipal waste disposal (Alloway, 1990; Raskin *et al*., 1994; Shen *et. al*., 2002). Heavy metals occur as natural constituents of the earth crust and are regarded as persistent environmental contaminants since they cannot be degraded or destroyed (Duruibe *et. al*., 2007). Although, these elements may not be in abundance, their environmental impacts may be quite significant (Chen and Chen, 2001). These elements are characterized by relatively high density, high relative atomic weight with an atomic number greater than 20 (Raskin *et al*., 1994) and have metallic properties such as ductility, malleability, conductivity, cation stability and ligand specificity (Chibuike and Obiora, 2014). Some of these metals like Co, Cu, Fe, Mn, Mo, Ni, V and Zn may be required in minute quantities by organisms for vital physiological functions. The heavy metals that are available for plant uptake are those that are present as soluble components in the soil solution or those that are easily solubilized by root exudates (Blaylock and Huang, 2000). Excessive amounts of these elements can become harmful to organisms while some (such as Pb, Cd, As, and Hg) do not have any beneficial effect in organisms and are thus regarded as the "main threats" due to their harmful effect on both plants and animals (Chibuike and Obiora, 2014).

Heavy metals have been classified to be among the major causes of environmental pollution and this has been observed to cause severe illness and sudden death in human for many centuries (Adedokun *et al*., 1989; Galadima *et al*., 2011). Some of the direct toxic effects caused by high metal concentrations in plants include inhibition of cytoplasmic enzymes and damage to cell structures due to oxidative stress (Assche and Clijsters, 1990; Jadia and Fulekar, 2009). An example of indirect toxic effect is the replacement of essential nutrients at cation exchange sites of plants (Taiz and Zeiger, 2002). They enter the human system through food chain or are absorbed through the skin when they come in contact with humans (Lin *et al*., 2004; Galadima *et al*., 2010).

Soils polluted with heavy metals have become common across the globe due to increase in geologic and anthropogenic activities (Alloway, 1990; Raskin *et al*., 1994; Shen *et al*., 2002). Growth reduction as a result of changes in physiological and biochemical processes in plants growing on heavy metal-polluted soils has been recorded (Chatterjee and Chatterjee, 2000; Oncel *et al*., 2000; Oancea, 2005). There is dearth of information on the seasonal dynamics of these metals in soil and tree system, hence this study to investigate the seasonal variation of heavy metal concentration in soil and tree leaves around a scrap metal recycling factory in Ile-Ife, Osun state, Nigeria.

MATERIALS AND METHOD

The study was carried out within the vicinity of the iron and steel recycling factory (latitude 7° 29´ 30´´ N and 7° 30´ 0´´ N and longitude 4° 28´ 30´´ E and 4° 29´ 30´´ E), along Ife-Ibadan expressway about 3 km from Ife-Ibadan-Ilesha roundabout and about 5 km from the Obafemi Awolowo University main campus, Ile-Ife, Nigeria.

Sampling plots were established along line transects at increasing distance from the Iron and Steel Recycling Factory, Ile- Ife, to determine the effect of distance on heavy metal accumulation by the tree species (Salami *et al.* 2014). The transects were located in the four cardinal directions of North (N), East (E), South (S), and West (W) of the factory. The plots were established starting from zero meters, (factory site) up to three hundred and fifty meters in each of the four directions. Soil and plant samples were collected during the dry and wet seasons. Dominant tree species with height of about 1.3 m and above with a girth size of 10 cm and above (indicative that the stand had become fully matured) were purposively selected and used for the study. Leaf samples were collected from tree species selected for the study while soil samples were collected under the canopy of the selected tree stands at a depth of 0 – 30 cm (top soil).

Matured fresh leaf samples were collected early in the morning from tree species of *Newbouldia laevis*, *Trema orientalis*, *Tectona grandis*, *Alstonia boonei*, *Bridelia micrantha* and *Senna siamea*. The tree species were selected using the randomized block method. The leaf samples were collected from the vicinity of the iron and steel recycling factory.

Soil samples were collected at 0 – 30 cm depth (top soil), using a soil auger at points of the selected tree stands. The collected soils were air-dried and transferred to the laboratory for analysis of some heavy metals.

The leaf samples were oven-dried at 70^0C and milled into a powdery form. To each sample (0.5 gm) put in a beaker was added 10 ml of acid mixture (perchloric/nitric acid) in the ratio 2:1 and heated for about 30 minutes to undergo digestion until it turned colourless. The digest was made up to 25 ml with distilled water and analysed for Iron (Fe), Copper (Cu), Lead (Pb) and Cadmium (Cd) using the Buck Atomic Absorption Spectrophotometer model 210/211 VGP.

The soil samples were air-dried and sieved using a 2 mm and 0.5 mm sieve. From the 0.5 mm sieved soil, 0.5 grams was weighed into a beaker and an acid (perchloric/nitric acid) mixture in the ratio 2:1 was added and allowed to undergo digestion until it turned colourless. The digest was allowed to cool, and volume made up to 25

ml with distilled water and analysed for Iron (Fe), Copper (Cu), Lead (Pb) and Cadmium (Cd) using the Buck Atomic Absorption Spectrophotometer Model 210/211 VGP.
The data collected were subjected to descriptive and inferential statistics using the Statistical Program for Social Sciences (SPSS) version 17. Results were considered significant at 95% Confidence Interval.

RESULTS

Seasonal Variation of Heavy Metal Concentration in Soils under Studied Tree Species

As shown in Fig. 1a and Table 1, the results revealed significant seasonal variation in the concentration of Pb in the sampled soils except the soil under *Alstonia boonei*. Soils under *Trema orientalis* and *Bridelia micrantha* accumulated more Pb [*Trema orientalis* (52.6 mg/kg) and *Bridelia micrantha* (49.9 mg/kg] in the dry season compared to soils under other studied tree species. The Pb content was observed to be higher in the soil during the dry season than the wet season except in *Alstonia boonei* which showed no relative change in Pb concentration. The Cd concentration of the soils under different tree species exhibited no significant seasonal variations except for *Newbouldia laevis* and *Bridelia micrantha* (Fig 1b and Table 1). As shown in Fig 1c and Table 1, there was a significant seasonal variation in the concentration of Cu in the soils samples taken under *Tectona grandis*, *Bridelia micrantha* and *Senna siamea*. Soil samples taken under *Tectona grandis* had a higher concentration of Cu (19.3 mg/kg) in the dry season than all the other tree species. The soils under the studied tree species exhibited significant seasonal variation in their Fe content except for *Bridelia micrantha*. Soil samples under *Newbouldia laevis* had the lowest Fe concentration both in the dry (34,287.5 mg/kg) and wet season (19,815.0 mg/kg) than all the other studied tree species. In the dry season, significant increase in the Fe concentration (57,841.0 mg/kg) in the soil under *Trema orientalis* were observed compared to other studied tree species (Fig 1d and Table 1).

Seasonal Variation in Heavy Metal Concentration in Leaves of Studied Tree Species

The result (Fig. 2(i) and Table 2) showed a higher Pb concentration in the leaves of all the tree species in the wet season than during the dry season, with *Tectona grandis* having the highest Pb concentration (90.2 mg/kg) in the wet season. *Trema orientalis*, *Tectona grandis* and *Alstonia boonei* were shown (Fig.2 (ii) and Table 2) to accumulate more Cd in the dry season; Cd concentration was more in the wet season in *Senna siamea*(2.3 mg/kg) while there was relatively no significant seasonal variation in the concentration of Cd in *Newbouldia laevis* and *Bridelia micrantha*. Furthermore, significantly higher concentrations of Cu and Fe were recorded in *Newbouldia laevis*, *Trema orientalis* and *Tectona grandis* during the wet season than the dry season. When compared with other tree species, there was no significant seasonal variation in the concentration of Cu and Fe recorded for *Bridelia micrantha* (Figures 2(iii – iv) and Table 2).

Figure 1(a – d): Seasonal Variation in concentrations of Heavy Metals in Soils under Different Tree Species

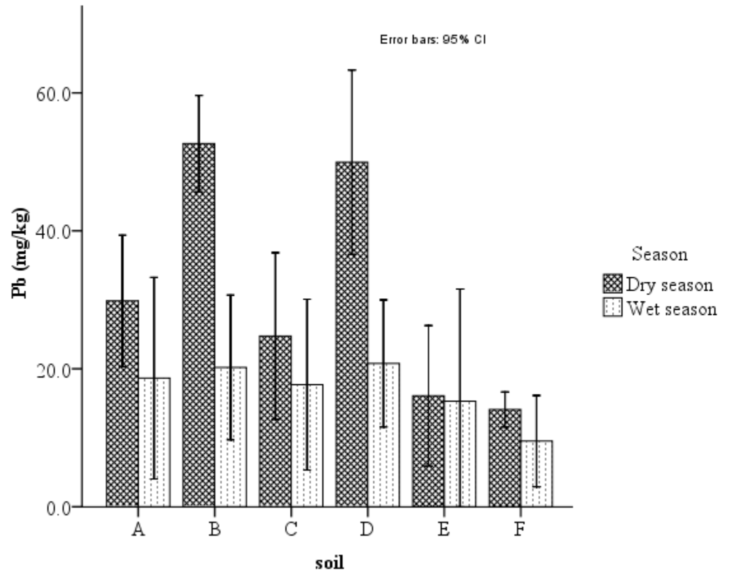

Fig 1a: Mean Seasonal Variation of Pb in Soils under Different Tree Species
Soil A= soil under *Newbouldia laevis*
Soil B= soil under *Trema orientalis*
Soil C= soil under *Tectona grandis*
Soil D= soil under *Bridelia micrantha*
Soil E= soil under *Alstonia boonei*
Soil F= soil under *Senna siamea*

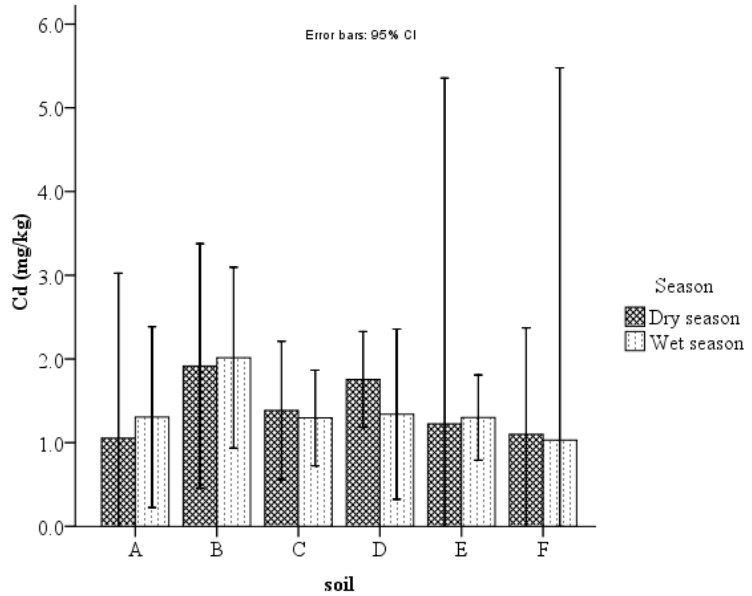

Fig1b: Mean Seasonal Variation in Concentration of Cd in Soils under Different Tree Species
Soil A= soil under *Newbouldia laevis*
Soil B= soil under *Trema orientalis*
Soil C= soil under *Tectona grandis*
Soil D= soil under *Bridelia micrantha*
Soil E= soil under *Alstonia boonei*
Soil F= soil under *Senna siamea*

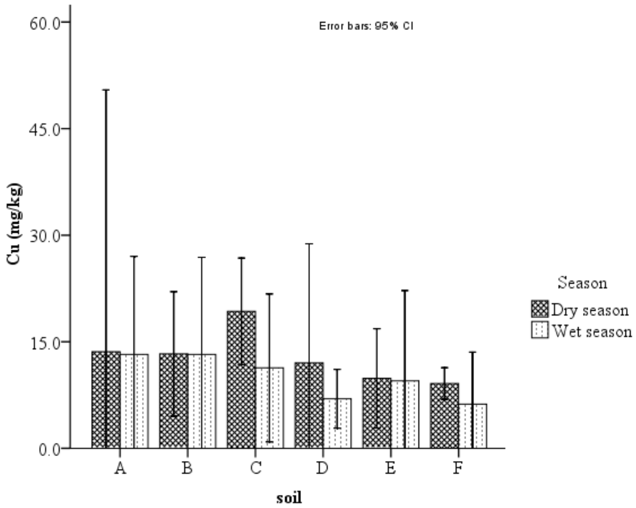

Fig1c: Mean Seasonal Variation in Concentration of Cu in Soils under Different Tree Species
Soil A= soil under *Newbouldialaevis*
Soil B= soil under *Tremaorientalis*
Soil C= soil under *Tectonagrandis*
Soil D= soil under *Brideliamicrantha*
Soil E= soil under *Alstoniaboonei*
Soil F= soil under *Sennasiamea*

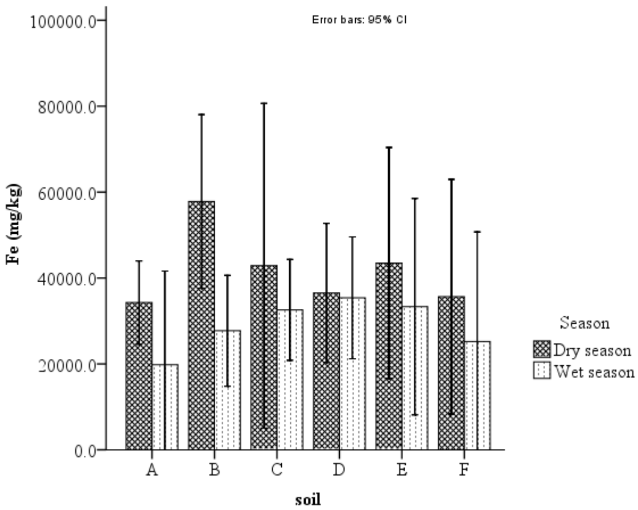

Fig1d: Mean Seasonal Variation of Fe Concentration in Soils under Different Tree Species
Soil A= soil under *Newbouldialaevis*
Soil B= soil under *Tremaorientalis*
Soil C= soil under *Tectonagrandis*
Soil D= soil under *Brideliamicrantha*
Soil E= soil under *Alstoniaboonei*
Soil F= soil under *Sennasiamea*

Table 1: Mean Seasonal Concentration of Heavy Metals in Soil at Points of the Selected Tree Species around the Scrap Metal Recycling Factory

	Pb (mg/kg)		**Cd (mg/kg)**		**Cu (mg/kg)**		**Fe (mg/kg)**	
Soil	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**
Newbouldia laevis	29.8 ± 0.8^a	18.7 ± 1.2^b	1.1 ± 0.2^a	1.3 ± 0.1^a	13.6 ± 2.9^a	13.2 ± 1.1^a	34287.5 ± 762.5^a	19815.0 ± 1715.0^b
Trema orientalis	52.6 ± 0.6^a	20.2 ± 0.8^b	1.9 ± 0.1^a	2.0 ± 0.1^a	13.3 ± 0.7^a	13.2 ± 1.1^a	57841 ± 1591.0^a	27715.5 ± 1015.5^b
Tectona grandis	24.7 ± 0.9^a	17.7 ± 0.9^b	1.4 ± 0.07^a	1.3 ± 0.04^a	19.3 ± 0.6^a	11.3 ± 0.8^b	42874 ± 2975.5^a	32575 ± 925.0^b
Bridelia micrantha	49.9 ± 1.1^a	20.8 ± 0.7^b	1.8 ± 0.04^a	1.3 ± 0.1^b	12.0 ± 1.3^a	6.9 ± 0.3^b	36525 ± 1275.0^a	35396.0 ± 1116.9^a
Alstonia boonei	16.1 ± 0.8^a	15.3 ± 1.3^a	1.2 ± 0.3^a	1.3 ± 0.04^a	9.9 ± 0.6^a	9.5 ± 1.0^a	43483.0 ± 2117.0^a	33333.0 ± 1983.0^b
Senna siamea	14.1 ± 0.2^a	9.5 ± 0.5^b	1.1 ± 0.1^a	1.03 ± 0.4^a	9.1 ± 0.2^a	6.2 ± 0.6^b	35650.0 ± 2150.6^a	25210.0 ± 2010.0^b

Values for each variable during the dry and wet seasons with different alphabet (superscript) indicate significant variation at $p<0.05$

Figure 2 i-iv: Seasonal Variation of Pb, Cd, Cu and Fe in Leaves of Selected Tree Species

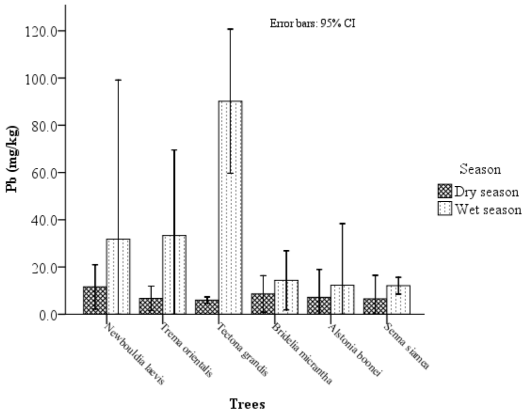

Fig 2 (i): Seasonal Variation of Pb in Leaves of Studied Tree Species

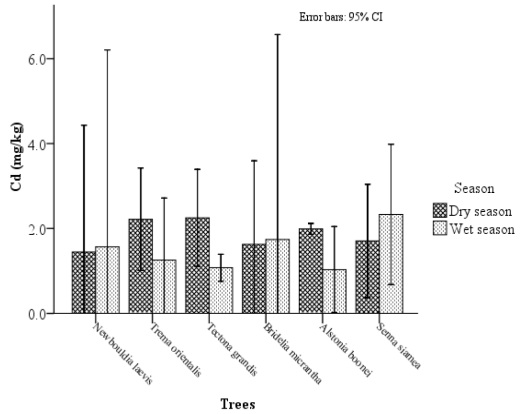

Fig 2 (ii): Seasonal Variation of Cd in Leaves of Studied Tree Species

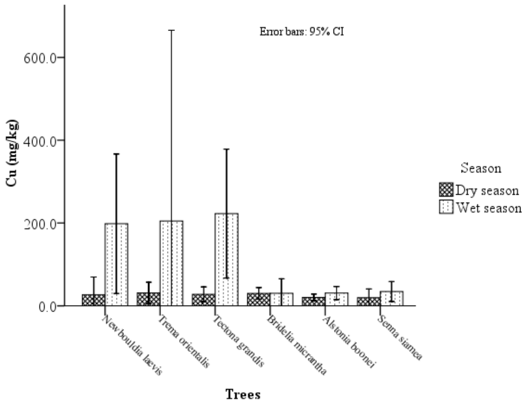

Fig 2 (iii): Seasonal Variation of Cu in Leaves of Studied Tree Species

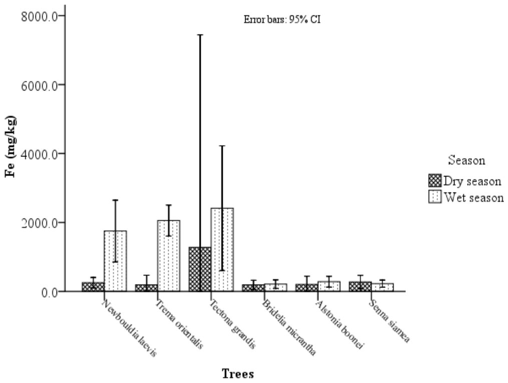

Fig 2 (iv): Seasonal Variation of Fe in Leaves of Studied Tree Species

Table 2: Mean Seasonal Concentration of Heavy Metals in Leaves of Selected Tree Species around the Scrap Metal Recycling Factory

	Pb (mg/kg)		**Cd (mg/kg)**		**Cu (mg/kg)**		**Fe (mg/kg)**	
Tree Species	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**	**Dry Season**
Newbouldia laevis	11.6 ± 0.7^{a}	31.8 ± 5.3^{b}	1.4 ± 0.2^{a}	1.6 ± 0.6^{a}	26.8 ± 3.4^{a}	198.3 ± 13.3^{b}	252.6 ± 11.9^{a}	1750.5 ± 70.5^{b}
Trema orientalis	6.7 ± 0.4^{a}	33.4 ± 2.9^{b}	2.2 ± 0.09^{a}	1.3 ± 0.1^{b}	31.2 ± 2.0^{a}	204.8 ± 36.3^{b}	190.4 ± 21.9^{a}	2055.3 ± 35.3^{b}
Tectona grandis	6.0 ± 0.1^{a}	90.2 ± 2.4^{b}	2.3 ± 0.1^{a}	1.1 ± 0.03^{b}	27.9 ± 1.9^{a}	222.8 ± 12.3^{b}	1280.0 ± 485.0^{a}	2412.5 ± 142.5^{b}
Bridelia micrantha	8.6 ± 0.6^{a}	14.3 ± 0.9^{b}	1.6 ± 0.2^{a}	1.7 ± 0.4^{b}	30.1 ± 1.1^{a}	30.4 ± 2.8^{a}	190.8 ± 10.3^{a}	210.7 ± 9.7^{a}
Alstonia boonei	7.2 ± 0.9^{a}	12.3 ± 2.1^{b}	1.9 ± 0.01^{a}	1.0 ± 0.1^{b}	20.4 ± 0.6^{a}	30.8 ± 1.3^{b}	202.3 ± 18.8^{a}	280.8 ± 12.4^{b}
Senna siamea	6.5 ± 0.8^{a}	12.1 ± 0.3^{b}	1.7 ± 0.1^{a}	2.3 ± 0.1^{a}	19.7 ± 1.7^{a}	34.6 ± 1.9^{b}	275.6 ± 15.1^{a}	224.4 ± 8.1^{b}

Values for each variable during the dry and wet seasons with different alphabet (superscript) indicate significant variation at $p<0.05$

DISCUSSION

The concentrations of Pb in the soil samples were found to be below the maximum permissible level according to WHO (1993) (90 – 400 mg/kg for Pb). The result showed that Cd and Cu concentrations in the soil were still within the maximum permissible level as stated by MAFF (1992) (0.01 – 3.0 mg/kg for Cd) and Kabata-Pendias (2004) (30 mg/kg for Cu). In the dry season, significant increase in the concentration Fe in the soil under *Trema orientalis* was observed compared to other studied tree species. The findings corroborates the study by Yahaya *et al*. (2010) who observed significantly higher Fe concentration in road side soils in Yauri relative to other heavy metals. The increase in the concentration of Fe in the soil could probably be related to the activities of the factory because most of the scraps were made from Fe and Al materials. The Fe concentrations in the soil under *Trema orientalis* (Figure 1) exceeded the maximum permissible level according to Ewers (1991) (50,000 mg/kg) during the dry season.

The significant increase in the concentration of Pb could be as a result of its dissolution by rain which made it available in soil solution to be easily taken up by the plant roots. The high Fe concentration in the leaves of *Tectona grandis* could be due to its proximity to the recycling factory and its large leaves, which are wide enough for deposition of metals and other particulates from the air, consequently leading to absorption by the leaves. Dobermann and Fairhurst, (2000) reported plant leaves with 300-500 mg/kg Fe concentration to be toxic to the plants. In this study, the concentration of Fe in the leaves of *Newbouldia laevis*, *Trema orientalis* and *Tectona grandis* exceeded the cited toxicity level. The leaves of the studied plant also contained Pb and Cd concentrations in excess of permissible levels of 0.3 mg/kg and 0.2 – 0.5 mg/kg respectively (FAO/WHO, 2007).

CONCLUSION

The concentration of heavy metals in the soil was significantly higher during the dry season compared to the wet season. The heavy metal concentrations were significantly higher in the leaves of the tree species during the wet season. Also, Fe concentration was recorded to be highest of all heavy metals during the dry and wet season both in the soil and leaves of the selected tree species. Elevation in Fe concentrations could possibly result from scraps being recycled, since the scraps are mostly made from Fe materials, in the studied environment.

RECOMMENDATION

Trees with high concentration of heavy metals (e.g. *Tectona grandis*, *Trema orientalis* and *Newbouldia laevis*) should be planted around metal recycling factories as part of facilities needed for ameliorating pollution in industrial sites.

Further research work should be carried out to study the accumulation of heavy metals in the crops grown around the vicinity of the scrap metal recycling factory.

ACKNOWLEDGEMENT

We are most grateful to God almighty for the privilege to carry out this research work and to write this paper.

REFERENCES

Adedokun, J. A., Emofureta, W. O. and Adedoji, O. A. (1989). Physical, Mineralogical and Chemical Properties of Harmattan Dust at Ile-Ife, Nigeria.*Applied Climatology*, 40:161-169.

Alloway, B. J. (1990). Heavy Metal in Soils, John Wiley & Sons, New York, NY, USA.

Assche, F. and Clijsters, H. (1990).Effects of Metals on Enzyme Activity in Plants.*Plant, Cell and Environment*, 24: 1–15.

Blaylock, M. J. and Huang, J. W. (2000). Phytoextraction of Metals, in Phytoremediation of Toxic Metals: Using Plants to Clean up the Environment, Raskin I. and Ensley, B. D. Eds., 53–70, Wiley, New York, NY, USA.

Chatterjee, J. and Chatterjee, C. (2000). Phytotoxicity of Cobalt, Chromium and Copper in Cauliflower. *Environmental Pollution*, 109(1): 69–74. 219.

Chen, Y.and Chen, M. (2001). Heavy metal concentrations in Nine species of fishescaught in coastal waters off Ann-ping S.W. Taiwan. *Journal of Food and Drug Analysis*, 9(2).

Chibuike, G. U. and Obiora, S. C. (2014).Heavy Metal Polluted Soils: Effect on Plants and Bioremediation Methods. *Applied and Environmental Soil Science* Volume 2014 Article ID 752708.

Dobermann, A. and Fairhurst, T. (2000). Rice, Nutrient Disorders and Nutrient Mamagement. Handbook Series.*Potash and phosphate institute of Canada*, 191.

Duruibe, J. O., Ogwuegbu, M. O. C. and Egwurugwu, J. N. (2007).Heavy Metal Pollution and Human BiotoxicEffects.*International Journal of Physical Sciences*, 2(5): 112- 118.

Ewers, U. (1991).Standards, guidelines and legislative regulations concerning metals and their compounds. In: Merian E, ed. Metals and Their Compounds in the Environment: Occurrence, *Analysisand Biological Relevance. Weinheim*: VCH, 458-468.

FAO/WHO, (2007). Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 13 Session. Report of the thirty eight session of the codes committee on food hygiene. Houston, United State of America, ALNORM 07/03/13.

Galadima, A., Muhammad, N. U. and Garba, Z. N. (2010).Spectroscopic Investigation of Heavy Metals in Waste Water from University Students' Halls of Residence. *International Journal of Chemistry*, 20(4): 239-244.

Galadima, A., Garba, Z. N., Leke, L., Almustapha, M. N. and Adam, I. K. (2011). Domestic Water Pollution among Local Communities in Nigeria: Causes and Consequences. *European Journal of Scientific Research* ISSN 14 216X 52(4): 592-603.

Jadia, C. D. and Fulekar, M. H. (2009). Phytoremediation of Heavy Metals: Recent Techniques. *African Journal of Biotechnology*, 8(6): 921–928.

Kabata-Pendias, A. (2004). Soil-Plant Transfer of Trace Elements – An Environmental Issue *Geoderma*, 122: 143–149.

Lin, H., Wong, S. and Li, G. (2004).Heavy Metal Content of Rice and Shellfish in Taiwan. *Journal of Food and Drug Analysis*, 12 (2): 167–174.

MAFF (Ministry of Agriculture, Fisheries and Food) and Welch Office Agriculture Department (1992).Code of Good Agriculture Practice for the Protection of Soil. Draft Consultation Document, MAFF, London.

Oancea, S., Foca, N. and Airinei, A. (2005). Effects of Heavy Metals on Plant Growth and Photosynthetic Activity, AnaleleS¸ tiint¸ifice ale Universitatii AL. I. CUZA1 IASI, Tomul I, s. Biofizica, Fizicamedicalasi Fizicamediului, 107–110.

Oncel, I., Keles, Y. and Ustun, A. S. (2000).Interactive Effects of Temperature and Heavy Metal Stress on the Growth and Some Biochemical Compounds in Wheat Seedlings. *Environmental Pollution*, 107(3): 315–320.

Raskin, I., Kumar, P. B. A. N., Dushenkov, S. and Salt, D. E. (1994).Bioconcentration of Heavy Metals by Plants. *Current Opinion in Biotechnology*, 5(3):285–290.

Salami, O. O. (2013). Heavy Metals Assessment of Soils and Vegetation Within and Around A Scrap Metal Recycling Factory Site in Ile-Ife, Osun State, Nigeria. M.Sc. Thesis, Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile- Ife.

Singh, R. P. and Agrawal, M. (2010) Variations in heavy metal accumulation, growth and yield of rice plants grown at different sewage sludge amendment rates *Ecotoxicology and Environmental Safety*, 73(4): 632-641

Shen, Z., Li, X., Wang, C., Chen, H. and Chua, H. (2002).Lead Phytoextraction from Contaminated Soil with High-Biomass Plant Species. *Journal of Environmental Quality*, 31(6): 1893–1900.

Taiz, L. and Zeiger, E. (2002). Plant Physiology, Sinauer Associates, Sunderland, Mass, USA.

World Health Organization (WHO) (1993).Standard Maxima for Metals in Agricultural Soils.

Yahaya, M. I., Ezeh, G. C., Musa, Y. F., Mohammad, S. Y. (2010). Analysis of Heavy Metals Concentration in Road Side Soil in Yauri, Nigeria. African *Journal of Pure and Applied Chemistry*. 4(3):022-030