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Determination of some heavy metals in vegetable garden soil and waste dumpsite soil in Mubi North, Adamawa State, Nigeria

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Abstract. *A research conducted on soil samples using different depths were carried out on the determination of heavy metals (Pb, Cu, Zn, Ni, Cd and As) in Wuro-Gude vegetable garden soil and waste dumpsite soil, Mubi Metropolis Adamawa State, Nigeria. The soil samples were collected on different depths and were transported to the department of animal production laboratory for digestion. The mixtures were digested with tri-acid mixture (HNO_3: HCO_4: H_2SO_4) and determination of the heavy metals was done using a Buck Scientific 200A Model, Atomic Absorption Spectrophotometer (AAS). It was found that the heavy metals concentration in both types of soils at the depth of 5, 15 and 25cm was as follows: a) Vegetable garden soil: Ni - 7.33mg/g, 5.06mg/g and 3.04mg/g; Zn - 16.31mg/g, 13.08mg/g and 8.37mg/g; Cu - 6.94mg/g, 4.77mg/g and 3.28mg/g; Pb - 1.07mg/g, 0.57mg/g and 0.42mg/g and Cd - 0.35mg/g, 0.31mg/g and 0.29mg/g, respectively; As was not detected in all the depths; b) Waste dumpsite soil: Ni - 6.75mg/g, 4.33mg/g and 1.95mg/g; Zn - 14.67mg/g, 12.55mg/g and 9.04mg/g; Cu - 8.34mg/g, 5.72mg/g and 3.82mg/g; Pb - 2.15mg/g, 1.06mg/g and 0.67mg/g and Cd - 0.68mg/g, 0.57mg/g and 0.84mg/g, respectively; As was not detected in all the samples. All measured heavy metals concentrations were within the permissible limit set by the World Health Organization, except Cd which was above the permissible limit in waste dumpsite soil. Therefore, waste dumpsite soil should not be used for farming and effort should be made to educate the public on the health effect of these metals when ingested, to avoid bioaccumulation and biomagnification in the food chain.*

Keywords: vegetable garden and waste- dumpsite soils, heavy metals, concentration, soil quality

Introduction

Heavy metals are members of a loosely defined subset of elements that exhibit metallic properties. It mainly includes the transition metals, some metalloid lanthanides, and actinide. They occur naturally in the ecosystem with large variations in concentrations (Mohsen and Salisu, 2008). Some of the metallic elements are toxic and have high density, specific gravity or atomic weight. Heavy metals occur naturally in the soil from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace (<1000 mg/kg) and rarely toxic (Pierzynski et al., 2000; Kabata-Pendias and Pendias, 2001). The geochemical cycle of metals by man resulted / caused most soils environments to have accumulated one or more of the heavy metals above defined background values high enough to cause risks to human health, plants, animals, ecosystems, or other media (D' Amore et al., 2005). Many of these metals undergo methylation, as a result of bioaccumulation where bacteria absorb these elements and convert them from a metallic state into a toxic organ metallic state, by incorporating with an organic component, these metals become readily available to the first tropic level of the food chain and eventually lead to biological magnification throughout the system (Laura and Susan, 2009).

Soil is unconsolidated material derived from rock weathering which has been acted upon by climate and vegetation. Soil is a collection of natural bodies on the earth surface which supports the growth of plants (Kwari, 2013). It is the principal source of our food and clothing. These natural bodies include organic matter, mostly the remains of plant and animal tissues, inorganic matter, mostly mineral and living forms such as earth worms and insects, air and water are also included (He et al., 2005). Some heavy metals in their trace state are bio-important to humans, a shift or deviation from their trace state has a bio-toxin effect in human bio-chemistry (Chang et al., 2014; Yu et al., 2017). This is largely as a result of consuming contaminated plants and animals among the circle of food chains. This can result in liver, kidney damage and Hepatic injury, hence becomes a great problem to all. Soil is of great importance to man; the toxic effect which may result due to heavy metal contaminants is of great concern (Zhang et al., 2014).

Heavy metals have a serious impact on the environment and can threaten the ecosystem's stability. The consumption of metal-contaminated river water, stream sediments and soil, poses a significant risk to the local population through the remobilization of heavy metals from agricultural lands into crops. Heavy metals have been well studied in aquatic organisms, for instance, Burger and Gibbons (1998); Guven et al. (1999); Koo and Koo, (2008); Taggart et al. (2009) and Shagufta et al. (2009) had reported that heavy metals cause poor breeding and high mortality in sea eagles (*Haliaetus* spp.) and ospreys (*Pandion haliaetus*), but the determination of heavy metals in soil is relatively less studied; hence this study is a step in that direction. This will create awareness to the people of Mubi North Local Government Area (LGA), those using waste dump-

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site soils as source of manure in their farming system, about the levels of these heavy metals in their community. This study was carried out mainly to determine the concentrations of lead, copper, zinc, cadmium, nickel and arsenic in the vegetable soil and waste dumpsite soil at Wuro-Gude, Mubi North LGA of Adamawa State, Nigeria, as the subsequent use of these soils may lead to passage of these metals to plants and other species that depend on such soil as nutrients/food, thereby causing bioaccumulation and biomagnification in the food chain. Hence, the heavy metals accumulation in soil may serve as a means of the plant and vegetables contamination, which are cultivated on such soil.

Material and methods

Sampling area

Sampling area and sampling site was from Mubi North LGA, Adamawa State of Nigeria. Mubi North is located at the North-Eastern part of Nigeria between the latitude 10°30'15'' N and 10°15'00'' N and longitude 13°15'00'' E and 13°45'06'' E. The area has a tropical climate with an average temperature of 32°C (Adebayo and Tukur, 2012).

Sample collection

A total of 300g of soil samples each were collected from Wuro–Gude vegetable garden and waste dumpsite Mubi North Metropolis Adamawa State, Nigeria. One hundred and fifty grams (150g) of soil from vegetable soil and also another one hundred and fifty grams (150g), from wastes dumpsite soil. Fifty grams (50g) from each depth were collected twice at an interval of four weeks. The soil samples were taken from depths of 5cm; 15cm and 25cm. The soil samples were collected in a polyethylene bag using a hand trowel and gently shaken off from the vegetable roots. All samples were sealed in polyethylene bags as in (Ndiokwere, 2006), further transported to the laboratory for the analysis.

Preparation of various working standards from stock solution

In the preparation of standard, the serial dilution method was used in order to obtain the concentration. The calculated masses were dissolved in separate solution of metals. The solution was further diluted to 1000ppm by pipetting 10mL stock solution and made up to 100mL with distilled water, working standard solution was prepared from reference solution for each metal using serial dilution method ($C_1V_1=C_2V_2$) (AOAC,2000).

Soil samples preparation for heavy metals analysis

Following the method of AOAC (2000), the soil samples were oven dried at 105°C for 24h, followed by grinding and sieving using 0.18mm sieve. 2.0g of each dried soil sample were poured into a 250mL digestion flask and were mixed with 25mL of aqua regia 1:3 (1 Concentration of HCl: 3 Concentration of HNO_3). The mixtures were digested on a hot plate at 95°C for 1hour and allowed to cool at room temperature. The samples were diluted with 100mL using distilled water and were allowed to settle overnight. The supernatant was then filtered prior to analysis using AAS.

The concentrations of heavy metals in the soil were determined according to the methods of AOAC (2000). 600mg of air-dried soil was mixed with 6mL of concentrated HNO_3-$HClO_4$ (87:13V/V) and 6mL of concentrated HCl. The mixture was digested and then dissolved in 2% HCl solution. Soil pH was measured in soil slurries using a 1:2:5, soil-to-water ratio with pH-meter (Jenway-3505-UK).

The determination of Pb, Cu and Zn in the soil sample was done directly on each of the prepared solutions using atomic absorption spectroscopy. The solution of each element determined was prepared. Reference solution was also prepared from the stock and finally the working standard, by the use of serial dilution following the method of (AOAC, 2000).

Data analysis

Data obtained were analyzed by one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) for means separation. Using a statistical software package (SPSS for Windows), the results were presented as mean ± standard error and $P>0.05$ was regarded as not statistically different.

Results

The results of this study reveal that all the heavy metals studied were observed in both soil types and at the different depths with the exception of arsenic which was not detected at all. The heavy metals (Ni, Zn, Cu, Pb, Cd and As) in the depth of 5cm have the highest concentration followed by 15cm and the lowest is found in 25cm depth, while As was not detected in all the depths of the soil. There was statistical difference in the concentrations of heavy metals observed in the depth of the soil as seen in Table1, at $P>0.05$.

Table 1. Heavy metals concentration in waste dumpsite soil (mg/g)

Soil depth, cm	Ni	Zn	Cu	Pb	Cd	As
5	6.75±0.007^{c}	14.67±0.007^{a}	8.34±0.007^{b}	2.15±0.007^{b}	0.68±0.007^{a}	ND
15	4.53±0.007^{bc}	12.55±0.007^{b}	5.72±0.007^{a}	1.06±0.007^{ab}	0.57±0.007^{c}	ND
25	1.95±0.007^{b}	9.04 ±0.007^{ab}	3.82±0.002^{c}	0.67±0.007^{bc}	0.84±0.007^{b}	ND

*Means with the same letters in each row are not significantly different at $P>0.05$, using ANOVA and DMRT for mean separation

ND= Not Detected

There was decrease in the concentration of the heavy metals (Ni, Zn, Cu, Pb and Cd) as the depth increased and statistically there were significant differences in the levels of heavy metals in the depths of the soil as seen in Table 2, As was not detected in all the depths of the soil.

Table 2. Heavy metals concentration in vegetable garden soil (mg/g)

Soil depth, cm	Ni	Zn	Cu	Pb	Cd	As
5	7.33±0.015[a]	16.31±0.014[b]	6.94 ±0.007[a]	1.07±0.031[a]	0.35±0.007[a]	ND
15	5.06±0.014[ab]	13.08±0.012[c]	4.77±0.007[b]	0.57±0.006[c]	0.31±0.007[a]	ND
25	3.04±0.007[b]	8.37±0.009[a]	3.26±0.011[ab]	0.42±0.016[b]	0.29±0.007[a]	ND

*Means with the same letters in each row are not significantly different at P>0.05, using ANOVA and DMRT for mean separation

ND= Not Detected

The average heavy metal concentrations from all soil depths for both types of soils are presented in Figure 1. The results reveal clear differences in the average concentrations of the investigated heavy metals both by elements and by soil type. In absolute terms, the Zn content is the largest, followed by Cu, Ni, Pb and Cd.

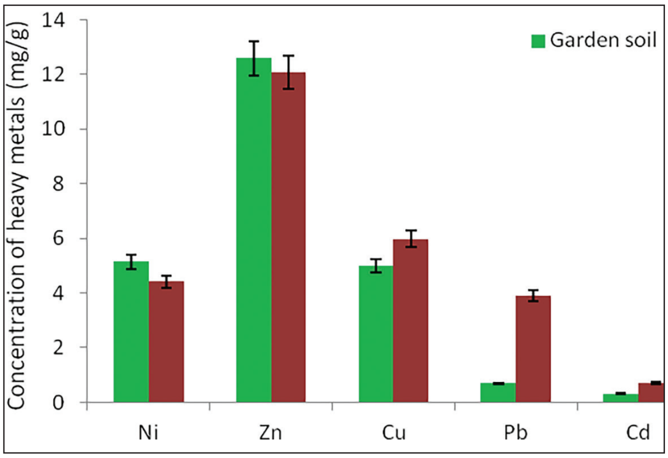

Figure 1. Comparison between mean concentrations mg/g) of heavy metals in Garden soil and Waste dumpsite soil

Discussion

The concentration of heavy metals based on their depths and soil types were observed in this study. The concentration of Zn in the garden soil was the highest with 16.32mg/g at the depth of 5cm followed by 13.09mg/g at the depth of 15cm and 8.37mg/g was the lowest at the depth of 25cm. In dumpsite soil the concentration of Zn was the highest at the depth of 5cm with 14.67mg/g followed by 12.56mg/g at the depth of 15cm and 9.04mg/g was the lowest at the depth of 25cm. The result of this study was in line with the findings of Akaeze (2001) who reported that the permissible Zn concentration level in soil is 12-60mg/g as stated by World Health Organization. The concentration of Zn in this study ranges from 8.37mg/g to 16.32mg/g.

Nickel concentration at the depth of 5cm in the vegetable garden soil was the highest with 7.33mg/g, followed by 5.07mg/g at the depth of 15cm and 3.04mg/g was the lowest at the depth of 25cm. At the depth of 5cm in dumpsite soil there are 6.75mg/g which was the highest concentration followed by 4.54mg/g at the depth of 15cm and 1.95mg/g was the lowest at the depth of 25cm. Ni was observed to be higher in garden soil than in waste dumpsite soil. This result conforms to the result of Lasat (2000) who stated that, nickel is among these heavy metals that are essentials for healthy plant growth.

Copper concentration in garden was 6.94mg/kg at the depth of 5cm which is the highest, followed by 4.76mg/g at the depth of 15cm and 3.26mg/g was the lowest at the depth of 25cm, while the concentration of copper in dumpsite soil was the highest with 8.34mg/g at the depth of 5cm, followed by 5.73mg/g at the depth of 15cm and 3.36mg/g was the lowest at the depth of 25cm. It was also observed that Cu was found to be higher in waste dumpsite soil than garden soil. This agrees with the work of Ebong et al. (2008) who stated that dumpsite soil always had large concentrations of Cu and Cd.

Cadmium concentration level in garden soil 0.36mg/g was the highest at the depth of 5cm followed by 0.32mg/g at the depth of 15cm and 0.29mg/g was the lowest at the depth of 25cm and these fall below the accepted range of heavy metals in the soil. As reported by Akaeze (2001) at dumpsite Cd concentration level, 0.84mg/g was the highest at the depth of 25cm, followed by 0.68mg/g at the depth of 5cm and 0.57mg/g was the lowest at the depth of 15cm. This agrees with the work of Ideriah et al. (2005) who reported in soils around Municipal Solid Wastes Dump in Port Harcourt that the concentrations of Cd and Cu in soil from waste dumpsite are sufficiently high.

Lead concentration in garden soil at the depth of 5cm was the highest with 1.08mg/g followed by 0.58mg/g at the depth of 15cm and 0.43mg/g at depth of 25cm that was the lowest. At dumpsite soil the highest concentration of lead was 2.16mg/g at the depth of 5cm, followed by 1.07mg/g at the depth of 15cm and the lowest was 0.68mg/g at the depth of 25cm. In comparison of the mean concentration of Pb in garden soil with waste dumpsite soil, the result reveals very high level of Pb in the waste dumpsite soil than the garden soil. There was disparity in the result of Pb of this study with the result of Ebong et al. (2008), who reported that there is decrease in the concentration level of heavy metals when there is increase in the depth of soil. Arsenic was not detected in both vegetable garden soil and waste dumpsite soil.

By comparing the results for the heavy metal content in both types of soils, it is evident that the average concentrations of Ni and Zn were higher in Garden soil than in Waste dumpsite soil, while for the concentrations of Cu, Pb and Cd a reverse trend was observed - their quantity was higher in waste dumpsite soil than in garden soil (Figure 1). The higher level of Cu, Pb and Cd in waste dumpsite soil than in garden soil could be a result of various sources some of which include burning of tyre, paints, dynes and especially refuse dumps and commercial activities as reported by Ali et al. (2005). In garden soil, heavy metals such as Zn and Ni are found in high concentration which is in line with the findings of Odukoya et al. (2000), who found high concentration of these metals in soil. This may be as a result of these metals being very essential for plant growth and are found in the fertilizers used.

Conclusion

The results obtained in this study show that the waste dumpsite soil and the garden soil at all the depths (5, 15 and 25cm) have concentration of Pb, Cu, Zn, Ni, Cd (in garden soil) and As within the permissible limit set by World Health Organization, except Cd in all the depths of dumpsite soil, which is slightly above permissible limits. Arsenic is not detected in all the soil samples. The mean concentration of Cd, Cu and Pb in the waste dumpsite soil samples is relatively higher than the garden soil sampled. From the outcome of this study, the following recommendations could be made: regular monitoring of heavy metals in the vegetable soil and vegetables in Mubi Metropolis should be carried out to ascertain the level of toxicants; other heavy metals should be studied to monitor their concentration in the vegetable soil; vegetable soil can be used for farming, since the levels of the heavy metals are within the permissible limit while waste dumpsite soil should be restricted for farming, since concentration levels of Cd are above the maximum permissible level to avoid bioaccumulation in the human food chain.

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