

EFFECTS OF LAND USE ON CONCENTRATION OF SOME HEAVY METALS IN SOIL AND PLANT LEAVES IN KASHERE AREA, AKKO LOCAL GOVERNMENT AREA OF GOMBE STATE, NIGERIA

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ABSTRACT

This study was conducted in Kashere Area Akko LGA of Gombe State, Nigeria to evaluate the impact of land uses on concentration of heavy metals (Cd, Cr, Cu and Pb) in soils and their uptake by plant. Soil samples were collected at 0-30 cm depths from arable, Fadama, forest and grazing lands and analyzed. The results showed that the mean concentration range of metals for all land use types were 0.14 ± 0.01 to 0.22 ± 0.01 Cu²⁺ and 0.15 ± 0.24 to 1.77 ± 0.24 Pb in soil samples and were all found to be below the Department of Petroleum Resources standards (DPR, 2002) while the values recorded in plants ranged from 0.14 ± 0.01 to 0.25 ± 0.01 Cu and 0.57 ± 0.24 to 1.77 ± 0.24 Pb and all found to be below the NAFDAC permissible limits of these metals in plants for all the land use types. However, Cd and Cr were not detected in all the land use studied. The values of transfer factor obtained from this study were in the following order: Pb > Cu > Cd: Cr. The TF values of studied heavy metals in all the studied sites were found to be < 1, thus there is possibility that soil is the main source of metal bioaccumulation in plants.

Keywords: Heavy Metals, Land Use, Anthropogenic, Non-biodegradable, Pollution, Bioaccumulation

INTRODUCTION

Heavy metal pollution is one of the global environmental pollution problems (Feng-jun *et al.*, 2012) and is spread in the environment by various industrial and agricultural activities and is generally phytotoxic at very low concentrations (Blaudez *et al.*, 2000). Several studies by (Adegoke, 2009; McGrath *et al.*, 2002; Rahman *et al.*, 2012) showed that soil of the world have been degraded and contaminated by various anthropogenic activities that change the physical, chemical and biological properties of soil; resulting in nutrient deficiency, soil toxicity, improper soil and crop management, alteration of agricultural lands and also human and animal health hazard via food chain. Increased concentration of heavy metals to plant roots is one of the factors that causes physiological stress. According to Heidarieh *et al.* (2013) metals are non-biodegradable with long biological half-lives as well as persistent environmental contaminants which might be likely deposited on the plant and then adsorbed

into their tissues. However, Haiyan and Stuanes, (2003); Sharma *et al.* (2008) stated that plants can absorb metals from both soil and from deposits on the plant's parts exposed to the air from polluted environments. The transfer factor (TF) is one of the key components of a metal to migrate from the soil and accumulated in roots and tissue of plant.

Metals uptake and bioaccumulation in plants are influenced by many factors particularly climate, atmospheric depositions, concentrations of metals in soils, nature of soil and the degree of plant maturity at the time of the harvest (Scott *et al.*, 1996). Other anthropogenic sources include the addition of manures, sewage sludge, fertilizers and pesticides which may affect the uptake of heavy metals by modifying the soil physico-chemical properties such as pH, organic matter, and bioavailability of heavy metals (Yusuf and Osibanjo, 2006; Odika *et al.*, 2020). Crops cultivated near highways are also exposed to atmospheric pollution in the form of metal containing aerosols. Asp *et al.* (1994) opined

that heavy metals not only inhibit root growth, but can also hamper many physiological processes and, in particular, the uptake of nutrients.

Globally, the major problem associated with heavy metal contamination are of great concern, particularly in agricultural production systems due to their increasing trends in human foods and environment (Kachenko and Singh, 2006). Metals most often found as contaminants in crop plants include As, Cd, Cr, Cu and Pb. These metals pose a significant health risk to humans, particularly in elevated concentrations (Gupta *et al.*, 2008). Excessive accumulation of heavy metals in food cause a number of diseases, such as cardiovascular, renal, neurological, and bone diseases (Chailapakul *et al.*, 2007). There are scanty studies on the concentrations of heavy metals in different land use in Nigeria, particularly northeastern Nigeria except those related researches by (Azeez, 2017; Bolaji *et al.*, 2009; Christopher and Therese, 2010; Iwegbue, 2014; Elias and Gbdegesin, 2011). The present study aimed at evaluating the effect of land use on the concentration of some heavy metals (Cu, Cr, Cd, and Pb) in soils, their uptake by plants.

MATERIALS AND METHODS

Study Area

The study was conducted during 2019 cropping seasons at Kashere located in Akko Local Government Area of Gombe State, Nigeria. The study area is situated at the southern part of Gombe metropolis on latitudes $9^{\circ} 46' 0''$ North of the equator and longitudes $10^{\circ} 57' 0''$ East of Greenwich meridian and 431 metres above sea level. It is in the Sudan Savannah zone of Nigeria, which lies in the Dry Sub-Humid Azare - Gombe -Yola Plain of Nigeria (FPDD, 2012). The area has average annual rainfall of 850 mm and temperature of 32°C . The area formed part of the Limestone and Shale of the Pindiga formation. The soil falls within the Leptosols, Cambisols and Luvisols from Limestone and Shale of the Pindiga formation. It is deep, whitish, clay loam and free from concretions and stones. It is well drained, with good moisture - holding capacity (Abubakar, 2013). The study area is divided into four land use types. The arable land which comprises of few trees like shear butter, locust bean trees, and shrubs with scattered grasses and mainly cultivated with maize, sorghum, cowpea, tomatoes, okra, amaranthus and water

melon. The Fadama land is characterized by the cultivation of annual crops such as maize, beans, okra, amaranthus, cabbages, pumpkins, and green pepper. The main cropping system in the study area is mixed, although rotation, inter-cropping and monocropping systems are also common. The land is relatively a flat. The forest is predominantly consists of Cashew trees. The grazing land is consists predominantly of very short grasses (pasture) and the land use system is denuded of trees, shrubs, and bushes and open for grazing. It is created due to the shrinkage of the forest cover as a result of deforestation due to human and animal interference. In these areas, manures, fertilizers and pesticides were used by farmers for cultivating crops. The soil fertility was managed by application of both organic manure and inorganic fertilizer. Weed and pest control were managed by both application of pesticides.

Sample Collection and Preparation

Soil and plant samples collection techniques were carried out as described by (Ibrahim *et al.*, 2017). In the field, soil samples were collected from 0 - 30 cm depths, by using soil auger. Soil samples from the farmers' fields were randomly collected and mixed together to form a composite sample and were packaged in clean polythene bags and properly labeled and then transported to the laboratory where it was air dried for five days. Thereafter, the samples were crushed and passed through 2 mm mesh sieve. Simultaneously, Plant samples were collected by randomly picking up some leaves from the plants in triplicate from the same field using sharp razor blade. In laboratory, the leaves were washed with distilled water to remove soil particles, sun dried, crushed and ground for heavy metals determination.

Soil and Plant Analysis

Soil samples were dried in an oven at 105°C for 24 h and plant samples sliced and dried in an oven at 45°C until they were brittle and crisp (USEPA, 1996). One gram of dried, disaggregated and sieved samples was placed separately in 100 cm^3 Teflon beakers and then digested with 15 cm^3 concentrated nitric acid at 550°C for about 3 h, the digests were then filtered into a 100 cm^3 volumetric flask (USEPA, 1996; Ademoroti, 1996). The concentration of Cu, Cd, Pb and Cr in the digested plant and soil samples were analyzed using an SP 1900 Pyre Unicam Atomic

Absorption Spectrophotometer (AAS). A part of the sieved soil was also used to determine the following soil properties as described by Agbenin (1995): Particle size distribution was determined using Bouyoucos hydrometer method, soil pH was measured using glass electrode pH meter. The Walkley-Black digestion method was used to determine soil organic carbon. Total Nitrogen was measured using macro Kjeldhal method while available phosphorous was determined using Bray No.1 method

Transfer Factors (TF) for Heavy Metals from Soil to Plants

Transfer factor is the ratio of the concentration of metals in a plant to the concentration of metals in soil. The transfer factors (TF) for each heavy metal were calculated as described Cui *et al.* (2004).

TF = Element concentration in plant, dry weight (mg kg^{-1}) / Element concentration in soil, dry weight (mg kg^{-1})

RESULT AND DISCUSSION

Soil Physicochemical Properties

Physical properties are presented in Table 1. The overall sand fractions were higher in soil under the forest land followed by the grazing lands than in other land use types while silt and clay fractions were higher in soil under the Fadama land followed by the arable lands than in other land use types (Table 1). Afolabi *et al.*, (2014) opined that, slow rate of weathering and relatively young age of the soils attributed the low silt and clay fractions in soils. Yimer *et al.* (2008) attributed the higher clay contents in soil under Fadama and arable lands than in forest and grazing land to continues cultivation which promotes further weathering processes as it shears and pulverizes the soil and changes the moisture and temperature regimes. Moreover, the textural class across all land use types ranges from sandy loam in forest land and grazing land and clay loam in arable land and Fadama land, indicating the homogeneity of soil forming processes and similarity of parent materials (Berg *et al.*, 1991).

The soil pH measured in water of Fadama land, arable land, forest land and grazing land varied from moderately acid to slightly acid (FAO, 2005). This may be due to granitic lithology of the study area or leaching of soil cations which have been found to increase soil acidity (Afolabi *et al.*, 2014; Aminu and Jaiyeoba, 2015). The organic

carbon content (Table 1) was low in all the land use types. Soil organic carbon plays an important role in nutrient availability and soil aggregate formation (Yang *et al.*, 2007). The generally low levels of soil organic matter in respective of land uses were reported in similar studies by (Afolabi *et al.*, 2014) which attributed low organic matter of the study area soils to rapid mineralization. This indicates that all soils over the different land uses are low in organic matter. However, the higher organic matter content over forest land use could be attributed to continuous litter deposition and minimum disturbance, while the lower organic matter content of arable lands might be due to the effect of sparse vegetation cover and persistent cultivation (Aminu and Jaiyeoba, 2015). For example, studies conducted by Afolabi *et al.* (2014) ; Aminu and Jaiyeoba, (2015) and Amuyou and Kotingo, (2015), opined that intensive cropping and tillage practices destroy soil structure through compaction, loss of soil moisture, increased bulk density and make such soils susceptible to soil wash and loss of basic cations. According to Nachtergaele *et al.* (2002) soil organic carbon play a significant role in metals retention by soil solids, thereby decreasing mobility, however metals tend to be more soluble and mobile in soils at lower soil pH. The total nitrogen of the different land use types was rated low, below 1.5 gkg^{-1} critical level recommended (Esu, 1991). However, the lower total nitrogen across the different land use maybe attributed to loss of total nitrogen through leaching and rapid mineralization due to exposure to solar radiation and to high temperatures which characterize the study area (Aminu *et al.*, 2016). Available phosphorus was found to be medium in all the land use types, except in arable land which is rated low, as also observed by Esu (1991), indicating serious deficiency problem of phosphorus. The medium mean values of available phosphorous over Fadama land, forest land and grazing land uses may be attributed to the addition of phosphate-bearing fertilizers (Aminu and Jaiyeoba, 2015). The mean value of exchangeable K was rated high in all the land use types as per Esu (1991) ratings. The higher exchangeable K obtained in forest land could be due to the availability of surface biomass through litter falling and little or no surface soil disturbance by rain drops, surface runoff and other severe erosion agents (Aminu *et al.*,

2016). This result is in agreement with the findings of Yitbarek *et al.* (2013) and Duguma *et al.* (2014) who reported that the exchangeable K of soil is higher in the forest land than cultivated and grazing lands.

Concentration of Heavy Metals in Soils

The mean concentration of Cu and Pb in different land use types are presented in Table 1. The mean concentration of the analyzed metals in the study areas was compared with maximum allowable limit set by Department of Petroleum Resources (DPR, 2002) and FAO/WHO (2001). The results showed that the mean concentrations ranged from 0.14 ± 0.01 to 0.22 ± 0.01 mg/kg Cu²⁺ and 0.15 ± 0.24 to 1.77 ± 0.24 Pb mg/kg. The concentration of Pb was found to be maximum (1.77 ± 0.24 mg/kg) in sample from Fadama land, followed by sample from arable land (1.64 ± 0.24 mg/kg) and the lowest concentrations are from forest and grazing lands (0.16 ± 0.01 and 0.14 ± 0.01 mg/kg respectively). The highest concentrations of Cu were also found at Fadama land (0.22 ± 0.01), followed by 0.20 ± 0.01 mg/kg in sample from arable land and the lowest concentrations are from forest and grazing lands with values of 0.16 ± 0.01 and 0.14 ± 0.01 mg/kg, respectively. While Cd and Cr were not detected in all the studied samples. Both Cu and Pb were below

the DPR, (2002) and FAO/WHO (2001) permissible limits of 100 mg/kg and 50 mg/kg, respectively. However, the values of Cu and Pb concentrations were found to be below the maximum permissible level of 5 ppm and 2.0 ppm respectively in soil (Chiroma *et al.*, 2014). Modrzewska and Wyszowski (2014) attributed variations in metal concentrations to the duration and intensity of the anthropogenic activities associated with a particular land use type, geological characteristics of the different sites, soil type (textural characteristics), pH, sorption capacity, organic matter content, cation exchange capacity and the type of metal, with trace elements which originate from parent rock demonstrate lower mobility than same elements imported to the soil from anthropogenic sources.

Studies have shown that high concentrations of heavy metals in soil have strong toxic effects on plants which in turn result in weak growth, yield depression, disorders in plant metabolism and reduced nutrient uptake (Ibrahim *et al.*, 2014). Moreover, the value of Pb recorded in this study was higher than the values reported by Ibrahim and Salem (2017) and Sulaiman *et al.* (2019). However, the maximum concentrations of Cu values obtained in this study were lower than the values reported by Bassey *et al.* (2014) and Sulaiman *et al.* (2019).

Table 1: Physico-Chemical Properties of the Soil and Mean Concentration of Heavy Metals (mg/kg) in Soil Under Different Land Use Types

Samples	Sand	Silt	Clay	Texture	pH	Organic C	Total N	Available P	K	Cu	Pb
Arable land	45.0	26.0	29.0	Clay loam	6.3±0.27	4.1±0.36	0.9±0.38	8.0±0.82	0.41±0.36	0.20±0.01	1.64±0.24
Fadama land	43.0	26.9	29.6	Clay loam	5.7±0.27	5.4±0.36	1.2±0.38	13.9±0.82	0.48±0.36	0.22±0.01	1.77±0.24
Forest land	72.0	20.8	7.2	Sandy loam	6.5±0.27	6.2±0.36	1.3±0.38	13.9±0.82	1.77±0.36	0.16±0.01	0.67±0.24
Grazing land	72.0	22.2	7.8	Sandy loam	6.5±0.27	3.7±0.36	0.4±0.38	11.6±0.82	1.57±0.36	0.14±0.01	0.64±0.24

Concentration of Heavy Metals in Plants

The mean concentration of heavy metals in plant samples in different land use is presented in Table 2. The mean concentrations ranged from 0.14 ± 0.01 to 0.25 ± 0.01 for Cu and 0.57 ± 0.24 to 1.77 ± 0.24 for Pb, while Cd and Cr were not detected in the plants in all the land use studied. The concentration of Cu and Pb were both below maximum permissible limit of 40 mg/kg and 5 mg/kg, respectively set for plants by NAFDAC as quoted by Abdulmojeed *et al.* (2011) and FAO/WHO, (2007). The results of heavy metals observed in plants in this study varied from one land use type to

another, this may be due to different usage of agro-chemical application and other human activities at each sampling site. The general trend for heavy metals content in plants samples was in the following order: Pb > Cu > Cd: Cr. The concentrations of Pb in this study were lower than the values reported by Ibrahim *et al.* (2014) and Sulaiman *et al.* (2019). However, the results obtained for Cu in this study were lower than results reported by Sulaiman *et al.* (2019) and Ibrahim and Salem (2017). Sager (2017), reported that the levels of Pb were lower and Cu were higher than the values obtained in this study.

Table 2: Concentration of Heavy Metals (mg.kg⁻¹) In Plant Samples Over Different Land Uses

Samples	Cu	Pb	Cd	Cr
Arable land	0.25 ± 0.01	1.77 ± 0.24	ND	ND
Fadama land	0.22 ± 0.02	1.72 ± 0.24	ND	ND
Forest land	0.19 ± 0.01	0.61 ± 0.24	ND	ND
Grazing land	0.14 ± 0.01	0.57 ± 0.24	ND	ND

Transfer Factor (TF) of the Heavy Metals

The transfer factors of the heavy metals from soil to plant are presented in (Fig. 1.). The (TF) values recorded in this study ranged from 1.00 to 1.25 Cu and 0.89 to 0.97 Pb (Figure 1). Lead recorded the highest value of transfer factor in almost all the studied sites followed by Cu. Mwegoha and Kihampa, (2010) stated that, when the transfer factor is less than one, there is possibility that soil is the main source of metal bioaccumulation in plants. However, when the transfer coefficients are greater than one, the total concentrations of metals in soil do

not necessary correspond to the metal bioavailability in plants. Higher transfer coefficients reflect high soil contents or greater potentials of plants to absorb metals and bioaccumulate into tissues (Abah *et al.*, 2012). The transfer factor in this study decline in the order of: Cu > Pb. The variation in transfer factors among different land use may be attributed to differences in metals concentrations in soil samples or agrochemicals and fertilizer application and other human activities, and differences in uptake by the vegetables (Cui *et al.*, 2004).

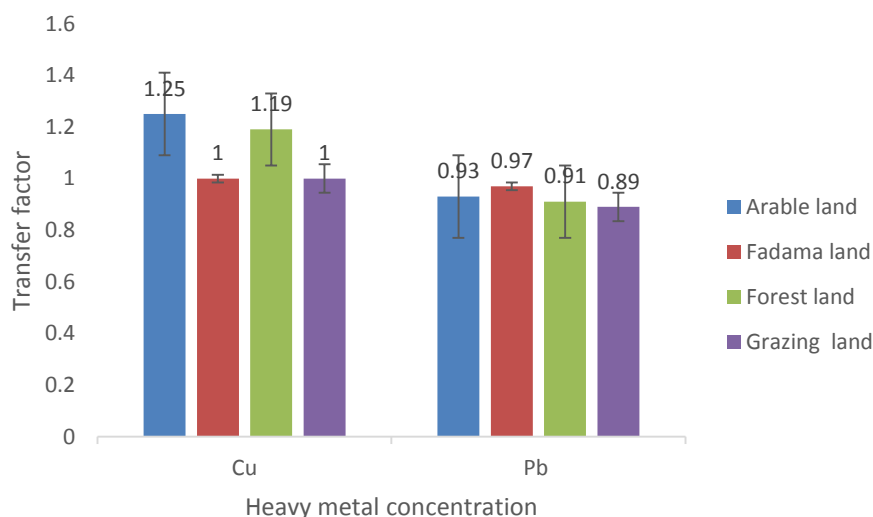


Fig. 1: Transfer factor of the heavy metals from soils to plants

CONCLUSION

The results indicate that there were no significant heavy metals pollution. However, low concentration of Cu, Cd, Cr and Pb might have come from soil parent materials. The concentrations of Cd, Cr, Cu and Pb were found at levels below the Department of Petroleum Resource permissible limits of these metals in soil and below the NAFDAC permissible limits of these metals in plants for all the land use types. The contamination of the environment was found in the following order of transfer coefficient: Arable lands > Fadama lands > Forest lands > Grazing lands for both Cu and Pb, respectively. Although the transfer factor of heavy metal from soils to plants were similar, but transfer factor values in arable lands were higher than other land use types.

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