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Impact Assessment of Tin Mining on Heavy Metals Accumulation in the Soils of Bukuru Jos North Central Nigeria

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Abstract: ***This research was carried out to assess the impact of tin mining on the soils of Bukuru-Jos, North Central Nigeria. The study was conducted in three (3) locations of Bukuru study area namely, Gyel, Rabi and Fwarti. Twelve (12) profile pits were cited, three (3) of which were cited at the mined sites and one (1) at the unmined sites (control) in each location of the study area. A total of sixty (60) soil samples were collected from all the profile pits taken at 0-10 cm, 10 -20 cm, 20 -30 cm, 30 - 40 cm and 40 -50 cm, in 4 replications in each of the three locations of the study area. The result of laboratory analyses revealed eight (8) heavy metals identified at Gyel and Rabi locations, namely, Zn, Pb, Cu, Fe, Mn, Cr, Ni and Cd. At Fwarti location, however, seven (7) of the heavy metals were identified, namely, Zn, Pb, Cu, Fe, Mn, Ni and Cd. Comparism of the mean values of these heavy metals with their respective FAO/WHO critical limits for agricultural soils showed that Gyel location was contaminated with Zn, Pb, Cu, Fe, Mn, Cr and Ni. Rabi location was contaminated with four of the heavy metals identified, namely, Pb, Cu, Fe and Mn, while the abandoned tin mine at Fwarti was contaminated with five (5) of the heavy metals, namely, Pb, Cu, Fe, Mn and Ni. The mean concentrations of the heavy metals identified at both the mined areas and control were above their respective WHO/FAO (2001) critical limits in agricultural soils except for Cd which was below its own critical limit, and Co which was not detected. Therefore, both the mined areas and the control, at least a kilometre away from the mined areas were contaminated with the identified heavy metals except for Cd. Bukuru soils were therefore contaminated with Zn, Pb, Cu, Fe, Mn, Cr, Ni, which occurred in the followingorder; Fe> Mn > Cr > Pb > Zn > Cu >Ni.***

Keywords: Impact Assessment, Tin mining, Heavy metals, Bukuru soils, North Central Nigeria

1. Introduction

Human beings exploit land for the purpose of cultivation of crops, building of roads, grazing of livestock, and extraction of solid minerals (Uchegbu, 1998; Adebayo, 2007; Ogunowo and Oderinde, 2007). These activities may have positive and negative impacts on the environment depending on the nature, type of usage and the manner of exploitation. According to Alao, (1983), the impacts of man's economic activities are felt not only in the rapid depletion of natural resources but also in the alarming rate at which the natural environment is being polluted, thereby obliterating the equilibrium that once existed. Mining is one of such human activities on land that has impact on the environment. The scale of operations involved in exploration, mining and processing of minerals determines the intensity and the extent of environmental degradation.

Tin is obtained chiefly from the mineral cassiterite, where it occurs as tin dioxide, SnO_2. Tin is a malleable, ductile and highly crystalline silvery-white metal. According to Ezeonu *et al.* (2012), the exploration of tin on the Plateau (Jos) started as early as 1808 by the British colonialists, who saw crude antimony and tin as being the produce of the country at a market in Kano. Tin ore (Cassiterite) are found in commercial deposits in the following local Government areas of Plateau State: Jos North, Jos South (Bukuru), Barki-Ladi, Bassa, Bokkos, Mangu, Pankshin and Riyom Local Government Areas. According to ITRI Reports, (2012), tin is a vital ingredient in a wide range of manufacturing sectors, including consumer goods, packaging, construction, vehicles and other forms of transport. Tin is used as solder in many industrial works, such as consumer goods, waste disposal, in automotive, aerospace and medical applications. The biggest use of organic tin chemicals is in PVC for construction of products such as doors and windows, to stop them degrading in heat and sunlight. Atkins *et al.* (2006) reported that the most important applications for inorganic tin chemicals are as catalysts for a wide range of industrial processes, glass coatings, electroplating baths, fire retardants, and in the ceramics and cement industries.

Environmental Impact Assessment (EIA) is the tool of environmental protection to test the compatibility of the environment before taking any decision to construct public, private or governmental projects and industries which could deteriorate the natural resources. It is a process of identifying likely consequences for the natural environment and for man's health and welfare of implementing particular activities. In understanding an assessment, planners are forced to consider the side effects of their proposals over a short, medium and long range, and also of possible alternatives, one of which is not to proceed (Srinivasan and Reddy, 2009). The International Association of Impact Assessment defines an Environmental Impact Assessment as "the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decisions being made and commitments taken (IAIA, 1999).

According to Ogezi and Adiku-Brown (1987), associated with tin mining is the possibility of an accelerated release from the rocks toxic trace elements such a Lead (Pb), Cadmium (Cd) and Zinc (Zn) around the mining areas causing pollution in the environment. This was corroborated by the findings of Adams (2010) who reported that studies on mine tailings from tin processing in Jos, revealed high concentrations of lead (Pb), Zinc (Zn) and Cadmium (Cd). Edun and Davou (2013), also confirmed that, tin mining and processing constitute a source of pollution to the environment because the accessory minerals such as lead, zinc, cadmium, and chromium, associated with tin are harmful even to human beings and animals at low concentrations. Therefore, the disposed mineral tailings can cause ailments such as cancer, leukemia and chromosomal breakage. Also, the deadlier diseases like, odeama of eyelids, tumor, congestion of nasal mucous membranes and pharynx, stiffness of head and gastrointestinal, muscular, reproductive, neurological and genetically infection have been documented (Kar et al. 2008). Environmentalists fear that people living in houses near these vicinities, risk being exposed to unhealthy levels of these radioactive elements.

The objective of this research therefore, was to assess the impacts of tin mining on heavy metals accumulation in the soils of Bukuru, Jos. North Central Nigeria and to ascertain the possible contamination of the environment as a result of heavy metals released to the environment due to tin mining operations.

2. Materials and Methods

2.1 Study area

The study area (Bukuru town) lays between longitudes 8° 50′ E and 9° 00′E and latitudes 9°45′N and 9°50′N (Figure 1). It was formerly dominated by mining activities in areas such as Maiadiko, Gold and Base settlements, and many others. It has an average elevation of about 1, 150 meters above mean sea level and the highest peak some 20 km eastwards from Jos-Shere hill, rising to 1777 meters above mean sea level (Figure 2).

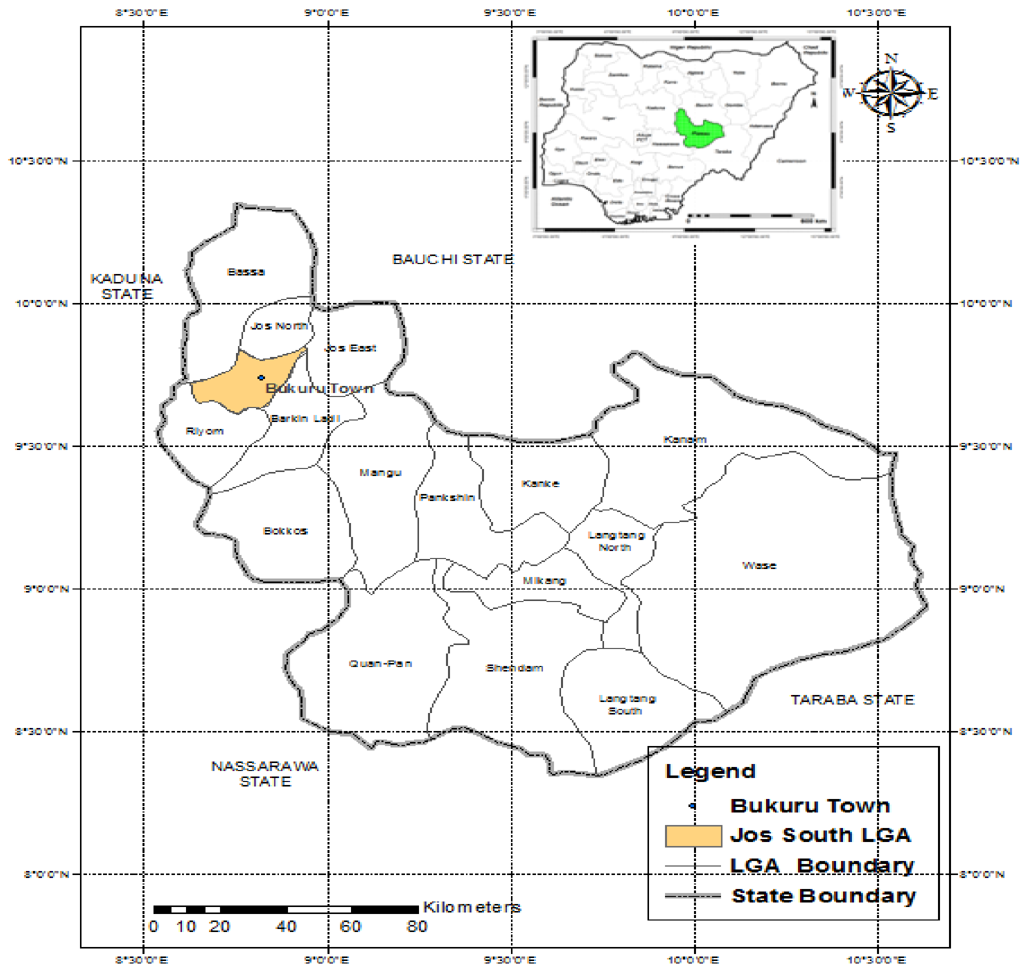

FIG. 1; Plateau State Showing Jos South LGA and Bukuru Town
Source; Adapted from Plateau State Ministry of Land Survey and Town Planning

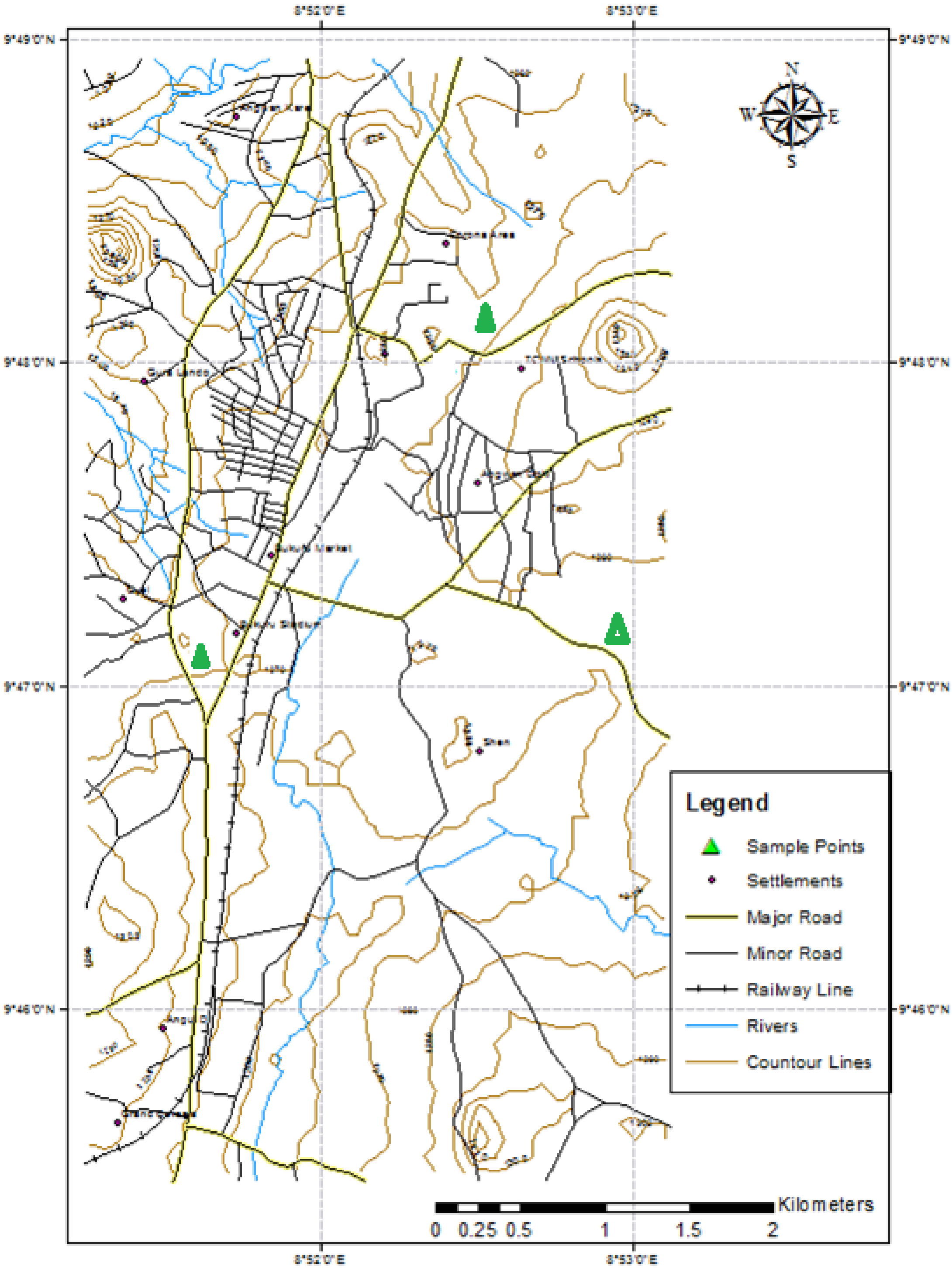

Figure 2: Topographic Map of Bukuru Town showing soil samples collection points. Scale: 1:100, 000
Source: Adapted from National Centre for Remote Sensing, Jos, Nigeria

2.2 Climate and vegetation

Temperatures on the Jos Plateau are lower than the surrounding areas, with minima of 15.5°C to 18.5°C and maxima of 27.5°C to 30.5°C. On the Plateau, the rainfall is around 2, 000 mm in the wetter southwest, and declines to around 1, 500 mm in the northeast. Average rainfall of Bukuru Jos is 1, 411 mm per annum. These figures compare with 1, 000 mm to 1, 200 mm per annum in the surrounding savannahs. The mean annual temperature is about 22^0C but the mean monthly varies between 19.4^0C and 29^0C in the hottest month. It has a cool climatic condition due to its high altitude and the soil temperature regime is inferred to be isothermal. Between November and February, average mean daily temperature is 18^0C, while it is warm between March and April before the onset of the rains. The rainy season which is between the months of May and October has its peak in August the precipitation arising from both conventional and orographic sources owing to the location of the city on the Jos Plateau (Weather Report, 2012).

The Jos plateau which is one of the highest points in Nigeria is in a grassland zone, but its vegetation depicts grassland at the top and base of the Plateau, while the slopes favoured by moisture-laden wind, are covered by forests. White (1983) identifies this eco-region as an isolated vegetation unit within the Guineo-Congolian/Sudanian regional transition Zone. Savanna woodland is likely to have been the climax ecotone of this eco-region, but human activities have resulted in extensive and severe degradation. The most numerous tree species in the remaining woodland is *Isoberlineadoka*, *Vitexdoniana*, *Lanneaschimperi*, and *Uapacasomon*, and the following rupicolous species found in bushland and scrub forest on the Plateau: *Carissa edulis*, *Dalbergiahostilis*, *Diospyrosabyssinica*, *D. ferrea*, *Dodonaeaviscosa*, *Euphorbia desmondii*, *E. kamerunica*, *E. poissonii*, *Ficusglumosa*, *Kleiniacliffordiana*, *Rhuslongipes*, *R. natalensis*, *Ochnaschweinfurthiana*, *Oleacapensis*, *Opiliaceltidifolia*, *and Pachystelabrevipes*, and along streams, *Syzygiumguineense* and *Berlinea*species are common (White, 1983). High human population densities combined with relative fertile soils in some areas have resulted in large-scale deforestation and conversion of montane grasslands to farmed areas. Natural trees are largely to wholly absent in most areas. Presently there are no activities to preserve the few remaining remnants of this ecosystem. The Forestry Department is considering the replanting of trees but unfortunately they are considering exotic species such as *Eucalyptus camaldulensis*, (World Wildlife Fund, 1998). Grasses commonly found in the area include, *Pennisetum*, *Andropogon*, *Panicum*, *Chloris*, *Hyparrhenia*, *Paspalum* and *Melinis* (Argheore, 2005).

2.3 Geology and Relief

According to Macleod *et al.* (1971), the geology of the area comprises of the Precambrian Basement Complex rocks (migmatite, gneiss and older granite), the Jurassic younger granites (mostly Biotite granite) and the tertiary and quaternary volcanic rocks (mainly basalts, pumice, lava flows and ash deposits). The rocks occur as hilly massifs, sharply differentiated from the smoother topography of the surrounding basement rocks. They are a petrologically distinctive series of alkali feldspar granites, associated with rhyolites and minor gabbros and syenites, which occur in sub volcanic intrusive complexes as ring dykes and related annular and cylindrical bodies (Turner, 1989). Partly decomposed basaltic boulders, plugs or domelike outcrops represent the older basalts which are known as the lateralized basalt.

The Jos-Bukuru Younger Granite Ring Complex is part of generalized ring complexes of the Younger Granite suite. According to Edun and Davou (2013), the mode of emplacement of the Younger Granite complexes is not related or associated to any orogenic event or activity. The lack of sediments associated with the volcanic rock of the younger granite complex, which erupted to a land surface undergoing erosion (non-deposition), is an indirect evidence to show that the Granites were associated with epirogenic upliftment. Imeokparia (1982) reported that the Jos Plateau tin deposits are within the Nigerian Younger Granite Province. The Younger Granites intrude the Nigeria Precambrian Basement gneiss and granite complex occur characteristically as ring complexes with prominent topographic features in the northern part of Nigeria. As a result of weathering activity, the rocks of the study area have undergone immense laterization resulting in the formation of laterites in areas that were formerly covered by rocks. The older basalts have been intensely weathered and only the ironstone capping can be seen on the surface.

The Jos Plateau is probably the most striking geographical feature in Nigeria. According to Udo (1970), the highest part of the plateau is around Bukuru and Gyel which presents a rather interesting aspect in that there are no striking relief features like high ridges or rocky-mountains. Rather the picture presented is one of undulating, swampy plain diversified by a few broken ridges and low granitic large areas in which recently extinct volcanic cones form the third type of hill masses on the plateau (Figure 2).

2.4. Field Work/ Samples Collection

In the study area three locations where active tin mining has been going on for several years were identified as sampling points, namely, Gyel, Rabi and Fwarti (Figure 2). Four profile pits were sunk in each of the location, three (3) at the mined sites (disturbed area) and one (1) at the control (undisturbed area), making a total of 12 profile pits sunk. The GPS of the profile pits are presented in Table 1.The dimension of each profile pit was 200 cm x 150 cm x 200 cm depth, except where hard rock or water table was encountered before 200 cm (Plate 1). Sixty (60) soil samples were collected from the affected area (mined sites) and non-affected area (control) from the twelve (12) soil profiles

Table 1: GPS positioning of the profile pits sunk in the three location of Bukuru study area

Location		Pedon 1	Pedon 2	Pedon 3	Control
Gyel	Latitude	9.735	9.784	9.786	9.788
	Longitude	8.620	8.859	8.859	8.855
	Altitude	14.16	14.57	15.06	15.21
	Accuracy	2.5m	3.3m	9.1m	2.2m
Fwarti	Latitude	9.805	9.806	9.806	9.03
	Longitude	8.873	8.877	8.878	8.877
	Altitude	3.28	13.33	13.23	13.03
	Accuracy	1m	2.4m	2.1m	2.2m
Rabi	Latitude	9.783	9.784	9.784	9.777
	Longitude	8.883	8.884	8.835	8.889
	Altitude	12.44	12.33	12.36	12.21
	Accuracy	7m	1.2m	1m	1m

Plate 1: Dimension of profile pits sunk at Bukuru for the collection of soil samples used for heavy metals analyses

in the Bukuru study area. Soil samples were collected by scratching the profile surface at 0 to 10 cm, 10 to 20 cm, 20 to 30 cm, 30 to 40 cm and 40 to 50 cm, that is, at intervals of 10 cm across the depth of 0 to 50 cm depth for each of the profile pits sunk.

2.5 Laboratory Analysis

The 60 soil samples were analysed by wet digestion method and the heavy metals determined using the Atomic Absorption Spectrophotometer Model: Varian Spectra AAS FS 240 plus (Rowell, 1994). Samples were aspirated into the flame, the heavy metals present in the sample absorbed some of the light from cathode lamp reducing the intensity of light transmitted. Heavy metals analyzed from the soil samples collected were Lead (Pb), Zinc (Zn), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Copper (Cu), Manganese (Mn), Cobalt (Co), and Iron (Fe) concentration. The computer data of the machine converted the intensity of light into the absorbance which was directly proportional to the concentration of heavy metal present. This was determined from the working curve after calibrating the instrument with standards of all the heavy metals to be analysed.

2.6 Analysis of Data

Data for laboratory analysis was subjected to statistical analysis using Genstat Discovery Edition 3.1. Data were subjected to analyses of variance (ANOVA) and significant means separated at probability level of 0.05 using the procedure of Fischer's least significant difference. Variability of heavy metals distribution was determined according to the procedure of Wilding (1985), using mean and coefficient of variation (CV) where, (CV) ranging from 1-15 are rated as little variation, 16-35 as moderate variation and from > 36 as high variation. Data were also presented using descriptive statistics: mean mode and coefficient of variability (CV). The levels of heavy metals in the soils were compared to their respective critical limit values being standard guidelines set by the World Health Organization (WHO) and the Food and Agricultural Organization of the United Nations (FAO) (Tables 2).

3. Results and Discussion

The result of laboratory analyses revealed eight (8) heavy metals identified at Gyel, namely, Zn, Pb, Cu, Fe, Mn, Cr, Ni and Cd whose concentrations were 0.77 mgkg^{-1}, 0.77 mgkg^{-1}, 0.23 mgkg^{-1}, 361 mgkg^{-1}, 1.44 mgkg^{-1}, 1.36 mgkg^{-1}, 0.06 mgkg^{-1}, and 0.01 mgkg^{-1}, respectively. Also at Rabi location, eight (8) heavy metals namely, Zn, Pb, Cu, Fe, Mn, Cr, Ni and Cd were identified whose mean concentrations were 0.29 mgkg^{-1}, 0.35 mgkg^{-1}, 0.11 mgkg^{-1}, 251 mgkg^{-1}0.75 mgkg^{-1}, 0.05 mgkg^{-1}, 0.05 mgkg^{-1} and 0.01 mgkg^{-1} respectively. At Fwarti location, however, seven (7)of the heavy metals were identified, namely, Zn, Pb, Cu, Fe, Mn, Ni and Cd with mean concentrations of 0.18 mgkg^{-1}, 0.29 mgkg^{-1}, 0.13 mgkg^{-1}, 434 mgkg^{-1}, 0.63 mgkg^{-1}, 0.08 mgkg^{-1}, and 0.01 mgkg^{-1}, respectively (Table 3, Figure 3 and 4).

The mean values of seven (7) of the heavy metals, namely, Zn, Pb, Cu, Fe, Mn, Cr and Ni at the mined area of Gyel location were higher than their corresponding FAO/WHO critical mean values of 0.3 mgkg^{-1} for Zn, 0.1 mgkg^{-1} for Pb, 0.10 mgkg^{-1} for Cu, 50mgkg^{-1} for Fe, 0.2 mgkg^{-1} for Mn, 0.1 mgkg^{-1} for Cr and 0.05 mgkg^{-1} Ni. Also, for Rabi location, the mean values of four (4) of the heavy metals, namely, Pb, Cu, Fe and Mn at the abandoned tin mine area were higher than their corresponding FAO/WHO critical mean values of 0.1mgkg^{-1} for Pb, 0.1 mgkg^{-1} for Cu, 50 mgkg^{-1}for Fe and 0.2 mgkg^{-1}.While Zn and Cd concentrations were below their respective FAO/WHO critical limits for agricultural soils, Cr and Ni have same values with their corresponding FAO/WHO critical limits. At Fwarti location, the mean values of five (5) of the seven (7) heavy metals, namely, Pb, Cu, Fe, Mn and Ni were higher than their corresponding FAO/WHO critical mean values of 0.27 mgkg^{-1} for Pb, 0.10 mgkg^{-1} for Cu, 50 mgkg^{-1}for Fe, 0.2 mgkg^{-1} for Mn, and 0.05 mgkg^{-1} for Ni. Cr was not detected while Cd concentration of 0.01 mgkg^{-1} was the same with its corresponding FAO/WHO critical limits for Agricultural soils (Table 3).

Table 2: FAO/WHO (2001) Critical limits for Heavy Metals in agricultural Soils

Heavy Metal	Critical limits (mgkg^{-1})
Zn	0.30
Pb	0.10
Cu	0.10
Fe	50.00
Mn	0.20
Cr	0.10
Ni	0.05
Cd	0.03
Co	0.05

FAO= Food and Agricultural Organizations; WHO = World Health Organization.

Table 3: Heavy Metals Identified in the Soils across the Three Locations of Bukuru

Heavy metals concentration (mgkg^{-1})								
Location	Zn	Pb	Cu*	Fe	Mn	Cr	Ni	Cd
Gyel	0.77	0.77	0.23	361	1.44	1.36	0.06	0.01
Rabi	0.29	0.35	0.11	251	0.75	0.05	0.05	0.01
Fwarti	0.18	0.29	0.13	434	0.63	ND	0.08	0.01
FAO/WHO(2001)	0.3	0.1	0.1	50	0.2	0.1	0.05	0.03

FAO= Food and Agricultural Organizations; WHO = World Health Organizations; ND= Not Detected

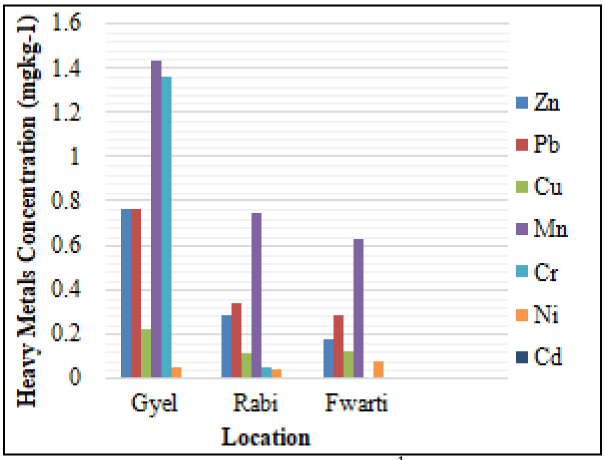

Figure 3: Mean concentrations (mgkg^{-1}) of Zn, Pb, Cu, Mn, Cr, Ni, and Cd at Bukuru

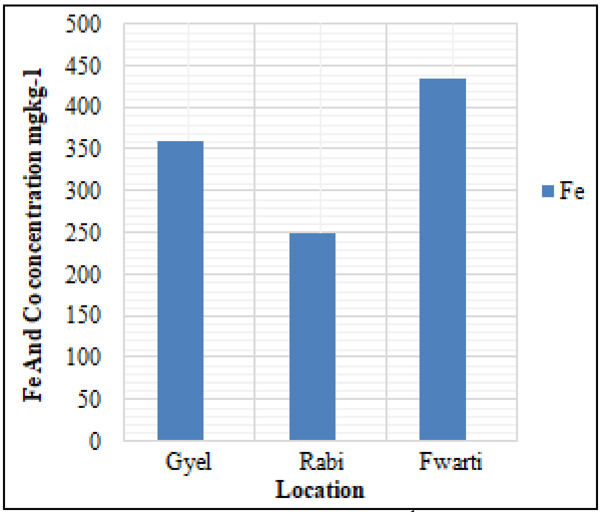

Figure 4: Mean concentrations (mgkg^{-1}) of Fe at Bukuru

These results therefore, revealed that Gyel location was contaminated with Zn, Pb, Cu, Fe, Mn, Cr and Ni. Rabi location was contaminated with four of the heavy metals identified, namely, Pb, Cu, Fe and Mn, while Fwarti location was contaminated with five (5) of the heavy metals, namely, Pb, Cu, Fe, Mn and Ni.

Comparison of all the heavy metal concentrations identified for the Control (Unmined area), located at least a kilometer away from the mined sites with their corresponding FAO/WHO critical limits for Agricultural soils revealed that the mean values at the Control for Zn, Pb, Fe, Mn, Cr and Ni which were 0.38 mgkg^{-1}, 0.27 mgkg^{-1}, 238 mgkg^{-1}, 0.94 mgkg^{-1}, 0.44 mgkg^{-1} and 0.06 mgkg^{-1} respectively, were all higher than their corresponding FAO/WHO critical limits for Agricultural soils (Table 4). Since the mean concentration of both the abandoned mined area and the Control (Unmined areas) were above the FAO/WHO critical limits for agricultural soils for Zn, Pb, Cu, Fe, Mn, Cr and Ni (Table 4), Bukuru soils were therefore contaminated with Zn, Pb, Cu, Fe, Mn, Cr and Ni in the following order: Fe>Mn>Cr>Mn>Cr>Zn>Cu>Ni, and this contamination were not limited to the abandon tin mine (Disturbed area)

Table 4: Comparison of Mean Concentrations of Heavy Metals between the Abandoned Tin Mined Areas and the Control Critical Limits for Agricultural Soils

Heavy metals concentration (mgkg^{-1})								
Location	Zn	Pb	Cu*	Fe	Mn	Cr	Ni	Cd
Gyel	0.77	0.77	0.23	361	1.44	1.36	0.06	0.01
Rabi	0.29	0.35	0.11	251	0.75	0.05	0.05	0.01
Fwarti	0.18	0.29	0.13	434	0.63	ND	0.08	0.01
Control	0.38	0.27	0.10	238	0.94	0.44	0.06	0.01
LSD (≤0.05)	ns	ns	0.05	ns	ns	ns	ns	ns
FAO/WHO(2001)	0.3	0.1	0.1	50	0.2	0.1	0.05	0.03

LSD = Least significant differences of means (5% level); CV= Coefficient of variation; BDL= Below Detection Limit; FAO= Food and Agricultural Organizations; WHO = World Health Organizations; FEPA = Federal Environmental and Protection Agency

Mines, but has spread to the surrounding environment up at least a km away from the Abandoned Tin Mine (Disturbed areas).

4. Conclusion

Sixty (60) soil samples were collected from twelve (12) soil profiles sunk in both the affected (mined sites) and non-affected unmined areas (control) in the three locations of Bukuru study area. Samples collected were used for the determination of heavy metals concentration in Bukuru soils. Heavy metals analyzed included Lead (Pb), Zinc (Zn), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Copper (Cu), Manganese (Mn), Cobalt (Co), and Iron (Fe) concentration in soil.

Data were subjected to analyses of variance (ANOVA) using Genstat Discovery Edition 3.1and significant means separated at probability level of 0.05 using the procedure of Fischer's least significant difference. Variability of heavy metals distribution was determined. Data were also presented using descriptive statistics: mean mode and coefficient of variability (CV). The levels of heavy metals in Bukuru soils were compared to their respective critical limit values being standard guidelines set by the World Health Organization (WHO), Food and Agricultural Organization of the United Nations (FAO) and the Federal Environmental Protection Agency (FEPA), of the Federal Republic of Nigeria.

Results showed that eight (8) heavy metals were identified at Gyel and Rabi locations, namely, Zn, Pb, Cu, Fe, Mn, Cr, Ni and Cd, while at Fwarti location only seven (7) of the heavy metals analyzed were identified namely, Pb, Cu, Fe, Mn, Ni and Cd. The mean values of seven (7) of the heavy metals identified at the mined area of Gyel location, namely, Zn, Pb, Cu, Fe, Cr and Ni were higher than their corresponding FAO/WHO critical mean values. Also, for Rabi location, the mean values of four (4) of the heavy metals, namely, Pb, Cu, Fe and Mn at the abandoned tin mine area were higher than their corresponding FAO/WHO critical mean values. While Zn and Cd concentrations were below their respective FAO/WHO critical mean values, Cr and Ni have same values with their corresponding FAO/WHO critical limits. At Fwarti location, the mean values of five (5) of the heavy metals identified, namely, Pb, Cu, Fe, Mn and Ni at the abandoned tin mine areas were higher than their corresponding FAO/WHO critical mean values. These results therefore reveal that Gyel location was contaminated with Zn, Pb, Cu, Fe, Cr and Ni; Rabi location was contaminated with Pb, Cu, Fe and Mn, while Fwarti location was contaminated with Pb, Cu, Fe, Mn and Ni.

Furthermore, comparison of all the heavy metal concentrations identified including the Control (Unmined area), located at least a kilometer away from the mined sites except for Cr and Cd were found to be higher than their corresponding FAO/WHO critical limits for agricultural soils. This revealed that the contamination of Bukuru soils with the identified heavy metals were not limited to the abandoned tin mines (Disturbed areas) only, but has spread to the surrounding environment up to at least a km away from the abandoned tin mine (Disturbed areas). Bukuru soils were therefore contaminated with Zn, Pb, Cu, Fe, Mn, Cr and Ni in the following order: Fe>Mn>Cr>Mn>Cr>Zn>Cu>Ni.

5. Recommendations

1) The decontamination and reclamation of Bukuru soils is recommended through cost effective phytoremediation methods, such as phytoextraction, and Phytostabilisation using heavy metals hyper accumulating plants species that can grow well in the localized environment.
2) Effects of these heavy metals on crops growing in Bukuru soils need further studies to determine their tolerance levels as well as hyper accumulating characteristics.
3) The results of this study demand for careful monitoring of the Bukuru environment due to the existing environmental pollution by heavy metals. Thorough monitoring database can be developed which gives a variety of useful information and methodology towards achieving the goal of providing safe and quality food.

References

[1] Alao, D. A. (1983). Nigeria environment today. (Special Feature).New Nigerian News Paper. February 13 and 22.
[2] Atkins, P., Shriver, D. F., Overton, T. and Rourke, J. (2006). Inorganic chemistry (4th ed.). W.H. Freeman. pp. 343, 345.
[3] Argheore, E. M. (2005). Country Pasture/Forage Resource profiles, Nigeria. University of South Pacific, School of Agriculture, Apia, Alafua Campus, SAMOA.
[4] Adams, M. (2010). Environmental impacts associated with tin mines in Bukuru, Rayfield, Jos South and Jos East, Plateau state. M.Sc. Thesis. Geology Department, University of Jos. Unpublished, pp 46
[5] Adebayo, M. A. (2007). Land Use and Resource Conservation for Sustainable Friendly Environment in Nigeria, *Journal of Environmental Conservation and Research, vol.* 1(1), pp 1-11
[6] Edun, E.O and, Davou, D. D. (2013). Inventory of abandoned mine ponds/dams On the Jos-Bukuru North-Central Nigeria Using G.I.S And Remote Sensing Techniques: *The International Journal of Engineering and Science (IJES)* Volume 2, Issue 5, pp. 62-71
[7] Ezeono, C. S., Tagbo, R., Anike, E., N., Oje, O.A. and Onwurah, I. N. E. (2012).*Biotechnology Research International*, Volume 2012
[8] FAO/WHO Codex Alimentarius Commission (2001). Food Additives Contamination Joint FAO/WHO standards, programme O1/12A: pp. 1- 28
[9] International Association for Impact Assessment, IAIA: (1999). Principles of Environmental Impact Assessment Best Practice. Institute of Environmental Assessment, UK
[10] Imeokparia, E. G. (1982).Petrologic and geochemical characteristics of some Nigeria soils.
[11] ITRI Reports (2012). (Tin Mining and Processing). Retrieved September, 9th 2015 http//www.australianminerals.gov.au.
[12] Kar D; Sur P; S. Mandai; Saha K.T; Kole R.K.(2008).Assessment of Heavy in Surface water. *Int.J. Environ. Sci. Tech, vol.5 (1),* pp 119-124
[13] Ogezi, A. E. and Adikwu-Brown, M.E. (1987).Trace Element and pollution studies on the Zurakand Jos Mining areas, Plateau state, Nigeria. Proceeding of Nigeria, Japan Joint Conf. Ehindero (Nig). Ltd., Jos.
[14] Macleod, W.N. Tuner, D.C., Berridge, N.G. and Black, R. (1971). Younger granite complex Bull. Geol. Survey Vol. 2 pp 47
[15] Ogunowo, C. O. and Oderinde, F. O (2007) Concomitant Environmental and Ecological problems of Mineral Resources Exploitation: A focus on the Niger-Delta Region of Nigeria. *Journal of Environmental Conservation and Research, Vol.* pp20-29
[16] Rowell, D.L. (1994). Soil Science: Methods and Applications. Pesticides and Metals. Longman Singapore Publisher (Pte) Ltd. Singapore.US Salinity Lab. Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA Handbook No.60, pp303-327.
[17] Srinivasan T.J. & Reddy R.V. (2009). Waste water Irrigation in India: An Analysis of its Heath Impact. A Conference paper of INSEE, Centre for Economic and social studies, Nizamiah observation Campus, Begumpet. Hyderabad, India.
[18] Turner, D. C. (1963). Structure and Petrography of the Younger Granite Ring Complexes. In: Geology of Nigeria (eds). Kogbe, C.A Elizabeth Publishing Company, Lagos, Nigeria.
[19] Uchegbu, S. (1998). Environmental Management and Protection, Precision Printers and Publishers, Enugu, Nigeria.
[20] Udo, R.K. (1970). Geographical regions of Nigeria. University of California press, Berkeley and Los Angeles, California, USA, pp 127
[21] Weather Travel. (2012). Jos Climate and Weather Averages, Nigeria: *Journal of Soil Science and Environmental Management* Vol. 3(4), pp.77-83.
[22] White, F. (1983). The vegetation of Africa, a descriptive memoir to accompany the UNESCO/AETFAT/UNSO. Vegetation map of Africa. UNESCO, Paris
[23] Wilding (1985). Spatial variability; Its ducomentation accommodation and implication to soil surveysin DR Neilsen and J. Bourma (Eds). Soil special variability pudoc, Wageningen, Netherlands, pp 166-194.
[24] World Wildlife Fund. WWF: (1998). A conservation assessment of terrestrial eco-regions of Africa. Draft proceedings of a workshop, Cape Town, South Africa. August, 1998. World Wildlife Fund, DC, USA.