International Journal of Multidisciplinary Research and Development
Online ISSN: 2349-4182 Print ISSN: 2349-5979
www.allsubjectjournal.com
Volume 2; Issue 12; December 2015; Page No. 386-389

Assessment of heavy metals in soils and surface water around mines in Jos metropolis, plateau state Nigeria

[1] Adamu GK, [2] Muhammad Auwal, [3] Abba Aliyu Kasim, [4] Halliru JL

[1] Department of Geography and Regional planning, Department of Biological Sciences, Federal University Dutsinma, Nigeria.

[2] Research Scholar, Department of Soil Science, Sam Higginbottom Institute of Agriculture Technology & Sciences, Allahabad, U.P., India.

[3] Research Scholar, Department of Soil Water Land Engineering & Management, Sam Higginbottom Institute of Agriculture Technology & Sciences, Allahabad, U.P., India.

[4] National Metallurgical Development Centre, Jos, P.M.B. 2116, Plateau State, Nigeria.

Abstract
Total heavy metals concentrations for Cu, Pb, Zn, Mn, Ni and Fe were evaluated in soils and surface water. Samples collected from two different mine sites A (old mines) and B (new mines) analyzed using Atomic Absorption Spectrophotometer. From the analysis, it was observed that except for Cu and Fe, at 50-100m from source, total trace metal concentrations were higher at the mines location B than in the mines location A. Cd was not detected, except in surface water samples after extraction with APDC/MIBK. Based on the findings, concentrations of these metals were above the limits specified for agricultural soils, except Cu, which was within the limits. The results also revealed that the concentrations of these metals in surface water samples were above the recommendation limits of World Health Organization (WHO) for drinking water.

Keywords: Soil, Surface Water, Heavy Metals, Atomic Absorption Spectrophotometer

1. Introduction

Mining is one of the important pathways by which soils are contaminated. It has considerable implication on the air and water quality, loss of biodiversity, soil pollution and land degradation (Jibiri *et al*, 2011) [12]. According to Adewole & Adesina 2011 [3], mining could also result in clearing of vegetation, reduces biological activities and decreases productivity of the soil. Mining operations distort the equilibrium in the geological environment and may set off geological hazards like landslide, subsidence, flooding, erosion and suchlike together with their secondary effects (Mallo, 2012) [10]. Generally, mineral exploration and exploitation directly or indirectly affect both the living and non-living things through the physical and chemical modification of the soil environment (Adewole & Adesina, 2011) [3]. Soil is a three dimensional natural body on earth's surface that is essential to numerous ecosystem functions such as production of biomass and net primary productivity, moderation of climate, purification of water, biodegradation of pollutants, storage of water and plant nutrients and recycling of elements. It is the essence of all terrestrial life (Lai, 2009) [9].

Heavy metal content in soil and surface water above permissible limits adversely affects fertility and nutrient status of soils. Similarly, it degrades the quality of surface water for drinking and irrigation purposes. Heavy metal concentration in soil and surface water has been a very useful indicator of environmental quality worldwide. It draws much attention of local, state and international communities because of their effects on human health and environment. Regarding most heavy metals particularly Pb, Cu and Zn, anthropogenic origins put in more to pollution than natural sources (Bilos, *et al*, 2001) [5]. These heavy metals in the terrestrial environment visibly constitute a significant risk to the quality of soils (Adriano, 2001) [4]. Waste water from industrial processes may contain significant load of zinc, copper, chromium and nickel (Sollitto *et al*, 2010) [13]. Mining and its aftermath is always devastating to the ecology of the host community, hence, the result of the decades of commercial mining left a legacy of damaged or derelict landscapes and impoverished agricultural farm lands as well as environmental problems (Aigbedion and Iyayi, 2007; Pasquini and Alexander, 2005). Plateau state is among the states were tin and columbite were discovered in large quantities and were being mined before the discovery of oil. The impacts of mining on the state is still felt as investigation has shown that there were more thant 3000 mining ponds in the state mostly located in Jos south, Barikin Ladi, Bassa, Jos East, Riyom, Bokos and Mangu Local governments. The traditional farming system of the peasants has become distorted today as a result of shortage of productive land. Therefore, people in the mining communities have to farm on the same piece of land yearly in spite of the poor quality of the land. Very poor productivity has been reported by (Jibiri *et al*, 2007). Therefore, this study is aimed at assessing the heavy metals content in soils and surface water around some mines in Jos metropolis.

2. Materials and methods

2.1. Study Area

2.1.1. Location and Extent

This study was carried out in Jos metropolis of Plateau State north central, Nigeria. Jos is enclosed between latitudes $9^0$51'30''N to $10^0$02'00''N and longitudes $8^0$48'00''E to $9^0$59'00''E at an altitude of 1,217 m (3,993 ft) above sea level. It has an area of 291km^2 (Adeniran, 2013; Wikipedia, 2015). Figure 1 shows the sampling site.

2.1.2. Climate

Jos has a tropical savanna climate denoted as *Aw* in the Köppen Climate Classification system. It receives about 1,400 millimetres (55 inches) of rainfall annually. Mean monthly temperatures range from 21–25 ^{0}C.

2.1.3. Soils

Tropical ferruginous soil is the predominant soil type of Jos Plateau. The soils are much thinner on the high plateau but attain greater depths in the southern part of the state. Loamy soils of volcanic origin are also found in the high Plateau (Community Portal of Nigeria, 2015) [6].

2.1.4. Sampling

Soil samples were collected from two locations A and B close to mining sites around Jos metropolis. The sampling was done at 0-50, 50-100, 100-150 meters intervals away from each mining site considering the topography of the area. At each point, five samples were collected at the depth of 5cm intervals (0-25cm). The samples were stored in polythene bags and were taken to the laboratory. The soil samples were air-dried at room temperature, grinded and sieved to 2mm. Surface water samples were also collected at 100 meters away from the mines.

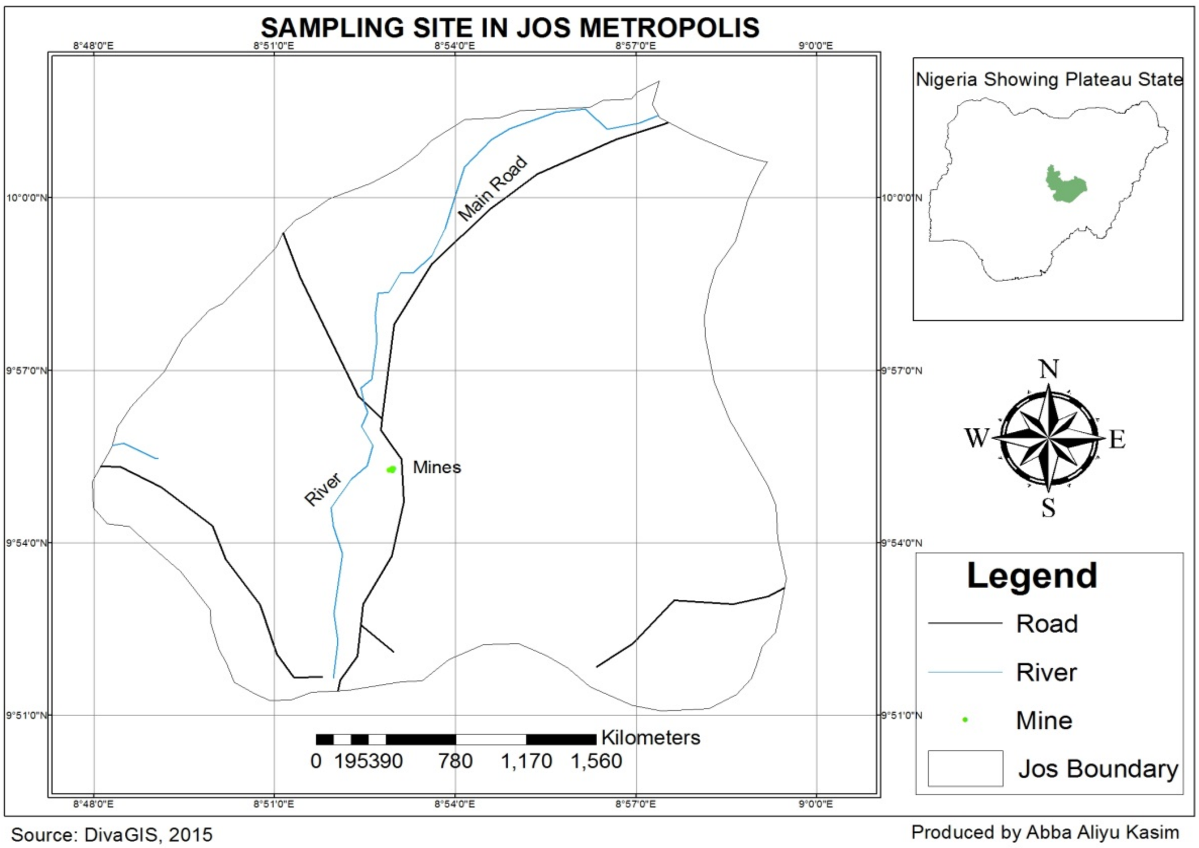

Fig 1: Sampling Site

2.1.5. Laboratory Analysis

Soil organic matter was determined using wet oxidation method (Walkley and Black, 1947); pH was determined using glass electrode in a 1:2.5 soil/water suspension (Jackson, 1973). Soil samples were digested with aqua-regia (4:1 HCl-to-HNO_3 by volume) to determine the concentrations of Cu, Zn, Pb, Mn, Ni, Fe and Cd (McGrath S P, Cunliffe C H., 1985). The extracts were analyzed with Flame Atomic Absorption Spectrophotometer (AAS). The metals in water samples were extracted by measuring 100ml of the sample into a separating funnel. Then, 7ml of 1% APDC and 15ml of MIBK were added into the separating funnel and were shaken for some minutes. The mixture was allowed to settle and separated into organic and aqueous layers. The organic layer was collected and analyzed for the metals using (AAS).

3. Results and discussion

3.1. Soils

The results of the total metal concentrations in both mine locations are presented in Tables 1, 2 and 3. The findings showed that Cu, Pb, Zn, Mn, Ni and Fe were detected in all soils, while Cd was not detected.

The organic matter content ranges from 4.57 to 10.58% in mine location A (old mines), while that of mine location B (new mines) ranges from 4.60 to 10.75%. Organic matter content and carbonates are among several components of the soil, which affect the availability, retention, and mobility of the metals in soils. These values of organic matter content could increase total metal concentrations in the soils. This is because a linear relationship between some of these metals and organic matter in the soils was reported by Abdel and Schwab (1994).

The pH values of mine location A ranges from 5.0 to 7.0, while that of mine location B ranges from 4.8 to 6.1. The concentrations of metals in both sites were above the specified limits for agricultural soils, except Cu, which was within the limits. Several studies have shown a decrease in the amount of these metals with an increase in pH. Therefore, there is a chance of finding much availability of the heavy metals in new mines than in old mines.

3.2. Surface Water

The concentrations of heavy metals in surface waters were found to be higher in old mines location A than in new mines location B except Ni, which was found to be higher in mine location B (Table 4). Cadmium was found in surface water. The concentrations of these metals in surface water were above the approved limits of World Health Organization (WHO) limits for drinking water, except Zn. which was within the limits

3.3. Statistical Analysis

Correlation analysis was carried out so as to assess the strength of relationships between the parameters. Generally, a poor correlation was found to exist between the parameters ($R^2 > 0.4$) at both old mines (A) and new mines (B), except in few cases. A Good correlation coefficient ($R^2 > 0.5$) was found among most of the parameters determined in surface water.

Table 1: Total heavy Metals Concentration at Source

Location	Depth (cm)			Heavy Metals Concentration (mg/L)						
		O.M%	pH	Zn	Pb	Cu	Cd	Fe	Mn	Ni
A	0-5	6.70	7.0	3.00	2.70	0.38	ND	1200	4.88	1.13
	5-10	4.57	6.7	3.60	2.40	0.39	ND	1300	5.03	1.20
	10-15	5.05	6.5	2.93	2.33	0.45	ND	1150	4.50	0.98
	15-20	5.43	6.2	3.08	2.70	0.38	ND	1250	3.75	1.43
	20-25	6.40	6.1	2.85	2.70	0.39	ND	1325	3.38	1.58
B	0-5	10.75	5.7	5.70	2.33	0.24	ND	1150	4.73	1.20
	5-10	8. 26	5.8	6.90	2.78	0.30	ND	1075	4.65	1.28
	10-15	9.69	5.6	5.85	3.53	0.45	ND	1350	4.88	1.50
	15-20	9.38	5.8	9.60	4.23	0.39	ND	1250	5.78	1 .73
	20-25	10.27	5.1	10.2	4.13	0.45	ND	1325	6.53	2.40

Table 2: Total heavy Metals Concentration at 50m -100m from Source

Location	Depth (cm)			Heavy Metals Concentration (mg/L)						
		O.M%	pH	Zn	Pb	Cu	Cd	Fe	Mn	Ni
A	0-5	10.58	6.3	4.05	3.15	0.75	ND	1275	9.15	2.63
	5-10	10.54	6.7	3.45	3.45	0.75	ND	1400	7.28	2.70
	10-15	10.10	6.5	3.38	3.45	0.75	ND	1475	7.50	2.78
	15-20	9.71	6.4	3.00	2.85	0.68	ND	1450	5.55	2.78
	20-25	9.83	6.2	2.85	2.85	0.60	ND	1425	4.13	2.70
B	0-5	6.27	5.5	5.03	2.40	0.23	ND	1075	4.10	0.90
	5-10	4.89	5.6	4.50	2.33	0. 21	ND	1000	2.70	0.90
	10-15	4.60	6.1	5.10	2.85	0.24	ND	1150	3.23	1.13
	15-20	5.12	5.7	5.10	2 73	0.24	ND	1100	2.85	1.20
	20-25	5.59	5.0	4.13	2.25	0.27	ND	1075	2.93	1.20

Table 3: Total heavy Metals Concentration at 100-150m from Source

Location	Depth (cm)			Heavy Metals Concentration (mg/L)						
		O.M%	pH	Zn	Pb	Cu	Cd	Fe	Mn	Ni
A	0-5	6.73	5.2	1.50	1.20	0.23	ND	825	2.93	0.83
	5-10	4.88	5.0	1.50	1.43	0.24	ND	850	3.75	0.98
	10-15	5.45	5.1	1.88	1.43	0.27	ND	900	3.45	1.28
	15-20	5.76	5.3	2.03	1.80	0.27	ND	1000	3.30	1.28
	20-25	6.25	5.4	2.18	1.80	0.30	ND	1075	3.38	1.35
B	0-5	8.43	5.5	3.60	2.15	0.45	ND	1000	5.40	1.20
	5-10	5.17	5.4	3.53	2.85	0.39	ND	850	4.58	1.13
	10-15	7.55	5.0	4.88	2.55	0.39	ND	1300	4.50	1.30
	15-20	8.30	4.8	5.48	2.98	0.53	ND	1325	4.65	1.73
	20-25	8.13	4.8	5.48	3.15	0.45	ND	1325	5.18	1.65

O.M = Organic Matter. ND = Not Detected

Table 4: Heavy Metals Concentration in Surface Water (mg/L)

Sample	Cu	Pb	Cd	Zn	Mn	Ni	Fe
Old mine A1	1.70	6.00	0.50	2.05	6.00	3.70	51.00
Old mine A2	1.40	5.70	0.30	2.90	6.00	3.70	53.00
New mine B1	1 .40	5.70	0.40	2.05	5.30	5.30	46.00
New mine B2	1.40	5.40	0.40	1.35	5.30	530	48.00

4. Conclusions

In conclusion, it was discovered that concentrations of these metals were higher in mines location B than in mines location A, except Cu and Fe, at 50-100m from source which were higher in mines location A. The range of these metals in soil samples analyzed was above the range specified for agricultural soils, except Cu, which, was within the range. The concentrations of these metals in surface water samples were above the approved limits for drinking water, except Zn, which was within the limits.

5. References

1 Abdel-Saheb I, Schwab AP. Leaching of Heavy Metals in Soil Columns Under Unsaturated Conditions. Proceedings of the 9th Annual Conference on Hazardous Waste Remediation, 1994, 123.

2 Adeniran MA, Ekpo Effiong AO, Ibekwe VJ. Application of Geographic Information System (GIS) in Internal Security Operations, A case study of Jos Metropolis, Plateau State, Nigeria. FIG Working Week 2013 Environment for Sustainability. Abuja, 2013.

3 Adewole MB, Adesina MA. Impact of marble mining on soil properties in a part of Guinea Savanna zone of southwestern Nigeria. Ethiopian J. Environ. Studies Manage. 2011; 4:1-8. (http://dx.doi.org/10.4314/ejesm.v4i2.1).

4 Adriano D. Biogeochemistry, Bioavailability and Risks of Metals: Trace elements in terrestrial environments''. 2nd Edn. New York: Springer-Verleg, 2001.

5 Bilos C, Colomobo JC, Skorupka CN, Presa MJR. Source, distribution and variability of airborne trace metals in La Plata city area, Argentina. Environ. Pollut. 2001; 111:149–158.

6 Community Portal of Nigeria, 2015.Retrieved from Online Nigeria: http://www.onlinenigeria.com/links/Plateauadv.asp?blur=461

7 Jackson M. L Soil Chemical Analysis. New Delhi: Prentice Hall of India Pvt. Ltd. 1973.

8 Jos Wikipedia, 2015. Retrieved November Thursday, 2015, from Wikipedia: https://en.wikipedia.org/wiki/Jos

9 Lai P. Soil degradation as a reason for inadequate human nutrition. Food Sec, 2009. (DOI 10.1007s12571-009-009-z).

10 Mallo SJ. The Socio economic Impact of Artisenal Mining in Kuru (Naraguta Sheet 168) Plateau State North Central Nigeria. Continental J. Engineering Sciences. 2012; 7(3):27-32.

11 McGrath SP, Cunliffe CH. A Simplified Method for the Extraction of the Metals Fe, Zn, Ni, Cd, Pb, Cr, Co and Mn from Soils and Sewage Sludges. Journal of the Science of Food and Agriculture, 1985; 36:794-798.

12 Jibiri NN, Alausa SK, Owofolaju AE, Adeniran AA. Terrestrial gamma dose rates and physical-chemical properties of farm soils from ex- tin mining locations in Jos-Plateau, Nigeria. African Journal of Environmental Science and Technology. 2011; 5(12):1039-1049.

13 Sollitto D, Romic M, Castrignano A, Romic D, Bakic H. Assessing heavy metal contamination in soils of the Zagreb region (Northwest Croatia) using multivariate geostatistics. *Catena,* 2010; 80:182-194.

14 Walkley A, Black IA. Critical examination of rapid method for determining soil organic carbon in soils, effect of variation in digestion conditions and inorganic soil constituents. Soil Science, 1947, 632-251.