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AN ASSESSMENT ON SOME SELECTED HEAVY METALS IN SOILS AROUND MAIGANGA COAL MINE AND IT'S ENVIRONS, GOMBE STATE, NIGERIA

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Abstract

This research work try to estimates the levels of some heavy metals concentrations in different soil depth around Maiganga coal mine and its environs using Atomic Absorption Spectrophotometer A total of 9 samples from mining site, Farmland, Residential area were collected and analyzed for (Ni, Cd, Cu, Pb, and Cr). Results obtained shows that Lead (Pb) concentration was below the detection limit of the instrument in all the samples in different depths of soil. Ni has lowest value of 5.06ppm at a depth of 0 - 5cm and 10-15cm in the residential areas (Jauro Buba) and highest value of 15.46ppm at depth of 0 - 5cm in Maiganga Coal Mine. Cd has the lowest value of 0.10ppm at a depth of 10-15cm in Maiganga Coal Mine and highest value 0.36ppm at a depth 10-15cm in farmland area while Cu, has the lowest value of 0.12ppm at a depth of 0-5cm and 5-10cm in residential areas (Jauro Lokonjo) and highest value of 0.23ppm at a depth of 5-10cm in Farmland areas. Cr has the lowest value of 0.46ppm at a depth of 0-5cm and 10-15cm in Jauro Lokonjol and highest value of 0.80ppm at a depth of 5-10cm and 10-15cm in farmland and residential areas (Jauro Buba) respectively. Therefore, with the exception of Ni in Maiganga Coal Mine and farmland areas which exceeded the permissible limit value 15mg/kg, the other heavy metals levels were within permissible limit set by WHO(2007). However, statistical analysis using t-test at

$p>0.05$, revealed that there is no significant difference between the values of the metals at different soil depth in all the location.

Keywords: Coal Mine, Heavy metals, Maiganga, Soil and t-test

INTRODUCTION

Mining is the process of extracting minerals from the earth. Typical of most mining operations are tailing that consist of crushed ores and rocks bodies debins after extracting the ores metals. In Mining activities operations grinding, ore concentration and disposal of tailing, along with mill waste water provide obvious sources of heavy metals contamination to the environment as well as a potential source of exposure to naturally securing radioactive materials. Coal consist of a complex range of materials, and varies greatly in quality from deposit to deposit, depending on the varying types of vegetation from which the coal originated, the temperature and pressure exerted on the deposit and length of time the coal has been formed. There are various stages of coal development peat (organic matter), lignite (lowest quality coal), sub-bituminous – bituminous – anthracite (highest quality and hardest coal). The most significant use of coal is in electricity generation, steel production, cements manufacturing and liquid fuel Cunningham, M.A and Cunningham, W. P.(2005). Its predominant use has always been for producing heat energy. It was the basic energy source that fueled the industrial revolution of 18^{th} and 19^{th} centuries and the industrial growth of that era in turn supported the large scale exploitation of coal deposits. Since the mid 2oth century, coal has yielded its place to petroleum and natural gases the principal energy supplier of the world. Soil is an important component of the biosphere that serves as an environmental sink for contaminants and also acts as natural buffer controlling the transportation of mineral elements and other substance to the atmosphere and living organisms (Kataba – Pendias, 2000) soil affected by heavy metals suffer degradation due to impairment of physico-chemical, biological and other properties, thereby undermining the agriculture processes potential. Soils constitute part of vital environmental, ecological and agricultural resource that has to be protected. The determination of elemental status of cultivated lands is necessary to identify yield limiting deficiencies of essential micronutrients and polluted soils Alloway, (1990).The introduction of excess amount of metal substance into the environment has effects on the health of living organism either directly or indirectly – via/through soil pollution which is a major source of soil degradation. These metals substance have damaging health effects on animals via pants and become hazard to human being. Above certain concentration, metals affect natural microbial populations, leading to disruption of vital ecological system processes. Therefore, this research attempts to assess the level of some selected heavy metals implications derived from mining activities in soil at different depth in Maiganga coal mine area and is helpful for pollution control and environmental management.

DESCRIPTION OF THE STUDY AREA

The study area, Maiganga village is located in Akko Local Government Area (LGA) of Gombe state. It is located 8 km off Gombe – Yola road. Maiganga village is located west of Kumo town between Latitude 09°18′ and 11°59′E (Fig. 1). According to Oruonye *et al.*,2016**,** The study area, Maiganga community (Fig: 2) covers an area of about 20,129.47 Acres (48.16 Km2) . Maiganga coal mine is where coal is being extracted, coal is a fossil fuel formed from the decomposition of organic materials that have been selected to geologic heat and pressure over millions of years. It is considered a non-renewable resource because it cannot be replenished on the human time frame (United State Environmental Protection Agency, 2000). The economic activity of the study area is farming which includes the cultivation of different crops such as maize, millet, guinea corn, groundnut, sorghum and groundnut.

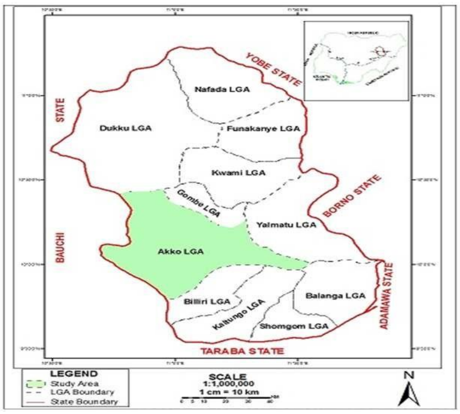

Fig. 1. Gombe state map showing study area (Oruonye *et al.*,2016)

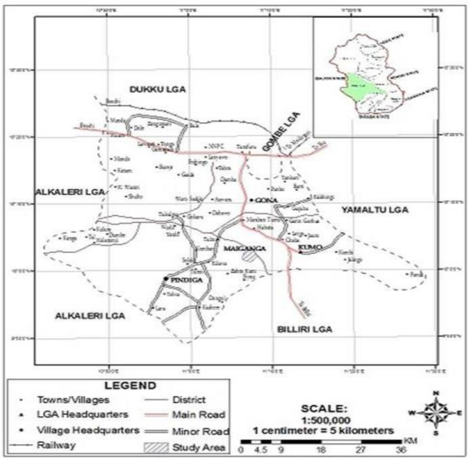

Fig. 2. Map of Akko showing Maiganga (Oruonye *et al.*,2016)

MATERIALS AND METHOD

Collection of Samples

Soil samples were obtained from various sites of the area of mining namely: - Maiganga coal area (W), Farmland (X) and residential area (Y) as showed (Fig. 3). The samples were collected from each part of the area mentioned using soil dagger at depths of 0 – 5cm, 5 – 10cm and 10 – 15cm.Eeach sampling was carried out in three replicate. A total of 42 soil samples were collected randomly. The samples collected from each of the plots were then stored in a polythene bag and leveled before taken to the laboratory for analysis.

Digestion of Samples

The samples were air-dried, to remove any clods and crumbs were removed, homogenized and sieved at 250um particle size. 0.5 g of the Soil samples were placed into 100ml beaker and moistened with few drops of distilled water. 5ml of Aqua-regia (a combination of HNO_3 and HCl in the ration1:3) was then added. The beaker was covered with a watch glass and placed on a hot plate in a fume cupboard. The mixture was boiled on a hot plate and allowed to simmer for 45 minutes. The mixture was removed from the hot plate and placed on a heatproof mat where it was allowed to cool. The watch glass was removed allowing any liquid to drain into the beaker. The content of the beaker was filtered through a whatman 41 filter paper into 100 ml volumetric flask. The filtered was made up to the mark with distilled water.

The volumetric flask was then inverted several times to ensure mixing and homogenization of the solution, the solution was then transferred into a labeled sample bottle and was analyzed for heavy metal content using AAS and then the concentration of Lead Cadmium, Chromium and Nickel and Copper in the Soil extract was read. (Vardaki and Kelepertsis,1999).

Calibration Solution

Standard solution of each sample Ni, Cd, Cu, Pb, and Cr were prepared according to SC 2000 manufacturer procedure for Atomic Absorption Spectroscopy to be used. A known 1000mg/l concentration of the metal solution was prepared from their salts.

Data Analysis

Data collected were subjected to one way analysis using students-t-test and were used to assess the significant different between different depth of the soil at ($P < 0.05$).

RESULT AND DISCUSSION

Table 1: Mean concentrations (ppm) of Heavy Metals in soil around Maiganga Coal Mining Area.

Samples location	Depth (cm)	Ni	Cd	Cu	Pb	Cr
Pit Soil (W1)	0 - 5	15.46	0.12	0.17	BLD	0.61
Interburden Soil (W2)	5 - 10	12.00	0.13	0.18	BLD	0.65
Overburden Soil (W3)	10 - 15	10.48	0.10	0.21	BLD	0.68
Mean		12.65	0.12	0.19	BLD	0.65
S.E ±		2.08	0.01	0.02	BLD	0.03

Table 1 shows the mean concentration in (ppm) of some selected heavy metals concentrations in soil at different depths of Maiganga coal mine area. From the result of the analysis Pb was found to be below the detectable limit of the instrument for all the different depths of the soil Ni has the mean 12.65 ± 2.08 with lowest of value of 10.48ppm at a depth of 10 – 15cm while highest value of 15.46ppm at a depth of 0 – 5cm. Cadmium has the mean of 0.12 ± 0.01 with the lowest value of 0.10ppm at a depth of 10 – 15cm while the highest value of 0.13ppm at a depth of 5 – 10cm, while copper has the mean of 0.19 ± 0.02 with the highest value of 0.21ppm at a depth of 10 – 15cm. Chromium has the mean of 0.65 ± 0.03 with lowest of 0.61ppm at a depth of 0 – 5cm and highest value of 0.68ppm at a depth of 10 – 15cm.

Therefore, this analysis reveals that the concentration of Ni are slightly above the permissible limit of 15mg/kg reported by WHO 2007 at 0 – 5cm depth, hence as it go down deep the concentration of NI reduces but statistically using students-t-test it reveal that there is no any significant different within different depth of the soil samples in all the selected heavy metals study from Maiganga coal mine.

Table 2: Mean Concentrations (ppm) of Heavy Metals in Soil Farmland Area.

Samples location	Depth (cm)	Ni	Cd	Cu	Pb	Cr
Lakwalog(X_1)	0 – 5	11.56	0.09	0.20	BLD	0.76
Maiganga(X_2)	5 – 10	10.48	0.14	0.23	BLD	0.80
Wuro Sarki (X_3)	10 – 15	12.29	0.36	0.18	BLD	0.59
Mean		11.44	0.20	0.20	BLD	0.72
S.E ±		0.74	0.12	0.02	BLD	0.10

Table 2 shows the mean concentration in ppm of some selected heavy metals (Ni, Cd, Cu, Pb, and Cr) concentration in the soil at different depths in Farmland area. From the analysis of result, Pb was also below the detectable limit of 0.001 – 0.01µm of the instrument at different depths of soil samples. Ni has mean of 11.44 ± 0,74 with lowest value of 10.48ppm at a depth of 5 – 10cm and highest value of 12.29ppm at 10 – 15cm. Cd has mean of 0.20 ± 0.12 with lowest value of 0.09ppm at a depth of 0 – 5cm and highest value of 0.36ppm at a depth of 10 – 15cm. Cu has mean of 0.20 ± 0.02 with lowest value of 0.18ppm at a depth of 10 – 15cm and highest value of 0.23ppm at a depth of 5 – 10cm. Cr has the mean of 0.72 ±0.10 with lowest value of 0.59ppm at a depth of 5 – 10cm. This result reveal that all the concentrations of the selected heavy metals analyzed are below the permissible limit of WHO 2007. Hence, no any significant difference within the difference depth, of soil sample in the selected heavy metals from Farmland areas.

Table 3: mean Concentration (ppm) of Heavy Metals in Residential Area (Juro Lokonjol)

Samples location	Depth (cm)	Ni	Cd	Cu	Pb	Cr
Y_1	0 - 5	19.54	0.15	0.12	BLD	0.46
Y_2	5 - 10	20.05	0.15	0.12	BLD	0.54
Y_3	10 - 15	4.45	0.17	0.13	BLD	0.46
Mean		14.68	0.16	0.12	BLD	0.50
S.E ±		8.86	0.01	0.01		0.05

Table 4: mean Concentration (ppm) of Heavy Metals in Residential Area (Juro Buba)

Samples location	Depth (cm)	Ni	Cd	Cu	Pb	Cr
Y_1	0 – 5	5.06	0.16	0.13	BLD	0.58
Y_2	5 - 10	5.28	0.16	0.15	BLD	0.57
Y_3	10 - 15	5.06	0.14	0.18	BLD	0.80
Mean		5.13	0.15	0.15	BLD	0.65
S.E ±		0.13	0.06	0.03		0.13

Table 5: mean Concentration (ppm) of Heavy Metals in Residential Area (Jauro Hamman)

Samples location	Depth (cm)	Ni	Cd	Cu	Pb	Cr
Y_1	0 – 5	7.43	0.15	0.18	BLD	0.79
Y_2	5-10	8.71	0.15	0.16	BLD	0.73
Y_3	10-15	8.63	0.14	0.17	BLD	0.74
Mean		8.27	0.15	0.17	BLD	0.75
S.E ±		0.72	0.01	0.01		0.03

Table 3, 4, and 5 shows the mean concentration (ppm) of heavy metal in different depth of the soil in residential areas: Juro Lokojol, Juro Buba and Juro Hamma respectively.From the result of analysis obtained its revealed that all the three (3) residential areas of study, Pb in the soil at different depth was found to be below the detectable limit of the instrument in all the three (3) areas. This also indicates lowest value (5.06 ppm) of Ni at 0 – 5cm depth and 10 – 15cm depths in Juro Buba residential area respectively. The highest value of 20.05ppm at depth of 5 – 10cm in Juro Lokonjol resident area, this shows that Ni is above the permissible limit of 15mg/Kg of WHO 2007 at a depth of 5 10cm in Juro Lokonjol resident area. Cadmium (Cd) has the lowest value of 0.14ppm at 0 – 5cm depth in both Juro Hamman and Juro Buba with highest value of 0.17ppm at 10 – 15cm depth in Juro Lokonjol. Copper (Cu) has the lowest value of 0.12ppm at 0 – 5cm and 5 – 10cm in Juro Lokonjol and highest of 0.18ppm at 0 – 5cm and 10 – 15cm depth in Juro Hamman and Juro Buba respectively. Chromium (Cr) has the lowest value of 0.46ppm at depth of 0 – 5cm and 10 – 15cm in Juro Lokonjol and highest value of 0.80ppm at depth of 10 – 15cm in Juro Buba. Hence it reveals that there is no any significant difference in all heavy metals within all three residential areas in terms of depths.

Comparison of heavy metal concentration among different soil depth at different locations.

The comparison in concentration of heavy metal in different soil depth among five sampling location are presented in figure 3,4,5, 6 and7.Figure 3: Ni ranged from 10.48ppm to 15.46ppm,Cd; 0.10ppm to 0.13ppm,Cu;0.17ppm to 0.21ppm, Cr;0.61ppm to 0.68ppm.the metal concentration decrease in the order *Ni* > *Cr* > *Cu*> *Cd* >*Pb* in Maiganga coal mine site. Figure 4: Ni ranged from 10.48ppm to 12.29ppm, Cd; 0.09ppm to 0.36ppm, Cu: 0.18ppm to 0.23ppm, Cr: 0.59ppm to 0.80ppm, the metal concentration in the decreasing order; *Ni* > *Cr* > *Cu* > *Cd* >*Pb* in farmland site. Figure 5; Ni ranged from 4.45ppm to 20.05ppm, Cd: 0.15ppm to 0.17ppm, Cu: 0.12ppm to 0.13ppm, Cr: 0.46ppm to 0.54ppm. The metal concentration decrease in the order; *Ni* >*Cr* > *Cd* > *Cu* > *Pb* in residential area A (jauro Lokonjol). Figure 6; Ni ranged from 5.06ppm to 5.28ppm, Cd: 0.14ppm to 0.16ppm, Cu: 0.13ppm to o.18ppm, Cr: 0.57ppm to 0.80ppm. The metals concentration decrease in the order of *Ni* > *Cr* > *Cd* > *Cu* > *Pb* in residential area B (jauro Buba). Figure 7; Ni ranged from 7.43ppm to 8.71ppm, Cd: 0.14ppm to 0.15ppm, Cu: 0.16ppm to 0.18ppm, Cr: 0.73ppm to 0.79ppm. The metal concentration decrease in the order of *NI* > *Cr* > *Cu* > *Cd* > *Pb* in residential area C (Jauro Hamman).According to Boadu, (2014) this may be as a result of car transport activities and application of fertilizers on the farmlands area and uncontrolled burning of coal.

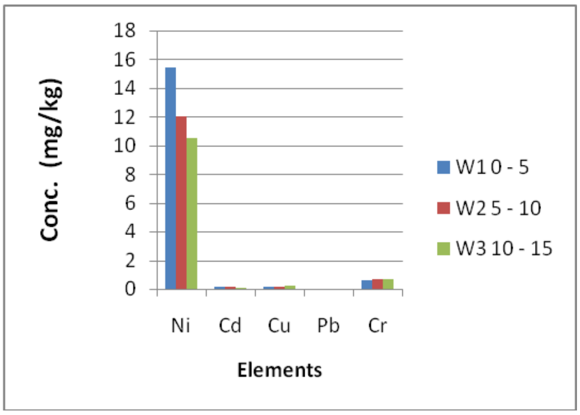

Figure 3: Mean concentration of heavy metals in different soil depth at Maiganga coal mine

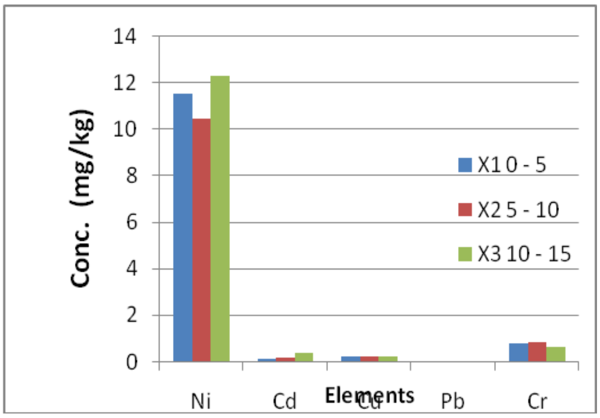

Figure 4: Mean concentrations of heavy metals in different soil depth at farmland area

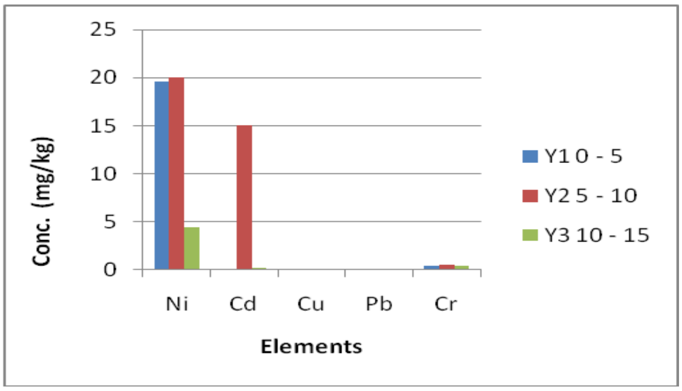

Figure 5: Mean concentrations of heavy metals in different soil depth at Residential site A (Jauro Lokonjol)

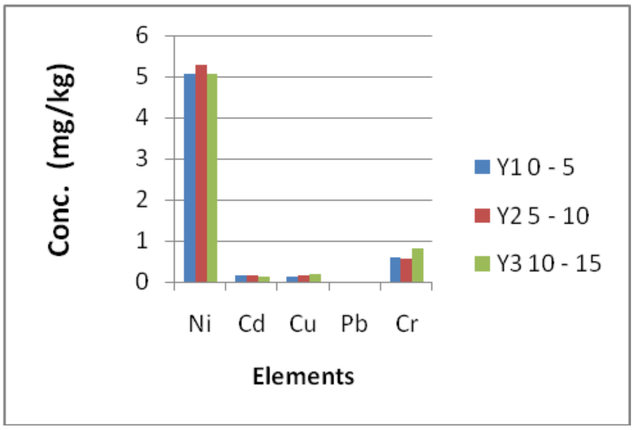

Figure 6: Mean concentration of heavy metals in different soil depth at Residential site B (juro Buba)

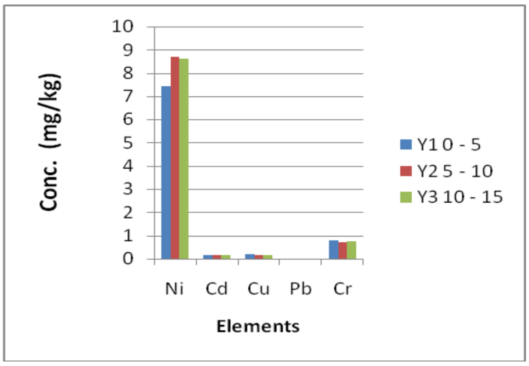

Figure 7: Mean concentration of heavy metals in different soil depth at Residential site C (Jauro Hamman).

CONCLUSION AND RECOMMENDATION

From the result of analysis carried out Pb was found to be below the detectable limit of instrument in all the area of study while Ni was found to be above permissible limit of WHO 2007 of 15mg/Kg in Maiganga Coal Mine at some few depths. There was no any significance different in all the depths in terms of heavy metals distribution within the study areas.

From the results of the research it recommended that more detailed work to be carried out during the peak of dry season (March – April) within the same depths of soils using Inductively Coupled Plasma-Atomic Emission Spectrophotometer (ICP-AES) so as to detect very minute concentrations of the metals in soil and compare with previous works.

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