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Estimation of some selected Heavy Metals in the Soil of Maiganga Coal Mine and Environs, Gombe-Nigeria

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ABSTRACT

A study to Estimate the concentration of some heavy metals: Ni, Cd, Cu, Pb and Cr in the soils around Maiganga coal mine and it environ was conducted, using Atomic Absorption Spectrophotometer. A total of 42 composite soil samples each was taken after every 120meters at the study area, about 42 soil samples were collected which comprises of ; 9 soil samples from coal mine area; 9 soil samples from farmland area, while about 24 soil samples were also collected from residential area respectively in July/August 2016.The result of this investigation reveals that Ni has a mean concentration of 12.65±2.08ppm, 11.44±0.74ppm and 9.45 ±6.12ppm from coal mine: farm land; residential area respectively, with the lowest value of 10.48ppm at Maiganga overburden, 10.48ppm at Maiganga farmland and 4.45ppm at Bakin Tasha, with highest values of 15.46ppm at Maiganga mining pit, 12.29ppm at Wuro Sarki Farmland and 20.05ppm at Kufayi. Therefore, the result reveals the concentration of Ni in coalmine area and residential area above the permissible limit of 15mg/Kg as reported by WHO 2007, while the concentration at the farmland area are within the permissible limit, the high concentration of Ni in the residential and coal mine area may be attributed to the combustion of fossil fuels from the cars that are transporting the coal which corroborate the findings of Boadu, 2014. In Cd the mean concentration ranges from 0.20± 0.12ppm, 0.15 ± 0.009ppm and 0.12, ± 0.01ppm from farm land, residential area and coal mine areas respectively, with a lowest value of 0.09ppm recorded at Lakwalag farmland, 0.14ppm at Kayel baga, 0.10ppm at Maiganga Overburden, with a highest value of 0.36ppm at Maiganga farmland, 0.17ppm at Gindin Gamji and 0.13ppm at Maiganga Inter burden. According to WHO 2007 the maximum acceptable limit for Cd is 0.35mg/Kg, therefore from the above result it reveals that only concentration of one sample from Maiganga farmland is above the maximum acceptable limit, while samples from the coalmine and residential areas are all within the permissible limit, and these may be as a result of the addition of fertilizers for organic amendments to the farmland area as discovered by Boadu, 2014. Cu has a mean concentration ranging from 0.20,±0.02ppm, 0.19±0.02ppm, 0.14 ±0.02ppm from farmland, coalmine and residential areas respectively, with the lowest value of 0.18ppm at Wuro Sarki Farmland, 0.17ppm at Maiganga mining pit and 0.12ppm at Jauro Lakonjol, with a highest value of 0.23ppm at Maiganga farmland, 0.21ppm at Maiganga overburden and 0.18ppm at

Lakwalag A, as such this reveals that the concentration of Cu from all the sampling areas are below the permissible limit of 30mg/kg as reported by WHO 2007.Cr mean concentration ranges from 0.72 ±0.10ppm, 0.65 ±0.03ppm and 0.62 ±0.13ppm from the farmland, coalmine and residential areas respectively, with the lowest value of 0.59ppm at Wuro Sarki farmland, 0.61ppm at Maiganga mining pit and 0.46ppm at Jauro lakonjol and kufayi, while the recorded highest values of 0.80ppm was at Maiganga farmland, 0.68ppm at maiganga overburden and 0.80ppm at kayel baga (J.H)respectively. Therefore, this reveals that the concentration of Cr in all the sampling area are below the acceptable limit of 100mg/kg set by NESREA, 2011.From the foregoing analysis Pb is the only element that was not detected in all the samples collected from all the experimental plots at the study area. The research recommend the continues monitoring of heavy metals concentration in the soils of Maiganga coal mine and environs by regular assessment of heavy metals concentration in their soils, as well as analysis of some selected vegetative covers to observed any vegetation changes that might be as a result of heavy metals pollution.

Keywords: Estimation of Some Selected Heavy Metals, Gombe-Nigeria, In the Soil of, Maiganga Coal Mine and Environs

INTRODUCTION

Coal Mining

Mining can be define as the extraction of valuable minerals or other geological materials from the ores in various part of the earth crust such as lode, vein, seam, or reef, which form the mineralized package of economic interest to miners. It can also be define as the process of obtaining useful mineral from the earth crust. Mining process is basically of two types viz underground mining and surface excavation. Mining is also define as an operation that involves the physical removal of rocks or a process of extracting useful minerals from the surface of the earth, including seas (Enger and Smith 2004). Manganese, tantalum, casserite, copper, tin, nickel, bauxite (aluminium ore) , iron ore, gold, silver, and diamonds are just some examples of what is mined.(Cunningham, 2005).

Coal is a fossil fuel formed from the decomposition of organic materials that have been subjected to geologic heat and pressure over millions of years. It is considered a non-renewable resource because it cannot be replenished on a human time frame (United State Environmental Protection Agency (U.S. EPA, 2000). Coal consists 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)- **subbituminous** - **bituminious** – **anthracite** (highest quality and hardest coal).The most significant uses of coal is in electricity generation, steel production, cements manufacturing and liquid fuel (Cunningham, 2005). Its predominant use has always been for producing heat energy. It was the basic energy source that fueled the Industrial Revolution of the 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-20[th] century, coal has yielded its place to petroleum and natural gases the principal energy supplier of the world.

The choice of mining method is largely determined by the geology of the coal deposit. Underground mining currently produces a bigger share of world coal production than open-cast, although in several important coal producing countries surface mining is more common. For example, surface mining accounts for arounds 80% coal production in Australia, while in the United State of America it accounts for about 67% of production (International Energy Agency, 2012).

Soil is an important component of the biosphere that serves as a geochemical sink for contaminants and also acts as natural buffer controlling the transport of chemical elements and substance to the atmosphere and living organisms (Kataba-pendias, 2000). Soils affected by heavy metals suffer degradation due to impairment of physicochemical, biological and geological properties hence undermine its agricultural potential (Adamu *et al.,* 2014).Pollution of soil ecosystem is the introduction of excessive amount of substances which impair the health of living organisms or interfere with the use of soil environment. Pollution of the soil ecosystem is a major source of soil degradation (Adamu *et al.,* 2014).These metals have damaging effects on the plants themselves and may become a health hazard to man and animals. Above certain concentration, these metals adversely affect natural microbial populations, leading to disruption of vital ecological process. Currently, micro organisms are being used as potential bio-indicators for the assessment of chemical risk to the ecosystem (Adamu *et al.,* 2015).

MATERIALS AND METHOD

There are countless number of procedures that are being used to digest soil and underground samples, we have like: DTPA, EDTA, Ammonium Acetate, Single acid, double acid and triple acid etc. DTPA, EDTA and Ammonium Acetate are all digestion procedures used in digesting environmental samples in situation where by ultra-violent visible Spectrophotometer is the machine to be used in doing the analysis. While single acid, double acid and Triple acid digestion procedures are used in situation when Atomic Absorption

Spectrophotometer is to be used in analyzing the heavy metal content of the samples (Jones *et al.,* 1990).

But for the purpose of this research work double acid wet digestion procedure was used on the soil samples to be analyze by way of using a combination of HNO_3 and HCl acids in a ratio of 1:3 so as to isolate all the inorganic materials in the samples and filtering techniques in water samples to enable the AAS records the accurate concentration of heavy metal content in the samples.

COLLECTION OF SAMPLES

The area under study has been divided into three sections namely (i) the area where the mining activities is taking place (referred to as area *W*),(ii) farms some meters away from the site of the coal mining activities (referred to as area X), and (iii) the Maiganga settlement site (Residential areas) some km's away from coal mine site (referred to as area Y). Area *W* is the central area where the mining activities is going on, and is in-between the farmland areas and Maiganga settlement, area X is the farms some meters away from coal mine and is located at the wind ward site of the coal mining areas, while area Y are places at Maiganga settlement situated 1km away from the mining area (approximately a distance of about 1km from the mining area) and some few residential areas (Office of Surveyor General, Gombe State).

Soil Samples Collection

During July/august with the help of hand auger. The Forty-two soil samples collected from each of the experimental plots (*W*,X and Y), including the control plot were achieved by taking composite soil samples each to the depth 0-5cm,5-10cm and 10-15 cm after 120 meters respectively.

DIGESTION OF SAMPLES

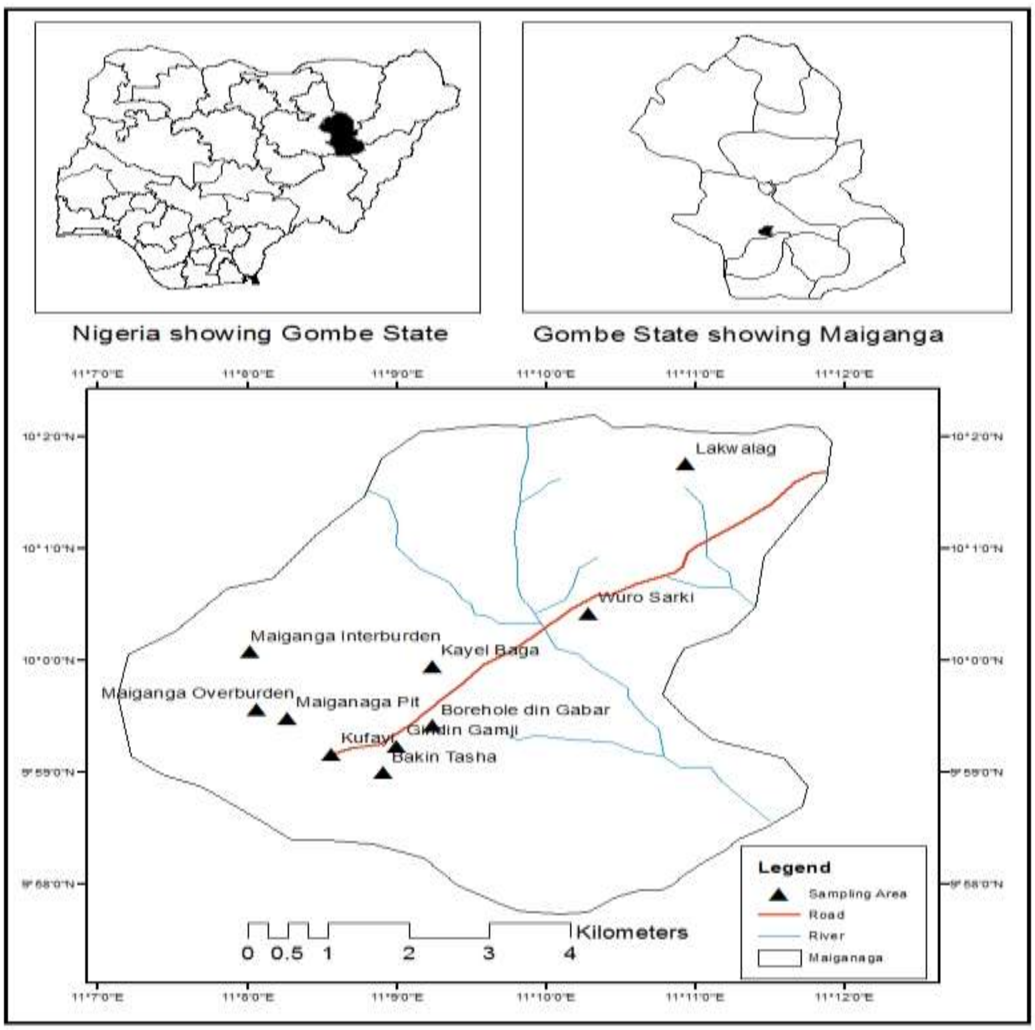
Soil Samples

The soil samples collected from each of the experimental plots, were then stored in a polythene bags, and labeled before taken to the laboratory for processing and analysis. The soil samples were air-dried, 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 (Adamu *et al.,* 2017). 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 541 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, 1990).

MAP OF THE STUDY AREA



Map of study area (maiganga and it environ.) showing sampling point

RESULTS AND DISCUSSION

Table 1: Showing the total concentrations (ppm) of heavy metals in coal mine soil samples

Samples Location	Elements Ni	Cd	Cu	Pb	Cr
W_1	15.46	0.12	0.17	ND	0.61
W_2	12.00	0.13	0.18	ND	0.65
W_3	10.48	0.10	0.21	ND	0.68
Mean	12.65	0.12	0.19		0.65
S.D	±2.08	±0.01	±0.02		±0.03

Field Investigation Adamu, 2016

KEY

ND – Not detected

W_1- Maiganga pit soil sample

W2 -Maiganga Interburden soil sample

W_3- Maiganga Overburden soil sample

Table 2: Showing the total concentrations (ppm) of heavy metals in farmland soil samples

Samples Location	Elements Ni	Cd	Cu	Pb	Cr
X_1	11.56	0.09	0.20	ND	0.76
X_2	10.48	0.14	0.23	ND	0.80
X_3	12.29	0.36	0.18	ND	0.59
Mean	11.44	0.20	0.20		0.72
S.D	±0.74	±0.12	±0.02		±0.10

Field Investigation Adamu, 2016

KEY

ND – Not detected

X_1- Lakwalag Farmland

X_2- Maiganga Farmland

X_3-Wuro Sarki Farmland

Table 3: Showing the total concentrations (ppm) of heavy metals in residential areas soil samples

Samples Location	Elements Ni	Cd	Cu	Pb	Cr
Y_1	19.54	0.15	0.12	ND	0.46
Y_2	20.05	0.15	0.13	ND	0.54
Y_3	4.45	0.17	0.13	ND	0.46
Y_4	5.06	0.16	0.13	ND	0.58

Y_5	5.28	0.16	0.15	ND	0.57
Y_6	5.06	0.14	0.15	ND	0.80
Y_7	7.43	0.15	0.18	ND	0.79
Y_8	8.71	0.15	0.16	ND	0.73
Mean	9.45	0.15	0.14		0.62
S.D	±6.12	±0.009	±0.02		±0.13

Field Investigation Adamu, 2016

KEY

ND – Not detected

Y_1- J/Lokonjol.

Y2- Kufayi

Y3- Gindin gamji

Y4- Bakin tasha

Y5- kayel baga (J.B)

Y6-Kayel baga (J.H)

Y7- Lakwalag A.

Y8- Lakwalag B.

DISCUSSION

Discussion of Heavy Metals in Soil sample

Tables 1-3 shows the mean concentration of heavy metals (ppm) in soil samples collected from the study as shown on the map of the study area. Ni has a mean concentration of 12.65±2.08ppm, 11.44±0.74ppm and 9.45 ±6.12ppm from coal mine: farm land; residential area respectively, with the lowest value of 10.48ppm at Maiganga overburden, 10.48ppm at Maiganga farmland and 4.45ppm at Bakin Tasha, with highest values of 15.46ppm at Maiganga mining pit, 12.29ppm at Wuro Sarki Farmland and 20.05ppm at Kufayi. Therefore, the result reveals the concentration of Ni in coalmine area and residential area are above the permissible limit of 15mg/Kg as reported by WHO 2007, while the concentration at the farmland area are within the permissible limit, the high concentration of Ni in the residential and coal mine area may be attributed to the combustion of fossil fuels from the cars that are transporting the coal which corroborate the findings of Boadu, 2014. In Cd the mean concentration ranges from 0.20± 0.12ppm, 0.15 ± 0.009ppm and 0.12, ± 0.01ppm from farm land, residential area and coal mine areas respectively, with a lowest value of 0.09ppm recorded at Lakwalag farmland, 0.14ppm at Kayel baga, 0.10ppm at Maiganga Overburden, with a highest value of 0.36ppm at Maiganga farmland, 0.17ppm at Gindin Gamji and 0.13ppm at Maiganga Interburden. According to WHO 2007 the maximum acceptable limit for Cd is 0.35mg/Kg, consequently from the above result it reveals that only concentration of one sample from Maiganga farmland is above the maximum acceptable limit, while sample from the coal mine and residential areas are all within the permissible limit, and these may be as a result of the addition of fertilizers for organic amendments to the farmland area and uncontrolled burning of coal as discovered by Boadu, 2014. Cu has a mean concentration ranging from 0.20,±0.02ppm, 0.19±0.02ppm, 0.14 ±0.02ppm from farmland, coalmine and residential areas respectively, with the lowest value of 0.18ppm at Wuro Sarki Farmland, 0.17ppm at Maiganga mining pit and 0.12ppm at Jauro Lakonjol, with a highest value of 0.23ppm at Maiganga farmland, 0.21ppm at Maiganga overburden and 0.18ppm at Lakwalag A, therefore this reveals that the concentration of Cu from all the sampling areas are below the permissible limit of 30mg/kg as reported by WHO 2007.Cr mean concentration ranges from 0.72 ±0.10ppm, 0.65 ±0.03ppm and 0.62 ±0.13ppm from the farmland, coalmine and residential areas respectively, with the lowest value of 0.59ppm at Wuro Sarki farmland, 0.61ppm at Maiganga mining pit and 0.46ppm at Jauro lakonjol and kufayi, while the recorded highest values of 0.80ppm was at Maiganga farmland, 0.68ppm at maiganga overburden and 0.80ppm at kayel baga (J.H)respectively. Therefore, this reveals that the concentration of Cr in all the sampling area are below the acceptable limit of 100mg/kg set by NESREA, 2011.From the foregoing analysis Pb is the only element that was not detected in all the samples collected from all the experimental plots at the study area.

CONCLUSION AND RECOMMENDATION

The results of the estimation/analysis indicate the presence of all the selected heavy metals under consideration with the exception of Pb in all the experimental plots at the study area. The research recommend the continues monitoring of heavy metals concentration in the soils of Maiganga coal mine and environs by regular assessment of heavy metals concentration in their soils, as well as analysis of some selected vegetative covers to observed any vegetation changes that might be as a result of heavy metals pollution. The research further recommends the investigation of heavy metal pollution in both surface and underground water of Maiganga so as to make sure that the local population there is not exposed to any medical complication as a result of heavy metal pollution of their sources of water at the study area.

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