DETERMINATION OF THE ELEMENTAL COMPOSITION OF SOIL SAMPLES FROM THE ZUNGERU ARTISANAL GOLD MINES IN NIGER STATE, NORTHERN NIGERIA

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ABSTRACT

The by-products of mining for gold are usually some other heavy metals such as Lead (Pb), Arsenic (As), Cadmium (Cd), Silver (Ag), and a host of others which when ingested into human body causes ill health and even death depending on whether or not the exposure is acute or chronic. Emphasis in this work is placed on Pb because of its being one of the most toxic elements in nature which has caused the deaths of so many people particularly, the children. The concentrations of Pb in a particular (mining) environment determines how safe it is for human activities like the agricultural practices. Ten soil samples were collected at intervals of 20m from one sampling point to another at the Zungeru artisanal gold mines, and analyzed using X-Ray Refraction (XRF) and all were found to contain Pb and other heavy metals in varying concentrations. The percentage concentrations of Pb in all the soil samples analyzed were found to be greater than 0.001% which is higher than the World Health Organization (WHO) safe limit. This is an indication that ingestion of soils or from this mine field could result to Pb poisoning of the who works or get into contacts with these soils.

Key words: *Lead (Pb), X-ray refraction, artisanal, acute and chronic*

INTRODUCTION

GOLD MINING AND THE ENVIRONMENTAL DEGRADATION AND POLLUTION

Mining can be said to be an occupation and activity involving the extraction of minerals which include petroleum oil,coal, baryte-limestone , lignite and quartz to list but a few (Ezeaku, 2012)

Mining generates wealth but at the same time affects environment negatively Ako *et al*., 2014). One of the most important sources of contamination of the environment is mining activities because mineral processing, metal recovery, dust control and supply of water needs of workers on site all revolves round the use of water (Azeez, 2011). The water used here percolates into the ground and taken up by the plants along the with some heavy metals. Several authors in their works corroborated this. Mining impacts among others also include soil structure alteration, instability of soil and rock masses, soil, water and air pollution, loss and overturning of the fertile top soil, causing mass exodus of species of animals, destruction of flora and fauna and noise pollution (Ojo and Adeyemi, 2003; Aigbedion and Iyayi, 2007; Adegboye, 2012).

In addition to the above assertion of various scholars, Mapanda *et al.,* (2009) stated that dirty gold mining has contributed to the destruction of vital ecosystems, contaminated water supplies, and ravaged landscapes. Mercury, Cyanide, and other toxic substances are released into the environment on regular basis due to dirty gold mining (Dube *et al*., 2000). Modern industrial gold mining create huge amounts of toxic waste and destroys landscapes (Aucamp, 2003)

Lead (Pb) is one of the most poisonous heavy metals known to man. It does not degrade in human body but may be transformed from one form to another. This is an aspect that makes it dangerous once ingested. Once it gets into the body Pb is not broken down as does food items by the digestive system but rather attack vital body organs and gradually destroy it which may lead to its malfunction or its complete seizure or failure and dare consequences such as ill health or even death may follow. In the words of Azubike (2011), unsafe mining practice has led to different health challenges and even deaths of the people in the host communities.

Lead and other heavy metals get into the human body through air, soil and water (Waziri, 2014). In mining areas, soil is the principal route of through which Pb is ingested. It could be in the air born dusts which is inhaled or through adhension of particulates to the body such as the hands during soil excavation, crushing or generally, or processing. It could be through the pica behaviour which is the hand to mouth behaviour of the children whom are the most vulnerable when it comes Pb poisoning through artisanal mining. Zungeru artisanal gold mine sites is one of the pockets of such mines scattered across Niger State in the North Central Parts of Nigeria.

SITE DESCRIPTION

The Zungeru artisanal gold mines are located at about two kilometers west of Zungeru town in Wushisi Local Government of Niger State, North Central part of Nigeria. The mines are bordered by a small river in the northern side, a trunk B or a major road by the Western part while farm lands bordered while farm lands bordered the mine at both the Eastern and Southern parts. In between the mines and the river is a plantation of Cashew and Mango trees.

MATERIALS AND METHODOLOGY

The debris were cleared and a hand scoop,ten soil samples were collected at a depth of 1-20 cm at intervals of 20 m from one sampling point to another at the Zungeru artisanal gold mines sites. The first reason because the retention of Pb is usually in the upper 2-5cm of soil, particularly soils having at least 5% organic matter or a pH 5 or above and the second reason is to give wider area of coverage for sampling.

The fresh samples were kept in polythene bags and labelled as ZS1, ZS2, ZS3 to ZS10 for easy identification and to avoid contamination. The collected soil samples were transported to the laboratory where they were air dried at room temperature. The dried samples were crushed using mortar and pestle and the sieved through 150 µm mesh and packaged in smaller polythene bags. The prepared soil samples were then analysed for the elemental composition at the National Geosciences Research Laboratory (NGRL), Nigerian Geological Survey Agency, Kaduna State, Nigeria.

About 55 – 60g of the soil samples were pulverized (grind to fine powder) using agate pulverizing machine (planetary micro mill pulverisette 7) to pass 150 micro mesh sieves (British Standard). The samples were further re-crushed and re-sieved to ensure homogeneity of the samples and maximum passage through the sieve. From these prepared samples, powdered pellets were produced for each of the sample by weighing 5g of the pulverized sample into a beaker, 1g of binding aid (starch soluble). The mixture was thoroughly mixed to ensure homogeneity, which was pressed under high pressure (6 "tones") to produce pellets; labelled and packaged for analysis.

The analysis was carried out using Energy Dispersive X-ray Fluorescence (EDXRF) spectrometer of model "Minipal 4" software as analysed according to the method described by Ezeaku, 2012. In this method, the prepared pellet from each of these ten (10) samples was carefully placed in the respective measuring positions on a sample changer of the X-ray machine. The current used was 20kv for the trace elements/rare earth metals and 14kv for major elements. Selected filter was Ag/Al-thin for the trace elements/rare earth metals. The filters were selected based on a guided periodic table for elemental determination. The elements analyzed include Cu, Zn, Ag, Ga, As, Pb, Mn, Y, Cr, Ni, V, Sr, Th, Zr, Co, Na, K, Al, Ca, Mg, Fe, Ti, Cd and Si elements in soil samples. The mean concentration of each element in the samples was compared with Wedepohl, (1995) and Taylor and McLennan, (1985) average concentration of elements in upper continental crust.

RESULTS AND DISCUSSION

Table 1, analysis of Zungeru soil samples

Elemental Composition (%)	ZS1	ZS2	ZS3	ZS4	ZS5	ZS6	ZS7	ZS8	ZS9	ZS10
Pb	0.17	0. 41	0.29	0.033	0.48	0.04	0.69	0.38	0.32	0.36
Zn	0.51	0.23	0.42	0.381	0.041	0. 067	0.16	0.044	0.031	0.47
Cr	ND	0.016	0.067	0.038	ND	0.049	ND	0.031	0.034	0.033
Cd	0.004	0.001	0.005	0.002	0.003	0.008	0.001	0.009	0.006	0.001
Ag	0.82	1.34	1.62	1.24	1.11	1.62	1.45	1.22	0.21	ND
Co	0.006	ND	0.002	ND	0.003	0.006	0.002	0.005	0.003	0.005
As	0.039	0.08	0.031	0.008	0.014	0.049	0.011	0.002	ND	0.09

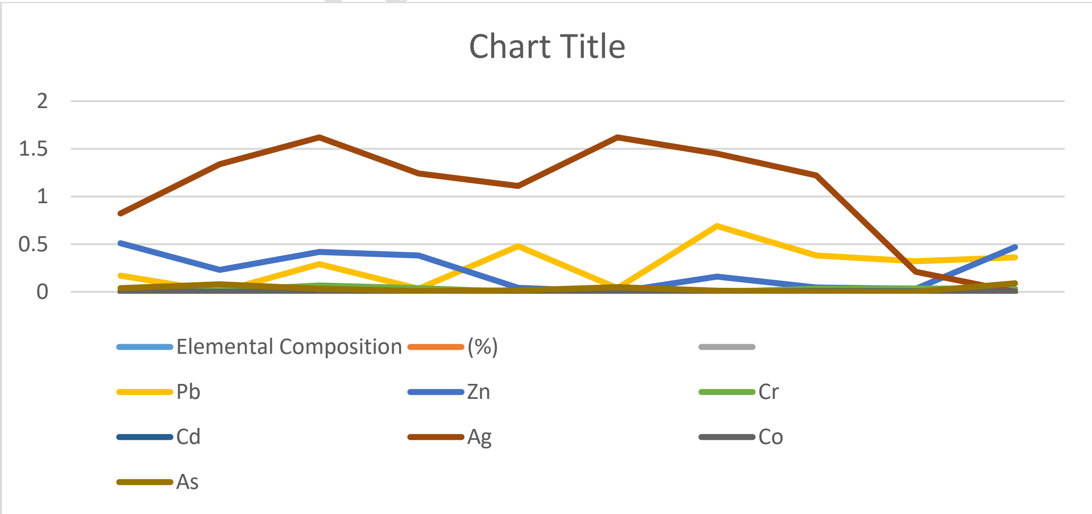

Figure 1; a graph showing the percent compositions of Pb and other heavy metals

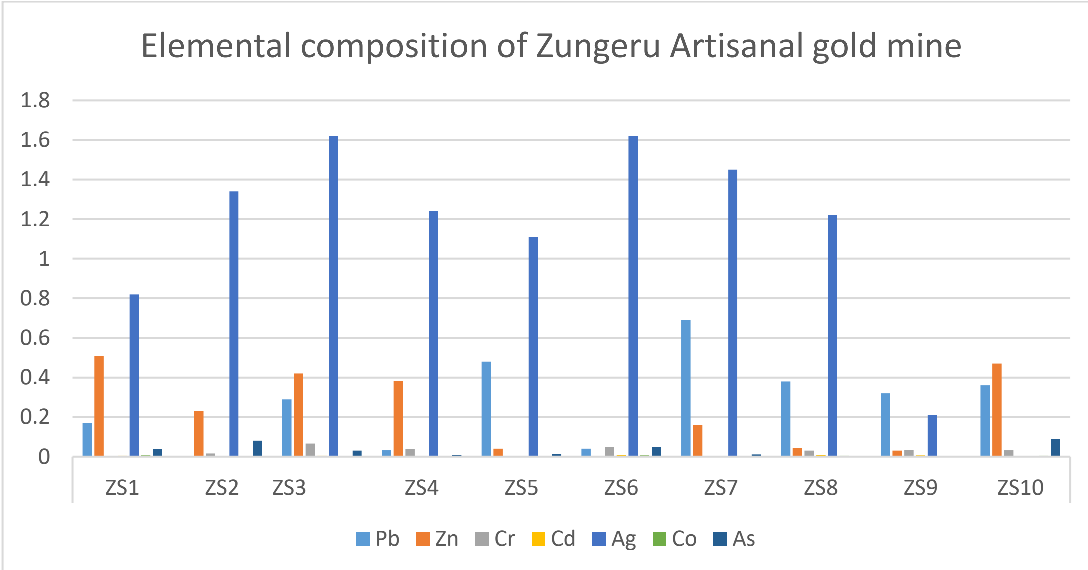

Table 2; analysis of Zungeru soil samples

The xrf results of some selected heavy metals contained in the ten soil samples collected from the Zungeru artisanal gold mine sited (table 1) was plotted in graph form in table 1and 2 for easier understanding and each of them was discussed below:

Lead (Pb)

The results of the analysis of the soil samples collected from the Zungeru artisanal gold mine sites is shown in table 1 below. The ten soil samples analysed using the XRF all contain Pb in varying percentages higher than the recommended WHO safe level of (0.001%) for humans.

Soil sample ZS 1 has the highest concentration of Pb (0.17%), followed by ZS7 (0.69%), ZS 5 (0.48%), ZS 2 (0.41%), ZS 8 (0.38%), ZS 10 (0.36%), ZS 9 (0.32%), ZS 3 (0.29%), ZS 1 (0.17) and ZS 4 (0.003) in the descending order.

The result of the analysis indicates that though all the soil samples contain Pb in higher concentrations which are not good for human consumption Monish *et al*., 2014), the percentage compositions of the available soil varied from one location to another location an indication that the entire mine site is contaminated with Pb above human safe level.

The presence of Pb in all the soil samples taken from this artisanal gold mine site irrespective of how low the concentrations may be, is an an important factor in determining how safe soil and plants either cultivated or wild on the site are for human ingestion as they could lead to Pb poisoning either directly or through food chain (Azeez, 2011).

Cadmium (Cd)

Cadmium (Cd) is another heavy metal contained in all the soil samples collected and analysed from the Kafin Koro artisanal gold mine site. Cadmium is a heavy that attacks and destroy vital organs of the body such as the liver and and the kidney and results into the ill health of its host, the human. As it is with all the heavy metals, Cd is a recalcitrant metal which is not digested in human body. The contents of Cd in all the soil samples are however, lower than those of the Pb and according to Monish *et al.*, 2014, once Cd gets into the soil, it remains there for decades. This does not in anyway, makes their ingestion into the human body less harmful.

The contents of Cd also varies from one sample location to another. The soil with the highest percentage of Cd is ZS8 (0.009%), then followed by ZS6 (0.008%), ZS9 (0.006%), ZS 3 (0.005%), ZS 1 (0.004%), ZS 5 (0.003%), ZS 4 (0.002%) and finally with ZS 2, ZS 7 and ZS 10 all having (0.001%) in descending order respectively.

Silver (Ag)

Silver being a heavy metal, is also present in the same artisanal gold mine in various percent compositions. The presence of silver in excess concentration posses health challenges to the host and can malfunction into vital body organs. The soil samples with the highest concentration of Ag are ZS 3 and ZS 6 both containing (1.62%) while the ZS 9 had the least percent composition of Ag with 0.82% respectively. The percentage compositions of Ag in the remaining analysed soil soil samples fall between these two limits. Silver was however, not detected in soil sample ZS 10 which made the exact location less harmful in terms of Ag content as at the time of the soil sample collection (Waziri, 2014).

Arsenic (As)

The soil samples with the highest concentration of As is ZS 10 with 0.09% followed by ZS 2 containing (0.08%) while the KKS8 had the least percent composition of As with 0.002% respectively. The percentage compositions of Ag in the remaining analysed soil samples can be found between these two limits. As in the case of Ag, As was not detected in ZS 9. The metal (Ag), have negative effects on the human health (Singh *et al*., 2007) and the silver mining community (Hughes *et al*., 1988 and Singh *et al*., 2007).

Cobalt (Co)

The results of the XRF analysis confirmed the presence of Cobalt Co, a heavy metal which is released into the environment through human anthropogenic activities (Dube *et al*., 2000), to be present in almost all the ten soil samples collected and analysed except in ZS 2 and ZS 4. The soil samples ZS 1 and ZS 6 had the highest concentrations of Co while soil samples ZS 3 and ZS 9 had 0.002% being the highest.

Mercury (Hg)

It is worth mentioning here, that mercury a very poisonous heavy metal and very dangerous to human life and employed in the amalgamation process to extract gold from ores is not detected in any of the these soil samples. This could have resulted from the fact that it is only used during the beneficiation process. Ingestion of Hg has negatives effects on human health since it destroys the brain, liver, and kidney (Veiga, 2003 and Monish *et al*., 2014).

Zinc (Zn)

Zinc is not a heavy metal and plays an important role in the protection of DNA from damage as an antioxidant and repair of proteins, unique because it bears antioxidant, anti-inflamatory and proapoptatic activity (Ho, 2004). Salgueiro *et al*, (2000) said that adequate Zinc in the body helps in immune response onset and regulation, antioxidant, insulin storage, vitamin A metabolism, cellular division, protein synthesis, energetic metabolism, spermtogenesis and stereoidgenesis to mention but a few. protection of DNA from damage as an antioxidant and repair of proteins, unique because it bears antioxidant, anti-inflamatory and proapoptatic activity. Occupational exposure can result from dust and fumes of Zinc, welding of Zinc-coated steels in the absence of improper respiratory protection and /or fume extraction engineering control (Ho, 2004). Zinc deficiency causes lack of apatite, affects reproductory system (causes infertility, hypogonadism and feminization), spontaneous abortion, skeletal malfunctions, prematurity or long gestation and complications during delivery through excessive loss of blood (Salgueiro *et al.,* 2000; Ho, 2004).

CONCLUSION

The following conclusions were drawn from this work:

1. The results of the XRF analysis indicates that all soil samples collected from the Zungeru artisanal gold mine contain lead and other heavy metals in varying percentages.
2. The Pb contents of all the soil samples analysed were greater than the World Health Organization (WHO) recommended safety health levels for human consumption of 0.001% and therefore dangerous to human health when ingested.
3. The results of the soil sample collected from the mine sites which was wide spread, indicated that the environment is contaminated with Pb and other heavy metals and therefore, very hazardous to work on without adequate and proper safety wears and measures.

RECOMMENDATIONS

It is worthy to end this work the the following recommendations:

1. People working on these mine sites should be educated on the dangers exposure to and ingestion of the soils is to their well being and those of their families particularly, the children who always bear the brunt of heavy metals, particularly, Pb poisoning.
2. Being artisanal miners, they need to be enlightened by professionals on the basic safety requirements of miners such as the safety wears (clothing, hand gloves, nose and face masks), personal hygiene, etc. This should be the sole responsibility of the government and also non governmental agencies. This will not be an easy task and will require a lot of time to convince the artisanal gold miners to understand the need to embrace the need to use of safety wears due to lack their lack of formal education.

Finally, there is the need for the remediation of the pockets of abandoned mine site to curb the spread of heavy metals/lead laden soils to other clean/lead free parts of the environments through agents of dispersion such as the air, water and even the animals (domesticated or wild) which may graze on these sites.

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