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ASSESSMENT OF HEAVY METALS CONCENTRATION IN SOILS AROUND MAIGANGA COAL MINES, AKKO LOCAL GOVERNMENT AREA, GOMBE STATE, NIGERIA

BUBA, S[1], ESSOKA, P. A[2] and MUSA, I[3]

[1]Department of Geography, Faculty of Humanities, Management and Social Sciences, Federal University of Kashere, Gombe State, Nigeria

[2]Department of Geography and Environmental science, University of Calabar, Nigeria

[3]Department of Geography, Faculty of Science, Gombe State University, Nigeria

Correspondence: bubasamaila24@gmail.com

Phone number: 08023089588

Abstract

The study examined the concentration of heavy metals in soils of Maiganga Coal Mining area. Soil auger samples were collected from farmlands of five communities majorly affected by the mining activities at an interval of 30mto 35m apart, along a line transect of 100m in each of the sampling communities. The collected samples were analysed for considered heavy metals (Pb, Cu, Zn, Fe and Mn) and the concentrations of the respective elements detected using the atomic absorption spectrophometer (AAS). The mean concentrations of the respective heavy metals were compared with permissible limits according to Food and Agriculture Organisation (FAO) standard. The results showed that Pb was detected only in Garin Alhaji Shugaba (0.01mg/kg) but it was below permissible standard of FAO (0.05 mg/kg) standard. Cu was detected in all the settlements except in Garin Alhaji Shugaba and the concentration which ranged from 0.06 mg/kg to 0.30 mg/kg was above the FAO (0.01mg/kg) permissible limit; indicative of soil pollution or contamination. Zn detected in two locations (Maiganga and Kantagari) showed a concentration of 1.07mg/kg in each of the locations which was below the FAO (2.0 mg/kg) standard. This suggests that, the Zn content in the two settlements constitute little or no potentials to cause soil pollution. Fe was detected in all the settlements but in concentrations (ranging from 0.13 mg/kg to 0.44 mg/kg), far below the FAO (1.5 mg/kg) standard. Similarly, Mn was only detected in Kayel Baga (0.10mg/kg) and in Garin Alhaji Shugaba (0.04 mg/kg), which were below the FAO (1000 mg/kg). Apart from Cu concentration, all other metals were either within or far below the FAO permissible limits implying they constitute no risk of soil pollution at the moment in the study area and its environs.

Keywords: Coal mining, heavy metals, concentration, permissible limit, Soil pollution, Maiganga.

Introduction

Heavy metals also known as trace elements, are vital constituents of rocks and minerals of the earth crust. Naturally, they are made available in the environment through the process of weathering and volcanic activities. However, human activities contribute greatly in the release of these elements within the environment in large amounts thereby constituting environmental problems. Anthropogenic sources of heavy metals contamination in the environment have been identified to include industrial manufacturing, mining operations, vehicular traffic, motor repairs, wastes/garbage production, petroleum/oil production etc (Elik, 2003; Essoka, Ubogu & Uzu, 2006; Olayinka, Akande, Bamgbose and Adetunji, 2017; Ugya and Imam, 2017; Obasi, Esom, Okolo & Edene, 2018).

Mining operations, which involve the blasting of rocks usually, result to the release of large quantities of heavy metals in addition to dust particles and other products into the environment. Moreover, the burning of fossil fuels by machineries and heavy trucks used during mining operations and transportation of mined products equally release heavy metals such as lead (Pb). Contamination of the environment by heavy metals is of global concern considering the fact that these elements enter the food chain from soils and could result to several health challenges. In high concentrations, most heavy metals become toxic to plants, animals and in turn, man through the food chain. Whereas some are carcinogenic in nature, heavy metals are generally non-biodegradable and so once present in the environment in excessive amounts, constitute perpetual health threat (Isirimah, 2000; Essoka *et al* 2006; Essoka and Umaru 2006; Olayinka *et al* 2017).

Several studies have highlighted associated health effects due to high concentrations of heavy metals in the soils to include the following liver/ kidney failure, bloody urine, anaemia/inhibition of haemoglobin synthesis, malfunctioning of nervous, reproductive and cardiovascular systems, damage to gastro-intestinal system, mental retardation in children, renal and brain disorder, cancer, bone marrow disorder, behavioural abnormality etc (Ferner 2001; Ubogu and Essoka, 2006; Ubogu, Musa and Essoka, 2008; Edori and kpee, 2018).

The contamination of soil by some metals is the most useful apprehension throughout the industrialized world. Metal pollution results in adverse effects on various parameters relating to plant quality and yield, and also cause changes in the size, composition and activity of the microbial community. Hence, metals are regarded as one of the major sources of soil pollution. For instance soil pollution may result from contamination by heavy metals such as Cu, Ni, Cd, Zn, Cr, and Pb (Yee, 2012). The adverse effects of metals on soil biological and biochemical properties are well documented. The soil properties i.e. organic matter, clay contents and pH have major influences on the extent of the effects of metals on biological and biochemical properties. Metals directly or indirectly affect soil enzymatic activities by shifting the microbial community which synthesizes enzymes (Din,Yahya and Adamu, 2013). Metals exhibit harmful effects towards soil biota by affecting key microbial processes and reduced the number and activity of soil microorganisms. Long-term metal effects can multiply bacterial community tolerance as well as the tolerance of fungi such as arbuscular mycorrhizal (AM) fungi, which is useful in the restoration of contaminated ecosystems. Metals can cause a reduction in bacterial species richness and some multiplication in soil actinomycetes or even reduces both the biomass and diversity of the bacterial communities in the soils with contamination.

The study area Maiganga coal mine was established in 2006. Operations began in 2007, and in 2008 it started providing coal to Ashaka cement the factory. It has an estimated 4.5 million tons of coal to be mined to serve the factory for at about 25 years, and about 2 million coal reserves for future exploitation. Coal mining at Maiganga is done at industrial and large scale which has the tendency to affect the environment namely; water, land/soil, and air; with potential health hazard to mankind (Maina, 2016).

Considering that excessive amounts of heavy metals in soils constitute a major source of soil pollution and can pose great danger to man's health, it becomes necessary to evaluate soils of Maiganga coal mine environs to determine the levels of heavy metals with a view of guarding against their build- up in the area. The objective of the study is therefore to assess the concentration of selected heavy metals in soils around the Maiganga coalmines in Akko local government area of Gombe State.

MATERIALS AND METHODS

Study Area

The study area Maiganga is situated in Akko Local Government Area of Gombe State. It is located between longitude 09^{0} 59^{I} N and 11 09^{I} N and latitude of 11^{O} 8E and $11^{O}9^{I}$ E. Maiganga covers a land area of about 48.16 km^{2} (Fig.1 & 2). it is bounded to the South by Billiri and to the West by Kumo town, the Headquarters of Akko Local Government Area.

Maiganga lies within the tropical continental type of climate. It has both wet and dry seasons. Rainfall ranges from 850 mm to 1000 mm annually. Temperature in the study area is relatively high for most part of the year (Oruoye, Iliya, and Ahmed, 2016). The mean maximum monthly temperature is 37 ^{O}C from March to October, but reduces to 21^{O} C in December to February.

Maiganga community is majorly dominated by Tangale, Fulani, and Jukun. Maiganga has a population of about 3,520 according to 2006, National Population Commission census, and projected using 3% growth rate 39,881.6 people in 2017. The main economic activities of the people among others are peasant farming with the cultivation of crops like maize, millet, rice, beans, sorghum, soya beans, ground nut, and guinea corn among others. Also, there is the practice of small scale open grazing because Maiganga mining activities has affected the natural vegetation cover in the study area.

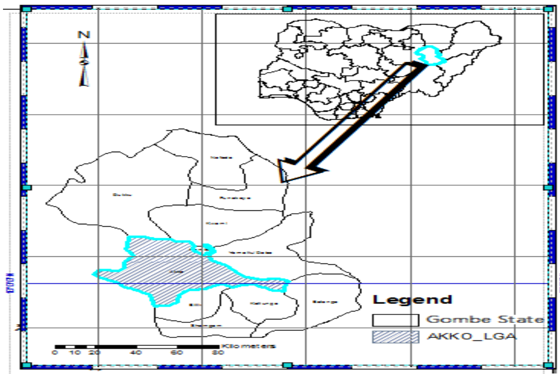

Fig.1: Gombe Showing the Study Area
Source:www.google.com.eg/search?q=akko+local+government&site

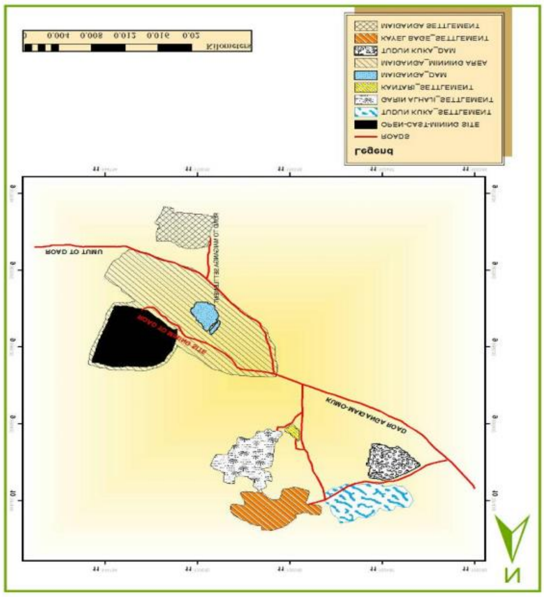

Figure 2: Maiganga and its Environs
Source: Google earth/Arcgis Analysis (2018).

Soil sampling and Laboratory procedures

The soil samples were collected in the dry season from farmlands of five communities majorly affected by the impact of Maiganga coal mining activities. These communities include Maiganga, Kayel Baga, Kantagari, Tudun Kuka, and Garin Alhaji Shugaba. Using a soil auger three soil samples were collected from each of the five sampling locations, along a 100m transect line at an interval of 30 to 35m apart.. The soil samples were collected at a pre-determined depth of 30cm where it is believed that the bulk of plants roots concentrate and from where most plants get their nutrients. A total of 15 soil samples were thus collected in all.

The collected soil samples were put in polythene bags, carefully labelled according to the sampling sites and the sampling points were recorded using Geographical Positioning System (GPS). The soil samples were taken to the laboratory for the determination of the considered heavy metals Lead, copper, zinc, iron and manganese (Pb, Cu, Zn, Fe & Mn) using the atomic absorption spectrophotometer (AAS). The mean values of the respective heavy metals examined were compared with the permissible limits according to the Food and Agriculture Organization (FAO) standards.

RESULTS AND DISCUSSION

Concentration of Heavy Metals examined in the area

This section presents the mean values of the respective heavy metals for the five sampled locations alongside with the permissible limits/FAO Standard.

Iron (Fe):

The results in Table 1 show that Iron was detectecd in all the five sampled locations of the study area. The highest concentration of Iron (Fe) was detected in Kayel Baga (0.44 mg/kg), while the least detected in Tudun Kuka with a concentration of (0.13 mg/kg). However, the concentration of Fe in all the locations was below the permissible/safety limit of 1000mg/kg by Food and Agricultural Organization (FAO).Since none of the sampled locations has Iron concentration above the safety limi, the area can be considered to be safe for crop productiion at the moment.

Table 1: Mean Concentration of heavy metals in soils compared with FAO soil permissible standards in the Study Area

Parameter (mg/kg)	**Maiganga**		**Tudun Kuka**		**Kayel Baga**		**Kanta Gari**		**G/Alh.Shugaba**		**FAO**
	Mean	Remark	mean	Remark	mean	Remark	mean	Remark	Mean	Remark	
Iron (Fe)	0.23	BP	0.28	BP	0.53	BP	0.35	BP	0.35	BP	1.5
Manganese (Mn)	0.10	BP	0.08	BP	0.13	BP	0.11	BP	0.11	BP	1000
Copper (Cu)	0.35	AP	0.41	AP	0.54	AP	0.41	AP	0.47	AP	0.01
Zinc (Zn)	19.10	AP	0.00	BP	1.79	BP	0.00	BP	0.00	BP	2.0
Lead (Pb)	0.03	BP	0.00	BP	0.00	BP	0.00	BP	17.55	AP	0.05

Source: Field survey and Laboratory Analysis, (2018)
NB: (AP= Above Permissible and BP= Below permissible)

Manganese (Mn)

From the results in Table 1, Manganese (Mn) was also detected in all the five sampled locations. Kayel Baga had the highest concentration (0.13 mg/kg) and the least concentration was observed in Tudun Kuka (0.08 mg/kg). Like Fe, the concentration of Mn in the studied locations was below permissible limit by the Food and Agricultural Organization (FAO). Hence, constitute no possible risk of soil pollution.

Copper (Cu)

Copper (Cu) was also dected in all the five sampled locations. The highest concentration of lead was found in Kayel Baga (0.30 mg/kg) and the least is detected in Tudun Kuka with a concentration of (0.06 mg/kg). The mean values of Cu obtained were rather above permissible limits (0.01mg/kg) by the FAO. This relatively high concentration of copper observed could constitute contamination to the soils of the area. Shahbaz (2015) observed that high copper in soil can affect the crops productivity and can cause different diseases to mankind.

Zinc (Zn)

The results also showed that Zinc was only detected in Maiganga and Kayel Baga out of the five sampled locations in the study area. The zinc concentration of (19.10mg/kg) at Maiganga was rated above permissible standard while Kayel Baga has zinc concentration of (1.79 mg/kg) and rated below the permissible standard when compared to the permissible limit of FAO (2.0 mg/kg). Shabhaz (2015) observed that high zinc content in soil can affect the crops produced and can cause different diseases in man.

Lead (Pb)

Table 1, reveals that lead was detected in only two settlements Garin Alhaji Shugaba and Maiganga. Garin Alhaji Shugaba with mean values of (17.55 mg/kg) was rated to be far above permissible limit compared to the FAO (0.05 mg/kg) limit while Maiganga with (0.03 mg/kg) was rated as far below permissible limit. This implies that only soils in Garin Alhaji Shugaba could probably be affected due to coal mining activities. This relatively high concentration of Pb could pose the risk of soil pollution, hence adversely affect crop production and in turn cause kidney failure in man via the food chain (Shahbaz, 2015).

CONCLUSION

The findings of the study indicate that only the concentration of Copper was above permissible standard in four of the five sampled locations. The concentrations of Zinc (Zn), Iron (Fe), Manganese (Mn) were below the permissible standard in all the sampled locations; while lead (Pb) was only detected in Garin Alhaji Shugaba and above permissible standard with a very high concentration. Therefore, copper and lead are the two heavy metals that stand the risk of soil pollution in the study area at moment due to coal mining activities of the Maiganga coal mines. In addition, though the concentrations of Fe, Mn and Zn are relatively below the FAO permissible limits, possible build- up in the future may occur.

RECOMMENDATIONS

Based on the findings of the study, the following suggestions have been made, namely, the need for routine monitoring of soil qualityto guard against heavy metals contamination by conducting soil analysis between 2 – 5 years. Also, necessary is a follow-up soil quality assessment of lead and copper concentration levels particularly at Garin Alhaji Shugaba and the other four studied locations be conducted to monitor the lead levels.

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