Impact of Coal Mining Activities on Crops around Maignga Coal Mining Site, Akko Local Government of Gombe State-Nigeria

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***Abstract:* - The study aimed to determine the impact of coal mining activities on edible crops around Maiganga coal mine site of Akko Local Government Area, Gombe State-Nigeria by assessing the level of some heavy metals in some selected crops and soil around the area so as to ascertain the influence of coal mining on crops around the area. Two regions were compared which include contaminated site (farms around Maiganga coal mine site) and a non-contaminated site (farm lands 40km away from Maiganga coal mines). Soil, maize and millet samples were collected from each of the two study areas, they were then labeled and stored in polythene bags. The leaves samples were shade dried, grinded and labeled before taken to the Biochemistry Department laboratory of Gombe State University for processing and analysis. Among the selected heavy metals analyzed Zn, Fe and Mn were detected while Co, Cd and Pb were not at detectable range of ASS machine. However, the result showed that the level of Fe and Zn concentration in maize, millet and soil samples were higher in the contaminated site while the level of Mn was higher in the control site than in the contaminated site. The mean concentration value in maize leaves samples of Zn=67.13 Fe =24.93 Mn = 198.0 and Zn=58.33 Fe =24.00 and Mn =235 in the contaminated and the uncontaminated site respectively, whereas the mean concentration value in millet leaves samples of Zn=59.53 Fe =30.00 Mn =119.0 and Zn= 55.67 Fe = 25.20 and Mn = 226.0 in the contaminated and the uncontaminated site respectably, and that of the mean concentration value in soil samples of Zn= 42.67 Fe = 32.27 Mn =191.0 and Zn= 4.80 Fe = 28.00 and Mn =260 in the contaminated and the uncontaminated site respectably. Moreover, the data collected were analyzed using student T test in SPSS version 16 for comparison of the two study areas. Moreover, the value obtained were all below the recommended level. If the concentration of toxic metals continue to increase it will pose a health threat to the local people who continue to consume on edible crops cultivated around the affected area.**

***Key words:* Maiganga, Coal mine, Heavy metals, Edible plants, Soil samples**

I. INTRODUCTION

Exploitation of mineral resources has been an important tool for national development in more than a few developing countries, for example, Nigeria is blessed with abundant mineral resources, which have contributed massively to the national wealth and socioeconomic benefits, as different types of environmental damage and hazards accompany mineral development (Maina et *al*., 2016).

Mining activities all over the country has had devastating effect on the physical environment. Most mining activities in Nigeria are open cast mining which has a highly damaging effect on the environment. Some of these environmental effects include loss of prime agricultural land, forest cover, water regime, air quality and biodiversity. Mining of solid minerals like coal has the potential of causing environmental degradation. Vegetation in form of natural forest and crop land are usually the first casualty in exploration and exploitation of coal in Maiganga. Land degradation associated with coal mining in the area includes deforestation, soil erosion, gullying and dis-configuration of the landscape (Oruonye *et al.,* 2016).

During actual mining operations, methane a known greenhouse gas may be released into the air. And by the movement, storage and redistributions of soil, the community of micro-organisms and nutrient cycling processes can be disrupted (USEPA, 2005). However, Heavy metals get into the soil by the chemicals emitted from mining process. According to Lenntch, (2008) heavy metals are defined as those metals that have their densities in excess of 5g/cm3, the term heavy metals are natural components of the earth's crust. Some of them (e.g. copper and zinc) are also called trace elements biologically, because in small amount they play a vital role in plants, animals and human nutrition, (Monier-Williams, 1994).

However, they could be toxic at higher concentrations, heavy metal poisoning could result, for instance, from drinking contaminated water, high ambient air concentrations near emission sources, intake via the food chain. Heavy metals are dangerous because they tend to bioaccumulate, bioaccumulation means an increase in the concentration of a chemical in a biological system over time, compared to the chemicals concentration in the environment. Such metals accumulate in living tissues anytime they are taken up and stored faster than they are broken down (metabolized) or excreted. However, the most important role of soil is it productivity, which is the basis for human survival (Kataba and Pendias, 2000).

II. MATERIALS AND METHODS

Location

The area of study is part of Maiganga village South-Western part of Kumo, headquarters of Akko Local Government of Gombe State, Nigeria, it lies between latitude N90 501 and N100 001 N and longitudes E100501and E100591E.

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 X), (ii) farms about 20meters away from the site of the coal mining activities (referred to as area Y), and (iii) the Maiganga settlement which serves as the control site 1km away from coal mine site (referred to as area Z). Area X is the central area where the mining activities is going on, and is in-between the farmland areas and Maiganga settlement, area Y is the farms 20meters away from coal mine and is located at the wind ward site of the coal mining areas, while area Z are farms at Maiganga settlement area and is situated 1km away from the mining area (approximately a distance of about 1km from the mining area) (Office of Surveyor General, Gombe State).

Soil Samples Collection

From each of the experimental plots, including the control plot, four composite soil sample each will be taken after 120 meters which will give a total of 12 soil samples collected at the beginning of the rainy season may/June with the help of hand auger. The twelve soil samples collected at the beginning of the rainy season may/June from each of the experimental plots, including the control plot will be achieved by taking four composite soil samples each to the depth 0-15cm and 15-30 cm after 120 meters.

Maize and millet plants Samples Collection

With a clean razor blade, four representative samples of maize and millet plant leaves from each of the experimental sites were taken after120 meters six Weeks After Planting (WAP) to give a total of twelve samples. The total of twelve maize samples collected at six weeks after planting (WAP) and at the peak of the rainy season august/ September from each of the experimental plots, including the control plot were also achieved by taking four representative samples of maize plant leaves with a clean razor blade.

Digestion of Samples

Soil Samples

The soil sample collected from each of the experimental plots, including the control plot were then stored in a polythene bags, and labeled before taken to the laboratory for processing and analysis. 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 HNO3 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 541 filter paper into 100 ml volumetric flask. The filtered was made up to the mark with distilled. 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, zinc, cadmium, chromium and nickel in the Soil extract was read. (Vardaki and Kelepertsis, 1999). In order to ensure quality control, soil samples were collected with plastic implements to avoid contaminations. Samples were kept in polythene hat were free from heavy metals and organics and well covered while being transported from field to the laboratory to avoid contamination from the external environment. Reagent blanks were used in all analyses to check reagent impurities and other environmental contamination during analysis (Anake *et al*., 2009). Analytical reagent and plastic containers used were washed with detergent solution followed by 20% (v/v) concentrated trioxonitrate (iv) acid and then rinsed with water and finally with distilled water (Audu and Lawal, 2005). All the instruments used were calibrated before use. Tools and work surfaces were carefully cleaned for each sample during grinding to avoid cross contamination (Anake *et al*., 2009).

Maize and millet Samples

The plant leaves samples collected from each of the experimental plots, including the control plot were stored in polythene bags and labeled before taken to the laboratory for processing and analysis. 0.5g of Maize plant was weighted into a 100ml beaker and the aqua-regia added. The beaker was covered with a watch glass and placed on hot plate in a fume cupboard. The mixture was boiled and allowed to simmer for 1 hour. The beaker was removed and allowed to cool. When no more fumes were given off, the watch glass was removed allowing the liquid attached to it to drain into the beaker. The content of the beaker was filtered through a Watman 541 filter paper into 100ml volumetric flask. The residue on the filter paper was washed thoroughly into the volumetric flask using deionizer water. The content of the flask was made to the mark still using deionizer water. The flask was inverted several times to achieve homogeneity of the solution. The solution was then transferred into a labeled specimen bottle and taken for analysis using AAS, and then the concentration of lead, zinc, cadmium, chromium and nickel in the Maize extract was read on the AAS. (Vardaki and Kelepertsis, 1999).

In order to ensure quality control, maize plant samples were collected with a clean razor blade to avoid contamination. Samples were kept on polythene bags that were free from heavy metals and organics and well covered while being transported from field to the laboratory to avoid contamination from the external environment. Reagent blanks were used in all analyses to cheek reagent impurities and other environmental contaminations during analysis (Anake *et al*., 2009).

Analytical reagent (Analar) grade chemicals and distilled water were used throughout the study. All glassware and plastic containers used were washed with detergent solution followed by 20% (v/v) concentrated trioxonitrate (iv) acid and then rinsed with water and finally with distilled water (Audu and Lawal, 2005). All the instruments used were calibrated before use. Tools and work surfaces were carefully cleaned for each sample during grinding to avoid cross contamination (Anake *et al*., 2009).

Statistical Techniques Used

The test for significance relationship in heavy metal concentration in the soils samples of the study area, maize plant and millet plant samples of the study will be carried out using ANOVA. (Butkus and Battrnait, 2007).

III. RESULTS AND DISCUSSION

Table 1 ASS of maize leaves samples at contaminated site

Metals	Station	A	Station	B	Station	C	FAO standard	FAO Standard II
	(mg/kg)		(mg/kg)		(mg/kg)		I (mg/kg)	(mg/kg)
Zn	81		61.8		58		60	100
Fe	30.6		24.0		20.2		50	60
Mn	214.8		199.8		180.4		100	250
Co	N.D		N.D		N.D		-	-
Cd	N.D		N.D		N.D		-	-
Pb	N.D		N.D		N.D		-	-

Keys

ASS: Atomic Absorption Spectrophotometer Mg/kg = milligram per kilogram

N.D = Not detected

Station A: a site 20 meters away from Maiganga coal mine site Station B: a site 40 meters away from Maiganga coal mine site Station C: a site 60 meters away from Maiganga coal mine site

FAO standard I: maximum tolerable level of heavy metals in maize plants by Food and agriculture organization

FAO standard II: toxic level of heavy metals in maize plant by Food and agriculture organization

Table 2 ASS of maize leaves samples at control site

Metals	Station	A	Station B (mg/kg)	Station	C	FAO standard	I	FAO Standard I
	(mg/kg)			(mg/kg)		(mg/kg)		(mg/kg)
Zn	72.6		60.6	41.8		60		100
Fe	30.2		20.2	21.6		50		60
Mn	280.4		204.0	222.0		100		250
Co	N.D		N.D	N.D		-		-
Cd	N.D		N.D	N.D		-		-
Pb	N.D		N.D	N.D		-		-

Keys

ASS: Atomic Absorption Spectrophotometer Mg/kg = Milligram per kilogram

ND = Not detected

Station A: a site 20 meters away from Maiganga coal mine site Station B: a site 40 meters away from Maiganga coal mine site Station C: a site 60 meters away from Maiganga coal mine site

FAO standard I: maximum tolerable level of heavy metals in maize plants by Food and agriculture organization

FAO standard II: toxic level of heavy metals in maize plant by Food and agriculture organization

Table 3 ASS of millet leaves samples at contaminated site

Metals	Station A (mg/kg)	Station B (mg/kg)	Station C (mg/kg)	FAO standard I (mg/kg)	FAO Standard I (mg/kg)
Zn	73.2	61.4	44.0	60	100
Fe	32.0	30.0	28.0	50	60
Mn	122.6	120.0	114.0	100	250
Co	N.D	N.D	N.D	-	-
Cd	N.D	N.D	N.D	-	-
Pb	N.D	N.D	N.D	-	-

Keys `

ASS: Atomic Absorption spectrophotometer

Mg/kg = milligram per kilogram

ND = Not detected

Station A: a site 20 meters away from Maiganga coal mine site Station B: a site 40 meters away from Maiganga coal mine site Station C: a site 60 meters away from Maiganga coal mine site

FAO standard I: maximum tolerable level of heavy metals in maize plants by Food and agriculture organization

FAO standard II: toxic level of heavy metals in maize plant by Food and agriculture organization

Table 4 ASS of millet leaves samples at control site

Metals	Station A (mg/kg)	Station B (mg/kg)	Station C (mg/kg)	FAO standard I (mg/kg)	FAO Standard II (mg/kg)
Zn	65.2	60.2	41.6	60	100
Fe	33.4	21.8	20.8	50	60
Mn	250.8	201.8	224.0	100	250
Co	N.D	N.D	N.D	-	-
Cd	N.D	N.D	N.D	-	-
Pb	N.D	N.D	N.D	-	-

Keys

ASS: Atomic Absorption Spectrophotometer Mg/kg = milligram per kilogram

ND = Not detected

Station A: a site 20 meters away from Maiganga coal mine site Station B: a site 40 meters away from Maiganga coal mine site Station C: a site 60 meters away from Maiganga coal mine site

FAO standard I: maximum tolerable level of heavy metals in maize plants by Food and agriculture organization

FAO standard II: toxic level of heavy metals in maize plant by Food and agriculture organization

Table 5 ASS of soil samples at contaminated site

Metals	Station A (mg/kg)	Station B (mg/kg)	Station C (mg/kg)	FAO standard
Zn	44.6	41.8	41.6	100
Fe	33.8	33.0	30.0	150
Mn	281.6	240.0	260.0	437
Co	N.D	N.D	N.D	-
Cd	N.D	N.D	N.D	-
Pb	N.D	N.D	N.D	-

Keys

ASS: Atomic Absorption Spectrometer Mg/kg = milligram per kilogram

N.D = Not detected

Station A: a site 20 meters away from Maiganga coal mine site Station B: a site 40 meters away from Maiganga coal mine site Station C: a site 60 meters away from Maiganga coal mine site

FAO standard: maximum tolerable level of heavy metals in soil by food and agriculture organization

Table 6 ASS of soil samples at control site

Metals	Station A	Station B	Station C	FAO standard
Zn	6.4	2.0	2.0	100
Fe	30.0	28.0	180.0	150
Mn	191	180	202	437
Co	N.D	N.D	N.D	-
Cd	N.D	N.D	N.D	-
Pb	N.D	N.D	N.D	-

Keys

Ass: Atomic Absorption Spectrophotometer Mg/kg = milligram per kilogram

N.D = Not detected

Station A: a site 20 meters away from Maiganga coal mine site Station B: a site 40 meters away from Maiganga coal mine site Station C: a site 60 meters away from Maiganga coal mine site

FAO standard: maximum tolerable level of heavy metals in soil by food and agriculture organization

The tables above provide the result and the ASS of selected heavy metals concentration in the contaminated and the uncontaminated site as well as the standard for the maximum tolerable level of the selected metals in maize, millet, humans, animals and soil. The comparison of table 1 and 2 showed that the level of Zn and Fe in the maize leaves of the contaminated site were higher than in the uncontaminated site while the concentration of Mn was higher in the uncontaminated site than the contaminated site. The comparison of table 3 and 4 showed the highest level Zn and Fe in the millet leaves of the contaminated site than in the uncontaminated site while the Mn concentration was higher in the uncontaminated site than the contaminated site. The comparison of table 5 and 6 showed that the level of Zn and Fe in the soil of the contaminated site were higher than in the uncontaminated site while the concentration of Mn was higher in the uncontaminated site than the contaminated site.

The concentration of Zn and Fe in the maize leaves of the contaminated area were more than that of the control area this is as a result of the mining operation taking place in the area while the concentration of Mn was higher in the control site, that is because of the high level of Mn in the farm land soil. However this work is in agreement with the findings of Adamu (2016) who reported to have high level of heavy concentration in the contaminated site around Maiganga coal mines site and a lower level at the control site. Moreover the level of Fe and Zn in both the control and contaminated site are within the standard level of limit level recommended by FAO while that of the Zn exceed the standard level recommended by FAO. The concentration of Zn and Fe in the millet leaves of the contaminated area was more than that of the contaminated area this is as a result of the mining operation taking place in the area while the concentration of Mn was higher in the control site, that is because of the high level of Mn in the farm land soil. However this work is in agreement with the findings of Aremu *et al*. (2010) who reported to have high level of heavy metals concentration in the contaminated site Around Udege Mines of Nasarawa State-Nigeria and a lower level at the uncontaminated site. Moreover the level of heavy metals in both the control and contaminated site are below the level of limit recommended by FAO. The concentration of Zn and Fe in the soil of the contaminated area was more than that of the uncontaminated area this is as a result of the mining operation taking place in the area while the concentration of Mn was higher in the control site, that is probably because of the high application of manure in the farm land soil. The work is in agreement with the findings of Mohammad and Mahmoud (2010) who reported to have high level of heavy metals concentration in the contaminated site and a lower level at the uncontaminated site. Moreover the level of heavy metals in both the control and contaminated site are below the level of limit recommended by FAO.

Zinc is considered essential for humans and animals, it acts as catalytic or structural component of numerous enzymes involve in energy metabolism and in transcription and translation as reported by Kiekens (1993). In plants Zn is believe to stimulate resistance of plants to dry and hot weather and also to bacterial and fungal disease However, a report by Kataba-Pendsias (2000) revealed that Zn concentration in soil between 100mg/kg-400mg/kg is injurious to most plant species. The zinc toxicity is medical condition involving an overdose on, or toxic exposure to zinc. Such toxicity level had been seen to occur at ingestion of greater than 50 mg of zinc. Excessive absorption of zinc can suppress cupper and iron absorption. The free zinc iron in solution is highly toxic to bacteria, plants, invertebrates and even vertebrate fishes. Zinc is an essential trace metals with very low toxicity in humans. Zinc toxicity to human is observed at levels of 100-300 mg per day, mommy the most important symptoms been the weakening of the immune system and the alteration of blood parameters and functionality, anemia, liver, kidney derangement, diarrhea and red urine. It's generally assumed that leaves zinc levels in excess of 300 to 600 mg/kg is considered to be toxic to plants. However, the threshold of zinc level, total soil and available zinc levels has not been established for phytotoxicity in different vegetable crops.

In some people, zinc may cause nausea, vomiting diarrhea, metallic taste, kidney and stomach damage, and other side effect. Zinc is possibly safe when taken by mouth in does greater than 40 mg per daily. There is some concern taking those doses higher than 40 mg daily may decrease how much cupper the body absorbs.

No clinical sign of toxicosis are expected in animals such as dogs ingesting lees than 20mg/kg of Fe. Doses ingesting between 20 and 60 mg/kg of elemental iron can develop mild clinical signs when the amount of elemental iron ingested is greater than 60mg/kg, serious clinical signs can develop In all oral doses between 100 and 200 are potentially lethal. Iron toxicosis manifest clinically in four stages. The first stage occurs in the first 6 hours after iron overdoes its marked my primarily by gastrointestinal effect such as vomiting diarrhea gastrointestinal bleeding and mucosal damage occur in an empty stomach. The second stage occur 20 hours after the over dose. This is refers to as lethal period, a period of a parental clinical recovery. The third stage occurs 12 to 96 hours after the initial clinical signs developed. This stage is marked by lethargy, recurrence of gastro intestinal signs metabolic, acidosis, shock hypotension, tachycardia, cardiovascular collapse coagulation deficits hepatic necrosis and possibly death. The fourth stage occurs 2 to 6 weeks after iron over dose. It presents abnormality such as gastrointestinal irritation, dehydration, anemia hepatic necrosis and liver failure. There is no report of acute toxicity of Mn in animals. Therefore all toxicity study described here are chronic in nature. A diet can be consumed without any adverse effect when the manganese level is 2000ppm for calves, 3000ppm for sheep, 3000ppm for chickens, 4000 for turkey, and 7000ppm for rats. However, the nutritional requirement in the dogs are estimated to be 0.16mg/kg/day with an estimated bioavailability, including absorption efficiency of 10% this is considerably low compared to manganese requirement that range from 2.5 – 5.0 mg/kg in human beings, 20mg/kg in small rodents, to as high as 600mg/kg in cattle or poultry. Deduct in the current case report ingested a Mn dose of 86kg/mg, which is 538 times the recommended dose per day. Thus when considering the relatively low nutritional manganese requirement for dose compare to rats, which have 125 higher manganese requirement a median lethal dose for Mn in dose is theoretically expected to be much lower than rats.

IV. CONCLUSION

In conclusion, the selected heavy metals concentration in both the control and contaminated site were determine except Cd, Pb, and Co which were not detected. However, the comparison between the levels of heavy metals in contaminated site and uncontaminated site shows that the level of heavy metals in Zn and Fe were higher in the contaminated site while the level of Mn was higher in the control site than in the contaminated site.

V. RECOMMENDATIONS

- Farmers should avoid farming close to Maiganga mining area as it can lead to the contamination of crops in the area.
- Monitoring of the presence of heavy metals around the mining site should be done to avoid accumulation of excess metals in the environment.

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