Assessment of Heavy Metal Concentration in Water, Soil and Vegetable in Ex-Mining Pond, Jos South L.G.A Plateau State, Nigeria.

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Abstract- This study assessed the effect of ex-mining pond water used for irrigation on the soil and two vegetable samples (Cabbage ant Tomatoes) by assessing the concentration of some heavy metals (Cu, Cr, Mn, Cd, and Fe) present in the pond water and comparing with the concentration of the metals in the soil and the vegetables using AAS. In the mining water all the selected metals were detected except for cadmium and were within the WHO permissible limit. In the soil sample, all the selected heavy metals were detected and were within the range of 0.001-216.50ppm. Chromium was within the WHO limit for heavy metals in soil while Cu, Cd, Mn, Pb and Fe were above the WHO limit. In the tomatoes samples, the heavy metal concentration ranges from 0.131-3.299ppm. Chromium and cadmium were not detected and Mn, Pb and Fe were above WHO permissible limit. In Cabbage, all the heavy metals were detected except chromium and was within the range of 0.006-1.900ppm. Mn, Pb, Cd and Fe were above WHO permissible limit except for Cu. From this result the concentration of heavy metals in the soil was higher than the concentration of the heavy metals in the water. This could be due to the parent materials that make up the soil as well as the application of chemicals like herbicide and pesticide. Continuous use of the mining water for irrigating the farmland results in accumulation of the heavy metals in the soil as well as the plants.

Index Terms- AAS, Concentration, Ex-mining, Heavy metals, Pond.

I. INTRODUCTION

Metal contamination in abandoned mines is a global environmental problem which various countries around the world are suffering from. This problem ranks among the most significant environmental challenges worldwide, which requires ongoing evaluation and urgent solution to overcoming this problem and its negative impacts (Kutty & Al-Mahaqeri, 2016). Uncontrolled mining activities and illegal mining in developing countries have generated a lot of environmental hazards and waste (Atafar et al, 2010). Metal mining is the second large source of heavy metal contamination in soil after sewage sludge (Gosh &Singh, 2005). In some cases, tailings present on steep slopes are unstable and prone to erosions. All these factors contribute to pollution for the soil, ground and surface water. Metals are non degradable and therefore can persist for long period in aquatic as well as terrestrial environments (Nouri et al., 2012). These metals may be transported through soils to reach ground water or may be taken up by plants including agricultural crops (Atafar et al., 2010). Eating vegetables regularly in diet can have many health benefits by reducing diseases and used to convert fats and carbohydrates into energy (Mercola. 2014). Plants are capable of using metals through different ways such as complexing them in their sedentary nature, binding them into cell wall, and/or combining them to produce certain organic acid or proteins (Galfati et al, 2011). Therefore, plant species are considered as good bio-indicators in the early stages of heavy metal pollution. As a result of soil, water and atmosphere represents a growing environmental problem affecting food quality and human health. Heavy metals may enter food chain as a result of their uptake by edible plants, thus the determination of heavy metals in environmental samples is very important (Daniel, Chundusu & Chup, 2014). Heavy metals are natural components which cannot be degraded or destroyed biologically. The toxic heavy metals entering the ecosystem may lead to geo-accumulation and bioaccumulation (Lokeshappa, Kandarp & Anil, 2012). A heavy metal is defined as any dense metal or metalloid that is noted for its potential toxicity especially in the environmental context (Sirivastava & Goyal,2010). The amount of metallic elements in plants is the measure of the level of the metal in the environment in which the plants grows over a period of time (Ahmed et al., 2012). This study assess the effect of mining activities on the concentration of the heavy metals (Cd, Cr, Cu, Mn, Fe,Pb) in the pond water, soil and vegetables (cabbage and tomatoes) using Atomic Absorption Spectrophotometer (AAS).

II. MATERIALS AND METHOD

STUDY AREA

The study site is located in Jos South Local Government area of Plateau state with latitudes 9^{o}E to 10^{o}N and longitude 8^{o}30'E. it is situated at the north western part of the state with its headquater at Bukuru which is about 15Km from the state capital Jos, with total land area of about 1,037Km^2 with a population of 301,096 at 2011 national population census. Samples were taken from ex mining pond and farm land irrigated with water from the pond in Rayfield, Jos south L.G.A of plateau state. (Ishola et al., 2016)

SAMPLING

100g of the soil sample was collected from the farm land irrigated with water from the ex-mining pond by using a plastic spoon within the depth of about 5 cm^3 and was put in a labeled polyethylene bag. The water from the ex-mining pond was sampled by using a 1 litre capacity plastic rubber that has been previously rinsed with distilled water and dilute nitric acid. The water was collected and labeled properly. The two vegetables; cabbage and tomatoes were sampled randomly in the farm land irrigated with water from the ex-mining pond using stainless knife and was put in a polyethylene bag and labeled properly.

SAMPLE PRE TREATMENT

The soil sample was air dried in the laboratory, grounded with mortar and pestle and was sieved with a 2mm mesh and stored in a labeled polyethene bag prior to analysis. The water sample collected was taken to the laboratory for preservation after treatment with concentrated nitric acid (HNO_3). While the harvested cabbage and tomatoes were washed with de-ionized water to remove soil particles and then cut with stainless steel knife and was oven dried at 70^0C until stable weight was obtained. It was then grounded in a mortar and sieved and kept until needed.

DETERMINATION OF WATER pH

About 50ml of the water sample was put in a 100ml beaker and the pH was measured by introducing a glass probe of the pH meter in to the water sample and the reading was recorded.

DETERMINATION OF WATER TEMPERATURE

500ml capacity rubber previously raised with dilute HCl was dipped into the mining water and the cover was opened and the water sample was collected to the marked region. The water sample collected was left 10mins and the thermometer (mercury thermometer) was inserted and left for 30mins and the reading was taken.

DETERMINATION OF SOIL TEMPERATURE

50g of the soil sample was weighed and put in a beaker. 100ml of distilled water was added and shaken thoroughly until it dissolves completely and a thermometer was inserted and the reading was taken.

DETERMINATION OF SOIL pH

1.0g of soil sample (passed 2mm sieve into a 50ml) was weighed and 20ml of distilled water was added, the suspension was stirred several times for 30mins with glass rod. The soil suspension was allowed to stand for 30mins. The electrode was calibrated by using buffer solution (standard buffer solution pH 7.0 and 4.0) the electrode of the pH was inserted into the partly settled suspension and the pH was measured. The electrode was not allowed to touch the bottom of the beaker and also the suspension was not stirred during measurement.

DIGESTION OF THE SOIL SAMPLE

1.0g of the soil sample was digested with 12ml of aqua-regia (HNO_3: HCl) to the ratio 3:1 in a pyrex beaker and heated on a hot plate at a temperature 110^0C for 3hours and was evaporated to dryness. The digested sample was further diluted with 20ml of 2% HNO_3, and was filtered using Whatman filter paper No.42 and was then transferred into a 50ml volumetric flask, the distilled water was added to mark up the mark and was kept until needed.

DIGESTION OF THE VEGETABLE SAMPLES

About 1.0g of vegetable sample was digested with 24ml 0f 80% aqua-regia and 5ml of 30% H_2o_2 in a 100ml pyrex beaker and was digested at 80^0C on a hot plate until a clear solution was obtained (Ang and Lee., 2005). After cooling, the digested samples were filtered using Whatman filter paper No.42 and diluted to 50ml with de-ionized water and kept until needed.

III. RESULTS AND DISCUSSION

The result of the temperature of water, soil pH and water pH are given below and the result of the chemical analysis of the water sample, soil samples and vegetables sample are given in table, 2, 3, 4, 5, 6 and 7 respectively. The mining pond water recorded a temperature of 27^0C and a pH of 7.47 while the soil sample recorded a temperature of 24^0c and a pH of 8.43. The normal pH range for irrigation water is from 6.5 to 8.4. The average pH of 7.47 recorded in the work was within the permissible range.

Table 1: Temperature and pH of Water and Soil Samples

Samples	Temperature	pH
Water	27^0C	7.47
Soil	24^0C	8.43

Table 2: Heavy Metal concentration in Water Sample

METALS	CONCENTRATION (ppm)		
	Mean ±SD	**Standard Error**	**WHO**
Cu	0.023±.0014	.001	2
Cr	0.3755±.0145	.0145	0.87
Mn	0.0645±.0025	.0025	0.1
Cd	0.415±.0212	.015	0.3

ND= Not detected
Duplicates determination

Table 3: Heavy Metal Concentration on Soil Sample

METALS	**CONCENTRATION (ppm)**		
	Mean ±.SD	**Standard Error**	**WHO Permissible Limit**
Cu	**5.520±.0323**	**.020000**	**2**
Cr	**0.001±.0012**	**.000001**	**0.87**
Mn	**0.800±.0021**	**.020000**	**1**
Cd	**0.010±.0014**	**.000000**	**0.003**
Pb	**0.187±.0112**	**.007000**	**0.05**
Fe	**216.5±.9892**	**3.500000**	**0.3**

ND = Not Detected, Duplicate determination

Table 4: Heavy Metal Concentration in Cabbage Sample

METALS	**CONCENTRATION(ppm)**		
	Mean±SD	**Standard Error**	**WHO Permissible Limit**
Cu	**0.2985±.0021**	**.001500**	**2**
Cr	**ND**	**-**	**0.87**
Mn	**0.5165±.0233**	**.016500**	**0.1**
Cd.	**0.0060±0071**	**.005000**	**0.003**
Pb	**0.2665±.0007**	**.000500**	**0.05**
Fe	**1.900±.0424**	**.030000**	**0.3**

ND = Not Detected
Duplicate determination

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Table 5: Heavy Metal Concentration in Tomatoes Sample

METALS	**CONCENTRATION (ppm)**		**WHO Permissible**
	Mean±SD	**Standard Error**	**Limit**
Cu	**.213±.0098**	**.007000**	**2**
Cr	**-**	**-**	**0.87**
Mn	**.533±.1103**	**.078000**	**0.1**
Cd	**-**	**-**	**0.003**
Pb	**.131±.0028**	**.002000**	**0.05**
Fe	**3.299±1428**	**.101000**	**0.3**

ND= Not Detected
Duplicate determination

IV. DISCUSSION

Concentration of Heavy Metals

Copper (Cu)

From the result of water sample and the soil sample shown in Table 1 and 2. Copper showed a concentration value of 0.024ppm in water and 5.51ppm in soil. The soil sample gave a higher concentration of copper than the water sample which may be attributed to the type of parent material that makes up the soil. It can be as a result of accumulation due to prolong use of the pond water for irrigation resulting in a significant level of copper in the soil. Similar work shows copper concentration in water to be 0.527ppm which is higher than the value reported in this work and the value of 0.605ppm for soil which is Far lower than the value of 5.54ppm reported in this work (Boamponsemetal., 2012). However the value for copper in water sample is within the WHO permissible limit. Cabbage in Table 3 showed a concentration value of 0.29850ppm while tomatoes in Table 4 showed a concentration value of 0.213001ppm. These concentration value were however lower than the concentration of copper in the soil, but higher than the concentration value of copper in the water sample. This expected as only a fraction will be bio-available for the plant uptake. The concentration value reported for cabbage in this work was however higher when compared to the concentration value of 0.145ppm reported for cabbage irrigated with mining pond water (Boamponsem et al., 2012). The value of 0.21300 reported for tomatoes in this study was lower than the value of 5.01ppm reported in the literature of tomatoes (miclean et al., 2009).

Chromium (Cr)

From the result of water sample and the soil sample shown in Tables 1 and 2, Cr shows a concentration value of 0.37550ppm in water and0.001ppm in the soil sample. It is however higher in the water sample than in the soil sample this may be due to the mining activity that take place. Cr was however not detectable in the two plants sample (Cabbage and tomatoes). However, the concentration value of Cr in the water was within the WHO permissible limit. Similar work showed the concentration value of Cr in water to be 0.005ppm which is lower than the concentration value recorded in this study. (Anita et al, 2010).

Manganese (Mn)

From the result of water sample and the soil sample shown in Table 1 and 2, Mn showed the concentration value of 0.06450ppm in water and 0.8000ppm in soil. This may be due to the parent material that makes up the soil indicating a significant level of Mn in the soil. Similar work shows Mn concentration in water to be 2.107ppm which is higher than the value reported in this work and the concentration of 5.465ppm for soil which is also higher than the concentration value reported in this work (Boamponsem, et al., 2012). However, the value for Mn in both water and soil sample were above the WHO permissible limit. Cabbage shows a concentration value of 0.5165ppm while tomatoes in Table 4 show a concentration value of 0.533ppm. the concentration value of Mn both in cabbage and tomatoes were higher than the concentration value of Mn in the mining water indicating that the Mn concentration of te vegetables is as a result of the concentration of the Mn in the soil and not from the water although the mining water used in irrigating the plants might have elevated the concentration of Mn in the soil.

Cadmium (Cd)

From the result of water analysis and the soil sample analysis shown in Tables 1 and 2, Cd was not detectable in the mining water. It may be present in the concentration that is below the detectable limit of the instrument while the soil sample recorded a concentration of 0.01ppm. The presence of Cd in the soil sample and absent in the water may be as a result of the parent material that make up the soil. Similar work shows Cd concentration in water to be 0.267ppm while in this work, Cd was not detectable (Boamponsem et al., 2012). The concentration value of Cd in soil in this work is above the WHO permissible limit of 0.01ppm. Cabbage recorded a concentration value 0.006ppm for Cd while it was not detected in tomatoes. The value of 0.006ppm reported for cabbage was lower when compared to the value of the 0.10ppm recorded for Cd in soil. The concentration value reported for cabbage in this work was however lower when compared to the concentration value of 0.001 reported for cabbage irrigated with mining pond water

(Boamponsem et al., 2012) and the concentration value of 0.21ppm reported for cabbage (Miclean et al., 2009).

Lead (Pb)

From the result of water sample and soil sample shown in Tables 1 and 2, Pb shows a concentration value of 0.001ppm in water and 0.187ppm in soil. The soil sample gave higher concentration of Pb than the water sample, which may be attributed to the type of parent material that makes up the soil indicating a significant level of Lead in the soil. Similar work shows Pb concentration in water to be 15.508ppm which is higher than the value reported in this work and the value of 1.775ppm for soil which is far higher than that value of 0.187ppm reported. (Boamponisem et al, 2012). However, the value of Pb in water and soil sample is above WHO permissible limit. Cabbage in Table 3 shows a concentration value of 0.26650ppm while tomatoes in Table 4 show a concentration value of 0.1310ppm. These concentration values were however higher than the concentration of Pb in the water and lower in the soil sampled. The concentration value reported for cabbage in this work was however lower when compared to the concentration value of 1.300ppm reported for cabbage irrigated with mining pond water (Boamponsem et al., 2012). The value of 0.131ppm reported for tomatoes in this study was lower than the value of 3.24ppm reported for literature of tomatoes (Miclean, et al. 2009).

Iron (Fe)

From the result of water sample and soil sample shown in Table 1 and 2, Fe shows a concentration value of 0.4150ppm in water and 216.500ppm in soil. The soil sample gave a higher concentration of Fe than in the water sample which may be attributed to the type of parent material that make up the soil indicating a significant level of Fe in the soil and Fe is one of the most abundant element in the earth crust. Similar work shows Fe concentration in water to be 15.508ppm which is higher that the value reported in this work and the value of 14.076ppm for soil which is lower than the value of 216.500ppm reported (Boamponisem et al., 2012). However, the value Fe in both water and soil sample were above WHO permissible limit. Cabbage in Table 3 shows a concentration value of 1.900ppm while tomatoes in Table 4 show a concentration value of 3.2990ppm. These concentration values were however lower than the concentration value of Fe in the soil. The concentration value reported for cabbage in this work is however lower when compared to the concentration value of 150ppm reported for cabbage irrigated with mining pond water. (Boamponsem et al., 2012).

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