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DETERMINATION OF THE ELEMENTAL CONCENTRATIONS IN ORGANS OF *AMARANTHUS HYBRIDUS* (AFRICAN SPINACH) AND *SORGHUM BICOLOR* (GUINEA CORN) FROM BONU ARTISANAL GOLD MINE SITES IN NORTHERN NIGERIA

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ABSTRACT

Consumption of plants which grows wild or cultivated on soils contaminated with heavy metals like lead (Pb) by the humans or animals could serve as pathways to Pb pollution trough food chain. The heavy metals contamination of soils from the artisanal gold mine sites is as a result of the human anthropogenic activities in search for precious metals such as gold. Samples of Amaranthus hybridus (African spinach) and *Sorghum bicolor* (guinea corn) *were collected at intervals of 20m from one sampling point to another from the Bonu artisanal gold mine sites, the plants organs (of the roots, stems, and the leaves) were dried, crushed, sieved, analyzed using X-Ray Refraction (XRF) and all were found to contain Pb and other heavy metals at varying concentrations. Lead is the*

Introduction:

Food consumption is a must for the survival of both humans and animals. The traditional methods for farming requires the use of land. The lands suitable for agricultural activities must be rich in nutrients needed for crops/plants to feed on for better yields. There is the need to take caution in the selection of land for such purposes to avoid contamination of food crops with heavy metals.

In the Northern parts of Nigeria, there so many contaminated land resulting from mining for precious metals such as gold in places

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principal heavy metal focused on in this research work. The percentage concentrations of Pb in all the Plant organs analysed varied with some greater than the 0.001% which the World Health Organization (WHO) recommended as the safe limit of Pb concentration for human consumption while in others they were found to be less. The toxic and recalcitrant nature of Pb and other heavy metals does not in any way, guarantee the consumption of any plant organs with concentrations of these metals no matter how low. The presence of these varying concentrations of Pb in the plant organs pose a threat for their consumption by animals either domesticated or wild which may in turn, be consumed by humans. There are other elements such as Potassium (K), Sodium (Na), Calcium (Ca), Magnesium (Mg), and Zinc (Zn) present substantial concentrations in the organs of the two plants analysed. These are essential element needed in our diets for the human growth and healthy living however, this should not tempt us to cultivate food crops on the contaminated mine site.

***Keywords**: Sida acuta, Hibiscus aspera, X-Ray Refraction (XRF) and Artisanal*

Ike Zamfara (Azubike, 2011) and Niger State and in Jos Plateau State where tin (Tn) is mined for ages all in Nigeria. These mining activities has led to agricultural lands left devastated and infested with contaminants (Akoh *et al.*, 2014).

Agricultural practices often take place on these worked or working mine sites by the small scale farmers living in such environments (Azeez,m2011). Mine workers cultivates food crops on these mine sites especially during the raining seasons or where the sites are close to stream or rivers, irrigation farming takes place. Crops cultivated or such land includes; *Amanas comosus* (Pineapple), *Carica papaya* (Pawpaw), as seen in Kataeregi artisanal gold mine, *Cucumeropsis* (Melon), *Dioscorea rotundata* (White yam), *Manihot esculenta* (Cassava), as seen in Paggo artisanal gold mine.

The cultivated crops or those that grow wild on these contaminated artisanal gold mines phytoextract heavy metals from the soil through their root systems and transport them to the harvestable parts. These parts are often consumed by both humans, animals and birds. The heavy metals contents in the harvestable parts are then transferred to the humans who

play permanent host to them since they are non bidegradable by digestive systems.

Heavy metals are generally those metals that have specific density greater than 5 g/cm^3 and have negative effects on the living organisms and environment (Jarup, 2003). They are natural deposits covered by the soil or rocks and brought to the surface of the earth through natural means such as erosion but most often than not, through human anthropogenic activities

The ingested Pb and other heavy metals attack and destroy vital body organs of their host, the human and this could result into the death of the host.

More often it is not all plants/crops that are good extractors of lead and other heavy metals from the soil through their root systems, however, food crops such as *zea mays* are very good phytoextractors of Pb and should not be cultivated on lands contaminated with such a heavy metal. Plants use their root systems in extracting heavy metals from the soil just as applicable to other nutrients and translocate them to the harvestable parts. Some plants, such as the *cowpea* are are not good translocators of Pb from roots to the harvestable parts such as the stems, roots, leaves and the seeds as most often, the greater concentrations of Pb is restricted to their root system.

Geographical location of the sampling points/artisanal gold mine site

Bonu artisanal gold mine site is located in Bonu village in Paikoro local government area of Niger State, in the North Central part of Nigeria. Tegina lies on latitude 10.0706 and longitude 6.1906 and covers a total area of 980 square kilometers and has an average temperature of 30 degrees centigrade.

MATERIALS AND METHODOLOGY

SAMPLE COLLECTION

The plant samples were collected at the mine sites at intervals of 200 meters apart to provide for a wide area coverage. Debris were cleared and plants were carefully uprooted to avoid dismembering the organs. Lumps of sand attached to their roots were carefully removed to avoid loss of plant hairs, washed with de-ionised water (Amin, 2014) to further clean the root of sand and other contaminants.

The plants were then cut into roots, stems and leaves and dried in a tray drier at a constant temperature of 40^{o}C in order to prevent the loss of some

low boiling points mineral contents. The plant were then ground to fine particles and 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 each plant sample 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. Values that correspond or fall below the expected limit were accepted as safe while values above the limits indicate very high concentrations of such elements in the soil which can cause serious environmental problems to plants and animals including man.

RESULTS AND DISCUSSION

Table 1: XRF results of plant of organs of *Amaranthus hybridus* and *Sorghum bicolor* on Bonu artisanal gold mine site

Comp %)	*Amaranthus hybridus*	Mean conc (%)	*Sorghum bicolor*	Mean conc (%)

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	Roots	Stems	Leaves		Roots	Stems	Leaves	
K	25.61	22.34	21.50	22.15	21.12	19. 97	20.08	20.39
Na	4.06	4.11	2.93	3.7	4.44	3.00	4.31	3.92
Ca	22.92	26.01	23.47	24.13	25.12	21.78	25.41	24.10
Mg	2.88	2.14	2.94	2.65	3. 22	2.58	3.18	2.99
Fe	10.26	11.88	10.11	10.75	12.42	11.39	12.18	11.10
Cr	0.0014	0.0019	0.0016	0.0020	0.0019	0.0013	0.0014	0.0020
Cd	0.0001	0.0002	0.0003	0.0002	0.0002	0.0001	0.0003	0.0002
As	0.0003	0.0002	0.0001	0.0002	0.0003	0.0002	0.0001	0.0002
Hg	ND	ND	ND	ND	ND	ND	ND	ND
Zn	0.0021	0.0012	0.0001	0.0021	0.0011	0.0010	0.0001	0.0007
Pb	0.0030	0.0018	0.0001	0.0016	0.0012	0.0004	0.0001	0.00057

Amaranthus hybridus (African spinach) and *Sorghum bicolor* (guinea corn)

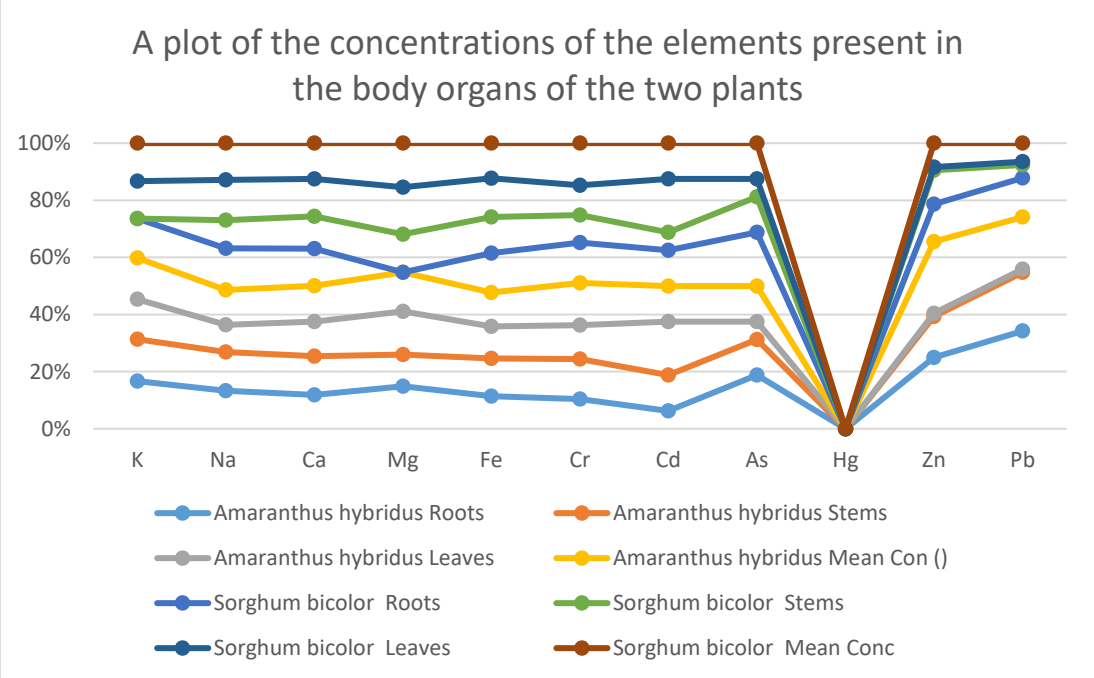

Figure1; elemental and mean concentrations (%) in the organs of *Hibiscus aspera* and *Sida acuta*

Lead (Pb), a dangerous element which is toxic to humans and other animals even at lowest concentrations is found to be present in all the body organs of the two plants. The percentage concentrations of Pb in the body organs of these plants are far ahead of the WHO permissible level of

0.001percent. This therefore, is an indication that consumption of these plants by the humans and animals is dangerous as they can serve as path ways to lead poisoning. Cultivation of edible plants/crops on non remediated artisanal gold sites should be discouraged as these crops can phytoextract Pb and other heavy metals present in the environment, translocate them to the edible parts for onward transmission to man and other animals.

Lead is not the only ill health causing element to the man. Other heavy metals if ingested, have the potentials of causing the same or similar adverse health effects. This is further explained in detail below.

Residential and occupational exposures makes 35 metals to be of concern to mankind and out of this total, 23 fall into the class of heavy metals: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium and zinc (Mosby *et al.*, 1996). They are common in insistence and can be found both in the environment and in our meals. In maintaining good health, hey are required in small quantities however, they become very harmful to our bodies when in larger quantities as they become toxic. The toxicity of heavy metals damages the functioning of the kidney, liver, lungs and the brain, blood composition and other important organs and lower energy level (Monish *et al.*, 2014). The negative effects of long-term exposure to heavy metals can result into degenerative physical, neurological, muscular, physical processes that may initiate diseases like Parkinson's disease, muscular dystrophy, Alzheimer's and multiple sclerosis (*ibid*). Exposure to some heavy metals and their compounds for a long-term may result into cancer (Jarup, 2003).

The results of the Xrf analysis on the plant organs of *sida acuta* and *Hibiscua aspera* have some of the heavy metals listed and briefly discussed above. They contain As, Cr and Pb in varying concentrations irrespective of the locations from where they were collected. This is an indication of wide spread contamination of the mine environment with these heavy metals. There are of course the presence of other heavy metals such as Arsenic(Cd), Cromiun (Cr), Magnessium (Mg), Calsium(Ca), Iron (Fe), Sodium (Na) and Zinc (Zn).

The concentrations of Pb and those of the other heavy metals are lower than the rest elements present in the plants (table 1) but more dangerous to human health and the environment. The concentrations of all the heavy metals present in the plant organs almost lied on the zero line of the y-axis (figure 1) since they are very low but are however, higher enough to cause ill health or even death.

Arsenic

Arsenic a semi metallic element, is one of the most important heavy metals which causes disquiet from the standpoints of human health and ecology (Hughes *et a*l., 1988). It is prominently carcinogenic and toxic and its mostly available in the form of salt iron, calcium, sodium, copper or oxides or sulphides (Singh *et a*l., 2007). This metal may be encountered by humans through natural, anthropogenic or industrial or even through unintended sources. The presence of arsenic in these plants in higher concentrations calls for thorough analysis of food crops cultivated on farm land very close to the mine sites to forestall Pb pollution through food poisoning.

Lead

Lead is a very highly toxic metal and widely used in the world but is responsible for severe health problems and environmental contamination. It is worthy to note that any plant having high concentration of lead will experience fasten production of reactive oxygen species (ROS) which will cause rapid membrane damage, chlorophyll and photosynthesis process and suppress the entire plant growth (Najeeb *et al.*, 2014). This is supported by the work of Yongshen *et al.*, (2011), who stated that the growth of tea plants on land contaminated with Pb can be inhibited by reducing the biomass and as well debase its quality by changing the quality of its components.

The growth of both *Sida acuta* and Hibiscua aspera seemed not to affected by the presence of Pb in them. The absence of the effects of the negative sign enumerated by plants could be due to the prime ages of the plants as at the time they were collected (Yongshen *et al.*, 2011 and Najeeb *et al.*,

2014). It is however, not safe to cultivate edible crops on the mine sites as the concentration of Pb no matter how low when consumed, is capable of biomagnefication.

Cadmium

According to Agency for Toxic Substances and Disease Registry (ATSDR) ranking, Cd is the seventh most toxic heavy metal (ATSDR, 2008). The moment Cd gets into human body, it remains for life (Monish *et al*., 2014). Primarily, humans can get exposed to this metal though ingestion and inhalation can from acute and chronic intoxication (*ibid*). The presence of Cd in the environment can last for several decades, gets extracted by plants and accumulated in their tissues, finally and ultimately, transferred to human body through food chain.

The presence of Cd in this environment is of serious concern due to its ability to remain in the soil for so long a period without disintegration and can be phytoextracted by the plants roots, translocated and ultimately consumed by humans calls for caution in the cultivation of the mines sites and the surrounding environment. There is the need for the remediation of the environment.

Mercury

Mercury (Hg) is a heavy metal that is exceedingly bioaccumulative and toxic. Once ingested into the human body, the brain is the principal organ targeted by mercury but it can also affect other body organs such as the liver, kidney and create inefficiency in the functionality of muscles (Monish *et al*., 2014).

Mercury was not detected in any organ of the two plants analysed. This does not rule out the possibility of its presence in the mine sites as it is often used in the amalgamation of gold. The beneficiation of gold from its ore is incomplete by the artisanal miners without the use of mercury. The presence of Hg might be restricted to the soils in the sites where gold is been processed.

Mercury could be present in the streams bordering the mine sites where the gangue is washed off the gold and could be ingested by the fish and

other aquatic species which are consumed by the humans leading to heavy metal pollution through the food chain Okechukwu and Madagwa, 2013 and Seasan *et al.*, 2013).

Presence of other elements in the plants

There are other elements such as Potassium (K), Sodium (Na), Calcium (Ca), Magnesium (Mg), and Zinc (Zn) present substantial concentrations in the organs of the two plants analysed. These are essential element needed in our diets for the human growth and healthy living. The presence of these essential elements in the plants that grew wild on the mine sites should not be a motivation to cultivate edible food crops therein as doing this makes the consumers of such food item subjects them to higher concentrations of Pb and the other heavy metals being ingested into their body systems which depends, on concentration can cause bodily harm.

CONCLUSION

The results of the Xrf analysis on the plants organs confirmed the contamination of the Bonu artisanal gold mine sites with heavy metals such as the Pb, As, Cd and possibly others with lower concentrations which could not be detected by the equipment used for the analysis. Mercury was not detected but could also be present. The detected heavy metals were phytoextracted by *Amaranthus hybridus* and *Sorghum bicolor* through the roots and translocated to their harvestable parts. The concentrations of these metals especially the Pb are higher than the safe limits recommended by the Word Health Organisation.

The two plants analysed here have the potentials to be used in event remediation of the environment is being considered using phytoremediation as an option for the remediation of sites.

RECOMMENDATION

The confirmation of the presence of heavy metals in the mine site calls for creating awareness for the artisanal gold miners to take preventive measure in avoiding bodily contacts with the soils while mining to avoid ingestion of Pb and other elements which can lead to poisoning. They should avoid eating fruits from trees such as cashew plantation on the site

as they may contain these metals. Farmers should be educated on the dangers associated with cultivating food crops on the mine sites close to it. There is the need to remediate the environment to reduce to the bearable limit the concentration of the these contaminants to save lives and to avoid the imminent pollution catastrophe.

REFERENCES

Agency for Toxic Substances and Disease Registry (2008) Public Health Statement Aluminium. ATSDR Publication CAS#7429-90-5.

Ako T. A. , Onoduku U. S. Oke S. A., Adamu I. A., Ali S. E., Mamodu A. Ibrahim A. T (2014) "Environmental Impact of Artisanal Gold Mining in Luku, Minna, Niger State, North Central Nigeria." *Journal of Geosciences and Geomatics* 2.1 pp 28-37.

Azeez, J.O (2011) Determination of the Trace metal Concentration in the soils of NNewi North Local Government area. *Journal of Toxicology and Environmental Health Sciences*,Vol 5 (1) pp. 1-11.

Azubike, A. L. The Technology of peaty soils in Mozambique and Angola. Transactions of the 5thInternational Congress of Soil Science, Leopoldville 3: 398-401, 2011.

Hughes, JP, Polissar, L and Van Belle, G (1988), Evaluation and synthesis of health effects studies of communities surrounding arsenic producing industries, Int *J Epidemiol*, 17, pp 407 - 413.

Jarup, L (2003) Hazards of heavy metal contamination, BiMedBull**68**(1), pp167 - 182

Mohanty, M and Kumar, P. H (2013) Effects of ionic and chealate assisted hexavalent chromium on mung bean seedlings (Vigna Rodiata I. Wilczek. Var k-85)during seedling growth. *JSPB9*(2), pp 232-241.

Monish J, Tenzin, T, Naresh, A, Blessy, B. M and Krshnamurthy N. B (2014), Toxicity, mechanism and health effects of some heavy meals, *Interdisp Toxicol.*, 7 (**2**), pp 60 - 72

Mosby C.V, Glanze, W.D and Anderson, K.N (1996) Mosby Medical Encycloppedia, The Signet: Revised Edition, St. Louis

Najeeb, U, Ahmad, W, Zia, M. H, Malik, Z and Zhou, W (2014) Enhancing the lead phytostabilization in wetland plant juncus effusus L. through somaclonal manipulationand EDTA enrichment, *Arab J Chem* [in press].

Okechukwu, E. B and Madagwa, B (2013)Phytoremediation potential of water hyacinth. *Eichhornia Crasspes* (mart.) Solms in crude oil polluted water, *J. App. Sci. Environ. Manage*. 17 (**4**) pp, 503-507. Available online at www.ajol.info and www.bioline.or.br/ja

Seasan A. A, Udeme, J. J. I, and Olabisi P. A (2013) Phytoremediation of Lead Polluted Soil by *Glycine maxL*, *Applied and Environmental Soil Science*, Vol 2013, Article ID 631619, 7pages. Available online at http://dx.doi.org/10.115/2013/631619

Singh, N, Kumar, D, and Sahu, A (2007) Arsenic in the environment: effects on human health and possible prevention, *J Environ Biol*, **28**(2 Suppl): pp.359-365.

Yongshen, W, Qihui, L and Qian, T (2011) Effects of Pb on growth, accumulation and quality of component of tea plant, Procedia engineering, 18, pp. 214-219.