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Bioconcentration of Heavy Metals by Wild Plants Along Holomorphic Soils in Sule-Tankarkar Local Government Area, Jigawa State, Nigeria

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Abstract
This study aims at assessing the heavy metals concentration levels in wild plants along the holomorphic soil in Suletankarkar Local Government Area of Jigawa State, Nigeria. Soil and Plant samples were collected from 7 different locations. Two (2) locations each from *Danaldi and Danzomo* districts while a location each from *Dangwanki, Jeke* and *Suletankarkar* districts. A 20cm^2 quadrant was thrown at random. At each location, soil sample was collected from 0 – 10cm depth and mixed to obtain one composite sample. Samples of all plant species found growing within 1 m radius of each sampling point were collected and preserved in pressed paper. Both Soil and Plant samples were analyzed for heavy metals concentration using Atomic Absorption Spectrophotometer. The results show that; Cd with 3.6 ppm has the highest while Zn with 0.28 ppm has the least concentration in the soil at Danzomo I. The plants have varying concentrations ranging from Pd with 0.04 ppm to Zn with 5.42 ppm in *Mitracarpus hirtus*; Cr with 0.07 ppm to Zn with 6.42 ppm in *Spermacoce radita*; Co and Cr both with 0.04 ppm to Mn with 1.47 ppm in *Corchonis olitorius*. The elemental concentration in the soil at Danzomo II ranges from Co with 0.4 ppm to Cd with 2.75 ppm. In plants, the concentration ranges from Cr with 0.04 ppm to Mn with 1.87 ppm in *Cenchrus biflorus*; Cr with 0.04 to Mn with 11.8 ppm in *Commelina erecta*; Cr with 0.04 ppm to Mn with 21.5 ppm in *Guiera senegalensis*; again Cr with 0.04 ppm to Mn with 3.1 ppm in *Cassia singueana*. Zn with 0.28 ppm has the least while Mn with 4.0 has the highest elemental concentration value in the soil at Danladi I. The mineral concentration ranges from Cr with 0.04 ppm to Mn with 2.54 ppm in Philliostigma thonningii; Co with 0.04 ppm to Mn with 16.8 ppm in Sida cordifolia; Co and Cr both with 0.04 ppm to Mn with 5.15 ppm in Alysicarpus vaginalis. These results support the conclusion that the heavy metal concentration in all the sampled plants exceeded the WHO standard limit for consumption. Therefore, the authors recommended that the heavy metal concentrations in plants, soils, water and air should be frequently monitored by the appropriate authority in the State.
Keywords: Heavy metals, Concentration, Plants, Soils

1. Introduction

Heavy metals are naturally present in the soil, geologic and anthropogenic activities increase the concentration of these elements in the environment to amounts that are harmful to both plants and animals. Some of these activities include mining and smelting of metals, burning of fossil fuels, use of fertilizers and pesticides in agriculture, production of batteries and other metal products in industries, sewage sludge, and municipal waste disposal (Chibuike and Obiora , 2014), (Alloway, 1990), (Rashin et al 1994) and (Shen et al, 2002).

Diverse amounts of heavy metals may be found everywhere; in soils, water, sediments and plants (Dube et al, 2001). Heavy metals contamination and toxicity is a very prominent environmental issue today in water, soils, air and plants. Heavy metals can be both beneficial and detrimental (at high concentration) to the environment and life. However, toxicity concerns overwhelm the benefits (Datta, 2015).

Heavy metals contamination may occur due to irrigation with contaminated water, the addition of fertilizers and metal-based pesticides, industrial emissions, transportation, harvesting process, storage and/or sale. Because of their cumulative behaviour and toxicity, they have a potential hazardous effect not only on crop plants but also on human health (Jibrin, and Joshua, 2015). Food chain contamination is one of the most important pathways for entry of these metals into the human, animals and other living organism (Shah et al, 2013), (Khan et al, 2013) and (Muhaamad et al, 2013).

In most developing tropical nations of sub Saharan West Africa, wild plant resources play significant role in food supply and other livelihood support (Sobukola *et al.*, 2007; Mohammed and Sharif, 2011). Wild plants are essential diet components providing protein, vitamins, iron, calcium and other nutrients to animals due to insufficient and unaffordability of proteins by vast majority of people in developing nations. Wild plants are commonly used as a supplement for healthy diets in most developed regions of the world presently (Redzic,

2006) and of recent times.

Wild plants are usually gathered freely from the forests by the rural inhabitants in the Sub Saharan West African region for domestic consumption as vegetables and food supplement during famine.

It is also well known that wild plants are crucial in traditional health care systems in rural West African communities. Vast majority of people live in rural areas depend on medicinal wild plants for health care delivery due to poverty, and non-availability of modern health care facilities (Amri and Kisangau, 2012).

Therefore, the importance of wild plants in the livelihood of rural and urban populations cannot be over emphasized.

This study aimed at assessing the heavy metals concentration levels in wild plants along the holomorphic soil formation in Sule-Tankarkar Local Government Area of Jigawa State, Nigeria.

2. Material and Methods

2.1 The Study Area

The Study area is about 160 km to the north of Dutse the capital of Jigawa State, Nigeria. It is located between Longitude 9°00' – 9°22'30" E and Latitude 12°23' – 12°51'N (Figure 1).

Sule Tankarkar Local Government Area came into being on 28th August, 1991, during the military Administration of Gen. Ibrahim Badamasi Babangida. It was created out of former Gumel and Maigatari Local Government Areas. It is composed of five (5) Districts, namely, Sule Tankarkar, Dangwanki, Danladi, Jeke and Danzomo.

2.2 Natural Resources

With regards to the mineral resources, much has been done by various agencies responsible for solid minerals discovery with little evidences of underground deposits at Tudun Kabobi (Sand Glass) and Gwandagwaro well (Rock). Though, much can be discovered in other places with further research and evaluation.

Sule Tankarkar Local Government is an Agrarian society with about 75% population living in rural areas who are mainly farmers. The climate nature of the Local Government couple with population factor gave raise to production of some arable crops noticeably, Millet, Sorghum, Cowpea, Groundnut, Sesame etc. while animal rearing is very common in almost all homes of the Local Government. The animals reared are cattle, sheep, Goats and poultry. Moreover the rural inhabitants engage especially women in wild plants gathering as other way of generating income from the vegetative resource.

2.3 Samples Collection

Soil and Plant samples were collected from 7 different locations. Two (2) locations each from *Danaldi and Danzomo* districts while a location each from *Dangwanki, Jeke* and *Suletankarkar* districts.

A 20cm^2 quadrant was thrown at random. At each location, soil sample was collected from 0 – 10cm depth and mixed to obtain one composite sample. The samples were put in leather and taken down to laboratory for analysis.

Similarly, samples of all plants species found growing within the 1 m radius of each sampling point were collected and preserved in pressed paper. The Plant species were identified and authenticated by the herbarium unit in the Department of Plant Biology, Bayero University Kano, Nigeria.

2.4 Samples Treatment

In the Laboratory, the collected soil samples were air dried and sieved in a 2mm mesh. 5g of the sieved soil samples were put in a 50ml of washed plastic container. 25ml of extractant (0.5m HCl and 0.0125m H_2SO_4) was added to the sample in the plastic container and shake for about 15 minutes in a reciprocating shaker and filtered the suspension through Whatman filter paper. The filtrates were analyzed for metals using Oluwaofor et al., method (1990).

Similarly, the plant species were shed dried and grinded separately into finely powdered particles. 0.5g of the powdered plant sample was placed in a 50ml beaker, 15 ml of aqua regia was added, and the beaker was placed on a hot plate and heated until white fumes were observed. The solution was then filtered in a 100ml plastic bottle using filter paper and make up to 50ml mark with distilled water. The filtrates were sends to Atomic Absorption Spectrophotometer for elemental analysis as used by George et al., (2013).

2.5 Elemental Analysis

The digested samples were analyzed for heavy metals using Atomic Absorption Spectrophotometer (ASS Buck Scientific VGP 210 Model) at the department of Geography, Bayero University Kano, Nigeria. The instrument setting and operational conditions were done in accordance with the manufacturer's specifications.

3. Result and Discussion

The result of heavy metals concentration in soil and plant samples obtained from Sule-Tankarkar Local Government area is displayed in Table 1.

The highest concentrated mineral in soil at Danzomo I was Cd with 3.6 ppm while the least was Zn with 0.28 ppm elemental values. However, the highest concentrated mineral in *Mitracarpus hirtus* was Zn with 5.42 ppm while the least was Pb with 0.04 ppm concentration values. Also in *Spermacoce radita,* the highest concentrated element was Zn with the value of 6.42 ppm and the least concentrated values of 0.07 ppm was recorded for Cr. In *Corchonis olitorius*, Mn was the highest heavy metal with concentration level of 1.47 ppm while Co and Cr have the least concentration level of 0.04 ppm. The concentrations of all the heavy metal in the soil exceeded the WHO guidelines except Zn. The level of concentration for all the heavy metals in *Mitracarpus hirtus* were above the WHO guideline except Cu, Fe, and Pb. In *Spermacoce radita*, Cu and Fe were the only metals found to be within the WHO guidelines. Similarly, the concentration of Cu, Zn, and Fe were found to be within the WHO guidelines in *Corchonis olitorius*. Although *Mitracarpus hirtus* heals old ulcers (Uphof, 1959); *Spermatococe radita* helps to cure kidney disease and diuretics (Burkill, 1985); and *Corchonis olitorius* are used as vegetables (Wikipedia, 2015). In this location, medication with these plants will be unsafe due to higher concentration of Zn. Notwithstanding, Zn is an essential trace element required for the functioning of over 200 metallo-enzymes. Zinc is also important in the regulation of DNA and RNA synthesis via interaction with DNA binding protein. It also plays a critical role in hormone-receptor interaction. Some zinc salts are used in the treatment of leg ulcer. Despite its importance, very high level of Zn can damage the pancreas and disturb the protein metabolism (Zhang et al, 2012). The health related problems of Zn salts are stomach cramps, skin irritation, vomiting, nausea, anemia, respiratory disease, eye irritation, fatigue,

The heavy metal with the highest concentration level in soil at Danzomo II was Cd with concentration value of 2.75 ppm while the least were Co and Cr with 0.04 ppm concentration value each. The concentration of some heavy metals in the soil exceeded the WHO limit except Zn which has concentration level of 0.56 ppm. Concentration of metals in *Cenchrus biflous* were also above WHO limit except Zn and Fe. The concentrations of Mn and Cr in all the plant samples were observed to be highest and least respectively. Mn has 1.87 ppm in *Cenchrus biflorus*; 11.8 ppm in *Commelina erecta*; 21.5 ppm in *Guiera senegalensis* and 3.1 ppm in *Cassia singueana* while Cr has 0.04 ppm in all the plant samples in this location. Interestingly, both Mn and Cr in this location were above the WHO safety limit. *Cenchrus biflorus* is used as grain food, sweet and milk substitutes. It is very medicinal, for genital stimulants/depressants bur-hooks (JSTOR, 2015). *Commelina erecta* is used in the treatment of wounds; a decoction is macerated in rum and then rubbed on spider bites to bring relief (UTP, 2015). *Guiera senegalensis* are used to treat a wide range of conditions such as: pulmonary and respiratory complaints, including coughs and fevers; digestive tract problems including colic, dysentery and diarrhea; infectious diseases including syphilis, beriberi and leprosy; and various other conditions (Burkill, 1985 in UTP, 2015). Though, there are few or less investigations on the toxicological effects of Mn on human health, exposure to excess Mn may cause Parkinson-like symptoms (Gerber et al., 2002; Erikson and Aschner, 2003), infertility in mammals and malfunction of the immune system (Vartanian et al., 1999). Therefore, medication using the above plants around Danzomo II may be of great risk due to higher concentration of Mn.

The highest concentrated metal in soil at Danladi I was Mn with the concentration value of 4 ppm while the least was Zn with the value of 0.28 ppm. The concentration of Mn found to be above the WHO guidelines limit while that of Zn was found to be within the WHO limit. Mn has the highest concentration value in all the plant samples; 2.54 ppm in *Philliostigma thonningii;* 16.8 ppm in *Sida cordifolia* and 5.15 ppm in *Alysicarpus vaginalis*. Cr has least concentration value of 0.04 ppm in *Philliostigma thonningii* while Co has the least concentration level of 0.04 ppm in both *Sida cordifolia* and *Alysicarpus vaginalis*. The elemental concentrations in all the plant samples were found to exceed the WHO safety limit. *Philliostigma thonningii* is used for various medicinal purposes in many African countries (Ighodaro and Omole, 2012, Siva et al, 1997). The root bark, for instant is used for cough remedy. The plant is also used to treat wounds, ulcers, gastric/heart pain, gingivitis and anti-pyretic (Akinpelu and Obuotor, 2000). *Sida cordifolia* is used to treat bronchial asthma, tuberculosis, colds, flu, swine flu, chills, lack of perspiration, headaches, nasal congestion, cough and wheezing, urinary infections, sore mouth, fluid retention etc. (WebMD, 2015). *Alysicarpus vaginalis*, is used as a fodder for livestock; for erosion control and as a green manure (Wikipedia, 2015). Cr is essential nutrient for humans, together with insulin. It removes excess glucose from blood. This implies that chromium deficit may enhance diabetes and cause diseases such as heart problems, and metabolic disorders. Yet when consumed in excess can be harmful. It can cause adverse health effect such as skin rashes. Concentration of Cr in both *Philliostigma thonningii* and *Alysicarpus vaginalis* is 4x while in *Sida cordifolia* is 7x higher than the WHO safety limit. To this end, therefore, using all the plants sampled in this location for consumption medicinally and those that are edible should be discouraged more especially the *Sida Cordifolia*.

Mn has the highest concentration level of 4 ppm while Zn has the least elemental concentration value of 0.28 ppm in the soil at Danladi II which shown similarity to the soil at Danladi I despite the distance apart. Zn

was recorded with highest concentration level of 3.36 ppm while Co and Cr have least concentration level of 0.04 ppm each in *Sebania bispinosa*. Mn has the highest metal concentration of 2.75 ppm while same Cr has the least concentration value of 0.04 ppm in "Yaryadi". The metal concentration in the all the plant samples were within the WHO limit except for Cr in *Yaryadi*. *Sebania bispinosa* is used in the treatment of inflammations, bacterial infections and tumours. They are prepared as poultices for external use or taken as a decoction for internal ailments. The seed, mixed with flour, is used to treat ringworm and other skin diseases and worms (UTP, 2015). Therefore, medication using these plant species in this location will increase the bioaccumulation of both Co and Cr.

Mn has the highest elemental concentration with 4.4 ppm and Co has the least concentration with 0.4 ppm in the soil at Jeke which were all above the WHO limit. Zn has the highest concentration level of 2.81 ppm and Cr has the least with 0.04 ppm in the *Leptadenia hastata* found in this location. In *Striga hermothica*, Zn also has the highest concentration level with 6.17 ppm while Cr still has the least value of 0.07 ppm. However, *Annona Senegalensis* accumulated higher concentration of Mn with concentration value of 1.52 ppm than any other element and still maintained the 0.04 ppm level of Cr as the least. The concentration values were above the WHO limit except Zn in *Leptadenia hastata*. The plant *Leptadenia hastata* is a very strong diuretic and generally strongly stimulates the flow of urine. It is also often used with a range of other plants to treat various conditions, including treating suckling babies who have green diarrhea; for all vein troubles such as varicose veins, bleeding and painful hemorrhoids; poisonings; anuria; syphilis; leprosy; trypanosomiasis, etc (UTP, 2015). The leaves of *Annona senegalensis* are used in the treatment of pneumonia. The bark can be processed and used as medicine for treating a wide array of ailments like worms in intestine, guinea worms, diarrhea, gastroenteritis, lung infections, toothaches and even snakebite. Natural gum in the bark is used to close open wounds (Wikipedia, 2015).

Table 1. Heavy Metals Concentration in Soils and Plants (ppm)

Location	**Sample**	**Ni**	**Co**	**Mn**	**Cu**	**Cr**	**Zn**	**Cd**	**Fe**	**Pb**
Danzomo I	Soil	2	0.8	2	1.7	0.7	0.28	3.67	0.4	0.43
	Mitracarpus hirtus	0.07	0.15	2.74	0.08	0.07	5.42	0.09	0.2	0.04
	Spermacoce radita	0.14	0.08	4.6	ND	0.07	6.42	0.28	0.2	0.13
	Corchonis olitorius	0.07	0.04	1.47	0.08	0.04	1	0.28	0.1	0.09
Danzomo II	Soil	2.2	0.4	2.4	0.85	0.4	0.56	2.75	0.7	0.43
	Cenchrus biflorus	0.15	0.08	1.87	ND	0.04	1.33	0.28	0.1	0.13
	Commelina erecta	0.22	0.08	11.8	ND	0.04	3.72	0.18	0.4	0.13
	Guiera senegalensis	0.15	0.08	21.5	0.17	0.04	2.08	0.37	0.2	0.09
	Cassia singueana	0.15	0.08	3.1	0.25	0.04	1.22	0.18	0.3	0.09
Danladi I	Soil	3.7	0.4	4	1.7	0.7	0.28	3.67	0.4	0.43
	Philliostigma thonningii	0.15	0.11	2.54	0.08	0.04	1.64	0.18	0.4	0.13
	Sida cordifolia	0.15	0.04	16.8	0.08	0.07	7.31	0.18	0.2	0.13
	Alysicarpus vaginalis	0.15	0.04	5.15	0.17	0.04	1.97	0.37	0.4	0.09
Danladi II	Soil	3.7	0.4	4	1.7	0.4	0.28	1.83	0.7	0.43
	Sebania bispinosa	0.07	0.04	2.89	0.07	0.04	3.36	0.28	0.3	0.17
	Yar yadi	0.15	0.08	2.75	0.08	0.04	2.69	0.18	0.2	0.09
Jeke I	Soil	2.9	0.4	4.4	0.85	0.7	0.56	0.92	0.7	0.43
	Leptadenia hastate	0.15	0.08	2.79	0.17	0.04	2.81	0.18	0.2	0.09
	Striga hermonthica	0.22	0.08	2.25	0.08	0.07	6.17	0.28	0.2	0.13
	Annona senegalensis	0.15	0.04	1.52	0.25	0.04	0.89	0.28	0.1	0.09
STK I	Soil	2.9	0.4	3.2	1.7	0.4	0.83	4.59	0.7	0.43
	Ipomoea asarifolia	0.15	0.04	1.6	0.17	0.04	1.31	0.46	0.2	0.09
	Andropogon gayamus	0.07	0.04	3.63	0.25	0.04	1.97	0.09	0.3	0.09
Dangwanki I	Soil	2.9	1.1	2.5	1.7	0.7	0.83	2.75	0.4	0.87
	Degitaria debilis	0.04	0.08	6.3	0.51	0.04	5.78	0.28	0.2	0.09
	Phyllanthus virgatus	0.15	0.04	15	0.25	0.04	2.19	0.09	0.5	0.09

ND = Not Detected

Table 2. WHO Heavy Metals Concentration in Soils and Plants (ppm)

Metal	WHO (ppm)	FEPA (ppm)
Ni	0.05	1
Co	NA	NA
Mn	0.01	0.05
Cu	1	2
Cr	0.01	0.05
Zn	5	20
Cd	0.005	1.8
Fe	0.3	1
Pb	0.05	1

NA= Not Available
Source: (Aremu et al, 2011)

Cd has the highest concentration level with 4.59 ppm while Co and Cr have the least value of 0.4 ppm in the soil at Suletankarkar. In *Ipomoea asarifolia*, Mn has the highest concentration value of 1.6 ppm while Cr has the least with 0.04 ppm concentration value. *Andropogon gayamus* which is mainly used as fodder for animals in the area, Mn has the highest elemental concentration level with 3.63 ppm and Cr with the least concentration value of 0.04 ppm. *Ipomoea asarifolia* a hairless succulent perennial plant, with anti-inflammatory and analgesic properties (Roem and Schult, 2015). In Nigeria, the leaf is used as compost material and as feed ingredient in pig production (Ekenyem, 2006). The elemental concentration values were above the WHO safety limit. Therefore, medication with Ipomoea asarifolia and feeding of livestock with Adropogon gayamus in this location will be very risky.

Ni has the highest metal concentration value of 2.9 ppm while Fe has the least in the soil at Dangwanki. The concentration value of Ni in this location was above the WHO safety limit while for Fe was within the WHO safety limit. Mn has the highest concentration level of 6.3 ppm while Co and Cr have the least value of 0.04 ppm each in *Degitaria debilis*. Mn also has the highest metal concentration value of 15 ppm while both Co and Cr were recorded to have the least concentration values of 0.04 each in *Phyllanthus virgatus*. The elemental concentration values in all the samples in this location were above the WHO standard. *Degitaria debilis* is a climbing plant producing much-branched and stems. The Leaves are cooked and eaten as a vegetable. The leaves are eaten by people suffering from heart trouble and a herb tea is drunk to relieve cough. A leaf decoction is taken internally, and also applied externally as an embrocation, in the treatment of headaches. The sap is used as an ointment to heal the umbilical cord. The stems are part of a mixture to remedy abdominal troubles and constipation. The grated stems are made into poultices to apply to abscesses to draw out pus (UTP, 2015). *Phyllanthus virgatus* has antiviral and antibacterial Pharmacological effects. Medication with these plants in this location has to be done with extra careful because there likely to bioaccumulation of heavy metals.

4. Conclusion and Recommendation

Various studies has shown that excessive bio-accumulation of heavy metals can result to numerous health abnormalities. Heavy metal contamination in the natural environment poses both short and long term environmental health risks. Wild plants growing on unpolluted soils absorb heavy metals from the soil naturally as micro nutrients and stored in their tissues. Some wild plants accumulate higher concentration of heavy metals in their tissues. Wild plants are used as food, fodder, and medicine especially in sub Saharan West Africa. The results obtained are supportive with the conclusions that the elemental concentration values in all the plant samples exceeded the WHO standard which indicated that using the plant species from these locations for consumption or medication can increases the health risks. Therefore, the authors recommended that the heavy metal concentrations in plants, soils, water and air should be frequently monitored by the appropriate authority in the State.

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