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Accumulation of Heavy Metals (Fe, Zn, Co & Cu) in Ceratotheca Sesamoides and Corchorus Olitorius Grown on Tannery Sludge Amended Soil in Kano Metropolis, Nigeria

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ABSTRACT

The study investigated the bioavailability of heavy metals from a tannery sludge, amended soil, control soil and vegetables plants (*Ceratotheca sesamoides* and *Corchorus olitorius)* grown on amended soil of Challawa industrial areas. The samples were collected, processed and analyzed for heavy metals (Fe, Zn. Co and Cu) and some physicochemical parameters (of the sludge and soils) using flame method of atomic absorption spectrometry (FAAS) and other appropriate methods. The results obtained indicated the mean concentration range of Fe, Zn and Cu as 3369.82-481.00 mg/kg, 1304.71-62.20 mg/kg and 28.78-2.00 mg/kg in the tannery sludge to the control soil samples, while in *Ceratotheca sesamoides* and *Corchorus olitorius* harvested from the amended and the control soils were 1754.47-404.20 mg/kg (Fe), 118.30-1.60 mg/kg (Zn) and 16.10-3.40 mg/kg (Cu) and 1049.37-177.80 mg/kg (Fe), 152.67-2.92 mg/kg (Zn) and 17.63-2.28 mg/kg (Cu). Fe and Zn were significantly higher in the root tissue parts of the *Ceratotheca sesamoides* as compared to the stems and leaves parts, while higher concentration of Cu (17.63 ± 1.61mg/kg) was observed in the *Corchorus olitorius* leaves as compared to the other parts. The heavy metals concentrations obtained were above the FAO/WHO prescribed limits, while, Cobalt was not detected in all the samples analyzed. The soil to roots bioaccumulation factor (BF > 1) of copper was highly exhibited by both vegetables, but only *Corchorus olitorius* species showed higher translocation factors which reveal its potential as accumulator of the metals studied. The sequence of the transfer factor (TF) of the heavy metals in both *Ceratotheca sesamoides* and *Corchorus olitorius* were Cu>Fe>Zn. This suggests ingestion of the vegetables will pose a risk to human health and animals. Therefore, the need for regular monitoring of agronomical practices with tannery sludge amended soil to avert environmental problems and attendant health hazards is recommended.

Keywords: Thiadiazole, Triazole; Cyclooxygenase; Inflammation; Docking

Introduction

Vegetables are the fresh and edible portions of herbaceous plants, which can be eaten raw or cooked. They contained valuable food ingredients, which can be successfully utilized to build – up and repair the body [1]. Leafy vegetables are rich sources of carotene, ascorbic acid, riboflavin, folic acid, minerals and dietary fibre, which have marked health effects. It also provides a chief source of antioxidant, vitamins and other phytochemicals with antioxidant characteristics that gives protections against

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diseases.

Heavy metals contamination of food items is one of the most important aspects of food quality assurance. Human activities for survival and comfort generates different kinds of wastes, which accumulates in a magnitude that alters the natural characteristics of the environment.Tannery sludge for instance, is a by-product of Tanning processes that converts hides and skin into leather. The operations generates large amount of organic and inorganic wastes known as sludge, although it gives opportunity to most farmers sourcing for cheap fertilizers for agricultural activities. However, sludge may contain heavy metals and its accumulation in plants is of great concern due to the probability of food contamination through the soil root interface. Vegetables contamination poses a threat to its quality and safety. Ingestion of vegetables grown on contaminated soil may lead to chronic accumulation of heavy metals in the kidney and liver causing disruption of numerous biological processes, leading to cardiovascular, nervous, kidney and bone diseases. Food chain contamination is one of the sources for the entry of toxic pollutants in to the human body. Heavy metals accumulation has been studied in various vegetables species, showed tomato and amaranth have a potential to absorb excessive copper and zinc in the roots, but only translocation of copper was observed to shoot in amaranth. The study was on two nutritionally important vegetables namely; Ceratotheca sesamoides (False sesame) and Corchorus olitorious (Jute). The vegetables were selected because of their short life cycle, short roots length, nutritionally important, wide consumption and suitability to local climate. In view of these, the present study was carried out to assess the accumulation of Fe, Zn, Co and Cu by the above vegetables grown on tannery amended soil [2].

The study Area

The study area was the Tannery sludge disposal pits located behind Kano Coca – Cola industry, Challawa industrial estate in Kumbotso local Government area. Kumbotso falls within the Northern part of Kano, Nigeria. It is bordered in the West by Madobi local government, in the Southwest by Rimin-Gado, in the South by Dala and Gwale, in the East by Kano municipal and Dawakin-kudu local government areas. Tanneries are the dominant industries in these areas which generate tannery sludge and leather remains as major waste. Poor wastes management services and lack of law enforcement to control disposal are the main factors that accounted for the continuous indiscriminate dumping in and around the pits environs. All the industries located in the area dumps their sludge in the pits. This practice has been going on for a longer period without any caution from the authorities to stop it. Hence, the sludge accumulated over the years has been a major source of organic fertilizer for the inhabitants.

Materials and methods

Samples collection

Sandy loam soil was obtained (0 – 20cm) from an abandoned farm at the new site of Bayero University, Kano Nigeria. The sample was air dried and screened for pebbles, stones and leaves and then thoroughly mixed to establish homogeneity. The sample (as control) was labeled in plastic container for laboratory analysis.Tannery sludge amended soil samples were formed by mixing sludge and soil samples in a 1:10 ratio. The homogenous mixture was transferred into ten plastic Pots measuring 16.50cm × 12cm × 14.50cm. The control pot contained only the soil (uncontaminated). Seeds of False sesame (Ceratotheca sesamoides) and Jute or Jews mallow (Corchorus olitorius) were purchased from Sharada Market in Kano metropolis. These were screened, labeled and stored in the laboratory for planting. Planting was conducted in the Botanical garden of Bayero University, Kano. Seeds of the vegetables were sown in each pot separately, depending on the vegetable species. The pots were arranged in a complete block design, in eleven columns and two rows. Each row contained a particular vegetable species. The eleventh column served as the control. Two weeks after planting, vegetables were thinned and left to grow under natural conditions with watering at regular

The results of the pH of the tannery sludge (8.19 ± 0.18) reported in Table 1 was higher than that of the amended (7.40 ± 0.20) and the un-amended (control) (6.67±0.08) soil (Table 2). All pH values obtained were within the safe limit (6.5 - 8.5) for appropriate growth and efficient uptake of nutrients materials from soil. Organic matter serves as an reservoir of nutrients and water in soil, aids in reducing compaction and surface crusting, and increases water retention capacity, these factors are important in agricultural practice and the results of the study indicated the tannery sludge (21.91 ± 4.99), as the richest with organic matter followed by amended (1.83 ± 0.47) and the control (0.90 ± 0.23) soil, this establishes the tannery sludge as good source of organic fertilizer. Soil electrical conductivity is an important indicator of soil health. It affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as nitrogen oxides, methane, and carbon dioxide, in this study the electrical conductivity of the tannery sludge, amended and the control soils were 13.46 ± 8.81, 1.12 ± 0.27 and 0.44 ± 0.66 mS/cm respectively; the tannery sludge (Table 1) is of better conductivity than the amended and the control soils (Table 2). Results obtained for the tannery sludge for both parameters were significantly higher when compared to the values obtained from the amended and the control soil samples. The electrical conductivity gives an index about the soluble salts in soil and is commonly used as a measure of salinity. Soil with EC below 0.4mS/cm is considered marginally or non-saline, while soils above 0.8mS/cm are considered severely saline. Therefore, the results obtained from the study indicated that the soils were moderately saline. It also indicated the presence of soluble contaminants in the amended soil as a result of the impacts of the sludge on the soil. Industrial activities and agrochemicals sectors have been potential causes of serious environmental pollution by heavy metals on a global scale and have threatens human health via accumulation in the food chain.

Table 2: **Mean physico-chemical characteristics of Background and Amended soil.**

Parameters	**Control soil**	**Amended soil**	**Limits**
pH	6.67 ± 0,08	7.40 ± 0.20	6.5 - 8.5
Electrical conductivity (mS/cm)	0.44 ± 0.66	1.12 ± 0.27	-
Organic carbon (%)	0.57 ± 0.04	1.06 ± .28	-
Organic matter (%)	0.90 ± 0.23	1.83 ± 0.47	-
Iron (mg/kg)	481.00 ± 0.99	6061.64 ± 101.43	NA
Zinc (mg/kg)	62.20 ± 0.09	624.48 ± 66.99	300 – 600
Cobalt (mg/kg)	BDL	BDL	50
Copper (mg/kg)	2.00 ± 0.36	13.50 ± 8.72	135 – 270

The of concentrations of the heavy metal obtained shows higher level of iron (3369.82± 267.82mg/kg) in the sludge followed by zinc (1304.71±17.31mg/kg) and copper (28.78 ± 2.44 mg/kg) while cobalt was not detected (Table 1).The concentrations of these metals could be attributed to the tanneries tanning agents, dyes, preservatives and other processes. The concentrations of zinc and copper in the sludge were below the allowable limit for land application. The amended soil shows the levels of Fe, Zn, Co, and Cu as 6061.64± 101.43mg/kg, 624.48±66.99mg/kg and 13.50 ± 8.72mg/kg, while Co was not detected (Table 2) because it was below the detection limit of the equipment used. The concentration may be related to the total metal ions dissolved in the sludge as well as a number of other factors [4].The concentrations indicated that the amended soil is moderately or slightly polluted with zinc, which was slightly above the higher limit (300 – 600mg/kg) specified for Agricultural soils. The concentration of copper was within the safe limits and cobalt was below the detection limits. The concentrations were also in agreement with the report on challawa agricultural farms soil. The control soil indicated the lowest concentrations of Fe (481.00± 0.99 mg/kg) Zn (62.20±0.09 mg/kg) and Cu (2.00±0.36 mg/kg) (Table 2) as compared to their concentrations obtained in the tannery sludge and the amended soil.

Heavy metals concentration in the vegetables samples

The results of heavy metals concentrations obtained from the roots, leafs and the stem of the Ceratotheca sesamoides and Corchorus olitorius vegetables are reported in Table 3. Results obtained from root, leafs and stem of Ceratotheca sesamoides indicated accumulation of iron and zinc in the roots significantly in higher concentration (more than two folds) in comparison to the stem and leaves. The higher concentration of zinc may be related to the higher organic matter content of the amended soil. Ogunkunle reported that, organic matter content of soil favour bioavailability of zinc, making it more abundant for uptake by vegetables. In other words, metals associated with organic matter have high mobility due to decomposition and oxidation of organic matter. Similarly, higher concentrations of copper were found in root tissues of the Ceratotheca sesamoides in comparison to shoot tissues. In contrast, Corchorus olitorius shoot (stems and leaves) tissues accumulated significantly higher concentration of copper than in the roots. The study confirmed the report which stated that stem of leafy vegetables serves not only the function of metal transfer from roots to the leaf through its conducting tissues but also stores some quantities of the heavy metals. Cobalt concentration in all tissues were below the detection limit this correlated with the non-delectability of cobalt in the sludge, amended and the control soil samples. In comparison, all the vegetables tissues accumulated high concentration of the metals but highest concentrations were observed in the roots. The roots are indeed the primary site for absorption of water and minerals including heavy metals. It has been reported that metal concentration in plant tissues was a fraction of heavy metal content in the growing environment. Thus in contaminated soil such as sludge, the root will contain more heavy metal load than the shoot. The root is adapted to carry out the functions of fixing the plant into the vegetables leading the whole plant and often serves to store minerals. This ability of roots to accumulate heavy metals is considered to be a way that the aerial parts of the plant are protected. Similarly, it has been well documented that accumulation of metals were more in the lower part of the plant grown on contaminated soil compared to upper parts, and this could be due to the complexation and sequestration of metals in cellular structures (e. g. vacuole) in the plant and unavailable for translocation to the shoot. Among all the tested metals, the accumulation of iron was found highest. This is similar to the findings of and all the metals concentration have exceeded the permissible limits. Hence, ingestion of vegetables grown in soils contaminated with heavy metals possesses possible risk to human health and animals.

Table 3: **Mean heavy metal concentrations (mg/kg) in vegetable tissues.**

Metal	**Samples**	**Ceratotheca sesamoides**			**Corchorus olitorius**			**Safe Limits**
		Roots	**Stems**	**Leaves**	**Roots**	**Stems**	**Leaves**	
Fe	Control	823.10 ± 0.07	404.20 ± 0.54	652.90 ± 0.08	661.20 ±0.29	177.80 ± 0.01	594.10 ± 0.59	20
	Amended	1754.47±330.48	479.66±155.48	1085.87±199.52	1681.82±258.86	829.64±285.70	1049.37±186.95	
Zn	Control	50.60 ± 0.02	45.40 ± 0.81	1.60 ± 0.06	17.10 ±0.11	10.60±0.01	2.95±0.02	50
	Amended	118.30 ± 64.77	66.92±17.88	27.25±14.96	152.67 ±34.74	80.16±38.40	150.31±38.12	
Co	Control	ND	ND	ND	ND	ND	ND	NA
	Amended	ND	ND	ND	ND	ND	ND	
Cu	Control	8.9±0.67	3.40±0.32	4.70±0.07	3.50±0.20	2.28±0.54	4.50±0.21	10
	Amended	16.10±2.95	7.21±1.01	12.75±1.09	15.26±2.25	15.11±2.27	17.63±1.61	

Bio-accumulation of metal by vegetables

The mobility of metals by plants can be determined by Bioaccumulation Factor (BF), also called Transfer Factor (TF). The higher the value of the transfer factor, the more mobile/available the metal is. If the BF > 1, then the plants can be consider as an accumulator. In the study, the BF values of the metals for the different vegetables studied varied. The BF for iron, zinc and