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LEVEL OF HEAVY METALS IN SOIL AND SOME VEGETABLES IRRIGATED WITH INDUSTRIAL WASTE WATER AROUND SHARADA INDUSTRIAL AREA, KANO, NIGERIA

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ABSTRACT

The level of some heavy metals in soil and plant samples from Sharada Industrial Area was analyzed. Plants absorb contaminants through root systems and store them in the root biomass and/or transport them to the stem and/or leaves. The waste water generated by industries was used to irrigate plants; onion (*Alium cepa*), lettuce (*Lactuca sativa*), okra (*Hibiscus esculentus*), Drumstick (*Moringa oleifera*) and carrot (*Daucus carota*) which are consumed locally. The level of heavy metals in these plants differs with plant species. Level of lead (Pb) ranged from 10.21±0.20-17.14±0.10µg/g in okra and onion respectively, and the level in soil was found to be 28.00±2.00µg/g. The level of heavy metal was higher in soil than in plants studied. Accumulation of heavy metals varied from plant to plant. The soil levels of copper (Cu) was found to be 9.00±2.00 µg/g with onion having the highest value (8.00±0.10 µg/g) compared to other plants. The uptake of cobalt (Co) by plants varies with plant species. *Moringa oleifera* had highest concentration of cobalt (14.00±8.00µg/g) and onion had the least concentration of Co (5.00±2.00µg/g). The high values of these metals might be attributed to the use of untreated effluents from industries by farmers for the irrigation of these plants. Thus, the high values of these metals in the plant samples could put the consumers of these vegetables at health risk, since the levels of these metals in plants and soil samples are all above WHO permissible limits.

Keywords: Accumulation, Heavy metals, Irrigation, Industrial effluents, Vegetables

Introduction

Soil pollution by metals has attracted considerable attention in recent decades (Garbisu and Alkorta, 2001). Metalliferous mining and processing, dumping of wastes and industrial effluents, often produce severe heavy metal pollution (Baker *et al*., 1994). The term ñheavy metalsò refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). ñHeavy metalsò is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3 or 5 times or more, greater than water (Nriagu and Pacyna, 1988). Heavy metals of widespread concern to human health are mercury, cadmium, lead, arsenic, chromium, copper, and zinc (Mason, 1996). Nriagu (1988) estimated that over one billion human beings are currently exposed to elevated levels of toxic metals and metalloids in the environment and several million people may be suffering from subclinical metal poisoning. The annual worldwide release of heavy metals reached (in tons) 22,000 cadmium, 939,000 copper, 783,000 lead and 1,350,000 zinc (Singh *et al*., 2003). To grow and complete the life cycle, plants must acquire not only macronutrients (N, P, K, S, Ca, and Mg), but also essential micronutrients such as Fe, Zn, Mn, Ni, Cu, and Mo (Lasat, 2010). Plants have evolved highly specific mechanisms to take up, translocate, and store these nutrients. For example, metal movement across biological membranes is mediated by proteins with transport functions. In addition, sensitive mechanisms maintain intracellular concentration of metal ions within the physiological range (Lasat, 2010). Estimation of the migration ability of any pollutant in the natural environment is considered to be a necessary stage for predicting the ecological situation. The process of heavy metals accumulation in agricultural crops is especially interesting because it contributes or introduces toxic elements into the human food chain.

Ingestion of heavy metals through food can cause accumulation in organisms, producing serious health hazards such as injury to the kidney, symptoms of chronic toxicity, renal failure and liver damage (Abou- Arab *et al*., 1999). Special attention should be paid to the dangerous health elements and to most consumed agricultural crops (Stobart *et al*., 1985).

Toxicity of non essential metals occurs through the displacement of essential metals from their native binding sites or through ligand interactions (Stiborova, 1988). For example, Hg^{2+}, Cd^{2+} and Ag^{2+} tend to bind to SH groups and thus inhibit the activity of sensitive enzymes. In addition, high levels, of both essential and nonessential metals can damage cell membranes; alter enzyme specificity; disrupt cellular functions; and damage the structure of DNA (Stiborova, 1988). Many divalent metal cations (e.g. Mn^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+} and Zn^{2+}) are structurally very similar. Also, the structure of oxyanions such as chromate resembles that of sulfate and the same is true for arsenate and phosphate. The main industrial areas of Kano ï Bompai, Sharada, and Challawa ï are located within these two river basins. (The Jakara River basin in the North and the Kano river basin lie to the south of the water divide. The basin is being drained by two major rivers: Kano River and Challawa River). The increasing discharge of industrial wastes in this river basin is posing serious danger to the water resources and the health of people in the area (Bichi and Anyata, 1999).

Since the polluted effluent is used for irrigation to water the vegetable crops along the bank, heavy metals and anions may enter the food chain through irrigated crops, thereby exposing consumers of these vegetable crops to bioaccumulation of trace metals and anions with time. The aim of this study is to investigate the accumulation of these toxic metals in plants irrigated with industrial waste water from Sharada industrial area.

Materials and Methods

Atomic Absorption spectrometer (Buck 210VGP scientific model) and oven muffle furnace (Gallen kamp FLS300010 Model) were used in this study.

Study Area

Kano (Latitude. 12^{o}02N, Longitude 08^{O}30E, in Northern Nigeria) is the largest and most populous state in Nigeria. The population of the state is estimated at over 10 million according to the 2006 national population census report. It is the commercial nerve center of Northern Nigeria. The high population is brought about by a lot of economic and industrial activities taking place in the city. Kano City is located on the main watershed, which separates the two main river basins in the metropolis. The Jakara River basin in the North and the Kano river basin lies to the south of the water divide. The basin is being drained by two major rivers: Kano River and Challawa River.

Plant matter

The soil and plants used in this study were obtained from two farm lands located around Sharada industrial area. These include: Onion (*Alium cepa*), Drum stick *(Moringa oleifera*), Lettuce *(Lactuca sativa*), Okra (*Hibiscus esculentus*) and Carrot *(Daucus carota)*.

Sample collection/Experimental Design

The area under study was divided into two plots; A and B.

Plot A: The farm close to Sharada industrial irrigation gutter/channel Plot B: The farm that is about 30m from plot A.

Sample preparation:

The plant samples were dried to constant weight in an oven maintained at 105^{o}C. They were then pulverized to fine powder using a laboratory grinder. They were put in labeled polyethene bags and placed in a desiccator.

Elemental analysis

Sample preparation

Plant samples were washed with deionised water, oven dried at 70^{O}C in the laboratory. Powdered samples (one gram each) of each plant were digested with 5cm^{3} mixture of nitric acid (HNO_3): perchloric acid ($HClO_4$) in the ratio of 5: 2. (AOAC, 1984). Deionised water was added to the digested samples and then filtered by Whatman-42 filter paper, and then made to 100cm^{3}.

Soil samples were air dried and ground with a mortar and pestle and then sieved and preserved in plastic bottles for chemical analysis.

The sieved soil samples were digested by mineralizing 1g of sample with 5cm^{3} mixture of perchloric acid and nitric acid in the ratio of 5: 2v/v (AOAC, 1984), to break down organic matter and dissolved minerals for analysis. The digested samples were taken for Atomic Absorption Spectrophotometer (AAS) analysis, as outlined by AOAC (1984).

RESULTS AND DISCUSSION

Result

Table 1 shows the mean heavy metal concentration of vegetables grown around Sharada industrial area, each column shows the distribution of a metal in the vegetables while; each row gives the distribution of the metal in each vegetable. Table 2 shows the mean distribution of metals of farms located along the wastewater gutter.

Table I: Mean Concentration of Plants Heavy Metals (µg/g)

Sample	Pb	Cr	Cd	Cu	Co	Zn	Ni
Carrot	13.00±6.00	64.00±13.00	7.00±4.00	6.00±1.00	8.00±4.00	82.30±16.00	9.00±3.00
Lettuce	15.00±8.00	59.20±12.00	5.01±2.00	1.00±0.20	7.00±4.00	73.00±38.00	31.00±10.00
Onion	17.14±0.10	58.12±24.00	9.20±4.00	8.00±0.10	5.00±2.00	48.02±9.00	29.00±2.00
Moringa	14.00±10.00	47.00±13.00	5.10±3.00	1.00±0.10	14.00±8.00	44.30±25.00	35.00±17.00
Okra	10.21±0.20	42.00±8.00	6.00±4.00	2.00±1.00	13.00±8.00	17.00±5.00	22.00±9.00

Values are presented as mean ± SD of triplicate measurements

Table 2: Mean Concentration of Soil Heavy Metals (µg/g)

Sample	Pb	Cr	Cd	Cu	Co	Zn	Ni
Soil	28.00±2.00	99.00±12.00	11.00±1.00	9.00±2.00	19.00±0.00	96.00±0.00	31.00±3.00

Values are presented as mean ± SD of triplicate measurements

DISCUSSION

Heavy Metal Concentration in Plants and Soil (µg/g)

From the mean concentrations of heavy metals in vegetables and soil (Tables 1 and 2), it can be seen that Pb was highly accumulated in onion followed by lettuce, with the least being in okra. The toxicity of lead is well documented in literature, being a zootoxic metal, needs to be monitored in plant parts used by humans and animals (Alloway, 1995). The result of this work indicates onion to be good accumulator of lead, it is therefore advisable to monitor/ evaluate lead content of any soil designed to cultivate onion for human/animal consumption in order to avoid/minimize incorporation of the toxic metal into food chain. In other words, this property of onion can be explored to clean up soil contaminated with lead as it harbours high soil lead content as shown by this research.

The level of lead (Pb) is highest in onion 17.14±0.10µg/g with soil level of lead 28.00±2.00 µg/g while okro had least concentration of Pb 10.21±0.20 µg/g. The chromium (Cr) level was high in carrot (64.00±13.0 µg/g) and the soil Cr level was found to be 99.00±12.0 µg/g. Cadmium is a very mobile and bioavailable metal which may accumulate in crops and humans (Alloway, 1995). Cadmium (Cd) was found to be very high in onion (9.02±4.00 µg/g) with lettuce having the least concentration of 5.01±2.00 µg/g. Copper is one of the most important essential element for plants and animals (Alloway, 1995). Copper was extensively translocated, as it is essential to the plant metalloenzymes diamine oxidase, ascorbate oxidase, cytochrome C oxidase, superoxide dismutase and plastocyanin oxidase (Van Assche and Clijsters, 1990) and photosynthesis (Hsu and Lee, 1988).

The soil level of copper (Cu) was found to be 9.00±2.00 µg/g, Cu accumulation appears to be highest (8.00±0.10 µg/g.) in onion compared to the other plants. The uptake of cobalt (Co) by plants varies with plant species. *Moringa oleifera* had highest concentration of 14.00±8.00 µg/g and onion had the least concentration of Co (5.00±2.00) µg/g. Zinc is a phytotoxic metal, but it is important as a micronutrient at the appropriate levels (Alloway, 1995). Zinc (Zn) was found to be high in carrot plant, 82.30±16.00 µg/g but okra had the least level of Zn, 17.00±5.00 µg/g. Nickel (Ni) absorption is very poor in carrot plant (9.00±3.00 µg/g.) while *Moringa oleifera* accumulated 35.00±17.0 µg/g. The levels of lead (Pb), cadmium (Cd), chromium (Cr) and nickel (Ni) were found to be above WHO permissible limits and therefore tend to be dangerous to the health of the consumers.

Plants uptake of heavy metals partly correlates with the total content of heavy metals in the soils. Grant and Dobbs (1977) reported that plant grown on soils possessing enhanced metal concentrations have increased heavy metal ion content. The uptake of metal ions has been shown to be influenced by the metal species and plant parts (Juste and Mench, 1992).

In recent past, Bunzl *et al.* (2001) investigated soil to plant transfer of heavy metals like, Cu, Pb and Zn by vegetables and found that vegetables grown at environmentally contaminated sites in Addis Ababa, Tanzania, could take up and accumulate metals at levels that are toxic to human health. This study also revealed that these plants accumulate metals that with time could be dangerous to body metabolic systems.

Cadmium, copper and nickel levels in vegetables from industrial and residential areas of Lagos City, Nigeria was studied by Yusuf *et al.* (2002).These workers found that levels of Cd, Cu and Ni in different edible vegetables along with the soils on which they were grown were higher in industrial areas than those of the residential areas due to pollution, and thus, similar to the findings of this research.

Fytianos *et al.* (2001) compared the heavy metal (Pb, Cd, Ni, Cu, Mn and Zn) contents of the plants grown in industrialised and rural areas, on 60 soil and vegetable samples. No differences were recorded in the heavy metal content of the vegetables grown in green houses and in urban areas, yet significant differences were noticed as to the heavy metal content of plants grown in industrialized and, rural areas. Heavy metal accumulation was lower in the plants at the beginning of the irrigation period, but increases were recorded after irrigation. This increase is especially important when the plant and seeds enter the food chain of animals and humans (Fytianos *et al.*, 2001).

Conclusion

The assessment of level of heavy metals in soil and plants irrigated with waste water of Sharada industrial site has been carriedout. The study, shows that the level of heavy metals in soil and plant samples is higher than the WHO permissible limit. This may be dangerous to human health, flora and fauna, as well as productivity of crop plants and livestock.

Recommendations

The research discovers that the toxic heavy metals are accumulated in the water, soil and body of edible parts of plants irrigated with Sharada Industrial waste water. These plants are usually consumed either raw or cooked, which eventually introduce these toxic metals into humans and animals body through food chain. Some plants are very good heavy metals accumulators. Further research should be done to identity and ascertain these plants for remediation of soil with high levels of these toxic metals.

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