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Evaluation of Lead in Crops Grown along the Bank of River Tiga, Kano Nigeria

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ABSTRACT

Contamination of vegetables (cabbage, tomatoes, onions and lettuce) with Lead (Pb) through the use of untreated irrigation water at farmlands located in the bank of River Tiga along Zaria-Kaduna road during dry season was determined. Samples of untreated water (as control) were collected from six different locations and vegetable crops were also collected from three different irrigation farms along the bank. The vegetable crop samples were digested using standard methods. Both the samples of water and vegetable were analyzed for Pb using atomic absorption spectrophotometry. The levels of Pb found in vegetables were: 2.5, 1.7, 1.8 and 1.8 parts per million (ppm) for cabbage, tomatoes, onions and lettuce respectively. These levels of Pb were within Food and Agriculture Organization/World Health Organization (FAO/WHO) limits in the vegetable crops. Also, concentration of Pb in the water was found higher compared to vegetable crops. Evaluation of transfer factor (TF) of Pb from water to vegetables showed: tomatoes > onions = lettuce > cabbage. Generally, lead has no benefit to human body. Despite the low level of Pb in the samples, vegetable crops grown from these farms may pose health risk to the consumers in a long-term.

Keywords: Lead, Vegetable Crops, Water, Transfer Factor, Tiga

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INTRODUCTION

Millions of people die every year as a result of water related diseases especially in developing countries and this is so because of the health hazard which arises from the presence of trace concentration of heavy metals in drinking and irrigation water. Heavy metal toxicity represents an uncommon, yet clinically significant medical conditions, which if not detected and treated appropriately, its toxicity can result to significant morbidity and mortality[1]. Human beings are continuously exposed to heavy metals for an immeasurable amount of time partly due rapid increase in populations coupled with other factors such as urbanization, rapid industrial development, agriculture etc. resulting in huge accumulation of wastes and pollutants which end up in polluting water bodies such as rivers, streams and lakes[2,3]. Heavy metals are also present in virtually every area of modern consumerism such as construction materials, cosmetics, medicines, processed food, fuel sources, personal care products, etc, it is very difficult for anyone to avoid exposure to any of the many harmful heavy metals that are so prevalent in our environment.

Furthermore, during the last decade the unique agro-ecological conditions of urban vegetable soils resulting from their input intensity, year-round vegetative cover, soil and hydrological characteristics and their spatial variability[4,5] have raised considerable research interest. This is especially so in developing countries where treatment of wastewaters is limited [6], thus raising concern about heavy metal contamination of these soils when irrigated with untreated and treated wastewater, and subsequently accumulation in the food chain through plant uptake.

Natural soils of the Nigerian savannah are characterized by low heavy metal concentrations due to their high weathering intensity and long period of pedogenesis[7,8]. However, with intensification of urbanization, agricultural activities and industrialization, the extent of heavy metal accumulation has grown. Kano city is characterized by intensive urban production of vegetables. Heavy metals may as well be accumulated in the profiles of the soils owing to the quality of irrigation water, high inputs of mineral fertilizers[9]and pesticides application [6]. While recent reports stressed the importance of heavy metal loads in irrigation water and soils used for urban vegetable production in Kano [10, 11,6], to our knowledge, studies of heavy metal pollution of urban vegetable and irrigation along Tiga river up to Tamburawa water works are not available.

There exists a plethora of literature [11,12,13,5]on heavy metal contamination of urban gardens in Kano, Nigeria. These researches were mainly based on the determination of concentrations heavy metals in vegetable crops from industrial areas of Challawa, Jakara and Bompai within

Kano Metropolis. None of them have attempted to determine the concentrations of heavy metals in River Tiga – Tamburawa water works. Also, the health risk associated with growing crops irrigated with untreated water has not been previously studied in this area of Kano. There was scarcity of information on heavy metal levels in River Tiga -Tamburawa water works and crops irrigated with untreated water from the river.

Thus, this study was aimed at determining the seasonal level of Lead (Pb) in untreated water and in crops irrigated with untreated water from Tiga River as well as the level of Pb in treated water from Tiga-Tamburawa water works.

MATERIALS AND METHOD

Study Area

The study area covers the origin of River Kano which flows from somewhere around Tiga, through some rural communities where agricultural activities (farming) do take place during dry and raining seasons to the tributaries which finally empty into the Tamburawa waterworks (the new Kano state water projects). The study area is very close to Kano - Zaria expressway which is known for its high automobiles and haulage activities, increasing agricultural, commercial and industrial activities with the attendant high possibilities of emission of heavy metals into the immediate environment[14]. The Tamburawa-waterworks supplies water through a network of pipes to the densely populated areas of Naibawa/Zaria road, Hotoro and Gyadi-Gyadi, as well as Nassarawa and Bompai government reservation area (GRA).

Sample Collection

Water samples

Raw or untreated water samples were collected at six different points along River Kano before emptying into the treatment plants. The selected points are: Tiga 1 (T1) and Tiga 2 (T2) at the origin of River Kano; Chiromawa 1 (C1) and Chiromawa 2 (C2) are the points between T1 and T2 and the tributary that empties into the treatment plant of Tamburawa water works while Tamburawa 1 (TM1) and Tamburawa 2 (TM2) are the channels that lead out of the treatment plant. In this study sampling of treated water served as control and samples were collected along the distribution channels of Tamburawa water works. Tamburawa public waterworks supplies nearly half of Kano metropolis and for the purpose of comprehensive analysis of the treated water, the samples were collected from six different zones of the networks as follows: Tamburawa waterworks (ZA), Naibawa/Zaria quarters road (ZB), Gyadi-Gyadi/Court road (ZC), Hotoro Quarters (ZD), Nassarawa G.R.A (ZE), and Bompai G.R.A (ZF).

Water samples were collected following the standard procedure described by the Department of Water Affairs and Forestry, Pretoria.(DWAF)[15] into a clean polythene bottles that have been acid-washed and rinsed thoroughly with distilled water. At each sampling locations, for the raw water: surface river water was collected into a 2-litre polythene bottle and for the tap water (control): tap water samples were collected into the containers at six collection points after each tap was allowed to run for 1 minute. The following data were collected at the sites: name of sample, time and date of collection, place of collection and pH of sample. Samples were collected during the months of August to October 2008 (Rainy Season) and the months of November 2008 to January 2009 (Dry Season) at each demarcated sites. Once collected, the samples were immediately stored on ice in a dark cooler box and transported to the laboratory.

Vegetable samples

Lettuce, onions, cabbage and tomato were purchased directly from farmers at farmlands closest to the river banks at the sites demarcated for sampling of raw water just before harvesting the crops. Request was made for vegetable stalls from different areas of the farms during the dry season. The vegetable samples collected were placed in polyethylene bags, labelled and taken to the laboratory for processing and preservation. On arrival at the laboratory, the vegetable samples were carefully and thoroughly washed in cool tap water and then with double distilled water. The samples were then cut into pieces in accordance with the specification for each vegetable into nearly uniform size. This was done to facilitate drying of the pieces at the same rate [16]. The cut pieces were placed in clean acid washed porcelain crucibles and over-dried at 105^0C for 24 hours, until they were brittle and crips[16]. At this stage, no micro-organism can grow and care was taken to avoid any source of contamination. All the crucibles were labelled according to sample number. The dried vegetable samples were pounded into fine particles using clean acid washed mortar and pestle which were oven-dried each time. The grinded or pounded samples were placed in labelled plastic petri-dishes and kept in desiccators to attain constant weight [11,16]. The samples were then stored in air-tight plastic containers and kept in desiccators.

Sample Digestion

a) **Water Samples**

The open-beaker digestion (OBD) method using nitric acid (HNO3) as described in Laboratory Procedure for Fertilizer and Water Analysis (LPFWA)[17] and as reported by Dike *et al.*[2] was employed for the chemical analysis of water samples. 50 ml of each water sample was measured into a 100ml-beaker and 10ml of HNO_3 was added. The beaker with its content was placed on a hot plate and digested till brown fumes of HNO_3

escaped. Heating was continued till the content had reduced to 10ml volume. The content was then washed into a 50ml volumetric flask and made up with distilled water to mark. The digest obtained was used for the determination of Pb.

b) **Vegetable Samples**

The triacid method of digestion as described in LPFWA[17] was employed here. The acids used were nitric acid (HNO_3), perchloric acid ($HClO_4$) and concentrated sulphuric acid (H_2SO_4) in the ratio 65:8:2 respectively. 0.2 g of each powdered plant sample was weighed into a 100 ml-glass beaker. 30ml of the acid mix was added and the content swirled then placed on a hot plate. The beaker was heated till brown fumes of nitric acid went off. Heating was continued till the content of the beaker reduced to about 5 ml volume. The contents were allowed to cool and a little amount of double distilled water was added and the beaker swirled. The content was then poured into a 50ml-volumetric flask and made up with distilled water to mark. The digest was then used for the determination of Pb using absorption spectrophotometry.

Preparation of standard lead solution

Dissolve 0.16g of lead nitrate in sufficient 0.1M nitric acid and make up to produce 1mg of Pb in 1ml. Serielly dilute the solution with double distilled water to produce 1.0, 2.0, 4.0, 6.0, 8.0, and 10 ppm of Pb in 1ml.

Procedure

To determine Pb level aUnicam 969 Atomic Absorption Spectrophotometer (AAS) with serial number 501361 equipped with a hollow cathode Pb lamp, at a wavelength of 229 nm. The flame type was air/acetylene, with a stoichiometric fuel flow of 0.9 – 1.2 L/min. 10 µl of water sample was transfered to a 10x5mm nickel crucible, 10 µl of double distilled water was added and heated at 150º to evaporate to dryness. The above procedure was repeated for vegetable samples.

Also the procedure was repeated using a series of nickel crucibles containing, individually, 10 µl of treated water and 10 µl of each diluted standard solution. The absorbance of each standard solution was ploted against the conccentration of lead. The curve was used to read off the concentration of lead in the respective samples.

RESULTSAND DISCUSSION

The mean pH values taken at the points of collection of both raw and treated water samples are shown in Tables 1 and 2 respectively. Ideally, portable water should have a pH range of 6.5±8.5.

Based on these study, samples collected during the dry season at all the sites T1,T2,C1,C2,TM1 and TM2 along river Kano recorded mean pH values between 6.5 and 6.9 which is slightly acidic even though is within the World Health Organization (WHO) [18] and United State Enviromental Protection Agency (USEPA)[19]recommended range. The slight aidity could be due to the nature of effluent discharge into the water which enhances the mobility of metals from one system of the water to another, that is from water to sediment and from sediment to aquatic habitat which indirectly affect man through the food chain.

In the rainy season, all the sites except C1 and C2 recorded pH of below 7.0. As in the dry season, raw water samples from all the sites fell within the recommended range, recording mean pH valueof 6.9. All the raw water samples collected in the rainy season recorded pH values within the acidic range, except at site C1 and C2 with pH of 7.0. This acid pH values could be due to dissolution of CO_2 in the rains (acid rain) in the rainy season.

Table 1 Mean pH values for raw water samples

Sampling Site	Mean pH value	
	Dry season	Rainy season
T1	6.9±0.04	6.9±0.04
T2	6.9±0.04	6.8±0.08
C1	6.6±0.03	7.0±0.05
C2	6.5±0.07	7.0±0.03
TM1	6.5±0.04	6.9±0.03
TM2	6.5±0.04	6.8±0.03

Table 2 Mean pH Values for treated water samples

Sampling Site	Mean pH value	
	Dry season	Rainy season
Z_A	7.0±0.03	7.0±0.07
Z_B	7.0±0.06	7.0±0.08
Z_C	7.1±0.18	6.9±0.09
Z_D	7.0±0.07	7.0±0.03
Z_E	6.9±0.03	6.9±0.03
Z_F	7.0±0.07	7.0±0.07

For treated water samples collected during the dry season, pH values ranging from 6.9 to 7.1 were recorded. This means that treated water samples from all the zones had pH values within the recommended range. In the rainy season however, samples from zones ZC and ZE recorded mean pH value of 6.9. These values are within the recommended range zone ZA (Tamburawa water treatment plant) recorded pH value of 7.0 in both dry and rainy season. This is within the recommended range and thus has passed the test. The implication of public water supply having pH value outside the recommended range could be serious. This is because acidity or alkalinity of waters either naturally or from added chemicals may promote the corrosion of plumbing systems and fixtures. If the plumbing systems are made of lead or copper materials, individuals consuming the water may be exposed to the toxic effects of these metals[20].

The concentrations of lead in untreated water for raining and dry seasons are presented in Figure. 1. The ranges of Pb in both seasons for untreated water are; 1.83 (Tiga II and Tamburawa I) – 2.67ppm (Tiga I and Chiromawa I) and 2.17 (Tamburawa II) – 3.33ppm (Tiga II) for Pb. While the results of the levels of Pb during raining and dry seasons for treated water is presented in Fig. 2. During wet season the Pb level was 0.83 (Gyadi-Gyadi) to 3.00 ppm (Bompai); while in dry season the range of Pb level was 1.33 (Gyadi-Gyadi) to 3.33ppm (Bompai). One-way analysis of variance in the results showed that there were significant differences ($p<0.05$) across the sites in all samples and between wet and dry seasons across the sites except for Hotoro and Tamburawa (treated water).

A study has demonstrated that the main source of the Pb is the alkyl derivatives in petroleum spillage in industrial areas[20]. Also it comes from other sources like metal manufacturing, sewage, paints, fertilizer, pesticides and ashes[21]. This is probably the most efficient mechanism of anthropogenic Pb contributions into the water. In study, especially in dry season in all the sites from where samples were taken, Pb levels in untreated and treated samples exceed the limits of 0.05ppm of WHO[18] and USEPA.[19] Duman*et al*[21] reportedthe Pb concentration of motorway's wastewater drainage that passes round the south of Sapanca Lake to be between 0.010 and 0.050ppm. Bompai is an idustrial area, showed elevated concentrations of the examined Pb in treated water compared to any other site in both seasons. These high concentrations of Pb might have resulted from the kind of anthropogenic activities going on in the industries. Pb is higher in this site probably due to local spillage of petroleum product from trucks and motor parks.

Pb is the most ubiquitous toxicant in the environment[22]. Therefore, the levels of Pb in the body depend on environmental exposure conditions. Pb may impair renal function, red blood cell production, the nervous system and causes blindness. Lead is the most significant toxin of the heavy metals, and the inorganic forms are absorbed through ingestion by food and water, and inhalation [1]. A notably serious effect of lead toxicity is its teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin; dysfunctions in the kidneys, joints and reproductive systems, cardiovascular system and acute and chronic damage to the central nervous system (CNS) and peripheral nervous system (PNS). Other effects include damage to the gastrointestinal tract (GIT) and urinary tract resulting in bloody urine, neurological disorder and can cause severe and permanent brain damage[20]. While inorganic forms of lead, typically affect the CNS, PNS, GIT and other biosystems, organic forms predominantly affect the CNS[1,23].

Lead affects children by leading to the poor development of the grey matter of the brain, thereby resulting in poor intelligence quotient (IQ) [24].

The levels of Pb in different vegetable crop samples are presented in Fig. 3. The samples were collected during the irrigation farming (dry season). The level of Pb in the samples ranged from 1.80 to 2.50ppm.The profiles of Pb in the vegetable crops are: cabbage has highest level of Pb, follows by onionsand lettuce which have equal level, then tomatoes has the lowest level of Pb.

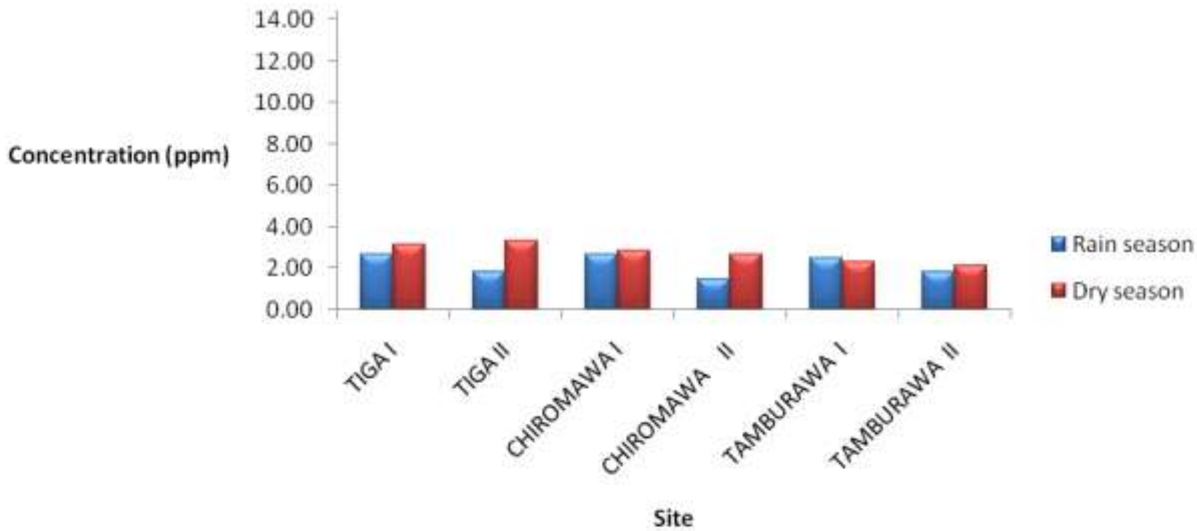

Figure 1 Concentration of Pb in untreated water across sampling sites

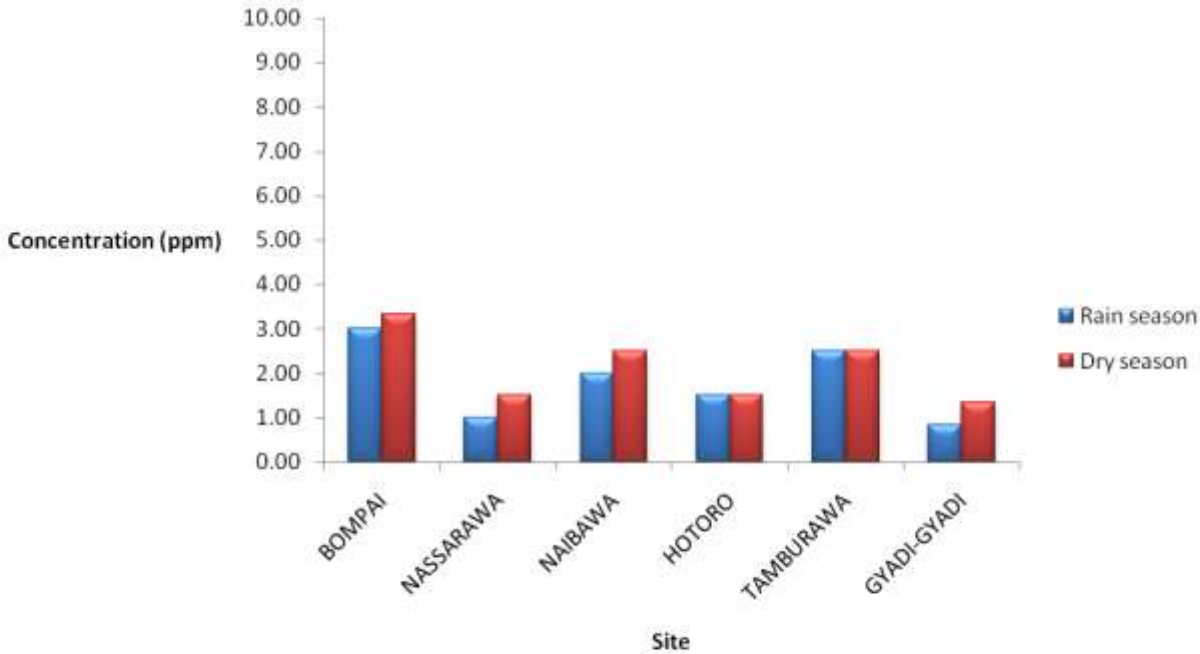

Figure 2 Concentration of Pb in treated water across sampling sites

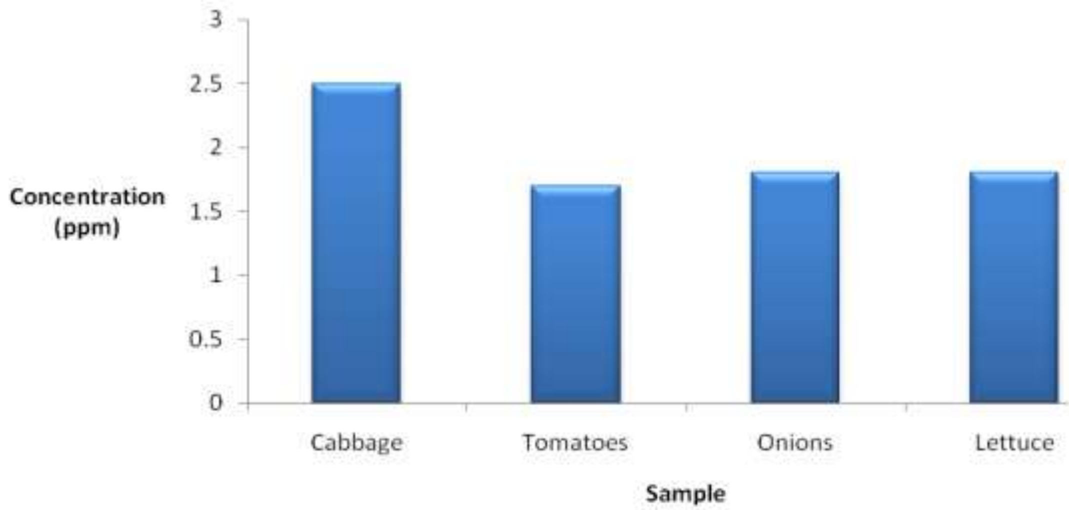

Figure. 3 Concentration of Pb in Irrigated Crops

The high concentration of Pb recorded in vegetables grown during the dry seasons might be due to the use of untreated waste water from various industries around the irrigated farmlands by farmers[12,16,25]. In a study carried out in Lagos, Southern Nigeria, Itua[14] reported a link between vehicular emission and high level of Pb in the studied area. Thus, exhaust emission due heavy haulage along Kano-Zaria high way close to where the irrigated farmlands were located, also contributed to high level of Pbin the vegetable crops Although the concentrations of Pb in all samples (vegetables) were high, they were within FAO/WHO (1985) guideline value[26].

CONCLUSION

This study demonstrated that vegetable crops grown on wastewater irrigated soils were contaminated with Pb, though the concentrations of Pb were within acceptable FAO/WHO limits. Since Pb, owing to its toxicity, is not required even at low concentrations, consumption of vegetable crops grown within the vicinity of River Tiga – Tamburawa works, Kano can pose health problems in the long-term.

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