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Full Length Research Paper

Heavy metal risk assessment on the consumption of *Talinum triangulare* grown on sewage dump site in University of Nigeria, Nsukka

Oguh CE[1]*, Ubani CS[1], Osuji CA[1], Ugwu CV[2]

[1]Biomonitoring and Environmental Control Unit, Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria

[2]Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria

E-mail: collinsoguh@gmail.com

ABSTRACT

Consumers, in most cases, consider dark green and broad leaves as good or healthy quality leafy vegetables safe for human consumption, unfortunately most of these vegetables may be cultivated in soil rich in heavy metals from sewage. This study investigated the health risks of heavy metal build-up in vegetables *Talinum triangulare* grown on sewage dump site. Soil samples were collected at 15 cm with the aid of soil auger and vegetable samples were collected from sewage dumpsite and other samples from a farm where there were no sewage dumpsite served as control. The soil samples were collected at random to have a represented sample and analyzed for Physicochemical properties, pH, Total Nitrogen, Total phosphorus, Organic matter, total organic Carbon, and Exchangeable cations (K^+, Mg^+ and Na^+) using a standard method and concentrations of the Heavy metals both in soils and vegetables, Cr, Zn, Pb, Cu, and Ni were analyze using Atomic Absorption Spectroscopy (AAS). The health risk from the consumption of these vegetables was calculated using standard methods and formula. The result showed a significant ($p<0.05$) increase in physicochemical properties for sewage soil, over the control. The pH of the Dump site and Control site were 5.19 and 6.95, respectively. The mean concentrations of metals (Cr, Zn, Pb, Cu, Ni) in the dump soil were 2.05, 1.03, 0.61, 0.58 and 0.42 mg/kg and in the control with no dump were 0.67, 0.07, 0.06, 0.20 and 0.24 mg/kg respectively. The mean values recorded were below the maximum permissible limit of metal in the soil by (WHO/FAO) with Cr (100), Zn (300), Pb (50), Cu (100) and Ni (50 mg/kg). The levels of Cr, Zn, Pb, Cu, and Ni in sewage dump *Talinum triangulare* were 2.04, 0.33, 0.37, 0.34, and 0.20 mg/kg and the control site were 0.01, 0.05, 0.00, 0.17, and 0.11 mg/kg respectively. However, the levels of Cr and Pb in the vegetable were above the levels recommended by WHO/FAO of Cr (0.3), Zn (27.3), Pb (0.3), Cu (3.0) and Ni (1.63 mg/kg) while Zn, Cu, and Ni were below the permissible limit for metals in vegetables. The values were all significant ($p<0.05$) compare to the controls samples for both vegetable and soil. The bioaccumulation factor showed that the vegetable exclude the element from soil. The HQ and HI shows that there is no harmful effect since the values obtain were less than >1. But continuous consumption can accumulate in the food chain especially for children. This study conclude that vegetables grown on sewage dumpsites are capable of accumulating high levels of heavy metals from contaminated and polluted soils with deleterious health effects.

Key words: Heavy metal, Risk assessment, Sewage, soil, *Talinum triangulare*

Abbreviations: AAS: Atomic Absorption Spectroscopy; ANOVA: Analysis of variance; BDL: Below Detectable Limit; CS: Control Site; DIM: Daily Intake of Metal; FAO: Food and Agricultural Organisation; HI: Hazard Index; HQ: Hazard Quotient; MPL: Maximum Permissible Level; ND: Not Detected; OM: Organic Matter; PTEs: Potentially Toxic Element; RFD: Reference Oral Dose; SDS: Sewage Dump Site; SE: Standard Error; SOM: Soil Organic Matter; SPSS: Statistical Product and Service Solution; TF: Transfer Factor; TT: *Talinum triangulare*; WHO: World Health Organization

INTRODUCTION

Consumption of vegetables directly affects human health either positive or negative. Both old and young require vegetables for proper and healthy living. Leafy vegetables are important components of daily diets, leafy-vegetables contain protein, essential minerals, fiber, vitamins, carotene and some essential amino acids required for normal metabolic activities of the body **(**Conrad et al., 2018**)**and do yields ofThese nutrients help to repair worn out tissues, reduce cancer risks, lower cholesterol levels, normalize digestion time, improve vision, fight free radicals, increase growth and boost immune system activity. Vegetables also act as antioxidants that help to protect human body from oxidative stress, cardiovascular diseases and cancers. The use of dumpsites as farm lands is a common practice in urban and sub-urban centers in Nigeria because of the fact that decayed and composted wastes enhance soil fertility (Hammed et al., 2017).

Generally, farmers are not bothered about the environmental effects or human hazards associated with irrigation of vegetables with waste water or cultivating around sewage dumpsite, rather they are primarily interested in the increase of yields and profits. Consumers, in most cases, consider dark green and broad leaves as good or healthy quality leafy vegetables safe for human consumption. Unfortunately most of these vegetables may be cultivated in soil rich in toxic elements, Microbial contamination, and anti-nutrients contaminated by sewage (Oti and Nwabue, 2013; Shuaibu et al., 2013; Sana et al., 2018). The Potentially toxic Element (PTEs) pollute the soil and mix with soil solution which enter into the plant body and hence can be accumulated at high levels in the edible parts of vegetables, even low levels in soil (Zhou et al., 2016).

Sewage consists of domestic effluent made up of black water (excreta, urine and associated sludge) and grey water (kitchen and bathroom wastewater) and also containing mineral and organic matter. Some potentially toxic elements (PTEs) are very useful if present in the soil at the right proportion. If these metals are however present at levels higher than the WHO standard, they become very toxic to man with very serious health implications (Shahid et al., 2018). Sewage water is an alternative water source where water is scarce. Some disadvantages are that wastewater can contain heavy metals, organic compounds, and a wide spectrum of enteric pathogens that may have a negative impact on the ecological system and human health (Samuel et al., 2013).

The sewage treatment plant at the University of Nigeria, Nsukka receives sewage from all the students' hostels, staff quarters, laboratory, office wastewater, and wastewater from the university clinic. Wastewater contains a lot of nutrients, which increase crop yields without use of fertilizer. However, it contains a variety of chemical substances from domestic and industrial sources (Khaled, 2016). Wastewater contains potentially toxic elements (PTEs) such as zinc, chromium, copper, iron, cadmium, nickel, lead, mercury, microbial loads and parasitic worms, which can induce severe risks to the human health and the environment (Mark et al., 2017). Soil in and around dumpsite is usually nutrient rich, which improve soil properties such as organic matter, and nutrients, which increases plant productivity, supply of macronutrients (N, P, and K) and can reduce the crop production cost (Okoro and Iwueke, 2017). Thus despite their important and yield benefits, outbreaks of human infections and environmental hazard is associated with the consumption of vegetables grown on sewage dumpsite.

Talinum triangulare is commonly called water leaf, it belong to the family Portulacaeae. It is an herbaceous, annual, and glabrous plant widely grown in tropical regions as a leafy vegetable (Catherine et al., 2017). In Nigeria, it is consumed as a leafy vegetable and constituent of sauces (or vegetable soups). Nutritionally, it is a good source of some minerals (e.g., calcium, magnesium, and potassium) and vitamins (e.g., ascorbic acid and pyridoxine). These nutrients help to repair worn out tissues, reduce cancer risks, lower cholesterol levels, normalize digestion time, improve vision, fight free radicals, and boost immune system activity. The vegetables also act as antioxidants that help to protect human body from oxidative stress, cardiovascular diseases and cancers (Santhakumar et al., 2018). The extract from the leaves and roots is used to cure asthma (Billa et al., 2017). It is known as Nte-oka in igbo, Gbure in Yoruba and Alenyruwa in hausa.

Risk assessment is an effective tool which enables decision makers to manage and control sites so contaminated in a cost-effective manner while preserving public and ecosystem health (Zhao et al., 2002). Ecological risk is the likelihood that a given activities/activity may have damaged or will damage the habitat, ecosystem or environment immediately or over a given period of time. Metal pollution index is a value that shows the level of contamination and pollution on a given substance under scientific investigation. On the other hand, human health risk assessment are usually done through a series of calculation to estimating the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media.

The term "Toxic element or heavy metals" has been defined as metals which have specific weights more than 5 g cm-3 (Hezbullah et al., 2016). In vegetables, these heavy metals can accumulate in edible parts (leaves). Heavy metals are generally more mobile at pH less than 7 and les mobile at pH greater than 7 (Fonge et al., 2017). Heavy metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities, and humans are exposed to them; therefore they tend to bio-accumulate, thus causing an increase in their concentration in a biological system (Woldetsadik et al., 2017). The bio-accumulation of heavy metals may interact directly with biomolecules, disrupting critical biological processes, which result in toxicity and the concomitant transfer of these metals through the food chain and ultimately pose risk to human life (Latif et al., 2018).The purpose of this study was to evaluate the bioaccumulation of heavy metals Cr, Zn, Pb, Cu, and Ni in soil and vegetables around sewage dumpsite and the risk in the consumption of this vegetable. The results are expected to create awareness among the public on the safety of consuming vegetables grown in such areas.

MATERIAL AND METHODS

Study Area

This study was carried out in farm around sewage dumpsite at University of Nigeria, Nsukka local government area in South-East, Enugu State of Nigeria. Nsukka is situated at 6.86° North latitude, 7.39° East longitude, 456 meters elevation above the sea level and has an area of 1810 km^2. The University of Nigeria, Nsukka lies between longitudes 7°24'E and 7°26'E, and longitudes 6°51'N and 6°53'N (Figure 1). The sewage plant site is located at the northeast, corner of the university and covers an area approximately 700 m^2.

Study Design

A randomized complete block design with three replications for each test sample was used to assess the concentration of heavy metal contamination on the vegetables of *Talinum triangulare* grown on sewage dumping site. The samples were collected at random and analyzed for heavy metal concentration in soil and vegetables, using Atomic Absorption Spectroscopy (AAS) (Figure 1).

Sampling

The vegetable leaves were harvested fresh from the sites located in UNN and these were done in triplicates for each samples analysis; leaves, and contaminated soil. Control for each was also collected for same analysis. The samples were collected between the months of October and November 2017. Soil samples were obtained from each farms by randomly taking soils of depth 15 cm with the aid of soil auger from three spots within the farm, and were mixed to give a representative samples. Leaves were also randomly sampled within the farm to get a representative sample. All samples were collected aseptically in a sterilized universal container and plastic bags. Analysis was conducted within 24 hours arrival at the Laboratory.

Determination of the Physico-Chemical Parameters on Soil

Physicochemical properties of the contaminated soil and the control soil samples were determined according to (Nimyel et al., 2015). They were soil type and texture, pH, total organic carbon, organic matter, total nitrogen, available phosphorus, exchangeable cation (sodium ion and potassium ion). The Physico-chemical properties of the soil were analysed in order to check the biodegradable process of the metals.

Determination of heavy metals

Vegetables: The edible portion of the vegetable samples were properly separated and thoroughly washed under a running tap water to remove dust, dirt and possible parasite or their eggs. Then 1% nitric acid solution was use to remove surface contaminants, and then rinsed with double distilled water. Each sample was chopped into small pieces using a clean stainless table knife and afterward dried to a

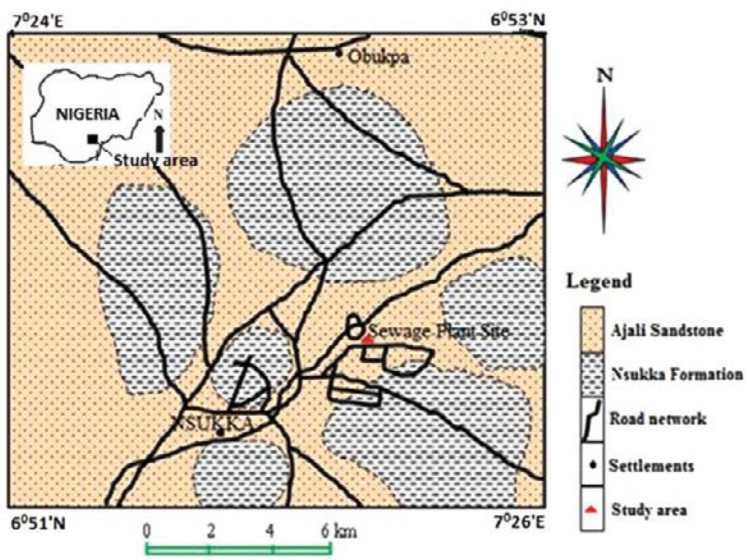

Figure 1. Geological map of University of Nigeria, Nsukka metropolis (68)

constant mass in an oven at 80°C for 48 h. Replicate samples of each dried vegetable from the site were combined and pounded to fine powder using a porcelain mortar and pestle. Particle sizes of 0.05 to 0.2 mm were obtained using laboratory sieves (Sobukola et al., 2010). Then 2 g of each vegetable powder was transferred into a clean dry round-bottomed flask and digested in a mixture of 4 ml, 25 ml, 2 ml and 1 ml of concentrated $HClO_4$, HNO_3, H_2SO_4 and 60 % H_2O_2, respectively, at 100°C on a hot plate for two hours in a fume cupboard. Each digest was filtered through a separate Whatman No.42 filter paper and the resulting solution was left over night and made up to 100 ml with de-ionized distilled water and concentrations of the elements was determined using AAS.

Soil: Soil samples were taken at different depths at 5 cm intervals to a depth of 15 cm. Sampling was carried out by using plastic equipment instead of metal tool to avoid any cross contamination. A soil sample to serve as control was also collected, Samples were collected into polyethylene bags, labelled and properly tied. The soil samples were spread on glass plates in the laboratory and then dried in an oven at 100^o C for six hours. The dried soil were grounded and sieved through 0-5 cm mesh sieve. The pH values of the soil samples were determined with a digital pH meter (Jenway Model). Then 1 g of the grounded soil samples was weighed into a 125 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml each of concentrated $HClO_4$, HNO_3 and H_2SO_4 respectively, on a hot plate in a fume cupboard. On completion of digestion, the samples were cooled and 50 ml of deionized distilled water was added and then filtered. The samples were made up to 100 ml with deionized water and concentrations of the elements determined using atomic absorption spectrophotometer (Sobukola et al., 2010).

Estimation of soil-plant Transfer Factor (TF): The transfer factor was calculated by dividing the concentration of heavy metals in vegetables by the total concentration of heavy metal in the soil (Olowoyo et al., 2010).

$TF=C_{veg}/C_{soil}$ ---(1)

Where; TF represent the transfer factor of vegetable

$C_{veg=}$Metal concentration in vegetable tissue, mg/kg fresh weight

C_{soil}=Metal concentration in soil, mg/kg dry weight.

TF greater than (>) 1 indicates that the vegetable are enriched in elements from the soil (Bio-accumulation) TF less than (<) 1 means that the vegetables exclude the element from soil (excluder)

Estimation of the Daily Intake of Metal (DIM): The DIM was calculated using the following formula used by (Olowoyo and lion, 2013).

$ADDM=DI \times MF_{veg}/WB$--(2)

Where; ADDM=represents the average daily dose (mg,kg/d) of the metal

DI=is the daily intake of leafy vegetable (0.182 kg/d for adults and 0.118 kg/d for children) according to (Nabulo et al., 2010)

MF_{veg}=is the trace metal concentration in the vegetables tissues (mg/kg)

WB=represent the body weight of investigated individuals (55.7 kg for adults and 14.2 kg for children).

Estimation of the Potential Hazard of Metal to Human (Hazard Quotient HQ): The Hazard Quotient (HQ) was used to calculate the possible human health risks associated with the consumption of vegetables harvested from the contaminated soils from Sewage areas. The following equation (Nabulo et al., 2010) for calculating human health risk from consumption of leafy vegetables used to calculate the Hazard Quotient of vegetables.

HQ is the ratio between exposure and the reference oral dose (RFD)

If the ratio is lower than one 1, there will be no obvious risk.

HQ=ADDM/RFDM--(3)

Where; ADDM=represents the average daily dose (mg,kg/d) of the metal

RFDM=is define as the reference dose (mg,kg/d)

RFDM=is the maximum tolerable daily intake of metal with no adverse effect.

Estimation of Hazard Index (HI): The hazard index (HI) was calculated to determine the overall magnitude of the toxicity of the vegetables consumed (USEPA, 2002). HI>1 indicates that the predicted exposure is likely to pose potential health risks. However, a hazard index >1 does not necessarily indicate that a potential adverse health effects will result, but only indicates a high probability of posing health risks.

$HI=\sum HQ_{Cr}+HQ_{Cu}+HQ_{Pb}+HQ_{Zn}+HQ_{Ni}$-------------------------------(4)

Statistical analysis: The data obtained were analysed using IBM Statistical Product and Service Solution (SPSS) version 20 and Microsoft excel 2013. The results were expressed as mean ± standard error (SE). One way analysis of variance (ANOVA) was carried out as p <0.05 considered statistically significant.

RESULTS

Soil Physico-chemical Properties

A number of physico-chemical properties of soils in this study were determined shown in Table 1. The pH of the Dump site and Control site were 5.19 and 6.95 respectively which are significantly different (P<0.05). The total nitrogen (7.47 and 5.27 %), total Phosphorus (4.36% and 3.57 %), organic matter (39.11 and 17.87 %), organic carbon (21.72 and 15.95 %) and calcium carbonate (27.54 and 23.30 %) for sewage dumpsite and control site are significantly (P<0.05) different. The exchangeable cations Na^+, K^+, Ca^+, and Mg^+ for sewage dumpsite are 7.17, 5.56, 21.53, and 3.02 meg/100 g and for the control site 6.95, 4.56, 14.56, and 20.56 meg/100g respectively. All the exchangeable cation in sewage dump are greater than the control except Mg^+ which is higher in the control. The physicochemical changes in parameter are due to the sewage use on the farmland.

Heavy Metal Concentrations in Soil

The mean concentrations of metals (Cr, Zn, Pb, Cu, Ni) in the dump soil were 2.05, 1.03, 0.61, 0.58 and 0.42 and in the control with no dump were 0.67, 0.07, 0.06, 0.20 and 0.24 respectively there was significant difference (p<0.05) between sites shown in Table 2. All the mean values recorded were below the permissible limit of metal in the soil by World Health Organization (WHO), Food and agricultural organisation (FAO) with Cr (100), Zn (300), Pb (50), Cu (100) and Ni (50 mg/kg).

Table 1. Physico-chemical properties of soil sample

Physico-chemical properties of soil sample		
Parameters	**Sewage Dump site soil (A)**	**Control Site soil (B)**
Soil pH	5.19 ± 0.05	6.95 ± 0.03
Total Nitrogen (%)	7.47 ± 0.03	5.27 ± 0.03
Total Phosphorus (mg/kg)	4.36 ± 0.01	3.57 ± 0.01
Organic Matter (%)	39.11 ± 0.13	17.87 ± 0.21
Organic Carbon (%)	21.72 ± 0.01	15.95 ± 0.02
Calcium Carbonate (%)	27.54 ± 0.11	23.30 ± 0.03
Exchangeable cation (Meq/100g)		
Na+	7.17 ± 0.04	6.95 ± 0.02
K+	5.56 ± 0.03	4.56 ± 0.01
Ca+	21.53 ± 0.01	14.56 ± 0.02
Mg +	3.02 ± 0.01	20.56 ± 0.01
n = 3 Results was expressed as Mean ± SE: Means values in A and B are significantly different (P<0.05).		

Table 2. Heavy metals concentrations on sewage dump soil and control soil

Treatments (Test sample)			
Heavy metals (mg/kg)	**SDS soil**	**CS soil**	**MPLsoil (mg/kg) WHO/FAO, 2001**
Cr	2.05 ± 0.02	0.67 ± 0.01	100
Zn	1.03 ± 0.00	0.07 ± 0.01	300
Pb	0.61 ± 0.06	0.06 ± 0.01	50
Cu	0.58 ± 0.00	0.20 ± 0.01	100
Ni	0.42 ± 0.01	0.24 ± 0.02	50

SDS: Sewage Dump Site; CS: Control Site; MPL: Maximum Permissible Level (mg/g); TT: *Talinum triangulare*; BDL: Below Detectable Limit n=3.

Heavy Metal Concentrations in Vegetable

Table 3 shows the mean concentration of heavy metals (Cr, Zn, Pb, Cu, and Ni) in vegetable leaves *Talinum triangulare* (TT) grown on sewage dump site (A) and a control site with no sewage (B). The levels of Cr, Zn, Pb, Cu, and Ni in SDS *Talinum triangulare* were 2.04, 0.33, 0.37, 0.34, and 0.20 mg/kg and the control site were 0.01, 0.05, 0.00, 0.17, and 0.11 mg/kg respectively. The values are all significant compare to the controls samples. The control site was all below the WHO/FAO standard of metals in vegetables. However, the levels of Cr and Pb in the vegetable were above the levels recommended by WHO/FAO, 2016 of Cr (0.3), Zn (27.3), Pb (0.3), Cu (3.0) and Ni (1.63 mg/kg) while Zn, Cu, and Ni were below the permissible limit for metals in vegetables.

Table 3. Heavy metals concentration in sewage vegetables and control

Test samples			
Heavy metal (mg/kg)	**SDS (TT)**	**CS (TT)**	**MPLveg (mg/kg) WHO/ FAO, 2016*, 1984****
Cr	2.04 ± 0.02	0.01 ± 0.01	0.3*
Zn	0.33 ± 0.01	0.05 ± 0.01	27.3**
Pb	0.37 ± 0.01	BDL	0.3*
Cu	0.34 ± 0.02	0.17 ± 0.01	3.0**
Ni	0.20 ± 0.00	0.11 ± 0.01	1.63**

SDS: Sewage Dump Site; CS: Control Site; MPL: Maximum Permissible Level (mg/g); TT: *Talinum triangulare*; BDL: Below Detectable Limit. n=3

Transfer factor (TF) of Heavy Metals from Soil to Plants

Table 4 shows the transfer factor (TF) of heavy metals from the soil to plants, which is the ratio of the concentration of metals in plants to the total concentration in the soil. The TF for the metal in sewage dump farm lands were significantly different from those for control. The highest TF value obtained for Sewage dump site (SDS) and Control site (CS) for *Talinum triangulare* (TT) were Cu(1.00) and Cu(0.85) respectively.

Daily Intake, Hazard of Metal (Hazard Quotient) and Hazard Index for Individuals

The hazard quotient (HQ) and Daily intake of metal (DIM) was calculated for individuals (both adults and children) from trace metals in leaves of *Talinum triangulare*, using the formula given by Nabulo et al., 2010). Chromium was the highest DIM found in sewage dumpsite with 0.017 in children. The daily intake of heavy metals was estimated according to the average vegetable consumption. The estimated DIM through the food chain is given in Table 5, for both individuals.

The HQ of metals through the consumption of vegetables for both adults and children is given in Table 5. The HQ of Cr, Zn, Pb, Cu and Ni in sewage dump vegetables ranged from 0.001 to 0.02 for adults, while ranged from 0.001 to 0.05 for children.

The estimated hazard index HI for both Adult and children in sewage dump and control are all greater than 1. The Value obtain for Adult is 0.024 and Children is 0.062 which shows that children are more affected with toxic elements from the consumption of *Talinum triangulare* grown on sewage dump site as shown in Table 5.

Table 4. Transfer factors (TF) of heavy metals from soil to plant

Transfer factors (TF) of heavy metals from soil to plant					
Samples	**Heavy Metal Transfer factor**				
	TFCr	TFZn	TFPb	TFCu	TFNi
SDS (TT)	1	0.32	0.61	0.59	0.48
CSC (TT)	0.01	0.71	ND	0.85	0.46
SDS = Sewage dump site; CS = Control site; TT = *Talinum triangulare*;. TF = Transfer factor. ND = Not detected. n = 3					
TF greater than 1 (>) indicates that the vegetable are en-riched in elements from the soil (Bio-accumulation).					
TF less than 1 (<) indicate that the vegetables exclude the element from soil (Excluder).					

SDS: Sewage Dump Site; CS: Control Site; TT: *Talinum triangulare*; TF: Transfer Factor. ND: Not Detected. n=3

TF greater than 1 (>) indicates that the vegetable are en-riched in elements from the soil (Bio-accumulation).

TF less than 1 (<) indicate that the vegetables exclude the element from soil (Excluder).

Table 5. Estimation of daily intake, and potential hazard (Hazard Quotient) for individuals

DIM and HQ for Individual				
Heavy Metals	**Individuals**	**Potential Hazard**	**SDS(TT)**	**CS (TT)**
Cr	Adult	DIM	0.007	ND
		HQ	0.02	ND
	Children	DIM	0.017	ND
		HQ	0.05	ND
Zn	Adult	DIM	0.001	ND
		HQ	ND	ND
	Children	DIM	0.003	ND
		HQ	ND	ND
Pb	Adult	DIM	0.001	ND
		HQ	0.003	ND
	Children	DIM	0.003	ND
		HQ	0.01	ND
Cu	Adult	DIM	0.001	ND
		HQ	ND	ND
	Children	DIM	0.003	0.001
		HQ	0.001	ND
Ni	Adult	DIM	0.001	ND
		HQ	0.001	ND
	Children	DIM	0.002	0.001
		HQ	0.001	0.001

SDS: Sewage Dump Site; CS: Control Site; TT: *Talinum triangulare*; DIM: Daily Intake Metal; HQ: Hazard Quotient; ND: Not Detected n=3

Table 6: Estimation of hazard index (HI) of metal for individuals

Estimation of hazard index (HI) of metal for individuals			
	HI for individuals		
HI = ∑HQ (PTEs)	**Individuals**	**SDS (TT)**	**CS (TT)**
	Adult	0.024	ND
	Children	0.062	0.001
SDS = Sewage dump site; CS = Control site; TT = *Talinum triangulare*; HI = Hazard index.			
∑ = Summation of the Hazard Quotient (HQ) from all the metals examined. n = 3			

SDS: Sewage Dump Site; CS: Control Site; TT: *Talinum triangulare*; HI: Hazard Index. ∑=Summation of the Hazard Quotient (HQ) from all the metals examined n=3

DISCUSSION

The observed pH in Dump site was below the recommended target limits (6.5-8.5) for agriculture (WHO, 2006), while the control site is within the recommended limits. In connection with this findings, (Mehmood et al., 2017) also reported that pH has influence in heavy metal accumulation. Heavy metals are generally more mobile at pH<7 than at pH>7. This can therefore be hazardous for agricultural purposes since crops are known to take up and accumulate heavy metal from sewage contaminated soils in their edible portions (Fonge et al., 2017). Such weak acidic pH in the study area can be attributed by Sewage, waste materials, and other anthropogenic activities. However, higher values of organic carbon and organic matter were recorded within sewage dump sites than the control site. This could be due to high organic waste input into the land undergoing decomposition. It revealed that the soils in the dump site area could be texturally classified as loamy soil which increases yields of crops as a result of sewage depositions in the soil. Physico-chemical parameters such as pH, calcium carbonate, Total Nitrogen, total phosphorus, and organic matter have a major influence on bacterial population growth and microbial activity in soil (Ratual et al., 2018). Therefore, large soil organic matter (SOM) inputs can greatly affect (increase or decrease) the mobility and availability of heavy metal in soils and their availability to plants. Organic matter (OM) also acts as a sink of essential nutrients in the soil which are important for plant growth (Linkhorst et al., 2017; Shahid et al., 2017). These results agreed with the findings of previous studies (Bloriska et al., 2017; Chahal et al., 2017). It is shown from these findings that sewage changes the physicochemical properties of the soil.

These values obtained for Sewage dump site were below the values reported for maximum permissible level of these metals in soil samples by World Health Organization (WHO), Food and agricultural organisation (FAO) 2001. On the other hand, the concentration of chromium (Cr) was higher than other metals Cr (2.05 mg/kg). While Nickel has the lowest concentration with 0.42 mg/kg at dump site. However, the higher concentration of metals around sewage dump sites maybe due to wastes, which originates mostly from domestic activities which generate wastes and refuse that are sources of these heavy metals also Cr increase in sewage dump could be as a result of its sources from automobile exhaust fumes as well as dry cell batteries, sewage effluents, runoff of wastes, cable wire, coloured polythene bags, discarded plastic materials, empty paint containers and atmospheric depositions could cause its bioaccumulation in vegetable via uptake from the soil and eventual entry into the food chain. Chromium accumulation in soil can cause serious problems and may affect the physiology of plants and animals. The levels of Cu recorded in this study were below the levels reported by Opaluwa et al. (2012) with range (0.82-0.91 mg/kg). The sequence of occurrence in both sites are Cr>Zn>Pb>Cu>Ni. The mean concentration values in the control site were generally lower than those in the studied areas which indicate that with continuous sewage on the soil, the heavy metal will accumulate in the soil then transfer to plant and to the food chain (Table 2).

The concentrations of metals in *Talinum triangulare* from dump sites were all above those obtained from the control site (non sewage dumpsite). This is also evident in the case of the soil which could be attributed to the mobility of metals from sewage dumpsites to farmlands through leaching and runoffs. The highest and lowest value of metal obtained were in Cr (2.04) and Ni (0.20 mg/kg) in SDS of TT. Generally Heavy metals observe in this study can cause severe problems, Lead can cause serious injury to the brain, nervous system, red blood cells, low IQ, impaired development, loss of memory, reduced fertility, renal system damage, nausea, insomnia, anorexia, and weakness of the joints when exposed to high concentration of lead. In plant lead affects photosynthesis and growth, chlorosis, inhibit enzyme activities and seed germination (Nagajyoti et al., 2010). High dose of Zinc in human causes Ataxia, depression, impotence, kidney and liver failure, prostate cancer, seizures, vomiting. In plant it affects photosynthesis, inhibits growth rate, reduced chlorophyll content, germination rate and plant biomas. In microorganism it causes death, decrease in biomass, and inhibits growth (Gumpu et al., 2015). Copper is essential, but high doses can cause anaemia, diarrhea, headache, metabolic disorders, nausea, vomiting, liver and kidney damage, stomach and intestinal irritation on human health . In plant it leads to Chlorosis, oxidative stress, and retard growth. While in microorganism it disrupts cellular function, and inhibits enzyme activities (Dixit et al., 2015). High Nickel can cause various kinds of cancer, cardiovascular diseases, chest pain, dermatitis, headache, kidney diseases, lung and nasal cancer. On plant it decrease chlorophyll content, inhibit enzyme activities and growth, while on microorganism it's disrupt cell membrane, and inhibit enzyme activities, oxidative stress (Fashola et al., 2016). High dose of chromium is observed to cause Bronchopneumonia, chronic bronchitis, diarrhea, emphysema, and headache, irritation of the skin, itching of respiratory tract, liver diseases, lung cancer, nausea, renal failure, reproductive toxicity, and vomiting. On plant it causes Chlorosis, delayed, senescence, wilting, biochemical lesions, reduced biosynthesis germination, stunted growth, and oxidative stress. On microorganism it elongates of lag phase, growth inhibition, inhibition of oxygen uptake (Barakat, 2011; Shahid et al., 2017b). The concentrations of metals in sewage dump site analysed are all above those obtained for the control site and there was significant difference ($p<0.05$) between the two site (Table 3).

The TF of all elements are within normal range in plant except Cr(1.00). Plants are known to take up and accumulate trace metals from contaminated soil (Opaluwa et al., 2012). Although the levels of these metals are not within normal range for plants, however consumption could lead to accumulation and adverse health implication particularly for Pb, Cu, and Cr (Opaluwa and Umar, 2010). Also the variation in values obtained for these heavy metals in the soil and Vegetable samples as against those from control sites is an indication of their mobility in the dumpsites. This is in agreement with the report of (Oluyemi et al., 2008). TF>1 indicates that the vegetable take up metals from the soil (Bio-accumulation). TF<1 means that the vegetables exclude the element from soil (Excluder).

The DIM values for heavy metals were significantly high in the vegetables grown on sewage dump soils. The highest intakes of Cr, Zn, Pb, Cu and Ni were from the consumption of *Talinum triangulare* grown in Sewage dump site soils for both adults and children.

The HQ values for heavy metals were significantly high in the vegetables grown on sewage dump soils. Most of the values obtain in HQ especially in sewage dump sites were above 1 (>1) as shown on (Table 5). Which indicate that consumption may lead to accumulation of these metals in the body.

CONCLUSION

This research has shown that vegetables grown on sewage dumpsites are capable of accumulating high levels of heavy metals from contaminated and polluted soils with deleterious health effects. The community needs to be informed about the consumption of these vegetables grown in such areas. The results also showed that all the five heavy metals (Cr, Zn, Pb, Cu, and Ni) analysed were present in soil and in the vegetable samples. The soils and vegetable samples from the study areas recorded significant levels of heavy metals, especially those around sewage dumpsite. The concentration of heavy metals in *Talinum triangulare* around dumpsite exceeded the WHO/FAO permissible limits in edible vegetable while the controls were within the permissible limit.

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