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Assessment of Uptake of Heavy Metals by Selected Vegetables in River Getsi Irrigation Area, Kano, Nigeria

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Abstract
Fresh vegetables are regarded as important part of healthy diet in many countries including Nigeria. The condition of heavy metals in irrigated vegetables may tend to reflect the sanitary quality of both the soil and the irrigation water including hygienic condition of the raw products at the time of harvesting. The aim of this study was to assess the heavy metals uptake of vegetables at river Getsi irrigation area. In this study, the physicochemical properties and heavy metal concentrations of river Getsi irrigation water, the heavy metal accumulation in the roots, stems, bulbs, leaves and fruits of the selected irrigated vegetables were determined. The results from the assessment of physicochemical properties of the irrigation water have revealed an average temperature of 30.1oC, pH of 7.3, a mean biochemical oxygen demand of 80.3 mg/l with Chromium as the highest available heavy metal 7.8 mg/l and Mercury as the unavailable heavy metal 0.0 mg/l, assessment of heavy metals concentration in the irrigation soil have shown a highest concentration of Chromium (T = 5.5 mg/kg, R = 0.4 mg/kg, SD = 0.1 mg/kg) while Mercury as the unavailable heavy metal (T = 0.0 mg/kg, R= 0.0 mg/kg, SD = 0.0 mg/kg) which are within the recommended dietary intake. From the results of this study, it was concluded that the water, soil and vegetables at river Getsi irrigation area are relatively contaminated by heavy metals. It was therefore recommended that, the farmers around river Getsi irrigation area should be enlighten on septic methods of irrigation and educating people on proper washing and processing of irrigated vegetables should be a top priority during health awareness campaigns in Kano.

Keywords: Heavy metals, Irrigation water, physicochemical properties, Soil, Vegetables

INTRODUCTION
Vegetables are beneficial and protective food required for the maintenance of health and prevention of diseases (Ngugen, 1994). They contain important ingredients that are valuable for proper function of the body (Siegel et al., 2014). Vegetables contain various medicinal and therapeutic agents and are valued mainly for their high vitamin and mineral content. Studies have evaluated the association of fruit and vegetables consumption with the reduction of risk of specific diseases (Hung et al., 2004). The incidence of heavy metal in irrigated vegetables may be expected to reflect the sanitary quality of both the soil and the irrigation water and the hygienic condition of the raw product at the time of harvesting (Ngugen, 1994).

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There has been an increased usage of wastewater in crop production as a result of increase in demand of food and dynamisms of climatic conditions which makes production of food by use of rainfall less reliable (Scott et al., 2004). Reusage of waste water in irrigation has been regarded as an indispensable option to compensate shortage of water in developing countries which includes Nigeria. Thus, utilization of waste water in production of crops now becomes a widespread practice in such countries (Souet al., 2011).

Depending on the type of activity from which the wastewater was derived, it may contain certain harmful microorganisms and heavy metals (Ngugen, 1994). As such, excessive usage of the wastewater for production of leafy and other vegetables has led to accumulation of heavy metals in the soil and their transfer to other vegetables under cultivation which incorporate harboring microbes (Sharma et al., 2007). Accumulation and uptake of microorganisms and heavy metals in vegetables may proceed through two different paths i.e. the foliar surface and roots. Hence, microbes and toxic metals may enter the food chain after been absorbed by the vegetables (Fytianoset al., 2001) and this may serve as the implicating source of human exposure to these toxic elements and microbes. Heavy metals are harmful contaminants in the environment and food in particular, and they possess a long half- life indicating that they are non-biodegradable (Heidariehet al., 2013). The implications associated with metals (embracing metalloids) contamination call for a great attention, most especially in agricultural production systems due to their increasing trends in the environment and human food specifically (Kachenko and Singh, 2006). Utilization of untreated wastewater in irrigation presents an essential route for transmission of harmful microorganisms and toxic heavy metals (Sabiena et al., 2000).In view of this, the was therefore aimed at assessing the uptake of heavy metals in water and soil associated with vegetables at river Getsi irrigation area in Kano metropolis, Nigeria.

MATERIALS AND METHODS

Study Area

This study was conducted in river Getsi irrigation area. River Getsi (12o 2′ N and 8o 32′ E) carries effluents from Bompai industrial estates and formed a confluence with river Jakara which drains municipal wastewater from Kano old city district. It is located within the metropolis of Kano in the Sahelian geographical region south of the Sahara (Imam and Balarabe, 2012). The climate features of the region lies within savanna vegetation and a hot semi-arid climate and about 690mm (27.2 in) precipitation per year the bulk of which falls from June through September (Imam and Balarabe, 2012).

Samples collection

The samples were selected to cover the entire basin of river Getsi irrigation site through a quadrant sampling technique. The water samples were collected for the determination of 5-Day biological oxygen demand, total dissolved salt, dissolved oxygen and heavy metals (Lead, Mercury, Chromium and Nickel). A 250ml BOD bottle was immersed into the water using sterilized surgical hand gloves to avoid contamination and was filled to the brim in order to expel air bubbles and gently closed to avoid trapped in air. The excess samples were removed and the rest were incubated at 20oC ± 0.5oC for 5 days. The samples were taken to laboratory of Department of Biological Sciences, Bayero University, Kano for digestion.

Soil samples were obtained from the land that was cultivated near the water source within the distance of 10 m from the irrigation water source. The Samples were obtained from the upper surface of the soil (0-20 cm). A 50 mm stainless steel rod was dipped into the depth of the soil, extruded the soil core when removed. The extruded soil was then packed into a sterile polyethylene bag with the aid of a stainless steel spatula. The soil sample was collected for 3 times, mixed with deionized water in a sterile plastic container and conveyed to the laboratory immediately. The samples collected were then dried at a temperature of 90°C in an electrical oven for about 25-30 minutes to remove the moisture. They are subsequently homogenized using a mortar and pestle to reduce the size to a fine powder.

Vegetable samples were taken from river Getsi irrigation site where they were known to be affected by wastewater. This was carried out with the aid of a sampling quadrant that was thrown at random. Samples of four different vegetables; tomato (Lycopercicum esculentum), onion (Allium cepa), spinach (Spinacia oleracea) and carrot (Daucus carota) were obtained from the same points of soil samples collection. In addition, about 25 g of the vegetable samples were washed thoroughly with fresh water and lastly washed with deionized water. The whole vegetable samples were dried at room temperature until it's dried completely. Then the samples were grinded into homogenous fine powder mass with the aid of ES-314 blender (220V, 50HZ and 300W) of SONCAP approved. Subsequently, they were placedinan airtight polythene bags and kept in a refrigerator for further analysis. The samples that were collected during the experiment were presented in Table 1.

Table 1: Selected samples of vegetable

Common name	ID	Scientific name	Edible parts
Tomato	TO	*Lycopercicum esculentum*	Fruit
Onion	ON	*Allium cepa*	Leaf
Spinach	SP	*Spincia oleracea*	Leaf
Carrot	CA	*Daucus carota*	Root

Physicochemical analyses

Determination of temperature

The temperature of the irrigation water was determined by means of mercury-in-glass thermometer. It was brought into contact with the water sample. The temperature was then read and recorded (Beuchat, 2002, Buck et al., 2003).

Determination of pH

The pH of the irrigation water was evaluated by means of digital laboratory pH meter. About 20ml of the irrigation water was measured in a beaker and the pH meters was switched on and allow warming for 15 minutes. It was then calibrated with buffer of pH 4.0 and 7.0, the electrode was rinsed and cleaned using cotton wool, the electrode was then dipped into the beaker containing the irrigation water, the pH value of the water was read from the digital screen of the pH meter (Hamilton et al., 2006).

Determination of Electrical conductivity (EC)
EC of the irrigation water was evaluated by means of Conductivity Bridge. 20ml of the collected water sample was measured in a beaker and the electrical conductivity bridge was switched on and allowed to warm-up for 15 minutes, and calibrated using 0.01ml KCl. The electrode of the machine was deepening into the beaker containing the irrigation water and the conductivity value was read from the digital screen of the conductivity meter (WHO, 2009; Akyalaet al., 2003).

Determination of Dissolved oxygen
The dissolved oxygen was determined using wrinkle method (Nordic Council of Ministers, 2013).

Determination of 5-Day biological oxygen demand (BOD5)
The biological oxygen demand was determined where by a BOD bottle of 250ml was filled with the samples by immersing the BOD bottle into the water up to the brim in order to avoid air bubbles. The bottles were incubated at 20oC for 5 days. The oxygen concentration of each sample was measured and the analysis of dissolved oxygen was also performed. The BOD5 was then obtained using the following formula (Nordic Council of Ministers, 2013).

$$BOD_5\ (mg/l) = \frac{[DOB-DOA] - [DOBB-DOBA]}{D}$$

Where

D = dilution factor

DOB = DO of sample before incubation

DOA = DO of sample after incubation

DOBB = DO of the blank sample before incubation

DOBA = DO the blank sample after incubation

Determination of Total dissolved solids (TDS)
The amount of TDS was determined by gravitational method (Nordic Council of Ministers, 2013), where by the water samples were well mixed and filtered through a standard glass fiber filter. The filtrate was then evaporated to dryness in a weighed dish and dried out to constant weight at 180oC. The increment in the weight represent the TDS, the filtrate from total suspended solid will be used for the analysis using the formula below (Nordic Council of Ministers, 2013).

TDS = A-Bx1000 Sample volume in ml

Where

A = weight of dry residue dish (mg)

B = weight of dish (mg).

Heavy metals analysis of the water used for irrigation water, soil and vegetables

Dry ashing of samples and preparation of solution

Accurate amount of water (5ml) were weight into three crucible, with 5g of soil and vegetable sampled were placed inside a Vectra furnace (250V, 13A, 3000W) with subsequent ashed at 460oC for 12 hours for further digestion of ash sample. Digest ash within a fume hood were place on hot plate containing 12ml of distilled water for about 2hour which were separately, transferred into a clean centrifuge bottle with each bottles contain digested ash put into a centrifuge machine for about 3000 revolution per minute for 15 minutes. The mixture of each sample was then finally transferred into a 50ml standard volumetric flask and filtered. The procedure was repeated for other samples.

Microwave digestion of sample

Homogenized solution contain about 3.0ml of water, vegetables and soil were transferred into a mixture of 70% Nitric Acid and 60ml of Teflon digestion vessels with the addition of 30% hydrogen peroxide. Mixture was carefully shaken and kept for about 10 minute before closing the vessels. The sample were based on microwaves digestion for optimization of microwaves digestion program sequences of 50W, 165oC (10 min); 80W, 190oC (20 min); and 0W, 50oC (10 minutes). Samples are thermally regulated and allowed to cool at room temperature to avoid foaming and splashing of digested fumes hood. Each digest were deionized with 25ml of diluted water and use for atomic absorption of spectrometry assay.

Heavy metals determination by atomic absorption spectrometer

Impurities of toxic heavy metals were experimentally analyzed using atomic absorption performance of spectrometry (AAS, VGP 2010 model). All experiment was analyzed using triplicate data collection and automatic processor attached to a PC. Trace element was prepared for 5days by dilution (0, 1, 5, 10, 15 and 20ml) with standard heavy metal stock solution. Dilute solution was put into 100ml volumetric flask each containing 5ml of concentrated HNO3, solution was deionized with 100ml of water giving; 0, 0.1, 0.5, 1.0, 1.5, and 2 ppm concentration for each heavy metal sampled. Values observed via absorption were recorded and filtered using linear regression method. A calibration curve was used to calculate concentration of trace elements in various vegetables samples.

Data analysis procedure

The data recorded were subjected to descriptive statistics in form of mean, standard deviations and range. All statistical tests were computed with SPSS software version 20.

RESULTS

The results from the assessment of physicochemical properties of the irrigation water have revealed an average temperature of 30.1oC, pH of 1.6, a mean biochemical oxygen demand of 80.3 mg/l, with chromium as the highest available heavy metal (7.8 mg/l) and mercury as the unavailable heavy metal (0.0 mg/l) as shown in Table 1 below. Results from the assessment of heavy metals concentration in the irrigation soil have shown a highest concentration of chromium (T = 5.5 mg/kg, R = 0.4 mg/kg and SD = 0.1 mg/kg) while mercury as the unavailable heavy metal (T = 0.0 mg/kg, R= 0.0 mg/kg and SD = 0.0 mg/kg) as seen in Table 2 below.

Results of heavy metals absorption in tomato as seen in table 3 below revealed that Lead and nickel were the highest and the least available metals in the root (Mean = 0.4mg/kg and 0.3

mg/kg) and shoot (M = 0.5 mg/kg and 0.2 mg/kg) respectively. Nickel was the highest in the leaves (M = 0.3 mg/kg) and least in the fruit part of tomato (M = 0.3 mg/kg) while chromium appeared the least available metal in the leaves (M = 0.2 mg/kg) and the highest in the fruit part of tomato (M = 0.6 mg/kg) respectively.

The results of heavy metals absorption in onion spring have revealed a higher concentration of chromium ion (M = 0.6 mg/kg and SD = 0.2 mg/kg) with least concentration of nickel in both the spring and bulb of the onion (M = 02 mg/kg, SD = 0.1 mg/kg and M = 0.3 mg/kg, SD = 0.1 mg/kg) as shown in table 4 below. Table 5 below have shown that nickel is the moderately concentrated metal in both the root and shoot of spinach (M = 0.3 mg/kg and 0.3 mg/kg) while chromium is the moderately concentrated metal in the leaves of spinach. Results of heavy metals assay in carrot shows moderate concentration of lead in both leaves and root (M = 0.4 mg/kg and 0.4 mg/kg) respectively as shown in table 6 below.

Table 1: Physicochemical properties of river Getsi irrigation water

	Samples ID						
Parameters	A1	B1	C1	A2	B2	C2	M ± SD
TDS (mg/l)	21.200	19.300	22.500	18.600	18.600	20.400	19.810 ± 1.980
BOD_5(mg/l)	73.000	66.000	89.000	82. 000	78.000	94.000	80.330 ± 10.280
DO (mg/l)	4.800	3.200	4.300	3.900	5.300	6.100	4.600 ± 1.030
EC (mg/l)	1.948	1.814	1.973	1.649	1.426	1.330	1.690 ± 0.290
pH	7.378	7.638	7.108	7.265	7.365	7.123	7.31 ± 0.190
Temp (°C)	29.000	30.000	29.000	31.000	31.000	31.000	30.160 ± 0.980
Cr (mg/l)	5.660	3.774	9.434	11. 321	11.321	5.660	7.860 ± 3.250
Pb(mg/l)	5.376	8.602	6.452	3.226	4.301	7.527	5.910 ± 2.010
Ni (mg/l)	2.727	3.602	1.818	0.909	1.818	2.727	2.270 ± 0.950
Hg (mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.000 ± 0.000

A, B and C = sampling at first, second and third month, 1& 2 = point of sampling, TDS = total dissolved solid, BOD = biological oxygen demand, DO = dissolved oxygen, EC = electrical conductivity, Temp = temperature, Cr = chromium, Pb = lead, Ni = nickel, Hg = mercury

Table 2: Concentrations of heavy metals in river Getsi irrigation soil

	Heavy metals concentration (mg/kg)			
Sample ID	Ni	Pb	Cr	Hg
Soil site 1A	0.452	0.267	0.560	0.000
Soil site 1B	0.301	0.356	0.435	0.000
Soil site 1C	0.377	0.178	0.373	0.000
Soil site 1D	0.527	0.089	0.498	0.000
Soil site 2A	0.301	0.267	0.311	0.000
Soil site 2B	0.226	0.178	0.622	0.000
Soil site 2C	0.226	0.089	0.435	0,000
Soil site 2D	0.377	0.178	0.249	0.000
Soil site 3A	0.527	0.356	0.684	0.000
Soil site 3B	0.301	0.445	0.498	0.000
Soil site 3C	0.452	0.267	0.560	0.000
Soil site 3D	0.377	0.178	0.373	0.000
Total	4.444	2.849	5.598	0.000
M ± SD	0.370 ± 0.103	0.237 ± 0.109	0.466 ± 0.128	0.000 ± 0.000
R	0.301	0.356	0.435	0.000

1, 2, 3, = number of sampling, A, B, C, D = sampling point, M = mean, SD = standard deviations, R =range.

Table 3: Mean concentrations of heavy metals in tomato

	M ± SD of parts of tomato (mg/kg)			
Metals	Root	shoot	Leaves	Fruit
Ni	0.337 ± 0.178	0.276 ± 0.133	0.391 ± 0.189	0.318 ± 0.129
Pb	0.430 ± 0.104	0.521 ±0.205	0.281 ± 0.190	0.489 ± 0.122
Cr	0.394 ± 0.101	0.497 ± 0.463	0.242 ± 0.065	0.621 ±0.222
Hg	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
N	6	6	6	6

M = mean, SD = standard deviations, N = No. of sample.

Table 4: Mean concentration of heavy metals in onion

	M ± SD of parts of onion (mg/kg)	
Metals	Spring	Bulb
Ni	0.288 ± 0.146	0.326 ± 0.113
Pb	0.430 ± 0.104	0.504 ± 0.200
Cr	0.632 ± 0.240	0.394 ± 0.122
Hg	0.000 ± 0.000	0.000 ± 0.000
N	6	6

M = mean, SD = standard deviations, N = No of sample.

Table 5: Mean concentration of heavy metals in spinach

	M ± SD of parts of spinach (mg/kg)		
Metals	root	shoot	Leaves
Ni	0.351 ± 0.182	0.310 ± 0.157	0.290 ± 0.157
Pb	0.311 ± 0.166	0.400 ± 0.166	0.578 ± 0.192
Cr	0.518 ± 0.160	0.141 ± 0.187	0.559 ± 0.211
Hg	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
N	6	6	6

M = mean, SD = standard deviations, N= No. of sample.

Table 6: Mean concentration of heavy metals in carrot

	M ± SD of parts of carrot (mg/kg)	
Metals	root	Fruit
Ni	0.426 ± 0.148	0.288 ± 0.146
Pb	0.474 ± 0.175	0.414 ± 0.193
Cr	0.591 ± 0.164	0.497 ± 0.395
Hg	0.000 ± 0.000	0.000 ± 0.000
N	6	6

M = mean, SD = standard deviations, N = No. of sample.

Table 7: Comparison of heavy metals in water, soil and vegetables with standard

Samples	Heavy	Mean total	Standard
Water (mg/L)			
	Ni	2.270	2.000[g]
	Cr	7.860	1.000[g]
	Pb	5.910	1.000[g]
	Hg	0.000	___
Soil (mg/kg)			
	Ni	0.370	75-150[a]
	Cr	0.239	2.3[b]
	Pb	0.466	10-70[b]
	Hg	0.000	10[c]
Tomato (mg/kg)			
	Ni	1.322	1.5[d]
	Cr	1.754	2.3[e]
	Pb	1.721	0.3[e]
	Hg	0.000	10[f]
Carrot (mg/kg)			
	Ni	0.714	1.5[d]
	Cr	1.000	2.3[e]
	Pb	0.888	0.3[e]
	Hg	0.000	10[f]
Onion (mg/kg)			
	Ni	0.614	1.5[d]
	Cr	1.026	2.3[e]
	Pb	0.924	0.3[e]
	Hg	0.000	10[f]
Spinach (mg/kg)			
	Ni	0.951	1.5[d]
	Cr	1.218	2.3[e]
	Pb	1.289	0.3[e]
	Hg	0.000	10[f]

[a]Indian standard awashthi and European Union, 2002; [b]FAO/WHO, codex general standard for contaminants and toxins in foods, 1996; [c]World Health organization, 2004 ; [d]WHO/FAO (Codex Alimentarius Commission. Joint FAO/WHO, 2007) and indian standard awashthi; [e]WHO (Codex Alimentarius Commission, Joint FAO/WHO, 2001 and codex alimentarius commission, 1994); [f]WHO/FAO (FAO/ WHO, codex general standard for contamination and toxin in foods, 1996); [g]Iran Environmental Protection Organization (1999)

Table 8: Transfer factors of heavy metals in the vegetables (TF = $C_{vegetable}$ / C_{soil})

	Transfer factor (TF= $C_{vegetable}$ / C_{soil})		
Vegetables	Nickel	Lead	Chromium
Tomato	1.794	3.627	1.882
Onion	0.830	1.968	1.100
Spinach	1.273	2.717	1.599
Carrot	0.966	1.744	1.167

TF = Transfer factor, $C_{vegetable}$ = Heavy metals concentrations in vegetables in mg/kg, C_{soil} = Heavy metals concentrations in the soil in mg/kg.

DISCUSSIONS

Analysis on physicochemical parameters of Getsi water irrigation was based on the standard protocol of Clemson University Cooperative Extension Services of interpreting the quality of irrigation water and correlation of its public health implications. (Table .1) Study on the average of heavy metals concentrations in river Getsi irrigation water. Present research on four elements analyzed, three elements (Cr, Pb and Ni) were detected whereas the other one (Hg) was below its corresponding detection limit. From the detected elements, the highest mean concentration obtained for Cr sample (7.860 ± 3.250 mg/l) and lowest for Ni sample (2.270 ± 0.950 mg/l).

Present study on the mean concentrations of heavy metals detected in the irrigation water samples are arranged in the order of Cr (7.860 ± 3.250 mg/l) >Pb (5.910 ± 2.010 mg/l) > Ni (2.270 ± 0.950 mg/l) > Hg (0.000 ± 0.000) in mg/l. It shows that chromium is present in the samples obtained from the three different samples of the irrigation water and the concentrations varied from 3.777 to 11.321 mg/l, the upper limit of which exceeded the recommended limit of short term irrigational use in reclaimed water. Therefore, previous reports compared with the values of other detected elements, the mean concentration of chromium in the irrigation water was higher (7.860 ± 3.250 mg/l) followed by lead which shows that, the irrigation water at the study area is high in chromium. Though Cr and other microelements are important in maintaining the metabolic systems of human body, still at higher concentration they could lead to poisoning (Qin et al., 2009).

It could cause damage to kidney, liver, stomach upsets and ulcers which may lead to death(Qin et al., 2009).The toxicity of chromium depends upon its chemical nature, the hexavalent chromium (VI) compounds is toxic with mutagenic and carcinogenic effects and the trivalent chromium (III), which is mostly seen in food has a low toxic effect. Tolerance limit of Cr in water is 0.3 mg/kg (Qin et al., 2009).

Present study on Lead values; ranged between 3.774 to 8.602 mg/l (Table 1). Although lead at higher concentration can reduce plant cell growth. Result from this study indicates the possibility of damage to vegetable cells is less, because the recommended limits for lead in used water for irrigation is 5 mg/l and 10 mg/l for long-term and short-term (Adapted from Rowe and Abdel-Magid, 1995).

Ni (2.270 ± 0.950 mg/l) is the least concentrated metals among the three detected heavy metals in river Getsi irrigation water and is also higher than the recommended limits for both long term uses 0.2 mg/l and short term uses (2.0 mg/l) of reclaimed water for irrigation(Adapted from Rowe and Abdel-Magid, 1995).Nickel is known to be toxic to a number of vegetables at 0.5 to 1.0 mg/l meanwhile the toxicity levels are mostly reduced at neutral or alkaline pH.Thus, the toxicity levels is seen less chronic cancer and health effects which comes as a result from exposure for long term to relatively low concentration of pollutants. Therefore, there are implicating dangers in the regular use of this water for irrigational purposes.

The quality of the irrigation water in terms of cations and salinity is determined by the parameters shown in table 1.The mean and standard deviations of pH was 7.31 ± 0.190 while the mean EC values across the samples ranged from 1.330 to 1.973 mg/l. The mean temperature of the irrigation water was 30.160 oC, BOD5 and DO were 80.330 mg/l and 4.600 mg/l respectively, while the range of TDS values was from 18.000 to 22.500 mg/l.

Generally previous report on the values of pHfor irrigation water should be between 6.0 and 7.0, while values above 7.0 are considered increasingly hazardous (Danko, 1997). This warer feature has an important impact on other attributes or activities in the soil including how plant conduct some activities.

The levels of total salt content in waters for irrigation wasestimated in terms of EC and might be the most significant parameter for determining the suitability of water for irrigation (Iyengar and Nair, 2000). It estimates the overall amounts of dissolved salts in the water, the overall amount and type of salts presents qualifies the water for irrigation purposes (Alamet al., 2003). Previous report on ranges consideration for irrigationwater suitability are 175, 175 to 525 and 525 to 1,400 mg/L being excellent, good and permissible limits for classes of irrigation water (Alamet al., 2003). From this perspective, the water source may not be facing any threat simply because the highest mean observed was within the recommended range.

The dissolved oxygen (DO) of water serves as a significant parameter in monitoring the quality of water biologically and to assess its best use. It supports aquatic organisms and regulates how organic pollutants are degraded biologically. DO level of river Getsi was fairly good, with a range between 3.200 to 6.100 mg/l and average of 4.600 mg/l. It was reported that the DO of river water is a function of temperature; turbulence, depth, and organic matter present (Tasrina et al., 2015). Therefore, this dissolved oxygen level in river Getsi could be as a result of the introduction of sewage upstream, industrial effluent of Bompai and domestic waste from the neighboring household.

For measuring the organic pollution in river Getsi, biological oxygen demand (BOD5) was determined. The BOD5 ranged from 66.000 to 94.000 mg/l and a mean value of 80.330 mg/l. The TDS ranged from 16.900 to 22.500 mg/l with a mean value of 19.810. These outcomes may justify that river Getsi irrigation water contained moderate levels of dissolved salts and trace elements, most of which come from the natural weathering of the earth's crust. Furthermore, water that drains from irrigated lands and effluents from city domestic sewage and industrial waste waters can influence water quality. In most irrigation scenerios, the primary concern in water quality is salinity levels, since dissolved salts can affect the soil structure and crop yield and this implies to river Getsi as well.

The predominant heavy metals found in the irrigated soil, in order of decreasing concentrations are Cr (5.598 mg/l), Ni (4.444 mg/l) and Pb (2.849 mg/l). These metals are significant as they have the capacity of reducing crop yield as a result of bioaccumulation and biomagnifications in the food chain. In addition, there is the potential of surface and groundwater contamination. The fate and movement of the heavy metals in soil depends largely on their speciation and chemical nature (Ikeda et al., 2000).

Heavy metals in soils are absorbed by fast initial reaction (minutes, hours), subsequently followed by less adsorption reactions (days, years) and are, hence, redirected into various chemical forms with varying degreeof bioavailability, mobility, and toxicity. This dispersion is believed to be under the influence of reactions of heavy metals in the soils such as mineral precipitation and dissolution, adsorption, ion exchange, aqueous complication, biological immobilization and mobilization, desorption, and plant uptake (Steele et al., 2005).

Soils irrigated around Getsi river maybe contaminated with heavy metals accumulated by emission from speedy robust industrial areas, domestic waste disposal, disposal of high metal wastes, bio solids, application of fertilizers on land, manures from animals, sewage sludge, pesticides, irrigation by wastewater, residues from coal combustion, spillage of petrochemicals, and atmospheric deposition. Therefore, the ultimate implications of this soil contamination are opportunistic transfer of the metals to the vegetables and to the consumers. There was an irregular pattern and uneven concentrations of heavy metals in the different parts of the vegetables.

Nickel, lead and chromium were all more distributed in the leaves than the fruits of carrot, with only chromium higher than nickel and lead in the spring of onion, while chromium is more concentrated than lead and nickel in spinach leaves and fruits of tomato as seen in Tables (3, 4, 5 and 6) respectively. The presence of Ni, Pb and Cr in these vegetables poses serious attention as these metals are known to be toxic to plants and animals including humans.

It might be that these metals are in relatively higher levels than the capacity of the plant can hold and might have result to the non-germination of seeds and/ or production of fruits. The accumulation of such heavy metals in the fruits was as a result of the presence of the metals in the soil due to irrigation with waste water. This idea was supported by the Submission from Dahdoh et al., (1996) supported the fact that Pb extractable in both cultivated and uncultivated soils increased by simultaneous increase in Pb added to the soil.

Badawy and EL-Motaium (2003) reported that the levels of toxic metals (Cu, Cr, Ni, Pb, etc.) in the soil has increased with simultaneous increase in sludge application rate. Consequently, the accumulation of such metals in the fruits may be as a result of plants and soils irrigated with polluted water. The claim was supported by Kandil et al., (2003), who observed a significantly higher relationship between the chemical composition of irrigation water utilized and the chemical properties of the soil. This reveals that the concentration of these metals in the fruits is a reflection of their levels in the soil. The result was in line with the outcome of Abd-EL-Fattah et al., (2002) that the Pb concentration in the leaves of corn has increased with elevating concentration of extractable Pb in the soils. They also revealed that plants irrigated with municipal sewage water had higher levels and accumulation of elements than those irrigated with river water. The results from this study conform favourably with these researchers.

Abdel-Sabour and Rabie (2003), revealed that irrigation with various waste water increased the heavy metals concentration significantly (Zn, Cu,Ni ,Pb, Cd and Co) in plants, vegetables, Spinach, Rochel and Jew's mellow most importantly in leafy kinds. Similarly, the selected vegetables involve both fruit and leafy vegetables, ultimately the outcome of this study conform with these findings above. Their findings have also revealed that, long irrigation periods were related with significant elevation in the general and available forms of heavy metals. Therefore, it could be inferred that prolonged irrigation with river Getsi irrigation soil may lead to these heavy metals reaching toxic levels.

Table 7 shows the results of comparison of heavy metals in water, soil and vegetables with the standard values of some internationals bodies and/or organizations. The values were below the standard limits in all the assessed elements in the irrigation water and soil with only higher values in lead in the entire vegetable samples compared with the standards. This may be either due high uptake of lead by the vegetables or high contamination of the water sources by lead. Lead poisoning is chronic non-communicable disease, with significant damages to internal organs and physical disability. The chance of lead poisoning and related diseases in among frequent consumers of river Getsi cultivated vegetables may be possible. The results also show a decreasing trend in the heavy metals accumulation from water to soil and soil to plant. There were higher and lower levels of the toxic heavy metals in the water and vegetables respectively. This may be due to lower uptake by the vegetables or excretion of the absorbed metals by the vegetables through transpiration.

Transfer factor of metals from soil to vegetable is a major endpoint of human exposure to heavy metals through the food chain. Metals transfer factor is important in investigating the health risk index of humans (Heuer and Smalla, 2007). Transfer factor of metals differs in various vegetables and was observed to be highest for lead as shown in table 8. Among the vegetables, tomato and spinach revealed a higher transfer factor to vegetables from soil than the other vegetables. The higher transpiration rate for sustaining growth and moisture contents of these vegetables may be the reason for higher uptake of heavy metals in them. Therefore, results of this study are substantial enough and pro-actively support and establish a delicate avenue of public health concern.

CONCLUSION

Vegetables consumption is an essential source of much required minerals and vitamins for the development of human body. The study indicated that the heavy metals availability in the water, soil and their uptake in the vegetables have slightly exceeded the ICSFM and WHO recommended limits for soil, wastewater and vegetables respectively.

RECOMMENDATIONS

It was therefore recommended that:

1. Irrigation farmers around river Getsi irrigation area should be enlighten on septic methods of irrigation through the state ministry of agricultural resources and the primary health care board respectively.
2. Kano state government should provide means of checking the quality and hygienic status of river Getsi irrigation water for the farmers.
3. Kano state ministry of environment should intensify monitoring and inspection of river Getsi irrigation area and propose the possible wastewater management measures.

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