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Comparative analysis of potentially toxic elements in the soils and some vegetables collected from wastewater and river water irrigated areas in Kano city and Bichi town, Kano state, Nigeria

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Abstract

Urban vegetables farming using untreated wastewater is raising a serious health concern associated with consumption of these vegetables. The potentially toxic elements (PTEs) contents in six selected vegetable samples and their soils from Kano City and Bichi town were evaluated by using atomic absorption spectrophotometer. The concentrations of these metals in both Kano City and Bichi town soils were respectively found to be: Cd (0.001±0.001 to 0.023±0.001 and ND); Co (ND to 0.322±0.004 and ND to 1.485±0.001); Cr (ND to 0.080±0.000 and 0.01±0.00 to 0.083±0.005); Mn (0.043±0.015 to 34.746±0.011 and ND to 25.00±0.000); Ni (0.723±0.011 to 2.8467±0.231 and 1.234±0.000 to 6.542±0.038); Pb (2.202±0.001 to 20.42±0.100 and 1.413±0.001 to 15.570±0.005). While the concentrations of these metals in both Kano City and Bichi town vegetables were respectively found to be: Cd (0.007±0.001 to 0.063±0.001 and ND); Co (ND to 0.133±0.003 and ND to 0.165±0.001); Cr (0.002±0.001 to 0.140±0.010 and 0.035±0.010 to 0.880±0.010); Mn (2.206±0.002 to 15.250±0.051 and 0.198±0.000 to 11.494±0.041); Ni (0.423±0.002 to 5.161±0.002 and 0.928±0.002 to 2.837±0.003); Pb (2.478±0.051 to 13.723±0.552 and ND to 9.668±0.007). The results showed that the concentrations of some PTEs in the analyzed samples are all below the WHO permissible limits, while in some the concentrations are above the WHO permissible limit.

1. Introduction

Human activities such as industrial production, mining, agriculture and transportation release high amount of toxic metals into surface water, soils and ultimately to the biosphere. Accumulation of toxic elements in crop plant is of great concern due to the probability of food contamination through the soil-root interface [1]. Though heavy metals like cadmium, lead, Nickel are not essential for plant growth, they are readily taken up and accumulated by plants in potentially toxic forms. Ingestion of vegetables irrigated with wastewater and grown in soil contaminated with toxic metals possesses a possible risk to human health and wildlife [2]. Heavy metal concentration in the soil solution plays an important role in controlling metal bioavailability to plants [3]. Most of the studies show that the use of wastewater contaminated with heavy metals for irrigation over long period of time increases the heavy metal content of soils above permissible limit. Ultimately, increasing the heavy metal contents in soil also increases the uptake of heavy metals by plants depending on the soil type, plant growth stages and plant species [4].

Vegetables constitute an important part of the human diet, containing carbohydrates and proteins, as well as vitamins, minerals and trace elements [5]. In recent years their consumption is gradually increasing, particularly among the urban communities, and this is due to the increased awareness on the food value of vegetables [6]. However, vegetables may contain both essential and toxic elements over a wide range of concentrations, with their accumulations posing a direct

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threat to human health [7]. Heavy metals such as cadmium, copper, lead, chromium and mercury, are important environmental pollutants, particularly in areas irrigated with wastewater. Heavy metals are the most important contaminants that can be found on the surface and in the tissue of fresh vegetables [8]. Earlier studies by Ewers [9] and Kabata–Pendias [10] as quoted by Lacatusu [11] and reported by Ekwue et al., [12] were aimed at interpreting the levels of soil heavy metals. However, the standards employed for interpreting soil heavy metals pollution/contamination vary from country to country based on chosen factors [11].

In this research work, similar comparison of heavy metals load in vegetables and soils irrigated with wastewater and river water was made using the method adopted by Lacatusu [11] in measuring the concentrations of heavy metals in the vegetables and soil using Atomic Absorption spectrophotometer (model 240FSAA, 200 Series Agilent Technology).

2. Material and methods

2.1. The Study Areas

Kano City is in the center of Kano State (Latitude. 12° 02 N, Longitude 08° 30E) in Northern Nigeria. Kano State is the most populous state in Nigeria. The population of Kano City is estimated at over 3 million according to the 2006 national population census report. Kano State 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 lay to the south of the water divide. The basin is being drained by two major rivers: Kano River and Challawa River [13].

Bichi Local Government Area is hosted by Kano state, the most populous state in Nigeria. Bichi bears almost similar geographical description with Kano City [13, 14].

In Kano City, the gardens of Zungeru-Kwaciri and Zungeru-Gayawa-Dankunkuru were evenly distributed across this stretch, and usually used different wastewater from Jakara dendritic types of drainage basin which carries all domestic and industrial wastewater comprises of over 200 hundred industries ranging from tanneries, rubber and plastic industries, textiles metal smelting industries and abattoirs all discharge their untreated wastewater into the Jakara-Kwaciri-Gama-Gayawa water streams. While in Bichi dry seasons farms distributed on the bank of Bagwai dam. Vegetables such as cabbage (*Brassica oleracea*), lettuce (*Lactuca sativa*), okra (*Hibiscus esculentus*)) spinach (*Amaranthus hybridus)* pepper (*capsicum*) and watermelon (*Citrullus lanatus*) are cultivated in this low laying areas which are believe to be fertile and source of water though, they may be reach in heavy metals.

2.2. Sampling

Ten farms were randomly selected, five (5) from Kano City along Zungeru-Gayawa-Dankunkuru dry seasons farms, and five (5) from Bichi Local Government along Bagwai dam dry season irrigation farms [13]. A total of six vegetables were randomly selected within 2-3 hectares of dry season farms in Kano City and Bichi town, between the month of October and November 2019. All the samples were collected in triplicate.

The entire vegetables samples were uprooted from a point and their respective soils were collected. The soil samples were collected within the depth of 0-15, 20-25, and 30-45 cm depths.

2.3. Chemical Analysis

All the samples were washed, air-dried for one week; oven dried at 65^OC for 24hours, and then digested using the procedure reported by Nafiu and Aisha [15] with slight modification.

The soil samples were dried at 40^OC for 48 hr in hot air oven and crushed and passed through a 2 mm nylon sieve. A diacid mixture was used. A measured amount (5 g) of the soil sample was then transferred into 100 ml beaker to which 25 ml of concentrated HNO_3 and 5 ml of perchloric acid were added in the ratio of 5:1. The mixture was placed on a hot plate at 105^OC for one hour and then temperature was increased to 140^OC until the sample completely dried. After cooling, the solution was mixed and filtered through Whatman No. 42 filter paper into a 50 ml volumetric flask, and made up to 50 ml with distilled water. Digested samples were then analyzed using Atomic Absorption spectrophotometer according to the AOAC [16] procedure as adopted and modified by Babandi et al., [13] Okalebo and Gathua [17]; Anthony and Balwant [18].

Digestion of the vegetables samples was done using a di-acid mixture (HNO_3 and $HClO_4$ in the ratio 3:1). Here 5 ml of concentrated HNO_3 was added to 1 g of the plant material and kept overnight. Then 12 ml of the diacid mixture was added and digested on hot plate until white reddish brown fumes of perchloric acid appeared. After a few hours, the plant sample completely dissolved in the digestion mixture and the solution was evaporated until about 2 ml was left in the flask. These digested samples were then transferred into digestion bottles for analysis using Atomic Absorption spectrophotometer according to the AOAC [16] procedure as adopted and modified by Babandi et al., [13] Emmanuel and Nurudeen [14]; Okalebo and Gathua [17]; Anthony and Balwant [18].

2.4. Quality Control Analysis

All the chemicals used were of analytical grade.

Double deionized water was used for solution preparation and glassware was washed with 10% HNO_3. Standards were prepared for each metal from their stock solution to calibrate the instrument. Precision and accuracy of analysis were checked through repeated analysis [13].

2.5. Statistical Analysis

The data were statistically analyzed by SPSS software version 16.0. All analyses were performed in triplicates. Results were expressed by means of ± SD. Statistical significance was established using one way analysis of variance (ANOVA). Means were separated according to Duncan's multiple range analysis ($p < 0.05$).

3. Results and discussion

The results for the mean concentration of heavy metals in Kano soils are presented in Table 1.0, while that of the mean concentration of heavy metals in Kano vegetables leaves are presented in Table 2.0. Similarly, the results for mean concentration of heavy metals of Bichi Soils are presented in Table 3.0, while that of the mean concentration of heavy metals of Bichi vegetables leaves are presented in Table 4.0. Table 5.0 shows the World Health Organization maximum permissible standard. Table 6.0 gives the significance of pollution indices of heavy metals in vegetables of different farms in Kano, while Table 7.0 gives the significance of pollution indices of heavy metals in vegetables of different farms in Bichi. Table 8.0 shows the significance of intervals of Contamination/Pollution Index (CPI) standard.

Table 1 Mean Concentration of Heavy Metals in Kano Soils

Area	Metals mg/Kg	CSK Mean ±SD	LSK Mean ±SD	OSK Mean ±SD	WSK Mean ±SD	SSK Mean ±SD	PSK Mean ±SD
Kano	Cd	0.007±0.001	0.001±0.001	0.014±0.001	0.009±0.00	0.023±0.001	0.005±0.000
	Co	ND	0.322±0.004	ND	ND	ND	ND
	Cr	0.050±0.010	ND	0.080±0.000	0.050±0.01	ND	ND
	Mn	34.746±0.011	10.382±0.146	3.323±0.103	21.77±0.02	15.920±0.700	0.043±0.015
	Ni	1.721 ±0.051	1.219±0.005	1.228±0.000	0.918±0.00	2.8467±0.231	0.723±0.011
	Pb	10.529±0.027	2.202±0.001	8.713±0.051	18.065±0.00	20.42±0.100	2.802±0.023

Key: CSK Cabbage Soil Kano, **LSK** Lettuce Soil Kano, **OSK** Okra Soil Kano, **WSK** Watermelon Soil Kano, **SSK** Spinach Soil Kano, **PSK** Pepper Soil Kano. **ND** Not Detectible

Table 2 Mean Concentration of Heavy Metals in Kano Vegetables Leaves

Area	Metals mg/Kg	CLK Mean ±SD	LLK Mean ±SD	OLK Mean ±SD	WLK Mean ±SD	SLK Mean ±SD	PLK Mean ±SD
Kano	Cd	0.009±0.00	0.018±0.001	0.063±0.001	0.007±0.001	0.027±0.001	0.022±0.001
	Co	ND	0.133±0.003	ND	ND	ND	ND
	Cr	0.126±0.005	0.063±0.003	0.353±0.025	0.140±0.010	0.002±0.001	0.010±0.00
	Mn	15.250±0.051	11.304±0.001	7.957±0.058	4.550±0.045	2.751±0.000	2.206±0.002
	Ni	2.591 ±0.010	3.544±0.001	3.361±0.048	5.161±0.002	2.152±0.000	0.423±0.002
	Pb	10.081±0.001	7.975±0.032	9.153±0.051	13.723±0.552	9.238±0.100	2.478±0.051

Key: CLK Cabbage Leaves Kano, LLK Lettuce Leaves Kano, OLK Okra Leaves Kano, WLK Watermelon Leaves Kano SLK Spinach Leaves Kano, PLK Pepper Leaves Kano. ND Not Detectible

Table 3 Mean Concentration of Heavy Metals of Bichi Soils

Area	Metals mg/Kg	CSB Mean ±SD	LSB Mean ±SD	OSB Mean ±SD	WSB Mean ±SD	SSB Mean ±SD	PSB Mean ±SD
Bichi	Cd	ND	ND	ND	ND	ND	ND
	Co	ND	1.095±0.005	ND	1.485±0.001	ND	ND
	Cr	0.042±0.040	0.083±0.005	0.070±0.010	0.01±0.00	0.067±0.020	0.020±0.010
	Mn	19.450±0.017	20.161±0.003	12.066±0.002	25.00±0.000	22.023±0.000	ND
	Ni	2.557 ±0.049	3.189±0.002	6.542±0.038	1.234±0.000	1.424±0.010	1.546±0.056
	Pb	5.355±0.019	1.413±0.001	2.291.±0.067	15.570±0.005	11.764±0.294	2.541.±0.001

Key: CSB Cabbage Soil Bichi, LSB Lettuce Soil Bichi, OSB Okra Soil Bichi, WSB Water melon Soil Bichi, SSB Spinach Soil Bichi, PSB Pepper Soil Bichi. ND Not Detectible

Table 4 Mean Concentration of Heavy Metals of Bichi Vegetables Leaves

Area	Metals mg/Kg	CLB Mean ±SD	LLB Mean ±SD	OLB Mean ±SD	WLB Mean ±SD	SLB Mean ±SD	PLB Mean ±SD
Bichi	Cd	ND	ND	ND	ND	ND	ND
	Co	ND	ND	0.022±0.001	ND	ND	0.165±0.001
	Cr	0.146±0.010	0.130±0.010	0.153±0.005	0.035±0.010	0.880±0.010	0.360±0.000
	Mn	2.025±0.001	11.444±0.009	4.673±0.041	11.072±0.019	11.494±0.041	0.198±0.000
	Ni	1.474 ±0.011	0.991±0.004	0.928±0.002	1.443.±0.001	2.837±0.003	1.747±0.022
	Pb	4.050±0.006	1.422±0.010	1.070±0.017	9.668±0.007	ND	3.267±0.304

Key: CLB Cabbage Leaves Bichi, LLB Lettuce Leaves Bichi, OLB Okra Leaves Bichi, WLB Watermelon Leaves Bichi, SLB Spinach Leaves Bichi, PLB Pepper Leaves Bichi. ND Not Detected

Table 5 World Health Organization Maximum Permissible Standard

Metals	MPL in Soils mg/Kg	MPL in Vegetables mg/Kg
Cadmium	3	1.00
Cobalt	50	0.10
Chromium	100	0.10
Manganese	2000	500
Nickel	50	5
Lead	100	0.30

Adapted from Mohsen and Mohsen [19]; Chiroma *et al.,* [20] and Toth [21]

Table 6 Significance of Pollution Indices of Heavy Metals in Vegetables of Different Farms in Kano City

Crop	Mn mg/Kg	Implication of Cp Index	Ni mg/Kg	Implication of Cp Index	Pb mg/Kg	Implication of Cp Index
Cabbage	0.43	Slightly contaminated	1.50	Slightly polluted	0.95	Severely contaminated
Lettuce	1.08	Slightly polluted	2.91	Moderately polluted	3.62	Moderately polluted
Okra	2.39	Slightly polluted	2.69	Moderately polluted	1.50	Slightly polluted
Watermelon	0.21	Moderately contaminated	5.63	Severely polluted	0.75	Severely contaminated
Spinach	0.17	Slightly contaminated	0.78	Slightly contaminated	0.45	Moderately contaminated
Pepper	0.20	Moderately contaminated	0.58	Severely contaminated	0.88	Very severely contaminated

Table 7 Significance of Pollution Indices of Heavy Metals in Vegetables of Different Farms in Bichi

Crop	Mn mg/Kg	Implication of Cp Index	Ni mg/Kg	Implication of Cp Index	Pb mg/Kg	Implication of Cp Index
Cabbage	0.14	Slightly contaminated	0.57	Severely contaminated	0.75	Severely contaminated
Lettuce	0.56	Severely contaminated		Moderately polluted	1.00	Very severely contaminated
Okra	0.38	Moderately contaminated	0.14	Slightly polluted	0.46	Moderately contaminated
Watermelon	0.44	Moderately contaminated	1.16	Moderately polluted	0.64	Slightly contaminated
Spinach	0.52	Severely contaminated	0.50	Slightly contaminated	0.00	Very slightly contaminated
Pepper	0.00	Very slightly contaminated	1.12	Slightly polluted	1.88	Very severely contaminated

Table 8 Significance of Intervals of Contamination/Pollution Index (CPI) standard

CPI	Significance
<0.1	Very slightly contaminated
0.10-0.28	Slightly contaminated
0.26-0.5	Moderately contaminated
0.51-0.75	Severely contaminated
0.76-1.00	Very severely contaminated
1.1-2	Slightly polluted
2.1-4	Moderately polluted
4.1-8	Severely polluted
8.1-16	Very severely polluted
>16	Excessively polluted

Adapted from Chiroma et al., [20]

3.1. Cadmium

Cadmium is a heavy metal classified as a group one carcinogen by IARC [22] affecting multiple systems in humans and animals. Exposure to cadmium occurs primarily through ingestion of contaminated water, food and to a significant extent through inhalation and cigarette smoking [23]. Cadmium has an extremely long biological half-life of 20 years, and it primarily affects the liver, intestine, and the kidneys, with prolong exposure proven to be carcinogenic to almost all body systems ranging from the kidneys, lungs, liver, to prostate and hematopoietic systems [24]. Cadmium is a bioavailable and very mobile metal that easily accumulates in crops and humans [13, 25]. The highest mean cadmium concentration in soils analyzed in this study was obtained from okro soil of Kano City was found to be 0.014±0.001 mg/Kg, with the lowest concentration of 0.001±0.001 mg/Kg equally obtained in the lettuce soil of Kano City, while all the Bichi soil samples reported none detectable cadmium concentrations. Similarly, the highest concentration of cadmium in vegetables was obtained from the Kano City samples, with the okro leaves recording a mean cadmium concentration of 0.063±0.001 mg/Kg, with the lowest concentration of 0.007±0.001 mg/Kg equally obtained in watermelon leaves of Kano, while all the Bichi vegetable samples reported none detectable cadmium concentrations. All the concentrations of cadmium obtained from this study are below the WHO maximum permissible standard of 0.10 mg/Kg. Also the results from this study are in agreement with similar results reported by Salawu *et al.,* [26] who reported a concentration of 0.022±0.0014 mg/Kg for cadmium in spinach, and Mohammad and Folorunsho [27] who reported a concentration of 0.018-8.02 mg/Kg. However, the results from this study are lower than that reported by Adeel and Riffa [28] who reported a higher cadmium concentration of 1.29-5.18 mg/Kg in spinach. The findings are below that reported by Nafiu and Aisha [15] who reported a range of 0.35 to 0.59 mg/Kg in three West African cities including Kano. The variation of this current research and that of the previous works may be due to soil types, soil depth and effluents discharge [27]. Bichi soils and vegetables that recorded no cadmium concentration may be attributed to zero atmospheric deposit of cadmium in the sample area, with the sample area found to experience less anthropogenic activities [19].

3.2. Cobalt

Cobalt is an element which is essential to human health (e.g. it is part of vitamin B), but which in excess amounts can cause serious effects to lungs and heart [29]. Cobalt presence was detected only in Kano lettuce soil and leaves, 0.322±0.049 and 0.133 mg/Kg respectively. This result is far below World Health Organization maximum permissible level of cobalt 50 mg/Kg Table 5 and European union (EU) 100 mg/Kg, this is as well lower than findings of Adeel and Riffa [28] who reported a range of 4.28 to 33.39 mg/Kg, and Babandi *et al.,* [13] reported lower concentration of cobalt in agricultural soil 19 µg/g. The recommended permissible level of cobalt in vegetable by world health organization in soils is 0.1 mg/Kg. Concentration of cobalt were also obtained in this current study in Kano vegetables spinach and pepper leaves 0.027±0.001 and 0.022±0.001 mg/Kg, all the findings are far below the World Health Organization permissible limit, but the findings are in agreement with report by Abdulmojeed and Abdulrahman [30] who recorded cobalt concentration in spinach between 0.24±0.09 to 0.73± 0.06 mg/Kg range and in okra between 0.24±0.16 to 0.97±0.81 range. The uptake of cobalt (Co) by plants varies with plant species. Other researches like Babandi *et al.,* [13] in their study reported cobalt in lettuce 7.00±4.00 µg/g and 13.00±8.00 µg/g, carrot leaves 8.00±4.00 µg/g. On the other

hand, Mohsen and Mohsen [19] reported cobalt concentration of 3.04 mg/Kg in reddish-leaf, higher than this current research. Bichi soil and vegetables samples did not record any trace of cobalt. This may not be unconnected with zero anthropogenic activities around Bichi sampled area, this also in agreement with Mohsen and Mohsen [19] who record no cobalt no (0.00 mg/Kg) in red pepper.

3.3. Chromium

Chromium (Cr) is the 7th most abundant element on the earth [31]. It is a trace mineral required by human health, due to its involvement in the synthesis of fatty acids and cholesterols, metabolism of carbohydrates, proteins, lipids and with role to facilitate the action of insulin [32, 33, 34] its ability to regulate glucose, preventing hyperglycemia or diabetes [35]. Chromium occurs in nature in bound forms that constitute 0.1–0.3 mg/kg of the earth's crust [36]. The highest mean chromium concentration in soils analyzed in this study was obtained from lettuce soil of Bichi was found to be 0.083±0.005 mg/Kg, with the lowest concentration of 0.01±0.000 mg/Kg equally obtained in the watermelon soil of Bichi, while the lettuce, spinach and pepper soil samples of Kano City all reported none detectable chromium concentrations. Also, the highest concentration of chromium in vegetables was obtained from the Bichi samples, with the spinach leaves recording a mean chromium concentration of 0.880±0.010 mg/Kg, with the lowest concentration of 0.010±0.00 mg/Kg obtained in pepper leaves of Kano City. The Bichi spinach leaf that recorded the highest mean chromium concentration is thus not suitable for human consumption since the concentration is far above the WHO maximum permissible limit. However, it can thus be suggested that spinach could be used in phytoremediation of chromium, with similar suggestion initially made by Hossein et al., [37]. All other concentrations of chromium obtained from this study are within or below the WHO maximum permissible standard of 0.10 mg/Kg. The concentrations of chromium in vegetables in the current study were lower than that reported by Babandi et al., [13]; Mohammad and Folorunsho [27] and Mohammed and Sharif [38] who respectively reported 99.00±12.00 µg/g, 21.35 to 35.50 mg/Kg and 4.9 to 13.0 mg/Kg for similar vegetable leaves. The highest means concentration chromium in soil (0.083±0.00 mg/Kg) was found in lettuce soil of Bichi, with the lowest chromium concentration (0.01±0.00 mg/Kg) found in watermelon soil of Bichi. The findings on this study are in agreement with that reported by Abdulmojeed and Abdulrahman [30] who reported some varying concentrations in different vegetables within Kano (spinach 0.85±0.15-0.19±0.03, okra 0.18±0.03-0.74±0.07, and tomatoes 0.16±0.05-0.58±0.03 mg/Kg). The variation in the concentrations of chromium between the sampling sites might be attributed to changes in the redox conditions and other chemical properties of the soil as a result of flooding during irrigation and modification of the soil pH, which might have helped in changing the oxidation state of Cr in the cultivated soil from the stable Cr (III) to the highly mobile Cr (VI) leading to a low residual concentration of this metal [39]. Binding to dissolved organic matter could also be responsible for low Cr concentration in the cultivated soil [39].

3.4. Manganese

Manganese, a naturally occurring element, is an essential nutrient for both animal and plants that comprises of approximately 0.1% of the Earth's crust, and is the twelfth most abundant element and the fifth most abundant metal [40]. As an essential nutrient, several enzyme systems have been reported to interact with or depend on manganese for their catalytic or regulatory function [41]. Human beings are exposed to manganese through consumption of food and water, inhalation of air, and dermal contact with air, water, soil, and consumer products that contain manganese [42], with the dietary source being the primary source of manganese intake. Although low levels of manganese intake are necessary for human health, exposure to high manganese level is highly toxic, with its toxicity resulting in a permanent neurological disorder known as manganism with symptoms that include laboured movement, facial muscle spasms and tremors [43, 44, 45]. These symptoms are often preceded by other lesser symptoms, including irritability, aggressiveness, and hallucinations [45]. Concentrations of manganese in both Kano City and Bichi soils vary considerably, with both the highest and lowest mean concentrations of 34.746±0.011 and 0.043±0.015 respectively coming from Kano soils (cabbage and pepper). However, all the Bichi soil samples recorded high mean values of manganese ranging from 12.066±0.002 to 25.00±0.000 mg/Kg. But all these results (Kano City and Bichi samples) are far below World Health Organization threshold level of manganese in agricultural soils (2000 mg/Kg). The current findings are found to agree with similar findings by Adeel and Riffa [28] who reported a range between 20.48 to 64.19 mg/Kg for manganese in some agricultural soil samples. All the vegetable samples analyzed in this study recorded significant amount of manganese, all of which are, however, far below the WHO maximum permissible limit. The highest recorded concentration of manganese, 15.250± 0.051 mg/Kg, was found in cabbage leaves Kano, while the lowest, 0.198±0.000 mg/Kg, was obtained in the pepper leaves of Bichi. The findings of this study are lower than the mean concentration of manganese reported by Mohsen and Mohsen [19] who reported a mean concentration of 284.75 mg/Kg; and that reported by Chiroma et al., [20] who reported a concentration of 512 to 561 mg/Kg for lettuce leaves. However, the present study falls within the range of concentrations reported by Mohammed and Sharif [38]; Kostova et al., [46]; and Umar et al., [47]. Variation in the manganese concentrations between vegetables might be due to

application of chemical fertilizers and pesticides, as well as soil type [47, 48, 49]. Comparing the contamination pollution index (Cp) of the two sample sites indicated Kano vegetable are more polluted with manganese than Bichi vegetables.

3.5. Nickel (Ni)

Nickel has been considered to be an essential trace element for human and animal health [50], and occurs in the environment only at very low levels and is essential in small doses, but it can be harzardous at extremely high doses [51]. Exposure to large quantities of nickel may be highly carcinogenic, resulting in the cancer of the lungs, nose, larynx and prostate [50]. Exposure to nickel has also been reported to cause birth defect, respiratory failure, lung embolism, asthma and chronic bronchitis [50]. Nickel is unique among plant nutrients because it functions in plant growth and development [52]. Availability of nickel in soil arises from both natural and man-made sources, with man-made source of nickel including sludge and fertilizer applications, metal refining, burning of coal, burning of petroleum products, disposal of waste sewage, metal plating, nickel mining and electroplating, as well as combustion of fossil fuels [53, 54, 55]. Nickel in the present study shows a diversifying results in the two sampling location, Kano vegetable generally shows higher concentrations (2.591±0.010 and 5.161±0.002 mg/Kg) compared to Bichi. High mean levels of nickel in Kano vegetables might be attributed to industrial discharges and emissions [56]. However, all the present findings are way below permissible limit set by World Health Organization of 5.0 mg/Kg, and in agreement with that reported by Abdulmojeed and Abdulrahman [30] in spinach (2.02±0.35 mg/Kg to 1.39± 0.10 mg/Kg); okra (0.08±0.06 to 1.13±0.01 mg/Kg). Similarly, the present study agree with similar result from Sawidis *et al.,* [57]; Sharma *et al.,* [58]; Elbagermi *et al.,* [59]; Guerra *et al.,* [60]. Mohsen and Mohsen [19] reported nickel concentrations (20.52 mg/Kg) far above what has been reported in this study. For concentrations of nickel in the soil samples, both Kano and Bichi recorded nickel between the ranges 0.918±0.005 watermelon soil Kano to 2.8467±0.389 mg/Kg of spinach soil Kano. These results are in agreement with the range of results (0.150 to 1.031 mg/Kg) reported by Ruqia *et al.,* [4]. These results are below permissible limit set by World Health Organization for agricultural soil and European commission (EU) 50 mg/Kg and 75. mg/Kg respectively. Contamination pollution index of all the sampled soil vegetables indicated Kano vegetables are more polluted with nickel than those of Bichi as result of atmospheric deposition as positive factor that increase concentration by transpiration.

3.6. Lead (Pb)

Lead is a naturally occurring toxic metal found in the Earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world [61]. Food is one of the major sources of lead exposure, with air (mainly lead dust originating from petrol) and drinking water being the other sources [62]. Plants may be contaminated with lead through its uptake from ambient air and soil, and animals may then ingest the lead contaminated vegetation. In humans, lead ingestion may arise from eating lead contaminated vegetation or animal foods [63]. In this study the highest mean concentration of lead in soil was found in Kano spinach soil (20.420±0.010 mg/Kg, while the lowest occurred in lettuce soil Bichi (1.413±0.001 mg/Kg), with all these values below the World Health Organization recommended level for agricultural soil of 100 mg/Kg. These values are in agreement with 1.7 to 16.5 mg/Kg range reported by Mohammed and Sharif [38], and 8.38 to 21.40 mg/Kg range reported by Adeel and Riffa [28]. Comparatively, concentrations of lead in this study indicated higher levels of lead in Kano vegetables than those obtained from Bichi vegetables. The highest mean lead concentration in the analyzed vegetables (13.723±0.552) was found in watermelon leaf of Kano. However, it is worthy of notice that watermelon leaves are note typically consumed in Kano and its environs. This result is far above 0.87-1.41 mg/Kg values reported by Mohammad and Folorunsho [27] and 28.00±2.00 mg/Kg reported by Babandi *et al.,* [13]. Lead concentration in the current study indicates that the levels of concentration are found to be above World Health Organization permissible level of 0.30 mg/Kg. Other researcher who reported mean lead concentrations in vegetables higher than the World Health Organization permissible levels include Abdulmojeed and Abdulrahman [30] who recorded lead concentration in spinach around Kano in the range of 0.97±0.05 to 1.60± 0.93 mg/Kg and 0.71±0.04 to 1.10±0.04 for okro. Similarly, Salawu *et al.,* [26] reported mean lead concentration of 0.613±0.0009 mg/Kg; Mohsen and Mohsen [19] reported 2.57 mg/Kg in spinach; Babandi *et al.,* [13] reported 15.00±8.00 mg/Kg in lettuce, and 10.21±0.20 mg/Kg in okro. Comparing the contamination pollution index (Cp) of the two sampled sites, Kano City vegetables are more polluted with lead than Bichi vegetables. Apart from atmospheric deposit of lead, lead concentration may be increased as result of large amount of waste containing lead presence in the environment. 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 [25]. Additionally, since Pb^{2+} is not biodegradable, once soil has become contaminated with it, it remains a long-term source of Pb exposure [64].

Using the criteria of Lacatusu [11] in Tables 6 and 7, the vegetables from the different farms in Kano are excessively polluted (C/P>16) with the three selected heavy metals Ni, Mn and Pb. The vegetables in Bichi are only slightly less contaminated. By the Lacatusu criteria [11], this implies that the urban drainage waters are not safe for vegetable irrigation. This is of very serious concern since the irrigated crops are consumed together with absorbed heavy metals

and thus find their way up the human food chain where they can be very poisonous to consumers. Some of the vegetable may be very dangerous in consideration of their ability to contain heavy metals in large concentrations.

4. Conclusion

Continuous using of untreated wastewater for irrigation for the urban farming has caused an ample buildup of toxic metals contamination in soils and plants, which subsequently bio accumulate in human body causing very dangerous diseases. Hence this necessitates the need for regular monitoring of such urban vegetables to curtail human health risks associated with their consumptions. This study reported the concentrations of some potentially toxic elements in six commonly consumed vegetables in Kano City and Bichi town. The results showed that the concentrations of some of the elements are above the permissible limit recommended by World Health Organization, thus should not be recommended for human consumption.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have no any conflict of interest to report.

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