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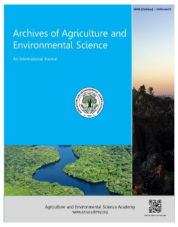

ORIGINAL RESEARCH ARTICLE

Evaluation of nickel levels in wastewater, soil and vegetable samples grown along Kubanni stream channels in Zaria, Kaduna State, Nigeria

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ABSTRACT

The concentration of nickel was evaluated in wastewater, soil and vegetable (carrot, lettuce, onion, spinach, cabbage, tomato and okra) samples that were collected on seasonal basis from January, 2013 to September 2014 along Kubanni stream channels in Zaria. The results showed nickel concentrations in wastewater were in the range of 7.69 – 38.46 mg/L for the year 2013 and 7.68 – 27.04 mg/L in 2014; 1.92 – 21.37 mg/Kg for the year 2013 and 8.24 – 24.32 mg/Kg in 2014 for the soil while the vegetables had concentrations in the range of 6.97 – 18.79 mg/Kg for the year 2013 and 3.78 – 18.27 mg/Kg in 2014. Statistical analysis revealed no significant difference in nickel levels across the locations and seasons for wastewater, soil and vegetables analyzed. Pearson correlation showed substantial ($r = 0.631$) relationship between nickel levels in wastewater for the year 2013 and 2014, negative ($r = -0.284$) relationship was obtained for the soil between these two years whereas substantial ($r = 0.634$) relationship was obtained for vegetables cultivated in 2013 and that of 2014, respectively. Thus, nickel concentrations obtained in this study was higher than maximum contaminant levels set by Standard Organizations such as WHO and FAO for wastewater whereas the soil and vegetables were less to limits set by these bodies.

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INTRODUCTION

Nickel occurs as a mixture of five natural stable isotopes with relative atomic masses of 58, 60, 61, 62 and 64. It is a constituent of most meteorites and its presence is one of the criteria used for identifying them (Wong, 1996). Nickel is used in a large number of alloys including stainless steel, other corrosion-resistant alloys, coins, nickel steel for armor plates, burglarproof vaults, vegetables-oils, ceramic and greenish glass, Al-Ni-Co magnets and Ni-Cd batteries and in the electrolytic coating of items such as chromium-plated taps and fittings used for tap water (David *et al*., 2008). Presence of nickel in the environment arises from both natural and anthropogenic sources. Nickel is present in drinking water, food, soil, air and dust. Small amount of it is needed by the human body to produce red blood cells however, in excessive amounts, can become toxic (ATSDR, 2005). Short-term overexposure to nickel is not known to cause any health problems but long-term exposure cause decreased body weight, heart and liver damage and skin irritation (WHO, 1991). Nickel can accumulate in aquatic organisms but its presence is not magnified along food chains. Acute nickel intoxications are rare and most reported cases are the result of industrial exposure to nickel carbonyl (WHO, 1989). Plants containing more than 100ppm Ni develop symptoms of toxicity. Toxicity in grasses or other monocots closely resembles iron deficiency, exhibiting pale yellow strips running the length of the leaf. In extreme cases, the entire plant may turn white with marginal necrosis (burn) of the leaf. In dicots, Ni toxicity causes an interveinal chlorosis (yellowing) that looks very similar to manganese deficiency (David *et al.,* 2008).

Modern agriculture is becoming nuisance to mankind. The insecticides, pesticides, chemical fertilizers especially nitrate and phosphate are used annually to boost agricultural production and these chemicals are leached down to the soil and eventually end up to contaminate the ground water and stream waterways and River Kubanni is equally surrounded by these types of activities which are likely to pollute the waterway (Iguisi *et al.,* 2001). The major causes of water pollution in most countries of the tropics can be linked to human activities such as sewage and refuse disposal, industrial effluents, agricultural activities, mining and quarrying activities (Olofin, 1991; Abdu *et al.,* 2011). The most common source of water pollution in developing nations is domestic sewage and refuse. Iguisi *et al.* (2001) is of the opinion that several chemical elements including nickel have their origin in the composing high refuse dumps that is similar to pollution pattern in the catchment area of Kubanni River. Several other studies have shown that a considerable number of elements are leached from refuse dumps during rainy season into ground water and stream (Ademoroti, 1996; Butu, 2013). Therefore, the present investigation was aimed to evaluate the levels of nickel in wastewater, soil and vegetable samples grown along Kubanni stream channels in Zaria, Kaduna State, Nigeria.

MATERIALS AND METHODS

Study area: Zaria city is in northern Nigeria on longitude 7˚42˙E and latitude 11˚03˙N, within the drainage of River Kubanni flowing to the south east direction through Ahmadu Bello University (Figure 1). The vegetation of the area is the savannah type with more grasses than hard wood trees. The average annual rainfall is 875mm and the temperature varies between 27 to 35˚C with a relative humidity (Frederick *et al.,* 2006). The geology of the study area is composed mainly of fine grain gneisses and migmatite with some coarse-grained granitic outcrops in few places. The soil of the study area is mainly sandy-clay loam with poor infiltration because of the high clay content. The entire vegetation and soils of the study area have been under great anthropogenic influences which have greatly modified the entire landscape (Iguisi, 1997). Kubanni River is known for its human activities like farming, source of drinking water, washing and fishing. Some peasant farmers use its bank for farming throughout the year especially Sabon-gari area, here there is planting of vegetables of different varieties.

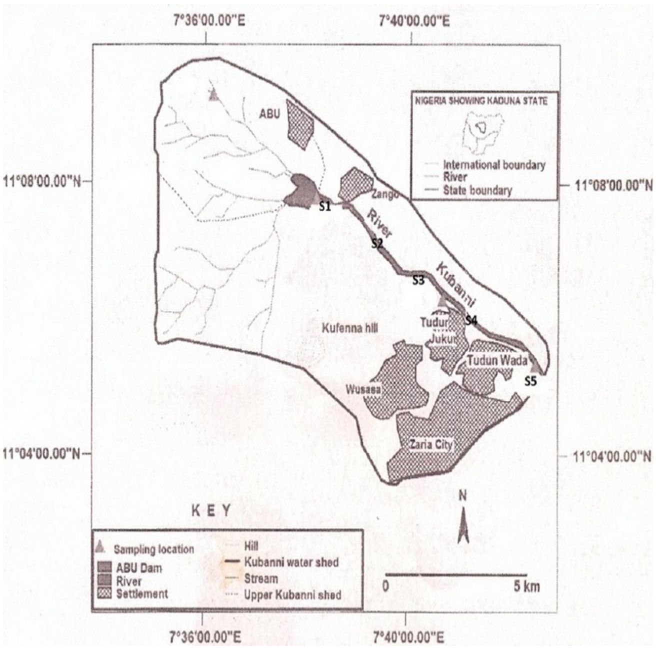

Figure 1. *Map of the study area showing sampling locations.*

This necessitates irrigated farming system to meet up with the demand for vegetables and promotes the use of wastewater, herbicides, fungicides, pesticides and fertilizers which are sources of pollutants. High population of the area coupled with the amount of waste that is indiscriminately discharged into the body of Kubanni River makes it prone for contamination which necessitates the study on the nature of vegetables consumed by people from the area. This study is aimed at ascertaining the extent to which nickel is accumulated in wastewater, soil and vegetables through man-made activities**.**

Sampling and analysis: Wastewater samples from Kubanni stream were obtained from five different sampling points on a four month basis along the stream channels for the period of two years. Sampling was conducted in the harmattan, dry and rainy seasons. Wastewater samples were collected using composite sampling in polyethylene plastic containers that were previously cleaned by washing in non-ionic detergent and then rinsed with tap water and soaked in 10% HNO_3 for 24 hours and finally rinsed with deionized water prior to usage (Ademoroti, 1996). During sampling, sample bottles used were rinsed with sampled water three times and then filled to the brim at a depth of one meter below the wastewater from each of the five designated sampling points. Wastewater sample bottles were labelled, stored in ice-blocked coolers and transported to the laboratory. While in the laboratory, they were stored in the refrigerator at about 4°C prior to the analysis (APHA, 1998). Soil samples were collected at three depths (0-5 cm, 5-10 cm and 10-15 cm) from both sides of the river banks by using spiral auger of 2.5 cm diameter. Soil samples were randomly sampled and bulked together to form a composite sample from each designated point. They were then put in clean plastic bags, labelled and transported to the laboratory. The full grown vegetable of spinach (*Amaranthus hybridus*), lettuce (*Lactuca sativa*), cabbage *(Brassica oleracea*), carrot (*Daucus carota*), okra (*Hibiscus esculentus*), onion (*Allium cepa*) and tomato (*Lycopersicon esculenetum*) were randomly handpicked from various garden plots along Kubanni stream channels using hand gloves, bulked together to form a composite sample, wrapped in big brown envelopes, labeled accordingly and transported to the laboratory.

Sample treatment: Wastewaters used for determination of nickel were acidified at the points of sampling with $1cm^3$ of concentrated HNO_3 to avoid microbial activities on the wastewaters which might reduce the concentrations of intended nickel before analysis and they were kept in a refrigerator prior to analysis (APHA, 1998). Soil samples were air-dried, crushed and passed through 2 mm mesh sieve. The soil samples were then put in clean plastic bags sealed and labelled accordingly. Each vegetable samples were washed with tap water, followed by deionized water, air dried in the laboratory, ground to powder and sieved using 250 µm sieve (Samira *et al.,* 2009).

Digestion of wastewater samples for nickel determination: 1000 cm^3 of each wastewater sample was transferred into a 1000 cm^3 beaker and 5 cm^3 concentrated HNO_3 was added. The beaker with the content was placed on a sand bath and evaporated down to about 20 cm^3 and this was analyzed as described by Association of Official Analytical Chemist (AOAC, 1995). Nickel was determined at 232 nm wavelengths using Atomic Absorption Spectrophotometer (AAS) Alpha-4 Model.

Determination of nickel in soil samples: 2 grams of each soil sample was weighed into acid-washed glass beakers. Soil samples were digested by the addition of 20 cm^3 of aqua-regia (mixture of HCl and HNO_3 in ratio 3:1) to each soil sample and 10 cm^3 of 30 % H_2O_2 were added in small portion to avoid any possible overflow leading to loss of material from the beaker. The beakers were covered with watch glasses and heated at 90 degrees Celsius on a water bath for 2 hours. The beakers wall and watch-glasses were washed with deionized water and the samples were filtered out to separate the insoluble solid from the supernatant liquid. Soil samples volume was made up to 100 cm^3 by adding deionized water to the mark levels. It was then analyzed for Ni at 232 nm wavelengths using Atomic Absorption Spectrophotometer (AAS) Alpha-4 Model (AOAC, 1995).

Digestion of vegetable samples for nickel determination: 3 grams of the dry sample of each vegetable sample was ashed using muffle furnace set at 450 °C for 3 hours. On cooling, the ash was transferred to a decomposition flasks and 1cm^3 of concentrated HNO_3 was added and then analyzed as described by (AOAC, 1995).

Statistical analysis: The results of nickel in wastewater, soil and vegetables analyzed were expressed in form of bar-charts. The results obtained were subjected to one way Analysis of Variances (ANOVA) and Pearson Product Moment Correlations (PPMC) using Statistical Package for the Social Sciences (SPSS) 20.0 version software. Null hypothesis was adopted and this was set at 95% confidence mean level to check if there is significant difference in the concentrations of nickel analyzed. Statistical decision for Pearson correlation coefficients (r) were in accordance to Robert (1992).

RESULTS AND DISCUSSION

Nickel levels in wastewater from Kubanni stream channels are presented in Figure 2. The concentrations determined were in the range of 7.69 – 38.46 mg/L for the year I. Highest level was noticed at Industrial-area along Jos road (38.46 mg/L) during the harmattan season followed by 27.04 mg/L at Sabon-gari in the dry season and closely followed by 23.50 mg/L at Unguwa-fulani in the same dry season whereas the lowest concentration of 7.69 mg/L was recorded at both Unguwa-fulani and Sabon-gari during the rainy season. Other sampling sites with high levels of nickel were Tundun-wada (23.08 mg/L) in the rainy season, Kwangila (23.10 mg/L) during the harmattan season, Industrial-area along Jos road (21.40 mg/L) and Tundun-wada (19.27 mg/L) both in the dry season. Similar concentration of 15.36 mg/L was observed at these sites; Unguwa-fulani, Sabon-gari and Tundun-wada sampling sites during the harmattan season.

High concentrations of nickel throughout the sampling could be traced to indiscriminate dispose of Ni-Cd batteries and number of alloys rich in nickel such as stainless steel, coins, burglarproof vaults coupled with industrial effluents around the sampling sites as suggested by David *et al*. (2008). Nickel concentrations in year II were in the range of 7.68 – 27.04 mg/L. Lowest level was found at Sabon-gari (7.68 mg/L) during the rainy season while highest concentration of 27.04 mg/L was obtained at Unguwa-fulani in the dry season. Other sites with high levels of nickel were Industrial-area along Jos road with concentrations of 24.42 mg/L and 22.04 mg/L respectively in the harmattan and rainy seasons, Tundun-wada (21.73 mg/L) during the dry season and 16.49mg/L at Sabon-gari in the dry season. Comparing the results obtained for the year I with that of year II, it was revealed from bar chart that harmattan season of year I (15.40 – 38.46 mg/L) had high level of nickel than harmattan season of year II (12.08 – 24.42 mg/L). Likewise, slightly increase was observed in nickel level from dry season of year I (17.40 – 27.04 mg/L) to dry season of year II (15.42 – 27.04 mg/L) whereas rainy season of year I (7.69 – 23.08 mg/L) showed high level of nickel in wastewater than rainy season of year II (7.65 – 22.04 mg/L). No much increment was observed in nickel levels across the sampling sites and seasons however, Industrial-area along Jos road (13.58 – 38.46 mg/L) showed more accumulation of nickel than other sampling sites. This was followed by Tundun-wada sampling site having concentrations in the range of 22.04 – 23.08 mg/L. The concentrations obtained in this study exceed maximum allowable limit of 1.40 mg/L set by FAO/WHO (1995).

Figure 3 presents nickel concentrations in soil from Kubanni stream channels. The concentrations determined were in the range of 1.92 – 21.37 mg/Kg for the year I. Highest level of 21.37 mg/Kg was obtained at Kwangila site during dry season followed by 19.23 mg/Kg at the same sampling site but in the harmattan season whereas the least level of 1.92 mg/Kg was noticed at Tundun-wada during the rainy season. High levels of nickel were also found at Tundun-wada (17.29 mg/Kg) in the dry season, Sabon-gari (15.68 mg/Kg) in the same dry season, 15.38 mg/Kg at Tundun-wada in the harmattan season and 12.05 mg/Kg at Industrial-area along Jos road in the dry season. Elevated levels of nickel during harmattan and dry seasons could be as a result of prolong use of these sampling sites for farming led to accumulation of heavy metals like nickel as suggested by Prasad (2004). There was gradual build-up in nickel levels from harmattan to dry season in these sites; Kwangila, Sabon-gari, Tundun-wada and Industrial-area along Jos road while a decline was observed at Unguwa-fulani as indicated in figure 3. This could be traced to excessive use of wastewater combined with fertilizer applications on the soil as suggested by Oyedele *et al*. (2006). Generally, rainy season showed low levels of nickel (1.92 – 7.60 mg/Kg) in the soil. In this period, highest concentration of 7.60 mg/Kg was found at both Sabon-gari and Kwangila sites while Tundun-wada (1.92 mg/Kg) had the least level. In the year II, concentrations determined for nickel were in the range of 8.24 – 24.32 mg/Kg. Highest level of 24.32 mg/Kg was found at Kwangila during the harmattan season followed by 23.04 mg/Kg at Industrial-area along Jos road in the rainy season and this was closely followed by 21.74 mg/Kg at Tundun-wada sampling site in the harmattan season while the least concentration of 8.24

mg/Kg was recorded at Kwangila sampling site in the dry season. Highest levels of nickel at Kwangila site in both years could be related to proximity of this site to refuse-depots as these riches in Ni-Cd batteries and other coated metallic objects which could easily leach beneath the earth crust as suggested by Nyle and Ray (1999). High concentrations of nickel were also observed at; Kwangila (20.04 mg/Kg) during the rainy season, Industrial-area along Jos road (18.89 mg/Kg) in the harmattan season, Sabon-gari (16.02 mg/Kg) during the rainy season and Unguwa-fulani (16.47 mg/Kg) in the harmattan season. The chart showed high levels of nickel in soil during the rainy season (13.75 – 23.04 mg/Kg) than dry season (8.24 – 15.29 mg/Kg). This could be as a result of excessive application of manure/fertilizers coupled with leaching from nearby refuse dumpsites as suggested by Wong (1996). Comparing the results obtained for the year I and II, it was observed that harmattan season of year I (7.69 – 19.23 mg/Kg) had less accumulation of nickel than harmattan season of year II (13.21 – 24.32 mg/Kg) whereas dry season of year I (6.87 – 21.37 mg/Kg) showed more concentrations of nickel than dry season of year II (8.24 – 15.29 mg/Kg). This disparity in concentrations might be traced to flooding in year I. However, rainy season of year I (1.92 – 7.60 mg/Kg) was far less to rainy season of year II (13.75 – 23.04 mg/Kg). Nickel had moderate level at Sabon-gari having concentrations in the range of 7.6 – 15.68 mg/Kg across the sampling periods. Generally, there was build-up of nickel from rainy season (1.92 – 7.60 mg/Kg) to harmattan season (13.21 – 24.32 mg/Kg) throughout the period of analyses. This might be related to high amount of wastewater and fertilizers applied to irrigate the vegetables during the drought of rain as suggested by workers like Abdu *et al.* (2011) and Kumar *et al.* (2009). Results obtained in this study was less than suggested concentrations by FAO/WHO (50.0 mg/Kg), European Union (75.0 mg/Kg), United Kingdom (50 - 110 mg/Kg) and United State of America (210 mg/Kg) for nickel in soil (CCME, 2001).

Nickel concentrations in vegetables grown along Kubanni stream channels are presented in Figure 4. The concentrations determined were in the range of 6.97 – 18.79 mg/Kg for the year I. Highest concentration of 18.79 mg/Kg was found in lettuce followed by 18.63 mg/Kg in okra and this was closely followed by 16.27 mg/Kg in onion, all these concentrations were obtained in the dry season whereas the least level of 6.97 mg/Kg was obtained in tomato cultivated in the harmattan season. Other vegetables with high levels of nickel were spinach (15.70 mg/Kg) in the dry season, 15.38 mg/Kg in carrot and 15.39 mg/Kg in tomato both results were obtained in the rainy season and 12.50 mg/Kg in cabbage during the dry season. Elevated levels of nickel during dry season could be attributed to the nature of wastewater use for irrigation coupled with indiscriminate discharge of industrial-effluents into the body of Kubanni River as suggested by Butu (2013). Vegetables analyzed had concentrations in the range of 3.78 – 18.27 mg/Kg for the year II. Highest level was noticed in cabbage (18.27 mg/Kg) cultivated in the harmattan season followed by okra (16.75 mg/Kg) during the dry season and this was closely followed by 14.37 mg/Kg in onion planted during the harmattan season while the least level of 3.78 mg/Kg was recorded in onion cultivated in the rainy season. Other vegetables with high levels of nickel were; tomato (14.05 mg/Kg), spinach (13.98 mg/Kg), carrot (13.75 mg/Kg) and lettuce (13.05 mg/Kg) all these results were obtained in the dry season. High level of nickel in the dry season could be traced to the reason given above as indiscriminate discharge of effluent increases the levels of nickel as suggested by Butu (2013). Comparing the results obtained in the year I with that of year II, it was revealed that dry season of year I (11.31 – 18.63 mg/Kg) was slightly higher than dry season of year II (9.43 – 16.75 mg/Kg). Likewise, rainy season of year I (7.00 – 15.39 mg/Kg) had high concentration of nickel in vegetables that the corresponding rainy season of year II (3.78 – 12.08 mg/Kg) whereas harmattan season of year II (4.63 – 18.27 mg/Kg) showed high concentration of nickel than harmattan season of year I (6.97 – 15.09 mg/Kg). The vegetables analyzed showed high accumulation of nickel throughout the sampling periods as indicated in figure 4 which could be attributed to industrial effluents coupled with numerous dumpsites within the sampling sites because of their proximity to Zaria city. Nickel level in this study was below permissible limit of 67.0 mg/Kgset by FAO/WHO (1995) thereby these vegetables are free of its contamination. Mohsen and Seilsepor, 2008 (0.01 – 20.52 mg/Kg) and Abdu *et al.* 2011 (0 – 17 mg/Kg) reported levels that were similar to the concentrations obtained in this study.

Analysis of Variance in Table 1 above shows, $p = 0.306 > 0.050$ this means that there is no significant difference in nickel concentrations from one sampling site to another. This is more elaborated from their mean and standard deviation as thus; Kwangila (16.325±3.658), Unguwa-fulani (15.687±7.996), Sabon-gari (14.957±7.135), Tundun-wada (17.885±4.035) and Industrial area along Jos road (22.633±8.750), respectively. ANOVA Table 1 also reveals $p = 0.789 > 0.050$ this means that there is no significant difference in nickel levels from one season to another. It indicates nickel concentration does not change significantly within the sampling period when dry season of year I compared with that of dry season of year II as it showed from their mean and standard deviation as thus; harmattan season year I (16.816±6.649), dry season year I (20.692±5.901), rainy season year I (14.400±3.933), harmattan season year II (16.924±7.496), dry season year II (19.272±10.853) and rainy season year II (16.880±5.845). Table 2 presents summary of Pearson Product Moment Correlation (PPMC) which conducted to establish the relationship between nickel levels in wastewater for the year I and II. The mean with standard deviation level of 18.912±7.761 was recorded in year I while 16.083±5.528 were obtained in year II. Statistical analysis indicated Pearson correlation $(r) = 0.631$, degree of freedom $(df) = 13$ and $p = 0.012 < 0.050$ this means that there is substantial relationship between nickel levels in wastewater for the first year to that of second year.

ANOVA in Table 3, shows $p = 0.677 > 0.050$ this means that there is no significant difference in nickel levels among the soil of sampling sites. This is reflected from their mean and standard deviation as thus; Kwangila

(16.815±7.073), Unguwa-fulani (11.678±6.667), Sabon-gari (12.417±3.228), Tundun-wada (13.880±6.621) and Industrial-area along Jos road (13.468±7.103) respectively. Also, the same Table 3 shows p = 0.840 > 0.050 this means that there is no significant difference in nickel concentrations across the seasons. This could be explained from their mean and standard deviation as thus; harmattan season year I (14.146±6.720), dry season year I (12.844±7.783), rainy season year I (12.464±7.001), harmattan season year II (16.312±4.733), dry season year II (11.210±3.856) and rainy season year II (14.934±7.681) respectively. Table 4 presents summary of PPMC for nickel concentrations in soil between the year I and II as to establish their relationship. Statistical data revealed the mean with standard deviation of nickel to be 10.647±5.986 in year I while 16.657±4.754 was obtained in year II with the degree of freedom (df) = 13, Pearson correlation (r) = -0.284 and p = 0.305 > 0.050 this mean that there is negative relationship in nickel levels for soil between year I to that of year II. The result is jusified since bar-chart showed remarkable increase in nickel concentrations during the rainy season of year II than usual.

Table 5 presents Analysis of Variance for nickel in vegetables and shows, p = 0.934 > 0.050 this means that there is no significant difference in nickel levels among various vegetables analyzed. Their mean and standard deviation illustrate these; carrot (12.558±2.102), lettuce (10.782±4.871), onion (11.175±4.980), spinach (9.757±3.995), cabbage (10.958±4.032), tomato (12.070±3.001) and okra (10.448±5.819), respectively. Also, Table 5 shows p = 0.448 > 0.050 this means that there is no significant difference in nickel concentrations across the seasons. Their mean with standard deviation give these; harmattan season year I (9.267±3.130), dry season year I (12.721±5.502), rainy season year I (12.107±4.338), harmattan season year II (10.041±4.254), dry season year II (12.529±3.291) and rainy season year II (9.976±3.311) respectively. In addition, Table 5 indicates p = 0.000 < 0.050 this means that there is high significant difference in nickel concentrations among wastewater, soil and vegetables of the sampling sites. Their mean and standard deviation show these; wastewater (17.497±6.775), soil (13.652±6.128) and vegetable (11.107±4.051), respectively. Table 6 presents summary of Pearson Product Moment Correlation (PPMC) to show relationship between nickel levels in vegetables for the year I and II. Statistical data showed that the mean with standard deviation level for nickel was 11.663±4.058 in year I while 10.551±4.065 was obtained in year II. Statistical analysis indicated Pearson correlation (r) = 0.634, degree of freedom (df) = 19 and p = 0.002 < 0.050 this means that there is substantial relationship between nickel concentrations in vegetables for the year I and II, respectively.

Table 1. Analysis of variance (ANOVA) for nickel in wastewater.

Analysis of Variance		Sum of Square	df	Mean Square	F	Significance
Nickel in Wastewater (Locations)	Between Groups	225.820	4	56.455	1.277	0.306
	Within Groups	1105.369	25	44.215		
	Total	1331.189	29			
Nickel in Wastewater (Seasons)	Between Groups	120.614	5	24.123	0.478	0.789
	Within Groups	1210.575	24	50.441		
	Total	1331.189	29			

Table 2. Summary of Pearson product moment correlation for nickel in wastewater.

Variables	N	$\bar{x}$	SD	r	df	Significance
Nickel Year I	15	18.912	7.761	0.631	13	0.012
Nickel Year II	15	16.083	5.528			

Table 3. Analysis of variance (ANOVA) for nickel in soil (Locations and seasons).

Analysis of Variance		Sum of Square	df	Mean Square	F	Significance
Nickel in Soil (Locations)	Between Groups	93.070	4	23.268	0.584	0.677
	Within Groups	995.863	25	39.835		
	Total	1088.993	29			
Nickel in Soil (Seasons)	Between Groups	84.954	5	16.991	0.406	0.840
	Within Groups	1003.979	24	41.832		
	Total	1088.933	29			

Table 4. Summary of Pearson product moment correlation for nickel in soil.

Variables	N	$\bar{x}$	SD	r	df	Significance
Nickel Year I	15	10.647	5.986	-0.284	13	0.305
Nickel Year II	15	16.657	4.754			

Table 5: Analysis of variance (ANOVA) for nickel in vegetables.

Analysis of Variance		Sum of Square	df	Mean Square	F	Significance
Nickel in Vegetable (Among various vegetable)	Between Groups	32.541	6	5.424	0.297	0.934
	Within Groups	640.174	35	18.291		
	Total	672.715	41			
Nickel in Vegetable (Seasons)	Between Groups	79.995	5	15.999	0.972	0.448
	Within Groups	592.720	36	16.464		
	Total	672.715	41			
Nickel Among Wastewater, Soil & Vegetable	Between Groups	714.952	2	357.476	11.443	0.000
	Within Groups	3092.837	99	31.241		
	Total	3807.789	101			

Table 6. Summary of Pearson product moment correlation for nickel in vegetable.

Variables	N	$\bar{x}$	SD	r	df	Significance
Nickel Year I	21	11.663	4.058	0.634	19	0.002
Nickel Year II	21	10.551	4.065			

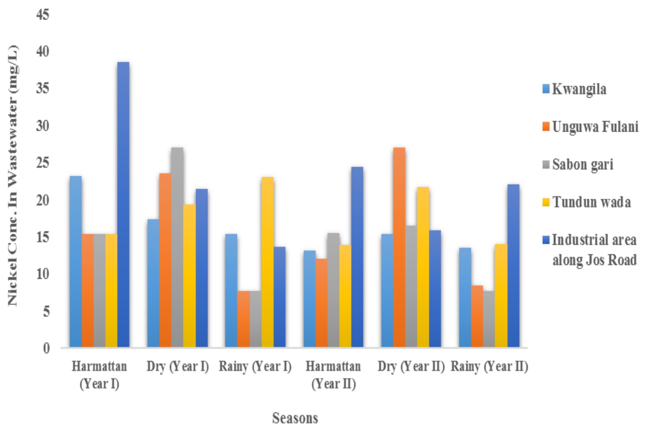

Figure 2. *Nickel concentrations in wastewater from Kubanni stream Channels, Zaria.*

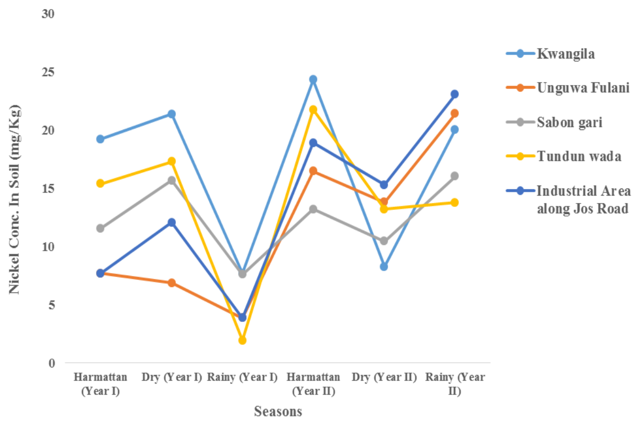

Figure 3. *Nickel concentrations in soil from Kubanni stream channels, Zaria.*

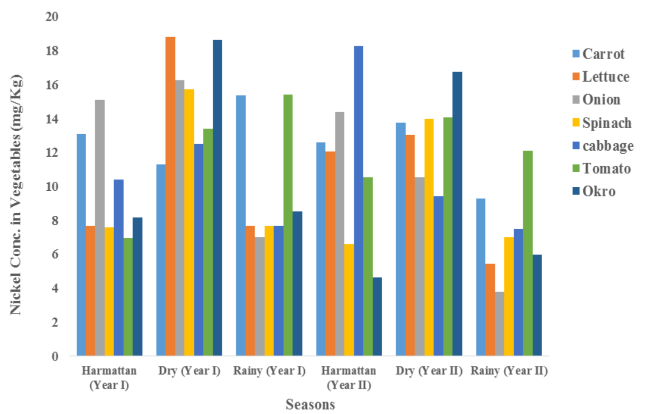

Figure 4. *Nickel concentrations in vegetables from Kubanni stream channels, Zaria.*

Conclusions

The levels of nickel analyzed in the various sampling sites were found in this order: Kwangila>Tundunwada> Industrial area along Jos road >Sabon-gari> Unguwa-fulani while the level of nickel in vegetables showed the order of carrot > tomato > onion > cabbage > lettuce > okra > spinach. In conclusion, it can be deduced that, there is need to find means of removing this heavy metal (nickel) which might make these vegetables unsuitable for human consumption in near future by stop using untreated wastewater to irrigate the farmlands in the studied area and stop indiscriminate discharge of refuse into the body of Kubanni River by providing appropriate dumpsites within the vicinity.

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