Oriental Journal of Chemistry Vol. **26**(4), 1299-1308 (2010)

Assessment of some heavy metals in lettuce, Sesame and Okra irrigated from the bank of Challawa river Kano, Nigeria

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(Received: September 03, 2010; Accepted: October 21, 2010)

ABSTRACT

The concentration of copper (Cu), Zinc (Zn), manganese (Mn), lead (Pb), Chromium (Cr) and Nickel (Ni) in various vegetables Viz, Lettuce, Sesame and Okra irrigated from the bank of River Challawa Kano, Nigeria were assessed using atomic absorption spectrophotometer. The concentration ranges of Cu, Zn, Mn, Pb, Cr and Ni in the leaves of lettuce and sesame were found to be from 3.20-6.40, 10.00-35.00, 9.00-19.00, 6.00-13.00, 8.00-19.00 and 5.00-10.00mgkg^{-1}and 3.20-7.20, 9.00-28.00, 10.00-24.00, 2.00-6.00, 6.00-14.00 and 2.00-6.00mgkg^{-1} on dry weight basis, respectively. For okra fruits, the ranges were from 3.20-8.40, 8.00-20.00, 9.00-22.00, 3.00-9.00, 4.00-13.00 and 4.00-9.00mgkg^{-1} dry weight. The mean concentration of Cu, Zn, Mn, Pb, Cr and Ni were found to be above the recommended maximum acceptable limits proposed by the Food and Agricultural organization (FAO), joint world health organization (WHO) / European Union (EU) and joint Food and Agricultural organization (FAO) and joint world health organization (WHO) experts limits. The mean concentrations of these metals determined in the study area were higher with the respective values of Cu(4.400mgkg^{-1}), Zn(19.375mgkg^{-1}), Mn(14.500mgkg^{-1}), Pb(9.437mgkg^{-1}), Cr(13.594mgkg^{-1}), Ni(7.188mgkg^{-1}) for lettuce while the vales for sesame and okra were; Cu(5.125mgkg^{-1}), Zn(16.688mgkg^{-1}), Mn(16.688mgkg^{-1}), Pb(3.656mgkg^{-1}), Cr(10.219mgkg^{-1}), Ni(4.013mgkg^{-1}) and Cu(5.947mgkg^{-1}), Zn(13.594mgkg^{-1}), Mn(14.469mgkg^{-1}), Pb(5.875mgkg^{-1}), Cr(8.969mgkg^{-1}), Ni(6.188mgkg^{-1}) respectively. These higher values in the samples compared with the control area might be attributed to the used of untreated effluents from tannery industries by the farmers for the irrigation of these vegetables. Thus, the high values of these heavy metals in the vegetable samples could put the consumers of these vegetables at health risk with time.

Key words: Heavy metals, Vegetables, Challawa river, Nigeria.

INTRODUCTION

Vegetables offer the most rapid and lowest cost source of vitamins, fibres and minerals to the majority of people in developing nations. Vegetables are usually consumed in relatively small amounts as side –dish or relish with the staple foods. They also constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins and trace elements (Dastane, 1987). However, in recent years their consumption is increasing gradually, particularly among the urban community. This is due to increased awareness on the food value of vegetables, as a result of exposure to other cultures and acquiring proper education (Fisseha, 2002).

Developing countries in dry season are expanding agricultural food production on marginal land surrounding cities with major ecological problems. These include the lack of waste water treatment facilities, the scarcity of high quality irrigation water and increasing heavy metal pollution of soil and water (Hetal, *et al.,* 1994). Considerable loads of heavy metals from domestic and industrial origins therefore find their way into soil through the agricultural irrigation drainage system. Similar increase in heavy metal pollution on many sites has occurred during the last decades due to increasing application of industrial materials and the lack of measures for population control. (Helal *et al.,* 1997). Heavy metals released from anthropogenic sources have entered the environment and have followed normal biogeochemical cycles. At a time when environmental quality and food production are of major concern to man, the transfer of heavy metal from polluted soils to the food chain has been a subject of extensive research over the last few years.

Past experience had shown that developmental projects created with the aim of producing social economic benefits, have also produce adverse environmental impacts (FAO, 2000) such as industrialization. The vegetable farms at Challawa are among the biggest farms in Kano where a substantial amount of vegetables is being produced seasonally. These farms are irrigated with the contaminated water from River Challawa. In the past, the water from River Challawa was clean. However, with increase industrialization, the water has now become contaminated with various pollutants, among which are heavy metals.

Kano, a city in northern Nigeria, is home to 70% of Nigeria's tanneries most of which are in Challawa industrial estate. The effluents generated by the tanneries are channeled into River Challawa. Consequently the amount of pollutants and wastes generated by the tanning industries pose significant health hazard to the vegetable crops grown on the bank of River Challawa. This is because, in a bid to struggle for survival, the Challawa farmers use the contaminated water for irrigation purposes. As a result, vegetables grown at the contaminated sites could take up and accumulate heavy metals at concentrations that are toxic thereby exposing consumers of these vegetables to bioaccumulation of heavy metals with time. So it has become necessary to asses the level of heavy metals in okra, lettuces and sesame in order to have an insight into the impact of tannery operations on vegetable crops grown on the bank of the River.

MATERIAL AND METHODS

Location of study area

The study area is Challawa industrial estate which is located in southern part of Kano metropolis, under Kumbotso local government area of Kano. Kano state is located in the Northern part of Nigeria, covering an area extending between latitude $12^0 40^1$ and $10^0 30^1$ and longitude $7^0 40^1$ and $9^0 30^1$. Kano is the centre of Nigeria's tanning industries (Faboya, 1997). Most of the tanneries in Kano are situated in Challawa industrial estate and the industrial effluent discharged from this area and other industries located within the estate are channeled into an important river called River Challawa where irrigation farming is taking place through out the dry season.

Location of sampling sites

The sampling sites are located along the River Challawa bank. The exposed site are located after the second effluent discharge point, while the control sites are the upstream before the effluent discharge point (Fig 3.3)

Sample collection

The vegetables used in this study were collected in May 2008 and a total of one hundred and forty four recently matured vegetables. (Lettuce, okra and sesame) were collected. Samples were collected from two regions, one being the control area before and the other the irrigated area after the effluent from three different farm sites. At each farm site, a transect of 5mx5m was selected at random from which vegetable samples were collected.

The edible portions of the three vegetables were randomly sampled from each transect. Leafy vegetables were preferred for sampling even though one fruit (okra) was also peck since a past research has indicated that leaves accommodate heavy metals at greater capacity than other vegetables (Jindasa *et.al.,* 1997).

Sample preparation and pre-treatment

After harvesting and transportation to the laboratory, the edible portions of the vegetable materials were prepared for analysis by carefully rinsing with tap water to remove surface dust. Dead or yellow leaves of lettuces and sesame were discarded. They were rinsed again with distilled water and cut into smaller portions and placed in larger crucibles where they were oven dried at 105^{o}C for about 24 hours. The dried samples were ground into fine particles using clean acid washed mortar and pestle. The finely ground samples were placed in labeled plastic Petri dishes and kept in desiccators to attain constant weights (Apha,1992). These were then stored in air tight polythene bags until they were needed for digestion for analysis.

Digestion of samples

0.5g of the dried samples were weighed with a digital balance (GR-200-EC) into 100ml beaker in triplicate.5cm^{3}of concentrated nitric acid and 2cm^3 of perchloric acid were added and the mixture was heated on a low heat hot plate for 15 minutes at 70^{0}C until a light coloured solutions were obtained. The obtained digests were filtered into 50ml standard flasks that were made up to the mark using distilled water. The sample digest were run on AAS machine model 210 VGP and the absorbance recorded, the concentrations of the metals were then read off from the calibration graphs.

RESULTS AND DISCUSSION

The mean concentrations, ranges and standard deviations of heavy metal concentrations in mgkg^{-1} in lettuce samples obtained from the study area were as shown in table 4.1. The concentrations of heavy metals in these samples were quite variable such as Cu (3.20-6.40 mgkg^{-1}), Zn (10.00-35.00mgkg^{-1}), Mn (9.00-19.00mgkg^{-1}), Pb (6.00-13.00mgkg^{-1}), Cr (8.00-19.00mgkg^{-1}) and Ni (5.00-10.00mgkg^{-1}) and these ranges gave the concentrations of these parameters in the order Zn > Mn > Cr > Pb > Ni > Cu. The levels of these heavy metals in lettuce were comparable generally to those previously found in the vegetables from the same area, but remarkable differences were recorded. Higher concentration than those reported by Musa (2oo8), and Awode (2008) were obtained. These metals were found at concentrations that were twice higher than those reported for tomatoes and onions. These differences may be ascribed to the fact that, heavy metal concentrations in harvested vegetables often show large variations from year to year even at the same location in the field due to variations in the emission rates, atmospheric transport, deposition processes and plant up take. The results obtained for Cu and Zn concentration in lettuce in this study were generally higher than most of the reported values for lettuce (Iyaka, 2007).

Table 4.2 shows correlation matrices between heavy metals contents in lettuce of the study sample (exposed). Some significant correlation were observed between Zn and Mn (r = 0.429), Zn and Cr (r = 0.468), Pb and Ni (r = 0.438) which means probably having the same source. The table also shows positive correlation between (Cu: Zn, Mn,Pb), (Zn : Mn, Pb, Cr, Ni), (Mn: Pb, Ni) and (Cr: Ni). These further suggest that the metals might have originated from the same anthropogenic or geochemical sources.

The means ranges and standard deviations of heavy metal concentrations (mgkg^{-1} dry weight) in sesame samples obtained from the study area were given in Table 4.4. For Cu, the concentrations ranged from 3.200-7.200mgkg^{-1}and for Zn, Mn, Pb, Cr and Ni, ranged from 9.00-28.00mgkg^{-1}, 10.00-24.00mgkg^{-1}, 6.00-14.00mgkg^{-1} and 2.00-6.00mgkg^{-1} respectively. The magnitudes of the mean metal concentrations were in the order Zn > Mn > Cr > Cu > Ni >Pb. Table 4.5 shows the correlation between heavy metals in sesame and significant correlations were observed between Zn and Cr (r=0.271), Mn and Ni (r=0.278), which means that these pairs of metals probably have the same sources. The table also shows positive correlation between (Cu: Zn, Mn, Pb, Ni, Cr), (Zn: Mn, Cr, Ni), (Mn: Pb, Cr, Ni), (Cr: Ni) and negative correlation between (Pb: Cr, Ni).

The levels of these metals determined showed that the study area had higher metal concentrations than the control area, which suggests that the investigated sesame leaves were noticeably contaminated by all the metals determined

The mean concentrations, ranges and standard deviations of the heavy metals; Cu, Zn, Mn, Pb, Cr and Ni (mgkg^{-1}) dry weight in okra were as presented in Table 4.7. The concentrations of these metals in the vegetable ranged between; Cu (3.20-8.40mgkg^{-1}), Zn (8.00-20.00 mgkg^{-1}), Mn(9.00-22.00 mgkg^{-1}), Pb(3.00-9.00 mgkg^{-1}), Cr(4.00-13.00 mgkg^{-1}) and Ni(4.00-9.00 mgkg^{-1}). Dan'azumi and Bichi (2000) also reported in the analysis of industrial pollution and heavy metals profile of Challawa River in Kano, Nigeria and found that the mean concentrations of Cu, Zn, Mn, Pb, Cr, Fe and Ni discharged into the river for both wet and dry season were found to exceed the maximum permissible limit given by the federal environment protection agency of Nigeria (FEPA) and WHO. The consequence of this is increased river pollution, loss of aquatic life and uptake of polluted water by plants and animals, which eventually gets into human body resulting in health related problems.

Table 4.1: Mean (±SD) and range (Mgkg^{-1}) d.w of heavy metal concentrations in Lettuce of the study sample

Sample	Cu	Zn	Mn	Pb	Cr	Ni
1	4.000	11.000	19.000	7.000	19.000	10.000
2	3.200	24.000	15.000	6.000	11.000	8.000
3	4.000	16.000	12.000	7.000	19.000	8.000
4	3.200	18.000	12.000	9.000	13.000	10.000
5	4.000	24.000	19.000	12.000	9.000	5.000
6	5.600	34.000	19.000	10.000	11.000	7.000
7	4.800	26.000	9.000	12.000	9.000	7.000
8	3.200	10.000	10.000	12.000	14.000	6.000
9	6.400	16.000	10.000	8.000	9.000	5.000
10	4.000	24.000	19.000	9.000	11.000	6.000
11	3.200	19.000	17.000	8.000	19.000	6.000
12	4.000	19.000	10.000	8.000	16.000	5.000
13	3.200	20.000	17.000	7.000	8.000	7.000
14	4.000	27.000	15.000	8.000	8.000	7.000
15	4.000	20.000	19.000	12.000	11.000	10.000
16	6.400	35.000	19.000	10.000	9.000	10.000
17	4.000	35.000	17.000	10.000	13.000	8.000
18	4.000	20.000	12.000	10.000	16.000	7.000
19	3.200	21.000	19.000	11.000	16.000	5.000
20	4.000	17.000	17.000	13.000	19.000	5.000
21	4.800	25.000	15.000	13.000	13.000	6.000
22	3.200	24.000	12.000	9.000	9.000	8.000
23	4.800	13.000	9.000	7.000	17.000	10.000
24	4.000	15.000	15.000	9.000	17.000	10.000
25	5.600	24.000	19.000	9.000	16.000	7.000
26	6.400	10.000	19.000	13.000	8.000	5.000
27	6.400	13.000	15.000	13.000	13.000	6.000
28	4.000	12.000	10.000	11.000	13.000	6.000
29	6.400	12.000	10.000	11.000	16.000	5.000
30	6.400	14.000	10.000	6.000	19.000	7.000
31	3.200	11.000	12.000	6.000	17.000	8.000
32	3.200	11.000	12.000	6.000	17.000	10.000
Mean	4.400	19.375	14.500	9.438	13.594	7.188
(±SD)	1.167	7.188	3.716	2.313	3.809	1.804
Range	3.200-6.400	10.00-35.00	9.00-19.00	6.00-13.00	8.00-19.00	5.000-10.00
FAO/WHO	5.0	0.3	-	0.5-1.0	-	-
WHO/EU	0.2	0.2	0.2	5.0	0.1	0.2
ICRCL	-	-	-	1-50	-	-
MAFF	50	20	-	-	-	-

The mean concentrations of Cu, Zn, Mn, Pb, Cr and Ni presented in this study were found to be in line with what was reported by Akan *et al* (2009). The mean concentrations of these metals in the okra were found to be in the order Mn > Zn > Cr > Ni > Pb > Cu and this could be as a result of the fact that okra has higher retention capacity for the essential metals (Cu, Zn and Mn) than the toxic

Table 4.4: Mean (±SD) and range (Mgkg^{-1}) d.w of heavy metal concentrations in Sesame of the study sample

Sample	Cu	Zn	Mn	Pb	Cr	Ni
1	6.400	12.000	12.000	3.000	13.000	3.000
2	4.800	11.000	15.000	2.000	14.000	3.000
3	5.600	15.000	14.000	2.000	11.000	4.000
4	5.600	9.000	22.000	5.000	11.000	4.000
5	4.000	17.000	21.000	4.000	6.000	3.000
6	3.200	18.000	21.000	3.000	6.000	5.000
7	3.200	13.000	24.000	2.000	14.000	6.000
8	4.000	10.000	24.000	5.000	11.000	6.000
9	4.800	14.000	24.000	3.000	13.000	4.000
10	5.600	11.000	12.000	4.000	13.000	5.000
11	3.200	12.000	14.000	2.000	8.000	4.000
12	4.800	18.000	21.000	3.000	10.000	5.000
13	7.200	13.000	14.000	4.000	8.000	2.000
14	5.600	12.000	14.000	3.000	6.000	2.000
15	7.200	11.000	21.000	3.000	10.000	4.000
16	7.200	11.000	21.000	5.000	10.000	4.000
17	5.600	12.000	15.000	5.000	13.000	5.000
18	3.200	12.000	15.000	3.000	11.000	5.000
19	4.800	14.000	10.000	2.000	14.000	5.000
20	5.600	12.000	21.000	4.000	14.000	2.000
21	6.400	27.000	14.000	6.000	10.000	3.000
22	4.800	17.000	12.000	6.000	6.000	2.000
23	3.200	25.000	12.000	3.000	8.000	3.000
24	5.600	28.000	20.000	3.000	13.000	6.000
25	6.400	21.000	21.000	4.000	8.000	6.000
26	4.000	28.000	14.000	3.000	8.000	4.000
27	5.600	17.000	10.000	3.000	6.000	5.000
28	7.200	26.000	14.000	6.000	11.000	5.000
29	3.200	17.000	21.000	6.000	13.000	3.000
30	6.400	19.000	15.000	6.000	10.000	3.000
31	3.200	26.000	12.00	2.000	10.000	4.000
32	6.400	26.000	14.000	2.000	8.000	4.000
Mean	5.125	16.688	16.250	3.656	10.219	4.031
(±SD)	1.361	6.035	4.461	1.382	2.697	1.231
Range	3.200-7.200	9.00-28.00	10.00-24.00	2.00-6.00	6.00-14.00	2.00-6.00
FAO/WHO	5.0	0.3	-	0.5-1.0	-	-
WHO/EU	0.2	0.2	0.2	5.0	0.1	0.2
ICRCL	-	-	-	1-50	-	-
MAFF	50	20	-	-	-	-

ones (Pb, Cr and Ni). These results were similar to the earlier ones obtained by Audu *et al* (2002).

Table 4.8 shows correlation matrices between heavy metal concentrations in okra. Some significant correlations were observed between Cu and Mn(r=0.079) and Cu and Cr (r=0.070) which means probably that these metals were furnished by the same source. The table also shows positive correlations between (Cu: Zn, Mn, Ni), (Zn: Mn, Pb,

Table 4.7: Mean (±SD) and range (Mgkg^{-1}) d.w of heavy metal contents in okra of the study sample

Sample	Cu	Zn	Mn	Pb	Cr	Ni
1	3.200	10.000	17.000	7.000	11.000	9.000
2	4.700	17.000	14.000	9.000	8.000	7.000
3	5.600	12.000	10.000	8.000	10.000	7.000
4	3.200	14.000	21.000	6.000	11.000	9.000
5	5.600	17.000	19.000	7.000	13.000	4.000
6	4.000	20.000	19.000	5.000	13.000	6.000
7	5.600	18.000	22.000	5.000	10.000	6.000
8	4.700	8.000	22.000	6.000	11.000	5.000
9	8.400	12.000	22.000	5.000	8.000	4.000
10	8.200	17.000	9.000	3.000	6.000	5.000
11	5.600	15.000	10.000	4.000	9.000	5.000
12	8.000	15.000	19.000	3.000	9.000	4.000
13	5.600	16.000	10.000	7.000	6.000	6.000
14	8.200	19.000	10.000	9.000	10.000	6.000
15	8.000	16.000	19.000	8.000	6.000	9.000
16	8.000	20.000	19.000	7.000	8.000	9.000
17	4.700	20.000	14.000	7.000	6.000	7.000
18	8.400	16.000	14.000	6.000	4.000	6.000
19	4.000	13.000	9.000	4.000	4.000	4.000
20	3.200	16.000	19.000	3.000	6.000	4.000
21	5.600	17.000	10.000	5.000	10.000	5.000
22	4.000	9.000	9.000	5.000	10.000	7.000
23	4.700	11.000	9.000	6.000	9.000	9.000
24	8.000	17.000	17.000	7.000	11.000	9.000
25	8.200	8.000	19.000	5.000	13.000	6.000
26	4.700	9.000	10.000	4.000	13.000	4.000
27	4.000	8.000	9.000	5.000	6.000	5.000
28	5.600	8.000	10.000	4.000	9.000	5.000
29	8.400	9.000	19.000	6.000	11.000	4.000
30	4.000	10.000	14.000	9.000	8.000	6.000
31	8.200	9.000	9.000	6.000	8.000	7.000
32	8.000	9.000	10.000	7.000	10.000	9.000
Mean	5.947	13.594	14.469	5.875	8.969	6.188
(±SD)	1.880	4.118	4.853	1.718	2.534	1.804
Range	3.200-8.200	8.000-20.000	9.000-22.000	3.000-9.000	4.000-13-000	4.000-9.000
FAO/WHO	5.0	0.3	-	0.5-1.0	-	-
WHO/EU	0.2	0.2	0.2	5.0	0.1	0.2
ICRCL	-	-	-	1-50	-	-
MAFF	50	20	-	-	-	-

Table 4.2: Correlation matrices between heavy metal concentrations in Lettuce of the study sample

	Correlations between Vectors of values					
	Cu	**Zn**	**Mn**	**Pb**	**Cr**	**Ni**
Cu	1.000					
Zn	.037	1.000				
Mn	.000	.429	1.000			
Pb	.268	.120	.240	1.000		
Cr	.154	.468	.202	.294	1.000	
Ni	.221	.054	.010	.438	.129	1.000

* Significant Correlation at P< 0.05

* Significant Correlation at P < 0.01

Table 4.5: Correlation matrices between heavy metal concentrations in Sesame of the study sample

	Correlations between Vectors of values					
	Cu	**Zn**	**Mn**	**Pb**	**Cr**	**Ni**
Cu	1.000					
Zn	.028	1.000				
Mn	.102	.242	1.000			
Pb	.322	.033	.144	1.000		
Cr	.029	.271	.199	.040	1.000	
Ni	.145	.084	.278	-.202	-.231	1.000

* Significant Correlation at P< 0.05

* Significant Correlation at P < 0.01

Table 4.8: Correlation matrices between heavy metal concentrations in Okra of the study sample

	Correlations between Vectors of values					
	Cu	**Zn**	**Mn**	**Pb**	**Cr**	**Ni**
Cu	1.000					
Zn	.103	1.000				
Mn	.079	.208	1.000			
Pb	.070	.143	.027	1.000		
Cr	-.057	-.193	.295	.058	1.000	
Ni	.024	.093	.004	.549	.051	1.000

* Significant Correlation at P< 0.05

* Significant Correlation at P < 0.01

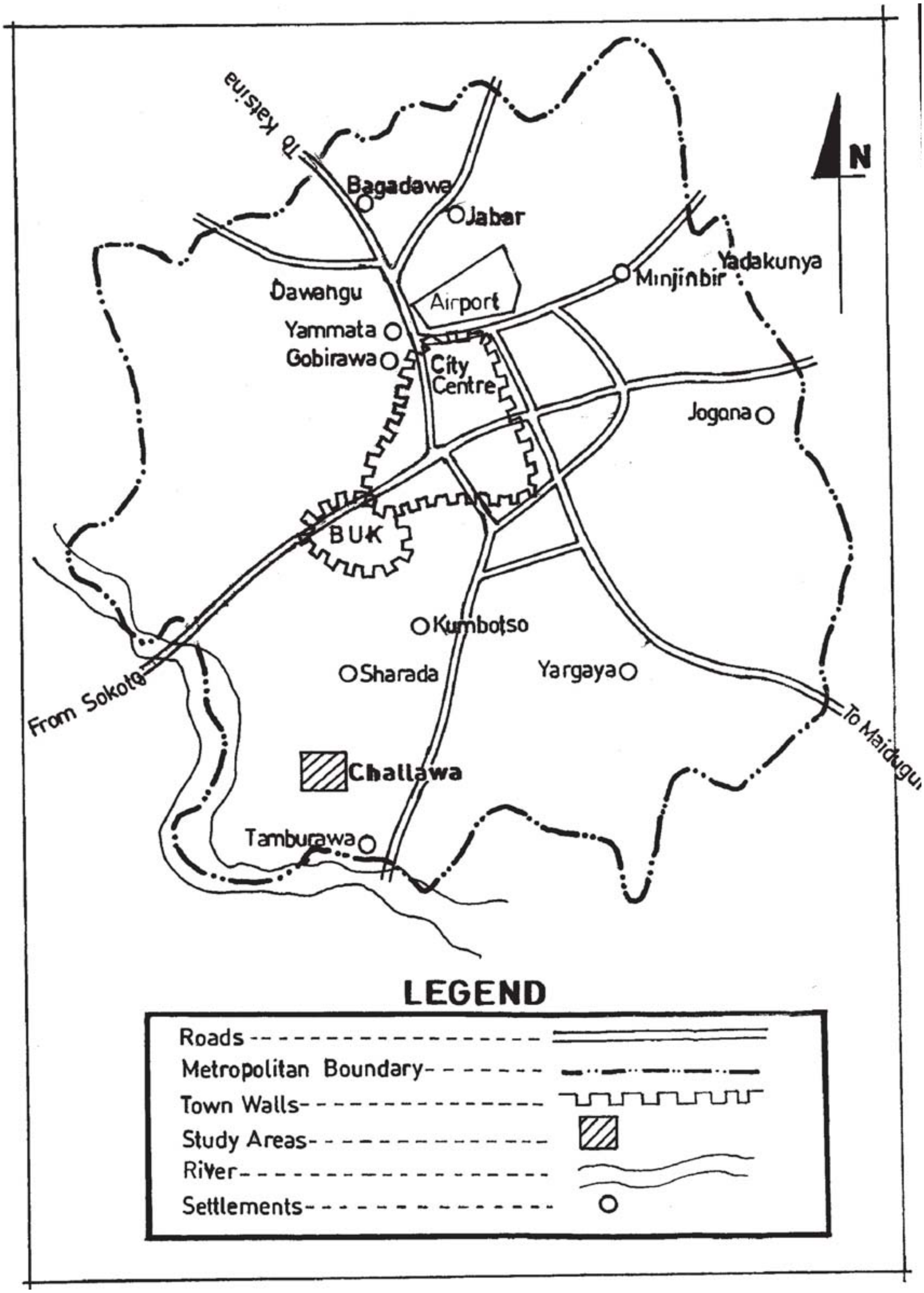

Fig. 1: Kano metropolis showing the study ara (Challawa)

Ni), (Mn: Pb, Cr, Ni), (Pb: Cr, Ni) (Cr: Ni) suggesting the metals might have originated from the same source.

Generally, most metals were found at higher concentrations normally observed in vegetables grown in contaminated areas, while increased values were obtained for Pb, Zn, Cr and Mn, particularly in the leafy vegetable. The levels of these minerals in the analyzed samples represented the fractions of the metals remaining in the plant tissues after the normal household preparations. The concentrations of heavy metals obtained from this study were higher than the FAO/WHO guideline values of 0.1 – 0.2μgg^{-1} Cr, 0.1μgg^{-1} Pb, 0.1μgg^{-1} Cu, 0.1μgg^{-1} Zn, 0.1μgg^{-1} Ni and 0.3μgg^{-1} Mn, with the exception of Pb which fells within the 1-50mgkg-1 limit recommended by ICRCL (1987)

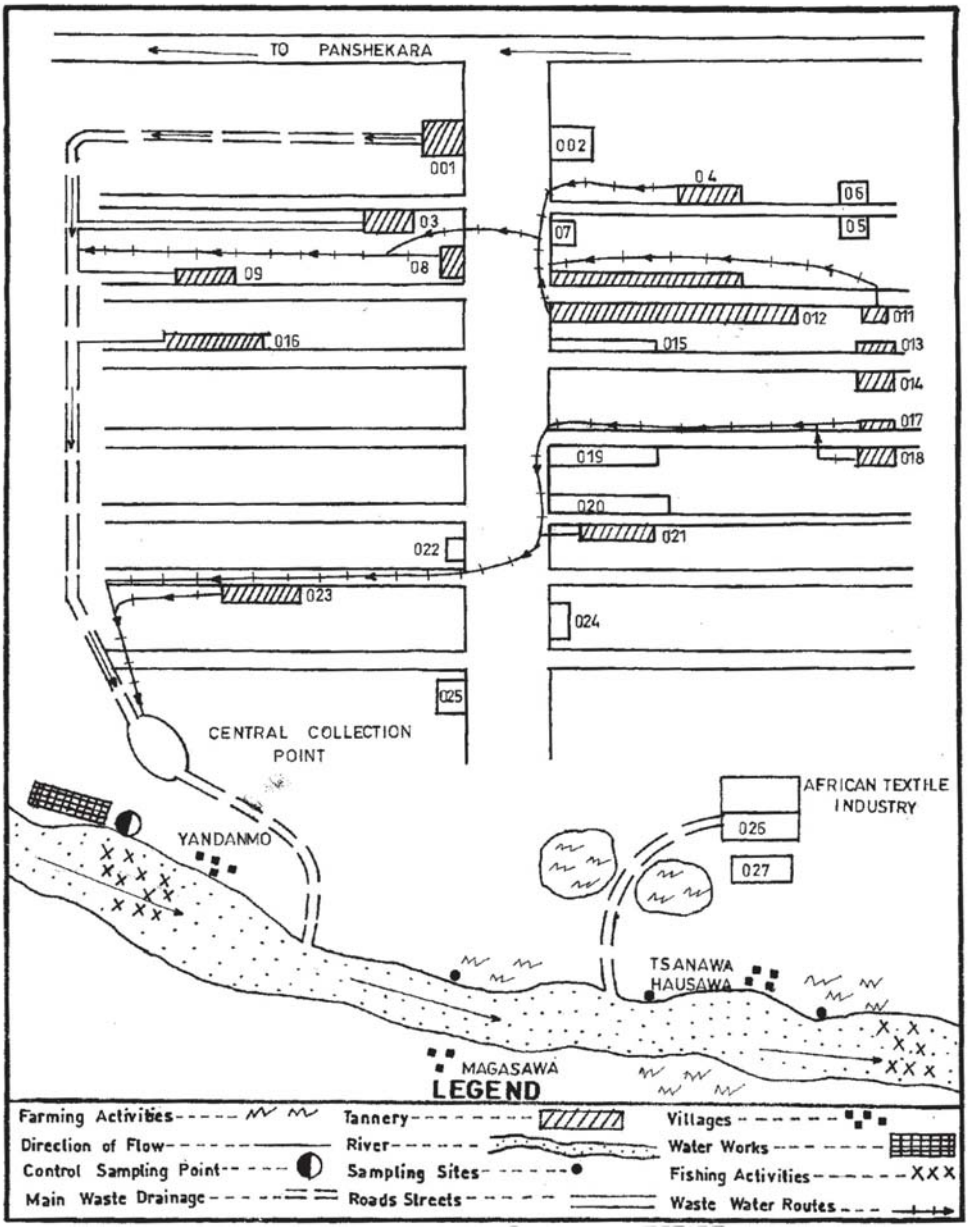

Fig. 2: Sketch map of Challawa industrial estate showing the samples sites

CONCLUSION

This present study found out that relatively high concentrations of heavy metals were found in vegetables irrigated along the bank of River Challawa. Most metals were at concentrations normally observed in vegetables grown in contaminated areas. Significantly high concentrations of Cu, Zn, Mn, Pb, Cr and Ni were found in the study samples compared with the control samples. The result also indicated that okra had higher retention capacity for the essential metals than the toxic ones. Heavy metals concentrations were higher than those recommended by food and agricultural organization (FAO), Federal protection Agency (FEPA) and the WHO/EU joint limit.

The high concentrations of these metals in the vegetables analyzed place the consumers of these and other vegetable crops cultivated along the bank of Challawa River at health risk with time unless an urgent step is taken by relevant agencies to address the issue.

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