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Comparative Assessement Of Heavy Metal Levels In Soil, Vegetables And Urban Grey Waste Water Used For Irrigation In Yola And Kano

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Abstract:- The heavy metal levels in grey waste water, soil and vegetables from urban irrigation sites of Yola and Kano were investigated. The concentrations in the irrigation waters are above the maximum permissible levels of 0.5 µg/ml, 0.2 µg/ml, 0.2 µg/ml and 0.017 µg/ml for Fe, Zn, Mn and Cu respectively for irrigation waters used on all types of soils. The concentrations of Cu in all the farm soils are above the maximum permissible level in soils. The Kano farm soils showed higher levels of heavy metal soil contamination compared to Yola farm soils. The extent of metal in irrigation waters and farm soils from the two study areas ranged from very severe pollution to excessive pollution and slight contamination to severe pollutions respectively. The heavy metals also showed similar distribution pattern in parts of the same species of vegetables from both sites. Hence higher concentrations were observed in vegetable parts from the Kano sites compared to those from Yola sites.

Keywords:- Heavy metals, pollution, grey waste, soil, vegetables

I. INTRODUCTION

The use of grey waste water for irrigation has been recorded in Germany and United Kingdom (UK) since 16^{th} to 18^{th} centuries respectively [11]. Irrigation with grey waste and other waste water also has a long history in China and India [11]. Waste water can be a supplementary source to existing water sources especially in arid/semi-arid climate regions. In any developing areas, the non developed urban lands, especially those lying along the courses of urban drainage systems are sometimes seen as locations for the production of some vegetable that are in high demand by urban dwellers [9]. The grey waste water is considered not only a rich source of organic matter and other nutrients but also harbor heavy metals like Fe, Mn, Cu, Zn, Pb, Cr, Ni, Cd and Co at high concentrations in receiving soils [10]. Heavy metals occur in the soil in soluble form and in combined state. However, only soluble, exchangeable and chelated metal species in soils are mobile and hence more available to plants [5]. The accumulation of heavy metals in edible parts of vegetables represents a direct pathway for their incorporation into the human food chain, because vegetables absorb heavy metals from soil, air and water. Vegetables are important part of human diet, in addition to this; it also serves as a source of components protein, vitamins, iron and calcium which have marked health effects. The cities of Yola (latitude 9^{o} 14'N, longitude 12^{o} 27'E) and Kano (latitude 11^{o} 59'N, longitude 08^{o} 30'N) in Northern Nigeria have estimated populations of over 3 and 10 million respectively according to Nigerian national census 2006[2]. Most of the vegetable leaves are used in the preparation of several delicacies in Northern Nigeria, and these vegetables are irrigated with grey waste water from urban drainages contaminated through processes such as defecations, urination, bath, washing, agro – chemicals and industrial effluents [8].

The main purpose of this study is to compare metal contents of grey waste irrigation water, soils and vegetables in Shinko and Fagge irrigation sites of Yola and Kano respectively, with the maximum permissible levels set by World Health Organization (WHO). The results are expected to create awareness among the public on the safety of consuming vegetables grown in such areas.

Earlier studies by Kabata – Pendias and Ewer [4] as quoted by Lacatusu [7] were aimed at interpreting the level of soil heavy metals. The standard employed for interpreting soil heavy metal contamination/pollution varies from country to country based on chosen factors [7].

C/P value = ———————————————

In this study, similar comparison of heavy metal loads in soil were made by using the method adopted by Lacatusu [7] in measuring the total heavy metals in soils with Atomic Absorption Spectrometry (AAS).A distinction between soil contamination and pollution range was established by means of this contamination/pollution index.

Table 1: Significance of intervals of contamination/pollution index (C/P)

C/P	Significance	Symbols
<0.1	Very slight contamination	Vsl
0.10 – 0.25	Slight contamination	sl
0.26 – 0.5	Moderate contamination	mi
0.51 – 0.75	Severe contamination	stl
0.76 – 1.0	Very severe contamination	vstl
1.1 – 2.0	Slight pollution	sp
2.1 – 4.0	Moderate pollution	mp
4,1 – 8.0	Severe pollution	stp
8.1 – 16.0	Very severe pollution	vstp
>16	Excessive	ep

The maximum allowable limits of heavy metals in soils and vegetables have been established by standard regulatory bodies such as World Health Organization (WHO), Food and Agricultural Organization (FAO) and Ewers U, Standard Guidelines in Europe as shown in Table 2 below:

Table 2: Maximum Allowable Limits of Heavy Metal in Irrigation Water, Soils and Vegetables (µg/g)

Chemical Element	Maximum permissible level in irrigation water (µg/ml)	Maximum permissible level in soils (µg/g)	Maximum permissible level in vegetables (µg/g)
As	0.10	20	-
Cd	0.01	3	0.10
Co	0.05	50	50.00
Cr	0.55	100	-
Cu	0.017	100	73.00
Fe	0.50	50000	425.00
Mn	0.20	2000	500.00
Ni	1.40	50	67.00
Pb	0.065	100	0.30
Se	0.02	10	-
Zn	0.20	300	100

II. EXPERIMENTAL

2.1 Study Areas;

The study areas are Fagge and Shinko irrigation sites along a major drainage in Kano and Yola municipality respectively. The soils texture is slight to moderately light texture, sandy loam that is alkaline (pH 7.6 – 9.5). Soil samples were obtained from each farm by randomly taking soils of depth 0 – 10cm from three spots within the farm, and were mixed to give a representative samples. Plants were also randomly sampled within the farm to get a representative sample. Samples of water used for irrigating each farm were taken for analysis of heavy metal content. In each of these samples, the concentrations of the heavy metals (Fe, Zn, Mn and Cu) were determined by atomic absorption spectrometric (AAS) technique, using the atomic absorption spectrophotometer (Pye. Unicam. Model Sp – 9, 1984). The detection limit and precision of the spectrometer for the enumerated elements were considered good enough. The sampling technique and sample treatment for the determination of the heavy metal concentrations are summarized below: -

2.2 SOIL

Soil samples were taken at different depths at 5 cm intervals to a depth of 30 cm. Samples were collected into polyethylene bags, labeled and properly tied. In the laboratory, the soil samples were spread on glass plates and then dried in an oven at 105^{O}C for six hours. The dried soil were ground and sieved through 0 – 5 cm mesh sieve. The pH values of the soils were determined with a digital pH meter (Jenway Model).

One gram each of the ground soil samples was weighed into a 125 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml each of concentrated $HClO_4$, HNO_3 and H_2SO_4 respectively, on a hot plate in a fume cupboard. On completion of digestion, the samples were cooled and 50 ml of de – ionized distilled water was added and then the samples were filtered. The samples were made up to 100 ml with de – ionized distilled water and concentrations of the elements determined using atomic absorption spectrophotometer (AAS Model SP 9 Unicam 1984).

2.3 PLANTS

The cleaning of the vegetable samples was done using a method previously used [12]. The samples were reduced to fine powder with a grinder prior to drying at 60 ^{o}C in an oven to a constant weight. Half gram each of the fine powdered samples was weighed into a flask and digested in a mixture of 4 ml, 25 ml, 2 ml and 1 ml of concentrated $HClO_4$, HNO_3, H_2SO_4 and 60 % H_2O_2, respectively, at 100 ^{o}C on a hot plate for two hours in a fume cupboard. The resulting solution was left over night and made up to 100 ml with de – ionized distilled water and concentrations of the elements determined using AAS SP 9 Unicam.

2.4 WATER SAMPLES:

One liter of the grey waste water used for irrigating each farm was collected and treated with 1.5 ml of concentrated HNO_3. 50 ml of the water sample was transferred to an evaporating dish and evaporated on a steam bath to about 20 ml. 10 ml of 8 M HNO_3 of 98 % purity was added and evaporated on a hot plate to near dryness. The residue was quantitatively transferred using two aliquot of 10 and 15 ml of concentrated HNO_3 into a 250 ml flask. 20 ml of $HClO_4$ was added and boiled until the solution became clear and white fumes of $HClO_4$ appeared. It was then cooled and de – ionized distilled water (about 50 ml) was added and the solution filtered. The filtrate was quantitatively transferred to a 100 ml volumetric flask with two portions of 5 ml of de – ionized distilled water. The solution was diluted to mark and mixed thoroughly by shaking. The heavy metals under study were determined as described in section 2.3.

III. RESULTS AND DISCUSSIONS

3.1 Mean Concentrations of heavy metals in urban drainage water used for irrigation.

The mean concentrations of Fe, Zn, Mn and Cu in the different irrigation waters used for Okro, Roselle, Bush green, Onions and Lettuce farms for the two sites have been illustrated in Figs. 1 to 4.

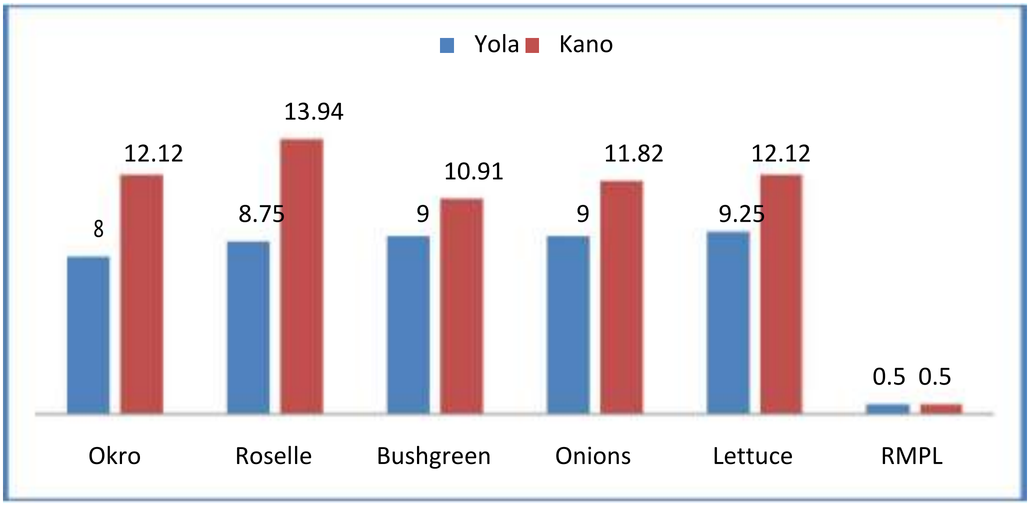

Fig.1: Mean concentration (μg/ml) of Fe in urban drainage used for irrigating vegetables

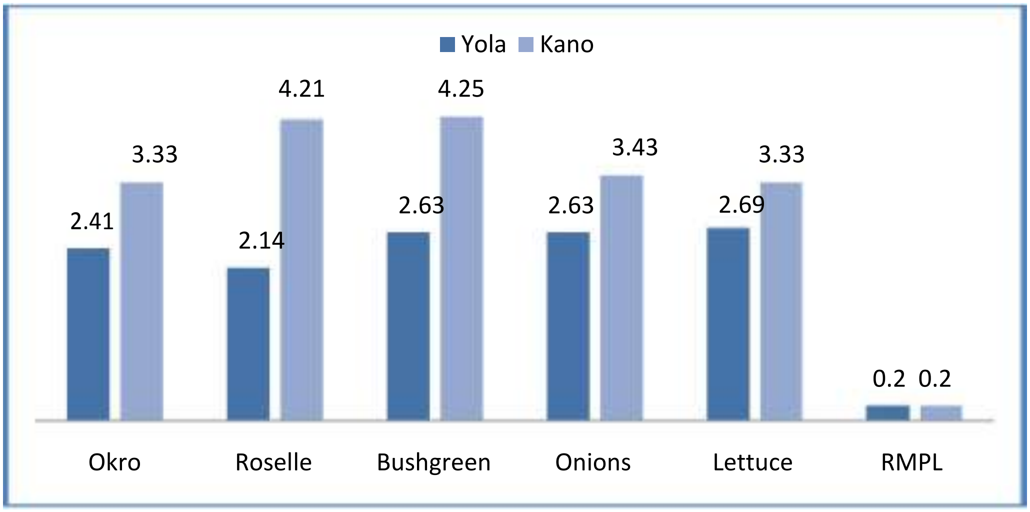

Fig.2: Mean concentration (μg/ml) of Zn in urban drainage used for irrigating vegetables

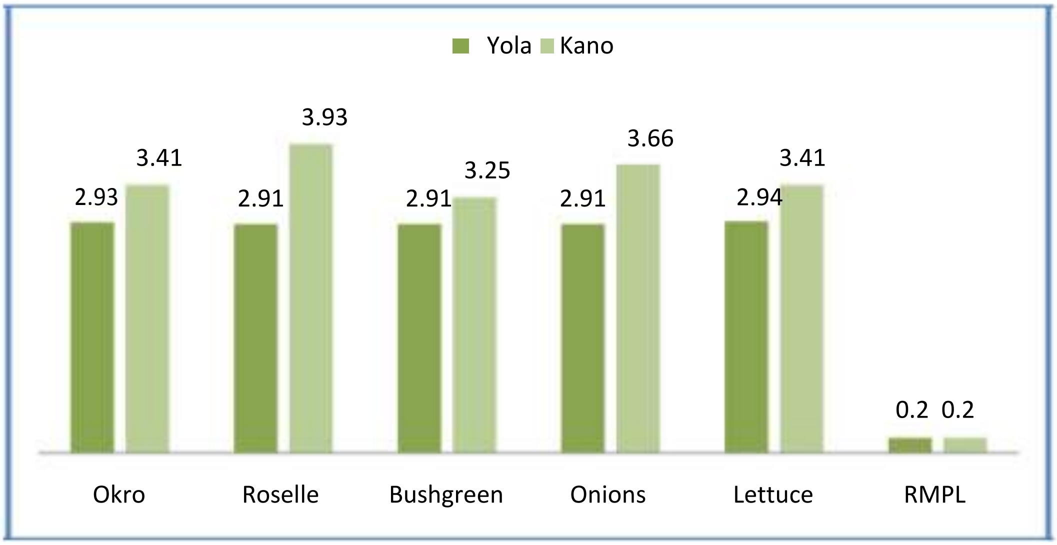

Fig.3: Mean concentration (μg/ml) of Mn in urban drainage used for irrigating vegetables

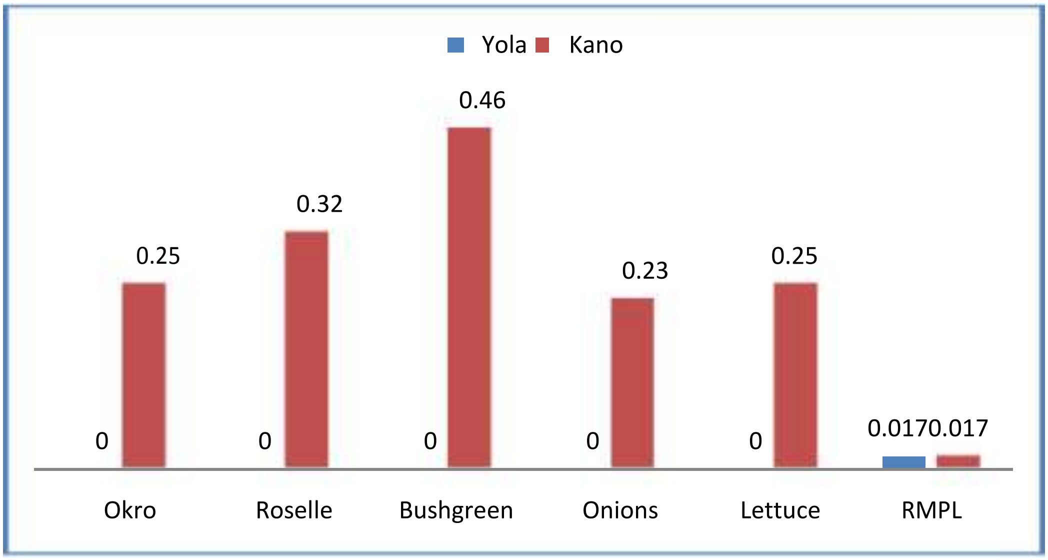

Fig.4: Mean concentration of Cu (μg/ml) in urban drainage used for irrigating vegetables

Note : RMPL = (World Health Organization's) Recommended Maximum Permissible Levels

Obvious from Figs. 1 to 4 are the following:

➢ The concentrations of the heavy metals in the irrigation waters to the different farms in Kano are much higher than those in Yola.

➢ These concentrations of the heavy metals in all the irrigation waters analyzed are much higher than the Recommended Maximum Permissible Levels (RMPL)

➢ No Cu was detected in the irrigation waters to the different farms in Yola

Table 3: Significance of pollution indices of heavy metals in the irrigation waters to the different farms in Yola and Kano.

Heavy Metal	Fe		Zn		Mn		Cu	
Farm Location	Yola	Kano	Yola	Kano	Yola	Kano	Yola	Kano
	17.60	24.36	12.50	18.55	14.60	17.66	0.00	17.76
Implication of C/P index	Excessively polluted		very severely	Excessively polluted	very severely	Excessively polluted	ND	Excessively polluted

Using the criteria of Lacatusu in Table 1, the irrigation waters to the different farms in Kano are excessively polluted (C/P>16) with the four heavy metals. The irrigation waters in Yola are only slightly less polluted. By the Lacatusu criteria, the irrigations waters in Yola are very severely polluted in Zn and Mn (8.1<C/P<16) and excessively polluted in Fe (C/P>16). 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.

The higher level of pollution in the irrigation waters in Kano may be as a result of the higher population of Kano. Kano also has more industrial activities than Yola. These explains the higher concentrations in Kano compared to those in Yola

However the pollution is more in Kano irrigation waters than those of Yola. The concentrations of Zn and Mn in the irrigation waters are very severely polluted and excessively polluted for Yola(C/P>10) and Kano(C/P>16) irrigation waters respectively. Copper (Cu) was not detected in Yola irrigation waters, but the level of pollution in the Kano irrigation waters ranged between very severely polluted to excessive polluted. Similar studies done in Vinayakiya Nallah region of Jodhpur district in India concluded that metals in irrigation water have a severe impact on vegetation and that such vegetables should not be consumed at all [1].

3.2 Mean concentrations of heavy metals in farm soils irrigated with urban drainage water.

The mean concentrations of the heavy metals in surface soils irrigated with urban drainage water have been illustrated in **Figs. 5 to 8.**

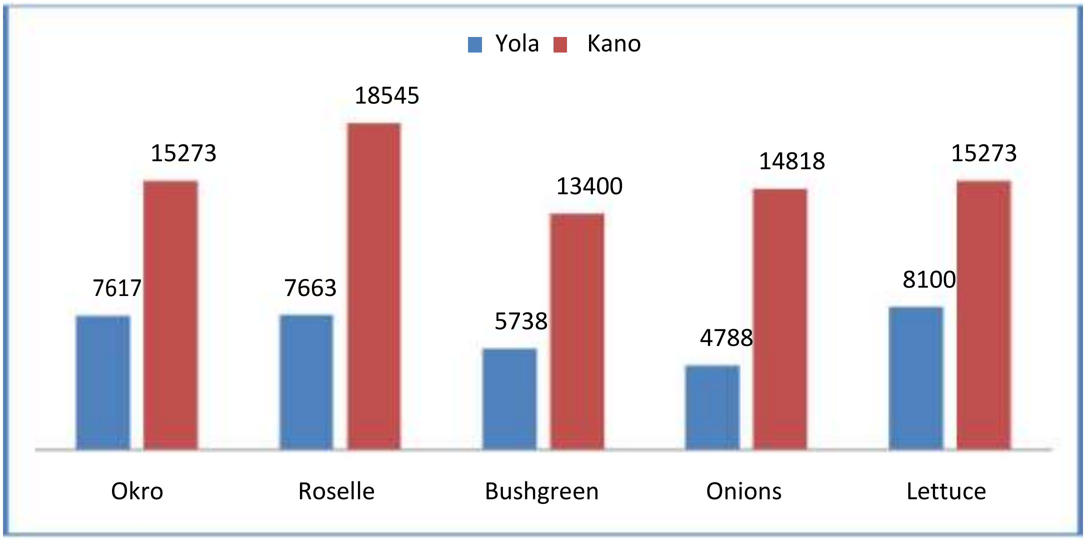

Fig. 5: Mean Concentrations (µg/g) of Fe in soils of different vegetables farms

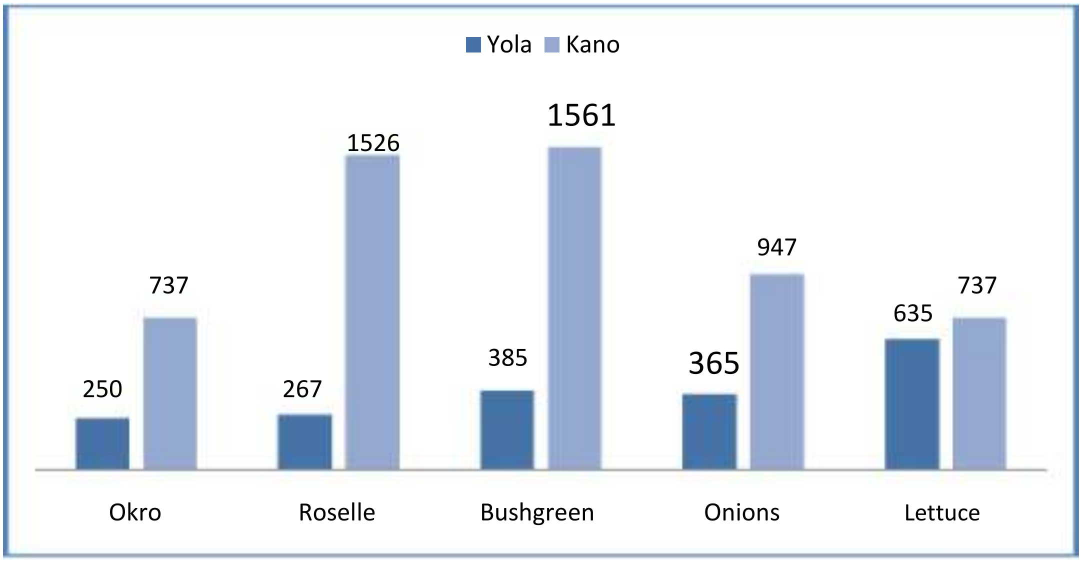

Fig. 6: Mean Concentrations (µg/g) of Zn in soils of different vegetables farms

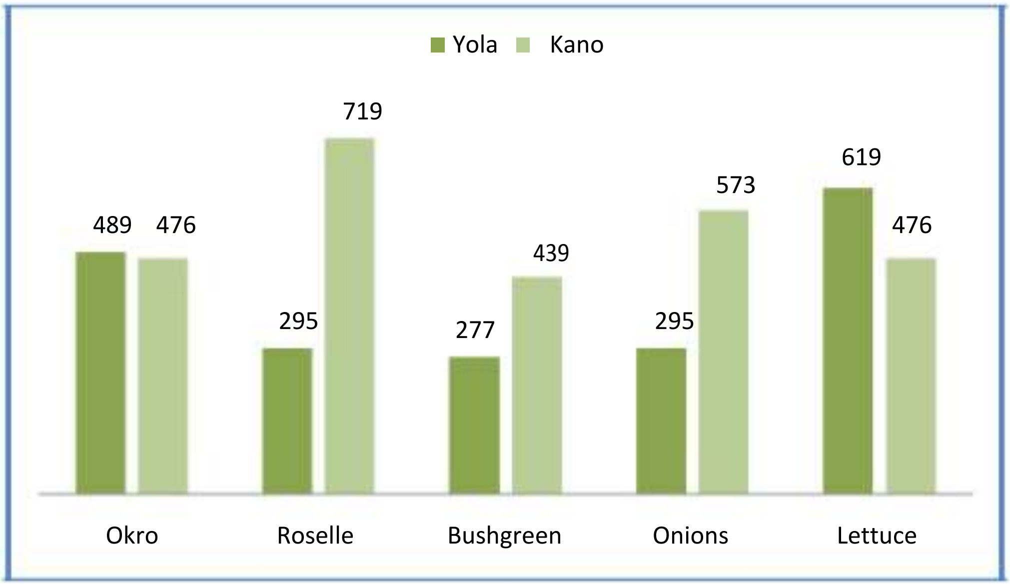

Fig. 7: Mean Concentrations (µg/g) of Mn in soils of different vegetables farms

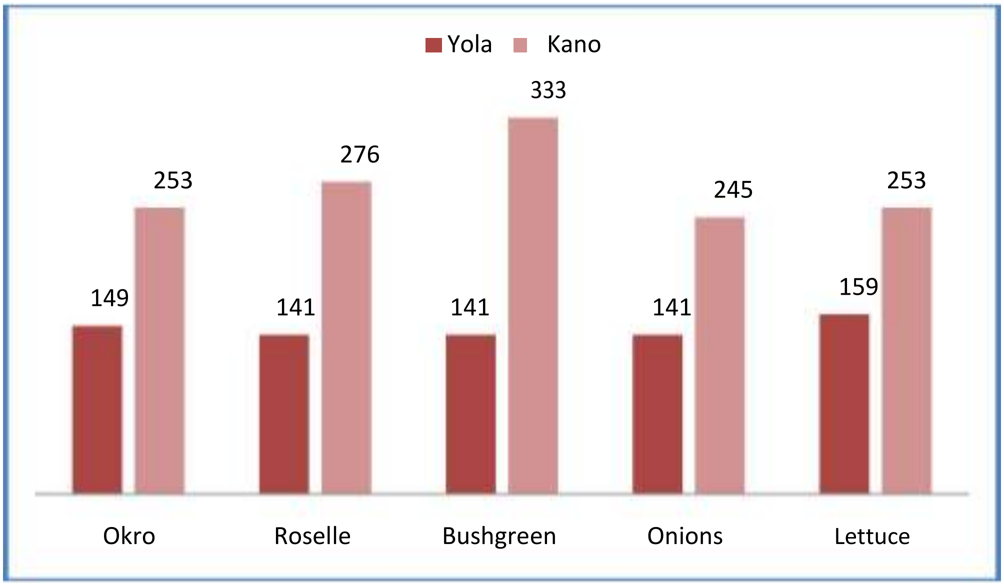

Fig. 8: Mean Concentrations (µg/g) of Cu in soils of different vegetables farms

The Kano site farm soils have higher concentrations of the metals compared to the Yola site farm soils. This may not be unconnected with their being irrigated with urban grey waste water of higher concentrations of these heavy metals, as seen in Figs. 1 to 4.

The concentrations of Fe and Mn in all farm soils in the two sites and Zn in Okro and Roselle farm soil in Yola sites are below their respective World Health Organization (WHO) maximum permissible levels in soils of 50,000, 2000 and 300 µg/g. However, the concentrations of Cu and Zn in all farm soils of Kano and Yola sites with the exception of Zn in Okro and Roselle farm soils in Yola sites are above the maximum permissible limits of 100 and 300 µg/g respectively. This implies contamination of these farm soils. The level of contaminations of the soils is that, Fe in Yola farm is slightly contaminated whereas Kano farm soils are moderately contaminated.

The concentration of Zn in Yola farm soils ranges between very severely contaminations to moderately polluted. However, concentrations of Zn in Kano farm soils ranges from moderate pollution to severe pollution. The pollution level of Mn in farm soils of both sites ranges between slight to moderate pollution. Also the farm soils of Yola and Kano are slightly and moderately polluted with Cu respectively.

3.3 Mean Concentrations of heavy metals in farm produce irrigated with urban drainage water.

The concentrations of Fe and Zn in different parts of okro are above the maximum permissible level set by WHO in plants in both sites-see Table 3. However, the concentrations in okro from Kano sites are much higher than Yola sites. It is a reflection of the concentrations in the soils [Figs. 5 and 6] . With exception of the stem and fruits of okro from Yola site, the Mn concentrations in both sites are also above the WHO maximum permissible levels. It is a source of concern that the concentration of Fe in the fruit of okro in Yola which is being consumed in large quantity daily is twice the maximum permissible level.

Table: 3: Mean concentrations of heavy metals (ug/g) in different parts of okro plant irrigated with grey waste water in Yola and Kano.

Parts	Mean concentration of heavy metals in vegetables (µg/g)							
	Fe		Zn		Mn		Cu	
	Yola	Kano	Yola	Kano	Yola	Kano	Yola	Kano
Leaves unwashed	3400	18182	322	807	597	827	ND	27
Leaves washed	1300	10121	315	772	567	756	ND	23
Stem	750	9091	305	491	493	634	ND	46
Fruits	883	-	306	-	478		ND	-
Roots	1850	13939	317	789	582	780	ND	1379
MPL (WHO)	425		300		500		73	

3.4 Mean concentrations of heavy metals (ug/g) in different parts of Bush green plant

Table 4: Mean concentrations of heavy metals (ug/g) in different parts of Bush green plant irrigated with grey waste water in Yola and Kano.

Parts	Mean concentration of heavy metals in vegetable (µg/g)							
	Fe		Zn		Mn		Cu	
	Yola	Kano	Yola	Kano	Yola	Kano	Yola	Kano
Leaves unwashed	2500	2424	372	2561	493	512	ND	138
Leaves washed	2000	1939	305	2123	343	341	ND	92
Stem	2450	2000	272	1877	463	488	ND	115
Roots	2850	2485	461	3175	507	561	ND	2138
MPL (WHO)	425		300		500		73	

The concentrations of Fe, Zn, Mn and Cu in all parts of Bush green plant from Kano sites are above the WHO maximum permissible level in plants as seen in Table 4. So also are the concentrations of Fe in Bush green parts from Yola, Mn in roots and Zn in leaves and roots. Thus consumption of the vegetable leaf of Bush green grown in these areas is a serious health risk to the populace. However the concentration of Zn in the stem, Mn in leaves and stems of Bush green from Yola sites and Mn in washed leaves from Kano site are below the maximum permissible levels set by WHO. The same observations of higher concentrations of the metals in plants of Kano site compared to Yola sites. Also Bush green plant tends to accumulate higher concentrations in the roots compared to the leaf and stem [3 and 6].

3.5 Mean concentrations of heavy metals (ug/g) in different parts of Roselle plant irrigated with grey waste water in Yola and Kano

With the exception of Cu in leaves(washed) and the stem of Roselle plant from Kano sites, the concentration of the heavy metals (Fe, Zn, Mn and Cu) in parts of Roselle from Kano site are above the maximum permissible level in plants. Also the levels of Fe in all parts of Roselle, Zn in leaves and roots of Roselle from Yola site are above the WHO set standards in plants. However Zn in leaves and stem, and Mn in all parts of Roselle from Yola site are below the maximum permissible level. This implies that the Roselle from Kano site is not safe for human consumption.

Table 5: Mean concentrations of heavy metals (ug/g) in different parts of Roselle plant irrigated with grey waste water in Yola and Kano.

Parts	Mean concentration of heavy metals in vegetable (µg/g)							
	Fe		Zn		Mn		Cu	
	Yola	Kano	Yola	Kano	Yola	Kano	Yola	Kano
Leaves unwashed	2850	2484	267	544	493	634	ND	115
Leaves washed	2150	1879	220	439	479	610	ND	69
Stem	1950	1091	300	667	446	512	ND	23
Roots	2950	2549	387	860	478	617	ND	368
MPL (WHO)	425		300		500		73	

3.6 Mean concentrations of heavy metals (ug/g) in different parts of Lettuce plant irrigated with grey waste water in Yola and Kano.

Table 6: Mean concentrations of heavy metals (ug/g) in different parts of Lettuce plant irrigated with grey waste water in Yola and Kano.

Parts	Mean concentration of heavy metals in vegetable (µg/g)							
	Fe		Zn		Mn		Cu	
	Yola	Kano	Yola	Kano	Yola	Kano	Yola	Kano
Leaves unwashed	2350	3697	317	649	463	512	ND	69
Leaves washed	2050	3212	289	596	448	488	ND	56
Stem	1950	909	437	1404	478	507	ND	23
Roots	3400	4364	439	1421	492	561	ND	207
MPL (WHO)	425		300		500		73	

These variations in the lettuce have been tabulated in Table 6. In Lettuce plant, with the exception of Zn in leaves washed, the concentrations of Fe and Zn in all parts of lettuce from both sites are above the maximum permissible level set by WHO. However the concentration of Zn in all parts of lettuce from Yola site and Cu in leaves and stem from Kano sites are below the maximum permissible level. Highest concentrations of the metals are found in the lettuce roots. The differences between the Mn concentration levels in parts of lettuce from both sites are not much compared to other vegetables. It is of concern that the concentrations of Fe in the edible part of the plant are four and six times for those from Yola and Kano respectively

3.7 Mean concentrations of heavy metals (ug/g) in different parts of Onions plant irrigated with grey waste water in Yola and Kano.

Table 7: Mean concentrations of heavy metals (ug/g) in different parts of Onions plant irrigated with grey waste water in Yola and Kano.

Parts	Mean concentration of heavy metals in vegetable (µg/g)							
	Fe		Zn		Mn		Cu	
	Yola	Kano	Yola	Kano	Yola	Kano	Yola	Kano
Leaves unwashed	2150	2606	378	982	478	659	ND	115
Leaves washed	900	1091	356	456	463	634	ND	23
Fruits	800	970	394	1018	465	585	ND	23
Roots	4500	9576	450	1158	582	683	ND	276
MPL (WHO)	425		300		500		73	

The concentration of Fe and Zn in all parts of onions from both sites, Mn in roots of onions from Yola site and all parts of onion, Cu in leaves and roots of onions from Kano site are above the maximum permissible limit set by WHO (Table 7). This indicates toxicity of these parts of onions with the heavy metal. The concentration of Zn in leaves, fruits and roots of onions from Kano site is about 2, 3 and 3 times respectively higher than the same parts of onions from Yola site. This indicates that parts of onions from Kano site are more polluted than onions from Yola site.

IV. CONCLUSIONS

From the present study the following conclusions could be made:

- The concentrations of the heavy metals in irrigation waters, soils and vegetables from Kano area showed higher levels of pollution than those from Yola area. These may be related to higher population density and more intense industrial activity of Kano
- The distribution of the heavy metals in the plants grown on the polluted soils differed from plant to plant
- Most edible parts of the vegetables from both study areas are heavily polluted with the heavy metals.
- Serious sensitization of the populace in the area is needed about the health implications of consuming such vegetables.

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