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ASSESSMENT OF HEAVY METALS IN READY-TO-EAT (RTE) VEGETABLES SALADS SOLD WITHIN KANO METROPOLIS, NIGERIA

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ABSTRACT

Ready-to-eat (RTE) salads prepared from leafy vegetables sold in the streets are now common in Kano metropolis due to their convenience and acceptance by consumers. Due to the unhygienic environmental conditions and other condiments used in its preparation, vegetable salad could be contaminated with heavy metals. This study aimed to determine heavy metals safety of RTE salads hawked in Kano metropolis, Kano state, Nigeria. Forty samples of RTE salads were purposely purchase from eight local government areas of Kano metropolis and were analyzed for the presence of Cd, Cr, Hg and Pb using Atomic Absorption Spectrophotometer. The results of the analysis showed the concentration of Hg (3.208 - 1.220 mg/kg), Cr (0.756 - 0.212 mg/kg), Pb (0.392 - 0.036 mg/kg) and Cd (0.056 - 0.044). It was therefore concluded that vegetable salad sold in Kano metropolis are prone to public health concerns since the levels of Hg, Cr and Pb were found to be above the permissible limits of 0.01, 0.1 and 0.1 (for leafy vegetables) ratified by the Codex Alimentarius Commission. Thus, prevention of heavy metals contamination in vegetables salads is necessary, this will help in prevention of acute and chronic health problems due to exposure to heavy metals from consuming street vended RTE vegetables salads in this region.

Key words: Green-leafy-vegetables, RTE vegetable salad, food safety, heavy metals

INTRODUCTION

Green leafy vegetable production contributes immensely to the food market due to their health benefits (Amissah-reynolds *et al.*, 2020). Their demand has increased explosively as consumers needs fresh, healthy, convenient and additive-free prepared products (Giusti *et al.*, 2010; Kim *et al.*, 2015; Gill *et al.*, 2017). Leafy vegetables are vital component of healthy diet, providing important phyto-nutrients, vitamins, minerals and fiber (Castro-rosas *et al.*, 2012; Gil *et al.*, 2017) and its consumption is encouraged in many countries by government health agencies to protect against wide range of illness such as cancer and cardiovascular diseases, therefore, their consumption has continued to escalate as a result of effort to promote better nutrition (Castro-rosas *et al.*, 2012).

Ready-to-eat (RTE) vegetable salad constitute a suitable and convenient meal for today's lifestyle because they need no cooking and can be taken immediately at the point of sales without advance treatment, as well as been considered low-calorie food, they are rich in fiber and provide a great variety of vitamins, minerals and other phytochemicals (Caponigro *et al.*, 2010; Tatsika *et al.*, 2019). The consumption of these vegetables greatly increased in Nigeria based on the evidence of their medicinal and nutritional benefits in Nigeria (Ajayeoba *et al.*, 2015).

As food safety continues to be globally public health issue, epidemiological studies have shown increased in the number of produce foodborne related sicknesses for more than thirty years (Varzakas &Arvanitoyannis, 2008). Vegetables provide renowned trace element and heavy metals which are for good health if they come from organic. In contrast, if they come from inorganic or metallic source, they become toxic (Bagdatlioglu & Nergiz, 2010). Green vegetables have a greater ability to accumulate heavy metals compared to other vegetables, making them more dominant in human exposure to heavy metals (Leblebici & Kar, 2020). Vegetables ingestion is one of the major ways in which these heavy metals enter human body, once entered, heavy metals are dumped in bone and fat tissues and overlapped the noble minerals causing a decrease of immunological defenses, slowly released into the body, HMs can cause an array of disease and disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Guerra *et al.*, 2012).

Industrialization, environmental pollution and poor waste management distress food and environmental safety in Kano (Abdullahi *et al.*, 2021). These industries discharge waste into rivers and due to the longer dry seasons than wet seasons, irrigation farming is mainly practiced. Tomatoes, spinach, lettuce, onions, carrots and so on are largely irrigated along the river site (Edogbo *et al.*, 2020) there by exposing the crop to these heavy metals.

Copper (Cu), iron (Fe), manganese (Mn), nickel (Ni) and zinc (Zn) are required by vegetables in trace quantities, but in excess these metals may become greatly harmful. However, nonessential (toxics) metals such as aluminum (Al), arsenic (As), cadmium (Cd), lead (Pb) and mercury (Hg) are not required for normal biological function and may quickly lead to harmfulness (Manzoor *et al.*, 2018). For the benefit of human health, the concentration of heavy metals in vegetables should not exceed the permitted limits set by organizations (Leblebici & Kar, 2020). Garba *et al.* (2021) stated that RTE salads can be contaminated with different HMs that can make them unsafe for human

consumption. More research work on safety and health concerns is still needed to be done on all species of vegetables grown and consumed in Nigeria. Reports from previous research has shown that, there was no information on heavy metals (HMs) accumulation in ready-to-eat (RTE) salads in the area for this study. All the previous work reviewed was on accumulation of HMs on various vegetables including green leafy vegetables in which some of them are the main components in our samples (lettuce, cabbage and cress) with addition of onion, tomatoes, cucumber and other ingredients mixed together. Hence, data collected and analyzed will argument the findings from previous works.

MATERIALS AND METHODS

Study area

Kano metropolis is the second largest industrial and commercial center in Nigeria after Lagos and it is experiencing a rapid population growth rate, the population of metropolis at (year 2000) is 1.6M. In 2003 the population raised to 2.3M (approximately) and in 2006 to 2.8M. The area covers almost 499 square kilometers. With a population density of about 1000 inhabitants per km^2 within the Kano closed-settled zone (UNDP 2004). Kano Metropolis comprises the six-core urban local government (Dala, Fagge, Gwale, Kano Municipal, Nassarawa and Tarauni) and two peri-urban local governments (Kumbotso and Ungogo). Residential uses dominate most part of the study area, however other land uses such as commercial, institutional, and educational are all located within areas (Isa *et al.*, 2016).

Sample collection

Forty (40) samples of RTE salads were purposely purchase from eight local government areas of Kano metropolis (Dala, Fagge, Gwale, Kano Municipal, Nassarawa, Tarauni, Kumbotso and Ungogo) and stored in cool environment during the field work. The samples were transported to Food Analysis Laboratory of Kano State University of Science and Technology, Wudil, Kano Satate, Nigeria for analyses.

Figure 1: Sample of ready-to-eat vegetable salads hawked in Kano Metropolis

Wet digestion and HMs determination

Wet digestion was done according to the method described by AOAC (2000). 5 g of each sample were weighed in a crucible and then placed in a muffle furnace for ashing at a temperature of 480^{o}C for 2 hours. A uniform solution was obtained by adding 10 cm^3 of 6M Nitric acid (HNO_3) to the digested sample and agitated, it was then filtered into a 50 cm^3 sample bottle. Distilled water was added to the filtrate until it was filled up to the 50 cm^3 level. Blank sample was prepared involving the addition of 10 cm^3 of 6M Nitric acid (Bagdatlioglu and Nergiz, 2010).

Concentration of the heavy metals (Cd, Cr, Hg and Pb) were determined; An alpha four model atomic absorption spectrophotometer equipped with adequate digital read out system was used following the operating conditions recommended by the instrument's manufacturer. Conditions for the flame atomic absorption were optimized for maximum absorbance and linear response. The working standard, blank and solution containing the HMs were aspirated directly into the flame. Thus, the element is dissociated from there chemical bonds and are in a condition to absorb radiation. Blank and standard deviation of each HM was recorded in mg/L, Absorbance was converted to concentrations using standard calibration curves (Bagdatlioglu and Nergiz, 2010). The reagents used were of analytical grade.

Data analysis

One-way ANOVA followed by Turkey's post hoc was used to compare the mean concentration of HMs in the samples gotten from different location in the study area. The mean difference was considered significant at $p \leq 0.05$. Statistical Package for Social Science SPSS, version 21 for windows, was used for the statistical analysis. Conversions and other calculations were done using Microsoft Excel.

RESULTS

Table 1: Concentration of Cadmium (mg/L) found in samples of ready-to-eat salads collected from 8 local government areas in Kano metropolis

S/N	DAL	FGE	GWL	KBT	KMC	NSR	TRN	UGG
1	0.024 ± 0.0032	0.012 ± 0.0016	0.012 ± 0.0019	0.010 ±0 0.0005	0.013 ± 0.0013	0.013 ± 0.0006	0.017 ± 0.0002	0.012 ± 0.0003
2	0.015 ± 0.0021	0.015 ± 0.0012	0.014 ± 0.0004	0.015 ± 0.0010	0.013 ± 0.0012	0.011 ± 0.0004	0.008 ± 0.0013	0.012 ± 0.0025
3	0.008 ± 0.0013	0.013 ± 0.0007	0.009 ± 0.0021	0.014 ± 0.0008	0.012 ± 0.0014	0.014 ± 0.0009	0.012 ± 0.0004	0.011 ± 0.0005
4	0.012 ± 0.0020	0.012 ± 0.0014	0.011 ± 0.0003	0.011 ± 0.0011	0.011 ± 0.0008	0.013 ± 0.0005	0.009 ± 0.0005	0.011 ± 0.0005
5	0.011 ± 0.0006	0.006 ± 0.0016	0.009 ± 0.0004	0.012 ± 0.0008	0.010 ± 0.0003	0.014 ± 0.0007	0.010 ± 0.0014	0.014 ± 0.0010

Table 1 showed the result of the cadmium (Cd) content in the samples collected from eight local government areas in Kano metropolis. The Cd content in ready-to-eat salad sample collected from Dala local government area range from 0.024 - 0.011, Fagge (0.012-0.006), Gwale (0.014-0.009), Kumbotso (0.015-0.010), Kano municipal (0.013-0.010), Nassarawa (0.014-0.011), Tarauni (0.017-0.008) and Ungoggo (0.014-0.011).

Table 2: Concentration of Chromium (mg/L) found in samples of ready-to-eat salads collected from 8 local government areas in Kano metropolis

S/N	DAL	FGE	GWL	KBT	KMC	NSR	TRN	UGG
1	0.411 ± 0.0025	0.427 ± 0.0006	0.078 ± 0.0256	0.078 ± 0.0306	0.027 ± 0.0112	0.100 ± 0.0182	0.100 ± 0.0119	0.087 ± 0.0255
2	0.108 ± 0.0232	0.106 ± 0.0199	0.057 ± 0.0077	0.154 ± 0.0117	0.052 ± 0.0118	0.007 ± 0.0081	0.019 ± 0.0140	0.000 ± 0.0000
3	0.070 ± 0.0300	0.216 ± 0.0056	0.017 ± 0.0393	0.162 ± 0.0208	0.021 ± 0.0195	0.082 ± 0.0154	0.199 ± 0.0526	0.049 ± 0.0093
4	0.250 ± 0.0299	0.011 ± 0.0259	0.055 ± 0.0102	0.119 ± 0.0140	0.150 ± 0.0106	0.127 ± 0.0162	0.215 ± 0.0355	0.030 ± 0.0147
5	0.104 ± 0.0310	0.012 ± 0.0142	0.057 ± 0.0159	0.039 ± 0.0127	0.072 ± 0.0161	0.052 ± 0.0085	0.099 ± 0.0084	0.232 ± 0.0152

Table 2 showed the result of the chromium (Cr) content in the samples collected from eight local government areas in Kano metropolis. The Cr content in ready-to-eat salad sample collected from Dala local government area range from 0.411-0.070, Fagge (0.427-0.011), Gwale (0.078-0.017), Kumbotso (0.162-0.039), Kano municipal (0.150-0.021), Nassarawa (0.127-0.0007), Tarauni (0.215-0.0019) and Ungoggo (0.232-0.000).

Table 3: Concentration of Lead (mg/L) found in samples of ready-to-eat salads collected from 8 local government areas in Kano metropolis

S/N	DAL	FGE	GWL	KBT	KMC	NSR	TRN	UGG
1	0.097 ± 0.0158	0.035 ± 0.0136	0.040 ± 0.0064	0.002 ± 0.0105	0.016 ± 0.0143	0.064 ± 0.0095	0.059 ± 0.0118	0.025 ± 0.0183
2	0.030 ± 0.0216	0.044 ± 0.0220	0.054 ± 0.0138	0.008 ± 0.0111	0.053 ± 0.0370	0.015 ± 0.0357	0.009 ± 0.0104	0.000 ± 0.0000
3	0.000 ± 0.0000	0.048 ± 0.0207	0.029 ± 0.0108	0.024 ± 0.0152	0.011 ± 0.0124	0.179 ± 0.0151	0.076 ± 0.0029	0.012 ± 0.0199
4	0.090 ± 0.0060	0.000 ± 0.0000	0.013 ±0.0136	0.008 ± 0.0111	0.021 ± 0.0154	0.119 ± 0.0255	0.048 ± 0.0179	0.014 ± 0.0188
5	0.023 ± 0.0033	0.010 ± 0.0218	0.009 ± 0.0252	0.004 ± 0.0222	0.016 ± 0.0197	0.116 ± 0.0292	0.022 ± 0.0085	0.053 ± 0.0116

Table 3 showed the result of the lead (Pb) content in the samples collected from eight local government areas in Kano metropolis. The Pb content in ready-to-eat salad sample collected from Dala local government area range from 0.097-0.000, Fagge (0.048-0.000), Gwale (0.054-0.009), Kumbotso (0.024-0.002), Kano municipal (0.053-0.011), Nassarawa (0.179-0.015), Tarauni (0.076-0.009) and Ungoggo (0.053-0.000).

Table 4: Concentration of Mercury (mg/L) found in samples of ready-to-eat salads collected from 8 local government areas in Kano metropolis`

S/N	DAL	FGE	GWL	KBT	KMC	NSR	TRN	UGG
1	1.707 ± 1.0734	0.762 ± 0.3173	0.466 ± 0.1620	0.180 ± 0.2067	1.069 ± 0.1786	0.859 ± 0.1633	0.581 ± 0.2706	0.447 ± 0.2572
2	0.386 ± 0.1936	1.094 ± 0.2874	0.621 ± 0.4132	1.078 ± 0.0772	1.180 ± 0.0364	0.070 ± 0.2537	0.271 ± 0.2258	0.526 ± 0.4013
3	0.455 ± 0.0490	0.376 ± 0.2061	0.055 ± 0.0510	0.927 ± 0.2646	0.771 ± 0.2365	0.795 ± 0.1921	0.552 ± 0.0303	0.880 ± 0.1502
4	0.804 ± 0.3244	0.688 ± 0.0129	0.292 ± 0.0697	0.594 ± 0.1076	0.554 ± 0.2024	0.778 ± 0.3027	0.000 ± 0.0000	0.560 ± 0.1224
5	0.138 ± 0.2429	0.000 ± 0.0000	0.177 ± 0.2839	0.589 ± 0.2060	0.435 ± 0.3597	1.075 ± 0.0412	0.122 ± 0.3182	0.837 ± 0.1291

Table 4 showed the result of the mercury (Hg) content in the samples collected from eight local government areas in Kano metropolis. The Hg content in ready-to-eat salad sample collected from Dala local government area range from 1.707- 0.138, Fagge (0.762- 0.000), Gwale (0.621-0.055), Kumbotso (1.078- 0.180), Kano municipal (1.180-0.554), Nassarawa (1.075- 0.070), Tarauni (0.581-0.000) and Ungoggo (0.880-0.447)

Table 5: Concentration of heavy metals in samples of ready-to-eat salads collected from 8 LGAs in Kano metropolis

LGAs	ANALYTE (mg/L)			
	Cd	**Cr**	**Hg**	**Pb**
DALA	0.014 ±0.006	0.189 ±0.142	0.698 ±0.612	0.048 ±0.043
FAGGE	0.012 ±0.003	0.154 ±0.174	0.584 ±0.414	0.027 ±0.021
GWALE	0.011 ±0.002	0.053 ±0.022	0.322 ±0.225	0.029 ±0.019
KUMBOTSO	0.012 ±0.002	0.110 ±0.052	0.674 ±348	0.009 ±0.008
KANO MUNICIPAL	0.011 ±0.001	0.064 ±0.052	0.802 ±0.321	0.023 ±0.017
NASSARAWA	0.013 ±0.001	0.074 ±0.046	0.715 ±0.380	0.098 ±0.062
TARAUNI	0.011 ±0.003	0.126 ±0.080	0.305 ±0.257	0.043 ±0.027
UNGOGGO	0.012 ±0.001	0.081 ±0.091	0.650 ±0.195	0.021 ±0.020

Table 5 gives the detail about concentration of heavy metals (cadmium, chromium, mercury and lead) in samples of ready-to-eat salads collected from eight local government areas in Kano metropolis. The Cd content ranges from 0.014-0.011. Dala local government area has the highest concentration of Cd 0.014 followed by Nassarawa (0.013), Fagge (0.012), Kumbotso (0.012), Ugoggo (0.012), Tarauni 0.011), Gwale (0.011) and Kano municipal (0.011). The concentration of chromium ranges from 0.189 with high level in Dala followed by Fagge, Tarauni, Kumbotso, Ungoggo, Nasarawa, Kano municipal and Gwale local government area. The table also highlight the concentration of mercury in the samples and the values ranges from 0.802-0.305, Kano municipal has the highest concentration of Hg 0.802 followed by Nasarawa (0.715), Dala (0.698), Kumbotso (0.650), Ungoggo (0.650), Gwale (0.322) and Tarauni (0.305). The concentration of lead ranges from 0.098-0.009, with highest value in Nassarawa followed by Dala (0.048), Tarauni (0.043), Gwale (0.029), Fagge (0.027), Kano municipal (0.023), Ungoggo (0.021) and Kumbotso (0.009).

Table 6: Concentration of heavy metals found in samples of ready-to-eat salads collected from 8 local government areas in Kano metropolis

LGAs	ANALYTE (mg/kg)			
	Cd	**Cr**	**Hg**	**Pb**
DAL	0.056 ±0.0245^{a}	0.756 ±0.5690^{a}	2.792 ±2.4500^{b}	0.192 ±0.1723^{b}
FGE	0.048 ±0.01345^{c}	0.616 ±0.6970^{b}	2.336 ±1.6580^{b}	0.108 ±0.0851^{bc}
GWL	0.044 ±0.00849^{d}	0.212 ±0.0885^{f}	1.288 ±0.9020^{d}	0.116 ±0.0749^{bc}
KBT	0.048 ±0.00829^{c}	0.440 ±0.2077^{cd}	2.696 ±1.3930^{bc}	0.036 ±0.0347^{c}
KMC	0.044 ±0.00522^{d}	0.256 ±0.2080^{e}	3.208 ±1.2830^{a}	0.092 ±0.0677^{bc}
NSR	0.052 ±0.00490^{b}	0.296 ±0.1846^{de}	2.860 ±1.5190^{b}	0.392 ±0.2480^{a}
TRN	0.044 ±0.01425^{d}	0.504 ±0.3230^{c}	1.220 ±1.0290^{d}	0.172 ±0.1089^{b}
UGG	0.048 ±0.00490^{c}	0.324 ±0.3630^{d}	2.600 ±0.7810^{bc}	0.084 ±0.0803^{bc}
Permissible limit	**0.06**	**0.1**	**0.01**	**0.1**

Values are means and standard deviation of five samples from each local government for Cd, Cr, Hg and Pb

Table6 gives the detail about concentration of heavy metals (cadmium, chromium, mercury and lead) in samples of ready-to-eat salads collected from eight local government areas in Kano metropolis. The Cd content ranges from 0.056 in Dala to 0.044 in Kano municipal which differ significantly. There is no

significant difference in the samples collected from Fagge (0.048), Kumbotso (0.048) and Ugoggo (0.048). samples from Nassarawa (0.052) also differed from other areas and there is ono significant difference between samples in Tarauni (0.044) and Gwale (0.044). Values are significantly different at $p \leq 0.05$. The concentration of chromium ranges from 0.756-0.212 with high level in Dala followed by Fagge, Tarauni, Kumbotso, Ungoggo, Nassarawa, Kano municipal and Gwale local government area. When compared, samples from Dala (0.756), Fage (0.616) and Gwale (0.212) are significantly different at $p \leq 0.05$.

The table also highlight the concentration of mercury in the samples and the values ranges from 3.208-1.220, Kanoo municipal has the highest concentration of Hg 3.208 followed by Nassarawa (2.860), Dala (2.792), Kumbotso (2.696), Ungoggo (2.600), Gwale (1.288) and Tarauni (1.220). There is significant difference in samples from Kano municipal and samples collected from other areas. The concentration of lead ranges from 0.392-0.036, with highest value in Nassarawa followed by Dala (0.192), Tarauni (0.172), Gwale (0.116), Fagge (0.108), Kano municipal (0.092), Ungoggo (0.084) and Kumbotso (0.036). Values from Nassarawa are different significantly. The heavy metal concentration found in all the samples were as follows: mercury (Hg) > chromium (Cr) >lead (Pb) >cadmium with values 3.208 > 0.756 > 0.392 > 0.056 respectively.

DISCUSSION

This study showed that the concentration of HMs (Cd, Cr, Hg and Pb) in RTE salad samples and their accumulation were listed as mercury (Hg) > chromium (Cr) > lead (Pb) > cadmium with values 3.208 > 0.756 > 0.392 > 0.056 mg/kg respectively. The level of Hg, Cr and Pb in our samples were found to be above the permissible limit of 0.01, 0.1 and 0.1 (for leafy vegetables) imposed by the World Health Organization/ Food and Agricultural Organization (WHO/FAO). Also, particularly the concentration of Hg was found at the highest level among the rest. However, samples collected from Kano municipal were more concentrated with Hg, samples from Dala local government area showed high concentration of Cr and Cd while Nassarawa local government with high Pb concentration, this could be as a result of anthropogenic and various activities in the areas differs.

High level of Hg and Pb in green leafy vegetables exceed the national food standard (Li *et al.,* 2018). Concentration of Cr and Pb were found to be above the permissible limit in some irrigated vegetables from Kano, Nigeria (Ringim and Mohammed, 2019). Onions and tomatoes from irrigated gardens in the Kano metropolis were similarly found with high level of Cr and Pb (Abdulmojeed and Abdulrahman, 2011). Kalu *et al.* (2018) carried out their study on vegetable from farms in Kano and observed high level of Cr. Concentration of Cd and Cr in vegetables (lettuce, onion and tomatoes) around Challawa area in Kano state, Nigeria were above the permissible limits (Edogbo *et al.,* 2019). Cabbage and lettuce produce along Jakara river in Kano were found to be contaminated with HMs (Doka *et al.,* 2020). Lettuce produce along the river also contains Pb and Cr above WHO/FAO permissible limits (Dawaki and Shu'aibu, 2013). A study conducted in Turkey also determined high level of Cd and Pb in lettuce and onion above the permissible limit set by WHO/FAO. High level of Cr and Pb in cabbage and lettuce samples in Ethophia (Gezahegn *et al.,* 2017). High level of Cr and Pb was also found in vegetables above the permissible limit and lower level of Cadmium established by Brazillian legislation (Guerra *et al.,* 2012). While in Egypt, very low level of Pb were obtained in vegetable (Radman and Salman, 2006). All these previous work findings strongly agree with the result of our findings as they also exceed the permissible limit.

Many sources of HMs exposure in Nigeria exist, but the degree of toxicity to human exposure depends on their daily intake (Edogbo *et al.,* 2002) and the probable tolerable daily intake were 0.0005mg/kg/day, 0.003mg/kg/day and 0.3mg/kg/day for Cd, Cr and Pb respectively (Elango *et al.,* 2017). 0.57 µg/kg/day for Hg (Codex, 2011). Continues usage of waste water with high level of HMs concentration to irrigate vegetables are among the major source of HMs to these vegetables and may also affect the environment for a long time (Chauhan and Chauhan, 2014). Incessant discharge of untreated effluent sewage, vehicular release, metal and plastic craps dumping and processing, local dyeing and tanning, atmospheric deposit and excessive use of agrochemicals are sources of HMs in Kano that continue to contaminate the surrounding soil and surface water (Abdullahi *et al.,* 2021). Local dyeing in some areas of Kano and untreated waste water from proximate industries are the prominent sources of HMs contamination (Ekevwe and Bartholomew, 2015). Rivers in Kano are not fit for agricultural activities due to HMs contaminations from untreated industrial effluents (Shawai *et al.,* 2019). High concentration of HMs in this study Could be as a result of irrigating these vegetables with contaminated water, soil and environment.

CONCLUSION

In this study, the heavy metal accumulation in ready-to-eat salads samples exceeded the permissible limit set by the World Health Organization/ Food and

Agricultural Organization (WHO/FAO) and the safety of this food was concluded to be an issue of public health concern. Thus, prevention of heavy metal contamination should start in the field to prevent their translocation from soil to food products.

RECOMMENDATIONS

It is vital to effectively monitor heavy metal in vegetables to reduce metal concentrations in the study area and investigate its effect on human health, this will help in prevention of acute and chronic health problems due to the heavy metal exposure in this region.

Public awareness on adequate treatment of waste-water before use for irrigation purposes and use of soil management practices that hinders HMs uptake will reduce contamination of vegetables with HMs.

Further studies on the microbiological safety of RTE vegetable salad sold in Kano metropolis could be carried out to complement the findings from this research.

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