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Health Risk Assessment on Selected Essential and Non-Essential Elements in Food Crops Grown in Kibera Slum, Nairobi-Kenya

Nyabuti George, Nawiri Mildred, Nyambaka Hudson

Department of Chemistry, Kenyatta University, Nairobi, Kenya
Email: georgeohingo@gmail.com

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Abstract

Peri-urban agriculture of food crops is practiced in many slum areas in developing countries. This often uses waste water whose levels of essential and non-essential elements are largely unknown but would be feared to contaminate soils, consequently exposing man to associated health risks. Inhabitants in Kibera slum, Nairobi City practice these growing kales, amaranthus, arrowroots, and spinach. Health risk assessment was done using daily intake of metals (DIM), target hazard quotient (THQ) and incremental lifetime cancer risk (ILCR). Atomic absorption spectroscopy was employed for elemental analysis. The levels of essential elements ranged as follows; Mn 91.04 - 374.44, Mg 261.28 - 532.96, Fe 350.74 - 1273.68, and Zn 1.18 - 6.3 μg/g per dry weight were found to be below the recommended limits by FAO/WHO. Non-essential elements ranged as follows; Cr 1.15 - 4.32 and Pb 0.14 - 0.91 μg/g above the EU recommendation. DIM of Fe 5.81 - 27.61 and Mn 1.97 - 8.12 μg/g is above the recommended daily intake amounts. THQ values for Mn and Fe were more than unit. THQ values for non-essential elements were generally below unit. ILCR showed that from lead alone 73 people (0.043% of 0.17M residents) are likely to develop cancer. There are foreseen health risks associated with consumption of food crops grown in Kibera slum that requires immediate address.

Keywords

Kibera Slum, Daily Intake of Metals (DIM), Incremental Lifetime Cancer Risk (ILCR), Target Hazard Quotient (THQ), Essential and Non-Essential Elements

1. Introduction

According to the World economic Report on Food Crises [1], over 795 million people in the world today need humanitarian assistance. The situation is no better in Eastern Africa where 10.7 million people are in need of food; of which 2.4 million are in Kenya. This is attributed to the ever-increasing population especially in the urban centers. Kibera slum for example has 170,000 people occupying 2.5 square kilometers of land [2]. In Kibera slum, peri-urban agriculture is practiced to mitigate the high cost of living and meet food and nutritional demands of the high population. During dry seasons, the agricultural practice is faced with the challenge of irrigation using contaminated water from mainly Nairobi River. Irrigating crops with untreated wastewater increase the levels of metals in both soil and food crops [3]. Research conducted by Budambula [4] pointed out that the river contains high levels of elements due to inappropriate industrial discharge and untreated domestic and sewerage. This contributes significantly to high levels of elements in the soils [5]. Many industries situated in and around Nairobi City discharge chemicals and toxic metals into the surrounding water bodies such as the Nairobi River that transverses the Kibera slum. Consequently, there are changes in the chemical composition of the ecosystems through bioamplification and bioaccumulation [6]. Elements find their way into the human body primarily through inhalation and oral ingestion and their bioaccumulation in the food chain is dangerous to human health, plants, and animals [7]. The levels of both essential and non-essential elements reported in this study were lower compared to those reported by Mahmood [8] that indicated the levels of Mn (16.58), Cu (0.44) μg/g and Zn (25.86) μg/g in vegetables being lower compared to WHO permissible levels. The major sources of Cr and Pb are industrial effluents and indiscriminate disposal of untreated or partially treated domestic or sewerage [9].

The health risk assessment has been done using a number of tools/indices such as Daily Intake of Metals (DIM), Target Hazard Quotient (THQ) [10], Health Risk Index (HRI), Enrichment Factor (EF), Uptake/Transfer Factor (UF)) and Incremental Lifetime Cancer Risk (ILCR) [10]. The values of these indices vary for adults and children and between ages as permissible by regulatory bodies such as WHO, EU and USEPA [11]. The standard levels of Mn, Zn, Cu, Cr and Pb elements by FAO/WHO are 500, 15, 20, 1, and 0.43 μg/g respectively. The oral reference doses used in obtaining DIM (mg/kg/day) are as follows; Mg (11.000), Zn (0.300), Fe (0.700), Mn (0.010), Cr (0.003) and Pb (0.004) [12]. The permissible DIM levels by WHO (1993) [13] are Mn (2.3 μg/g), Fe (8 μg/g), Zn (11 μg/g) and Cu (0.9 μg/g). The daily intake of metals by human beings depends upon their daily average food crops consumption per person [14]. In Kibera slum, the residents consume about 255 g per day per adult of vegetables [15] compared to the desirable intake of WHO 400 g per day per adult [16].

Studies have reported on the assessment of the health risks of metals in food crops. Zhuang and co-workers [14] considered this for consumption of vegetables and rice South China. Mahmood [8] carried out health risk on vegetables using DIM and THQ. In Romania Banat County, THQ exceeded the safe levels for parsley, lettuce, and cabbage. This was done for male and female adults, and the result showed that THQ for a female was higher than that for men [17]. Contrary to the aforementioned studies THQ was used to study health risk in vegetables and fruits in Bangladesh where the result showed that no health risks [17]. Odukoya [18] used ILCR on his study in south-west Nigeria. The results indicated that using six non-essential elements over 2% of the 0.21 M population were likely to develop cancer in a lifetime. In Kenya it is estimated that 39,000 new cases of cancer are reported every year with the leading cancer being prostrate (men) and breast cancer (female) [19].

The health risk indices DIM, THQ and ILCR are calculated as per Equations (1)-(3), respectively [20].

$$\text{DIM} = [M] \times k \times l \tag{1}$$

where;

[*M*]: Metal concentration in plant (mg/kg);

k: conversion factor of fresh plant weight consumed to dry weight estimated as 0.085;

l: average daily intake of food crop estimated at 0.255 kg/day per adult.

$$\text{THQ} = \frac{\text{EF} \times \text{FD} \times \text{DIM}}{\text{RfD} \times \text{W} \times \text{T}} \tag{2}$$

where;

EF: exposure frequency (183.5 days/year);

FD: exposure duration (66.5 years, the average lifespan);

DIM: in mg/person/day);

RfD: oral reference dose (mg/kg/day);

W: average adult body weight (74 kg);

T: average of time for non-carcinogens [17].

ILCR is obtained using the CSF as shown in Equation (3). The CSF is the risk produced by a lifetime average dose of 1 mg·kg^{-1} BW·day^{-1} and is contaminant specific [6].

$$\text{ILCR} = \text{CDI} \times \text{CSF} \tag{3}$$

where;

CSF: cancer slope factor (0.085 for Pb);

CDI (mg·kg^{-1} BW·day^{-1}); lifetime average daily dose of exposure to the chemical contaminant.

The CDI value was computed using Equation (4)

$$\text{CDI} = \frac{\text{EDI} \times \text{EF}_r \times \text{ED}_{tot}}{\text{AT}} \tag{4}$$

where;

EDI: estimated daily intake of metal via ingestion;

EF_r: exposure frequency (365 days/year);

ED_{tot}: exposure duration of 66.5 years average lifetime for Kenyans;

AT: averaging time for non-carcinogens.

The total cancer risk of exposure to multiple contaminants was assumed to be the sum of the individual metal incremental risks.

EDI of metals determined using Equation (5).

$$\text{EDI} = \frac{C_{\text{metal}} \times W_{\text{food}}}{B_w} \tag{5}$$

where;

C_{metal}: concentration of metal in the contaminated vegetable (mg/kg);

W_{food}: average daily consumption of vegetable in this region;

B_w: average body weight (74 kg).

Research has shown that soil, water, and food crops in Kibera slum have high levels of essential and non-essential elements [21]. However, high levels do not necessarily lead to health risks and therefore it is necessary to carryout health risk assessment, which has not been carried out in the area. The purpose of the study was to determine the levels of essential (Mg, Al, Mn, Fe, and Cu) and non-essential elements (Cr and Pb) in food crops grown in Kibera slum, Nairobi County and assess the health risk associated with their consumption using DIM, THQ and ILCR indices for adults.

2. Materials and Methods

2.1. Research Design

The study focused on analyzing samples from gardens in Kibera slum in one dry season, using the result to calculate the DIM, THQ and ILCR indices and hence assess the potential health risk.

2.2. Sampling Site

Kibera is in the south-west part of Nairobi, latitude −1˚18'60"S and longitude of 36˚46'99"E it is about 6.6 kilometers from the city center. Much of its southern border is bound by the Nairobi River and the Nairobi Dam. The Nairobi dam is an artificial lake that is currently used as a dumpsite. Kibera slum is divided into villages, which include Makina, Laini Saba, Lindi, Gatwekera, Soweto East, and Kianda [22] (**Figure 1**). Motoine River and Silanga stream both drain to Nairobi River that drains to the Nairobi Dam. Kibera slum in Nairobi is the largest urban slum in Africa [23].

The Kenya Population and Housing Census Report [2] indicate that the population in Nairobi city is approximately 6.54 million with that of Kibera estimated to be 170,070 people although [22] approximates its population at 950,000 people. Kibera slum is heavily polluted with human refuse, garbage, soot, dust and other wastes due to the open sewage system. Poverty, high population density and high cost basic commodities has pushed the Kibera slum residents to resorted

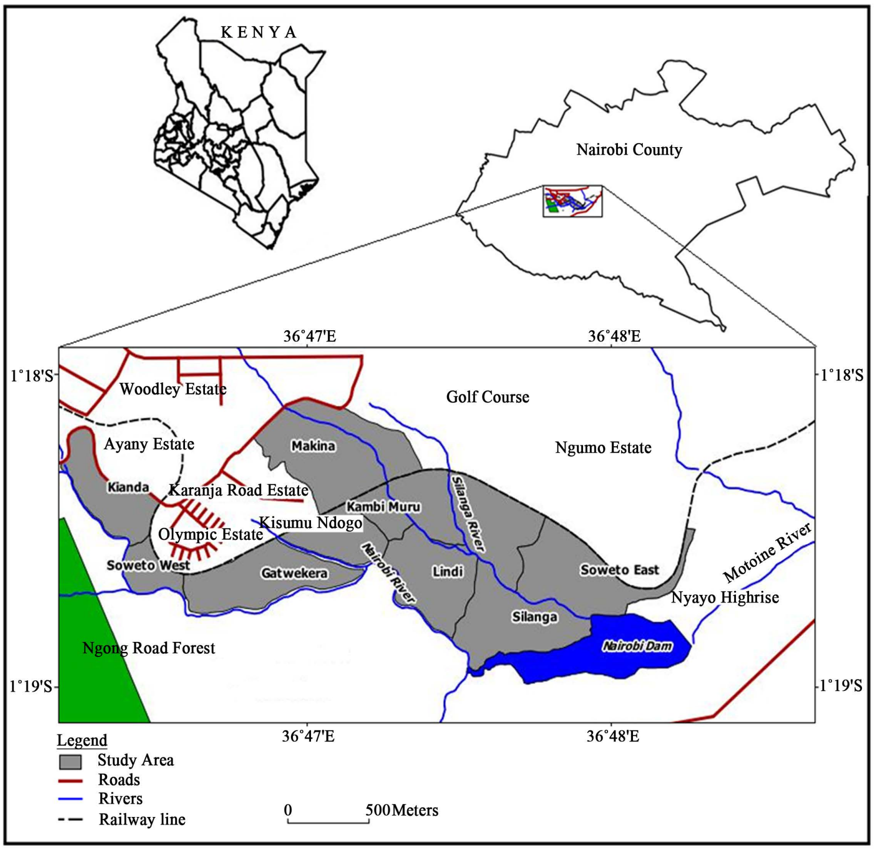

Figure 1. Map of the study area showing water basin and sampling sites in Kibera Slum, Nairobi County. Source: http://kenyapage.net/pictures/kibera.html, January, 2019.

to peri-urban farming of kales, Dhania, cowpeas, onions, amaranthus, spinach and arrowroots for nutritional benefits. The sampling sites include Gatwekera, Kisumu Ndogo, Kianda, Lindi, Laini Saba and Siranga in Kibera slum coded as U001 - U006 respectively.

2.3. Sample Collection and Pretreatment

Five grams of Amaranths, Kales, Arrowroots, and Spinach samples were randomly collected from six gardens in Kibera Slum by randomized design. For the control, 5 g of arrowroots, kales, amaranths, and spinach samples were also obtained from a garden about 400 km from Kibera slum, with no surrounding industrial activities and irrigation done using clean tap water.

The vegetable samples (kales, amaranths, and spinach), were washed with tap water to remove the soil particles adhered to the surface of the vegetables then rinsed with distilled water. The water on the surface of the leaves was removed with blotting papers, samples were cut into pieces and dried in an oven at 100˚C until a constant weight was achieved after which their midribs were removed. The dried samples were ground, sieved through 2 mm pore size sieve, and then stored at room temperature. Arrowroots were pilled, crushed, and dried in the oven at 100˚C before being pulverized and stored in polythene zip-bags.

2.4. Sample Preparation and Acid Digestion

Acid Digestion of Samples

The procedure according to [24] was employed. Exactly 1.0 g of each sample was weighed and placed in 500 mL Kjeldahl digestion flask followed by 10 mL of 68% concentrated nitric (V) acid. The mixture was heated gently in the digestion block until brown fumes disappeared then allowed to cool for 15 minutes. To the mixture, 5 mL of 70% perchloric acid was added and heated until the solution turned clear and white fumes seen. The resulting mixture was left to cool and then filtered using Whatman No. 42 filter paper. Then 5 mL of the filtrate was put into 50 mL volumetric flask and topped to the mark with distilled water. The final solution was transferred into the acid cleaned plastic bottle, sealed, and stored in a deep freezer. Three replicate digestions were performed.

2.5. Atomic Absorption Spectroscopy (AAS) Analysis

2.5.1. Chemicals and Reagents

The chemicals and reagents were of analytical grade (99.99% purity) manufactured by Sigma Aldrich Company. These were ; manganese metal wire, magnesium metal strip, chromium metal strip, iron metal fillings, zinc metal granules, copper strips, aluminium wire, lead metal, 70% perchloric acid, 68% concentrated nitric (V) acid, 6% nitric (V) acid and 10% nitric (V) acid.

2.5.2. Preparation of Standard Solutions

Standard solutions of elements (1000 mg/L) were prepared using metals (manganese metal wire, magnesium metal strip, chromium metal strip, iron metal fillings, zinc metal granules, copper strips, aluminium wire, lead metal) of analytical grade (99.9% pure) and concentrated acids [25].

2.5.3. Instrumentation

The operating parameters for the AAS (Shimadzu AA-6300) equipment were set according to the manufacturer's specifications. The Air-C_2H_2 flame was used to analyze all the metals. The detection limit was set at ≤0.01000 ppm, repeatability ≤ 2.00%, and stability ≤ 6.0% [25].

2.6. Statistical Analysis

Data were analyzed using SPSS software version 21 for parameters as mean, standard deviation, one-way ANOVA (at 95% confidence level).

3. Results and Discussions

3.1. Levels of Essential and Non-Essential Elements in the Food Crops

The mean levels (μg/g) of essential and non-essential elements in kales, amaranths, spinach, and arrowroots from gardens in Kibera slum are presented in **Table 1** and **Table 2** respectively. The ranges for essential elements were Mn (91.04 - 374.44), Mg (261.28 - 532.96), Fe (350.74 - 1273.68) and Zn (1.18 - 6.3)

Table 1. Mean levels of essential elements in food crops (Mean ± SE) μg/g.

Sample (*n* = 3)	Gardens	Mn	Mg	Fe	Zn	Cu	Al
Arrowroot	**Control**	148.57 ± 0.98^{a}	261.22 ± 0.44^{a}	809.33 ± 0.93^{a}	1.18 ± 0.03^{a}	2.79 ± 0.05^{a}	<LOD
	U001	148.71 ± 0.41^{a}	274.44 ± 1.38^{b}	1114.50 ± 8.96^{b}	2.06 ± 0.01^{c}	4.16 ± 0.03^{e}	<LOD
	U002	193.40 ± 0.74^{b}	261.28 ± 0.33^{a}	1191.83 ± 3.37^{c}	1.36 ± 0.05^{a}	3.52 ± 0.02^{d}	<LOD
	U003	226.42 ± 2.99^{c}	275.47 ± 0.14^{b}	1273.67 ± 2.19^{f}	1.57 ± 0.03^{b}	3.52 ± 0.02^{d}	<LOD
	U004	189.73 ± 4.97b	274.22 ± 1.18^{b}	1212.67 ± 2.35^{d}	5.68 ± 0.11^{e}	3.29 ± 0.03^{c}	<LOD
	U005	150.76 ± 0.64^{a}	282.86 ± 0.80^{c}	1233.00 ± 3.62^{e}	2.26 ± 0.12^{c}	3.17 ± 0.02^{b}	<LOD
	U006	185.74 ± 0.41^{b}	273.21 ± 0.83^{b}	1222.83 ± 4.85^{d}	2.63 ± 0.02^{d}	3.10 ± 0.04^{b}	<LOD
	P-Values	<0.001	<0.001	<0.001	<0.001	<0.001	
Amaranth	**Control**	176.73 ± 2.29^{a}	282.54 ± 0.02^{b}	422.50 ± 3.33^{a}	1.07 ± 0.02^{a}	4.20 ± 0.06^{a}	<LOD
	U001	171.04 ± 1.06^{a}	287.07 ± 0.20^{c}	722.50 ± 5.86^{f}	4.05 ± 0.05^{c}	5.39 ± 0.11^{d}	<LOD
	U002	234.61 ± 0.33^{c}	282.81 ± 0.40^{b}	687.17 ± 1.76^{e}	3.74 ± 0.04^{b}	6.48 ± 0.15^{f}	<LOD
	U003	293.62 ± 5.92^{e}	284.85 ± 0.10^{c}	604.50 ± 2.08^{e}	6.33 ± 0.07^{d}	6.01 ± 0.08^{e}	<LOD
	U004	198.75 ± 1.61^{b}	279.46 ± 1.33^{a}	621.83 ± 3.47^{d}	3.60 ± 0.07^{b}	4.52 ± 0.02^{b}	<LOD
	U005	250.40 ± 1.47^{d}	279.62 ± 0.30^{a}	788.50 ± 1.04^{g}	3.55 ± 0.06^{b}	5.38 ± 0.11^{d}	<LOD
	U006	174.23 ± 0.89^{a}	277.79 ± 0.36^{a}	512.17 ± 6.93^{b}	3.55 ± 0.06^{b}	4.85 ± 0.09^{c}	<LOD
	P-Values	<0.001	<0.001	<0.001	<0.001	<0.001	-
Spinach	**Control**	116.24 ± 0.71^{a}	529.73 ± 0.18^{a}	517.33 ± 3.81^{a}	0.57 ± 0.04^{a}	5.25 ± 0.12^{a}	<LOD
	U001	193.00 ± 6.76^{d}	532.03 ± 0.09^{c}	696.33 ± 2.80^{e}	4.28 ± 0.05^{d}	7.82 ± 0.09^{c}	1.09 ± 0.00^{a}
	U002	181.12 ± 1.9^{0c}	532.89 ± 0.02^{d}	624.00 ± 4.48^{c}	4.48 ± 0.07^{e}	9.53 ± 0.02^{e}	1.06 ± 0.00^{a}
	U003	153.39 ± 0.16^{b}	532.96 ± 0.03^{d}	596.67 ± 2.89^{b}	4.74 ± 0.01^{f}	8.53 ± 0.17^{d}	2.00 ± 1.41^{a}
	U004	148.41 ± 0.97^{b}	532.28 ± 0.25^{c}	719.83 ± 2.24^{f}	4.96 ± 0.04^{g}	9.29 ± 0.10^{e}	1.22 ± 0.00^{a}
	U005	374.44 ± 1.55^{e}	531.06 ± 0.05^{b}	637.83 ± 1.92^{d}	3.98 ± 0.07^{c}	6.77 ± 0.03^{b}	1.63 ± 0.00^{a}
	U006	172.84 ± 0.98^{c}	531.21 ± 0.41^{b}	618.00 ± 3.75^{b}	1.18 ± 0.04^{b}	6.99 ± 0.10^{b}	2.29 ± 0.05^{a}
	P-Values	<0.001	<0.001	<0.001	<0.001	<0.001	0.618
Kales	**Control**	74.74 ± 1.54^{a}	527.36 ± 0.41^{a}	268.05 ± 2.61^{a}	0.51 ± 0.01^{a}	2.44 ± 0.04^{a}	<LOD
	U001	147.06 ± 2.44^{d}	529.00 ± 0.12^{b}	518.17 ± 3.28^{d}	5.41 ± 0.14^{f}	4.57 ± 0.06^{b}	1.16 ± 0.03^{a}
	U002	121.43 ± 1.64f	531.26 ± 0.02c	619.50 ± 0.87e	2.22 ± 0.07e	5.92 ± 0.12^{c}	1.07 ± 0.02^{a}
	U003	121.43 ± 1.64^{c}	531.26 ± 0.02d	619.50 ± 0.87^{g}	2.22 ± 0.07^{b}	5.92 ± 0.12^{b}	1.23 ± 0.03^{b}
	U004	171.09 ± 3.31^{e}	530.68 ± 0.10^{c}	± 585.671.64^{f}	2.59 ± 0.04^{c}	4.13 ± 0.57^{b}	1.53 ± 0.02^{d}
	U005	141.92 ± 1.07^{d}	527.06 ± 0.12^{a}	362.67 ± 3.49^{c}	2.97 ± 0.07^{d}	3.02 ± 0.02^{a}	1.46 ± 0.04^{c}
	U006	91.04 ± 2.31^{b}	530.02 ± 0.22^{c}	350.74 ± 2.34^{b}	2.59 ± 0.04^{c}	2.81 ± 0.06^{a}	1.27 ± 0.06^{b}
	P-values	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
[27]				500 - 15 20 -			

Mean values followed by the same small letter(s) within the same column do not differ significantly from one another (SNK-test, α = 0.05). Where *n* is the number of replicates and LOD is lower limit of detection.

Table 2. Mean levels of non-essential elements in food crops.

Sample (n = 3)	Gardens	Cr (Mean ± SE) μg/g	Pb
Arrowroots	Control	2.03 ± 0.02^{a}	<LOD
	U001	2.45 ± 0.02^{b}	0.86 ± 011^{f}
	U002	2.73 ± 0.04^{c}	0.94 ± 0.32^{d}
	U003	3.72 ± 0.04^{f}	0.43 ± 0.05^{e}
	U004	3.05 ± 0.02^{d}	0.32 ± 0.02^{d}
	U005	3.36 ± 0.05^{e}	0.46 ± 0.01^{c}
	U006	2.63 ± 0.02^{c}	0.65 ± 0.02^{e}
	P-value	<0.001	<0.001
Amaranthus	Control	1.55 ± 0.02^{a}	<LOD
	U001	3.72 ± 0.03^{f}	0.34 ± 0.07^{d}
	U002	4.32 ± 0.03^{g}	0.35 ± 0.02^{a}
	U003	3.25 ± 0.04^{e}	0.79 ± 0.02^{d}
	U004	2.99 ± 0.01^{d}	0.31 ± 0.01^{a}
	U005	2.09 ± 0.02^{b}	0.33 ± 0.08^{a}
	U006	2.56 ± 0.02^{c}	0.14 ± 0.01^{b}
	P-value	<0.001	<0.001
Spinach	Control	1.15 ± 0.02^{a}	<LOD
	U001	2.64 ± 0.03^{d}	0.02 ± 0.17^{c}
	U002	2.44 ± 0.01^{c}	0.32 ± 0.16^{e}
	U003	2.65 ± 0.06^{d}	0.44 ± 0.14^{c}
	U004	2.38 ± 0.04^{c}	0.21 ± 0.18^{f}
	U005	4.07 ± 0.01^{e}	0.62 ± 0.32^{d}
	U006	1.80 ± 0.05^{b}	0.45 ± 0.07^{c}
	P-value	<0.001	<0.001
Kales	Control	2.35 ± 0.06^{a}	<LOD
	U001	2.58 ± 0.02^{a}	0.75 ± 0.01^{a}
	U002	3.35 ± 0.04^{c}	0.84 ± 0.02^{b}
	U003	2.57 ± 0.03^{a}	0.63 ± 0.01^{a}
	U004	2.95 ± 0.01^{b}	0.44 ± 0.00^{a}
	U005	3.16 ± 0.03^{c}	0.86 ± 0.03^{c}
	U006	3.01 ± 0.03^{b}	0.91 ± 0.06^{d}
	P-value	<0.001	<0.001
Permissible levels of [28]		1	0.43

Mean values followed by the same small letter(s) within the same column do not differ significantly from one another (SNK-test, $\alpha = 0.05$). n is a number of replicates. LOD is Lower limits of detection.

being below [16] recommended limits and decreased in the order Fe > Mg > Mn > Cu > Zn. For non-essential elements, the ranges were Cr (1.15 - 4.32) and Pb (0.14 - 0.91) being above the [16] recommendation. The levels of elements were higher in vegetables from Kibera slum gardens than from the control garden in Kisii. The levels of the elements varied within the vegetables, for example, while spinach had the highest levels of Mn that was not case in amaranths. The levels of essential elements in the six gardens were significantly different ($P < 0.001$) this can be attributed to the location of the gardens. For instance, gardens U001 and U002 were found to be very close to the polluted Nairobi River. The levels both essential and non-essential elements reported in this study were lower compared to those reported by [8].

As shown in **Table 2**, the average level of Cr in amaranths and kales were higher than the permissible levels of FAO/WHO. The highest levels of lead were observed in kales and lowest in Spinach while Cr was highest in Amaranths and lowest in spinach. The high levels could be attributed to the traffic activities such as fuel combustion, lubricating oils road abrasion and surface runoffs observed in the area [3].

3.2. Health Risk Assessment Indices

3.2.1. Daily Intake of Metals (DIM)

The DIM values calculated for adults are presented in **Table 3**. The range of DIM values for Mn and Fe were 1.97 - 8.12 and 5.81 - 27.61 respectively. The DIM values were higher in food crops grown in Kibera than the control. These levels were higher than the WHO permissible levels hence man risks exposure to being irritable, intestinal upsets, and hypertension [8]. The DIM indices were highest for Mn and Fe across all the food crops and therefore could pose a health risk. Result consistent with those obtained by [8] which showed that the values of DIM were lower than those allowed by European Union.

For non-essential elements, the ranges were Cr 0.02 - 0.09 and Pb 0.01 - 0.02 being below the standards of [13]. This does not however rule out such symptoms as Cancer, renal failure, diabetes, irritability and stomach upsets associated with high levels of these elements as a result of t0heir bioaccumulation [7]. The

Table 3. Daily intake of metals (DIM) for essential and non-essential elements in food crops.

FOOD CROP [13]	DIM VALUES (mg/day) in food crops							
	ESSENTIAL ELEMENTS						NON ESSENTIAL ELEMENTS	
	Mn (2.3)	Mg	**Fe (8.0)**	Zn (11)	Cu (0.9)	Al	Cr (1.5)	Pb (0.5)
Arrowroots	**3.85**	5.89	**24.95**	0.05	0.07	-	0.06	0.02
Amaranths	**6.11**	6.11	**13.5**	0.08	0.11	-	0.06	0.01
Spinach	**11.53**	11.53	**13.66**	0.07	0.17	0.03	0.05	0.01
Kales	**11.48**	11.48	**10.11**	0.07	0.09	0.03	0.06	0.01

index for Cr and Pb were generally lower than the permissible levels of [13] except in garden U002. The result was similar with those reported by [8] which showed that the DIM for Cr and Pb were below those provided [13].

3.2.2. Target Hazard Quotient (THQ)

The THQ values from the levels of essential and non-essential elements are presented in Table 4 respectively.

The range of the values is Mn (1.65 - 8.27), Fe (1.18 - 5.63) Cu (0.003 - 0.007). Zn (0.001 - 0.006), Mg (0.0 1 - 0.01), and decreased in the same order (Mn being highest). The results point out to health risks such as irritability, stomach upsets, cancer and dibetes that would be associated with consumption of the food crops with high levels of Mn and Fe whose THQ was greater than unity [26]. The highest of these values is determined in spinach from garden U006 and arrowroots in garden U003. This can be attributed to the fact that the two gardens are closest to the Nairobi River.

The results on the levels of non-essential elements in food crops grown in Kibera slum were used to calculate the THQ values and result are presented (Table 4). The findings show that Target hazard quotient values for non-essential elements were <1 in all the gardens except for arrowroots in garden U002. The THQ value ranges were Cr 0.16 - 0.45 and Pb 0.00 - 1.45 below USEPA standards it showed that non-essential elements were not likely to cause a health risk.

3.2.3. Incremental Lifetime Cancer Risk (ILCR)

The calculated results for ILCR for Pb in adults are given in Table 5.

Table 4. THQ for essential and non essential elements in food crops.

FOOD CROP [26]	THQ Values in food crops						
	ESSENTIAL ELEMENTS					NON ESSENTIAL ELEMENTS	
	Mn > 1	Mg	**Fe > 1**	Zn < 1	Cu < 1	Cr < 1	Pb < 1
Arrowroots	**3.923**	0.008	**5.084**	0.002	0.023	0.285	0.084
Amaranths	**4.697**	0.008	**2.751**	0.039	0.039	0.287	0.034
Spinach	**4.228**	0.015	**2.784**	0.061	0.061	0.238	0.203
Kales	**3.067**	0.015	**2.060**	0.032	0.032	0.285	0.340

Table 5. Incremental lifetime cancer risk per 170,000 people in Kibera Slum.

Vegetable	U001	U002	U003	U004	U005	U006	Total
Arrowroots	4	17	2	2	2	2	29
Kales	4	4	2	2	4	4	20
Spinach	2	2	2	2	2	2	12
Amaranths	2	4	2	2	2	0	12
Grand total	12	27	8	8	10	8	73

This results showed that ILCR for lead alone a total of 73 residents of the 0.17 M which translates to 0.043% likely to develop cancer in a lifetime due to the long-term exposure to non-essential elements. In Kenya cancer is the third leading cause of morbidity (7% deaths per year), after infectious and cardiovascular diseases. It is estimated that 39,000 new cases of cancer are reported every year with more than 27,000 deaths per year with the leading cancer being prostrate (men) and breast cancer (female) [19]. If the result obtained is calculated considering more non-essential elements and slum areas then no doubt the country is already in a cancer crisis.

4. Conclusions and Recommendations

Amaranths, spinach, arrow roots, and kales grown in Kibera slum through peri-urban agriculture contained high levels of essential and non-essential elements and consequently alarming DIM and THQ health risk indices for Mn and Fe elements. Incremental lifetime cancer risk index (ILCR) showed that from lead alone almost 73 (0.043%) residents are likely to develop cancer in Kibera slum.

A sensitization strategy is called for use of safe water for peri-urban farming in this slum.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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