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Heavy Metal Status of Major Vegetable Farmsoils in Ilorin Metropolis, Kwara State, Nigeria

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ABSTRACT: Soils in developing areas have been confirmed by researchers to be contaminated with heavy metals which are a major category of pollutants. Previous projects had been carried out to ascertain different levels of heavy metals in soils but this paper targets heavy metals and degree of pollution of major vegetable farm soils in Ilorin metropolis, Kwara State, Northern Nigeria. Therefore, this work aimed at determining the; concentrations of total heavy metals (HMs) and the pollution index of the major vegetable farm soils. Total cadmium (Cd), copper (Cu) and lead (Pb) in soils were determined by acid digestion and Atomic Absorption Spectrophotometry method. Data generated were subjected to Analysis of Variance (ANOVA) and mean separated using Duncan Multiple Range Test (DMRT) at 5% significance. HMs in soils were: Cd (0.00-4.67), Cu (1.71-30.08) and Pb (1.29-82.00) mg/kg with pH range of 6.62-9.33 and pollution index range of Cd (0.00-2.90), Cu (0.86- 11.72) and Pb (0.70-14.30). Some soils showed elevated concentration of Cd and Pb higher than the recommended permissible – limit (Cd=1.00 mg/kg, Pb=70.00mg/kg) with pollution index of HMs ranged from low pollution to very strong pollution (0.00±0.00-14.30±1.77). The study therefore, suggested that there could be a risk of Cd and Pb associated diseases on the consumption of vegetables planted on some of these soils. Keywords: Heavy metal content, pollution index, vegetable farmsoils, Ilorin metropolis.

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Soil is very important natural resource which sustains the agricultural activities and civilization of mankind. They are the major reservoirs of heavy metals which are released as a result of human activities like domestic waste disposal, agricultural practices, products of mining, vehicular exhaust emission, solid discharge and industrial discharges and effluents, gas flaring, insecticides and pesticides, municipal wastes and practices of fertilizer application, spillage of petrochemical and combustion of coal, fossil burning and combustion of coal (Afzal shaliet*,* 2013). The level of heavy metals in soil above normal level are toxic, non-biodegradable and their concentrations vary from soil to soil which can influence the rapid increase of microbial multiplication and enzymatic activities which may lead to decrease in the rates of the biochemical process in the soil environment (Syed and Mohammad, 2012)

The negative effect of heavy metals in soil from anthropogenic activities without treatment in compliance with the safe and standard disposal regulatory limit on agricultural lands as reported by (Burmamu *et al.*, 2014) as are sources of pollution and are of great concern.

Studies had shown results on pollution problems of some farm soils in Nigeria but not much has been done on the level and distribution of heavy metals and the degree of pollution in soil of major vegetable farms in Ilorin, Kwara State, Northern, Nigeria, Therefore, it is important to investigate the pollution status of soils of the major vegetable farms in order to keep a check on the environment, formulate, recommend appropriate policies that support reduction of contamination and to provide data for future research works.

MATERIALS AND METHODS

The Study sites are the twelve major vegetable farm soils in Ilorin, Kwara State. They are Otte, Budo Egba, Budo Abio, Mubo, Oyun, Ojagboro, Olaolu, Eroomo, Okeodo, Cocacola, Isale Aluko,Odoore vegetable farms and Botanical garden (Control site).

Otte vegetable site is located at Otte town in Asa Local Government Area of Kwara State. The soil lies between latitude latitude 8^0 31^1 N and longitude 4^0 39^1 E. The farm site is located behind Otte

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Budo Egba vegetable site is located at Budo Egba town in Asa Local Government Area of Kwara State. The soil lies between latitude $8^0 32^1$ N and longitude 4^0 39^1E. The farm site is located by the major road.

Budo Abio vegetable site is located at Budo Abio town in Asa Local Government Area of Kwara State. The soil lies between latitude 8^0 30^1 N and longitude 4^0 53^1E. The farm is cited behind the village.

Mubo vegetable site is located at Mubo area in Ilorin town in Ilorin East Local Government Area. The soil lies between latitude latitude 8^0 50^1 and longitude 4^0 70^1E. The farm site is located near two major roads with thick vehicular emission

Oyun vegetable site is located at Oyun area in Ilorin town in Ilorin East Local Government Area. The soil lies between latitude 8^0 50^1 and longitude 4^0 70^1E by the road.

Ojagboro vegetable site is located in Ojagboro area in Ilorin town in Ilorin East Local Government Area. The soil lies between latitude $8^0 15^1$ and longitude 4^0 57^1E.

Olaolu vegetable site is located at Olaolu area in Ilorin town in Ilorin South Local Government Area. The soil lies between latitude 8^0 47^1 and longitude 4^0 57^1E.

Eroomo vegetable site is located at Eroomo area in Ilorin town in Ilorin South Local Government Area. The soil lies between latitude 8^0 45^1 N and longitude 4^0 58^1E.

Okeodo vegetable site is located at Okeodo area in Ilorin town in Ilorin West Local Government Area of Kwara State. The farm soil lies between latitude 8^0 47^1 N and longitude 4^0 64^1E. The farm site is located behind the University of Ilorin road with thick vehicular emission.

Coca cola vegetable site is located at Coca cola area in Ilorin town in Ilorin West Local Government Area. The soil lies between latitude 8^0 47^1 N and longitude 4^0 56^1E.

Isale Aluko vegetable site is located at Isale Aluko area in Ilorin town in Ilorin West Local Government Area. The soil lies between latitude 8^0 49^1 N and longitude 4^0 54^1E.

Odoore vegetable site is located at Odoore area in Ilorin town in Ilorin West Local Government Area. The soil lies between latitude 8^0 43^1 N and longitude 4^0 50^1E.

The control sample was taken from the Botanical garden at the University of Ilorin main campus in Ilorin town in Ilorin South Local Government Area (Table 1).

Table1: Geographical coordinates of sampling points

S/N	Site(Vegetable farms)	LGA	Latitude (N)	Longitude (E)	Altitude (meters)
1	Otte	Asa	8^0 31^1	4^0 39^1	347.0
2	Budo Egba	Asa	8^0 32^1	4^0 39^1	346.6
3	Budo Abio	Asa	8^0 30^1	$4^0 53^1$	365.0
4	Mubo	Ilorin East	8^0 50^1	$4^0 70^1$	270.4
5	Oyun	Ilorin East	8^0 53^1	4^0 60^1	284.5
6	Ojagboro	Ilorin East	8^0 15^1	4^0 57^1	262.2
7	Olaolu	Ilorin South	8^0 47^1	4^0 57^1	282.7
8	Eroomo	Ilorin South	8^0 45^1	4^0 58^1	327.1
9	Okeodo	IlorinSouth	8^0 47^1	4^0 64^1	332.8
10	Coca cola	Ilorin West	8^0 47^1	4^0 56^1	265.5
11	Isale Aluko	Ilorin West	8^0 49^1	4^0 54^1	302.9
12	Odoore	Ilorin West	8^0 43^1	4^0 50^1	354.1
13	Botanical garden (Control site)	Ilorin south	8^0 47^1	4^0 66^1	290.9

LGA means Local Government Area. N=North of the Equator. E= East of the Greenwich Meridian

Heavy metal was determined in the soil samples using the method (Sahrawat *et al.*, 2002). This was done by weighing One gram of the oven-dried ground soils samples from each site in pre-washed 100 cm^3 Kjedahl digestion flask. The soil samples were subjected to wet digestion by adding 2 cm^3 of 60% perchloric acid ($HClO_4$) to 10 cm^3 concentrated nitric acid (HNO_3) and 1.0 cm^3 concentrated sulphuric acid (H_2SO_4) after which it was left for 15 min to cool and diluted with distilled water. The mixture was filtered through Whatman filter paper 24 into a 100 cm^3 volumetric flask and made up to mark with distilled water. The blank and the samples were digested alongside. The concentration of the metal was obtained from the calibration plot made with various concentrations of the standard and heavy metal concentration was read against the absorbance using An Analyst 200 Perkin Elmer Atomic Absorption Spectrophotometer and operated as per the manufacturer's manual. The reagents used for this study were all of analytical grades (British Drug Houses-BDH) chemical Ltd., Poole England) and standard solutions were prepared from 1000 μg g^{-1} stock solution of Cd, Cu and Pb. The glassware used were thoroughly washed with (1:4) HNO_3 and then rinsed with distilled water

The pH of the soil samples was determined using a pre-calibrated pH 7310 no 1 LAB glass electrode pH metal in buffer 4, 7, 9 (Oyinloye, 2007).

Pollution index of the soils was estimated (Deng *et al*. (2012). This parameter evaluates the degree of pollution of soil from each site.

$P_y = C/Sj$

Where p_y is the pollution index of the heavy metal j in the *i*-th functional area soil. Cis the measured contamination value of metal in the *i* -th functional area soil, and S_i is the background contamination value of heavy metal**.**

Where P y ≤ 1 (No pollution), Py ≥ 1≤ 2 (Low pollution), Py ≥ 2 ≤ 3 (Moderate pollution), P_y ≤ 3≥ 5 (Strong pollution) and Py ≥ 5(Very strong pollution) (Yang *et al.,* 2013)

RESULTS AND DISCUSSION

Table 2-5 show the pH, the mean concentrations of the total heavy metals and the pollution indices of the soils from major vegetable farms in Ilorin metropolis in dry and rainy seasons (2015 and 2016). The soils of dry season tend towards slightly acidic to neutral (6.62±0.04^{e} and 7.18±0.03$^{a)}$). The slightly acidic nature of some soil mostly in the dry season could be due to seasonal variation which could have resulted from the effect of bush burning, harmattan dust and partially to the changing in concentration of the salt in the soil solution (Burmamu*, et al.,* 2014) and the values were within the recommended pH range (6.0-7.5) for optimum nutrient availability in soil (Fagbote and Olanipekun, 2011). Total cadmium concentration of soils ranged between 0.21±0.05 mg/kg and 4.67±0.29mg/kg in the dry season with the lowest mean Cd concentration at the control site and the highest at soil of Olaolu, (Table 2) showing a higher Cd range than the permissible safe limit for agricultural soil (0.01-1.00 mg/kg EU,2007, Toth *et al,* 2016) .This could be due to activities around the sampling site such as the exhaust from factories, surfaces of the roads which increase the wearing of tyres, and run-offs from the roadsides and spillage from mechanic workshops around the sites (Afzal Shaliet*,* 2013). The Cd content of soils was higher in the dry season than in the rainy season. This could be due to seasonal variation which could have affected metal mobility, speciation and availability in soil, copper ranged between 1.71±0.46 mg/kg and 4.50±0.12 mg/kg showing Cu content was within the range of the safe limit of agricultural soil (46.00 mg/kg EU.EPA, 1989) while lead ranged between 1.29±0.22mg/kg and 11.67±15.12 mg/kg indicating lower Pb range than the permissible limit for agricultural soil (70.00mg/kg EU, 2007) in the dry season. The lowest mean lead concentration was recorded for the control soil while the highest was recorded for Mubo soil (Table 2). This could be due to the farm location and the types of activities at the sites. Lead (11.67 ± 2.12 mg/kg) ranked highest of the total metals followed by Cd (4.67±0.29mg/kg) and Cu (4.50 ±0.12 mg/kg) for the soil samples, that is, the mean of total concentration of metals in this study was in the order Pb ≥ Cd ≥ Cu in the dry season (Table 2) Table 3 shows the mean pH and the concentrations of total heavy metals of the soil samples in the rainy season (2016)..

Table 2. Mean concentrations of the total heavy metals (mg/kg) of the soils from major vegetable farms in the dry season (2015).

Site	pH	Cd	Cu	Pb
Otte	6.93±0.01^{bcd}	2.92±0.38^{d}	2.42±0.80^{de}	3.92±0.15^{cd}
Budo Egba	6.62±0.04^{e}	2.15±0.14^{e}	2.00±0.90^{ef}	3.58± 0.21^{cde}
Budo Abio	6.88±0.01^{cd}	0.93±0.07^{g}	3.00±1.52^{c}	3.42±0.64^{def}
Mubo	7.18±0.03^{a}	3.05±0.25^{c}	3.67±1.61^{b}	11.67±2.12^{a}
Oyun	7.05±0.04^{ab}	2.83±0.12^{de}	2.58±0.14^{d}	5.08±7.54^{bc}
Ojagboro	6.81±0.01cd	3.76 ±0.14^{bc}	2.33±1.90^{e}	2.50±0.33^{ef}
Olaolu	6.69±0.01^{de}	4.67±0.29^{a}	4.50±0.12^{a}	5.08±0.69^{bc}
Eroomo	6.63±0.04^{e}	0.75±0.09^{gh}	4.42±3.00^{ab}	3.42±0.64^{de}
Okeodo	6.85±0.01^{bc}	4.62±0.14^{ab}	4.42±3.25^{ab}	5.17±0.47^{b}
Coca cola	7.08±0.04^{ab}	3.98±0.14^{b}	3.08±2.02^{c}	10.75±0.70^{ab}
IsaleAluko	6.94±0.01^{b}	1.75±0.25^{f}	3.42±1.84^{bc}	4.12±0.76^{c}
Odoore	6.68±0.01^{de}	0.67±0.11^{h}	2.08±2.00^{ef}	1.58±0.63^{fg}
Bot garden	6.67±0.01^{de}	0.21±0.03^{i}	1.71±0.46^{g}	1.29±0.22^{g}

Values represent mean ± SD. Mean value with same alphabet along the same column are statistically the same at p≤0.05. EU, 2007; Toth, et al., 2016; Cu=100mg/g. Pb=60mg/g. Cd=1.0mg/g, pH = 5.5-7.0

The soils tend toward neutral to strong alkaline ($7.11\pm0.02^{f}$and 9.33 ± 0.02^{a}) with the lowest recorded in the soil of Isale Aluko and the highest in the soil of Odoore (Table 3). Most soils even the control recorded higher pH values than the recommended permissible safe limit for agricultural soil (5.5-7.0). This could be attributed to high phoshphate precipitation in the **soil** solution and calcium carbonate-rich parent material weathering. Cadmium was between 0.00±0.00 mg/kg and 1.33±1.26 mg/kg suggesting a lower Cd concentration for the rainy season (2016) than dry season (2015) but higher than the permissible limit for agricultural soil (0.00-1.00 mg/kg (EU, 2007; Toth *et al*, 2016) therefore, could pose serious health risk. A non-detectable Cd content (0.00± 0.00 mg/kg) was recorded for the soil of the Control while the highest was recorded for soil of Otte (Table 3). Higher Cd concentration for soil of the Control in the dry season than the rainy season was indicated which could have been due to seasonal variation and pH which could have affected the mobility, availability and speciation of Cd in the soil during the dry season. Total copper of soil was betwwen 3.33±1.33 mg/kg and 30.08 ± 4.40 mg/kg in the rainy season (Table 3). Lower than the (EU, 2007; Tosh *et al*, 2016) permissible limit of Cu for agricultural purpose (Cu=100 mg/kg). The concentration of Pb in the rainy season was 8.00±0.50 mg/kg and 82.00 ± 6.00 mg/kg indicating higher Pb concentration for the soil in the rainy season than the dry season (2015) which shows higher Pb content than the permissible limit for agricultural soils (70mg/kg EU 2007, Tosh *et al*, 2016).This may be as a result of seasonal rainfall, dilution and runoff during the wet season that flushed the contaminants from the dumpsites into the environment. It could also be due to the higher pH in the rainy season which supports metal dynamics, redox reaction and metal speciation. The lowest Pb concentration was recorded for the Control farm soil in the rainy season (8.00±0.50 mg/kg) higher than the value for the Control soil of the dry season (1.29±0.22 mg/kg). The higher seasonal pH variation could have enhanced Pb complexation and speciation making Pb viable in the rainy season than in the dry season (Table 3) (Burmamu *et al.,* 2014). Soil of the Control site recorded the lowest concentrations of selected heavy metals; Cd, Cu and Pb

Table 3: Mean concentrations of the total heavy metals (mg/kg) of the soils from major vegetable farms in the rainy season (2016).

Sites	pH	Cd	Cu	Pb
Otte	8.04±0.01d	1.33 ± 0.06^{a}	14.67 ± 2.26^{cd}	19.67 ± 4.76^{ef}
Budo Egba	7.97±0.02de	1.17 ± 0.29^{ab}	11.83 ± 7.75^{e}	17.17 ± 3.75^{ghi}
Budo Abio	8.55±0.03cd	0.83 ± 0.76^{b}	6.33 ± 5.25^{h}	14.67 ± 9.25^{hi}
Mubo	8.67±0.03c	0.17 ± 0.29^{c}	16.67 ± 15.12^{c}	62.50 ± 60.00^{b}
Oyun	9.05±0.05ab	0.00 ± 0.00^{d}	8.83 ± 1.26^{g}	22.50 ± 2.50^{def}
Oja gboro	7.37±0.02e	0.00 ± 0.00^{d}	9.00 ± 0.05^{fg}	18.67 ± 2.26^{fg}
Olaolu	8.96±0.04b	0.18 ± 0.28^{c}	30.08 ± 4.40^{a}	82.00 ± 6.00^{a}
Eroomo	8.78±0.03bc	0.17 ± 0.29^{c}	20.00 ± 2.00^{b}	17.75 ± 11.67^{gh}
Okeodo	8.67±0.03c	0.00 ± 0.00^{d}	9.50 ± 3.00^{f}	19.67 ± 0.29^{efg}
Coca cola	7.29±0.03ef	0.00 ± 0.00^{d}	13.83 ± 6.75^{d}	$24.00\pm0.00d^{e}$
Isale Aluko	7.11±0.02f	0.00 ± 0.00^{d}	12.83 ± 3.25^{de}	58.50 ± 6.00^{c}
Odoore	9.33±0.02a	0.00 ± 0.00^{d}	7.83 ± 6.25^{gh}	28.33 ± 25.06^{d}
Botanical garden(Control.site)	8.30±0.05cd	0.00 ± 0.00^{d}	3.33 ± 0.33^{i}	8.00 ± 0.50^{i}

Values represent mean ± SD. Mean value with same alphabet along the same column are statistically the same at p≤0.05. EU, 2007: Toth, et al., 2016: Cu=100mg/g. Pb=60mg/g. Cd=1.0mg/g, pH = 5.5-7.0

Table 4 shows the pollution index (degree of pollution) of metals of soils for dry season (2015). The range was between 0.29±0.08 and 1.50±0.13 indicating the range of no Cd pollution to low Cd pollution of the studied soils in the dry season. The lowest Cd pollution index was recorded for soil of the Control (0.50±0.08) while the highest was recorded for Coca cola soil (1.50±0.13) suggestion difference in activities and sources of pollution in both sites where the soils were sampled (Anhwangbe *et al*., 2007). Copper pollution index ranged between 0.86 ±0.09 and 1.93±0.08 which indicated the range of no pollution (P≤1) to low Cu pollution. Soil of the Control had mean pollution index of Cu of 0.86±0.09 indicating no Cu pollution (Pi≤1) while the highest was recorded for soil of Isale Aluko (1.93±0.08). This shows the difference in the activities in both areas. (Table 4). The range of lead (Pb) pollution index of soils for the dry season planting ranged between 0.70 ±0.11 and 5.19 ±0.13 indicating the degree of Pb pollution in the sampled soils from no pollution to very strong Pb pollution. Mean pollution index for lead was lowest for the Control soil and highest for Mubo soil with pollution index greater than 5, this indicates that there is difference in the types of activities in the sampled areas such as vehicular emission, mechanic workshop pollution and industrial waste discharge in the sites where the soils (Table 1). This result also indicated that heavy metal contents of the soils varied significantly from site to site and season to season.

Table 4: Pollution Index of soils from major vegetable farms in the dry season (2015).

SITES	Cd	Cu	Pb
Otte	0.84±0.11^{d}	1.04±0.06^{d}	2.74±0.11^{c}
Budo Egba	1.34±0.08^{b}	1.00±0.11^{d}	2.76±0.14^{c}
Budo Abio	0.66±0.10^{d}	1.11±0.09^{d}	1.00±0.09^{e}
Mubo	0.50±0.08^{ef}	1.58±0.04^{b}	5.19±0.11^{a}
Oyun	0.66±0.15^{e}	1.29±0.07^{c}	4.78±0.04^{b}
Ojagboro	1.34±0.12^{b}	1.32±0.08^{c}	1.83±0.12^{de}
Olaolu	1.34±0.10^{b}	1.47±0.09^{b}	2.70±0.11^{c}
Eroomo	1.00±0.09^{c}	1.00±0.10^{d}	1.11±0.09^{e}
Okeodo	1.34±0.19^{b}	1.90±0.04^{a}	2.68±0.13^{cd}
Coca cola	1.50±0.13^{a}	1.90±0.11^{a}	2.74±0.22^{c}
IsaleAluko	1.16±0.07^{c}	1.93±0.08^{a}	2.38±0.12^{d}
Odoore	1.00±0.07^{c}	0.89±0.11^{f}	1.00±0.02^{e}
Botanical garden(control site)	0.29±0.08^{ef}	0.86±0.09^{f}	0.70±0.11^{f}

Mean value with same along the same column alphabet are statistically the same. Values represent mean ± SD. Pi=pollution index, Pi≤1 (no pollution), Pi≥1≤2 (low pollution), Pi≤2≥3 (moderate pollution), Pi ≥3≤5 (strong pollution) and Pi≥5 (very strong pollution) (Yang et al., 2014).

Table 5 shows the mean pollution index of the heavy metals of soils in the rainy season (2016). The range was 0.00 ± 0.00 and 3.11 ± 0.17 showing the range of no Cd pollution to strong Cd pollution (P≥3≤5). The result shows that even in areas with little industrialization, lack of adequate waste management controls could cause the unusual high levels of heavy metals contamination of soil as recorded in the soil of Budo Abio and Eroomo (Ghosh, 2012). Soil of the Control soil (0.00 ± 0.00) had no detectable Cd pollution Index (0.00±0.00) indicating no Cd pollution (Table 5), indicating the site is far from sources of contamination. Soils of Otte (3.11±0.17) had strong Cd pollution level (P≥3≤5), Budo Egba (2.85± 0.15) had moderate Cd pollution level (Pi≥2≤3), Budo Abio (1.35±0.15) suggesting low Cd pollution level (Pi≥1≤2). It was found that most of the soils were not polluted with Cd in the rainy season. Only soil of Budo Abio was found to be of low Cd pollution, soil of Budo Egba was moderately polluted with Cd while Otte soil was recorded to be strongly polluted with Cd (Table 5). The Cu pollution indices for the soils for the rainy season (2016) ranged between (1.05 ± 0.14) and (5.37 ± 0.60) showing the range of low Cu pollution level (Pi≥1≤2) to very strong Cu pollution level (Pi≥5) in the rainy season. The Cu pollution index of the Control soil (1.05 ± 0.14) had the lowest value than other soils (Table 5). Pollution Index for Pb of soils in rainy season (2016) ranged between 1.00±0.00 and 14.30 ± 1.77 showing the range of low Pb pollution to very very strong Pb pollution(Pi≥1≤2) to (Pi ≥5). The Control soil had the lowest Pb pollution Index (1.00 ± 0.00) while soil of Olaolu (14.30 ± 1.77) recorded the highest value suggesting a very high degree of Pb pollution range (Table 5). This could have been due to the types of activities around the site such as the mechanic workshops, the site is near the road and factories are around the site, could also be due to higher pH in the rainy season which supported Pb speciation, mobility, complexation and redox reaction (Ghosh, 2012). The pollution index of soils in this study showed that even in areas with little industrialization, lack of adequate waste management controls could have caused the unusual high levels of heavy metals contamination of some of the soils (Hazard, 2012).

Conclusion: This study concluded that soils of some vegetable farms in Ilorin metropolis are contaminated with heavy metals. The concentrations of cadmium and lead of some of the vegetable farm soils investigated were above the WHO/EU/FAO/UK permissible limit values therefore unfit for planting food crops. High degree of pollution of the studied heavy metals have toxic potential and long term chronic effect, therefore, it becomes imperative to monitor heavy metals in soils for growing edible crops, in order to prevent excessive buildup of these metals in human through food chain.

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