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 (0.00-2.98), Cu (0.86-17.72) 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). 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°31' N and longitude 4°39' E. The farm site is located behind Otte.
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$^3$ Kjeldahl 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$\text{$_2$SO}_4$) 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 mixture was filter-

**Table 1: Geographical coordinates of sampling points**

| S/N | Site (Vegetable farms) | LGA       | Latitude (N) | Longitude (E) | Altitude (meters) |
|-----|------------------------|-----------|--------------|---------------|-------------------|
| 1   | Ote                    | Asa       | 8° 31'       | 4° 39'        | 347.0             |
| 2   | Budo Egba              | usa       | 8° 32'       | 4° 39'        | 346.6             |
| 3   | Budo Abio              | usa       | 8° 30'       | 4° 51'        | 365.0             |
| 4   | Mubo                   | Ilorin East | 8° 50'      | 4° 70'        | 270.4             |
| 5   | Oyun                   | Ilorin East | 8° 53'      | 4° 60'        | 284.5             |
| 6   | Ojagbore               | Ilorin East | 8° 15'      | 4° 57'        | 262.2             |
| 7   | Olaolu                 | Ilorin South | 8° 47'     | 4° 57'        | 282.7             |
| 8   | Eroomo                 | Ilorin South | 8° 45'      | 4° 58'        | 327.1             |
| 9   | Okeodo                 | Ilorin South | 8° 47'      | 4° 64'        | 332.8             |
| 10  | Coca cola              | Ilorin West | 8° 47'      | 4° 56'        | 265.5             |
| 11  | Isale Aluko            | Ilorin West | 8° 49'      | 4° 54'        | 302.9             |
| 12  | Odoore                 | Ilorin West | 8° 43'      | 4° 50'        | 354.1             |
| 13  | Botanical garden       | Ilorin south | 8° 47'     | 4° 66'        | 290.9             |

LGA means Local Government Area. N=North of the Equator. E= East of the Greenwich Meridian
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) HNO₃ 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.

\[ P_y = \frac{C}{S_i} \]

Where \( P_y \) is the pollution index of the heavy metal \( j \) in the \( i \)-th functional area soil. \( C \) is 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 \( P_y \leq 1 \) (No pollution), \( P_y \geq 1 \leq 2 \) (Low pollution), \( P_y \geq 2 \leq 3 \) (Moderate pollution), \( P_y \geq 3 \leq 5 \) (Strong pollution) and \( P_y \geq 5 \) (Very strong pollution) (Yang et al., 2013)

RESULTS AND DISCUSSION

Table 2 and 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) and (7.18±0.03). 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 (Burmanu 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±0.29 mg/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±0.22 mg/kg and 11.67±15.12 mg/kg indicating lower Pb range than the permissible limit for agricultural soil (70.00 mg/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±0.29 mg/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 (mg/kg) | Cu (mg/kg) | Pb (mg/kg) |
|---------------|------|------------|------------|------------|
| Otete         | 6.93±0.01<sup>b,c</sup> | 2.92±0.38<sup>b</sup> | 2.42±0.80<sup>c</sup> | 3.92±0.15<sup>c</sup> |
| Budo Egba     | 6.62±0.04<sup>c</sup> | 2.15±0.14<sup>c</sup> | 2.00±0.90<sup>c</sup> | 3.58±0.21<sup>c</sup> |
| Budo Abo      | 6.88±0.01<sup>c</sup> | 0.95±0.07<sup>c</sup> | 3.00±1.32<sup>c</sup> | 3.42±0.64<sup>c</sup> |
| Mubo          | 7.12±0.03<sup>d</sup> | 3.05±0.25<sup>d</sup> | 3.67±1.61<sup>d</sup> | 11.67±2.12<sup>d</sup> |
| Ogun          | 7.05±0.04<sup>c</sup> | 2.83±0.12<sup>c</sup> | 2.58±0.14<sup>c</sup> | 5.08±0.76<sup>c</sup> |
| Obaro         | 6.81±0.01<sup>c,d</sup> | 3.76±0.14<sup>c</sup> | 2.33±1.90<sup>c</sup> | 2.50±0.33<sup>c</sup> |
| Olaloa        | 6.69±0.01<sup>c</sup> | 4.67±0.29<sup>c</sup> | 4.50±1.12<sup>c</sup> | 5.08±0.69<sup>c</sup> |
| Eromo         | 6.63±0.04<sup>c</sup> | 0.75±0.09<sup>c</sup> | 4.42±0.03<sup>c</sup> | 3.42±0.64<sup>c</sup> |
| Osaroa        | 6.55±0.01<sup>c</sup> | 4.62±0.14<sup>c</sup> | 4.42±2.56<sup>c</sup> | 5.17±0.47<sup>c</sup> |
| Obelefe       | 7.09±0.04<sup>c</sup> | 3.98±0.14<sup>c</sup> | 3.08±2.03<sup>c</sup> | 10.75±0.70<sup>c</sup> |
| Isala-Akoko   | 6.94±0.01<sup>c</sup> | 1.75±0.25<sup>c</sup> | 3.42±1.84<sup>c</sup> | 4.12±0.76<sup>c</sup> |
| Oloore        | 6.68±0.01<sup>c</sup> | 0.67±0.11<sup>c</sup> | 2.08±2.02<sup>c</sup> | 1.58±0.63<sup>c</sup> |
| Bot garden    | 6.87±0.01<sup>c</sup> | 0.21±0.03<sup>c</sup> | 1.71±0.46<sup>c</sup> | 2.89±0.22<sup>c</sup> |

Values represent mean ± SD. Mean value with same alphabet along the same column are statistically the same at \( p \leq 0.05 \). 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±0.02* and *9.33±0.02*) 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 phosphate 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 between 3.33±1.33 mg/kg and 30.08 ± 4.40 mg/kg in the rainy season (Table 3).

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°  | 14.67±2.26 df  | 19.67±4.76 df  |
| Budo Egba | 7.97±0.02de | 1.17±0.29 Ab | 11.83±7.75 sb  | 17.17±3.75 sb  |
| Budo Abio | 8.55±0.03cd | 0.83±0.76 a  | 6.33±5.25 a  | 14.67±9.25 a  |
| Mubo      | 8.67±0.03c  | 0.17±0.29 a  | 16.67±15.12 e  | 62.50±60.00 b  |
| Oyun      | 9.05±0.05ab | 0.00±0.00 d  | 8.83±1.26 a  | 22.50±2.50 a  |
| Oja gboro | 7.37±0.02c  | 0.00±0.00 d  | 9.00±0.05 ef  | 18.67±2.26 b  |
| Olaolu    | 8.96±0.04b  | 0.18±0.28 de | 30.08±4.40 h  | 82.00±6.00 b  |
| Eroomo    | 8.78±0.03bc | 0.17±0.29 a  | 20.00±2.00 e  | 17.75±11.67 b |
| Okodo    | 8.67±0.03c  | 0.00±0.00 d  | 9.50±3.00 ef  | 19.67±2.94 b  |
| Coca cola | 7.29±0.03ef  | 0.00±0.00 d  | 13.83±6.75 e  | 24.00±6.00 d  |
| Isale Aluko | 7.11±0.02f | 0.00±0.00 d  | 12.83±3.25 a  | 58.50±6.00 a  |
| Odoore    | 9.33±0.02a  | 0.00±0.00 d  | 7.83±6.25 ab  | 28.33±25.06 d |
| Botanical | 8.30±0.05cd  | 0.00±0.00 d  | 3.33±0.33 f  | 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) suggesting 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 (Pi≤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 | 1.04±0.06 | 2.74±0.11 |
| Budo Egba      | 1.34±0.08 | 1.00±0.11 | 2.76±0.14 |
| Budo Abio      | 0.66±0.10 | 1.11±0.09 | 1.00±0.09 |
| Mubo           | 0.50±0.08 | 1.58±0.04 | 5.19±0.11 |
| Oyun           | 0.66±0.15 | 1.29±0.07 | 4.78±0.04 |
| Ojagboro       | 1.34±0.12 | 1.32±0.08 | 1.83±0.12 |
| Oloalu         | 1.34±0.10 | 1.47±0.09 | 2.70±0.11 |
| Eroomo         | 1.00±0.09 | 1.00±0.10 | 1.11±0.09 |
| Okeodo         | 1.34±0.19 | 1.90±0.04 | 2.68±0.13 |
| Coca cola      | 1.50±0.13 | 1.90±0.11 | 2.74±0.22 |
| Isale/Akoko    | 1.16±0.07 | 1.93±0.08 | 2.38±0.12 |
| Odoore         | 1.00±0.07 | 0.89±0.11 | 1.00±0.02 |
| Botanical garden (control site) | 0.29±0.08 | 0.86±0.09 | 0.70±0.11 |

Mean value with same along the same column 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 (P≥2≤3), Budo Abio (1.35±0.15) suggesting low Cd pollution level (P≥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 4).

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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