Heavy Metal Level Evaluation in Commonly Cultivated Vegetables from Different Farming Areas in Kano State

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Abstract: Metal toxicity on food substances has been a major cause of diseases and conditions in many parts of the world including African countries. In Nigeria, vegetables, which are an integral part of dishes and delicacies, could be liable to heavy metal toxicity and consumption of such could have devastating health consequences. This study aimed to evaluate levels of some heavy metals in vegetables sources from major farming areas in Kano, Northern part of Nigeria. Samples of some commonly consumed vegetables and irrigation waters were obtained from 4 different farming locations in Kano. The samples including the irrigation waters were oven dried and subjected to digestion processes using acid methods. The solution obtained was used to determine levels of Pb, As, Cd, Ni, Zn and Cu using spectrophotometry. The results showed elevated levels of Pb and Cd in water and vegetables from 2 farming sites compared to other location. The results were also higher than the acceptable limits by WHO/FAO. From these results, it was inferenced that vegetables from such areas have significant higher levels of some of these toxic heavy metals and should be point of concern for food monitoring authorities.

Keyword: Vegetables, Heavy-metals, Kano, spectrophotometry, health, toxic.

INTRODUCTION

Heavy metals have been known to accumulate due to various human and environmental activities (O E Orisakwe et al., 2017). The quality of ecosystem becomes altered, when heavy metals find their way, somehow, into it through human and natural activities (Tchounwou et al., 2012). Human activities including mining processes improper waste disposal and other activities have been reported as major causes of accumulation and intoxication by heavy metals (Jaishankar et al., 2014). These metals bio-accumulate in plants grown in these areas. The metals have detrimental effects on agricultural production, decreasing both yield and quality of vegetables when their concentrations reach toxic levels (Singh et al., 2011). In addition, through bio-multiplication, the accumulated metals’ levels increases in amount resulting addition deposits of the heavy metals in various plants’ parts including stem, roots and leaves (Krupa & Swida, 1997).

Heavy metals have been known to have devastating health effects and are associated with many human diseases and conditions (Singh et al., 2011). The metals, having large structural densities include but not limited to Pb, Co, Cd, Ni, Fe, Cu, Hg etc. Although some of these metals are required for proper body physiology, a lot of them should be carefully considered and monitored (Gillis et al., 2012). Thus various regulatory bodies such as the World health organizations (WHO), FAO, NAFDAC etc have all set recommende levels or ranges for each metal in different sources including drinking water, vegetables and other food stuff (Jan et al., 2015). Thus metals such as Pb should not exceed certain recommended value set by WHO. Higher levels of Pb for example, is associated with respiratory difficulties and anemia (Wani et al., 2015). It is an inhibitor of porphobilinogen synthase and ferrochelatase and strongly reduced heme biosynthesis. Pb has also been shown to be associated with oxidative stress and free radical generation (Gillis et al., 2012). Finally, it has been strongly implicated in cognitive dysfunction and neurological impairment. Once it enters the body, Pb is easily distributed in the kidney, liver, brain, muscles and bones (Kim et al., 2015). Similarly, Ni, Co, Cd, accumulations have shown to be associated with respiratory failure,
Vegetables are important food components particularly in African countries (Bar-On et al., 2018). Most local dishes in Nigeria are vegetable based (Sheshe et al., 2019). Additionally, they form the largest food sources in the North-western part of Nigeria. In Kano, Spinach, Cabbage, Lettuce, water leaf, etc are the most common vegetables widely grown in specified areas (Mohammad et al., 2017). Most of the areas in Kano where these vegetables are grown are usually water close areas (State et al., 2010). The vegetables grown in these areas cover over 90% of the total amount of vegetables consumed in Kano, Jigawa, and some parts of Kaduna and Katsina states (Sheshe et al., 2019).

This study aims at determining and comparing levels of some heavy metals in widely consumed vegetables grown in 4 major areas of Kano state. Specific objectives of the study include;

i. Determining the levels of the heavy metals As, Pb, Cd, Ni, Zn and Cu in vegetables; Cabbage, Lettuce, Spinach and water samples from Wudil farm areas

ii. Determining the levels of the heavy metals As, Pb, Cd, Ni, Zn and Cu in vegetables; Cabbage, Lettuce, Spinach and water samples from Noomansland farm areas

iii. Determining the levels of the heavy metals As, Pb, Cd, Ni, Zn and Cu in vegetables; Cabbage, Lettuce, Spinach and water samples from Shirmu farm areas

iv. Determining the levels of the heavy metals As, Pb, Cd, Ni, Zn and Cu in vegetables; Cabbage, Lettuce, Spinach and water samples from Sharada farm areas

**2.0 MATERIALS AND METHODS**

**Sample collection and Preparation**

Vegetable and water samples were collected from Wudil, Noomansland, Shirmu and Sharada areas of Kano state in Nigeria. Vegetables samples were oven-dried, grinded and sieved. The samples were then transferred into to labelled sample bottles which were then subjected to ashing and digestion. Water samples were labelled in containing vessels and were filtered using Whatman glass tube fiber filters. The extracted was further extracted (digested) using HNO_3_. The levels of metals were determined using Atomic Absorption Spectrometer in all the samples.

**Methods of Ashing and Digestion**

**PLANTS SAMPLES**

1 gram of each sample was weighed and put into the 250 ml beaker. 30 ml of aqua regia (HCL +HNO_3_) was poured into the beaker, placed on hot plate and added to the samples each. The mixture was initially heated low temperature and later rigorously at a temperature of 90 - 95°C for an 1hr until a transparent solution. The solution was then transferred into 50cm³ volumetric flack and then made up to the mark with deionized water. Two small sample bottles were used for each metal.

**WATER SAMPLE**

Similarly, 100cm³ of water sample was put into the 250cm³ Beaker. 50cm of conc. Nitric acid was added into the Beaker and placed on hot plate for a while. The residue was then transferred into 100cm³ volumetric flack and then made up to the mark with deionized water. The digest was used for heavy metal analysis.

**Absorbance Measurement**

The absorbance of the metals was determined by Atomic Absorption Spectrophotometer Agilent technologies 200 series (model No: 240FS).

The concentration of the metals in each sample were analyzed statistically using the Graphpad Prism version 6.0.1 for windows 32-bits. Data for each sample were subjected Unpaired *t*-test with values considered significantly different when *p*<0.05.

**RESULTS**

**Table 1: Showing data of Heavy metals from Sharada farm areas**

<table>
<thead>
<tr>
<th>Samples</th>
<th>Pb (mg/kg)</th>
<th>Cd (mg/kg)</th>
<th>Ni (mg/kg)</th>
<th>Zn (mg/kg)</th>
<th>Cu (mg/kg)</th>
<th>As (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>0.426±.0.055³</td>
<td>0.215±.005³</td>
<td>ND</td>
<td>8.13±1.203³</td>
<td>10.85±0.926³</td>
<td>ND</td>
</tr>
<tr>
<td>Water Leaf</td>
<td>8.732±0.243³</td>
<td>0.637±0.0176³</td>
<td>ND</td>
<td>6.09±2.241³</td>
<td>20.25±1.415³</td>
<td>ND</td>
</tr>
<tr>
<td>Lettuce</td>
<td>36.28±0.29³</td>
<td>0.283±0.02³</td>
<td>0.953±0.043³</td>
<td>3.55±1.73³</td>
<td>14.57±0.271³</td>
<td>ND</td>
</tr>
<tr>
<td>WHO/FAO</td>
<td>10.00</td>
<td>0.2</td>
<td>67.00</td>
<td>100.00</td>
<td>73.00</td>
<td>ND</td>
</tr>
<tr>
<td>Water(mg/l)</td>
<td>0.078±0.005³</td>
<td>ND</td>
<td>ND</td>
<td>0.104±0.005³</td>
<td>0.091±3.33³</td>
<td>ND</td>
</tr>
</tbody>
</table>
### Table 2: Showing data of Heavy metals from Nomansland farm areas

<table>
<thead>
<tr>
<th>Samples</th>
<th>Pb  (mg/kg)</th>
<th>Cd  (mg/kg)</th>
<th>Ni (mg/kg)</th>
<th>Zn  (mg/kg)</th>
<th>Cu  (mg/kg)</th>
<th>As  (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>ND</td>
<td>0.215 ± 0.0005&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
<td>18.13 ± 1.203&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.85 ± 0.926&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Water Leaf</td>
<td>8.723 ± 0.243&lt;sup&gt;Ь&lt;/sup&gt;</td>
<td>0.637 ± 0.018&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
<td>1.847 ± 0.035&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Lettuce</td>
<td>ND</td>
<td>0.870 ± 0.056&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND</td>
<td>24.06 ± 0.198&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.46 ± 0.272&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>WHO/FAO</td>
<td>10.00</td>
<td>0.2</td>
<td>67.00</td>
<td>100.00</td>
<td>73.00</td>
<td>ND</td>
</tr>
<tr>
<td>Water</td>
<td>0.049 ± 0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND</td>
<td>ND</td>
<td>0.072 ± 0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.061 ± 0.005&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND</td>
</tr>
</tbody>
</table>

### Table 3: Showing data of Heavy metals from River Wudil Farm areas

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Pb  (mg/kg)</th>
<th>Cd  (mg/kg)</th>
<th>Ni (mg/kg)</th>
<th>Zn  (mg/kg)</th>
<th>Cu  (mg/kg)</th>
<th>As  (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>5.223±0.064&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND</td>
<td>22.42±0.409&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.69±0.371&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Water leaf</td>
<td>14.75±0.179&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.530±0.046&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND</td>
<td>111.4±0.549&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.37±0.381&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Lettuce</td>
<td>9.703±0.249&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.633±0.044&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
<td>89.8±1.164&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.14±0.201&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>WHO/FAO</td>
<td>10.00</td>
<td>0.2</td>
<td>67.00</td>
<td>100.00</td>
<td>73.00</td>
<td>ND</td>
</tr>
<tr>
<td>Water(mg/l)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.78±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.1±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND</td>
</tr>
</tbody>
</table>

### Table 4: Showing data of Heavy metals from Shirmu farm areas

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Pb  (mg/kg)</th>
<th>Cd  (mg/kg)</th>
<th>Ni (mg/kg)</th>
<th>Zn  (mg/kg)</th>
<th>Cu  (mg/kg)</th>
<th>As  (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>13.73 ± 0.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.41 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.00 ±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.01 ±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Water leaf</td>
<td>2.12 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.17 ± 0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.42 ±0.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.15 ±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Lettuce</td>
<td>9.39 ± 0.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.22 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.89 ± 0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.69 ±0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.81 ±0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>WHO/FAO</td>
<td>10.00</td>
<td>0.2</td>
<td>67.00</td>
<td>100.00</td>
<td>73.00</td>
<td>ND</td>
</tr>
<tr>
<td>Water(mg/l)</td>
<td>0.0089±0.023&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.06±0.024&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.24 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.14 ± 0.009&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND</td>
</tr>
</tbody>
</table>

![Fig-1](image1.png)  
**Fig-1: Levels Heavy metals in 3 vegetables grown in Sharada farm area**

![Fig-2](image2.png)  
**Fig-2: Levels Heavy metals in 3 vegetables grown in Nomansland farm area**
The results obtained from table 1 and figure 1 confirmed the presence of the heavy metals in Sharada farm areas of Kano Municipal Local government. The heavy metals analyzed were Pb, Cd, Ni, Zn and Cu. The concentration of Pb ranges from 36.28±0.291 to 0.007±0.005 mg/kg while Cd ranges from 0.637±0.17 to 0.215±0.005 mg/kg in the 3 analyzed vegetables. Ni is only present in the lettuce among the samples. Zn concentration ranges from 76.09±2.24 to 0.14±0.005 mg/kg, while the concentration of Cu in the Sharada area is between 20.25±1.415 to 0.09±3.33 mg/kg. Table 2 showed the results obtained from Nomansland area of Fagge Local Government. Ni was not detected in the samples while Pb was only detected in Water leaf and found to be 8.723±0.243 mg/kg. Table 3 showed results from River Wudil area. Data showed Ni was not detected in all the samples analyzed although Pb, Cd, Zn and Cu detected. The Pb concentration ranges from 14.75±0.179 mg/kg in water leaf, 9.703±0.249 mg/kg in Lettuce and 5.22±0.06 mg/kg in Cabbage. Cd ranges from 0.633 ± 0.044 to 0.530 ± 0.046mg/kg.

Lastly, Table 4 showed results from Shirmu area with Pb 13.73 ± 0.15mg/kg in Cabbage 2.12 ± 0.11 mg/kg in Waterleaf and 9.39 ± 0.19 in Lettuce. Ni was however not detected in both Cabbage and Waterleaf while all other metals were significantly detected in all samples. Water samples from the 4 locations used in growing these vegetables are also analyzed and the results showed Cd and Ni were not detected in Sharada and Nomansland areas. Pb, Cd, and Ni were not detected in River Wudil farm areas while only Cd was not significantly detected in Shirmu areas.

**DISCUSSION**

Results of the study showed a varying comparison of the metals in the 3 vegetable samples in addition to the water samples used at the locations of growing these vegetables. The present study revealed that the Pb concentrations in Cabbage and Waterleaf from Sharada farm areas were below acceptable value by WHO/FAO while the concentration was higher in
Lettuce sample. Further, Pb concentrations were found higher in few vegetables from Shirmru (Cabbage) and Wudil (Waterleaf) farm areas. Similarly, water sample from the Sharada area contained Pb below the WHO/FAO in drinking water (0.01mg/L). Although Pb accumulation in plants is mostly seen in areas widely associated with mining activities, it amounts could be higher in moving waters due industrial waste contamination as well as domestic activities such as battery parts burning. Sharada area being one areas with a significant number of industries could be subjected to irrigation water intoxication by Pb. Such waters are mostly used by Sharada farms growing many vegetables, fruits and berries which are widely consumed within Kano and beyond. Shirmru and Wudil areas contain moving waters which might have linked with moving waters from Sharada areas. Babandi et al. (2012) showed the levels of Pb to significantly higher in Onion, Lettuce, Moringa and Okra as well as soil samples also grown within industry Zones of Sharada (Phase 3). Additionally, Reports showed slight increase in Pb amounts in some vegetables’, water and soil samples from Barkin Ladi and Bukuru in Jos, central part of Nigeria (Orish Ebere Oriaikwe et al., 2017). Pb is a metal with confirmed toxic effects on organs that include kidneys, liver, lung and spleen that cause different biochemical defects (Assi et al., 2016).

Cd concentrations in Cabbage and lettuce were slightly higher than the WHO/FAO acceptable value (Godt et al., 2006). However, the concentration was higher when compared with the previous vegetables as well as the WHO acceptable value. Similar higher values of Cd were seen in a number of leafy vegetables grown and irrigated with moving waters from Southern Bangkok province, Thailand (Choprathumma et al., 2019). Cd is becoming an increasing health concern in wastewater irrigated agriculture as it’s associated with damage of kidneys, bones and its probable carcinogenic nature (Alina et al., 2012).

The Ni contents of the samples were mostly non detectable from the 3 locations. Few vegetables having Ni content were all below the permissible limit set by WHO in our study. Sheshe et al. (2019) showed lower Ni contents as well in certain medicinal plants commonly used in Kano. It contents in moving waters and soil samples was also largely not detected in Kwakwaci and Jakara areas of Kano (Dawaki et al., 2013). Nickel has been considered trace though its presence in higher levels could have neurological implications element for human and animal health (Nazir et al., 2015).

Zn and Cu levels were mostly significantly higher in Waterleaf and Lettuce compared with Cabbage. Both metals in all the samples were below the WHO acceptable values. Although both essential elements, these heavy metals levels if higher than acceptable limits could pose serious human health risk. Additionally, Zn and Cu were not usually found in higher amounts in drinking or moving irrigation waters (Dawaki et al., 2013).

**CONCLUSION**

The Results of these study higher levels of some heavy metals in the vegetables samples collected from widely known irrigation sites in Kano. Interestingly, there is also higher levels of these heavy metals in the water samples of locations where such metals concentrations are higher. It could be concluded that such areas might be susceptible to certain metal intoxication which could prove fatal in the long term. Addition, it could also be concluded that a proportional correlation exist between other domestic activities such battery and car spare part burning, disposal in moving waters and heavy metals accumulation in these vegetables grown with such water samples.

**RECOMMENDATION**

This study covered a limited area of vegetable farming and growing which served as a source for public consumption. We recommend that further studies be expanded to related and diverse areas within Kano and beyond to have a comprehensive data on the levels of these heavy metals. Additionally, it is further recommended that more samples of the vegetables, more irrigation & moving water and soil samples are analyzed to further elucidate the correlation between heavy metal accumulation in plants and irrigation with such waters and the growing soil.

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