Evaluation of Heavy Metals Content and Human Health Risk Assessment via Consumption of Vegetables from Selected Markets in Bayelsa State, Nigeria

Kingsley Patrick-Iwuanyanwu¹ and Ngnwuchu Chinnyere Chioma*²

¹Department of biochemistry, University of Portharcourt, Nigeria
²Department of Pharmacognosy, Port Harcourt Polytechnic, Nigeria

Abstract

The aim of this study was to evaluate the concentration of heavy metals namely (Lead (Pb), Nickel (Ni), Cadmium (Cd) and Chromium (Cr)) via consumption of vegetables from selected markets in Bayelsa State, Nigeria. Sixteen different vegetable samples comprising of Bitter leaves (Vernonia amygdalina), Curry leaves (Ocimum basilicum), Scent leaves (Ocimum gratissimum), Water Leaves (Talinum triangulare), Uziza (Piper guineense), Fluted pumpkin (Telferia occidentalis), Okazi (Gnetum africanaum), and Okra (Abelmoschus esculentus) were digested and analyzed for heavy metals using Solar Thermo Elemental Flame Atomic Absorption Spectrophotometer (STEF-AAS). Results obtained were used to estimate the health risk of these heavy metals via consumption of the vegetable samples. The results from the study showed that the highest concentration of Pb, Cd, Ni and Cr were 0.903 to 3.625 mg/kg, 0.93 to 1.387 mg/kg, 0.028 to 1.487 mg/kg, 0.983 to 2.478 mg/kg for Pb, Cd, Ni and Cr respectively. The concentration of Pb was below permissible limit recommended by WHO/FAO. The concentration of Cd in O. gratissimum and T. triangulare from both markets exceeded the permissible limit recommended by WHO/FAO and EC/CODEX. The concentration of Ni in O. gratissimum and T. occidentalis from Kpanshia market exceeded the permissible limit recommended by NAFDAC while Cr from both markets exceeded permissible limit recommended by European community/CODEX. The Hazard Index (HI) values for all the samples under study were greater than (> 1) which indicates that there is potential health risk to those consuming these vegetables except A. esculentus in Kpanshia market for adults which was less than (< 1). The Target Hazard Quotient (THQ) concentrations of Pb in O. gratissimum, T. occidentalis and O. africanaum from Kpanshia market and O. basilicum from Swali market, Cd in T. triangulare and O. gratissimum from both markets and Ni in T. occidentalis from Swali market for children only were all greater than 1 which indicates level of concern that the population may be at risk of either Pb, Ni or Cd toxicity. The Estimated Daily Intake (EDI) concentrations of Pb in O. gratissimum, T. occidentalis and O. africanaum all from Kpanshia market, Cd in T. triangulare from both markets, and Ni in all the samples from both markets were all above the permissible tolerable daily intake (PTDI) limit as recommended by EFSA (European Food and Safety Agency) meaning that those who consume this product may be at risk. The results from the present study tends to suggest that consumption of vegetables from both markets under study in Bayelsa state could be one of the contributory factors to the heavy metal burden among consumers due to their frequent consumption.

Keywords: Air pollution; Sewage sludge; Chemical properties; Organic matter; Bioavailability

Introduction

Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, vitamins, minerals as well as trace elements. The contamination of vegetables with heavy metals due to soil and atmospheric contamination poses a threat to its quality and safety. Dietary intake of heavy metals also poses risk to animals and human health. High concentrations of heavy metals (Ca, Cd and Pb) in fruits and vegetables were related to high prevalence of upper gastrointestinal cancer. Many anthropogenic sources such as waste incineration, industrial processes and most importantly, vehicular traffic emit heavy metals into the atmosphere. Regulations have been set up in many countries and for different industrial set up to control the emission of heavy metals. The uptake and bioaccumulation of heavy metals in vegetables are influenced by many factors such as climate, atmospheric depositions, the concentrations of heavy metals in soil, the nature of soil and the degree of maturity of the plants at harvest [1,2]. Air pollution may pose a threat to post-harvest vegetables during transportation and marketing causing elevated levels of heavy metals in vegetables. Elevated levels of heavy metals in vegetables are reported which such as long term uses of treated or untreated water as well as other anthropogenic sources of heavy metals include the addition of manures, sewage sludge, fertilizers and pesticides which may affect the update of heavy metals by modifying the physico-chemical properties of the soil such as pH, organic matter, bioavailability of heavy metals in the soil [3]. Whatmuff and McBride [4,5] found that increasing concentrations of heavy metals in soil increased the crop uptake. Cultivation areas near highways are also exposed to atmospheric pollution in the form of metal containing aerosols. These aerosols can be deposited on soil and absorbed by vegetables, or alternatively deposited on leaves and fruits and then absorbed. High accumulation of Pb, Cr and Cd in leafy vegetables due to atmospheric depositions has been reported by Voutsas et al. and De Nicola et al. [2,6]. The levels of heavy metals (Zn, Mn, Cu and Pb) in vegetable (Talinum triangulare) collected from selected markets of bayelsa, Nigeria were found to be high. The partitioning of heavy metals is well known, with accumulation of greater concentrations in the edible portions of leafy or root crops than the storage organs or fruits [7-9].

*Corresponding author: Chinnyere Chioma Ngnwuchu, Department of Pharmacognosy, Port Harcourt Polytechnic, Nigeria, Tel: 234 806 721 3049; Email: ngnwuchuchinyere@gmail.com

Received: August 28, 2017; Accepted: September 11, 2017; Published: September 20, 2017


Copyright: © 2017 Patrick-Iwuanyanwu K, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Urban activities may significantly contribute to elevated heavy metal loads in atmospheric deposits and consequently in the edible portion of the vegetables. Thus, the present study was conducted with the objectives to investigate the accumulation of heavy metals (Cu, Zn, Pb) on the vegetables. Water-washing by shaking mechanically removes much of the particulate found on the leaf surfaces, allowing the fractions of particle-bound heavy metals to be estimated. This study, therefore, aimed to distinguish the water-removable fraction of heavy metals and the fraction present in leaves, potentially supplying useful information on the pollutant fraction damaging to leaf physiological processes. Heavy metals enter the body system through food, air, water and bio-accumulate over a period of time. Excess heavy metal accumulation in the environment is capable to have toxicological implications in human. Heavy metal pollution is of significant ecological/environmental concern this is due to the fact that they are not easily biodegradable or metabolized, thus precipitating far reaching effects on the biological system.

The aim of this study is to analyze the selected vegetables for the level of heavy metals. Also carry out health impact assessment at the various locations in order to suggest necessary measure that can alleviate the effects of such environmental contamination.

Materials and Methods

The present study was carried out in Bayelsa state located in the South-South region Nigeria. The climate of the region is tropical with two distinct seasons i.e., dry and rainy. The dry season (November to April) is associated with high temperature during the day ranging from a minimum of 30°C to a maximum of 36°C. Rainy season starts in May and continue till end of October. During the rainy season, the temperature varies from a minimum of 24°C to a maximum of 32°C. Bayelsa is one of the riverine cities of Nigeria. There are several retailed markets in Bayelsa.

Vegetable markets

Two multipurpose retail markets were sampled. The magnitude of urban activities such as industrial, commercial buying and selling, varied between the sampling locate.

Leafy vegetables

Sixteen different vegetable samples comprising of Bitter leaves (Vernonia amygdalina), Curry leaves (Oximum basilicum), Scent leaves (Oximum gratissmum), Water Leaves (Talinum triangulare), Uziza (Piper guineese), Fluted pumpkin (Telferia occidetalis), Okazi (Gnetum varius), and Okra (Abelmoschus esculentus) each were collected from Kpanshia and Swali markets in Bayelsa state, Nigeria.

Pretreatment and washing of samples

After collection, samples were brought to the laboratory and processed further for analysis. Edible portions of the samples were used while bruised or rotten portions were removed. The edible portions of the collected vegetable samples were properly washed to eliminate adsorbed dust particles. The vegetables were air-dried for twelve (12) days under hygienic condition to prevent further contamination from in-situ environment.

Digestion

A total volume of 100 ml of H₂SO₄, HNO₃, and HClO₃ in the ratio of 40%:40%:20% was mixed together. A portion (5 g) of the samples was weighed and digested with a 2 ml of the mixed acid to each of the samples in a kjedahl flask. The samples were then digested in a fume cupboard with hot plate until white fumes appeared. After that, the solution was then cooled, filtered and transferred into a 100-ml volumetric flask and made up to mark with distilled water.

Heavy metal health risk assessment

To assess the health risks associated with the ingestion of heavy metals from vegetables, the Estimated Daily Intake (EDI) of heavy metals, Target Hazard Quotient (THQ), Hazard Index (HI) and Total Carcinogenic Risk (CR) were calculated.

Estimated Daily Intake (EDI)

\[
\text{EDI} = \frac{C_{\text{metal}} \times D_{\text{food intake}}}{B_{\text{average weight}}} \]

Where:

- \( C_{\text{metal}} \) is the metal concentration in vegetable in mg/kg,
- \( D_{\text{food intake}} \) is the daily intake of food in kg person\(^{-1}\) and
- \( B_{\text{average weight}} \) is average body weight in kg person\(^{-1}\)

An average daily consumption of 0.2 kg of vegetable was assumed in this study. This value was adopted because vegetable constitute a major part of the diet. Average adult body weight was considered to be 60 kg.

Non-carcinogenic health effect

Target hazard quotient: Non-carcinogenic risk estimation of heavy metals consumption was determined using THQ values. THQ is a ratio of the determined dose of a toxicant to a reference dose considered harmful. If the ratio is equal to or greater than 1, an exposed population is at risk. THQ values were calculated using the following formula below [10].

\[
\text{THQ} = \frac{\text{Efr} \times \text{ED} \times \text{FIR} \times C}{\text{RfDo} \times \text{Baverageweight} \times \text{ATn} \times 10^{-3}}
\]

Where

- \( \text{Efr} \) is exposure frequency in 156 days year\(^{-1}\),
- \( \text{ED} \) is exposure duration in 56 years equivalent to an average lifetime,
- \( \text{FIR} \) is average daily consumption in Kg person\(^{\text{day}}\),
- \( C \) is concentration of metal in food sample in mg/kg
- \( \text{RfDo} \) is reference dose in mg/Kg day\(^{-1}\) and
- \( \text{ATn} \) is average exposure time for non–carcinogens in days (156 × 56).

The following reference doses were used (Cd=0.001 mg/kg, Ni=0.02 mg/kg, Cr=1.5 mg/kg, Pb=0.0035 mg/kg) [11,12].

Calculation of hazard index: Hazard index is used to evaluate the potential risk to human health when more than one heavy metal is involved. Hazard index was calculated as the sum of hazard quotients (HQs) [13-16]. Since different pollutants can cause similar adverse health effects, it is often appropriate to combine HQs associated with different substances [17-21].

\[
\text{HI} = \text{THQ}_1 + \text{THQ}_2 + \text{THQ}_3 + \ldots \ldots \text{THQ}_n
\]

Carcinogenic health effect

Incremental lifetime cancer risk is the lifetime probability of an
The cancer risk was calculated using the equation below:

Carcinogenic risk = EDI × CSF

Where:

EDI is the estimated daily intake of each heavy metal (mg/kg/day)

CSF is ingestion cancer slope factor (mg/kg/day)^1 (Cd=0.38, Pb=0.0085)

US EPA, 2011 states that 10^-6 (1 in 1,000,000) to 10^-4 (1 in 10,000) represent a range of permissible predicted lifetime risks for carcinogens. Chemical for which the risk factor falls below 10^-4 may be eliminated from further consideration as a chemical of concern.

**Results**

**Concentration (mg/kg) of heavy metals in selected vegetables**

The results of different vegetable samples analyzed for lead, cadmium, nickel, and chromium are shown in Table 1. The results from the study showed that the concentration of Pb ranged between 0.016 to 1.387 mg/kg with the highest level recorded in G. africanum (1.387 mg/kg) followed by O. gratissimum (1.358 mg/kg) and T. occidetalis (1.163 mg/kg) all in Kpanshia market while the lowest level Pb was recorded in A. esculentus from Swali market (0.016 mg/kg). Cadmium concentration ranged from 0.028 to 1.487 mg/kg with the highest seen in T. triangulare (1.487) from Kpanshia market [31-36]. However, V. amygdalina from both markets and O. basilicum from Kpanshia market were below detectable limit (BDL<0.001). Nickel concentration ranged from 0.093 to 3.625 mg/kg. The highest concentration of Ni was observed in O. gratissimum (3.625 mg/kg) from Kpanshia market while the lowest level was recorded in O. gratissimum (0.009) in Swali market [37-43]. Cr concentration in the samples ranged from 0.893 to 2.478 mg/kg with the highest concentration recorded in T. triangulare (2.478 mg/kg) while the lowest level was recorded in G. africanum (0.893 mg/kg) both from Kpanshia market.

**Estimated daily intake of metals for adults (mg/kg)**

The results of the EDI for adults are shown in Table 2. The concentration of Pb ranged between 0.001 to 0.012 mg/kg. Calculated EDI for Pb in children was highest in O. gratissimum (0.012 mg/kg) from Kpanshia market. Cadmium ranged from 0.001 to 0.013 mg/kg with T. triangulare recording the highest value (0.013 mg/kg). Calculated EDI for Ni ranged between 0.004 to 0.032 mg/kg with the highest value recorded in O. gratissimum (0.032 mg/kg) from Kpanshia market. The EDI for Cr in children ranged between 0.008 to 0.022 mg/kg with the highest value recorded in T. triangulare (0.022 mg/kg) from Kpanshia market (Tables 1-3). The non-carcinogenic risk of four heavy metals exposure to consumption of vegetables from Kpanshia and Swali markets in Bayelsa state are presented in Table 4. The THQ value greater than (>1) indicates health concern.

The non-carcinogenic risk of four heavy metals exposure to consumption of vegetables from Kpanshia and Swali markets in Bayelsa state are presented in Table 5. The THQ for Pb ranged from of

<table>
<thead>
<tr>
<th>Location</th>
<th>Sample</th>
<th>Pb</th>
<th>Cd</th>
<th>Ni</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kpanshia Market</td>
<td>V. amygdalina</td>
<td>0.247</td>
<td>BDL</td>
<td>1.182</td>
<td>1.652</td>
</tr>
<tr>
<td></td>
<td>O. basilicum</td>
<td>0.538</td>
<td>BDL</td>
<td>0.873</td>
<td>1.059</td>
</tr>
<tr>
<td></td>
<td>P. guineense</td>
<td>0.315</td>
<td>0.036</td>
<td>1.354</td>
<td>1.786</td>
</tr>
<tr>
<td></td>
<td>G. africana</td>
<td>1.358</td>
<td>1.204</td>
<td>3.625</td>
<td>1.369</td>
</tr>
<tr>
<td></td>
<td>T. triangulare</td>
<td>0.479</td>
<td>1.487</td>
<td>1.576</td>
<td>2.478</td>
</tr>
<tr>
<td></td>
<td>T. occidetalis</td>
<td>1.163</td>
<td>0.155</td>
<td>2.815</td>
<td>1.683</td>
</tr>
<tr>
<td></td>
<td>G. africana</td>
<td>1.387</td>
<td>0.091</td>
<td>1.052</td>
<td>0.893</td>
</tr>
<tr>
<td></td>
<td>A. esculentus</td>
<td>0.074</td>
<td>0.028</td>
<td>0.483</td>
<td>1.027</td>
</tr>
<tr>
<td></td>
<td>V. amygdalina</td>
<td>0.279</td>
<td>BDL</td>
<td>1.782</td>
<td>1.049</td>
</tr>
<tr>
<td></td>
<td>O. basilicum</td>
<td>0.716</td>
<td>0.093</td>
<td>0.984</td>
<td>1.308</td>
</tr>
<tr>
<td></td>
<td>P. guineense</td>
<td>0.27</td>
<td>0.184</td>
<td>1.604</td>
<td>1.537</td>
</tr>
<tr>
<td></td>
<td>G. africana</td>
<td>0.438</td>
<td>0.439</td>
<td>0.093</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>T. triangulare</td>
<td>0.396</td>
<td>1.268</td>
<td>1.525</td>
<td>1.725</td>
</tr>
<tr>
<td></td>
<td>T. occidetalis</td>
<td>0.168</td>
<td>0.158</td>
<td>2.39</td>
<td>0.958</td>
</tr>
<tr>
<td></td>
<td>G. africana</td>
<td>0.153</td>
<td>0.102</td>
<td>1.258</td>
<td>1.063</td>
</tr>
<tr>
<td></td>
<td>A. esculentus</td>
<td>0.016</td>
<td>0.042</td>
<td>0.848</td>
<td>1.343</td>
</tr>
</tbody>
</table>

**Table 1: Concentration of heavy metals in mg/kg in selected vegetable samples.**

<table>
<thead>
<tr>
<th>Location</th>
<th>Sample</th>
<th>Pb</th>
<th>Cd</th>
<th>Ni</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kpanshia Market</td>
<td>V. amygdalina</td>
<td>0.001</td>
<td>0</td>
<td>0.006</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>O. basilicum</td>
<td>0.003</td>
<td>0</td>
<td>0.004</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>P. guineense</td>
<td>0.002</td>
<td>2.00E-07</td>
<td>0.007</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>O. gratissimum</td>
<td>0.007</td>
<td>0.006</td>
<td>0.018</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>T. triangulare</td>
<td>0.002</td>
<td>0.007</td>
<td>0.005</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>T. occidetalis</td>
<td>0.006</td>
<td>8.00E-04</td>
<td>0.014</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>G. africana</td>
<td>0.007</td>
<td>5.00E-04</td>
<td>0.005</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>A. esculentus</td>
<td>4.00E-04</td>
<td>1.00E-04</td>
<td>0.002</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>V. amygdalina</td>
<td>0.001</td>
<td>0</td>
<td>0.009</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>O. basilicum</td>
<td>0.004</td>
<td>5.00E-04</td>
<td>0.005</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>P. guineense</td>
<td>0.001</td>
<td>9.00E-04</td>
<td>0.008</td>
<td>0.006</td>
</tr>
</tbody>
</table>

**Table 2: Estimated Daily Intake (EDI) of heavy metals in mg/kg for adults (70 kg) from consumption of vegetables.**

BDL<0.001; BDL: Below Detectable Limit
The intake of food contaminated with chemicals may result to intoxication that can be described as acute or when the disease appears after a latent period of time and long term or chronic intoxications. Ingestion of contaminated food is the main route of human exposure to these toxic compounds accounting for more than ninety percent compared to other routes. The present study has highlighted the contamination profile of vegetables commonly consumed from selected major markets in Bayelsa state, Nigeria and the possible public health implications.

Lead concentration in the samples under study from both Kpanshia and Swali market was lower than the 2.0 mg/kg value as recommended by WHO/FAO. Among all samples analyzed for Pb, O. basilicum, O. gratissimum, T. occidetalis and G. africanum all from Kpanshia market were above 0.3 mg/kg as recommended by European communities (Commission of the European Communities, 2001). Lead is known to induce reduced cognitive development and intellectual performance in children and cardiovascular disease and increased blood pressure in adults (European Communities, 2001).

The concentration of cadmium in the samples collected from both Kpanshia and Swali market varied. The Pb concentrations in O. gratissimum and T. triangulare from both Kpanshia and Swali markets exceeded the permissible limit of 1.0 mg/kg and 0.2 mg/kg as recommended by WHO/FAO and EC/CODEX respectively. Cadmium has been reported to accumulate in the human body and hence induce kidney dysfunction, skeletal damage and reproductive deficiencies (EC, 2001).

Nickel concentration in the samples from both Kpanshia and Swali market showed that levels recorded in O. gratissimum and T. occidetalis was below 3.7 mg/kg as recommended by NAFDAC. Inhaled nickel carbonyl, a carcinogenic gas that results from the action of nickel with heated carbon monoxide, from cigarette smoke, car exhaust, and some industrial wastes is very toxic. Nickel allergy can also cause systemic reactions.

The concentration of Cr in the samples collected from Kpanshia and Swali market exceeded the permissible limit of 2.7 mg/kg recommended by NAFDAC. The THQ value of Cr was within the range 0.003 to 0.008 mg/kg and 0.008 to 0.15 mg/kg for adult and children respectively. The highest value was recorded in T. triangulare (0.008 and 0.015 mg/kg) in both adult and children respectively from Kpanshia market.

On the other hand, the result of HI of adults and children from both Kpanshia and Swali market were in the range 0.370 to 8.871 mg/kg and 0.791 to 15.61 mg/kg respectively. The highest HI value in adult was recorded in O. gratissimum (8.871 mg/kg) whereas the highest HI value in children was recorded in O. gratissimum (15.61 mg/kg) from Swali market (Tables 4 and 5).

**Discussion**

The THQ value of Cd ranged between 0.180 to 7.435 mg/kg and 0.317-13.09 mg/kg for adult and children respectively. However, T. triangulare from Kpanshia market recorded the highest THQ values of 7.435 and 13.09 mg/kg for both adult and children respectively [61-65].

The THQ value for Ni ranged between 0.023 to 0.906 mg/kg and 0.041 to 1.595 mg/kg for adult and children respectively. However, the highest values adults and children were seen in O. gratissimum (0.906 mg/kg and 1.595 mg/kg) from Swali and Kpanshia markets respectively.

The THQ value of Cr was within the range 0.003 to 0.008 mg/kg and 0.006 to 0.015 mg/kg for adult and children respectively. The highest value was recorded in T. triangulare (0.008 and 0.015 mg/kg) in both adult and children respectively from Kpanshia market.

The concentration of Cd ranged between 0.180 to 7.435 mg/kg and 0.317-13.09 mg/kg for adult and children respectively. However, T. triangulare from Kpanshia market recorded the highest THQ values of 7.435 and 13.09 mg/kg for both adult and children respectively [61-65].

The THQ value for Ni ranged between 0.023 to 0.906 mg/kg and 0.041 to 1.595 mg/kg for adult and children respectively. However, the highest values adults and children were seen in O. gratissimum (0.906 mg/kg and 1.595 mg/kg) from Swali and Kpanshia markets respectively.

The THQ value of Cr was within the range 0.003 to 0.008 mg/kg and 0.006 to 0.015 mg/kg for adult and children respectively. The highest value was recorded in T. triangulare (0.008 and 0.015 mg/kg) in both adult and children respectively from Kpanshia market.
of 0.3 mg/kg. Chromium (III) is an essential nutrient that helps the body use sugar, protein, and fat but Chromium (VI) is carcinogenic (Institute of Medicine, 2002). Adverse health effects may arise from excessive amount of chromium (III) (Agency for Toxic Substances and Disease Registry, 2004). There is no upper tolerable intake level for chromium according to the Institute of Medicine but the AI of chromium for women and men 51 to 70 years old is 20 mg/day and 30 mg/day respectively. Deficiency of Cr results in impaired growth and disturbances in glucose, lipid and protein metabolism. However, Cr (IV) is carcinogenic [66-71].

Discussion

Risk assessment

Estimated daily intake of metals: The EDI is used to calculate the amount of metal taken by an adult or children per day. From the results for both adults and children, the concentrations of lead in O. gratissimum, T. occidetalis and G. africanaum all from Kpanshia market, Cadmium in T. triangulare from both markets, and nickel in all the samples from both markets were all above the permissible tolerable daily intake (PTDI) limit as recommended by EFSAs European Food and Safety Agency meaning that those who consume this products may be at risk while consumption on Chromium was below the PTDI thereby attracting no health risk.

Hazard index

The HI is the calculation which shows when a population is at risk. From the result in the present study for both adults and children, it was observed that the HI values for all the samples under study were greater than (>) 1 which indicates that there might be a potential health risk to those consuming these vegetables except for A. esculentus in Kpanshia market for adults which was less than (<) 1.

Target hazard quotient

The THQ value is a dimensionless index of risk associated with long term exposure to chemicals. From the result in the present study for both adults and children, the concentrations of Pb in O. gratissimum, T. occidetalis and G. africanaum from Kpanshia market and O. basilicum from Swali market, Cd in T. triangulare and O. gratissimum from both markets and Ni in T. occidetalis from Swali market for children only were all greater than 1 which indicates level of concern that the population may be at risk of either Pb, Ni or Cd toxicity.

Conclusion

The results from the present study tends to suggest that consumption of vegetables from both markets under study in Bayelsa state could be one of the contributory factors to the heavy metal burden among consumers due to their frequent consumption.

Recommendation

It is therefore necessary to monitor extensively and occasionally heavy metals in vegetables especially those grown in areas where you have oil pipes which have been vandalized as a result of war or conflict by authorized government agencies in order to safeguard the health of the population.

References

Pesticides and heavy metals levels in Egyptian leafy vegetables and some aromatic medicinal plants. Food Addit Contam 21: 323-330.


