Concentrations of some metals in three species of terrestrial molluscs (*Achatina fulica*, *Achatina achatina* and *Archachatina marginata*) in bushes within University of Calabar, Calabar, Nigeria

Kalu A. Okorafor* and Promise Otielu

1Ecology and Environmental Biology Unit, Department of Zoology and Environmental Biology, University of Calabar, Calabar, Nigeria
2Marine Biology Unit, Department of Zoology and Environmental Biology, University of Calabar, Calabar, Nigeria

ABSTRACT

The study on heavy metals concentrations in three species of terrestrial molluscs (land snails) in University of Calabar, Cross River State was carried out for a period of four months (August to November 2014). Three terrestrial molluscs namely: *Achatina fulica*, *Achatina achatina* and *Archachatina marginata* were used for the study. Snail samples were collected within University of Calabar Farm and along the shores of the Great Kwa River near University of Calabar Staff Quarters. Metals such as: Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb and Zn were analyzed after digestion using Graphite Furnace Atomic Absorption Spectrophotometer. Cd and Hg were Below Detectable Level (BDL) in the three species. Mean values of metal concentrations in *Achatina fulica* were: Co, 0.029±0.020mg/kg; Cr, 0.029±0.020mg/kg; Cu, 0.047±0.008mg/kg; Fe, 0.042±0.001mg/kg; Mn, 0.035±0.005mg/kg; Ni, 0.011±0.023mg/kg; Pb, 0.029±0.058mg/kg and Zn 0.047±0.005mg/kg. Mean values of metal concentrations in *Achatina achatina* were: Co, 0.030±0.021mg/kg; Cr, 0.028±0.019mg/kg; Cu, 0.043±0.004mg/kg; Fe, 0.043±0.002mg/kg; Mn 0.035±0.005mg/kg; Ni, 0.014±0.028mg/kg; Pb, 0.027±0.055mg/kg and Zn 0.043±0.012mg/kg. Mean metal concentrations in *Archachatina marginata* were: Co, 0.019±0.022mg/kg; Cr, 0.016±0.019mg/kg; Cu, 0.037±0.005mg/kg; Fe, 0.043±0.009mg/kg; Mn, 0.040±0.006mg/kg; Ni, 0.125±0.250mg/kg; Pb, 0.058±0.067mg/kg and Zn 0.046±0.012mg/kg. The concentrations of the metals did not vary statistically (p > 0.05) in the three species of molluscs, therefore were not statistically significant. Total rank score assessment showed that *Archachatina marginata* had the highest level of metals followed by *Achatina fulica* while *Achatina achatina* had the least concentrations, although the concentrations of metals in the three species were within the tolerance limits set out by WHO. Therefore consumption of snails picked within University of Calabar farm and along the shores of the Great Kwa River near University of Calabar Staff Quarters is recommended though continuous monitoring of these metals is necessary since metals can bio-accumulate in biological tissues over a period of time.


Received October 20, 2015; Accepted October 26, 2015; Published November 4, 2015.

Copyright: © 2015 Okorafor and Promise. 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. JETPH is a journal publication of BRSF.

Competing Interests: The authors have declared that no competing interests exist.

E-mail: okoraforka@yahoo.com

Keywords: concentrations, metals, *Achatina fulica*, *Achatina achatina*, *Archachatina marginata*, Calabar, Nigeria.

1. INTRODUCTION

The common land snails: *Achatina achatina*, *Archachatina marginata* and *achatina fulica* are found in agricultural areas, forests and riparian zones, scrub/shrub lands, urban areas and wetlands. *Achatina achatina* and *Archachatina marginata* are the largest snails in the world and are widely sought after due to their size, distinct markings and nutritional value [1]. Snails constitute an important source of diet of most villagers especially the rural dwellers in Africa and elsewhere in the world. Apart from serving as a source of protein, they are used for medicinal purposes especially, their shell in many parts of the world [2]. Giant African land
snails are widely consumed. Snails are delicacies that supplement low protein diets. Giant African land snails (made up of the genera Achatina, Archachatina and Burtoa) and snails of the genus Limicolaria are known as edible tropical land snails [3]. These snails are soil living and herbivores, easily prone to environmental contaminants. Snails are usually collected in forests and farmlands for consumption or transported to nearby rural or urban markets for sale.

Heavy metal contamination and pollution of terrestrial and aquatic eco-systems has long been recognized as a serious environmental concern. This is largely due to their non-biodegradability and tendency to accumulate in plant and animal tissues. As a result, metal bioaccumulation is a major route through which increased levels of the pollutants are transferred across food chains/web, creating public health problems wherever man is involved in the food chain [4]; [5]; [6]. Therefore, it is important to always determine the bioaccumulation capacity for heavy metals by organisms especially the edible ones, in order to assess potential risk to human health. The land snails are consumed by a vast majority of people living in the tropics. Therefore there is need to always investigate the concentrations of metals in tropical snails. This research is aimed at determining heavy metals concentrations in three terrestrial snails: Achatina fulica, Achatina achatina and Archachatina marginata in order to ascertain the suitability of the snails for consumption.

1. MATERIALS AND METHODS

2.1 Collection of samples

Samples of the three snail species were collected alive from the bush around University of Calabar farm and the shoes of the Great Kwa River near Staff Quarters located behind hall 8 and 9 of female hostels. Sampling was done monthly for a period of four months (August to November, 2014). The snails were collected and put in a container which allows air passage, in order to keep the snails alive. The collected snail samples were transported to chemistry laboratory, University of Calabar for heavy metals analysis.

2.2 Laboratory processing and analysis of snail samples

In the laboratory, the snails were washed thoroughly with distilled water. The shells were cracked with a wooden hammer and the body (viscera) washed with distilled water and stored at -18°C prior to analysis. The viscera were oven-dried at 105°C for 45 hours. The dried samples were ground to powdery form and 5.00g were digested in 10ml concentrated HNO₃ at 135°C until the liquid became clear. Then 10 ml of HNO₃ and 2 ml HClO₄ were added till the liquid became colorless [7]. The digest slowly evaporated till near dryness, cooled and dissolved in 1 molar HNO₃, filtered through Whatman filter paper and diluted to 25ml with 1 molar HNO₃ [7]. The resulting solution was analyzed for Cd, Cu, Cr, Mn, Pb, Zn, Ni, Co, Hg and Fe with Graphite Furnace Atomic Absorption Spectrophotometer.

2.3 Presentation of Data/ Statistical Analysis

The range and mean values of metal concentrations of the three terrestrial Snail species are arranged and presented in a table in order to enhance proper interpretation of data. The statistical tool, ANOVA was used to test if there were any significant differences in the heavy metal concentrations between the three terrestrial snail species.

3. RESULTS

3.1 Metals Concentrations in Achatina fulica

Table 1 shows the range, mean and standard deviation values of metals concentrations in Achatina fulica. Cd and Hg were not detected in Achatina fulica. Co concentrations ranged from BDL to 0.043 mg/kg, with a mean and standard deviation of 0.029±0.020. Cr ranged from BDL to 0.043 mg/kg with a mean and standard deviation of 0.029±0.020. Cu concentrations ranged from 0.040 to 0.060 mg/kg, with a mean and standard deviation of 0.047±0.008. Fe ranged from 0.040 to 0.043 mg/kg, with a mean and standard deviation of 0.042±0.001. Mn ranged from 0.030 to 0.040 mg/kg, with a mean and standard deviation of 0.035±0.005. Ni ranged from BDL to 0.046 mg/kg, with a mean and standard deviation of 0.011±0.023. Pb ranged from BDL to 0.116 mg/kg, with a mean and standard deviation of 0.029±0.058. Zn ranged from 0.040 to 0.053 mg/kg, with mean and standard deviation of 0.047±0.005. The mean metals concentrations in Achatina fulica had a decreasing trend of Cu>Fe>Mn>Co=Cr>Pb>Ni>Cd=Hg.

3.2 Metals Concentrations in Achatina achatina

Metals concentrations in Achatina achatina can also be seen in table 1. Cd and Hg were not detected. Co concentration ranged from BDL to 0.046 mg/kg, with a mean and standard deviation of 0.030±0.021. Cr ranged from BDL to 0.043 mg/kg with a mean and standard deviation of 0.028±0.019. Cu concentration ranged from 0.040 to 0.050 mg/kg, with a mean and standard deviation of 0.043±0.004. Fe ranged from 0.040 to 0.046 mg/kg, with a mean and standard deviation of 0.043±0.002. Mn ranged from 0.033 to 0.043 mg/kg, with a mean and standard deviation of 0.035±0.005. Ni ranged from BDL to 0.056 mg/kg, with a mean and standard deviation of 0.014±0.028. Pb ranged from BDL to 0.110 mg/kg, with a mean and standard deviation of 0.027±0.055. Zn ranged from 0.026 to 0.053 mg/kg, with a mean and standard deviation of 0.043±0.012. The mean metal concentrations in Achatina achatina had a decreasing trend of Cu=Fe> Zn>Mn>Co>Cr>Pb>Ni>Cd=Hg.
Table 1. Mean and range values of metals concentrations in the three snail species (*Achatina fulica*, *Achatina achatina* and *Archachatina marginata*) in Bushes Within University of Calabar, Calabar, Nigeria

<table>
<thead>
<tr>
<th>Metals</th>
<th><em>Achatina fulica</em></th>
<th><em>Achatina achatina</em></th>
<th><em>Archachatina marginata</em></th>
<th>F-Value</th>
<th>P-Value</th>
<th>Observed</th>
<th>Inference</th>
<th>WHO Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd (mg/kg)</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>not sig.</td>
<td>2.0</td>
</tr>
<tr>
<td>Co (mg/kg)</td>
<td>0.029±0.020</td>
<td>0.030±0.021</td>
<td>0.019±0.022</td>
<td>0.315</td>
<td>&gt;0.05</td>
<td>-</td>
<td>not sig.</td>
<td>-</td>
</tr>
<tr>
<td>Cr (mg/kg)</td>
<td>0.029±0.020</td>
<td>0.028±0.019</td>
<td>0.016±0.019</td>
<td>0.550</td>
<td>&gt;0.05</td>
<td>not sig.</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Cu (mg/kg)</td>
<td>0.047±0.008</td>
<td>0.043±0.004</td>
<td>0.037±0.005</td>
<td>2.411</td>
<td>&gt;0.05</td>
<td>not sig.</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Fe (mg/kg)</td>
<td>0.042±0.001</td>
<td>0.043±0.002</td>
<td>0.043±0.009</td>
<td>0.098</td>
<td>&gt;0.05</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Hg (mg/kg)</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mn (mg/kg)</td>
<td>0.035±0.005</td>
<td>0.035±0.005</td>
<td>0.040±0.006</td>
<td>1.135</td>
<td>&gt;0.05</td>
<td>not sig.</td>
<td>0.1-0.5</td>
<td></td>
</tr>
<tr>
<td>Ni (mg/kg)</td>
<td>0.011±0.023</td>
<td>0.014±0.028</td>
<td>0.125±0.250</td>
<td>0.790</td>
<td>&gt;0.05</td>
<td>not sig.</td>
<td>0.5-0.6</td>
<td></td>
</tr>
<tr>
<td>Pb (mg/kg)</td>
<td>0.029±0.058</td>
<td>0.027±0.055</td>
<td>0.058±0.067</td>
<td>0.324</td>
<td>&gt;0.05</td>
<td>not sig.</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Zn (mg/kg)</td>
<td>0.047±0.005</td>
<td>0.043±0.012</td>
<td>0.046±0.012</td>
<td>0.119</td>
<td>&gt;0.05</td>
<td>not sig.</td>
<td>10-75</td>
<td></td>
</tr>
</tbody>
</table>

3.3 Metals concentrations in *Archachatina marginata*

Cadmium and Mercury were not detected in *Achatina marginata* (Table 1). Co concentrations ranged from BDL to 0.043 mg/kg, with a mean and standard deviation of 0.019±0.022. Cr ranged from BDL to 0.033 mg/kg, with a mean and standard deviation of 0.016±0.019. Cu concentrations ranged from 0.033 to 0.043 mg/kg, with a mean and standard deviation of 0.037±0.005. Fe ranged from 0.036 to 0.053 mg/kg, with a mean and standard deviation of 0.043±0.009. Mn ranged from 0.033 to 0.050 mg/kg, with a mean and standard deviation of 0.040±0.006. Ni ranged from BDL to 0.050 mg/kg, with a mean and standard deviation of 0.125±0.250. Pb ranged from BDL to 0.126 mg/kg, with a mean and standard deviation of 0.058±0.067. Zn ranged from 0.040 to 0.060 mg/kg, with a mean and standard deviation of 0.046±0.012. The mean metals concentrations in *Archachatina marginata* had a decreasing trend of Ni>Pb>Zn>Fe>Mn>Cu>Co>Cr>Cd=Hg (Table 1).

3.4 Metals concentrations across the three species

Cd and Hg were not detected in the three species (*Achatina fulica*, *Achatina achatina* and *Archachatina marginata*) (Table 1). The highest Co concentration was observed in *Achatina achatina* (0.030 mg/kg), while the lowest was observed in *Archachatina marginata* (0.019 mg/kg). The highest Cr concentration was observed in *Achatina fulica* (0.029 mg/kg), while the lowest was observed in *Archachatina marginata* (0.016 mg/kg). The highest Cu concentration was observed in *Achatina fulica* (0.047 mg/kg), while the lowest was observed in *Archachatina marginata* (0.037 mg/kg). The highest Fe concentration was observed in *Achatina achatina* and *Archachatina marginata* (0.043 mg/kg), while the lowest concentration was observed in *Achatina fulica* (0.042 mg/kg). The highest Mn concentration was observed in *Archachatina marginata* (0.040 mg/kg), while the lowest was observed in *Achatina fulica* (0.043 mg/kg). The highest Ni concentration was observed in *Archachatina marginata* (0.125 mg/kg), while the lowest was observed in *Achatina fulica* (0.011 mg/kg). The highest Pb concentration was observed in *Archachatina marginata* (0.058 mg/kg), while the lowest was observed in *Achatina achatina* (0.027 mg/kg). The highest Zn concentration was observed in *achatina fulica* (0.047 mg/kg), while the lowest was observed in *achatina achatina* (0.043 mg/kg).

4. DISCUSSION

Total rank score assessment showed that metals concentrations varied in the different species, with *Archachatina marginata* having the highest metal concentrations, followed by *Achatina fulica* and *Achatina achatina*. The variations in metals concentrations could be as a result of variation in the physiological properties of different species [8]. [9]; [10] and [11] reported that the accumulation of metals in invertebrates depend on soil pH, availability of metal and mostly on physiological characteristics of invertebrate species; such as...
assimilation and excretion capacity. This could also be the reason for the variations in metal accumulation in the different snail species. *Achatina fulica* accumulated more metals than *Achatina achatina* despite being smaller in size, showing that accumulation was not dependent on size. This corroborated with the report of [12] and [9] who reported that levels of accumulation of metals in invertebrates do not depend directly on the trophic level and body size but on the type of food or the form in which the metal is bound. On the contrary, this is different from the report of [13], who reported that metal accumulation in snails is dependent on size.

A higher concentration of copper, lead, iron and zinc for *Achatina achatina* has been reported [1] when compared to the metal ranges for *Achatina achatina* in the present study. The differences could be as a result of differences in the metal forms and type of food available in the different study areas [12]. [1] also reported a higher concentration of copper, lead, iron and zinc for *Pila ovata* when compared to the metal ranges for three snail species in the present study. These variations could be because *Achatina fulica*, *Achatina achatina* and *Archachatina marginata* have stronger physiological properties to assimilate and excrete heavy metals.

Higher values of mercury, lead, chromium, copper, nickel and zinc for *Archachatina marginata* has been reported [14] when compared to the metal ranges for *Archachatina marginata* in the present study, and mercury was not detected at all in the present study. The differences could be as a result of differences in the metal forms and type of food available in the different study areas.

Statistical analysis (ANOVA) showed that there were no significant differences in the metals concentrations in the three terrestrial snail species (P>0.05). The metal concentration for *Achatina fulica*, *Achatina achatina* and *Archachatina marginata* in the present study were all below the WHO maximum permissible limit. This means that the three species of snails within University of Calabar Community are safe for human consumption.

5. CONCLUSION/RECOMMENDATIONS

From the results of this study, the concentrations of all the metals in the three species of molluscs were not statistically significant (p>0.05). Although the concentrations of metals in the snails were below permissible limits set out by WHO, preventive measures should be taken in order to prevent human exposure to levels higher than the permissible limits for these metals. There should be control of the use of pesticides, fungicides as well as phosphates and sewage sludge fertilizers to reduce accumulation of metals in the environment were the snails feed. Anthropogenic activities that can result in the input of metals in the environment should be reduced to avoid the concentration of metals in both the environment and biological organisms over time. Continuous monitoring of metals in snails within University of Calabar Community is advised.

AUTHOR CONTRIBUTIONS

KAO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. PO carried out the field sampling, managed the literature searches and the analyses of the study. All authors read and approved the final manuscript.

REFERENCES