Journal of Sustainable Veterinary & Allied Sciences
P-ISSN-2695-2661 e-ISSN: 2811-1346
JoSVAS 2024 December Vol 6 Issue 4: 236-240

Original Research

Public health risk assessment of heavy metal contamination in ready to eat snails in Umuahia, Abia State, Nigeria

***Kalu, E., Akporube, K.A., Akpabio, U., Obinnaya, O.D. & Ezenduka, V. E.**

[1]*Department of Veterinary Public Health and Preventive Medicine, Michael Okpara University of Agriculture, Umudike,*
[1]*Department of Veterinary Public Health and Preventive Medicine, Nsukka, Nigeria*

**Correspondence:* Kalu.ekenma@mouau.edu.ng, +234703 383 6963

ABSTRACT
The recent increase in the acceptance of snails as meat in different parts of Nigeria is mostly due to their nutritional and health benefits. The feeding pattern of these snails and their habitat are factors predisposing them to come in contact with pollutants that include heavy metals. Upon consumption of such contaminated snails, these heavy metals get transferred to humans. This study was aimed at determining the heavy metal concentration in ready-to-eat snails (RTE) and assessing their potential health risk. Thirty RTE snails were purchased from 5 different eateries and analyzed for their heavy metal content using an atomic absorption spectrophotometer (AAS) according to standard technique. Data were presented using mean ± SEM and analysed by ANOVA. The Daily intake of metal (DIM), Hazard quotient of metal to human (HQ) and Hazard index (HI) were assessed to determine any potential health risk. The mean concentrations of Pb, Cd, Zn, Cu and Fe were all above the recommended levels by WHO/FAO. The mean concentration of Pb, Cd, Cu and Fe did not vary significantly between the locations ($p>0.05$) but there was a significant variation in the concentration of Zn among RTE snails within the locations. The DIM for Cd, Pb and Cu was greater than the oral reference dose of 0.001, 0.004 and 0.004 respectively. The HI index for the locations was greater than one (HI > 1). In this study, the heavy metal concentration, the DMI, HQ and HI values observed in this study reveals a potential health hazard to consumers of RTE snails.

Keywords: heavy metals, public health risk, ready-to-eat snails, Nigeria

INTRODUCTION
Nigeria is richly endowed with different species of snails which may vary in sizes, colors, adaptability and performance (Ibom, 2009; Ejidike & Adewuyi, 2018). Snails are abundant in many terrestrial and aquatic ecosystems and are easily available for collection. Snail meat is nutritious containing high levels of protein, iron, calcium, phosphorous and contains all the amino acids essentially required in human diet. Snail meat is also very low in fat, sodium and cholesterol (Akinnusi, 2002; Nica *et al.*, 2012).

Snails are highly tolerant to many pollutants and exhibit high accumulations of the pollutants, particularly heavy metals (Nica *et al.*, 2012). In a polluted environment, snails can accumulate substantial amounts of heavy metals (Carbone & Faggio, 2019). Heavy metals accumulate in snails, enter the human food chain and when such contamination and exposure are significant, the heavy metals cause serious harm to humans who consume such contaminated snail (Goyer, 1997; Papagianis *et al.*, 2004; Turkmen *et al.*, 2005; Fernandez *et al.*, 2007).

The persistent occurrence and accumulation of heavy metals and the potential exposure to humans from numerous sources such as food, water, soil and air have made them the most hazardous and toxic substance in the environment (ATSDI, 2001). Snails act on trophic level, both as herbivorous and detritivore organisms and are involved in the biomagnifications of heavy metals along the food chain (Viard *et al.*, 2004 & Notten *et al.*, 2005). Therefore, it has become necessary to determine the concentrations of heavy metals in ready to eat (RTE) snails and to evaluate the public health risk of consumption of such snails.

MATERIALS AND METHODS

STUDY AREA
Umuahia is located along the rail road that lies between Port Harcourt to its south and Enugu city to its north. Umuahia has a population of 359,230 (2006 Nigerian Census). Umuahia

http://doi.org/10.54328/covm.josvas.2024.207

has a latitude of 50 31' 29.68'N and longitude of Umuahia has a latitude of 50 31' 29.68'N. Umuahia comprises of two local government areas: Umuahia North and Umuahia South. These local government areas are also composed of clans such as Umuopara, Ibeku, Olokoro, Ubakala, and Ohuhu communities (Asiegbu &Johnson, 1985).

SAMPLE COLLECTION AND PREPARATION

SAMPLE COLLECTION, DIGESTION AND HEAVY METAL EXTRACTION USING AAS

Thirty (30) snails were purchased from five different meat vendors around Umuahia.

The snail samples were rinsed using distilled water, drained and oven dried until thoroughly dried. The dried samples were then homogenized using pestle and mortar until powdered. One gram (1g) of each homogenized sample was mixed with 5mls of concentrated Nitric Acid (HNO_3), 2.5mls of Hydrogen Peroxide (H_2O_2) and 2.5mls of Perchloric Acid ($HClO_4$) and left to stand undisturbed overnight in a sample digestion block. The pre-digested samples were then heated step by step up to a final temperature at 120^0C for complete digestion until the solution became clean, colourless and crystal clear (Alonso *et al.,* 2000). This procedure was repeated for solutions that were not crystal clear until they became clear. The crystal clear solution was then transferred into a 25ml volumetric flask and the flask was filled up to the 25mls mark with distilled de-ionized water. The digested samples were then filtered and stored in a nitric acid prewashed polyethylene bottle for heavy metal analysis (Stahr, 1991 &Tessier *et al.,* 1999). The concentrations of Pb, Cd, Zn, Cu and Fe were determined in accordance with the instructions on the manual using a Model 200 Atomic Absorption Spectrophotometer (AAS) (Buck Scientific: Norwalk, Connecticut).

STATISTICAL ANALYSIS

Data generated from the study were used to analyse statistical differences using IBM SPSS. One way analysis of Variance (ANOVA) was used to determine if the mean concentrations of the various heavy metals were statistically significant. Duncan Multiple Range Test (DMRT) was used to test for differences between means of the concentrations from the different locations.

HEALTH RISK ASSESSMENT MODELS

DAILY INTAKE OF METAL (DIM)

The DIM which is the average daily dose ($mgkg^{-1}/d$) of the metal was calculated using the formula below

$$\mathrm{DIM} = \frac{\mathrm{DI} \times \mathrm{Msnail}}{\mathrm{WB}}$$ (USEPA, 2002)

Where DI = represents the daily intake of snail for adults which is 0.10274 kg/person/day, Msnail = Heavy metals concentration in the snail tissues (mg/kg), WB = Average body weight of adults (70kg).

HAZARD QUOTIENT OF METAL TO HUMAN (HQ)

The hazard quotient (HQ) was used to calculate the possible human health risks associated with the consumption of RTE snails. HQ is the ratio between exposure and the reference oral dose (RFD). If the ratio is lower than one (1), there will be no obvious risk.

$$\mathrm{HQ} = \frac{\mathrm{DIM}}{\mathrm{RFDM}}$$ (USEPA, 2017)

Where DIM = represents the average daily dose ($mgkg^{-1}/d$) of the metal, RFDM = is the reference dose of the metal ($mgkg^{-1}/d$), which is defined as the maximum tolerable daily intake of metal with no adverse effect.

HAZARD INDEX (HI)

The hazard index (HI) was calculated to determine the overall health risk of exposure to all the heavy metals via the ingestion of a RTE snail described by (USEPA, 2002). The hazard index (HI) was calculated as the summation of the hazard quotient (HQ) arising from all the metals examined.

$$\mathrm{HI} = \sum \mathrm{HQ}$$

$$\mathrm{HI} = \sum \mathrm{HQ}_{Cd} + \mathrm{HQ}_{Pb} + \mathrm{HQ}_{Zn} + \mathrm{HQ}_{Cu} + \mathrm{HQ}_{Fe}$$

The value of the hazard index is proportional to the magnitude of the toxicity of the snail consumed. HI > 1 indicates that the predicted exposure is likely to pose potential health risks.

RESULTS

The mean concentration of Pb was highest in sampling unit C with mean concentration of 66.60 ± 21.96 mg/kg, while those from sampling unit E had the lowest mean concentration of 00 ± 00mg/kg. The mean concentrations of Pb in sampling units A, B, C and D were higher than the MPL. The RTE snails had a mean concentration of zinc (Zn) that ranged from 24.21±3.20 from sampling unit B to 40.81±5.46mg/kg in sampling unit C. These mean concentrations of Zn were higher than the MPL. There was a significant variation in the concentration of Zn among RTE snails within the locations. The lowest and highest mean concentrations in the sampled locations were 242.61±42.98 and 362.10±38.62mg/kg respectively. The mean copper (Cu) concentrations in the RTE snails were higher than the recommended MPL. The difference in the mean concentrations of Cu did not vary significantly within the locations. The samples from sampling unit C had the highest mean concentration of 342.85 ± 40.71 mg/kg, while those from sampling unit E had the lowest mean concentration of 211.40 ± 16.51 mg/kg for iron. The mean iron (Fe) concentrations in the RTE snails in the 5 locations were higher than the WHO/FAO, 2013 recommendation for Fe in snails. The mean concentration of Fe did not vary significantly between the locations (p>0.05).

Table I: Mean concentration of heavy metals in RTE snails in Umuahia, Abia state, Nigeria

LOCATION	Mean (Mg/kg)				
	Pb	Cd	Zn	Cu	Fe
A	19.52 ± 11.90[ab]	34.90 ± 4.21[a]	25.38 ± 1.98[a]	250.88 ± 24.57[a]	280.77 ± 25.77[ab]
B	55.83 ± 23.76[ab]	32.67 ± 6.04[a]	24.21 ± 3.20[a]	257.50 ± 37.62[a]	303.80 ± 41.68[ab]
C	66.60 ± 21.96[b]	58.44 ± 8.85[b]	40.81 ± 5.46[b]	362.10 ± 38.62[b]	342.85 ± 40.71[b]
D	39.80 ± 26.83[ab]	40.98 ± 8.10[ab]	27.31 ± 4.26[a]	242.61 ± 42.98[a]	241.13 ± 50.92[ab]
E	00.00 ± 00.00[a]	41.83 ± 3.83[ab]	30.85 ± 2.79[ab]	248.23 ± 19.42[a]	211.40 ± 16.51[a]

Mean concentrations with the same alphabet along the columns are not significantly different at $p < 0.05$ by Duncan

Table II: Daily intake of metal (DIM) from RTE snails for adult

	HEAVY METALS				
LOCATION	Cd	Pb	Zn	Fe	Cu
A	0.05	0.02	0.04	0.40	0.37
B	0.04	0.08	0.04	0.44	0.38
C	0.09	0.10	0.06	0.50	0.50
D	0.06	0.06	0.04	0.35	0.36
E	0.06	0.00	0.05	0.31	0.36
RfD	**0.001**	**0.004**	**0.30**	**0.70**	**0.004**

*Reference for calculation (USEPA, 2002)

The DIM for adults that consumed RTE snails was estimated according to the average snail consumption via food chain. As seen in table II, the DIM for Cd, Pb and Cu was greater than the oral reference dose of 0.001, 0.004 and 0.004 respectively while those of Zn and Fe were less than the oral reference dose of 0.30 and 0.70. The daily intake of metal (DIM) for location C was higher than that in other locations in all the heavy sampled.

The HI index for the locations was greater than one (HI > 1).

Table III: Hazard quotient (HQ) and HI of heavy metals in RTE snails

	HEAVY METALS					
LOCATION	Cd	Pb	Zn	Fe	Cu	HI
A	51.22	07.16	0.12	0.59	9.21	68.30
B	47.95	20.49	0.12	0.64	9.45	78.65
C	85.77	25.17	0. 20	0.72	13.29	125.15
D	60.15	14.60	0.13	0.51	8.91	84.30
E	61.39	0.0	0.15	0.44	9.11	71.09

All the HI's was greater than 1 and this is of great health concern.

DISCUSSIONS

MEAN CONCENTRATION OF HEAVY METALS IN RTE SNAILS

The mean concentration of Pb and Cd did not vary significantly between the locations (p>0.05). Lead has been known to cause liver and kidney damage in humans. Lead (Pb) and Cd are toxic, persistent, and non-biodegradable in the environment, and hence, they can be easy bioaccumulated and biomagnified along terrestrial food chains (Agarwal, 2009).

The mean concentrations of the sampled heavy metals in the RTE snails from the locations were generally high and alarming. These high concentrations may be attributed to the fact that Snail farming is yet to become popular in Nigeria therefore most snails consumed are usually collected from the bush, farms and sold to consumers in nearby markets. Wild snails are often contaminated with heavy metals due to environmental pollution (Chronopoulos *et al.,* 1997 & Coeurdassier *et al.*, 2005).

The difference in the concentrations of heavy metals in RTE snails in the different locations could be due to the fact that African giant snail feeds on debris from the soil surface and these soils are often contaminated with heavy metals and organic pollutants. With continuous consumption, these snails accumulate harmful levels of these pollutants. Therefore the concentration of heavy metals in snails depends on the location where they were bred (Nica *et al.,* 2012 & Ajayi and Oyewole, 2023).

DAILY INTAKE OF METAL (DIM) FROM RTE SNAILS FOR ADULT

The findings observed from the DIM for adults reveals that the consumption of RTE snails from all the locations was not free from health risk especially for Cd, Pb and Cu. And this is of great public health concern since continuous consumption of RTE snails leads to bioaccumulation. Cadmium is a dangerous element because it can be absorbed via the alimentary track; penetrate through placenta during pregnancy and damage membrane and DNA. Significant concentration of Cd may have gastrointestinal effect, reproductive effect on livestock and causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and the immune system (Maobe *et al.*, 2012).

HAZARD QUOTIENT (HQ) AND HI OF HEAVY METALS IN RTE SNAILS

THE VALUE of the hazard index (HI) is proportional to the magnitude of the toxicity of the snail consumed. HI that is greater than one (> 1) indicates that the predicted exposure is likely to pose potential health risks. The HI values shows that the overall health risk associated with consumption of RTE snails in the 5 locations is capable of causing potential health hazards to adults that consume them.

CONCLUSION

This study revealed the presence of heavy metals in the ready-to-eat snail sold in Umuahia and its environs which is higher than the minimum stipulated amount by WHO/FAO. The public health risk assessment indices revealed that a health risk is associated with the consumption of RTE snails sold in Umuahia, Abia state, Nigeria. Due to the results obtained from the EDI, THQ and HI, routine screening tests of snails, should be conducted in Umuahia to determine the safety of RTE snails. Also, the populace should be informed about the dangers of consuming such snails.

REFERENCES

Agarwal S.K. (2009). Heavy metal pollution. New Delhi: APH Publishing Corporation.1–89.

Ajayi A.A. & Oyewole B.O. (2023). Giant African land snails (*Achatina achatina* and *Archachatina marginata*) as bioindicator of heavy metal pollution. *African Journal of Environmental Science and Technology*, 17(4), 80-88.

Akinnusi, O. (2002). Introduction to snails and snail farming. Triolas Exquisite ventures. Abeokuta. 25pp.

Asiegbu, Johnson U.J. (1985). Traditional African Societies And Indigenous Technology: A Case Study Of The Umuahia-Igbo Communities Of South-Eastern Nigeria. Pg.95-105.

Association of official Analytical Chemist (2009). *Official method of Analysis.* 11th Edition.

Agency for Toxic Substances and Disease Registry (ATSDR) (2001). Division of Toxicology, U.S. Study Of The Umuahia-Igbo Communities Of South-Eastern Nigeria. Pg.95-105

Carbone, D. & Faggio, C. (2019). Helix aspersa as sentinel of development damage for biomonitoring purpose: a validation study. *Molecular reproduction and development*, 86(10), 1283-1291.

Chronopoulos, J., Haidouti, C., Chronopoulos, A. & Massas, I. (1997). Variation in Plant and Soil Lead and Cadmium Content in Urban Parks in Athens, Greece. *Sci. Total Environ.* 196: 91-8.

Coeurdassier, M., De Vaufleury, A., Crini, N., Scheifler, R., & Badot, P.M. (2005). Assessment of whole effluent toxicity on aquatic snails: Bioaccumulation of Cr, Zn, and Fe, and individual effects in bioassays. *Environ. Toxicl.* Chem. 24(1), 198-204

Duffus, J.H. (2002). Heavy Metal-A Meaningless Term? Pure and Applied Chemistry, 74, 793-807

Ejidike, B.N. & Adewuyi, C.O. (2018). The Giant African Land Snail (GALS) Archachatina marginata Egg and Adult Sizes: Case Study. *Journal of Biodiversity, Bioprospecting and Development,* 5(171), 2376-0214

FAO/WHO (2016). List of maximum levels for contaminants and toxins in foods. Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 10th Session 150 p.

FAO/WHO (2013). Joint FAO/WHO food standard programme codex committee on contaminants in foods, fifth session pp 64- 89Agriculture. (Coag) Meeting from Jan. 25–26. FAO, Rome.

Fernandes C., Fontaínhas-Fernandes A., Peixoto F., Salgado M.A. (2007). Bioaccumulation of heavy metals in Liza saliens from the Esmoriz–Paramos coastal lagoon, *Portugal. Ecotoxicology and Environmental Safety*. 66(3), 426–431.

Goyer R.A. (2001). Toxic effects of metals. In: Klaassen CD, editor. *Cassarett and Doull's Toxicology: The Basic Science of Poisons.* New York: McGraw-Hill Publisher; 2001. pp. 811–867.

Ibom, L.A. (2009). Variations in reproductive and growth performance trait of white-skinned x black-skinned African giant snail hatchlings [Archachatinamarginata (Swainson)] in Obubra, Nigeria. Ph.D. Thesis, Department of Animal Science, University of Calabar, Calabar, 166.

Maobe M.A.G., Gatebe E., Gitu L., Rotich H. (2012). Profile of heavy metals in selected medicinal plants used for the treatment of diabetes, malaria and pneumonia in Kisii region, Southwest Kenya. *Global J. of Pharmacology*. 6(3), 245–251.

Nica, D.V., Bura, M., Gergen, I., Harmanescu, M. and Bordean, D.M. (2012). Bioaccumulative and Conchological Assessment of Heavy Metal Transfer in a Soil-Plant-Snail Food Chain. *Chemistry Central Journal*, 6, 55-60.

Notten M.J., Oosthoek A.J., Rozema J., Aerts R. (2005). Heavy metal concentrations in a soil-plant-snail food chain along a terrestrial soil pollution gradient. *Environ Pollut.*, 138, 178–190.

Papagiannis, L., Kagalou, L., Leonardos, J., Petridis, D., and Kalfakakou, V. (2004). Copper and zinc in four freshwater fish species from lake Pamvotis (Greece). *Environ. Int.,* 30: 357–362.

Türkmen A, Türkmen M, Tepe Y, Akyurt İ. (2005). Heavy metals in three commercially valuable fish species from İskenderun Bay, Northern East Mediterranean Sea, Turkey. *Food Chemistry*.91(1), 167–172.

USEPA, (2017). Human Health Risk Assessment Model Ecological Risk Assessment; Retrieved from https://www.epa.gov/risk/human-health-riskassessment#self on 26th march, 2017.

USEPA, (2002). Multimedia, Multi-pathway and Multi-receptor Risk Assessment (3MRA) Modellling System.

U.S Environmental Protection Agency, Office of Research and Development, Washington DC, Pp. 1-9.

Viard B., Pihan F., Promeyrat S., Pihan J.C. (2004). Integrated assessment of heavy metal (Pb, Zn, Cd) highway pollution: bioaccumulation in soil, Graminaceae and land snails. *Chemosphere*. 55, 1349–1359.

WHO/FAO. (2016). Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 10th Session. Working document for information and use in discussions related to contaminants and toxins in the gsctff (prepared by japan and the Netherlands) 4 – 8.