Health Risk Assessment of Potentially Toxic Elements in *Archachatina marginata* (Giant Land Snail) around Olomore Dumpsite in Abeokuta Southwestern Nigeria

Olufunlola Odunayo Akinola; Oluwatoyin Opeyemi Akintola*; Adepeju Rebecca Falana; Micheal Smart; Adewale Opeyemi; Agbo-Adediran; and Rebecca Titilayo Ibode.

Federal College of Forestry, P.M.B. 5054, Ibadan, Oyo State, Nigeria.

E-mail: toyinakintola73@gmail.com*

ABSTRACT

Indiscriminate waste disposal often leads to environmental pollution. Information on the health risks associated with potentially toxic elements (PTEs) in terrestrial land snail is still limited. In this study, the human health risks associated with PTEs associated with ingestion of *A. marginata* (snails) from the Olomore dumpsite were assessed by Estimated Daily Intake (EDI), Target Hazard Index (THQ), and Hazard Index (HI).

A total of 40 snails, 10 snails each from the dumpsite, downslope, upslope, and control farmlands were collected and analyzed for Fe, Mn, Pb, Zn, Cu, Cr, Co, Ni, and Cd. Data were analyzed using descriptive statistics and health risk indices. PTE concentrations were found to be higher in snails from dumpsite and downslope farmlands than in snails from upslope and control farmlands. The EDI trend of the PTE in snails from the study site was in the order of Fe > Zn > Mn > Pb > Cu > Co > Ni > Cd >> Cr. THQ levels do not indicate carcinogenic risk in humans, with the exception of possible Cd exposure. The hazard index (HI) of snail PTEs ranged from 0.02 to 3.62, indicating an adverse health risk from consumption by people living in the study area.

(Keywords: *Archachatina marginata*, giant land snail, carcinogenic risk, insidious health, waste dumpsite)

INTRODUCTION

Development and population growth have continually contributed to the urbanization and industrialization in most developing countries of the world. This in turn has led to the haphazard deposition of wastes leading to the release of dangeorous chemicals into the soil, organisms, plants, and water sources. The continuation of these chemicals above a certain amount can be of risk to environment.

According to Singh, *et al*., (2011) municipal solid waste (MSW) is habitually from human settlements, industries, agricultural, and commercial activities. When these wastes decomposed, dangerous chemicals consisting of inorganic and organic substances are released into the environment and their aftermath can be detrimental to living organisms and water resources and can become a threat for human health (Pattnaik and Reddy, 2009; Akintola, *et al*., 2022a).

Contamination of soils by potentially toxic elements (PTEs) can have unsympathetic effects on human health, animals, plants and soil productivity (Ali, *et al*., 2014) Environmental contamination has become a prime ecological concern due to the persistence of PTEs in nature and its contamination effects on soils (Mamut, *et al*., 2015). PTEs are common and vital unmanageable pollutants that affect numerous microbial activity in soil. The harmful effects of potentially toxic elements depends on the number of metals bioaccumulated by absorption, migration, and transformation (Akintola, *et al.,* 2022b).

Toxicity and uptake of the PTEs in soils has been reported extensively. Soils act as a sink for these toxic elements, released them into the groundwater, plants, and organisms; and they end up in humans through the food chain, thereby causing various toxicological effects (Ojo, *et al.,* 2017). A number of works have shown the significance of molluscans as good indicators for monitoring heavy metal pollution (Kiffney and Clement, 1993; Onuoha, et al., 2016) and may also affects several biological processes that occur in their abundance, development and maintenance (feeding, growth, reproduction, general physiological activities, and maturity). However, the accumulation of these toixc elements in land snail is of immense apprehension due to the rate at which they have be consumed due to their richly health benefits to humans. This study thus assessed the heath risk associated with PTEs in *A. Marginata (*giant land snail) around the Olomore dumpsite in Abeokuta, Ogun state, Nigeria.

MATERIAL AND METHODS

Study Area Description

The study area, Olomore dump site, is located at Latitudes 7° 5′N to 7° 20′N and Longitudes 3° 17′ E to 3° 27′ in Abeokuta, Ogun State, Southwestern Nigeria (Figure 1). The area enjoys a tropical with mean annual rainfall of 1,270 mm and temperature of 28°C. The estimated mean annual potential evaporation is 1,100 mm. The study area is underlain by crystalline Basement complex of rocks of igneous and metamorphic origin. The area is drained mainly by River Ogun which passes through and divides the city into two, and the drainage pattern is dendritic (Akintola, *et al.*, 2022b).

Sampling Collection and Analysis

*A. marginata (*giant land snail) were collected in and around the dumpsites; that is dumpsite, downslope side of the dumpsite, upslope side, and the control which is about 100m away from the upslope sde of the dumpsite. At each sampling sites, ten (10) samples of the same size and species ranging from 7-9 inches in length of *A. marginata* were collected, making a total of 40 samples. Samples were collected and labelled accordingly. The collected snails were taken to the laboratory for elemental analysis. The snail's shell was cracked with a wooden hammer; the body was washed with distilled water and stored at 18°C prior to analysis. Five grams of muscle of the samples of snail were pre-digested in 10 ml concentrated HNO_3 at 135°C until the liquid was clear. Ten (10) ml HNO_3 and 2 ml $HClO_4$ were then added to the mixture until it became colorless. The mixture was evaporated slowly untill it was nearly dry, coded, and redissolved in 1M HNO_3. It was later filtered through Whatman No 1 filter paper and diluted with 1M HNO_3 up to 25 ml. The solution was analysed for Fe, Cu, Pb, Zn, Mn, Ni, Cd, Cr, and Co using atomic absorption spectrophotometry instrumentation method. Quality assurance and control procedure were taken into consideration for reliability of the results. Each sample was analyzed in triplicate for all determined elements. Analytical blanks were run in the same way as the samples and concentrations were determined using standard solutions prepared in the same acid matrix. Standards for the instrument calibration were prepared on the basis of monoelement certified reference solution procedures.

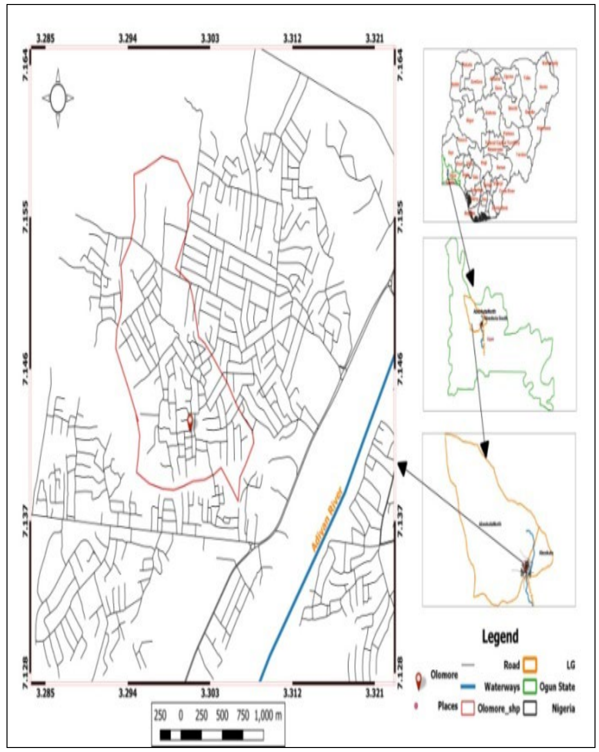

Figure 1. Location Map of the Study Area

Data Analysis

Data were analysed using descriptive statistics and risk indices for evaluation of potential health risks of the elements in the snails. The risk assessment were based on the estimated daily intake (EDI), estimated weekly intake (EWI) target hazard quotient (THQ), and hazard index (HI) of the PTEs.

The estimated daily intake of PTEs (EDI) is calculated as shown in equation 1 (Okereke, *et al.*, 2016; Isiuku and Enyoh, 2020).

$$EDI = \frac{CPTEs \times Dfi \times Cf}{Abw} \ldots. \quad 1$$

Where CPTEs is the concentration of PTEs in mg/kg, Dfi is the food intake, which is the average daily consumption rate of snails, while Abw is the average body weight. The average t body weights for children and adults were considered to be 32.70 and 60 kg respectively while average daily snail intake for children and adults were considered to be 0.069 and 0.10274 kg/person/day, respectively.

The conversion factor (Cf) is 0.085 (Rattan, *et al*., 2005) The calculation was based on standard assumption given by FAO/WHO (2011), USDOE (2011), and USEPA (2011).

$$EWI = 7 X EDI \quad 2$$

Where EDI is estimated daily intake of PTEs and 7 is the number od days in a week

Health risks from consumption of snails by human were assessed based on the Target Hazard Quotient (THQ). THQ is calculated as shown in equation 3:

$$THQ = \frac{EDI}{Ofd} \ldots. \quad 3$$

Where EDI is the estimated daily intake of heavy metals in the snails and Ofd is the oral reference dose as given by ATSDR (2004); USEPA (2007); WHO (1996); Ogundele. *et al*., (2015); and Dabanović, *et al*., (2016): Cu (0.04), Fe (0.70), Zn (0.30), Co (0.02), Mn (0.014), Ni (0.02), Cd (0.001), Pb (0.004) and Cr (1.5). If THQ of the PTEs in the snails is greater than 1, the consumer population is at risk.

Hazard index (HI) was used for assessing multiple risks of PTEs in the snails. This is done by summing all the calculated THQ values for the determined PTEs [26].

$$HI = Summation\ THQi \quad 4$$

where THQ is the target hazard quotient of an individual elements and i is the number of elements determined in the present study.

RESULTS AND DISCUSSION

Concentrations of PTEs in Snails

The values of the determined PTEs from the four locations were presented in Table 1. The respective concentration values of PTEs in the snails from dumpsite, downslope, upslope, and control soils were Fe (2.11-15.88), Zn (0.31 – 7.55), Mn (0.25 – 4.15), Pb (0.20 - 4.05), Cu (0.11- 3.11), Co (0.05 – 1.55), Ni (0.03-1.32), Cd (0.02- 1.11), and Cr (0.001).

The PTEs had the highest concentration in snails collected from dumpsite, followed by those from the downslope side of the dumpsite while those from the control site had the lowest values. This is expected as the impact of the wastes will be more on the snails collected from the dumpsite area than the other locations.

The values of PTEs recorded in the snails in this study were lower than those determined in snails from similar work conducted by Akintola, *et al*., (2022b) from Ajakanga dumpsite in Ibadan, Oyo State, Nigeria.

The concentrations of PTE in snail samples decreased in the order Fe > Zn > Mn > Pb > Cu > Co > Ni > Cd >> Cr. This is likely due to the different bioavailability of the element in terrestrial organisms.

The high concentrations of Fe, Cu, and Zn in the snail samples also indicate a high affinity for the snails to absorb the elements. These elements are also essential and integral parts of important physiological compounds such as enzymes and proteins (Chien, *et al*., 2002).

Table 1: Range Values of PTEs in *A. marginata (Land Snail).*

PTEs	Concentrations of PTEs in mg/kg			
	Dumpsite	Downslope	Upslope	Control
Fe	6.11-15.88	4.35 - 8.59	2.98 – 6.01	2.11 - 4.01
Cu	1.65 - 3.11	0.98 - 2.11	0.67 – 1.88	0.11 - -0.21
Pb	1.21 - 4.05	1.01 - 2.78	0.51 - 0.91	0.20 - 0.38
Mn	1.21 – 4.15	1.11 - 3.04	0.62 - 2.01	0.25 - 0.62
Zn	3.99 - 7.75	1.78 - 3.56	1.11 – 2.91	0.31 – 0.89
Ni	0.99 - 1.32	0.62 - 1.02	0.48 – 0.97	0.03 - 0.11
Co	0.71 - 1.55	0.53 - 1.29	0.51 - 0.99	0.06 - 0.16
Cr	0.001	0.001	0.001	0.001
Cd	0.65 - 1.11	0.42 – 0.98	0.22 – 0.58	0.02 - 0.10

Table 2: Mean Estimated Daily Intake (EDI) of PTEs through Consumption of Snail in Adult and Children from the Study Area.

PTEs	Person	EDI (mg kg-1 bw/day)			
		Dumpsite	downslope	upslope	Control
Fe	Children	0.012 - 0.032	0.01 – 0.02	0.01 – 0.02	0.004 – 0.01
	Adult	0.001 - 0.003	0.001 – 0.002	0.001 – 0.002	0.0004 – 0.001
Cu	Children	0.003 – 0.006	0.002 – 0.004	0.001 – 0.004	0.0002 - 0.0004
	Adult	0.0003 – 0.001	0.0002 – 0.0004	0.0001 – 0.0004	0.00002 – 0.00004
Pb	Children	0.001 – 0.002	0.001 – 0.002	0.001 - 0.002	0.0001 - 0.0004
	Adult	0.0001 – 0.0002	0.0001 – 0.0002	0.0001 - 0.0002	0.00001 - 0.00004
Mn	Children	0.002- 0.008	0.002 – 0.006	0.001 – 0.004	0.001 – 0.002
	Adult	0.0002- 0.0008	0.0002 – 0.0006	0.0001 – 0.0004	0.0001 – 0.0002
Zn	Children	0.008 – 0.016	0.004 – 0.007	0.002 – 0.006	0.001 – 0.002
	Adult	0.0008 – 0.0016	0.0004 – 0.0007	0.0002 – 0.0006	0.0001 – 0.0002
Ni	Children	0.002 – 0.003	0.001 – 0.002	0.001 – 0.002	0.0001 - 0.0002
	Adult	0.0002 – 0.0003	0.0001 – 0.0002	0.0001 – 0.0002	0.00001 - 0.00002
Co	Children	0.001 – 0.003	0.001 – 0.003	0.001 - 0.002	0.0001 - 0.0003
	Adult	0.0001 – 0.0003	0.0001 – 0.0003	0.0001 – 0.0002	0.00001 - 0.00003
Cr	Children	0.000002	0.000002	0.000002	0.000002
	Adult	0.0000002	0.0000002	0.0000002	0.0000002
Cd	Children	0.001 – 0.002	0.001– 0.002	0.0004– 0.0001	0.00004- 0.0002
	Adult	0.0001 – 0.0002	0.0001 – 0.0002	0.00004 – 0.00001	0.000004- 0.00002

Table 3: Mean Estimated Weekly Intake (EWI) of PTEs through Consumption of Snail in Adult and Children from the Study Area.

PTEs	Person	EDI (mg kg-1 bw/day)			
		Dumpsite	downslope	upslope	Control
Fe	Children	0.08- 0.22	0.07 – 0.14	0.07 – 0.14	0.028 – 0.07
	Adult	0.007 - 0.021	0.001 – 0.014	0.007 – 0.014	0.0028 – 0.007
Cu	Children	0.021 – 0.042	0.014 – 0.028	0.007 – 0.028	0.0014 - -0.0028
	Adult	0.0021 – 0.007	0.0014 – 0.028	0.0007 – 0.0028	0.00014 – 0.00028
Pb	Children	0.014 – 0.07	0.014 – 0.07	0.007- 0.014	0.007 - 0.028
	Adult	0.0014 – 0.007	0.0014 – 0.007	0.0007 - 0.0014	0.0028 - 0.0007
Mn	Children	0.014- 0.056	0.014 – 0.042	0.007 – 0.014	0.007– 0.014
	Adult	0.0014- 0.0056	0.0014 – 0.0042	0.0007 – 0.0028	0.0007 – 0.0014
Zn	Children	0.056 – 0.112	0.028 – 0.049	0.014 – 0.042	0.007 – 0.014
	Adult	0.0058 – 0.0112	0.0028 – 0.0049	0.0014 – 0.0042	0.0007 – 0.0014
Ni	Children	0.014 – 0.021	0.007 – 0.014	0.007 – 0.014	0.0007 - 0.0014
	Adult	0.0014 – 0.0021	0.0007 – 0.0014	0.0007 – 0.0014	0.00007 - 0.00014
Co	Children	0.007 – 0.021	0.007– 0.021	0.007 - 0.014	0.0007 - 0.0021
	Adult	0.0007 – 0.0021	0.0007 – 0.0021	0.0007 – 0.0021	0.00007 - 0.00021
Cr	Children	0.000014	0.000014	0.000014	0.000014
	Adult	0.0000014	0.0000014	0.0000014	0.0000014
Cd	Children	0.007 – 0.014	0.007– 0.014	0.0028– 0.007	0.00028- 0.0014
	Adult	0.0007 – 0.0014	0.0007 – 0.0014	0.00028 – 0.0007	0.000028- 0.00014

Table 4: Mean Target Hazard Quotient (THQ) and Summation of THQ (HI) through Consumption of Snail in Children from the Study Area.

PTEs	THQ (mg kg-1 bw/day)			
	Dumpsite	Downslope	Upslope	Control
Fe	0.02 – 0.05	0.01- 0.03	0.01 – 0.03	0.006 - 0.01
Cu	0.08 – 0.15	0.05 – 0.1	0.03 - 0.1	0.005 – 0.01
Pb	0.25 – 0.50	0.25 – 0.50	0.25 – 0.50	0.03 – 0.10
Mn	0.14 – 0.57	0.14 – 0.43	0.07 – 0.29	0.07 – 0.14
Zn	0.03 – 0.05	0.01 – 0.02	0.01 – 0.02	0.003 – 0.01
Ni	0.1 – 0.15	0.05 – 0.1	0.05 – 0.1	0.005 – 0.01
Co	0.05– 0.15	0.05 – 0.15	0.05 – 0.1	0.005 – 0.02
Cr	0.00000133	0.00000133	0.00000133	0.00000133
Cd	1.00 - 2.00	1.00 - 2.00	0.04 - 0.10	0.04 – 0.20
HI= Summation of THQ				
	1.67 - 3.62	1.63 - 3.60	0.51 – 1.24	0.16 - 0.50

Table 5: Mean Target Hazard Quotient (THQ) and Summation of THQ (HI) through Consumption of Snail in Adults from the Study Area.

PTEs	THQ (mg kg-1 bw/day)			
	Dumpsite	Downslope	Upslope	Control
Fe	0.002 – 0.005	0.001- 0.003	0.001 – 0.003	0.0006 - 0.001
Cu	0.008 – 0.015	0.005 – 0.01	0.003 - 0.01	0.0005 – 0.001
Pb	0.03 – 0.05	0.03 – 0.05	0.03 – 0.05	0.003 – 0.001
Mn	0.01 – 0.06	0.01 – 0.04	0.01 – 0.03	0.01 – 0.02
Zn	0.003 – 0.01	0.001 – 0.002	0.001 – 0.002	0.0003 – 0.001
Ni	0.10 – 0.015	0.005 – 0.01	0.005 – 0.01	0.0005 – 0.001
Co	0.005– 0.015	0.005 – 0.015	0.005 – 0.01	0.0005 – 0.002
Cr	0.000000133	0.000000133	0.000000133	0.000000133
Cd	0.10 – 0.20	0.10 - 0.20	0.004 - 0.01	0.004 – 0.02
HI= Summation of THQ				
	0.26 - 0.38	0.16 – 0.33	0.06 - 0.13	0.02 – 0.05

Concentrations of PTEs in snails studied are lower than those reported by some researchers (Markmanueland Horsfall,Jr,, 2015; Onuah. *et al*., 2016; Oguh, *et al*., 2019). However, overdose of them is known to have dangerous effects on human health, such as weakening the immune system, damaging the body's major organs (lungs, liver, kidneys), and can even lead to death. (Kuhnlein and Chan, 2000; Horsfall, 2011). Concentrations of PTEs in this study were also within the recommended reference values of FAO/WHO (2011) and USEPA (2011).

Availability of the heavy metals in the environment and other factors such as climatic condition influence the biomagnification of metals in shell animals (Mubiana and Blust, 2007). Aside from these, metal chemistry is affected by temperature through changes in physical reaction rates, pH, solubility, chemical speciation, or reaction rates (Rouane-Hacene et al. 2015). In mollusks, the reaction to different natural stressors, homeostasis, nourishment take-up, and development rates are impacted by abiotic variables (temperature, chemical contaminants) and biotic (e.g., regenerative cycle) (Rouane-Hacene, *et al*., 2015). It has been accentuated that propagation period influences propensity of the heavy metal bioavailability and bioaccumulation (Rouane-Hacene, *et al*., 2015).

Human Health Risk Assessment

Human health risks from eating snails in the study area were assessed by EDI, EWI, THQ, and HI.

The estimated daily intake (EDI) and estimated weekly intake (EWI) for snails for both children and adult are shown in Table 2 and Table 3, respectively . The EDI and WDI trends for PTE in all snail samples are in the order Fe > Zn > Mn > Pb > Cu > Ni > Co > Cd > Cr. The EDI for Cr from A. marginata ingestion was 2.0 x 10-6 and 2.0 x 10-6 mg kg-1 body weight per day for children and adult respectively. EDI is well below the daily tolerable intake of 1.5 mg kg-1 body weight per day specified by FAO/WHO (2011), USEPA (2011) and USDOE (2011). This result was consistent with a similar study by Onuoha, *et al.* (2016) and Oguh, *et al.* (2019), and Akintola, *et al.* (2022b).

Target Hazard Quotient (THQ) values, an index of risk associated with long-term exposure to chemicals based on safety limits, are used by the United States Environmental Protection Agency (USEPA, 2011) to estimate potential health risks associated with long-term exposure. This method has recently been used by several researchers (Onuoha, *et al*., 2016; and Oguh, *et al.*, 2019).

A number of studies have demonstrated that snails can produce large amounts of food in soft tissues without major metabolic disturbances (Laskowski and Hokin, 1996; Beeby and Richmond, 2003; Notten, *et al*., 2005; Dallinger, *et al.*, 2005, Otitoloju, *et al*., 2009). The target hazard quotient (THQ) of PTE for children and adult from eating snails in the study area is shown in the table.

The THQs of the PTEs at the four studied locations are below the reference THQ with values less than 1, except for Cd through consumption of Snail in children from dumpsite and downslope location site of the study area (Table 4 and 5). This is believed to be due to the contamination of soil, plants and other soil materials with toxic elements from the decomposition of wastes that snails need to live. However, THQ levels of Cd greater than 1 may pose a carcinogenic risk to consumers in the study area. This is similar to the report by Li, *et al*. (2014) and Onuoha, *et al.* (2016) reported a higher potential health risk posed by PTE when ingested by humans, especially for people living in areas with high levels of contamination.

The Hazard Index (HI) totals for the four sites ranged from 0.16 to 3.62 and 0.02 to 0.38 for children and adult respectively (Table 4 and 5). HI values less than 1.0 indicate little or no potential health risk while values of HI greater than 1, indicate that these snails are harmful to human health.

CONCLUSION

This study investigated the risk to human health from potentially toxic elements (PTEs) in snails collected from landfills. In this study, tissues of the African giant snail (*A. marginata*) contained significant levels of potentially toxic elements from contaminated landfills, The toxicity of these elements in snails can affect natural ecosystems and food chains, causing harmful problems to animal and human health. Precautions are necessary to prevent further contamination of PTE in the study area.

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SUGGESTED CITATION

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