



EVALUATION OF CARCINOGENIC AND NON-CARCINOGENIC RISK OF CADMIUM AND NICKEL IN LAND SNAILS (*A. ACHATINA* AND *L. FLAMMEA*) AND MARINE SNAILS (*P. AURITA* AND *T. FUSCATUS*) COMMONLY CONSUMED IN NIGERIA

DOUYE P. MARKMANUEL^a and MICHAEL HORSFALL JNR^{*}

Department of Pure and Industrial Chemistry, College of Natural & Applied Sciences,
University of Port Harcourt, P. M. B. 5323, Port Harcourt, NIGERIA

^aDepartment of Chemistry, School of Science, Isaac Jasper Boro College of Education,
Sagbama, P.M.B. 74 Yenagoa, BAYELSA STATE, NIGERIA

(Received : 01.12.2016; Revised : 21.12.2016; Accepted : 24.12.2016)

ABSTRACT

The Carcinogenic and non-carcinogenic health risk of Cd and Ni in Land Snails (*A. achatina* and *L. flammea*) and Marine Snails *P. aurita* and *T. fuscatus*) commonly consumed in Nigeria were investigated. The metal concentrations were determined using atomic absorption spectrometer (GBC Avanta 2.02 model). The results of the mean concentrations (mg kg⁻¹ dry wt basis, mean ± SD) of Cd were 17.8 ± 4.37 (*A. achatina*), 6.3 ± 0.47 (*L. flammea*), 2.1 ± 0.26 (*P. aurita*) and 2.8 ± 0.64 (*T. fuscatus*), while Ni values were; 16.7 ± 5.03 (*A. achatina*), 7.3 ± 1.04 (*L. flammea*), 17.7 ± 7.68 (*P. aurita*) and 11.3 ± 1.65 (*T. fuscatus*), respectively. The mean concentrations of Cd and Ni in the Snail samples were higher than the acceptable limits set by WHO, FAO, FEPA and EU. For Cd the mean concentrations are in the decreasing order of *A. achatina* > *L. flammea* > *T. fuscatus* > *P. aurita*, while Ni mean concentrations are in the order of *P. aurita* > *A. achatina* > *T. fuscatus* > *L. flammea*. The provisional tolerable daily and weekly intake (PTDI and PTWI) of Cd estimated in this study were all higher than the limits set by WHO and FAO, while for Ni, *A. achatina* and *P. aurita* were higher than the limits of WHO and FAO, and *L. flammea* and *T. fuscatus* were lower than the limits. For the non-carcinogenic and carcinogenic risk evaluation, the results showed that the hazard index, HI (Sum of THQ) for all the snail samples were higher than the acceptable limits of 1 set by USEPA. The HI values are in the decreasing order of *A. achatina* > *L. flammea* > *T. fuscatus* > *P. aurita* and the risk values were 7.67, 2.74, 1.22 and 1.38 with Cd been the major risk contributor, contributing up to 70-95% of the HI values. This is a source of concern considering the fact that excessive consumption of these snails may lead to severe chronic cadmium poisoning. Also, the target Cancer risk (TR) values for Cd and Ni in all the Snail Samples were higher than the acceptable limits of 10⁻⁶ – 10⁻⁴ established by USEPA, indicating a potential health risk effects to consumers. Therefore, moderate intake of these snails from Bayelsa State is strongly recommended to consumers.

Key words: Heavy metals, Bioaccumulation, Toxicity, Bio-indicators, Gastropods, Carcinogenic and Non-carcinogenic risks.

INTRODUCTION

Heavy metals according to Lide¹ are subset of chemical elements with a specific gravity that is at least five (5) times the specific gravity of water. These include; arsenic, cadmium, mercury, lead, Nickel, iron, copper, zinc, cobalt, cerium, manganese, etc. These elements have biological accumulation, toxicity and environmental sustainability properties². In recent years, the presence of these metals has become an

international environmental and health concern³ due to rapid development of industrialization which has resulted in the alteration of the ecosystem⁴. This has a significant environment hazard for invertebrate, fish, animal and humans, respectively⁵. These metals are released or discharged into the environment through numerous anthropogenic sources such as oil and gas activities (combustion of fossil fuel), transportation process industrial activities (especially metal production), solid waste combustion, agricultural application and domestic application and are collectively received by sediment, soil, water and air⁶⁻⁸. Heavy metals are one of the pollutants that can spread in sediment soil and water components and react through ion exchange, absorption and precipitation⁹, which may directly or indirectly be toxic to the aquatic and terrestrial fauna and flora¹⁰.

Heavy metals tend to accumulate in advanced organisms through bio-magnification effects in the food chain. They enter into the human body, and accumulate in the human tissues to pose chronic toxicity. Chronic assimilation of some heavy metals is known to cause cancer¹¹ and can damage vital organ functions. Accumulation of heavy metals in the food web can occur either by accumulation from the surrounding medium, such as soil, water or sediment, or by bioaccumulation from food source¹². Reports have shown that, heavy metals may affect organisms directly or indirectly by transferring to the next trophic level of the food chain¹³ due to their persistence nature. In the aquatic environment, (water & sediment) heavy metals in dissolved form are easily taken up by aquatic organisms where they are strongly bound with sulfhydryl groups of proteins and accumulate in their tissues¹⁴, while in the terrestrial environment (soil), heavy metals occur in various chemical forms such as carbonates, metal hydroxides organic matter and silica¹⁵ and remobilized in to plants & animal tissues through adsorption and inhalation¹⁶. The accumulation of heavy metals in the tissues of organisms can result in chronic illness and cause potential damage to the population.

Geochemical factors that influence bioaccumulation of heavy metals in an aquatic environment are; organic carbon, water hardness temperature, pH, Salinity, dissolved oxygen, sediment, grain size and hydrologic features of the system,¹⁷ while the bioavailability of metals in the soil depends on the soil properties such as; pH, organic matter, redox potential, cation exchange capacity, sulphate, carbonate, hydroxide, soil texture and clay content^{18,19}. These properties in turn influence the uptakes of these metals by plants and animal in both terrestrial and aquatic environment. For instance, it has been reported that very low transfers of heavy metals to plant tissues occur at high pH²⁰.

Recent studies^{21,22} have shown that heavy metals such as Cd, Ni, AS, Pb pose a number of health hazards to humans, which include damage or reduced mental and central nervous system function, lower energy levels, and damage to blood composition, lungs, kidneys, liver and other vital organs. These metals are also potent carcinogenic and mutagenic²³. Long-term exposure may result in slowly progressing physical, muscular and Alzheimer's disease, Parkinson' disease, muscular dystrophy and multiple Sclerosis²⁴. According to Ferner²⁵, heavy metal toxicity is a clinically significant condition when it does occur especially, if unrecognized or inappropriately treated, toxicity can result in significant illness and reduced quality of life.

The awareness and concern about the protection of the public from avoidable contamination and exposure to heavy metals (especially Pb, Cd, Ni, Hg and As) and their attendant adverse effects on health have led to increase in strategies and methodologies for detecting their presence in the environment. One of such methods is by using non-vertebrate wildlife species (gastropods) as bio-indicators²⁶. These organisms detect both the levels of pollutants in an ecosystem as well as their long-term effects^{27,28} because of their ecological role as intermediate consumers in pelagic as well as benthic food chain of aquatic ecosystem²⁹. The effectiveness of biomonitors for environmental pollution assessment as revealed by many studies^{30,31} is based on the ability of these organism to accumulate contaminants such as heavy metals in their tissues. Examples, uptake and accumulation of these pollutants in deposit feeders would be expected to correlate to

metal concentrations in sediments, whereas accumulation in filter feeders would most likely reflect metal concentration in water³². Presence of heavy metals in edible tissue of organisms (depending on the type and concentration) could pose series of health hazards to consumers especially in the Niger Delta region of Nigeria, where gastropods and bivalves are abundant and therefore serve as cheap sources of protein for indigenous people who could not afford meat from domestic species and bush meat. It is against this background that Land and Marine Snails (*A. achatina*, *L. flammea*, *P. aurita* and *T. fuscatus*) were chosen in order to assess the concentration of Cd and Ni in the tissues of these edible gastropods and relate their effects to the exposed population.

Another important method in evaluating the levels of heavy metals in environmental biota is to assess the human health risk arising from the presence of these pollutants in foods products. This is done by estimating the actual dietary intake of the metal and comparing with corresponding toxicological reference intake³³. Risk assessment is one of the fastest method, which is needed to evaluate the impact of the hazards on human and also needed to determine the level of treatment which are tend to solve the environmental problem that occur in daily life³⁴. The risks may be divided into carcinogenic and non-carcinogenic effects¹⁰. The carcinogenic risk is based on the Target Cancer Risk (TR_C), while the non-carcinogenic risk is based on the Target Hazard Quotient (THQ)³⁵.

Therefore, the purpose of this study is to determine the total concentration of Cd and Ni in edible tissue of land and marine snails and evaluate the carcinogenic and non-carcinogenic risk associated with the consumption of these gastropods by human.

EXPERIMENTAL

Materials and methods

Sample collection and preparation

Land and marine snails, *Achatina achatina* (Giant Land Snail), *Limicolaria flammea* (Garden Snail), *Pachymelania aurita* (Periwinkle with Spiny Shell) and *Tympanotonus fuscatus* (periwinkle Without Spine) were purchased from commercial sellers from Yenagoa main market Bayelsa State. The giant land snail and garden snail (terrestrial mollusks) and the periwinkle (aquatic mollusks) have hard shells, which house and protect the soft tissue (visceral lump). The shells are often greater in quantity than the tissue. Upon collection, the samples were washed with tap water and rinsed thoroughly with distilled water. There after samples were rapped in a cellophane bag labeled accordingly and transported to the laboratory. These mollusks were properly identified at the Departments of Animal and Environmental Biology, University of Port Harcourt, Nigeria. The whole soft tissues (edible parts) of these snails were obtained by cracking the shells. Thereafter, the samples were thoroughly washed several times and rinsed with distilled water. Samples were dried in the oven at 105°C to a constant weight. The oven-dried samples were ground and sieved with 0.15 mm mesh size to obtain uniform particles size.

Sample digestion

Heavy metal (Cd and Ni) were determined from 0.5 g of finely ground and sieved tissue samples of the snails and homogenized with 10 mL of 3.1 (v/v) of con.HCl/HNO₃ (aqua regia) then 1 mL of HClO₄. The mixture were boiled off to near dryness, cooled and diluted with 25 mL distilled water and filtered³⁶. Metal concentrations were analyzed using flame atomic absorption spectrometer (GBC, Avanta Ver 2.02 model). Cd and Ni were determined using acetylene flame. For quality assurance, the samples were digested in triplicate along with blanks to minimize error. The instrument was calibrated with series of standard solution supplied by the manufacturer. All determinations were replicated three times. Thus, the results obtained from this analysis were the average of triplicate determination.

Human health risk evaluation for the snail consumption

The exposure pathway of heavy metals to human through ingestion of contaminated food has been studied by many researchers^{33,34,37}. The estimated daily (EDI) and intake (EWI) of each metal in this exposure pathway was determined by the equation³⁸.

$$\text{EDI/EWI (mg kg-bw/day/week)} = \frac{\text{MI}_s \times \text{CM}_s}{\text{BW}}$$

Where EDI/EWI are the daily/weekly intake of the metals, MIs is the mass of the snail ingested per day; CM_s is the concentration of metal in snail; BW is the body weight (60 kg for adult).

Non-carcinogenic risk evaluation

For the non-carcinogenic risk evaluation, the target hazard quotient (THQ) was calculated as per USEPA Region III Risk Based Concentration Table³⁵.

The equation used for estimating THQ was as follows.

$$\text{THQ} = \frac{\text{EF} \times \text{ED} \times \text{MI} \times \text{CM}}{\text{RfD} \times \text{BW} \times \text{AT}} \times 10^3$$

Where; THQ is the target hazard quotient, EF is the exposure frequency (day year⁻¹) or number of exposure events per year exposure, ED is the exposure duration, total for adult (year), MI is the mass of snail ingested (g, day⁻¹), CM is the metal concentration in the snail (mg kg⁻¹), RfD is the reference dose (mg kg⁻¹ day⁻¹), BW is the body weight, adult (60 kg) and AT is the average time, non-carcinogenic (day year⁻¹), 10⁻³ is the unit conversion factor. Also, the hazard index (HI) from THQ_s can be expressed as the sum of the hazard quotient³⁵. HI = THQ_{Cd} + THQ_{Ni}. Where HI is the hazard index; THQ_{Cd} is the target hazard quotient for Cd intake and THQ_{Ni} is the target hazard quotient for Ni intake, respectively.

Target cancer risk (TR)

The target cancer risk (TR) was used to indicate carcinogenic risks. The method to estimate TR was also provided in USEPA Region III Risk-Based Concentration Table³⁵. The model for estimating TR was shown as follows:

$$\text{TR} = \frac{\text{EF} \times \text{ED} \times \text{MI}_s \times \text{CPS}_o \times \text{MC}_s}{\text{BW} \times \text{AT}}$$

Where; TR is the target cancer risk, EF is the exposure duration (i.e. incremental probability of an individual developing cancer over a life time of 70 years³⁵, MIs is the mass of the snail ingested, (mgg⁻¹), CPS_o is the Carcinogenic potency slope, oral (mg kg⁻¹bw⁻¹ day⁻¹), MC is the snail mass of the snail ingested g day⁻¹). AT is the averaging time, carcinogens (day year⁻¹). The input parameters used in the health risk estimation for the snail intake from Bayelsa state are represented in Table 1.

Table 1: Summary statistic of input parameters in the health risk estimation

Symbol	Description	Unit	Value
MC	Metal concentration	mg kg ⁻¹	Presented in table 2
MI	Mass of the snail ingested	g day ⁻¹	24.7

Cont...

Symbol	Description	Unit	Value
EF	Exposure	Days	365
	Frequency	Year ⁻¹	
ED	Exposure duration	Year	51.86
RfD	Reference dose	mg kg ⁻¹ day ⁻¹	Cd = 0.001; Ni = 0.002
BW	Body weight (adult)	kg	60
ATn	Averaging time non-carcinogens	Days	365 × 51.86 = 18928.9
ATc	Averaging time carcinogens	Days	365 × 70 = 25550
CPSo	Carcinogenic potency slop, oral	mg g ⁻¹ day ⁻¹	Cd = 0.38; Ni = 1.7

Exposure duration

The exposure duration is defined as the exposure frequency of 365d/yr for 51.86 yr (which corresponded to the average life expectancy of a Nigerian³²). The averaging time and number of fish consumed are required to provide input for an estimate of human health risk from exposure through snail ingestion. An averaging time of 365 d/yrs for 70 yrs (ie AT_C = 25550 days) was used for to characterize lifetime exposure for cancer risk calculation and averaging time of 365d/yr for 51.86 yr (i.e. AT_n = 18928.9 days) was used in charactering non-cancer risk³⁵.

Snail ingestion

The per capita consumption of fish and shellfish in Nigeria for human food is averaged 9.0 kg³⁹, which is equivalent to 24.7 g per day was used for the risk estimation.

Body weight

We used body weight of 60 kg for average Nigerian adult.

Toxicity factors

The reference dose (RfD) and carcinogenic potency slop factor (CPS) used for health risks (TR & THQ) evaluation was provided by USEPA³⁵. The cancer slop factors for ingestion of cadmium and Nickel (subsulfide) are 0.38 and 1.7, respectively. While the RfD (reference dose) for Cd and Ni are 0.001 and 0.02 (i.e. the dose that is likely to be without appreciable risk of deleterious effects during a life time).

Acceptable risk distribution

The acceptable risk distribution was assigned by constraints on percentiles. The lower end of the range of acceptable risk distribution is define by a single constraint on the 95th percentile of risk distribution that must be equal or lower than 10⁻⁶ for carcinogens (TR) and may be up to 10⁻⁴ in some circumstance. While the health protection standard of life risk for THQ is 1.⁴⁰

RESULTS AND DISCUSSION

Concentration of Cd and Ni in the snail sample

Concentration range and mean of cadmium and Nickel in the edible tissue of the snail sample from Bayelsa state were presented in Table 2. The concentration in the snail samples varies considerably among species. This was possibly due to differences in metabolism and feeding patterns of the snails.

Table 2: Cd and Ni levels (mg kg⁻¹ dry wt.) in selected land and marine snails from Bayelsa State, Nigeria

Snail samples	Statistics		
		Cd	Ni
<i>Achatina achatina</i>	Range	14.4-24.0	13.5-20.0
	Mean ± SD	17.8 ± 4.37	16.7 ± 5.03
<i>Limicolaria flammea</i>	Range	6.0-7.0	6.2-9.1
	Mean ± SD	6.3 ± 0.47	7.3 ± 1.04
<i>Pachymelenia aurita</i>	Range	2.0-2.2	11.5-28.5
	Mean ± SD	2.1 ± 0.26	17.7 ± 7.68
<i>Tympanotonus fuscatus</i>	Range	2.0-3.5	9.5-13.5
	Mean ± SD	2.8 ± 0.64	11.3 ± 1.65
Guidelines			
FAO/ WHO (1993)		0.5	-
WHO (1985)		2.00	0.60
FEPA (2003)		2.00	0.50
EU (2006)		0.02	-

The concentration of Cd in *A. achatina* ranged from 14.4-24.0 mg kg⁻¹ with the mean of 17.8 ± 4.37 mg kg⁻¹, *L. flammea* ranged from 6-7.0 mg kg⁻¹ with mean of 6.3 ± 0.47 mg kg⁻¹, *P. aurita* ranged from 2.0-2.2 mg kg⁻¹ with mean of 2.1 ± 0.26 mg kg⁻¹ and *T. fuscatus* value ranged from 2.0-3.5 mg kg⁻¹ with mean of 2.8 ± 0.64 mg kg⁻¹, respectively. The highest concentration, 17.8 ± 4.37 mg kg⁻¹ was recorded in *A. achatina*, while the lowest mean concentration 2.1 mg kg⁻¹ was recorded in *P. aurita*. The amount of Cd found in the snail samples exceeded the limit set by regulatory bodies, FAO, WHO⁴¹, WHO⁴², FEPA⁴³, EU⁴⁴. This call for concern, because report⁴⁵ has shown that ingestion of high levels of Cd can lead to acute renal failure in humans. From the results, it can be predicted that consumption of snail species such as *A.achatina*, *L. flammea*, *P. aurita* and *T.fuscatus* from Bayelsa state can lead to severe chronic Cd poisoning, if consumed excessively. While Ni concentration in *A. achatina* ranged from 13.5-20.0 mg kg⁻¹ with the mean ± SD of 16.7 ± 5.03 mg kg⁻¹, *L.flammea* value ranged from 6.2-9.1 mg kg⁻¹ with the mean ± SD of 7.3 ± 1.04 mg kg⁻¹, *P.aurita* ranged from 11.5-28.5 mg kg⁻¹ with the mean of 17.7 ± 7.68 mg kg⁻¹ and *T. fuscatus* value ranged from 9.5-13.5 mg kg⁻¹ with the mean of 11.3 ± 1.65 mg kg⁻¹, respectively. For Ni, the highest concentration, 17.7 ± 7.68 mg kg⁻¹ was recorded in *P. aurita*, while the lowest concentration, 7.3 ± 1.04 mg kg⁻¹ was recorded in *L. flammea*. Also, the amount of Ni found in all the snail samples exceeded the limits set by WHO⁴¹ and FEPA⁴³.

Nickel is essential for growth and reproduction in animal and human beings, but shows carcinogenic effects when consumed in high amount while Cd has no known biological or beneficial role in human body. The concentration Ni & Cd in this study is higher than the values reported by Kumar and Mukherejee³³, Osakwe³⁹, Ijeoma et al.²⁶, and Akoto et al.⁴⁶

Generally it was observed that the concentration of Cd and Ni in these snail samples were higher than the limits set by regulatory bodies. This call for concern considering that both Cd and Ni are toxic and their accumulation overtime may lead to serious health issues.

Table 3: Comparison of Cd and Ni levels (mg/kg) in the four snail samples from Bayelsa state with other fish and shell fish species in other states/countries

Samples	Cd	Ni	State/Country	Reference
<i>A. Achatina</i>	17.8	16.7	Bayelsa/Nigeria	This study
<i>L. Flammea</i>	6.3	7.3		This study
<i>P. aurita</i>	2.1	17.7		This study
<i>T. fuscatus</i>	2.8	11.3		This study
Crab	0.023	0.69		[26]
Water snail	0.037	1.007	Delta/Nigeria	
Periwinkle	0.028	0.63		
Oyster	0.029	0.76		
<i>Sarotherodon melanotheron</i> Muscle	0.275	0.36	Cape Coast/Ghana	[45]
African catfish (<i>auriasgariepinus</i>) Edible part	1.125	1.12	Imo/Nigeria	[39]
Catlacatla (<i>oreochromisnilotica</i>)	-	3.74	Tropic Wet-Land/India	[33]
<i>Labeorohita</i>		1.95		
		3.49		

Human health risk assessment of Cd and Ni in Land and marine snails

Risk assessments are based on assumptions. The USEPA Region III, Risk- Based Concentration Table³⁵ presents methods for estimating the target cancer risk (TR) and the non-cancer risk (THQ_s). The risk associated with the carcinogenic effects of target metals is expressed as the excess probability of contracting cancer over a lifetime of 70 years. The USEPA established the acceptable guideline values for THQ and TR as 1 and 10⁻⁶ and 10⁴, respectively. The theoretical and estimated lifetime target cancer risk (TR) and target hazard quotient (THQ_s) as well as dietary intakes of Cd and Ni in the snail samples were calculated and presented in Table 4. THQ higher than 1, implies that the estimated exposure exceed the USEPA reference dose for the contaminant of interest.

As indicated in Table 4, the estimated daily intake (EDI) and estimated weekly intake for Cd in the snail samples were; 7.33 and 51.31 mg kg⁻¹bw day⁻¹ & week⁻¹ in *A. achatina*, 2.59 and 18.13 mg kg⁻¹bw day⁻¹ & week⁻¹ in *L. flammea*, 0.86 and 6.02 mg kg⁻¹bw day⁻¹ & week⁻¹ in *P. aurita* and 1.15 and 8.05 mg kg⁻¹bw day⁻¹ & week⁻¹ in *T. fuscatus*, respectively. The highest daily and weekly intake of Cd is record in *A. achatina*, while the lowest daily and weekly intake is recorded in *P. aurita*. The provisional weekly intake of Cd is set at 2.5 µg kg⁻¹ bw, while provisional daily intake Cd is set at 0.36 µg kg⁻¹bw by the European Food Safety Authority (EFSA)⁴⁷. But the results obtained from this study are all higher than the provisional daily and weekly intake of Cd set by EFSA. This implies that the daily and weekly consumption of these snails based on the per capita consumption of 24.7 kg, which is equivalent to 9.0 g may cause health risk effects to consumers in future.

Table 4: Estimated dietary intake, (mg kg⁻¹bw/day/week), Target hazard quotient (THQ), Hazard index (HI) and Target cancer risk (TR) for intake of Cd and Ni in Land and Marine Snails from Bayelsa state

Snail samples	Risk model	Cd	Ni	Hazard index (HI)
<i>A.achatina</i> (Giant land snail)	EDI	7.33	6.87	
	EWI	51.31	48.09	
	THQ	7.33	0.34	7.67
	% HI	95.56	4.43	
	TR	2.9×10^{-3}	1.2×10^{-2}	
<i>L.flammea</i> (Garden snail)	EDI	2.59	3.01	
	EWI	18.13	21.07	
	THQ	2.59	0.15	2.74
	% HI	94.53	5.47	
	TR	9.8×10^{-4}	5.1×10^{-3}	
<i>P.aurita</i> (Periwinkle with spine)	EDI	0.86	7.29	
	EWI	6.02	51.03	
	THQ	0.86	0.36	1.22
	% HI	70.49	29.51	
	TR	3.3×10^{-4}	1.2×10^{-2}	
<i>T.fuscatus</i> (Periwinkle without spine)	EDI	1.15	4.65	
	EWI	8.05	32.55	
	THQ	1.15	0.23	1.38
	% HI	83.33	16.67	
	TR	4.4×10^{-4}	7.9×10^{-3}	

The estimated daily intake (EDI) and estimate weekly intake (EWI) for Ni calculated for snail consumption in this study were; 6.87 mg kg⁻¹ bw day⁻¹ and 48.09 mg kg⁻¹bw week⁻¹ in *A. achatina*, 3.01 mg kg⁻¹bw day⁻¹ and 21.09 mg kg⁻¹bw week⁻¹ in *L. flammea*, 7.29 mg kg⁻¹ bw day⁻¹ and 51.03 mg kg⁻¹ bw week⁻¹ in *P. aurita* and 4.65 mg kg⁻¹bw day⁻¹ and 32.55 mg kg⁻¹ bw week⁻¹ in *T. fuscatus*, respectively. The highest Ni EDI and EWI intake is obtained from the consumption of *P. aurita* while the lowest Ni EDI and EWI are obtained from the consumption *L. flammea*. The Joint FAO/WHO Expert Committee on food Additives has established a PTWI and PTDI for Ni and its compounds, which is 35 µg kg⁻¹bw week⁻¹ and 5 µg kg⁻¹ bw day⁻¹,³³ which is equivalent to 0.035 and 0.005 mg kg⁻¹bw day⁻¹ & week⁻¹, respectively. Based on the results obtained from this study the EDI and EWI for all the snail sample were higher than the PTDI and PTWI of FAO/WHO for Ni, which indicates an adverse health effects to the consumers.

The THQ_s of Cd and Ni in the four snail samples were *A. achatina* is 7.33 and 0.34 with HI values of 7.67, *L. flammea* is 2.59 and 0.15 with HI value of 2.74, *P. aurita* is 0.86 and 0.36 with HI value of 1.22 and *T. fuscatus* is 1.15 and 0.23 with HI value of 1.38, respectively. The hazard index (HI) of Cd and Ni in *A. achatina* and *L. flammea* is 7.76 and 2.74, which were all higher than the acceptable limits of 1 set by USEPA³⁵. This implies that the continuous consumption of these snails over a long period of time will pose a potential health risk to consumers. While for the periwinkles (*p.aurita* and *T.fuscatus*) the hazard Index values (i.e. the sum of THQ) is equal to 1, this indicates no adverse health effects to consumers. However, it is advisable that these periwinkles should be consumed moderately.

The average values of target cancer risk (TR) for Cd and Ni for the consumption of the four snail samples were; *A. achatina* is 2.9×10^{-3} and 1.2×10^{-2} . These values are higher than the USEPA³⁵ acceptable limits of $10^{-6} - 10^{-4}$, respectively. This implies that out of one thousand and out of one hundred there would be like-hood that up to two (2) and one (1) consumers of this snail will be contracting cancer if exposed continuously over 70 years (the assumed lifetime), rather than the acceptable limit of one in million (10^{-6}) and one in ten thousand (10^{-4}). TR values for Cd and Ni in *L. flammea* were 9.8×10^{-4} and 5.1×10^{-3} , these values are also far greater than the acceptable limits of one in a million (10^{-6}) and one in ten thousand established by USEPA, rather it implies that nine (9) consumers out of ten thousand and five (5) in one thousand would likely contract cancer if exposed continuously to given concentration over 70 years (the assumed lifetime). For *P. aurita*, the TR values for Cd and Ni were 3.3×10^{-4} and 1.2×10^{-2} , these values are also higher than the acceptable limits of $10^{-6} - 10^{-4}$ (i.e one in a million and one in ten thousand). Rather, there will be a likelihood that up to three (3) out of ten thousand and one out of one hundred consumers will be contracting cancer if exposed continuously. While for *T. fuscatus* the TR values were 4.4×10^{-4} and 7.9×10^{-3} . Again, these values are higher than the acceptable limits set by USEPA⁴⁰, which is $10^{-6} - 10^{-4}$, rather it implies that out of ten thousand there will be four (4) consumers (for Cd) and out of one thousand there will be seven (7) consumers (for Ni) contracting cancer over 70 years (assumed life time). The TR values of Cd in the snail samples are in the decreasing order of *A. achatina* > *L. flammea* > *T. fuscatus* > *P. aurita* with TR values of 2.9×10^{-3} , 9.8×10^{-4} , 4.4×10^{-4} and 3.3×10^{-4} , while the TR values for Ni are in the decreasing order of *A. achatina* and *P. aurita* > *T. fuscatus* > *L. flammea* with TR values of 1.2×10^{-2} , 1.2×10^{-2} , 7.9×10^{-3} and 1.2×10^{-2} , respectively. These values are comparable to result obtained by Kumar and Mulcherjee³³ in some fish species but lower than the values obtained by Manual et al.⁴⁷ in some shellfish from Todos and OS Santos Bay, Bahia, Brazil. Also the THQ of the individual metals and the combined THQ (i.e. the hazard index, HI) in the presents study is higher than the value obtained by Osakwe et al.³⁹ in African catfish from Imo river, Nigeria.

CONCLUSION

In this study, concentrations of Cd and Ni in land snail (*A. achatina* and *L. flammea*) and marine snails (*P.aurita* and *T. fuscatus*) were investigated. Generally, the results shows that the mean concentrations of Cd and Ni in all the snail samples were higher than the acceptable limits set by regulatory bodies⁴¹⁻⁴⁴ and the concentrations varies considerably among species. This is a source of concern because; literature revealed that Cd and Ni are human carcinogens²³. More so, Cd has no known biological or beneficial role in humans rather, report²⁴ has shown that Cd is an endocrine disturbing substance and high accumulation may lead to development of prostate cancer and breast cancer in humans. The provisional daily and weekly intake (PDI and PWI) of Cd and Ni in all the snail samples were higher than the limits set by FAO /WHO. For the non-carcinogenic and carcinogenic risk evaluation, the results shows that the hazard index (sum of THQ) for all the snail samples were higher than the acceptable limits of 1 set by USEPA³⁵. The HI values for each snail were mainly contributed by Cd, which ranged between 70-95% respectively. Also, the TR values for all the snail samples were higher than the limits established be USEPA³⁵, which implies that potential health risk for excessive consumption of snails from Bayelsa State is significant as per Cd and Ni contents. Therefore, moderate amount of intake is advisable to prevent human health risk to consumers in future.

ACKNOWLEDGEMENT

The authors are thankful to the Department of Pure and Industrial Chemistry and Mr. .T. Peter, Graduate Laboratory Attendant, for the kind permission to use reagents and facilities in their Laboratory. Also, we acknowledge Anal Concepts LTD for their Facilities (AAS).

REFERENCES

1. D. Lide, Handbook of Chemistry and Physics 73rd Ed., Boca Ration, FLCRC Press (1992).
2. H. Pekey, D. Karakas and M. Bakaglu, Source Apportionment of Trace Metals in Surface Waters of a Polluted Stream using Multivariate Statistical Analyses, Marine Poll. Bull., **49**, 809-818 (2004).
3. D. Dogaru, J. Zobrist, D. C. Balteanu, M. Sima, M. Amini and H. Yang, Community perception in Water Quality in a Mining Affected area. A Case Study for the Certijcatchment in the Apuseni Mountains in Romania, Environ. Manage., **43**, 1131-1145 (2009).
4. L. Jarup, Hazards of heavy metal contamination, British Med. Bull., **68**, 167-182. <http://dx.doi.org/10.1093/bmb/dg032> (2003).
5. M. Tuzen, Determination of Heavy Metals in Fish Samples of the Middle Black Sea (Turkey) by Graphite Furnace Atomic Absorption Spectrometry, Food Chem., **80**, 119-123 (2002).
6. A Adoki and T. Orugbani Influence of Nitrogen's Fertilizer Plants Effluents on Growth of Selected Farm Crops in Soils Polluted with Crude Petroleum Hydrocarbons, Afir. J. Agric. Rec., **2(11)**, 569-573 (2007).
7. Ana Gree, M. K. C. Sridhar and Emerole Gao, Comparative Assessment of Soil Pollution by polycyclic Aromatic Hydrocarbons in two Niger Delta Communities, Nigeria, Afri. J. Pure Apple Chem., **3(3)**, 31-41 (2009).
8. J. G. Fabris, B. J. Richardson, J. E. O. Sulvian and F. C. Brown, Estimation of Cadmium, Lead and Mercury Concentration in Estuarine Waters using the Mussel *Mytilusedulisplanulatus* L. Environ. Toxicol. Water Qual., **9**, 183-192 (1994).
9. C. G. Yuan, J. B. Shi, J. F. Liu, L. N. Liang and G. B. Jiang, Speciation of Heavy Metals in Marine Sediments from the East China Sea by ICP-MS with Sequential Extraction, Environ. Int., **30**, 769-783 (2004).
10. Y. Yujun, Y. Zhifeng and Z. Shanghong, Ecological Risk Assessments of Heavy Metals in Sediment and Basic J. Environ. Poll., **159**, 2575-2585 (2011).
11. A. Nabawi, B. Heinzow and H. Kruse, AS, Cd, Cu, Pb, Hg and Zn in fish from Alexendria Region, Egypton (J), Bull. Environ. Contamination and Toxicol., **39**, 889-897 (1987).
12. T. Tulonen, M. Pihistron, L. Arvola and M. Rask, Concentrations of Heavy Metals in Food Web Components of Small, boreal Lakes, Boreal Environ., Res, **11**, 185-194 (2006).
13. S. L. Shah and A. Altindag, Effects of Heavy Metal Accumulation on the 96 – h LC₅₀ Values in TenchTinca, Turk J. Vet Anim. Sd., **29**, 139-144 (2003).
14. J. R. Dojlido and G. A. Best, Chemistry of Water and Water Pollution, Ellis Horwood Limited, Herts, 65-69, 84-91, 108-114, 201-205 (1993).
15. Y. A. Yobouet, K. Adouby, A. Trokourey and B. Yal, Cadmium, Copper, Lead, and Zinc Speciation in Contaminated Soils, Int. J. Engg. Sci. Technol., **2(5)**, 802-812 (2010).
16. W. S. Beckett, G. F. Nordberg and T. W. Clarkson, Routes of Exposure, Dose and Metabolism of Metals, In Handbook on the Toxicology of Metals (3rd Ed), Elsevier Inc. (2007) pp. 39-64.
17. J. F. Elder and J. J. Collins, Freshwater Molluses as Indicators of Bioavailability and Toxicity of Metals in Surface Water Systems. Rev Environ. ContToxicol., **122**, 36-79 (1991).

18. S. Prebpai, L. Charerntanyarak, B. Siri, M. R. Moore and B. N. Noller, Effects of Residues from Municipal Solid Waste Landfil on Corn Yield and Heavy Metal Content, *Waste Manage.*, **29**, 2316-2320 (2009).
19. S. D. Gual, F. A. Vega and E. F. Covelo, The Dynamics of Heavy Metals in Plant-Soil interactions, *Ecological Modelling*, **221**, 1148-1152 (2010).
20. S. R. Smith, A Critical Review of the Bioavailability and Impacts of Heavy Metals in Municipal Solid Waste Composts Compared to Sewage Sludge, *Environ. Int.*, **35**, 142-156 (2009).
21. M. K. Raikwar, P. Kumar and A. Singh, Toxic Effect of Heavy Metals in Livestock Health. *Veterinary World*, **1(1)**, 28-30 (2008).
22. G. Cimino and C. Carisi, Acute Toxicity of Heavy Metals to Aerobic Digestion of Wasted Cheese. *Whey Bio Waste*, **33**, 201-202 (1990).
23. G. Robert, G. Mari, C. Harlal, H. Micheal, K. Elaine and S. Marc, Issue papper on the Human Health Effects of Metals, U.S. Environmental Protection Agency Risk Assessment Forum, **4**, 23-28 (2003).
24. R. Singh, N. Gantam, A. Mishra and R. Gupta, Heavy Metals and Living Systems. An overview, *India J. Pharmacol.*, **43(3)**, 246-253 (2011).
25. D. J. Ferner, Toxicity, Heavy Metal. *Emed. J.*, **2(5)**, 1 (2001).
26. H. M. Ijeomah, D. I. Edet, E.K. Oruh, and A.U. Ijeomah, Assessment of Heavy Metals in Tissues of Selected Non-vertebrate Wildlife Species in Oil Polluted Sites of Delta State, Nigeria, *Agricultural and Biology Journal of North America*, **6(2)**, 63-73 (2013).
27. D. J. H. Phillip and P. S. Rainbow, Biomonitoring of Trace Aquatic Contaminants (Series Eds. J. Cairns Jnr. and Harrison, R. M.), *Appl. Sci. London*, 371 (1993).
28. M. Horsfall, I. C. Howard and A. I. Spiff, Tissue distribution of Heavy Metals in Mudskapper (*PeriophthalmusPapillo*) from the Mangrove Swamps of the Coastal New Calabar River, Nigeria. *J. Appl. Sci. Environ. Manage.*, **1(1)**, 50-55 (1998).
29. A. Valavandidis and V. Thiome, Metal Pollution in Ecosystem. *Ecotoxicological Studies and Risk Assessment in Marine Environment*, **150**, 162-173 (2006).
30. I. R. Egon Wan, On the Biology of *Tympanotonus Fuscatus* Var *radula* (Gastropanotonus; Prosobranchia, Potamidea) MSC Dissertation, University of Lagos, Nigeria (1980).
31. A. Farkas, J. Salarik, I. Kamarda and K. S. Roza, Molluscs in Biological Monitoring of Water Quality, *Toxicity Lett.*, **140/141**, 403-410 (2003).
32. B. C. O. Okoye, Heavy Metals and Organisms in the Lagos Lagoon, *Int. J. Environ. Studies*, **37**, 285-292 (1991).
33. B. Kumar and D. P. Mukherjee, Assessment of Human Health Risk for Arsenic, Copper, Nickel, Mercury and Zinc in fish Collected from Tropical Wet Lands in India, *Adv. Life Sci. Technol.*, **2**, 13-24 (2011).
34. N. S. Chary, C. T. Kamala and D. S. Raji, Assessment Risk of Heavy Metals from consuming food Grown on Sewage irrigated soil and Food Chain Transfer *Ecotoxicology and Environmental Safety*, **69(3)**, 513-524 (2008).
35. USEPA (2011), USEPA Regional Screening level (RSL) Summary Table: November 2011, Available at <http://www.epa.gov/regshwmd/risk/human/index.htm>, last update: 6th December (2011).

36. D. N. Olowoye, Heavy Metal Concentrations in Periwinkle (*Litorinalittorea*) and Tilapia (*Tilapia Zilli*) from the Coastal Waer of Warri, Nigeria, *Am. J. Food Nutrition*, **1(3)**, 102-108 (2011).
37. Z. J. Xue, S. O. Liu and Y. L. Liu, Health Risk Assessment of Heavy Metals for Edible Parts of Vegetables Grown in Sewage-Irrigated Soil in Surburbs of Boarding City, China, *Environ. Monit. Assess.*, **184**, 3503-3513 (2012).
38. I. B. Francisca, C. O. Fehintola, M. A. Chukwujindu, N. O. Vincent and A. Christopher, Effects of Processing on the Proximate Metal Contents in three Fish Species from Nigerian Coastal Waters, *Food Sci. Nutrition*, 2(3), **272-281** (2014).
39. J. O. Osakwe, P. Adowei and M. Jr. Horsfall, Heavy Metals Body Burden and Evaluation of Human Risks in African Catfish (*Clariasgariepinus*) from Imo River, Nigeria, *ActaChim Pharm Indica*, 4(2), 78-89 (2014).
40. USEPA (United States Environmental Protection Agency), Guidance for Assessing Contaminant Data for Use in Fish Advisories: Vol. 1 Fish Sampling and Analysis 3rd Ed., Office of Science and Technology of Water, Washington, D.C EPA 823-B-00-007, 1-200 (2000).
41. WHO, 41st Report of the joint FAO/WHO Expert Committee on Food Additives, WHO Technical Report (1993).
42. WHO, Guidelines for Drinking Water Quality, Vol. 1, Recommendation WHO: Geneva 130 (1985).
43. FEPA, Guideline and Standards for Environmental Pollution Control in Nigeria (2003) p. 238.
44. NAS-NRC, National, Drinking Water and Health Academy of Science-National Research Council National Academic Press, Washington DC (1982).
45. O. Akoto, F. Bismark Eshun, G. Darko and E. Adei, Concentrations and Health Risk Assessments of Heavy Metals in Fish from the fosu Lagoon, *Int. J. Environ. Res.*, **8(2)**, 403-110 (2014).
46. EFSA (2011), Scientific opinion Statement ion tolerable weekly intake for Cadmium. *EFSA, J.*, **9**, 1975, Available athttp://www.efsa.europa.eu/en/efsa_journal/1975.pdf.
47. Manuel M. de Souza, Claudia C. Windmoller and Vanessa Hatje, Shellfish from TodosOs Santa Bay, Bahia, Brazil: Treat or Threat? *Marine Pollution Bulletin*, (2011) 2254-2263 (2011).
48. USEPA (Environmental Protection Agency), Guidelines for Assessing Chemical Contaminant Data for use in Fish Advisories V.I: Fish sampling and Analysis 3rd Ed Office of Science and Technology, Office of Water (2000).