CHILDHOOD RISK ESTIMATION OF LEAD METAL POISOINING FROM EDIBLE LAND SNAIL AT ABANDONED BATTERY FACTORY ENVIRONMENT

*Ebenso, I. E. [1] and Ebenso, G. I.[2]

Abstract

The childhood lead (Pb) poisoning risk from consumption and risk model data of snail meat from Pb metal contaminated sites of entrance (control), storage dump, dried effluent and waste dump at an abandoned battery factory, in Niger Delta, Nigeria were estimated. Results implicated snail meat from waste dump site with hazard quotient of 2.40 and childhood exposure of 0.12mg/kg/day Pb associated with non carcinogenic adverse effects on health. Control site was risk free. Childhood exposure and snail meat Pb accumulation was dependent on Pb concentration being significantly higher at non-control sites. This study should fast track industrial environmental audits of existing (including abandoned) industrial projects and epidemiological studies in communities around contaminated/polluted sites.

Introduction

The Environmental Protection Agency has classified inorganic lead (Pb) metal as possible human carcinogen (EPA, 1991). The Pb metal has no nutritional function. In developing countries, Pb continues to be a significant public health problem (Tong *et al*., 2000), especially exposure to Pb from Pb mining, smelting, battery factory and cottage industries. Environmental exposure to Pb is a continuing source of mortality and morbidity throughout the world (Adebamowo *et al.,* 2006). About 400 children with mean blood Pb concentration of 12.00mg/L (leads as low as 1.00mg/L are associated with impaired neurological development in young children) died of Pb poisoning, many lived and played around environments of processing of Pb-rich ore for the extraction of gold from local gold mines in Zamfara State, Nigeria in 2010 (Lead 2010). Canfield *et al*., (2003) reported blood levels of 0.6 – 4mg/L during the first years of life of children, and for intellectual performance at pre-school and primary school ages.

Human exposure to Pb results from various sources, of which food is one of the major routes of exposure in non-occupationally exposed persons (Ebenso and Ologhobo, 2010). In adults, gastrointestinal absorption of Pb is within the range of 4-11% (Watson *et al*., 1986) and may reach 50% in children (0' Flaherty, 1995). In addition, it has been shown that Pb was better absorbed from an empty stomach (Polak *et al*., 1996). About 99% of Pb that enters the adult body and 33% in children is excreted in 2 weeks after ingestion (ATSDR, 1999). The half-life of elimination (body clearance) is between 2-18 years (Rabinovitz, 1991), with the major route of elimination being faeces. Snails are usually found in large numbers at night at waste dump sites, plantations, covered farmlands and woody debris (Udosen, 2000). Snails are abundant during wet season, when they are easily gathered especially at night and before dawn (Ebenso 2002), by villagers for consumption and sale (Aboua, 1995).

Edible land snails are consumed in Nigeria as a delicacy that supplement low protein diets (Ebenso and Okafor, 2002), such snails are picked (by children) from open and unrestricted environments of wide geographical distribution in diverse terrestrial ecosystems prone to uptake of pollutants. Geographical location of snails could result in patterns of shell shape variation (Ebenso, 2005). Snails might act as sensitive indicator of environmental changes (Ebenso and Ologhobo, 2008a); Ebenso *et al*., 2010), and can reveal the biologic impact of pollution over geographical and temporal scale (Ebenso and Ologhobo, 2008b). Edible land snails are of interest not only to agriculturists, biogeographers, environmental impact assessors, but also to public health experts and epidemiologists.

The aim of this study was to estimate potential non-carcinogenic risk associated with ingestion of Pb contaminated edible land snail (*Achatina achatina*) using consumption and risk model equations for children, a sensitive sub-population, at abandoned battery factory environment, in Niger Delta, Nigeria.

[1]*Department of Animal Science, University of Uyo, Nigeria*

[2]*Department of Geography and Regional Planning, University of Uyo, Nigeria*

Corresponding author email: imeebenso@yahoo.com

Methodology

The study area (Figure 1) was the abandoned Sunshine Batteries Limited (SBL) located at Ukana, in Essien Udim Local Government Area, Akwa Ibom State, Niger Delta, Nigeria, Latitude $5^o80'N$ and $7^o41'E$. The major raw material for the factory was Pb metal. This area had an annual precipitation 1300mm, temperature 26 ± 2^oC, relative humidity 80-90% and photoperiod 12h light: 12h darkness. The experimental sample, edible land snail (*Achatina achatina*) were from previous study (Ebenso and Ologhobo, 2010), of 4 contaminated soil sites, of entrance (as control), storage dump, dried effluent and waste dump respectively.

Live snails were collected into clean labeled cellophane bags and taken to the laboratory, killed, shocked and weights of shell, foot and offal recorded. A 1 g tissue sample of snail oven-dried at 60°C for 2 days was digested in 2 ml 4:1 HNO_3 (65%) and HCl (37%) at 140°C for 7 h. The sample volume was made up to 10 mL with distilled water. All digestion procedures included 3–5 control blanks. Atomic Absorption Spectrophotometer (AAS) was used to analyze for Pb using Perkin Elmer Graphite Furnace AAS 2100.

All data collected from each site for all parameters considered were subjected to analysis of variance using SAS (1999). The means were separated using Duncan Multiple Range Test.

In this study, the estimation (quantification) of non-carcinogenic elevated Pb risk level to children, were calculated from previous data of Ebenso and Ologhobo, (2010) (Table 1); data from literature (Table 2); data from assumptions in this study (Table 3); using consumption and risk model equations 1 and 2 (EPA, 1989; 2001).

$$\text{Chronic daily consumption of snail (E)} = \frac{CF \times IR \times FI \times EF \times ED}{BW \times AT} \qquad (1)$$

$$\text{Non-cancer hazard quotient (HQ)} = \frac{E}{R} \qquad (2)$$

Where
E = Exposure (mg/kg/day);

IR = Consumption rate (kg/meal);

EF = Exposure frequency (meals/year);

BW = Body weight (kg);

R = Reference dose of Pb (mg/kg/day)

CF = Pb concentration in snail (mg/kg)

FI = Fraction consumed from Pb

ED = Exposure duration (years)

AT = Averaging time (days);

Results and Discussion

According to previous study by Ebenso and Ologhobo, (2010) the Pb accumulated in the snail meat (Table 1) is above the maximum permissible level (MPL) of 1.5mg/kg in molluscs, oyster shell and clams as defined in European Commission regulation (EC, 2004).

The Joint FAO/WHO Expert Committee on Food Additives (JECFA), (WHO, 2000) has established a provisional tolerable weekly intake (PTWI) for Pb of 0.25mg/kg body weight/week (equivalent to 0.04mg/kg body weight/day) for children. On the basis that Pb is accumulating in the body and an increase of the body burden of Pb should be avoided (WHO, 2000). In Table 4, children were at risk of consuming snails from the waste dump site having value of 0.12mg/kg body weight/day, with an associated increasing body Pb burden.

With EPA's non-cancer toxic elevated effect risk level, the level at which there is no increased risk of toxic effect, is a hazard quotient (HQ) of 1. The risk of snails from waste dump site was HQ >1. At this high HQ of 2.40, it indicates cardiovascular, reproductive, developmental and immunological effects, as well as blood and metabolic disorders and effects on general brain function (EPA, 1991). Data by Tong *et al.,* (1998), showed that even when such children stopped ingesting Pb from snail, after first exposure, such effects are largely irreversible.

Accumulated epidemiological evidence indicates that such exposure in early childhood causes a discernible deficit in cognitive development during the immediately ensuing childhood years (Tong, 1998).

It is important to note that, the measure of effect for Pb is the reference dose (R). This is defined as an estimate of a daily exposure to Pb in humans (EPA, 2001) including sensitive sub-population like children, which is the main target of this study. Once R is exceeded (as in the case of children at non-control sites, Table 4), a child is at increased risk of adverse health effects.

The Human Health Focus Group (EPA, 2001) reported that children who eat more than 0.18kg/meal of shell fish are at risk of an additional chance of developing adverse health conditions, due to increasing Pb toxicity, not diluted.

In risk assessment, the inclusion of the toxicity of chemical(s) and the exposure assessment helps to determine the level of risk. Therefore, in this study the acceptable level of risk (beyond which adverse health effects are clinically noticed) for children who consumed Pb contaminated snails from abandoned factory environments is 0.05mg/kg, this is also the R for Pb (Krasovskii *et al*., 1979; Rice and Karpinski, 1988). Childhood Pb poisoning will occur when children consume snails from non-contaminated sites (see Table 4), above 0.04mg/kg bodyweight/day (PTWI for Pb).

Even though at HQ of 2.40, the snail from sites except the waste dump sites may be considered safe for consumption, however, the PTWI for Pb and the R data implicated snails from all the non-control sites, and hence childhood risk is at elevated levels due to Pb toxicity, supported by R data. According to Canfield *et al*., (2003), detectable deficits may occur even at exposure levels previously considered to be safe. Due to their smaller body weights, children with a high consumption of food with high Pb levels are at a greater risk to exceed the PTWI for Pb than adults (Opinion on Lead, 2004).

Observed contaminations in food chain at abandoned should kick-start industrial environmental audits and epidemiology studies (Ukpong, 2009). This environmental problem calls for urgent intervention (Udofia, 2010).

Conclusion

This study is the first attempt of use of snail biodiversity to estimate non-cancer risk of adverse childhood Pb poisoning from contaminated sites. Data were limited by absence of Nigerian national population census data of 2006 on children around the factory environment. This study goes a long way to show that lack of incorporation of uptake and bioavailability data of metal in food chain does not give a true picture of impacts of hazardous chemicals in communities, as only chemical data in soil and water are usually considered in environmental impact assessment (EIA).

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Table 1 Lead contaminated snail (*Achatina achatina)* meat from battery factory sites

PARAMETER	CONTROL	STORAGE DUMP	DRIED EFFLUENT	WASTE DUMP	SEM
Carcass analysis					
Live weight g/s	83.54a	80.29b	79.85b	72.49c	0.47
Foot weight g	37.23a	36.46b	35.63c	32.46d	0.01
Offal weight g	21.12a	20.95b	20.57b	20.16c	0.01
Shell weight g	24.34a	22.93b	21.34c	19.47d	0.01
Dressing %	46.37a	45.45b	45.06c	44.63d	0.01
Shell weight/Live weight %	28.04a	28.52a	26.72b	26.99b	0.01
Offal weights/Live weight %	24.57d	26.07c	25.76b	27.98a	0.01
Lead accumulation in snail meat					
Pb mg/kg	1.76d	12.20c	91.38b	468.50a	0.13

abc.. means followed by different letters are significantly different α = 0.05
 Source: Ebenso and Ologhobo (2010).

Table 2 Data from literature used for childhood non-carcinagenic risk estimation

ABBREVIATION*	DATA	AUTHOR
BW	20.00kg (children ≤ 7 years)	EPA, (2001)
IR	0.18Kg/meal(Shellfish)	EPA, (2001)
R	0.05mg/kg Pb day	Krasovskii *et al.,* (1979)
FI	0.40	EPA, (1997)
CF	Snail Pb mg/kg**	Ebenso and Ologhobo, (2010)

* See equations 1 and 2
** See Lead accumulation in snail meat (Table 1)

TABLE 3 Data from assumptions by present authors in childhood non carcinogenic risk estimation

ABBREVIATION*	DATA	ASSUMPTION
ED	20 years	Period since abandonment of SBL factory till date
EF	26 meals/year	26 weeks (6 months of rainy season**), with snail in a meal/week

* See equations 1 and 2
** Udosen, (2008)

Table 4 Childhood non-carcinogenic risk estimation of Pb contaminated snail meat

PARAMETER	CONTROL	STORAGE DUMP	DRIED EFFLUENT	WASTE DUMP
Measured				
Pb concentration in snail meat (mg/kg)*	1.76	12.20	71.38	468.50
Modeled				
E (mg/kg/day)	0.001	0.01	0.02	0.12
HQ	0.02	0.20	0.46	2.40

* See Table 1

Figure 1: Study Area