DEPOSITION OF ENVIRONMENTAL CONTAMINANT IN PROCESSED BUSHMEAT ALONG HIGHWAYS IN SOUTH-WESTERN NIGERIA

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Abstract. *A study was conducted to investigate deposition of environmental contaminants in bushmeat with emphasis on some heavy metals {Nickel (Ni), Lead (Pb), Cupper (Cu) and Cadmium (Cd)}. The major bushmeat markets on these highways were studied in terms of their distance to the highways, traffic volume (TV) and land uses. Face-to-face interview was also conducted with one hundred and twenty processed bushmeat buyers on these highways to determine the most commonly preferred processed bushmeat while the concentrations of Ni, Pb, Cu and Cd in the three most commonly purchase processed bushmeat identified were determined using Atomic Absorption Spectrophotometry. It was revealed that the average distance of the market at {Ibadan-Lagos (IL)Ibadan-Ife (IF), Ore-Sagamu (OS) and Abeokuta-Ibadan (AI)} were 6.70m, 3.50m and 10.20m, respectively. TV followed IL>OS>IF>AI trend. Heavy metals examined were present in the three commonly purchased processed bushmeat (Grasscutter, Duiker and Monitor-lizard) at varying levels. Pb concentration in grasscutter (0.01±0.01mg/kg) at OS was lower than the maximum permissible level (MPL) while the concentrations of Ni, and Cd in duiker at IF (0.06±0.09mg/kg) and AL (0.06±0.05mg/kg), respectively were higher than the MPL. The concentrations of the verified heavy metal in these bushmeat had significant effects (p< 0.05) on the distance.*

Key words: *Bushmeat, heavy metals, pathway, highways, ecotoxicology*

1. INTRODUCTION

Unsustainable hunting of wildlife in South-western Nigeria is fast threatening non-timber forest products especially bushmeat, considering the actions driven by continuous demand for the product particularly among the travelers on highways. Ogunjobi *et al.* (2013) reported that the persistent indiscriminate collection of biological resources of either plant or animal origin in the developing countries, particularly in the tropical region of the world, continues to generate a lot of new idea or innovation, perhaps due to its unselective consequences on human being which may be hazardous and uneconomical to abate. Irrespective of geographical location of man, highways serve as essential amenity for easy movement of people and goods from one location to the other. Highways in tropical areas are well known to bring open access to remote areas for agricultural development, and resource extraction (Arima *et al.* 2005; Caldas *et al.* 2010), and facilitate development by providing market access for rural producers, integrating economic sectors and reducing the cost of spatial mobility (Perz *et al.* 2007).

Despite various benefits of highways to mankind, using them often results in negative impacts on the environment (Forman and Alexander 1998; Spellerberg 1998; Fahrig and Rytwinski 2009; Perz *et al.* 2012). An eample of such impact of highways is the introduction of pollutants (Forman and Alexander 1998; Keller and Largiader 2003; Laurance *et al.* 2004; Shyama Prasad Rao and Saptha Girish 2007). In Nigeria, some highways are either constantly or seasonally used to display many non-timber forest products, particularly bushmeat. Bushmeat is the meat obtained from wild animals for consumption due to their protein source (Bowen-Jones *et al.* 2003; Martin 1983). According to Juste *et al.* (1995) who postulated that wild animals such as primates, antelopes, porcupine, bush-pig, grasscutter, pangolin, monitor lizard, guinea fowl, among others are valued food by many urban dwellers. Moving along the highways, many anthropogenic activities take place on a daily basis and its consequential effect could be devastating to the physiological condition of man.

Bai *et al.* (2009) and Li *et al.* (2001) informed that exhaust of the vehicles resulting from the combustion of fuel was one of the causes of environmental pollution along the highways. Environmental pollutants include a wide range of chemicals present in products that are used by man on a daily basis (Rhind *et al.* 2010). To achieve sustainable food security in an era of geometric increase in human population, proper integration of non-timber forest products into food system is required. Food systems, as illustrated by Erickson (2008), involve the activities related to food production, processing, distribution, preparation and consumption of food. Vehicle exhausts emit heavy metals so that soils, plants and even residents along the roads with heavy traffic loads are subjected to increasing levels of heavy metal contamination (Ghrefat and Yusuf 2006). Regrettably, excess of these heavy metals beyond stipulated maximum permissible level is hazardous irrespective of the host (Gray *et al.* 2003; Bai *et al.* 2009). It was mentioned that some of these heavy metals are cumulative poisons that pose potential hazards and toxicity (Ellen *et al.* 1990; Jarup 2003). The risks associated with the exposure to heavy metals present in food products have aroused widespread concern in human health (Nkansah and Ansah 2014). Emissions from road traffic that uses fossil fuel, industry, agriculture, sewage sludge, and waste incineration was declared as the chief sources of air pollution (Celik *et al.* 2005; Ediagbonya *et al.* 2016).

It was reported that food absorbed heavy metals from polluted environments (Zurera-Cosano *et al*. 1989) and these metal may enter human body through consumption of contaminated food (Cambra *et al*. 1999). Contamination of food with heavy metals is a serious threat because of their toxicity and bioaccumulation in the food chain (Demirezen and Uruc 2006). Heavy metal becomes toxic when they are not metabolized by the body and accumulate in tissues (WHO 2011). It was reported that bitumen and mineral filler materials in the asphalt road surfaces contain different heavy metals including Cu, Zn, Cd and Pb (Pope 2006). Emission from heavy traffic were reported to contain Lead (Pb), Cadmium (Cd), Zinc (Zn), and Nickel which are present in fuel (Suzuki *et al*. 2008; Atayese *et al*. 2009; Ediagbonya *et al*. 2014).

Since ecosystem-based management recognises that people are part of the ecosystem and that the protection of ecosystem integrity includes the well-being of human, to identify significant environmental contaminants capable of disrupting ecosystem should as a matter of urgency be a topical issue. Undoubtedly, quantitative investigation of heavy metal such as nickel, lead, copper and cadmium in processed bushmeat displayed along major highways in South-western Nigeria will be very helpful to determine ecotoxicological effects of displaying consumable goods near to the road and also give direction in tackling food poisoning that may be linked with meat from wildlife origin.

2. MATERIALS AND METHOD

South-western part of Nigeria comprises of six states viz.: Oyo, Ondo, Ogun, Osun, Ekiti and Lagos States (Figure 1). Only four out of these states (Oyo, Ondo, Ogun and Osun) was surveyed in this study. For better and accurate research execution, the study was divided into four stages. The first stage of the study lasted for seven months (December, 2013 to July, 2014). During this stage, one bushmeat market along the highway with high patronage of travellers in each of the four selected states was considered. The major difference across the bushmeat markets during our survey were the distance (used as the only factor in the study) of the markets to the highway that was measured with meter tape. Traffic volume (TV) was also recorded across the study area.

In the second stage of this study which lasted for four months (October 2014 to July 2015), each of the study sites were visited twenty times between the hours of 12.00 – 4.00 pm. During this period, face-to-face interview was conducted with thirty (30) buyers of processed bushmeat purposively selected from each study area based on their readiness to supply needed information and computed to determine the commonly processed bushmeat. Methods of singeing the animals across the four sites were also observed but not considered as a factor.

Third stage of this study was the collection and proper labelling samples of the three most commonly purchased bushmeat across the four sites. In the laboratory, each sample (2.0g) was put into digestion tubes and mixed with 10ml each of nitric acid and perchloric acid. The digestion block was activated for three hours at 45°C. The digested samples were cooled, diluted to 100 ml with distilled water and filtered into sample bottles. Quantitative examination of heavy metal in each sample was using Atomic Absorption Spectrophotometry (Perkin Elmer Analyst 300). Data generated were analyzed using descriptive statistics, and one-way Analysis of Variance while the significant differences between the means were determined using the LSD test.
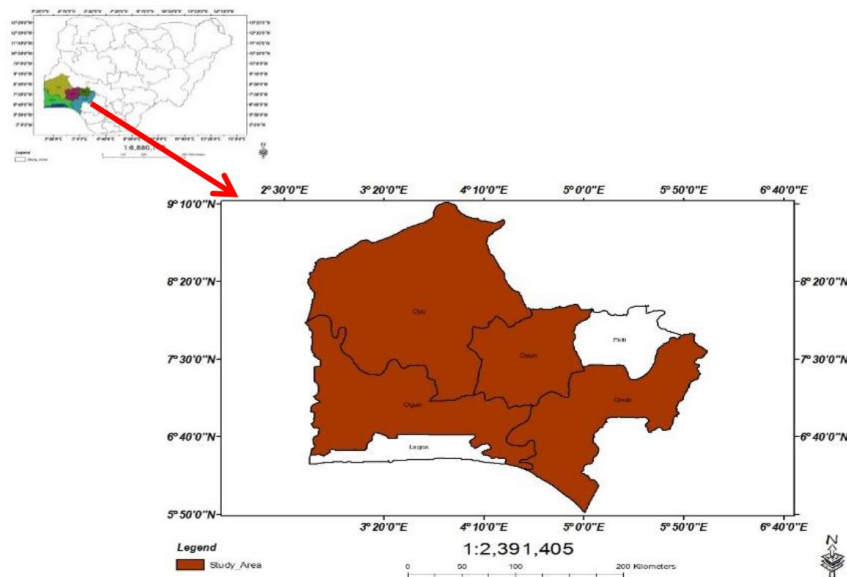
Fig. 1 Location of south-western States in Nigeria and the study area

3. RESULTS AND DISCUSSION

3.1. Description of Bushmeat Selling Points in South western Nigeria

Reconnaissance survey was conducted to identify bushmeat markets and processing points in South-western Nigeria as shown in Table 1. It was revealed that bushmeat market at IF are at an average distance of 3.50m distance to the highway followed by AI (5.80m), IL (6.70m) and OS (10.2m). Movement of dust particles particularly during overtaken on unpaved roads was noticed. A lot of dust experience on these highways agreed with the submission of Farmer (1991) who stated that unpaved roads are particularly important sources of dust pollution. There was no mechanism to determine the actual number of vehicles that passed through these roads during our study. Notwithstanding, our visual observation and counting revealed that the TV followed (IL>OS>IF>AI) trend and processed bushmeat displayed very close to the highways were more exposed to dust particles. Table 2 described the trend of processed bushmeat commonly purchased during this study. Generally, larger proportion of processed bushmeat are purchased at OS (326) followed by IF (319), IL (241) and AI (192). In terms of species diversity, grasscutter was the highest (326) followed by duiker (294), monitor-lizard (190), bushbuck (161) and brush-tailed porcupine (91). Our findings on the bushmeat commonly purchased agreed with the position of many scholars (Onadeko 1996; Tee *et al.* 2012; Adewumi *et al.* 2013; Adefalu *et al.* 2014) where they ranked antelopes, grasscutter and monitor-lizard high among different species of commonly consumed in some parts of Nigeria.

Table 1 Description of selected smoked Bushmeat markets

Sites	State of Location	Highway routes	Average distance of displayed Bushmeat products to the highways	Land uses
Toll-gate	Oyo	Ibadan-Lagos(IL)	6.70m	IIA, SPRA, HT, ICA, LIA
Iyana-Ikoyi	Osun	Ibadan-Ife (IF)	3.50m	SPRA, HT, NCA, NIA, HT, FCA
Omotosho	Ondo	Ore-Sagamu (OS)	10.20m	SPRA, HT, ACA
Kila	Ogun	Abeokuka-Ibadan (AI)	5.80m	SPRA, LT, ACA

IIA – In Industrial Area, SPRA – Sparsely populated Residential Area, HT – High Traffic, LT – Low Traffic, ICA – In Commercial Area, NCA – Near Commercial Area, ACA – Away from Commercial Area

Table 2 Commonly purchased bushmeat in South-western Nigeria Highways

Common name	Scientific names	OS	IF	IL	AI	Rank
Duiker	*Cephaloplus spp*	83 (25.86)	109 (34.17)	68 (28.22)	34 (17.71)	2nd
Grasscutter	*Thryonomys swinderianus*	98 (30.50)	73 (22.88)	82 (34.03)	73 (38.02)	1st
Brush-tailed porcupine	*Atherurus africanus*	29 (9.03)	21 (6.58)	31 (12.86)	10 (5.21)	5th
Bushbuck	*Tragelaphus scriptus*	62 (19.32)	54 (16.93)	15 (6.22)	41 (21.35)	4th
Monitor-lizard	*Varanus niloticus*	49 (15.26)	62 (19.44)	45 (18.67)	34 (17.71)	3rd
Total		321(100)	319(100)	241 (100)	192 (100)	

For the fact that these animals are already cut into parts, it was impossible to determine their sexes. Singeing (the remover of animal hair) is basically done either by the use of flame in form of smoking or use of boiled water in form of steaming. As monitored, application of flame was common with the bigger game (bushbuck) and moderate size game (duiker) compared to what was observed in the case of grasscutter and monitor lizard. However, none of these animal species were exempted for smoking. Our observation also revealed that the flames used were fuelled majorly by wood with small proportion of dried grasses, used plastics and nylon materials. This was in line with the observation of Ekenma *et al.* (2014) where they mentioned that bushmeat vendors and cattle hides vendors, respectively uses various substances/methods in singeing off the hair of the animals. The concentration contents of heavy metal observed in this study can also be linked to the methods of processing as reported (WHO 2000; Stołyhwo and Sikorski 2005; Ishizaki *et al*. 2010).

Table 3 Concentration of selected heavy metals
in processed bushmeat commonly purchased in the study area

Locations	Sampled Bushmeat	Ni (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	Cd (mg/kg)
	Duiker	0.04±0.06	0.03±0.02	0.05±0.08	0.05±0.07
IL	Grasscutters	0.03±0.02	0.02±0.01	0.02±0.05	0.03±0.05
	Monitor Lizard	0.03±0.06	0.02±0.01	0.03±0.02	0.04±0.03
	Duiker	0.06±0.09	0.06±0.06	0.06±0.05	0.05±0.02
IF	Grasscutters	0.04±0.03	0.03±0.05	0.05±0.14	0.03±0.01
	Monitor Lizard	0.05±0.00	0.03±0.01	0.04±0.12	0.05±0.02
	Duiker	0.03±0.02	0.03±0.02	0.04±0.03	0.04±0.08
OS	Grasscutters	0.02±0.01	0.01±0.01	0.02±0.02	0.02±0.05
	Monitor Lizard	0.03±0.07	0.02±0.02	0.03±0.01	0.03±0.07
	Duiker	0.05±0.07	0.05±0.05	0.06±0.01	0.06±0.05
AL	Grasscutters	0.03±0.02	0.02±0.03	0.03±0.01	0.04±0.02
	Monitor Lizard	0.02±0.00	0.02±0.06	0.02±0.01	0.04±0.00
MPL(EC)		0.05	0.01	NA	0.05

N – Sample size per bushmeat, NA – Not Available, MPL – Maximum Permissible Level,
EC – European Commission, 2006.

Table 4 Analysis of Variance indicating effects of bushmeat displayed distance
on concentrations of heavy metals deposition

		Sum of Square	df	Mean of Square	F	Sig
Heavy metals	Between Groups	0.013	3	0.004	2.595	0.055
concentration*	Within Groups	0.232	140	0.002		
Locations						
	Total	0.245	143			

Tables 3 show the concentrations of heavy metal in the three commonly purchased bushmeat in South-western, Nigeria. Ni concentration in duiker at IF was the highest (0.06±0.09mg/kg). This was slightly higher than the Maximum Permissible Level (MPL) recommended by European Commission. Pb concentration in all the samples was slightly higher than the recommended except grasscutter meat obtained at OS. The concentration of Cu was higher (0.06±0.01mg/kg) in duiker at AI followed by same duiker at IL (0.05±0.08mg/kg). Duiker at AI had highest content of Cd (0.06±0.05mg/kg) followed by duiker at IL (0.05±0.07mg/kg) which was slightly higher than the MPL. It was evident from this study that duiker species displayed the highest concentration of Ni, Cu and Cd. The nearness of the bushmeat vendors to the highways is relatively proportional to the concentration of heavy metals deposition in the samples. It was observed from the one-way analysis of variance (Table 4) that distance at which these bushmeat were displayed to the highways had significant effect on the concentration of heavy metals ($p < 0.05$). This finding agreed with the submission of Ndiokwere (1984) and Hafen and Brinkmann (1996) where it was mentioned that the concentrations of heavy metals decrease with increasing roadside distance. It also confirmed the position of previous studies (Ninomiya *et al*. 1971; Nyberg *et al*. 2000; Forman *et al*. 2003) where they mentioned that traffic intensity is one of the factors that determined deposition rate of dust from the road and that the size of dust declines with the distance from road.

4. Conclusion and Recommendation

It is evident from this study that most commonly patronized bushmeat on South-western Nigeria highways are contaminated with the studied heavy metals. Due to the fact that a wide range of factors are interacting together in the environment, it was not certain at this stage to conclude that the samples of bushmeat examined are contaminated with the selected heavy metals before or after their arrival at these bushmeat markets.

To this end, we encourage further studies to determine the concentration of such heavy meat in the carcasses of the bushmeat before they are processed. In the same vain, we encourage qualitative assessment of water available for processing these wildlife products and the surrounding air of these bushmeat markets for quality assurance.

The findings of this research work demand for appropriate institutional framework to urgently enforce that all bushmeat vendors irrespective of their geographical locations to strictly apply food safety standard.

Bushmeat sellers on those highways should be encouraged to increase the distance of their display points from the road especially where the road is unpaved and ensure that they always cover their displayed products to avoid dust deposition. Since bushmeat is of nutritional significant to man and man is an important component of ecosystem, we recommended further studies to ascertain the pathway(s) in which heavy metals contaminated these processed bushmeat to ensure safety of the consumers.

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TALOŽENJE ZAGAĐUJUĆIH MATERIJA U MESU DIVLJIH ŽIVOTINJA SA PODRUČJA U BLIZINI AUTOPUTEVA U JUGOZAPADNOJ NIGERIJI

U radu su prikazani rezultati ispitivanja taloženja zagađujućih materija u mesu divljih afričkih životinja, posebno teških metala {kao što su nikal (Ni), olovo (Pb), bakar (Cu) i kadmijum (Cd)}. Izvršena je procena najvećih pijaca za prodaju mesa divljih životinja sa lokacijama u blizini autoputa u pogledu udaljenosti od puta, obima saobraćaja i upotrebe zemljišta. U istraživanju je lično intervjuisano 120 kupaca kako bi se odredila vrsta mesa koja se najčešće kupuje, dok su koncentracije Ni, Pb, Cu i Cd u tri najzastupljenije vrste mese određene uz pomoć Atomske Apsorpcione Spektrofotometrije. Rezultati su pokazali da je prosečna udaljenost pijace od autoputa {na putevima Ibadan-Lagos (IL), Ibadan-Ife (IF), Ore-Sagamu (OS) i Abeokuta-Ibadan (AI)} bila 6,70m, 3,50m i 10,20m, respektivno. Pošlo se od činjenice da je IL> OS> IF> AI. Prisustvo teških metala potvrđeno je u tri vrste mesa koje se najviše kupuje (meso divljeg pacova, meso afričkog dujker goveda i meso guštera varana). Koncentracija olova u mesu divljeg pacova na autoputu OS (0.01 ± 0.01mg / kg) je bila niža od maksimalnog dozvoljenog nivoa (MPL), dok su koncentracije Ni i Cd u mesu dujker goveda na autoputu IF (0,06 ± 0,09 mg / kg) i AL (0,06 ± 0,05 mg / kg), respektivno, bile veće od MPL. Koncentracije teških metala u mesu divljih životinja imaju statistički značajan uticaj (p <0,05) na rastojanje.

Ključne reči: *meso divljih afričkih životinja, teški metali, staza, autoputevi, ekotoksikologija*