Bull Environ Contam Toxicol (2012) 89:424–427
DOI 10.1007/s00128-012-0667-y

Arsenic and Chromium in Sea Foods from Niger Delta of Nigeria: A Case Study of Warri, Delta State

Friday O. Uhegbu · Godwin C. Chinyere · Amadike E. Ugbogu · Kingsley C. Nwoku

Received: 17 December 2011 / Accepted: 3 May 2012 / Published online: 17 May 2012

Abstract This study determined the concentration of Arsenic and Chromium in sea foods samples from Ethiope River. The sea foods were bought from different locations along the bank of the river. Arsenic concentration ranged from 0.046 ± 0.01 to 0.083 ± 0.05 mg/kg, while the chromium concentration ranged from 0.079 ± 0.04 to 0.152 ± 0.14 mg/kg. *Palaemon serratus* has the highest concentration of arsenic and chromium, 152 ± 0.14 mg/kg and 0.081 ± 0.04 mg/kg respectively, while *Harengula jaguana* has the lowest concentration of arsenic and chromium, 0.079 ± 0.04 mg/kg and 0.046 ± 0.01 mg/kg respectively. There are various oil prospecting companies and oil and gas related industries in this area which discharge untreated waste products into Ethiope River. In view of this, there is need to determine the level of arsenic and chromium contamination of the river, since the inhabitants depend on the river for fishing and other domestic uses.

Keywords: Sea foods · Heavy metals · Toxicants · Contaminants · Health hazards

The presence of metals in the environment poses a serious threat to both man and the environment (Tchounwou et al. 2004). Specifically metals are non-degradable and therefore can persist for long periods in aquatic as well as terrestrial environments. Most rivers and lakes in industrialized areas are contaminated by these metals (Nouri et al. 2009). At higher concentrations metals are toxic to man and animals when ingested. They can also be toxic to microbial population at sufficiently high concentrations. Arsenic and chromium are examples of trace elements. The presence of arsenic in water has been reported from several parts of the world, like USA, China, Chile, Bangladesh, Taiwan, Mexico, Argentina, Poland, Canada, Hungary, Japan, India, Vietnam, Nepal (Jack et al. 2003).

Numerous studies have described environmental exposure of humans to metals in Nigerian population (Agaolu and Olaofe 2004; Adefemi et al. 2008). Little is known about the exposure of metal toxins from sea foods consumed in Nigeria, and little or no data exists on the food concentrations of arsenic and chromium in sea foods which are potential carcinogens and systemic toxicants.

The issue of environmental safety and pollution has been the focus of many investigators in the developed and developing countries alike (Tchounwou et al. 2004). The free style way of disposing agricultural, industrial and domestic effluents into natural water-bodies results in serious surface and groundwater contamination (Burger et al. 2002; Karimi et al. 2010). Unfortunately these water bodies are the main source of sea foods that sustain human life because of their rich protein content (Young et al. 2004).

Inorganic Arsenic is considered to be the major form of Arsenic in groundwater, surface water, soil and various foods and have been classified as group I carcinogens based on human epidemiological data (Hughes 2002). In addition to anthropogenic sources of arsenic contamination, human activity can aggravate and accelerate the release of naturally occurring arsenic. Organic arsenic compounds usually containing carbon, are mainly found in sea-living organisms. (Jack et al. 2003).

F. O. Uhegbu (✉) · G. C. Chinyere · A. E. Ugbogu · K. C. Nwoku
Department of Biochemistry, Faculty of Biological and Physical Sciences, Abia State University, Uturu PMB 2000, Nigeria
e-mail: fouhegbu@yahoo.com

Chromium is a naturally occurring element found in rocks, soil, plants, animals, and in volcanic dust and gases and is found commonly in the environment in trivalent [Cr III] and hexavalent [Cr VI] forms (Upreti et al. 2004). Food is the main source of chromium intake by man. Chromium is fairly evenly distributed throughout the various food groups, highest concentrations are found in meat, fish and sugar groups (Upreti et al. 2004).

Arsenic and chromium are of interest because of their physiological roles in man at the trace level while being toxic at higher concentration (WHO 1996).

Sea foods are animals or marine organisms that serve as food or are suitable for eating, particularly sea water animals such as fish and shell fish (including crustaceans) etc. which are major sources of protein (Tchounwou et al. 1996). The term sea food is also applied to similar animals from fresh water and all aquatic environments. The sea foods constitute major components of aquatic habitats and they act as bio-indicators of metal levels in aquatic environment. They have been recognized as good bio-accumulators of organic and inorganic pollutants (Burger et al. 2002; King and Jonathan, 2003).

The present study therefore is to determine the arsenic and chromium levels in some sea foods consumed in the Niger Delta region of Nigeria where various multi-national oil companies are involved in crude oil prospecting and drilling; and other oil servicing companies and review its effects and implication on public health.

Materials and Methods

The fish samples were collected from Ethiope River in Igu district in Warri city, Delta State, Nigeria during the wet season of the year between June and August, 2011, in the morning hours. The river serves as a major source of portable drinking water and sea foods for the populace. The samples (five of each species) were bought fresh from fishermen. The sea foods were bought from four different locations along the bank of the river, once every month and their length was between 11.5 and 12.5 cm.

The samples include *Claria garie pinus, Pleurotus eryngii, Crago nigricando, Palaemon serratus, Uca pugrlater, Scyll serrata, Anguilla anguilla, Litorina littorea, Harengula jaguana and Tilapia zilli.* The fish samples were dipped into distilled water thrice and properly rinsed with ultra pure water to avoid contaminations. They were transported to the laboratory frozen until analyzed. Identification of the various samples was carried out at the Department of Animal and Environmental Biology, Abia State University, Uturu, Nigeria.

They were subsequently put into stainless steel drying pans and put into the oven at a temperature of 60°C for 3 days to remove moisture. The samples were separately ground in a hammer mill into a fine powder and then passed through a 0.1 mm sieve. The sieved sample was then analyzed using the atomic absorption spectrophotometer.

0.5 g of the samples was digested in a mixture of con.H_2SO_4, HNO_3 and $HClO_4$ prepared in a ratio of 3:2:1. The resulting digest was made clear using 0.5 ml of H_2O_2. The residue was then made up to 50 mL with ultra pure water, mixed thoroughly and centrifuged at 1500 rpm for 10 min. The resulting supernatant was then used for Arsenic and Chromium determination using the atomic absorption spectrophotometer (AAS) model 205, with a lower limit of detection of 0.01 mg/kg (dry weight). Arsenic and Chromium content was calculated using an external standard curve.

To test the reproducibility of the method, a homogenized sample of fish was divided into 10 identical parts. Each was fortified with 100 μg of standard arsenic and chromium separately and analyzed for Arsenic and Chromium. The mean and median were equal (0.14 mg/kg dry weight), the standard deviation was 0.1. All measurements fell within 1.96 standard deviations of the mean and the coefficient of variation (cv = standard deviation/mean) was very low (0.07). This is why a normal distribution was assumed and the test of reproducibility considered as satisfactory. The percentage recoveries were 65.6 % and 67.4 % for Arsenic and Chromium respectively.

Data obtained are expressed as mean ± SEM. Values were subjected to two-way analysis of Variance (ANOVA) followed by Dennett's test to determine the statistical significance. SPSS software was used to analyze data. Values were considered significant when $p \leq 0.05$.

Results and Discussion

In this study we have found that these sea foods contain well over the prohibitive level as set by the US, EPA guideline (Table 1). Provincial limit of arsenic in drinking water is 0.05 mg/L; for mineral 0.021 mg/L (WHO 1996). Generally the arsenic levels in these sea foods ranged from 0.079 ± 0.04 mg/kg to 0.152 ± 0.14 mg/kg. *P. serratus* showed higher Arsenic level of 0.152 ± 0.14 mg/kg compared to 0.079 ± 0.04 mg/kg for *H. jaguana* as the lowest which is not significantly ($p \leq 0.05$) different. The upper limit of this range is feared to be too high at least considering the high frequency of *P. serratus* (Prawns) consumption in the area. Another group that may be at risk is the pregnant women/unborn children considering the placental transfer of the arsenic and the attendant health hazards to the unborn foetus. (Patlolla and Tchounwou 2005a, b).

Recent reports have shown that arsenic poisoning appears to be one of the major public health problems of

Table 1 Arsenic and Chromium levels of sea foods. (mg/kg)

Scientific Name	Local Name	Arsenic	Chromium
Claria garie pinus	Mud cat fish	0.129 ± 0.11	0.077 ± 0.04
Pleurotus eryngii	Oyster brown	0.114 ± 0.05	0.058 ± 0.03
Crago nigricando	Shrimps	0.096 ± 0.03	0.054 ± 0.05
Palaemon serratus	Prawns	0.152 ± 0.14	0.081 ± 0.04
Uca pugrlater	Crabs (broad flap)	0.107 ± 0.04	0.069 ± 0.03
Scyll serrata	Crabs (small flap)	0.144 ± 0.12	0.083 ± 0.05
Anguilla anguilla	Eel	0.127 ± 0.10	0.073 ± 0.03
Litorina littorea	Periwinkle	0.089 ± 0.05	0.051 ± 0.02
Harangula jaguana	Sardine	0.079 ± 0.04	0.046 ± 0.01
Tilapia zilli	Tilapia	0.118 ± 0.13	0.056 ± 0.02

* Values are mean ± SD of triplicate determination

pandemic nature. Arsenic exposure may occur via the dermal and parenteral routes, but the main pathways of exposure include ingestion and inhalation. It has also been reported that millions of people are at risk of cancer, and other diseases because of chronic exposure (Tchounwou et al. 2004). Slow Arsenic poisoning has been observed in scalp hair samples among Arsenic contaminated water consumers. These range from skin lesions (hyper-pigmentation, de-pigmentation, melanosis, keratosis, etc.) to cancers of the bladder, kidney, lungs and cardiovascular problems (Christen 2010). Arsenic exposure induces cardiovascular diseases, developmental abnormalities, neurologic and neurobehavioral disorders, diabetes, hearing loss, hematological disorders and various types of cancer (Tchounwou et al. 2004). Kitchin (2001) also reported that long term consumption of arsenic contaminated water leads to serious health effects often referred to as arsenicosis. The symptoms of arsenicosis manifests after several years; as skin lesions, then to gangrene, and eventually cancers of the skin, lung, bladder and kidneys (Kazia et al. 2009).

Chromiun levels in these sea foods ranged between 0.046 ± 0.01 mg/kg for *H. jaguana* and 0.083 ± 0.05 mg/kg for *S. serrata*. Cr(III) and Cr(VI) compounds have been shown to be potent occupational carcinogens (Upreti et al. 2004). Chromium poisoning can be acute or chronic. Death in acute chromium poisoning is usually due to uraemia (Upreti et al. 2004). Chromium intoxication by inhalation or skin contact leads to incapacitating eczematous dermatitis, with oedema and ulceration. The reduction of Cr(III) results in the formation of reactive intermediates that together with oxidative stress and oxidative tissue damage and cascade of celluar events including modulation of apoptosis regulatory gene p^{53} contribute to the cytotoxicity, genotoxicity and carcinogenicity of Cr(VI) – containing compounds (Hauser and Hauser 2008). The chromium range found in this study is high which calls for serious public health concern on the consumers. The WHO recommended maximum permissible limit for chromium is 0.01 mg/L (Caldwell et al. 2003). Chromium is an essential element in glucose metabolism, and too little chromium in the diet may lead to insulin resistance (Kleefstra et al. 2004). Despite the popular opinion on increasing chromium intake as one of the essential elements, consumers of these fish and sea foods may be exposed to higher levels considering the relative contribution of the element in the diet by these sea foods. Tchounwou et al. (2004) also reported of the potential health risks associated with ingesting metals in fish collected from a hazardous-waste contaminated wetland in Louisiana USA. Chronic-low level exposure of consumers to these metals calls for public health concern.

Acknowledgments We wish to thank the Vice Chancellor, Abia State University, Prof Chibuzo Ogbuagu for his interest and financial support for this investigation.

References

Adefemi SO, Asaolu SS, Olaofe O (2008) Major elements in fish (*Illisha africana*), sediments and water from selected dams in Ekiti State. Res J Environ Sci 2(1):63–67

Agaolu SS, Olaofe O (2004) Biomagnification of some heavy and essential metals in sediments, fish and crayfish from Ondo State coastal region. Pak J Sci Ind Res 48:96–102

Burger J, Gaines KF, Boring S, Stephens L, Snodgrais J, Dixon C, McMahon M, Shulila S, Shulila T, Goshfeld M (2002) Metal levels in fish from the Savannah River: Potential hazards to fish and other receptors. Environ Res 89:85–97

Caldwell BK, Caldwell JC, Mitra SN, Smith W (2003) Tubewells and arsenic in Bangladesh: Challenging a public health success story. Int J Popul Geogr 9(1):23–38

Christen K (2010) The arsenic threat worsens. Environ Sci Tech 35(13):286A–291A

Hauser R, Hauser M (2008) The dangers of heavy metals. In: Benutsnews: caring medical and rehabilitation services. Available via hptt://heart disease bypass surgrey.com. Assessed 22 April 2012

Hughes MF (2002) Arsenic toxicity and potential mechanisms of action. Toxicol Lett 133(1):1–16

Jack CN, Wang J, Shraim AA (2003) Global health problem caused by arsenic from natural sources. Chemosphere 52(9):1353–1359

Karimi N, Ghaderian SM, Maroofi H, Schat H (2010) Analysis of arsenic in soil and vegetation of a contaminated area in Zarshuran, Iran. Int J Phytoremediation 12:159–173

Kazia TG, Araina MB, Baig JA, Jamali MK, Afridi HI, Jalbani N, Sarfraz RA, Shah AQ, Niaza A (2009) The correlation of arsenic levels in drinking water with the biological samples of skin disorders. Sci Total Environ 407:1019–1026

King RP, Jonathan GE (2003) Aquatic environment perturbations and monitoring. African experience, USA

Kitchin KT (2001) Recent advances in Carcinogenesis: models of action, animal model systems, and methylated arsenic metabolites. Toxico Appl Pharmacol 172:249–261

Kleefstra N, Bilo HJ, Bakker SJ, Hauweling ST (2004) Chromium and insulin resistance. Ned Tijdschr Geneeskd 148(5):217–220

Nouri J, Khorasani N, Lorestani B, Yousefi N, Hassani AH, Karami M (2009) Accumulation of heavy metals in soil and uptake by plant species with phytoremediation potential. Environ Earth Sci 59(2):315–323

Patlolla AK, Tchounwou PB (2005a) Serum acetyl cholinesterase as a biomarker of arsenic induced neurotoxicity in Sprague-Dawley rats. Int J Environ Res Public Health 2(1):80–83

Patlolla AK, Tchounwou PB (2005b) Cytogenetic evaluation of arsenic trioxide toxicity in Sprague-Dawley rats. Mutat Res 10, 587(1–2): 126–133

Tchounwou PB, Abdelghani AA, Pramar YV, Heyer LR, Steward CM (1996) Assessement of potential health risks associated with ingesting heavy metals in fish collected from a hazardous-waste contaminated wetland in Louisiana USA. Rev Environ Health 11(4):191–203

Tchounwou PB, Centeno JA, Patolla AK (2004) Arsenic toxicity, mutagenesis and carcinogenesis- a health risk assessment and management approach. Mol Cell Biochem 255(1–2):47–55

Upreti RK, Shrivastava R, Chaturvedi UC (2004) Gut microflora and toxic metals. Chromium as a model. Indian J Med Res 119(2): 49–59

WHO (1996) Health criteria and other supporting information. In: World Health Organization, Guidelines for drinking-water quality, 2nd, 2, Geneva

Young S, Ballez L, Mallilay J (2004) Natural and technological hazardous material releases during and after natural disasters- a review. Sci Total Environ 322:3–20