iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** IV **Month of publication:** April 2016

DOI:

www.ijraset.com

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Volume 4 Issue IV, April 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Assessment of Heavy Metals Levels in Some Commonly Consumed Species of Prawns in Southwestern Nigeria

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Abstract— Three different kinds of prawns (Macrobrachium Felicium (MF), Macrobrachium macrobrachium (MM) and Demoscaris Trispinose (DT)) were collected from Ilaje (water side) area of Ondo State, Nigeria. The concentrations of heavy metals namely Pb, Cr, Cu, Cd and Mn in these samples were evaluated by Atomic Absorption spectrometry. The determined concentration of heavy metals Pb, Cd and Mn in all the samples, except the concentration of Pb in MF, are found to be higher than the maximum permissible values prescribed by WHO in 1989. Contrarily, the concentrations of Cr and Cu in all the species are lower than their respective prescribed values. The levels of Pb, Cd, and Mn obtained in this report poses a serious treats to human in all the three species of prawns, therefore, these aquatic species must be carefully examined before consumption.
Keywords— ***Prawns, heavy metals, bioaccumulation, atomic absorption spectrometry, Southwestern Nigeria***

I. INTRODUCTION

Naturally occurring heavy metals are not dangerous to the environment and they play essential roles in tissue metabolism and growth of plants and animals. However severe metal imbalances are toxic and marginal imbalances contribute to deformities and impede health [1] – [8]. Metals of major interest in bioavailability studies, as listed by the US Environmental protection Agency (EPA) are aluminum, beryllium, arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium, antimony [9]. Other metals that are presently of lesser interest to the EPA are silver, barium, cobalt, manganese, molybdenum, sodium, thallium, iron and zinc. These metals were selected because of their potential for human exposure and increased health risk.

There has been a growing interest in assessing the levels of trace heavy metals in consumed aquatic organisms like prawns and fish [1] – [7]. The ingestion of food is an obvious means of exposure to metals not only because many metals are natural components of food stuffs but also because of environmental contamination during food processing/packaging. Heavy metals are considered to be the most important form of aquatic pollution because of their accumulation by aquatic organisms [10]. Metal pollution in the environment is not very visible but its impact on delicate marine ecosystems and human are drastic. Trace metals are significant either from the Cu viewpoint of their essentiality or their toxicity.

Metals occur in mineral deposits and can enter the environment naturally through weathering of rock and ores. Human activities such as refining of ores and many industrial processes also release metals into the environment, often at a rate far higher than natural processes. Metal contamination can be directly linked to both industrial sources and urban runoff. The wearing of vehicle part such as tyres, brake pads and brake lining is a major source of metal contamination. Other sources include vehicle and aircraft exhaust, leaking lubricating oil, smelters, power station, port facilities, WWTPs, chemical producers and manufacturing plants. Other sources include aeroplanes, paved roads and motor vehicles, commercial shipping and to a lesser extent, recreational, boating, railways and fuel combustion [11].

Some heavy metals are naturally present in some natural water sources. Some of them are essential for healthy living of organisms. However, when the concentrations of the metals are very high beyond certain tolerable limits, they become toxic [12] – [13]. Metals such as copper and zinc have biological functions and are essential elements for many organisms, although they can be toxic at higher concentrations. Some other metals, including cadmium, lead and mercury, have not known biological functions and even at low concentrations can be toxic to some form of life.

Impact of heavy metal on organisms can be in a number of ways. Their effects can be in a number of ways. These effect can be acute (or immediate), or more long-term or chronic. Metals can vary in their mode of action within organisms, with variations in the rate of uptake, metabolism and excretion resulting in variations of toxic effects exhibited by the metals. When a number of metals are present at one time, the total toxicity of the metals may be greater than would be expected from the sum of the individual toxicities of each metal. This synergistic effect is not taken into account in current water quality or sediment guidelines [14]. Heavy

metals can also be bioaccumulated in some organisms. Bioaccumulation occurs when the metal is taken up at a faster rate than it is excreted or broken down. In polluted areas bioaccumulation can make some animals unsafe for human consumption.

One of such animals is prawn. Living prawns are divided among seven families, five in the superfamily Panaeoidea, and two in the Sergestoidea, although molecular evidence disagrees with some aspects of the current classifications. Collectively, these include 540 extant species, and nearly 100 exclusively fossil species. Three species of prawns are common in waterside rivers of southwestern Nigeria. As sources of proteins, they make up parts of the ingredients of many local and confectionary dishes in Nigeria. The level of bioaccumulation of heavy metals in aquatic species can not be determined by mere inspection or through unaided senses. It is therefore important to determine the bioaccumulation of heavy metals in consumed prawns in these localities in order to assess their suitability for human consumptions. The technique most widely used for heavy metal analyses in food include inductivity coupled plasma optical emission spectrometry (ICP-OTS), inductivity coupled plasma mass spectrometry (ICP-MS), flame atomic absorption spectrometry (FAAS) and atomic absorption spectrometry (AAS).

In this study, the levels of heavy metals Pb, Cr, Cu, Cd and Mn in three different species prawns that are common and majorly consumed in south western Nigeria were investigated and compared with the consumable standards.

II. MATERIALS AND METHODS

Three different kinds of prawns were collected from Ilaje (water side) area of Ondo State, Macrobrachium Felicium (MF), Macrobrachium macrobrachium (MM) and Demoscaris Trispinose (Guinea swamp shrimp) (DT). In the laboratory, the dried prawns were ground and preserved in a labeled sample bottle. The dry pulverized samples (1g) from each of the various prawns were in each case placed in a 100ml decomposing beaker. Concentrated nitric acid (20mls) and perchloric acid (10mls) were added to contents of the beakers which were evaporated to near dryness on a hot plate at a temperature of between 200 – 250^{o}C [15]. The resulting residues were dissolved and washed into 50ml volumetric flasks with 0.1m HNO3 and made up to mark with distilled de-ionised water and stored for 2 to 3 weeks until metal concentrations could be determined. The metals, cadmium, chromium, copper, nickel, lead and zinc were analysed using an atomic absorption spectrophotometer (Alpha 4AAS, Chemical Tech, Aalytical, Euro) according to the method of [16]. Water samples were not given further treatment but were aspirated into the flames of the atomic absorption spectrophotometer. The atomic absorption spectrophotometer was standardized using stock standard solutions from the respective metals. By following standard procedures [17], the accuracy of the method employed was assessed by the analysis of two replicate samples which yielded standard deviations less than 5% for Pb, Cr, Cu, Cd and Mn.

III. RESULTS AND DISCUSSION

The mean concentration of Pb, Cr, Cu, Cd and Mn in prawns from Ilaje (water side) area of Ondo State; Macrobrachium Felicinum (MF), Macrobrachium Macrobrachium (MM) and Desmoscaris Trispinose (DT) are presented in Table 1. Significant variation exists in the amount of metals bioaccumulated by the various species. The distribution pattern across the various species is presented in Fig. 1. The results as obtained in this study show that there are variation in the level of intake and concentration of heavy metals in different species of prawns. That is, the extent of bioaccumulation varies from species to species. The observed differences in metal levels are believed to be due to variable membrane passage capabilities due to different electrical charges and chemical interaction.

The results show MM to possess the highest concentration of all the heavy metals tested except for Cd (cadmium) which is in highest concentration in DT. Also, MF shows the least concentration of all the metals except for Cr that is lower in DT. Thus, MM is considered as the most suitable bio-indicator of heavy metal among the species which MF is considered the least.

It can be inferred from the results that different species of prawns accumulate heavy metals at different rate. Each species had somewhat different concentration of metals from the others. The variation in metal levels concentration or accumulation in different species of prawns is an indication of the degree to which particular specie picks up particulate matter from the surrounding water and particular, sediment while feeding. In addition, such information is critical in making accurate risk assessment for seafood safety purpose.

TABLE I

Volume 4 Issue IV, April 2016
ISSN: 2321-9653
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CONCENTRATION OF HEAVY METALS (MEAN ± S.D, MG/KG) IN ALL THE PRAWNS

Elements	Macrobrachium Felicium (MF)	Macrobrachium Macrobrachium (MM)	Desmoscaris Trispinose (DT)	WHO (1989) (mg/kg)
Pb	1.51± 0.332	3.02±0.110	2.15±0.160	2
Cr	1.82± 0.079	9.62±0.210	1.18±0.140	50
Cu	7.91±0.110	18.26±0.220	12.32±0.350	30
Cd	2.30±0.065	3.16±0.400	3.29±0.180	1
Mn	1.37±0.020	6.57±0.260	1.55±0.130	1

The increasing order in metal level across all the species is Mn ≤ Pb < Cr ≤ Cd < Cu. The Mn content is least (1.37 mg/kg) in MF followed in DT (1.55 mg/kg) and highest (6.57 mg/kg) in MM. All these values are higher than the specified Maximum acceptable concentration (1 mg/kg) prescribed as permissible limits by WHO [13]. Like many heavy metals, only small amounts of Manganese are required in the human body for several biological functions. High levels of manganese in human body can cause dermatitis, problems in the glucose metabolism and of proteins, mitochondria abnormalities, infertilities, bad formation of the bones, decrease of the serum cholesterol, and other diseases [18]. Excess of manganese can be a toxicant and the nervous system seems to be the most vulnerable to it.

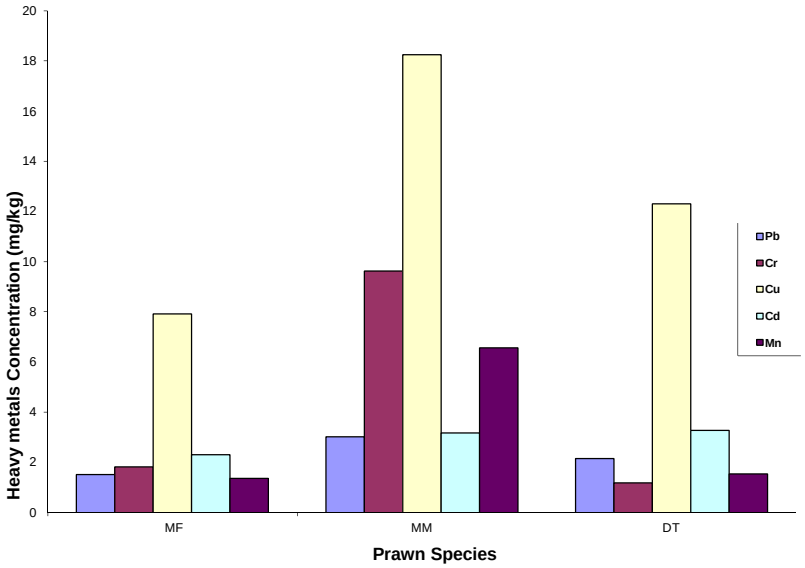

Fig. 1 Concentrations of the heavy metals in all the prawns

The mean Pb concentration (in mg/kg) in MF, MM and DT are respectively 1.51, 3.02 and 2.15 which ranged from 1.18 – 9.62 across the species. It is only the concentration Pb in MF in all the understudied species that is lower than the specified Maximum acceptable concentration 2 mg/kg as prescribed by WHO [13]. However, none of the samples is safe for consumption according to the latest reviewed value of FAO/WHO [19] (0.5ppm). Pb is known as deadly and accumulative poison even when consumed in small quantities and is capable of deadline nerve receptor in man [20]. From the public health point of view, lead toxicity reportedly causes renal tubular dysfunction indicated by proteinuria, aminoaciduria, glucosuria, hyperphosphaturia and impairment of sodium transport [21].

Cr concentrations (in mg/kg) in MF, MM and DT are respectively 7.91, 18.26 and 12.32. Chromium is a compound of biological interest in view of its role in glucose and lipid metabolism as an essential nutrient [22]. However, the compounds of this mineral have been found to be mutagenic and carcinogenic in a variety of test systems. Death in acute chromium poisoning is usually due to uraemia. Chronic intoxication by inhalation or skin contact leads to incapacitating eczematous dermatitis, with oedema and ulceration [22]. It is interesting to know that the values of Cr in the three samples are far lesser than the prescribed value of 50 mg/kg as prescribed by WHO [13]

The corresponding values of Cd concentrations in the three prawns that range from 2.30 – 3.29 across the species are above the

prescribed value of 1 mg/kg (WHO 1989). Cadmium a highly toxic metal, is present throughout the environment and accumulates in liver and kidney of mammals through the food chain [23].

In the three species, Cu has the highest concentration among all the other elements being retained by them. Although, Cu is an essential micronutrient required for growth, but in high doses are toxic. Excess accumulation of copper in hepatic cells is known to cause liver diseases [24]. While abnormal accumulation of copper in the tissues and blood is a point of similarity with genetic disease of man called Wilson's disease [25] – [26]. Most absorbed copper is stored in liver and bone marrow where it is bound to metallothionein [27], and acute exposure to copper results in nausea, vomiting, bloody diarrhea, hypertension, uremia and cardiovascular collapse [28]. While copper interaction with the environment is complex, the results obtained in this study showed that Cu concentrations in the three prawns that range between 7.91 -18.26 mg/kg are lower than the maximum prescribed values of 30 mg/kg [13].

IV. CONCLUSION

The study showed that the concentration of heavy metals is highest in Macrobrachium while the least concentration was recorded in Macrobrachium Felicium. The concentrations of the determined heavy metals Pb, Cd and Mn in all the samples, except the concentration of Pb in MF, are found to be higher than the maximum permissible values prescribed by WHO [13]. Contrarily, the concentrations of Cr and Cu in all the species are lower than the prescribed values of WHO [13].

The relatively high levels of Cu in the species should b given urgent attention, especially in Trispinose Desmoscaris species which is readily available in these communities. The relative high concentration of Cu in all the prawns reveals that Cu is not easily released once absorbed into the organisms. With this limited data, it appears that imminent Pb, Cd, and Mn pollution of aquatic food organisms is threatening in these communities, therefore, these aquatic species must be carefully examined before consumption.

This study has showed that the consumption of this three species of prawns from the community poses a great danger to human health. It is therefore hoped that more study would be carried out on other species of prawns. This is necessary in other to be able to evaluate the potential of each species as biological indicator of heavy metals.

V. ACKNOWLEDGMENT

The author thanks Michael Olajide for the supports rendered when carrying out this research

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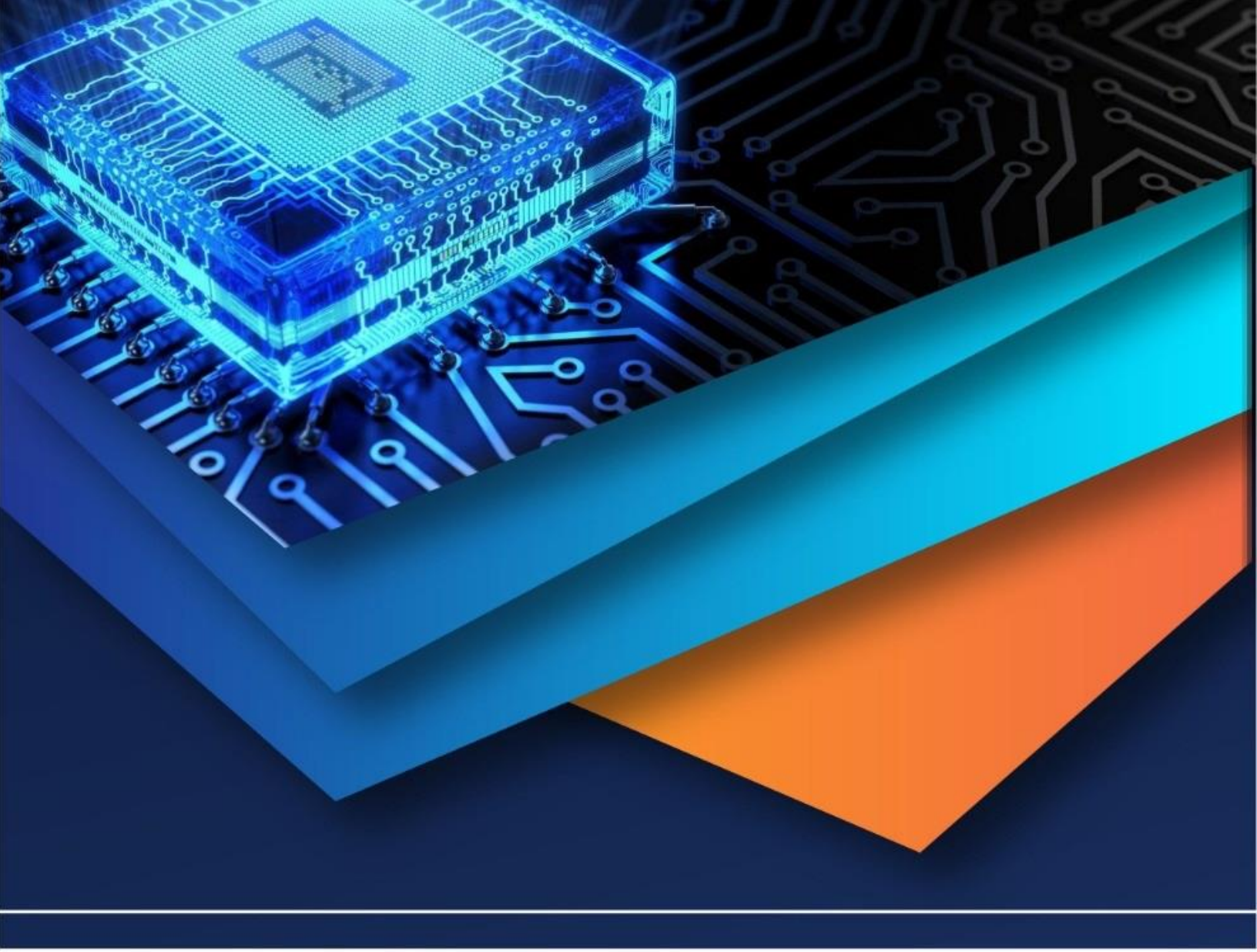

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