EVALUATION OF HEAVY METALS CONCENTRATION IN SELECTED SEAFOOD IN OGONI LAND

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Abstract

Periwinkle, clam, mudskipper, shrimp and catfish are favoured seafood in Ogoni Land. The quantitative estimation of heavy metals in these favoured seafood from Kaa and Kono Rivers have not really been established. This study was undertaken to evaluate the concentration of chromium, iron, lead and cadmium in the aforementioned seafood. Fresh, clean samples of periwinkle, clam, mudskipper, shrimp and catfish were collected from fishermen at landing beaches of Kaa and Kono Rivers. These samples were transported to the chemistry laboratory of Kenule Beeson Saro-Wiwa Polytechnic where digestion was done. Quantitative estimation of heavy metals was done using atomic absorption spectrophotometer at corporate analytical service limited. Analysis showed that all heavy metals in periwinkle are greater than normal guidelines, with the exception of Fe from both rivers and Cr from Kaa. Cr is higher than the normal standards for clam in both rivers, but all others were lower. Except for Fe, all heavy metals in mudskipper exceed acceptable limits for both rivers. For shrimp, Cr and Pb levels are greater than recommended in both rivers, whereas Fe and Cd levels are lower. Cr was not detected in catfish, however Pb and Cd levels are greater than recommended for both rivers, whereas Fe levels are lower. According to a one-time evaluation, periwinkle, clam, mudskipper, shrimp and catfish from Kaa and Kono Rivers have heavy metal concentrations higher than recommended levels for safety. To minimize heavy metal bioaccumulation, these samples should not be consumed for long periods of time. Serial analysis over a long period of time should be carried out in order to provide a more definitive statement concerning the consumption of these seafood.

Keywords: Seafood, Ogoni Land, Heavy Metals, Digestion, Consumption.

1.0 INTRODUCTION

Seafood refers to any aquatic animal that humans eat both of freshwater and seawater origin [1]. The harvesting and consumption of seafood is a long-standing practice that dates back to the upper Palaeolithic period in history [2]. Seafood, which contains between 75 to 80 percent water and a good source of high-quality proteins, is crucial to global food security [3,4]. After cereals, fish and other seafood may be humanity's most significant food, providing around 15% of the world's protein intake with individual consumption of fish and shellfish estimated to be over 13 kg per year depending on geography and personal preferences [1,5]. The low fat content of many seafood species, as well as the protective effects of n-3 polyunsaturated fatty acids found in oily (pelagic) fish on coronary heart disease, are critical for health-conscious people, especially in countries where cardiovascular disease is common. The seafood industry has evolved in recent years, with significant expansion in aquaculture, geographic shifts in trade, and rising commoditization and vertical integration [6,7]. All bony fishes, as well as the more primitive sharks, skates, rays, sawfish, sturgeons, and lampreys; crustaceans such as lobsters, crabs, shrimp, prawns, and crayfish; molluscs such as clams, oysters, cockles, mussels, periwinkles, whelks, snails, abalones, scallops, and limpets are seafood [1]. Shrimp (*Penaeus notialis*) , clam (*Egeria radiata*) , periwinkle (*Tympanotonus fuscatus*), mudskipper (*Periophthalmus barbarus*) and catfish (*Chrysichthys nigrodigitatus*) are favoured seafood in Ogoni Land.

Mudskippers are amphibious fish that live both in water and on land [8]. They consume a wide variety of food and feed both underwater and on land [9,10]. Silver catfish (*Chrysichthys nigrodigitatus*) is demersal; it is omnivorous, feeding on seeds, insects, bivalves, detritus, decapods and fish [11]. According to Asuquo *et al*., 2013, *Chrysichthys nigrodigitatus* forages on a variety of benthic food sources in the tropical estuaries of Nigeria. Shrimps, whether brine shrimp or malacostracan shrimp, are crustaceans [13]. Shrimps are mostly omnivorous filter feeders found on the seafloor of most coasts, estuaries, lakes, and rivers. [14,15]. Clams are filter feeders that feed on phytoplankton, zooplankton, and algae and can be found buried in the sand or mud of the seafloor or riverbeds to depths of 0.6 meter. [16,17]. African periwinkle (*Tympanotonus fuscatus*) is mostly found in the sea, in the upper and middle intertidal zones, and it can also be found in muddy environments like estuaries [18]. Periwinkles are omnivorous, feeding on algae and tiny organic debris such as barnacle larvae, and may survive out of water for several days [19].

Seafood is not just a source of nutrients in human diet but also of environmental contaminants and unregulated consumption could pose a risk to consumer's health [20]. Heavy metals are an important group of chemical contaminants and food is the major vehicle for their entry into human systems [21]. Heavy metals are normal constituents of marine environments; they are neither created nor destroyed by man but are inert and are often considered to be conservative pollutants if left undisturbed [22,23]. Although there are natural concentrations of heavy metals in all waters, sediments and seafood referred to as background concentration, mining, geological or biological processes can release large enough quantities that may affect biota since they do not disappear overtime [24]. These metals are released into the environment by both natural and anthropogenic sources, but anthropogenic environmental impacts such as rapid industrialization, urbanization, population growth, and agriculture have significantly increased naturally occurring levels in the environment, resulting in severe heavy metal pollution worldwide. [25,26].

Unlike organic contaminants, heavy metals are not degradable with time but their concentration can only increase through bioaccumulation [27]. Metal bioaccumulation and distribution in organs in seafood is very intraspecific, with parameters like sex, age, size, reproductive cycle, swimming pattern, feeding behavior, pH, temperature, hardness, exposure time, geographical location, and habitat complexity all influencing metal intake. [28,29,30]. Fish, which are often at the top of the aquatic food chain, absorb heavy metals directly through their meals and water, and harmful residues can build up to levels hundreds or thousands of times greater than those measured in the water, sediments, and food [22,31]. Seafood is considered one of the main dietary sources of these contaminants since they exist in a marine environment that could be contaminated by these ubiquitous molecules that, regardless of their anthropic or natural origin, are prone to widespread distribution. [32]. In Nigeria, fish contribute over fifty percent of protein intake with per capita consumption of 7.52Kg per annum thus making the human body largely susceptible to heavy metals enrichment [33,34].

Heavy metals are known to have toxic effects even at low concentration and their concentration in biota can be increased through bioaccumulation [35]. An excessive amount of lead and cadmium could be detrimental to living cells and a prolonged exposure to the body can lead to illness or death [36]. Cadmium and lead may cause health problems such as skin lesions, nerve damage, skin cancer, blood vessel diseases and affect nervous system development, particularly in children, infants, and developing foetuses; while these health implications may sound alarming, severe poisoning due to consumption of heavy metal-containing seafood is unlikely to occur unless there is severe environmental pollution [37]

Heavy metals pose a great concern to scientists as they cause environmental contamination [38]. Pollution by toxic heavy metals due to their toxicity in relatively low concentration and tendency to bioaccumulation in the ecosystem, agriculture and human body has received widespread attention in recent years [39]. With fish constituting an important link in the food chain, its contamination by toxic heavy metals has become an important worldwide concern not only because of the threat to fish and the aquatic environment but also to the health of humans that utilize it as food [40,41]. The rippling concerns of scientists with respect to the bioaccumulation and contamination of seafood by heavy metals also got to Ogoni Land. It is this concern that has led to the evaluation of heavy metals concentration in selected seafood and by using standard guidelines to tell if these seafood are safe for continual consumption.

2.0 METHOD

2.1 Study Area

Ogoni Land is located in Rivers State on the Guinea Coast 4°45'6.55"-4°47'37.87"N, 7°17'12.75"-7°23'41.58"E, covering approximately 1000 square kilometers with four local government areas: Eleme, Tai, Gokana and Khana [42]. Khana is one of the local government areas of Ogoni and its capital Bori is the traditional headquarter of the Ogoni people. Khana LGA was created in 1992 and covers 560 square kilometers with an average temperature of 25°C and total precipitation at 2900mm of rainfall per annum [43]. With several rivers and tributaries flowing into its territories with abundance of seafood, the people of Khana are involved in fishing; they are also farmers and traders [43]. Kaa and Kono Rivers are in Khana local government area of Ogoni Land. There are no direct industrial effluents into Kaa and Kono Rivers but agricultural runoff into these rivers occur. Repairs of boat engines also occur along these rivers and there is the general crude oil pollution of Ogoni Land.

2.2 Sample Collection

Fresh and clean samples of silver catfish (*Chrysichthys nigrodigitatus*) clam (*Egeria radiata*), shrimp (*Penaeus notialis*), mudskipper (*Periophthalmus barbarus*) and periwinkle (*Tympanotonus fuscatus*) were collected from fishermen at landing beaches of Kaa and Kono Rivers. The researchers had had a prior discussion with the fishermen of the intent of the collection and all samples were gotten from Kaa and Kono Rivers within March of 2021. From each landing beach, 40 pieces of periwinkle, 3 pieces of silver catfish, 10 pieces each of clam, shrimp and mudskipper were collected. Collected samples were placed in their respective labelled plastic containers and transported to the "Chemistry Laboratory" of the Department of Science Laboratory Technology in Kenule Beeson Saro-Wiwa Polytechnic, Bori. The containers for shrimp, mudskipper and catfish had perforated covers and water in the plastic containers.

2.3 Sample Analysis

At the laboratory, the meat of periwinkle and clam were removed from the shells for use. Exoskeleton of the shrimps were also removed and discarded. Of the catfish samples from each landing beach, one was randomly selected and chopped into chunks. Mudskippers, that had been cleaned, were not specially treated. All collected samples were then oven dried with a hot air oven for 24 hours at 60°C. The dried samples were ground into homogenized powder form using mortar and pestle; these were later packaged in prelabelled containers.

Digestion was done in triplicates for the samples from the two rivers. Two grams of each sample was weighed into a beaker and 20ml of nitric acid/perchloric acid ($HClO_4$-$HN0_3$) was added [33]. The content of the beaker was heated at 60°C for 30 minutes using the heating mantle, allowing all brown fumes to disappear. After heating, the beaker and its contents were allowed to cool; thereafter samples were filtered into volumetric flasks using Whatman No. 1 filter paper and a glass funnel and the filtrate made up to 50ml with distilled water [22]. The metal content of digested samples were quantified using atomic absorption spectrophotometer at corporate analytical service limited.

2.4 Data Analysis

The concentration of heavy metals were presented in mean and as mg/Kg. The mean and standard deviation were calculated with calculator.net. T-test was used to compare differences between mean concentration of metals of Kono and Kaa River samples. All T-test calculations were done on socscistatistics at www.socscistatistics.com. Statistical significance level for the comparison of means was set at $p<0.05$. World Health Organization (WHO) standard guideline values for the heavy metals was gotten from 44,45,46,47&48.

3.0 RESULTS AND DISCUSSION

The concentrations of the heavy metals, Cr, Fe, Pb and Cd in periwinkle, clam, mudskipper, shrimp and catfish are presented in tables 1-5. The tables also have standard guideline values for the metals in the respective seafood species.

Table 1: Heavy Metals Concentration (Mean & SD) **in Periwinkle and Standard Guideline**

S/No.	**Parameters**	**Location**	**Location**	**Guideline** (mg/kg)
		Kono (mean & SD)	**Kaa** (mean & SD)	
1.	**Cr** (mg/Kg)	0.099 + 0.004	0.036 + 0.004	0.05
2.	**Fe** (mg/Kg)	22.349 + 0.045	19.914 + 0.019	100
3.	**Pb** (mg/Kg)	1.320 + 0.066	1.395 + 0.063	0.2
4.	**Cd** (mg/Kg)	0.150 + 0.005	0.134 + 0.038	0.05

Table 2: Heavy Metals Concentration (Mean & SD) **in Clam and Standard Guideline**

S/No.	Parameters	Location	Location	Guideline (mg/kg)
		Kono (mean & SD)	**Kaa** (mean & SD)	
1.	**Cr** (mg/Kg)	0.248 + 0.051	0.168 + 0.019	0.05
2.	**Fe** (mg/Kg)	15.261 + 2.761	14.391 + 2.735	100
3.	**Pb** (mg/Kg)	0.209 + 0.044	0.129 + 0.027	1
4.	**Cd** (mg/Kg)	0.019 + 0.004	0.013 + 0.003	1

Table 3: Heavy Metals Concentration (Mean & SD**) in Mudskipper and Standard Guideline**

S/No.	**Parameters**	**Location**	**Location**	**Guideline** (mg/kg)
		Kono (mean & SD)	**Kaa** (mean & SD)	
1.	**Cr** (mg/Kg)	0.431 + 0.007	0.209 + 0.001	0.05
2.	**Fe** (mg/Kg)	6.599 + 0.234	6.570 + 0.178	100
3.	**Pb** (mg/Kg)	0.623 + 0.114	0.685 + 0.007	0.2
4.	**Cd** (mg/Kg)	0.065 + 0.004	0.059 + 0.008	0.05

Table 4: Heavy Metals Concentration (Mean & SD**) in Shrimp Standard Guideline**

S/No.	**Parameters**	**Location**	**Location**	**Guideline** (mg/kg)
		Kono (mean & SD)	**Kaa** (mean & SD)	
1.	**Cr** (mg/Kg)	0.119 + 0.075	0.130 + 0.044	0.05
2.	**Fe** (mg/Kg)	13.143 + 0.220	23.984 + 0.224	100
3.	**Pb** (mg/Kg)	0.708 + 0.539	0.814 + 0.065	0.5
4.	**Cd** (mg/Kg)	0.118 + 0.005	0.041 + 0.002	0.5

Table 5: Heavy Metals Concentration (Mean & SD**) in Catfish and Standard Guideline**

S/No.	**Parameters**	**Location**	**Location**	**Guideline** (mg/kg)
		Kono (mean & SD)	**Kaa** (mean & SD)	
1.	**Cr** (mg/Kg)	ND	ND	0.05
2.	**Fe** (mg/Kg)	2.208 + 0.075	8.963 + 0.117	100
3.	**Pb** (mg/Kg)	0.853 + 0.081	0.947 + 0.032	0.2
4.	**Cd** (mg/Kg)	0.056 + 0.008	0.063 + 0.006	0.05

Chromium

Chromium was not found in Kono or Kaa catfish samples. Cr concentrations in Kono samples of periwinkle, clam, mudskipper and shrimp were greater than standard guidelines. Cr concentrations are higher in clam, mudskipper, and shrimp samples than in normal guidelines, but lower in periwinkle of Kaa samples. Kono periwinkles, clams, and mudskippers had higher chromium concentrations than Kaa periwinkles, clams, and mudskippers, whereas Kaa shrimp have higher chromium concentrations than Kono shrimp; these differences are however not statistically significant. Mudskipper>clam>shrimp>periwinkle is the order of chromium concentration in Kono. This sequence can be found in Kaa as well as the overall chromium concentration in the samples.

Iron

Fe concentrations in both rivers are lower than the standard guidelines in all samples. Fe concentrations in Kono periwinkles, clams, and mudskippers are higher than in Kaa periwinkles, clams, and mudskippers, whereas Fe concentrations in Kaa shrimp and catfish are higher than in Kono shrimp and catfish; nevertheless, the difference in concentrations is not statistically significant. Periwinkle>clam>shrimp>mudskipper>catfish is the iron concentration sequence in Kono, whereas shrimp>periwinkle>clam>catfish>mudskipper is the pattern in Kaa.

Lead

Lead concentrations are higher than the recommended levels in periwinkle, mudskipper, and catfish from both Kono and Kaa rivers, but lower in clam and shrimp from both rivers. Pb levels are higher in Kaa periwinkles, mudskippers, shrimp, and catfish than in Kono periwinkles, mudskippers, shrimp, and catfish, but lower in Kaa clams than Kono clams; the differences are however not statistically significant. Periwinkle>catfish>shrimp>mudskipper>clam is the sequence of lead concentration in Kono; this is also the sequence of Kaa and the overall concentration of Pb in the samples.

Cadmium

The concentration of Cd in periwinkles, clams, and catfish from Kono and Kaa is higher than the recommended levels. Cd levels in clams and shrimp from both rivers are lower than the recommended levels. Kono periwinkles, clams, mudskippers, and shrimp have higher Cd concentrations than Kaa periwinkles, clams, mudskippers, and shrimp, whereas Kono catfish have lower Cd concentrations than Kaa catfish; the differences are not statistically significant. Periwinkle>shrimp>mudskipper>catfish>clam is the order of Cd concentration in Kono while in Kaa the sequence is Periwinkle>catfish>mudskipper>shrimp>clam.

Mudskippers live both in water and land; catfish is demersal and forages in tropical estuaries; shrimps are mostly found on seafloor; clams are found buried in the sand or mud of the seafloor or riverbed and periwinkles can be found in muddy environment, all with low ranges [8,11,12,14,15,16,17]. All samples were gotten from Kaa and Kono rivers with varying concentration of the heavy metals of concern and like Kpobari *et al.,* (2013) noted, heavy metals are normal constituents of marine environments; chromium, iron, lead and cadmium are present in Kaa and Kono rivers. Heavy metals are not biodegradable but concentration can only increase through bioaccumulation with time [27]; the samples under consideration have with time bioacumulated these heavy metals. The concentration of the heavy metals Cr, Fe, Pb and Cd are higher in most of the samples than the standard guidelines. For periwinkle, apart from Fe of both rivers and Cr of Kaa, all other heavy metals are higher than standard guidelines. For clam, Cr is higher than standard guidelines for both rivers. For mudskipper, all heavy metals apart from Fe are higher than standard guidelines for both rivers. For shrimp, Cr and Pb are higher than standard guidelines for both rivers. In catfish, Pb and Cd are higher than standard guidelines for both rivers.

Knowing that humans consume seafood at either 13Kg/yr. or 7.5Kg/yr. [5,33] and heavy metals are not degradable, neither are they created nor destroyed [23,27], the consumption of periwinkle, clam, mudskipper, shrimp and catfish will lead to the build up of these heavy metals in Ogonis, making their bodies largely susceptible to heavy metals enrichment. For a one time analysis, its not safe to consume periwinkle, clam, mudskipper, shrimp and catfish from Kaa and Kono rivers. For long time consumption, it is not also advisable to consume these samples to avoid bioaccumulation of these heavy metals.

4.0 CONCLUSION

The quantitative analysis of the heavy metals chromium, iron, lead and cadmium in periwinkle, clam, mudskipper, shrimp and catfish from Kaa and Kono Rivers showed that these metals are present in varying concentration. In periwinkle, apart from Fe of both rivers and Cr of Kaa, all other heavy metals are higher than standard guidelines. For clam, Cr is higher than standard guidelines for both rivers but all others are lower. In mudskipper, all heavy metals apart from Fe are higher than standard guidelines for both rivers. For shrimp, Cr and Pb are higher than standard guidelines for both rivers while Fe and Cd are lower. In catfish, Cr was not detected, Pb and Cd are higher than standard guidelines for both rivers while Fe is lower. Periwinkle, clam, mudskipper, shrimp, and catfish from Kaa and Kono Rivers are unsafe to eat, according to a one-time analysis. These samples should not be consumed for lengthy periods of time to avoid heavy metal bioaccumulation.

It is recommended that a two years serial analysis of these heavy metals in the selected seafood be conducted so as to make a more authoritative statement about the safety of the consumption of these favoured seafood.

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AUTHORS CONCERNS

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2. This work has no competing interest.