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The Use of Eel Fish as a Bioindicator for Heavy Metals Pollution of Surface Water: A Case Study of Ibeno Beach, Akwa Ibom State

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ABSTRACT

The pollution of the aquatic environment with heavy metals is a worldwide problem. Given their hazardous nature, lack of biodegradability, and cumulative tendencies, these substances are deemed hazardous environmental contaminants that require monitoring. One of the effective ways is by analyzing their accumulation in water, sediments, and biota. This study evaluates the levels of some heavy metals in water samples from Ibeno Beach using the Eel fish *(Anguilliformes*). Water samples were taken from four different sampling points 400 meters apart. The fish samples from the beach were homogenized and digested using an oxi-acidic mixture. Both water and fish samples were analyzed using Graphite Furnace Atomic Absorption Spectrophotometer (GF-AAS). Mean concentration of the five heavy metals in this study in the water samples analyzed gave the following results of 0.236±0.067, 0.041±0.014, 2.231±0.430 and 0.056mg/L for Cr, Cd, Fe and Ni respectively. Pb was not detected. The mean concentrations obtained for the fish samples were as follows; 0.294±0.027, 0.060±0.005,1.371±0.061, Ni 0.044 and 0.232±0.020 mg/L for Cr, Cd, Fe, Ni and Pb respectively. The order of the metals occurrence in the beach water is Fe > Cr > Ni > Cd > Pb and for the Eel fish samples, Fe > Cr > Pb > Cd > Ni. These orders show close similarity indicating that the Eel fish can be used as a bioindicator for the assessment of heavy metal pollution of surface water such as the Ibeno Beach.

KEYWORDS: Eel fish, Ibeno Beach, Biota, Bioaccumulation.

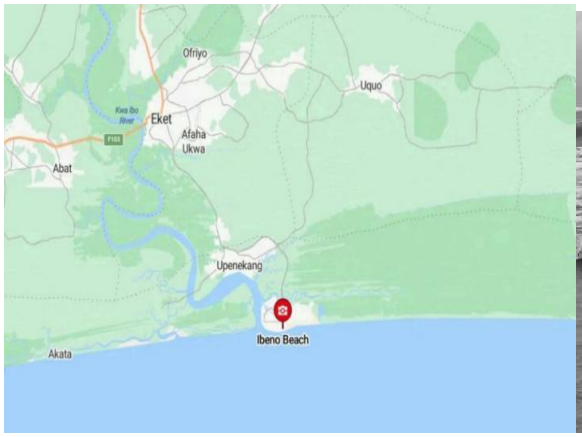
1. INTRODUCTION

Environments along the sea coast related to land are mostly affected by pollution emanating from anthropogenic activities and the discharge of effluents. Potentially toxic elements can affect the aquatic biota, posing health hazards to fish consumers, through the food chain.[1,2] Given their hazardous nature, lack of biodegradability, and cumulative tendencies, these substances are deemed hazardous environmental contaminants that require monitoring. The majority of metals with a geochemical origin are found in less accessible or unreachable forms. Living organisms are affected by both essential and non-essential components in an ecotoxicological way.[3,4] Although metabolic activities in organisms necessitates the presence of some metals like iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), and other trace elements, potentially toxic metals such as lead (Pb), nickel (Ni), cadmium (Cd), mercury (Hg), chromium (Cr), and arsenic (As) are marked as hazard due to their toxic nature. Generally, an analysis of the accumulation of these metals in water, sediments, and related biota is used to track their levels in the aquatic environment. Accumulated metal in water are found considerably lower when compared to sediment and biota. Macroalgae has been used as bio-monitors of heavy metal contamination in a tropical estuary in Malaysia.[5] The use of fish and shrimps as an environmental indicator for heavy metal pollution in water and sediments was reported[6]. Fish are widely regarded as a significant bio-indicator of the aquatic environment. A few environmental factors influence the amount of bioaccumulated heavy metals in fish bodies.[7] Eel Fish is an aquatic organism that is rich in Omega 3 and it is of great economic importance.[8] Consuming Eel supports brain development, helps maintain good eye health, strengthens the bones, prevents stroke and anemia.[9] It has the ability to aid skin cells regeneration thereby reducing wrinkles and improving the look of the skin, hair and nails; due to its high collagen content.[10] The presence of potentially toxic elements in Eket River will affect the aquatic life, and individuals consuming any fish or seafood. This study is therefore aimed at assessing the presence and levels of these elements using the Eel fish which is commonly found in this river and around its environs.

2. MATERIALS AND METHODS

2.1. Study Area

The sample area,Ibeno Beach is in Akwa Ibom State, Nigeria. It is located at 4.568693^{0}N and 7.976396^{0}E and occupies a vast coastal area of over 1, 200km^2.



Picture 1: Map showing Ibeno Beach

Picture 2: A section of Ibeno Beach

The occurrence of heavy metals in this surface water is mostly from anthropogenic sources. The boats are usually washed at the beaches where metal scraps and particles are discharged into the water making them available to the aquatic biota. The runoffs from farms and settlements around the beach contribute to the levels of heavy metals in the marine ecosystem.

2.2. Sample collection

Water samples were collected from the activity side of the beach where the landing platform is in plastic bottles from four different points away from the landing point. The Eel fish *(Anguilliformes*) was collected with the help of local fishermen in clean sterile poly bags.

2.3. Physicochemical analysis

The pH and temperature were determined *in situ*.

2.4. Digestion of Fish samples

The fish samples were cut up in small pieces and placed in the oven to dry at a temperature of 120^{o}C until crisp. They were crushed using a porcelain mortar and pestle in the laboratory. 1g of the homogenized crushed fish sample was weighed out in triplicates into three different beakers and 20 ml of the oxi-acidic digestion mixture of nitric acid and perchloric acid (4:1) were added to each beaker. The samples were heated in the fume chamber until clear solution was obtained and the contents of the beakers were allowed to cool, then filtered using Whatman filter papers (No 40) into 50ml volumetric flasks. These were made up to the mark with deionized water. The water and fish samples were taken to the laboratory for analysis using a graphite furnace Atomic Absorption spectrometer (GF-AAS) with air-acetylene flame.

3. RESULTS AND DISCUSSION

The results obtained from the four sampling points for the water samples are presented in Table 1. The mean concentrations for Cr, Cd, Fe and Ni are 0.236 ± 0.067 mg/L, 0.041 ± 0.014 mg/L, 2.231 ± 0.430 mg/L and 0.056 ± 0 mg/L respectively. Pb was not detected. Fe concentrations were much higher than the other metals. This can be attributed to the human activities including ship and boat traffic at this beach. The wear and tear from them can contribute to the natural quantities of Fe present in the water.

Cr in its VI oxidation state is of no benefit. It causes skin ulceration, liver and kidney damage, severe cardiovascular, gastrointestinal and respiratory problems.[11] Ni enters water bodies through weathering of soils and rocks,[12] leaching and discharge of Ni-containing effluents from nearby industries.[13] This accounts for the high levels of Ni found in this study which is above the maximum acceptable limit of 0.02 mg/L by WHO. However, the result is lower than that reported by Luczynska et al.[14] in a similar study. Ni is essential in the synthesis of red blood cells in trace quantities. However, in high doses, it causes damage to the liver and heart, reduction in cell growth, CNS dysfunction and cancer.[15, 16] Cd is not essential in biological systems. It causes renal dysfunction, lung and prostate cancer, osteomalacia [17] and is classified by IARC as group carcinogen even at low concentrations. From the result obtained the heavy metal concentration in the water sample follows the order Fe >Cr > Ni > Cd > Pb. All the metal analyzed in the water samples were above WHO[21] acceptable limits.

Table 1: Heavy metal concentration for water samples

Water sample	Cr (mg/L)	Cd (mg/L)	Fe (mg/L)	Pb (mg/L)	Ni (mg/L)
Point 1	0.210	0.052	1.816	ND	0.056
Point 2	0.196	0.020	2.701	ND	ND
Point 3	0.200	0.042	2.486	ND	ND
Point 4	0.336	0.049	1.920	ND	ND
Mean	0.236	0.041	2.231	-	0.056
Std Dev.	0.067	0.014	0.430	-	0
WHO	0.1	0.003	0.5	0.015	0.02

The results from the eel fish samples collected from the four sampling points are presented in Table 2. From these results, Fe has the highest concentration ranging from 1.287 mg/kg to 1.428 mg/kg with an average of 1.371 ± 0.061 mg/kg. This value is lower than that obtained from the water samples. Fish samples from Point 2 has the highest concentration (1.428 mg/kg). Fe is an essential element in human metabolism and other living things. It is a major component of heam. High levels of Fe in the human body leads to iron overload and this is not acceptable. The average concentration of Cr is 0.294 ± 0.027 mg/kg which is higher by 0.068 mg/kg than that obtained from the water samples. Sampling Point 3 recorded the highest (0.320 mg/kg) followed by Point 4, then Points 2 and 1. The levels of Cr in this edible fish is within FAO[22] acceptable limits. The results for Cd are slightly higher than that obtained from the water samples by 0.020 mg/kg. According to Aytekin et al.[6] the levels of Cd and Pb in fish and shrimp can serve as a marker for the environmental levels of these metals. Pb is extremely toxic, harms hemoglobin synthesis and has been implicated in carcinogenic processes, replacing Zn in certain proteins.[17, 18] The levels of Cd and Pb were found to be within acceptable limits[22]. The average concentration is 0.232 ± 0.020 mg/kg with sampling point 3 having the highest (0.256 mg/kg) and sampling point 2 having the least (0.210 mg/kg). From these results, there is no risk of Pb poisoning from consuming the eel fish from this beach. Ni was detected from only sampling point 1and its value (0.044 mg/kg) is within the acceptable limits[22]. The heavy metal concentration in the fish samples follows the order Fe > Cd > Ni > Pb > Cr. All the heavy metal analyzed in the fish samples were found to be within acceptable limits[22] except Fe.

Table 2: Heavy Metal Concentration for Fish Samples.

Fish sample	Cr (mg/kg)	Cd (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Ni (mg/kg)
Point 1	0.258	0. 059	1.370	0.221	0.044
Point 2	0.288	0.066	1.428	0.210	ND
Point 3	0.320	0.055	1.398	0.256	ND
Point 4	0.308	0.060	1.287	0.239	ND
Mean	0.294	0.060	1.371	0.232	0.044
Std Dev.	0.027	0.005	0.061	0.020	0

FAO	2.30	0.20	0.30	5.0

Table 3 gives the chronic daily intake and hazard quotient for the metals. The daily reference dose (R_fD) is the dosage that indicates the level of exposure of a particular heavy metal in the body system of an individual without causing any harmful effect to such an individual. R_fD values (mg/kg/day) for the metals are as follows: Cr 0.0003, Cd 0.0015, Fe 0.007, Pb 0.0035, Ni 0.02.[20] HQ >1 represents an adverse non-carcinogenic effect; HQ < 1 represents permissible levels of no concern. From the HQ results, it shows that the metal concentrations are within acceptable levels and therefore there is no concern.

Table 3: Values for Chronic Daily Intake and Hazard Quotient for the metals

Metal	Mean concentration (mg/L)	CDI (mg/kg/year)	Daily CDI (mg/kg/day)	HQ $(\frac{CDI}{RfD})$
Cr	0.294 ± 0.027	0.024	6.58 E-5	0.219
Cd	0.060 ± 0.005	0.005	1.37 E-5	0.027
Fe	1.371 ± 0.061	0.113	3.10 E-4	0.044
Pb	0.232 ± 0.020	0.019	5.21 E-5	0.015
Ni	0.044 ± 0.000	0.004	1.10 E-5	0.001

4. CONCLUSION

From the HQ results, it shows that the metal concentrations are within acceptable levels and therefore there is no concern. However, care should be taken in the continuous consumption of eel from this beach. It can lead to the bioaccumulation of these potentially toxic elements, as fishes have been known to have a strong potential for accumulating pollutants including metals. The continuous monitoring of this beach and other water fronts for the presence of potentially toxic elements using the indigenous fishes that are predominantly found in such surface water is recommended.

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