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Bioaccumulation of heavy metals in some tissues of croaker fish from oil spilled rivers of Niger Delta region, Nigeria

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ABSTRACT

Objective: To investigate the level of heavy metals (Cu, Zn, Fe Mn Ni, Pb and Cd) in muscles, gills and liver tissue of Croaker fish from oil spilled rivers of Bonny and Finima, Niger Delta region, Nigeria.

Methods: Twenty four Croacker fishes (*Genyonemus lineatus*) weighing between 250 and 260 g and 24–26 cm length were collected from each sampling sites (Bonny and finima rivers). The frozen fishes were thawed and dried at 105 °C until they reach a constant weight. The dried samples were homogenized and digested with 10 ml tri-acid mixture (HNO_3: $HClO_4$:H_2SO_4), and then the digested samples were diluted to 100 ml with deionized water. Heavy metals (Cu, Ni, Zn, Pb, Mn, Iron Fe, and Cd) concentrations were determined by atomic absorption spectrophotometer.

Results: Our results revealed that concentrations and distribution patterns of all heavy metals studied varied significantly ($P < 0.05$) amongst the fish tissues analyzed and sampling sites. Moreover, liver tissue of fish caught from Finima creek accumulated the highest concentrations of Cu (52.64 ± 3.01 μg/g dry wt), Zn (166.50 ± 6.45 μg/g dry wt) and Fe (801.50 ± 14.15 μg/g dry wt) in comparison to the liver of fish caught from Bonny river in which the levels of Cu, Zn and Fe were (45.00 ± 2.79), (49.90 ± 2.91) and (216 ± 6.11 μg/g dry wt), respectively. In addition, Mn, Ni, Pb and Cd exhibited their highest concentrations in gills from both locations. As expected, muscle tissue contained the least concentrations of all metals investigated from both sampling sites. Furthermore, all the metals investigated exhibited highest concentration in fish collected from Finima creek. These abnormal high level heavy metals accumulation observed in this location could be linked to the frequent crude oil spills as well as industrial activity around the area which might get discharged into Finima creek. In general, the mean concentrations of some toxic heavy metals investigated exceed the recommended maximum permissible limits set by the Joint FAO/WHO committee. However, some metals are within the acceptable limits.

Conclusions: In conclusion, our data showed the abnormal higher concentration of these metals and this might be toxic to the fish and other aquatic organisms directly or by extension to humans that frequently consumed such contaminated fishes.

1. Introduction

Pollution can be caused by many sources, including agricultural drainage, industrial effluent discharge, sewage discharge, accidental chemical wastes disposal, oil spills, and gasoline from fishing boats [1,2]. In addition, global rapidity in the development of crude oil exploration and transportation has increased the tendency of oil spill incident which release heavy metals including Pb, Ni, V, Zn, Cd as the major contaminants into the environments which might caused many adverse health effects to humans [1,3]. The need for agricultural growth and industrialization in Nigeria has resulted in the increase of heavy metals pollution particularly in the Niger Delta region in which oil exploration, transportation and refining activities are conducted [4]. Oil spill is the uncontrolled release of crude oil into the environment and a major contributor for the higher levels of heavy metals

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in different types of environment such as soil, seawater and freshwater in oil producing areas of Niger Delta region [5,6]. An oil spill incident in various parts of the region has been reported at such a frequent rate in the country [7]. Crude oil through spills often spread out over a wide area, destroying crops and aquaculture through contamination of rivers, lakes, ground water and soils, making the environment uninhabitable for living things [5,8]. Moreover, these pollutants from crude oil tend to spread faster and wider when in aquatic environment as most moving water bodies are connected. Crude oil and its refined petroleum products have been reported to contain several toxic organic and inorganic components such as polycyclic aromatic hydrocarbon compounds and molecules of sulfur, nitrogen, oxygen as well as metals such as iron, vanadium, sodium, nickel, chromium and other metals [9], which constitutes a significant health risk to both marine organisms and people. Excessive levels of heavy metals are a global concern, due to their potential toxic effects and ability to bioaccumulate in aquatic ecosystems and food chains [10–13]. Moreover, consumption of fish in the world has increased especially due to the available information regarding their nutritional and beneficial health effects in humans. For instance, fish is considered as an important source of animal proteins and other essential minerals, vitamins and unsaturated fatty acids [14]. However, fishes are relatively situated at the top of the aquatic food chain and normal metabolism of fishes can bioaccumulates several heavy metals from contaminated food, water and sediments [15,16]. The contents of toxic heavy metals in fish can counteract their beneficial health effects in humans [17]. Because of serious threats associated with consumption of heavy metals contaminated fish such as renal failure, liver damage, cardiovascular diseases and even death [18,19]. In Nigeria, fish and other aquatic organisms constitute a large part of daily meal of human population, consumption of heavy metal-contaminated fish for prolonged period results in accumulation of heavy metals in human. Bonny River and Finima creek are the major sources of fish and other sea foods for the people of the region. However, incidence oil spills and environmental pollution of nearby rivers and lakes posed a serious health risk to the people of the region due to crude oil spillage and natural gas exploration and refining activities. Although, several studies demonstrated that fishes are important biological indicator for investigation of heavy metal contamination and health risk to both animals directly and human upon consumptions of aquatic foods in different parts of the world [20–24]. However, most of these studies focused mainly to the fish muscle tissue, which is the main part consumed by humans [25,26]. Therefore, herein the present study, our focus is to investigate the level of some heavy metals (Cu, Zn, Fe Mn Ni, Pb and Cd) in muscles, gills and liver tissue of Croaker fish caught from oil spilled rivers of Bonny and Finima which is commonly consumed by the people of Niger Delta region and also assess the quality and safety of the fish for human consumption.

2. Materials and methods

2.1. Study sites and sample collection

Bonny River and Finima creek are located in Rivers state Niger Delta region. Bonny river lies between Latitude 4° 26′ 0″, Longitude 7° 10′ 0″ (Figure 1). The river expands along the coast from the river's basin in the west. The area is characterized by extensive inter-connection of creek. Whereas Finima, is a small town near Bonny Island surrounded by long stretches of creek. Finima's creek is situated 4.8 km away from Bonny river. Bonny river is among the Niger Delta rivers that drain into the Atlantic Ocean and is connected to other rivers via creek. Twenty four Croacker fishes (*Genyonemus lineatus*) weighing between 250 and 260 g and 24–26 cm length were collected from each sampling site described above. The fishes were immediately preserved in an ice box and transferred to the laboratory where they were identified and stored at −80 °C until analysis.

2.2. Sample preparation, digestion and heavy metals determination

Prior to analyses, Croacker fishes were thawed at room temperature, washed with deionized distilled water, then liver, gills and muscles were removed using stainless knives. Each organ was dried at 105 °C until they reach a constant weight. The dried samples were homogenized to fine powder using ceramic mortar and pestle. One gram of each of the ground fish tissues were transferred to a porcelain basin and put into a Thermicon P muffle furnace at a temperature of 550 °C for 5 h. Samples were digested with 10 ml tri-acid mixture (HNO_3:$HClO_4$:H_2SO_4) in a ratio of 6.5:6:2. The samples were heated at 105 °C until a clear colorless solution was obtained. The digested samples were allowed to cool and then diluted to 100 ml with deionized distilled water and then filtered through Whatman filter paper No. 42 and the filtrate was diluted to 100 ml with deionized water for determination of heavy metals (Cu, Ni, Zn, Pb, Mn, Iron Fe, and Cd) concentration by atomic absorption spectrophotometer (Shimadzu Model 6800 with graphite furnace Model GFA 7000). Heavy metals concentrations were expressed as μg/g dry weight.

2.3. Statistical analysis

Data were expressed and presented as mean values ± SEM from triplicates of independent experiments (n = 3) using GraphPad Prism 5.01 version (GraphPad Software Inc., San Diego, CA, USA). Comparisons were made using one-way ANOVA. Turkey's Post hoc test was employed to test the significance of difference between metal species in single organ. Student's *t*-test was used for comparison of data between Bonny and Finima rivers and $P < 0.05$ was considered as statistically significant.

3. Results

This study revealed significant concentrations of Cu, Ni, Zn, Pb, Mn, and Fe in the liver, gills and muscles of fishes sampled from Finima creek and Bonny River, River State Nigeria. The results of fishes from Finima Creek presented in Table 1, showed the highest mean concentrations of heavy metals compared to fishes from Bonny River (Table 2). For instance the mean concentrations of Cu, Zn Fe Mn Ni, Pb, and Cd in fish tissues from Bonny river were in the range of 3.50–45.00 μg/g, 14.00–49.90 μg/g, 102.00–216.03 μg/g, 9.34–11.02 μg/g, 5.33–9.60 μg/g, 0.20–0.50 μg/g and 0.00–1.50 μg/g, respectively. The distribution ranking of Cu, Zn, and Fe were in the order of liver > gills > muscles whereas Mn, Ni, Pb and Cd distributions