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Evaluation of Heavy Metals in Gills, Bones and Muscles of Fishes from Crude Oil Polluted Water of Ogoniland, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author MOM designed the study, wrote the protocol and supervised the work. Author GSI carried out all laboratories work, performed the statistical analysis, managed the analyses of the study, wrote the first draft of the manuscript, managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This study was carried out to determine the concentrations of heavy metals (cadmium, chromium, zinc, manganese, lead and iron) in organs (gills, bone and muscle) of *Iutjanus campechanus and Chrysichthys nigrodidatatus* from Gokhana, and Khana local government areas in River State, Nigeria were investigated.

This heavy metals were determined using atomic absorption spectrophotometer (AAS). The result show that Iron was significantly more abundant in the gills, bone and muscle tissue than other element with mean concentration of 144-144.58 mg/kg in the gills, 18.19-39.77 mg/kg in the bone and 5.47-21.50 mg/kg in the muscle of both catfish and red snapper in Kaa while in bodo-city the concentration varies from 189-238 mg/kg in the gills, 42.16-45.39 mg/kg in the bone and 11.74-43.84 mg/kg in the muscle of both fishes respectively. Maximum concentration of Zinc was recorded in gills from Bodo-city for both fishes and minimum value was recorded in the muscle of both fish

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species in Kaa. High level of chromium, manganese and lead were recorded in bone of both species while the least concentration of all elements was recorded in the muscle of catfish and red snapper. It was observed that the level of metals in all organs were high except for chromium in the muscle which was lower than the permissible limits for human consumption designated by the USEPA, WHO, FAO. The result revealed that the distribution of the heavy metals follow the order Fe>Zn>Mn>Pb>Cd>Cr for *Chrysichthys nigrodidatatus* and Fe>Zn>Pb>Mn>Cd>Cr for *lutjanus campechanus* while the distribution in the organs follow the other Gills>bone>muscle for both fish spices in Kaa and Bodo-City respectively. This reveal the health effect the people in the study area could be exposed to by the consumption of the muscle of catfish and red snapper which have high levels of these metals. Measures need to be taken as the level of Heavy metals detected in organs from the two site posed serious threat to the populace that feed on them.

Keywords: Catfish; red snapper; heavy metals; Gokhana; Kaa.

1. INTRODUCTION

The contamination of aquatic systems with heavy metals has become a matter of concern [1,2]. However metals such as Cr, Mn, Fe and Zn play important biochemical role in the life processes of many organism, and their presence in trace amount are essential. But at high concentration toxic effect are observed. The bioaccumulation of heavy metals in tissues of aquatic organism is an indirect measure of the abundance and availability of metals in the aquatic environment [3]. For this reason fish are widely used as bio-indicator for aquatic pollution and have also been used to evaluate ecological risk [4,5,6]. Humans can be exposed to these heavy metals via food chain, causing health problems to fish consumers. Nigeria is the largest fish consumer in Africa and among the largest fish consumers in the world with over 1.5 million tons of fish consumed annually. Yet, Nigeria imports over 900,000 metric tons of fish while its domestic catch is estimated at 450,000 metric tons/year [7].

2000–2015: Therefore, in the present study assess the heavy metals concentration in tissues (gills, bones and muscle) of two most commonly found and consumed fish species (Catfish and Red snapper) sold in Bodo-city and Kaa beach market Ogoni, Rivers State Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study area, Bodo-city and Kaa, are located in Gokhana and Khana local government area of Rivers State, Nigeria with geographical coordinates of approximately latitudes 4.05° and 4.20° north and longitude 7.10° and 7.30° east. It has a population of close to 832,000 consisting mainly of the Ogoni people.

These areas are a multi-use resource for artisanal and commercial fishing and transportation. Other economic activities in and around the estuary include oil exploration. Oil exploration and production projects may have impacts on the natural environment long before any oil is actually produced. These are complex, multi-faceted projects, with many different phases, including: land survey, land clearance for seismic lines, establishment of seismic and drilling camps, site preparation, infrastructure construction, drilling for oil (even when the effort is unsuccessful) and development of transportation infrastructure. Once a facility begins operating other issues have to be dealt with, such as spills caused during oil production and the disposal of water (often salty and known as 'produced water') and flaring of gas ('produced gases) generated alongside the oil. All of these activities and their effects leave an environmental footprint (UNEP – OEA, 2011).

2.2 Sample Collection and Preparation

Two fish sample Catfish (*Chrysichthys nigrodidatatus*) and Red snapper (*lutjanus campechanus*) were collected from Bodo-city and Kaa water side in Gokhana and Khana local government area of Rivers State, Nigeria. A total of 56 fifty-six Fishes ranging between 350-568 g in weight for catfish and 175-205 g for red snapper were collected. At two site, 28 (14 for each site) individual fish of each species were collected, cleaned and transported in an ice-box to the laboratory where the gills, bones, and muscle were removed. The organs were washed with distilled water and put in petri dishes to dry at 144°C in oven for three days for thorough drying and after that ground to powder using silimic mortar. Five gram of each dried tissue of gills, bone, and muscle were weighed into a crucible container, and then introduced into a furnace to derive the ash for 6 hours. Five ml of

10% HCl was used to dissolve the ash content. It was then filtered into a measuring cylinder and made up to 20 ml with distilled water for the metal analysis using atomic absorption spectroscopy.

2.3 Atomic Absorption Spectroscopy (AAS) Analysis

For each of the metal, atomic absorption spectroscopy was calibrated using metal standard (Cr – 357.90 nm, Cd – 228.80 nm, Pb - 283.30 nm, Zn – 213.9 nm, Mn – 279.50 nm, Fe –248.3 nm). 5 grams of the sample was digested in 20 ml 10% HCL on a heating mantle to near dryness. The extract was aspirated directly into the atomic absorption spectroscopy machine.

3. RESULTS AND DISCUSSION

The result of the analysis (Tables 1 and 2) showed heavy metal concentrations of elements were present in the gills, bone and muscle of the fish sample and at varying concentrations. Iron and zinc had higher concentrations in the gills of *Chrysichthys nigrodidatatus* when compared with other elements measured. Among all the heavy metals analyzed, chromium and cadmium had the least concentration. Their concentrations from the two sites were; 0.68±0.04 and 1.11±0.04 for cadmium and 2.90 ±0.35 and 3.5±0.05 mg/Kg (dry wt.) for chromium from gill of Catfish collected from Kaa, and Bodo-City.

In the bone of the *Chrysichthys nigrodidatatus*, iron and zinc also gave higher concentration as compared to other elements measured from the two sites. Chromium and cadmium had the least concentration.Their concentrations from the two sites were; 0.89±0.02 and 1.03±0.09 for cadmium and 2.76 ±1.60 and 6.48±0.05 mg/Kg (dry wt.) for chromium from bone of catfish collected from Kaa, and Bodo-City respectively.

The muscle of *Chrysichthys nigrodidatatus*, had highest concentrations of iron and zinc in the muscle compared to other elements measured from the two sites. The concentrations of iron varied from 21.50±2.12 and 43.39±2.51 mg/Kg (dry wt) while zinc level were 8.0±0.07 and 10.12±0.17 mg/Kg (dry wt.) from Kaa, and Bodo City respectively. Similarly concentrations of manganese ranged from 0.79±0.46 to 1.56±0.08 mg/Kg (dry wt.) while that of lead were 3.40±0.46 and 4.58±0.10 mg/Kg (dry wt.) from Kaa, and Bodo City respectively. Among all the heavy metals analyzed, cadmium had the least concentrations but not below WHO permissible limits. Their concentrations from the two sites are as follows; 0.23±0.01 and 0.28±0.09 for cadmium and chromium was not detected from the muscle of catfish collected from Kaa, and Bodo-City.

In *lutjanus campechanus*, Iron and zinc gave higher concentration in the gills, bone and muscle when compared to other elements measured from the two sites. Concentrations of iron varied from 144.58±2.87 to 238±2.47 mg/Kg (dry wt.), zinc level were 30.73±1.42 to 34.26±1.21 mg/Kg (dry wt.), manganese ranged from 4.04±0.04 to 10.98±0.89 mg/Kg (dry wt.) while that of lead were 8.88±0.74 and 16.32±0.43 mg/Kg (dry wt.) from Kaa, and Bodo City respectively in the gill. Among all the heavy metals analyzed, chromium and cadmium were lowest. Their concentrations from the two sites are as follows; 0.88±0.09 and 3.06±0.79 for cadmium and 0.85 ±0.01 and 2.89±0.16 mg/Kg (dry wt.) for chromium from gills of *lutjanus campechanus* collected from Kaa, and Bodo City.

In the Bone of Lutjanus *campechanus*, Iron varied from 18.19±0.01 and 42.16±2.44 mg/Kg (dry wt), zinc level were 8.72±4.44 and 19.75±0.66 mg/Kg (dry wt.), manganese ranged from 3.41±0.12 to 11.44±0.63 mg/Kg (dry wt.) while that of lead were 8.32±0.78 and 11.45±0.72 mg/Kg (dry wt.) from Kaa, and Bodo City respectively. Among all the heavy metals analyzed, chromium and cadmium were lowest. Their concentrations from the two sites are as follows; 0.46±0.23 and 0.94±0.01 for cadmium and 2.80 ±1.61 and 5.13±0.01 mg/Kg (dry wt.) for chromium from bone of *Lutjanus campechanus* collected from Kaa, and Bodo City.

In the muscle of *Lutjanus campechanus also* manganese ranged from 0.12±0.08 to 0.86±0.01 mg/Kg (dry wt.) while that of lead were 2.16±0.05 and 4.76±0.66 mg/Kg (dry wt.) from Kaa, and Bodo City respectively. Among all the heavy metals analyzed, chromium and cadmium were lowest but not below WHO permissible limits. Their concentrations from the two sites are as follows; 0.12±0.05 and 0.48±0.14 for cadmium and chromium was not detected from the muscle *Lutjanus campechanus* collected from Kaa, and Bodo city.

The result showed that heavy metal accumulated at varying levels in different tissues of catfish and red snapper. The concentration of heavy metals in different organs of fish followed the decreasing order Fe> Zn> Mn> Pb> Cr> Cd for both the gills and bone, and Fe> Zn> Pb> Mn> Cr> Cd for the

Table 1. Heavy metal concentrations (means ± S.E.M, mg/kg dry wt.) in gills, bone and muscle of *Chrysichthys nigrodigitatus* from the study areas (Kaa and Bodo-city). n=14

Heavy metals mg/kg	Kaa Gills	Bodo-city Gills	Kaa Bone	Bodo-city Bone	Kaa Muscle	Bodo-city Muscle
Cr	2.90± 0.35	3.5±0.05	2.76±1.60	6.48±0.05	BDL	BDL
Cd	0.68 ± 0.04	1.11±0.05	0.89±0.02	1.03±0.09	0.23±0.01	0.28±0.01
Pb	5.31± 0.68	9.0±0.71	9.60±0.42	10.32±0.17	3.40±0.46	4.58±0.10
Zn	19.10± 0.24	28.12±1.10	18.85±0.15	20.76±0.49	8.00±0.07	10.12±0.17
Fe	144.0±0.08	189±0.03	39.77±0.84	45.39±0.76	21.50±2.12	43.84±2.51
Mn	6.63±0.69	12.49±2.54	8.21±0.66	14.30±0.53	0.79±0.46	1.56±0.08

Table 2. Heavy metal concentration (means ± S.E.M, mg/kg dry wt.) in gills, bone and muscle of *Lutjanus campechanus* from the study areas (Kaa, and Bodo City)

Heavy metals mg/kg	Kaa Gills	Bodo-city Gills	Kaa Bone	Bodo-city Bone	Kaa Muscle	Bodo-city Muscle
Cr	0.85± 0.01	2.89±0.05	2.80±1.61	5.13±0.01	BDL	BDL
Cd	0.88 ± 0.09	3.06±0.05	0.46±0.23	0.94±0.01	0.12±0.05	0.48±0.14
Pb	8.88± 0.74	16.43±1.21	8.32±0.78	11.45±0.72	2.16±0.05	4.76±0.66
Zn	30.73± 1.42	34.26±1.21	8.72±4.44	19.75±0.66	4.10±1.75	9.47±0.01
Fe	144.58±2.87	238.0±2.47	18.19±2.01	42.16±2.44	5.47±1.25	11.74±0.75
Mn	4.04±0.04	10.98±0.89	3.41±0.12	11.44±0.63	0.20±0.46	0.86±0.01

Value are expressed as mean ± standard error of mean (SEM) (n=14)

muscle and gills of catfish and red snapper while the distribution of the heavy metals in the investigated part (organs) is shown to follow the order gills> bone> muscle for both catfish and red snapper. This observed trend clearly reveals organ specific accumulation of the heavy metals in catfish and red snapper obtained from Kaa and Bodo-city River from where the fish was caught. The result show that Iron had the highest concentration of all the heavy metals in the order of gills >bone> muscle which exceeded the permissible limits of WHO, and USEPA (0.30/0.5 mg/kg) followed by Zn in same other with permissible level of 5 mg/kg. Also Pb varies from gills>bone>muscle in the red snapper and bone> gills> muscle in catfish with WHO limit of 2 mg/kg. Mn followed the bone> gills> muscle in both fish sample with WHO and USEPA of (0.02 and 0.5 mg/kg). Cd and Cr also had the least concentration but higher than the permissible limit of 0.01 mg/kg and vary as gills>bone> muscle for Cd in both fish samples and bone> gills >muscle for Cr. The result also revealed that among the organs, gills and bone were found to accumulate the highest amount of all the metals indicating the importance of these organs as bio indicators to study levels of heavy metals.

Humans that rely on the fish and water from Ogoni-Land are at great risk. The bioaccumulation of these metals may pose great hazard to health of humans. Chronic lead poisoning is characterized by neurological defects, renal tubular dysfunction and anemia. Damage of Central Nervous System is a marked feature especially in children [8]. In men, lead affects the male gametes resulting in sperm abnormalities and decreased sexual desire as well as sterility [9]. In women, lead poisoning is associated with abnormal ovarian cycles and menstrual disorders in addition to spontaneous abortion [10].

The accumulation of metals by the fish depends on the location, feeding behavior, trophic level, age, size; duration of exposure to metals and homeostatic regulation activities of fish [11,12]. Therefore, metals concentration in fish could be used as an index to estimate level of pollution especially in aquatic bodies [13] even in the lake system. Chemical analysis of fish, therefore, ensures dietary safety of the fish from a particular body of water [14].

Consequently, it can be concluded that the levels of heavy metals in these fish species are at unacceptable levels for all the studied organs from these sites. Only chromium in the muscle of catfish and red snapper were lower than the acceptable values for human consumption designated by the [15]. This study shows that measures need to be taken in order to prevent future heavy metal pollution and such data provide valuable information on safety of fishes commonly consumed by the public.

4. CONCLUSION

In this study, heavy metals concentrations in the gills, bone and muscle of both *lutjanus campechanus* and *Chrysichtys nigrodidatatus* from Khana and Gokhana have been analysed. From the result, mean concentration of Cr, Cd, Pd, Zn, Fe and Mn are high and above the maximum recommended values by EC [16], thus consumption of these fishes may pose significant health risk to the populace who consume this fish species.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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