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Original Research Article

Bacteriological and Physiochemical Assessment of Water, Sediment and Fish Qualities along Wetland in Isoko Region of Delta State Nigeria

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Abstract

There is need for the investigation into heavy metals and microbial loads in edible aquatic organisms, to evaluate their safety and compliance with standards approved by international regulatory bodies' which regulates food and water quality. The heavy metals and total heterotrophic bacterial (THB) concentrations in catfish, surface water bodies and sediments collected from the wetlands of Isoko region of Delta State, Nigeria were determined in accordance to standard approved methods. The laboratory results revealed that the lead, cadmium, zinc and THB concentrations in the fish body parts (gills and muscle) sampled were lower, compared with those obtained from sediments samples. The lead concentration was 1.13 mg/kg and 28.01 mg/kg for the water and sediment samples respectively. Cadmium concentration of 0.19 mg/kg and 1.64 mg/kg was recorded for the water and sediment samples respectively. Then the zinc concentration was 0.39 mg/kg in the water sample and 87.17 mg/kg in the sediment samples. In terms of the fish body parts, the results revealed that the zinc, lead, cadmium and THB concentrations in the fish gills were higher, compared to the values recorded in the fish muscle. It was observed that the cadmium concentration in the fish gills and muscle was higher than the maximum allowable limit of 0.17 mg/kg approved by the FAO; while the lead and zinc concentrations in the fish gills and muscle were lower than the maximum allowable limit of 0.5 mg/kg and 67.1 mg/kg respectively, approved by the FAO for edible fish. Finding from this study will be helpful in taking appropriate measures to prevent bioaccumulation of toxic heavy metals and microbes in aquatic organisms, to levels above the maximum allowable limits approved by FAO or other regulatory bodies.

Keywords: Catfish, heavy metals, microbial load, sediment, wetland.

1.0 INTRODUCTION

Pollution of the aquatic ecosystem is a growing global concern. This is due to the accumulation of toxic materials in the water bodies and in aquatic organisms. Accumulation of heavy metals and microbial load in the bodies of aquatic organisms has been identified as an indirect measure of the abundance and availability of these contaminants in the aquatic ecosystem (Kucuksezgin *et al.*, 2006; Mendis *et al.*, 2015). This pollution which is caused mainly by anthropogenic activities is further aggravated by increase in the world's human population, industrialization, agriculture practices, oil exploration and production, etc. This pollution has led to the continuous increment of heavy metals and harmful microorganisms in the ecosystems, especially in the aquatic ecosystem (Gupta *et al.*, 2009; Abdel-Baki *et al.*, 2011; Ogbaran and Uguru, 2021a). Wang and Rainbow (2008) reported that the aquatic ecosystem can be polluted by toxic heavy metals through: direct atmospheric deposition, geologic weathering or/and discharge of industrial waste materials into the environment (Ogbaran and Uguru, 2021b).

According to Agbi *et al.*, (2021), emissions from vehicular traffic activities substantially ($p \leq 0.05$) increased the heavy metals (copper, zinc, lead, and cadmium) contamination of the terrestrial ecosystem. Similarly, Wiseman *et al.*, (2013) and Ogundele *et al.*, (2015) reported that automobile activities increased the accumulation of toxic heavy metals (lead, nickel and copper) in the roadside vegetation and soils. These will eventually be wash/leach into the surface water bodies, hence contaminating the aquatic ecosystem. Ofomola *et al.*, (2017) studied the effect of solid wastes leachates on the groundwater quality, and reported that the solid wastes leachates had harmful effects on the groundwater quality and the ecosystem. Contaminants are intentionally or unintentionally discharged into the environment daily, which result in potential deterioration of the environment with proven harmful effects on both plants and animals (Li, 2018; Akpomrere and Uguru, 2020a).

Fishes are the most suitable specimens employed in the determination of the bioaccumulation levels of toxic materials (heavy metals and microbial load) in organisms living in the water. This is because it is presumably the best understood organisms in the aquatic environment, and also because its importance as a main source of protein to human beings (Buikema *et al*., 1982; Mendis *et al*., 2015). Several researches (Chakraborty *et al*., 2003; Malik *et al*., 2010; Younis *et al.*, 2015; Topanou *et al*., 2020) had indicated the negative impact of polluted water bodies on the fishes inhabiting such contaminated waters. Abdel-Baki *et al*., (2011) reported the bioaccumulation of metals (Pb, Cd, Hg, Cu and Cr) in the gills, tissues and liver of tilapia fish; which they attributed to the high concentrations of Pb, Cd, Hg, Cu and Cr in the water and sediment samples. Sediment, just like soils, act as natural reservoirs for the accumulation of contaminants, which include metals (Akpomrere and Uguru, 2020b). Hence, the contamination of the sediments significantly affects the water quality, which will lead to the bioaccumulation of these contaminants in aquatic organisms. When the aquatic organisms, e.g. fishes are assimilated by human beings, it can result in potential long-term implications on human health (Fernandes *et al*., 2007; Gupta *et al*., 2009; Agah *et al*., 2009).

Although several research findings had revealed the level of heavy metals accumulation in several species of fishes, there is no recorded literature on the bioaccumulation of heavy metals and microbial load contamination in catfish harvested from the freshwater of Isoko region of the Niger Delta, in Southern Nigeria. Therefore, the main objective of this study is to determine the concentration of heavy metals and microbial load in the water, sediment and organs of catfish harvested from Isoko region of Delta State, Nigeria, as measure of the degree and impact of contamination of such waters.

2.0 MATERIALS AND METHODS

Study Site

Isoko wetland is a large vast area covering several communities in the south-eastern and north eastern parts of the Isoko region of Delta State, Nigeria. Isoko is characterized by two main climatic seasons, which are: the rainy season which occur between April and October, with an average annual rainfall of about 1800 mm; and the dry season which occur between November and March, with an average temperature of about 30^{0}C. Isoko wetland is usually subjected to high flood levels during the rainy season, when fishing business become lucrative to the fishermen (Eboibi *et al*., 2018).

The wetland is subjected to various anthropogenic activities, such as indiscriminate solid and liquid wastes disposal, uncontrolled agricultural activities, etc. During flood period the area receives most of its water from some of the tributaries of River Niger. The flood water from the tributaries of River Niger usually carries various effluents, sediments and contaminants from upstream.

Samples Collection

The catfish (order Siluriformes) samples were harvested by using a fishing basket, at the beginning of dry season (January 2020). The fish samples were code labeled and placed in a clean ice packed box, and taken immediately to the laboratory for biochemical analysis.

Also the sediment samples were collected from the wetland area within which the fish samples were collected, by using the Van-Veen grab sampler, employed according to procedures described by Akpomrere and Uguru (2020b). The sediment samples were also coded and placed in an ice box, and taken immediately to the laboratory for biochemical analysis.

Water samples were randomly collected from the same vicinity in sterilized bottles, which were also coded and placed in an ice box, and taken immediately to the laboratory for biochemical analysis.

Laboratory Analysis

Heavy metals determination

Water samples

Water samples were digested according to methods described by ASTM D1971-16 (2016). The zinc concentration of the digested water was determined in accordance with ASTM D1691-17 (2017) recommended procedures; the cadmium concentration of the digested water was determined in accordance with ASTM D3557-17 (2017) recommended procedures; while the lead concentration of the digested water was determined in accordance with ASTM D3559-15 (2015) recommended procedures, using the Atomic Absorption Spectrophotometry.

Sediment samples

The sediment samples were digested after drying, in accordance with methods described by ASTM D3974-09 (2015). Then the zinc, cadmium and lead concentrations in the digested sediment samples were determined in accordance with ASTM International procedures, using the Atomic Absorption Spectrophotometry.

Fish samples

The gills and muscles were extracted from the fish and their biochemical properties tested separately. The different fish parts were digested after drying according to AOAC (1995) methods. The levels of Pb, Cd and Zn concentrations in digested samples were determined by using the atomic absorption spectrophotometer (Younis *et al*., (2015).

Microbial load determination

The Total Heterotrophic Bacterial (THB) of all the samples was determined by using standard APHA procedures (APHA, 2001). The samples were incubated at 22°C for 3 days to obtain a mixed culture. Then the isolated colonies were recorded and purified to obtain pure culture by repeated sub-culturing on fresh media used for primary isolation as described by Chikozie (2015).

All the laboratory tests were conducted in triplicate and the average values obtained were recorded.

Statistical Analysis

The one-way Analysis of Variance (ANOVA) was used to analyze the results obtained from this study. While the means were separated using Duncan's Multiple Range Tests (DMRT) at 95% confidence level ($p \leq 0.05$). Then Microsoft excel was used to determine the average and standard deviation of the data obtained from the laboratory tests.

3.0 RESULTS AND DISCUSSION

RESULTS

The ANOVA results of the study are presented in Table 1. As shown in Table 1, significant ($p \leq 0.05$) difference existed between the concentrations of heavy metals and THB, in the water, sediment, gills and muscle tissue samples.

Furthermore, the results of the mean concentrations of heavy metals and Total Heterotrophic Bacterial in the water, sediments and fish parts samples are presented in Table 2. Results of the concentrations of the parameters were generally higher in the sediment samples than in the water samples. As presented in Table 1, although significant ($p \leq 0.05$) difference existed among all the parameters tested for in the water, sediment and fish parts samples; there was however no significant ($p \leq 0.05$) difference between the lead and cadmium concentrations of the water, fish gills and fish muscle tissue samples, as shown in Table 2.

Table 1: One-way ANOVA of the results obtained from this study

Variable		SS	df	MS	F	p-value
Pb	Between Groups	1685.48	3	561.83	598.42	9.52E-10*
	Within Groups	7.51	8	0.939		
	Total	1692.99	11			
Cd	Between Groups	3.576	3	1.19	6.99	0.013*
	Within Groups	1.36	8	0.17		
	Total	4.94	11			
Zn	Between Groups	15750.83	3	5250.28	616.56	8.45E-10*
	Within Groups	68.12	8	8.53		
	Total	15818.96	11			
TBH	Between Groups	7.08	3	2.36	23610.89	4.0E-16*
	Within Groups	0.001	8	0.00		
	Total	7.08	11			

*significant at $p \leq 0.05$ according to Duncan's multiple range tests (DMRT)

Table 2: The concentrations of the parameters investigated in the study

Parameter	Water	Sediments	Fish part	
			Gills	muscle tissue
Lead (mg/kg)	$1.13^{a}\pm0.14$	$28.01^{b}\pm1.94$	$0.44^{a}\pm0.02$	$0.36^{a}\pm0.02$
Cadmium (mg/kg)	$0.19^{a}\pm0.03$	$1.64^{b}\pm0.82$	$0.78^{a}\pm0.11$	$0.45^{a}\pm0.03$
Zinc (mg/kg)	$0.39^{a}\pm0.02$	$87.17^{d}\pm5.67$	$7.34^{c}\pm1.22$	$3.37^{ab}\pm0.63$
Total heterotrophic bacterial ($x10^{5}$)	$2.85^{c}\pm0.02$	$3.04^{d}\pm0.16$	$1.53^{b}\pm0.01$	$1.31^{a}\pm0.01$

±Mean and standard deviation; rows with the same common letter (superscript) are not statistically different according to DMRT at $p \leq 0.05$; n=3.

DISCUSSION

Water and sediment samples

As presented in Table 2, the concentrations of the heavy metals in the water and sediment samples were generally high. The lead, cadmium and zinc concentration recorded in the water sample was 1.13 mg/kg, 0.19 mg/kg and 0.39 mg/kg, respectively. Likewise, lead, cadmium and zinc concentration recorded in the sediment sample was 28.01 mg/kg, 1.64 mg/kg and 87.17 mg/kg, respectively. It was observed from the results that the lead and zinc concentrations in the sediment samples were lower than the maximum allowable of 85mg/kg and 140 mg/kg respectively, approved by the Nigeria Department of Petroleum

Resources (DPR) for wetland sediments. In contrast, the cadmium concentration in the sediment samples was higher than the maximum allowable of 0.8 mg/kg, approved by DPR for wetland sediments. Similarly, the results depicted that the THB concentration in the water samples (2.85 x 10^5) was significantly ($p \leq 0.05$) lower than the THB concentration (3.04 x 10^5) in the sediments samples; this could be attributed to the bioaccumulation of their microbial load in the wetland sediments.

The high THB concentration recorded in the water and sediment samples could be attributed to indiscriminate waste disposal and other anthropogenic sources. Similarly, the fairly high concentration of the heavy metals concentrations in the study area, mostly the cadmium concentration, could be attributed to the type of wastes and effluents the area received. According to Akpokodje and Uguru (2019) petroleum products and automobile parts can significantly alter heavy metal concentrations and physic-biological properties of sediments. Similarly, Ogbaran and Uguru (2021a) stated that effluents from solid wastes have the ability of contaminating the ecosystem; hence, they can increase the heavy metal concentrations in sediments and water bodies.

Results obtained from this study were similar to results of precious studies obtained by Akpomrere and Uguru (2020b) and Ogbaran and Joseph-Akwara (2021), for wetlands within Isoko metropolis. Although the results of heavy metals concentrations recorded in this study were lower, when compared to the results reported by Akpomrere and Uguru (2020b), the differences could be attributed to the types of anthropogenic activities taking place within the area covered by Akpomrere and Uguru. According to Akpomrere and Uguru (2020b), their study area was prone to illegal crude oil refining and crude oil spill; and it had been established (Akpokodje *et al.*, 2019; Idisi and Uguru, 2020) that crude oil increased the physic-chemical properties of soil/sediments, which explains why remediation becomes inevitable after crude oil spills.

Fish parts (gills and muscle tissue) samples

The results of the study represented in Table 2 depicted that the heavy metals and THB concentrations recorded in the fish gills were higher, when compared to the values recorded in the fish muscle tissues. In the gills, lead and cadmium concentrations of 0.44 mg/kg and 0.78 mg/kg were recorded, which were not significantly ($p \leq 0.05$) higher than the 0.36 mg/kg and 0.45 mg/kg recorded in the fish muscle tissues. In contrast, the zinc concentration (7.34 mg/kg) recorded in the fish gills was significantly ($p \leq 0.05$) higher than the concentration (3.37 mg/kg) recorded in the fish muscle tissues. This finding compared well with previous findings of Demirak *et al*., (2006) and Younis *et al.*, (2015), where the gills of the fishes, irrespective of the species, accumulated high heavy metals and microbial load than the fish muscles.

The high concentration of Pb and Zn accumulation in the catfish body can be attributed to the fact that the Pb and Zn concentrations of the water and sediment samples were very high. Similar results were reported by Mendis *et al*., (2015), for gray mullet fish (*Mugil cephalus*) samples collected from Negombo estuary in the West coast of Sri Lanka. The zinc concentration obtained from this study compares well to the previous report by Mastan (2014) on two freshwater fish (*Labeo rohita* and *Channa striatus*) species harvested from the Pradesh coastal region of India.

As presented in Table 2, the lead and zinc concentrations in the fish body, irrespective of the body parts were lower than the maximum allowable limit of 0.5 mg/kg and 67.1 mg/kg respectively approved by FAO; in contrast, the cadmium concentration in the fish body, irrespective of the body parts, was higher than maximum allowable limit of 0.17 mg/kg (FAO, 1983). Cadmium toxicity includes renal malfunction in human beings (Payen, 2007). In terms of the microbial load, the findings of the study revealed that the fish gills accumulate a significantly ($p \leq 0.05$) higher THB concentration (1.53 x 10^5), when compared to the 1.31 x 10^5 recorded in the fish muscle tissues.

Furthermore, the finding of this study calls for proactive measures to be taken to prevent further accumulation of heavy metals and microbial loading in the region, to prevent bioaccumulation of toxic metals and microbes in the aquatic organisms (mostly the edible ones), to level above the maximum allowable limits approved by FAO or other regulatory bodies.

4.0 CONCLUSION

The concentration of toxic heavy metals and bacterial in aquatic organisms had become a major concern, since the accumulation of these materials in edible aquatic organisms, could have harmful effects on human beings. This study was carried out to investigate the cadmium, lead, zinc and THB concentration of the water, sediment and fish body parts (gills and muscle tissue) samples collected from the wetland in Isoko region of Delta State, Nigeria. Results obtained from the laboratory tests revealed that the heavy metals (lead, cadmium and zinc) and THB concentrations in the water sample were lower than the concentration recorded in the sediment samples. Likewise, it was observed from the results, that the heavy metals and THB concentrations in the fish gills was higher, when compared to the values obtained in the fish muscle tissues. Regarding standard regulator limits, the findings of this study revealed that the cadmium concentration in the fish body was higher than the maximum permissible limit approved by FAO. Additionally, from the study, it can be concluded that the lead and zinc concentrations of the catfish, were lower than the maximum permissible limits set by FAO. Results obtained from this study had revealed that, necessary precautionary measures should be taken to prevent accumulation of more heavy metals and microbes, in edible aquatic organisms inhabiting the region.

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