International Journal of Multidisciplinary Comprehensive Research

Level of heavy metals status in Osara Dam

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Article Info

ISSN (online): 2583-5289
Volume: 02
Issue: 01
January-February 2023
Received: 25-12-2022;
Accepted: 11-01-2023
Page No: 14-18

Abstract
Aquatic ecosystems such as rivers, dams and lakes provide livelihood for rural populations in many developing countries in Africa. However, in the recent past, they have been subjected to various forms of degradation due to pollution arising from domestic wastes, industrial effluent, agricultural run offs and bad fishing practices. The study determines the heavy metal concentrations of water from Osara dam in Okehi local government area of Kogi state, as well as their sediments and parts of two fish species using Atomic Absorption Spectrometer (AAS). Water samples were collected from eight selected sampling sites from Osara dam. There results were below or within the range of the recommended limit of world health organisation (WHO). Similarly, the head, gills, muscle and liver of the two fishes sample collected from Osara dams were found to contain all the analysed heavy metals (Mn, Cu, Pb, Cd, Fe, Zn, Cd, Cr, and Ni) at different levels.
Some of the determine metals in the parts of the fishes may not be harmful to consumers because the observed values of heavy metals were below the permissible limits issued by WHO for human consumption however, elements like Cr, Ni and Pb call for serious concerned.

Keywords: osara, dam, anthropogenic

Introduction

Aquatic ecosystems such as rivers, dams and lakes provide livelihood for rural populations in many developing countries in Africa. However, in the recent past, they have been subjected to various forms of degradation due to pollution arising from domestic wastes, industrial effluent, agricultural run offs and bad fishing practices (Ndimele, 2008) [20]. Increasing pollution in water bodies is directly or indirectly related to increasing urbanization and indiscriminate disposal of agrochemical and industrial effluents (Dua and Gupta, 2005, Bakare, *et al*., 2003) [11-12]. As a result, many water resources have been rendered polluted and hazardous to man and other living systems.

The aim of this study was to assess the heavy metals content (Pb, Hg, Cd, Cr, Zn, Ni, Cu, Co, Fe, Mn) in water, sediments and in fishes from Osara Dam in Okehi local government of Kogi state. The results obtained from this study would provide information for background levels of metals in the water, sediment and fish species of the dam, contributing to the effective monitoring of both environmental quality and the health of the organisms inhibiting the dam ecosystem. Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bio accumulate in aquatic ecosystems (censi, *et al*.; 2006) [10]. Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biota (Camusso, *et.al*; 1995) [9] which generally exist in low levels in water and attain considerable concentration in sediments and biota (Aladesanmi & Awotoye 2014) [1]. Interest in metals like Zn, Cu, Fe and Mn, which are required for metabolic activities in organisms, lies in the narrow "window" between their essentiality and toxicity. Other heavy metals like Cd, Hg, Cr and Pb may exhibit extreme toxicity even at low levels under certain conditions, thus necessitating regular monitoring of sensitive aquatic environments (Fatoki & Mathabatha, 2001) [13]. The essential metals like Cu, Zn, Fe and Co have important biochemical functions in living organisms at the levels, which allow the enzymes systems to function without interference. These essential metals can also produce toxic effects when the metal intake is excessively elevated (Tüzen, 2003) [26].

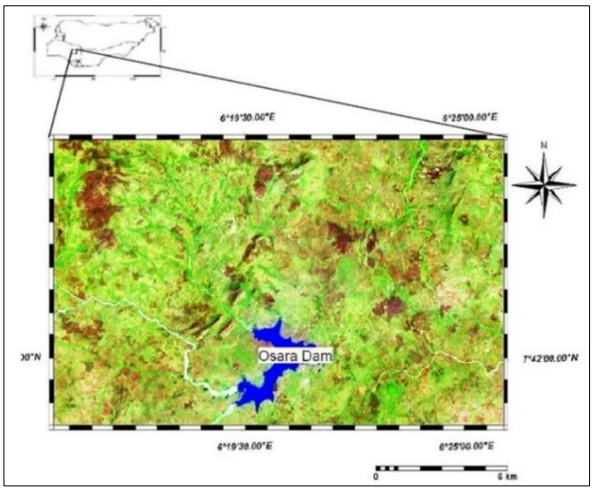
Bioaccumulation of chromium, lead, mercury, zinc, copper and nickel is known to adversely affect liver, muscle, kidney and other tissues of fish, disturb metabolism and hamper development and growth of fish (Ali & Shakoori, 2008, Birge *et al;* 2000) [2 &8]. Studies on heavy metals in rivers, dams, fish and sediments have been a major environmental focus especially during the last decade (Özmen, 2004, Begüm, *et al*; 2005, Fernandes, *et al*; 2008, Öztürk, *et al*, 2008; Pote, *et al*; 2008 and Praveena, *et al;* 2008) [21, 7, 14, 22, 23 & 24]. Sediments are important sinks for various pollutants like pesticides and heavy metals and also play a significant role in the remobilization of contaminants in aquatic systems under favourable conditions and in interactions between water and sediment. Fish samples can be considered as one of the most significant indicators in freshwater systems for the estimation of metal level (Rashed, 2001) [25]. Osara Dam was constructed to help Alleviate the water problems of the residents and many inhabitants of the area also carry out farming and fishing activities on the Dams. Aside these, the vicinity of the dams also serves as refuse dump. As a result of these agriculture and human activities, the quality of these dams is been degraded. To the best of our knowledge and from literature survey so far, no work has been carried out on the environmental quality of water, sediments and biota of the dam. The aim of this study was to determine the heavy metals status (Pb, Hg, Cd, Cr, Zn, Ni, Cu, Co, Fe, Mn) in water, sediments and in fishes from Osara Dam. The results obtained from this study would provide information for background levels of metals in the water, sediment and fish species of the dam, contributing to the effective monitoring of both environmental quality and the health of the organisms inhibiting the dam ecosystem.

Materials and methods

Site Description

Osara dam is located in Okehi Local Government area of Kogi State in the north central part of Nigeria. It is bounded between Latitude 70 401 and 70 471 North of equator and longitude 60 151 and 60 261 East of the Prime Meridian. The Dam site is situated about 6km north of the NIOMCO and it is accessible through Lokoja-Okene highway and Abobo-Dam untarred road. The outcrops in this area were accessed through these routes and cattle tracks, footpaths and river and stream channels. The Osara dam is located approximately 8 km from main settlement. It is used for irrigation and fisheries.

Water and fish samples were collected from the dam. Three (3) sampling locations were chosen along the course of the water body. A sampling location was located upstream, mid-stream and downstream where collection of water, sediment, and fish samples was done. Eight sampling sites were chosen to represent different sub basins that drain into the reservoir in order to understand the influence of natural and human activities on the reservoir.



***Sources*:** www. Academia.edu/5029064/osara_ work_1 [19]

Fig 1: Map of Osara Dam

The study period comprises of 3 months of wet season and 3 months of dry season (between August and October for wet season and the dry season was between January and March). Samples were obtained within the hours of 7.00 am during the designated days. Digestion of water sample was done according to Julius *et al* 2015[16]. The samples of available fish species in the dam were caught using the local fisherman. Samples of snake head fish (parachanna sp.) and flat head fish (pylodictis) were collected with the services of local fisher men licensed to explore the fisheries of the Dam, using cast and gill nets. Fish samples were digested according to AOAC, 2000 [3]. Method validation was carried out to ascertain the validity of the analytical method used. The analysis of heavy metals with AAS was done using perkin Elmer model 460. Accuracy of analytical procedure was validated by recovery test. The statistical software package Graphpad – prism 8 was used for the analysis of variance ANOVA to examine the significance level of all parameters measured. Tukey's multiple comparisons test was used for means comparison. The level of significance for the t-test and means comparison was at $p<0.05$.

Results and Discussion

The percentage recovery for the water samples lies in the range of 103 – 83%, 85% - 110% for sediment. The recoveries obtained in Flat head fish and Snake head fish from Osara dam varied from 105-83% and 110 - 84% respectively. These values were within the acceptable range of 80 to 120% for the elements indicating good accuracy for the analysis procedure (Machado & Griffith 2005) [17].

The results of the physicochemical parameters of water in Osara Dam were presented in table 1 below. The average values of the physicochemical parameters are as follows temperature-29.66 ° C, pH -6.98, Dissolved Oxygen - 3.72 mg l^{-1}, Conductivity - 3.73 µs cm^{-1}, Total Alkalinity - 3.21

mgl^{-1}, Total hardness - 4.75 mg l^{-1}, Total Dissolved Solids - 1.73 mgl^{-1}. Except temperature and pH values which are within the permissible range of WHO, all the values are by far below the regulatory body values as shown in table 1 suggesting that the water may be very suitable for aquatic animals and also good for domestic and agricultural use.

Table 1: Comparison of Physio-Chemical Parameters and Means metal Concentration in Water Samples with WHO Standards

parameter	This Study Osara	WHO Standard Highest Desirable	WHO Standard Maximum Permissible
Temperature (° C)	29.66	30-32	30-32
pH	6.98	7.0-8.9	6.5-9.5
Dissolved Oxygen (mg l^{-1})	3.72	-	-
Conductivity (µs cm^{-1})	3.73	900	1200
Total Alkalinity (mgl^{-1})	3.21	100	100
Total hardness (mg l^{-1})	4.75	100	100
Total Dissolved Solids (mg l^{-1})	1.73	500	1500

As shown in Table 2, the mean concentration (mg/L) for Mn, Cu, Cr, Fe, Ni, Pb, Co, and, Zn, are 0.41 ±0.22, 0.20 ±0.06, 0.25±0.08, 1.84 ± 0.42, 0.17 ± 0.07, 0.22 ±0.14, 0.20 ±0.08**,** 0.30 ± 0.10 for dry season and 0.42 ± 0.23, 0.25 ±0.12, 0.26 ±0.14, 1.80 ±0.24, 0.30 ± 0.13, 0.36 ±0.07, 0.20 ±0.06, 0.31 ±0.09 for wet season respectively. Iron concentrations in Osara water samples constituted a major portion of the total metal ions determined, while Ni and Co concentrations were the lowest value investigated in dry and wet seasons respectively. The order occurrence of the metals in the water samples in descending trend was as follows: Fe >Mn, >Zn >Cr >Pb >Co & Cu >Ni for dry season and Fe >Mn, > Pb >Zn > Ni >Cr > Cu > Co for wet season.

In terms of seasonal variation of metals, some dry season values were higher than wet season values or vice versa. The reasons for lack of seasonal variations are not clear but may be attributed to high variability over large areas of samplings and restriction of number of samples.

It appears that seasonal variations in the concentrations of heavy elements in the dam is strongly dependent on both the drainage water discharged from the various drains in the dam as well as the velocity and direction of winds. This could also be as a result of evaporation which leads to concentration of the metals; however, it could also be as a result of slow water currents in the dry season, which allows particles to settle.

The presence of heavy metals in the dam are mainly of allochthonous origin due to either agricultural influx, wastes of farms or sewage via surrounding cultivated lands.

The concentration level of iron in the study area (1.84mg/l) is high than what was obtained in Sudha dam in india with a value of 0.072mg/l (Mane, 2013) [18] as well as WHO set limit of 0.3mg/l. The high value of Fe in the study area could be attributed to the proximity of the dam to an iron mining company.

Generally, the average concentrations of heavy metals in the study dam were found to be relatively higher than other studies in the literatures sited except in Zn where it appeared to be lower and also found to be within the permitted limit of 3.0 set by WHO 2011[27] as shown in Table 2. Differences between our data and the literatures sited may have probably originated from variations in geological mining history of localities and urban as well as domestic activities.

Table 2: Comparison of heavy metal concentrations (Mg/L) in the water samples with different literature

	Metals									
Guidelines	**Mn**	**Cu**	**Cr**	**Fe**	**Ni**	**Pb**	**Co**	**Cd**	**Zn**	**Reference**
Sudha dam/India	0.069	0.025	0.002	0.072	-	-	-	-	0.63	Mane, *et al;* 2013[18]
Osara dam	0.41±0.22	0.20±0.06	0.25±0.08	1.84±0.42	0.17±0.07	0.22±0.14	0.20±0.08	-	0.30±0.10	This study (Dry season)
Osara dam	0.42±0.23	0.25±0.12	0.26±0.14	1.80±0.24	0.30±0.13	0.36±0.07	0.20±0.06	-	0.31±0.09	This study (Wet season)
Jibiya dam/katsina	-	-	-	0.75	0.11	0.1	-	0.24	-	Ibrahim, *et al;* 2018[15]
Thomas dam kano	-	0.012	1.01	-	0.63	0.04	-	0.16	0.51	Butu, *et al*; 2019[5]
WHO	0.5	2.0	0.05	0.3	0.02	0.01	-	0.003	3.0	WHO 2011[27]

The levels of heavy metal concentrations recorded in the head, gills, muscle and liver of the two investigated fish species from the osara dam are presented in Table 3 and 4.

For all metals, the mean values of metals do not differ significantly between the head, gills, muscle and liver. But Fe concentrations were highly significant in the livers than in any other part of the tissue ($p<0.05$) in each case). Metal concentrations in the fish samples did not vary between the sampling sites and metal concentrations did not differ between fish species ($p<0.05$).

In this study, the liver organ contains the highest level of all the analysed heavy metals in the two fish except in Pylodictis where Pb appeared to be high in the Head of the fish. This conforms to the results of previous studies where heavy metals were more concentrated in the liver than in other parts of fish tissues/organs (Ali, 2008) [2].

The 0.18mg/kg value of Ni found in the liver organ is in agreement with what was obtained in the liver of fish species obtained from Kowa dam, Gombe state (Ezekiel, 2019) [12].

The concentration value of Mn and Co in all the organs analyse is less than what was obtained in the same study in Kowa dam. The concentration value of some metals like Cr and Fe of the two fish in this study appeared to be higher as compared to the set limit of the WHO as shown the Table 3

and 4.

Table 3: The heavy metal concentrations (mg/kg dry weight) of Pylodictis-Flat Head Fish (FHF) from Osara Dam

Parameter	Mn	Cu	Cr	Fe	Ni	Pb	Co	Cd	Zn
Head	0.12^{a} ±0.02	0.12^{a} ±0.04	0.11^{a} ±0.01	1.10^{a} ±0.07	0.17^{a} ±0.04	0.13^{a} ±0.04	0.12^{a} ±0.02	BDL	0.08^{a} ±0.01
Gill	0.15^{a} ±0.04	0.11^{a} ±0.00	0.13^{a} ±0.04	1.11^{a} ±0.04	0.15^{a} ±0.04	0.12^{a} ±0.05	0.13^{a} ±0.01	BDL	0.08^{a} ±0.02
Muscle	0.13^{a} ±0.04	0.12^{a} ±0.01	0.13^{a} ±0.04	1.07^{a} ±0.01	0.15^{a} ±0.00	0.10^{a} ±0.01	0.11^{a} ±0.00	BDL	0.08^{a} ±0.00
Liver	0.18^{a} ±0.04	0.16^{a} ±0.05	0.14^{a} ±0.04	$1.17^{b, a}$ ±0.01	0.18^{a} ±0.06	0.11^{a} ±0.01	0.13^{a} ±0.0	BDL	0.10^{a} ±0.00
mean	**0.15**	**0.13**	**0.13**	**1.11**	**0.16**	**0.12**	**0.12**	-	**0.09**
	±0.03	**±0.02**	**±0.01**	**±0.04**	**±0.02**	**±0.01**	**±0.01**	-	**±0.01**
WHO	-	0.5-2.0	0.05	0.8	-	0.4	-	-	60

Mean values in the same column followed by the same superscript letters are not significantly different ($p<0.05$). BDL- Below detection limit

Table 4: The heavy metal concentrations (mg/kg dry weight) of Parachanna sp.-Snake Head Fish – (SHF) from Osara Dam

Parameter	Mn	Cu	Cr	Fe	Ni	Pb	Co	Cd	Zn
Head	0.26^{a} ±0.01	0.11^{a} ±0.01	0.14^{a} ±0.02	1.56^{a} ±0.01	0.13^{a} ±0.02	0.22^{a} ±0.03	0.11^{a} ±0.03	BDL	0.10^{a} ±0.02
Gill	0.24^{a} ±0.01	0.09^{a} ±0.00	0.15^{a} ±0.01	1.61^{b} ±0.03	0.12^{a} ±0.02	$0.23^{a, b}$ ±0.01	0.10^{a} ±0.04	BDL	0.09^{a} ±0.00
Muscle	0.24^{a} ±0.04	0.09^{a} ±0.02	0.12^{a} ±0.00	1.56^{a} ±0.05	0.12^{a} ±0.01	0.21^{a} ±0.01	0.09^{a} ±0.01	BDL	0.09^{a} ±0.01
Liver	0.31^{b} ±0.01	0.12^{a} ±0.01	0.15^{a} ±0.01	1.64^{b} ±0.01	0.13^{a} ±0.01	0.27^{b} ±03	0.12^{a} ±0.01	BDL	0.13^{a} ±0.04
mean	**0.26**	**0.10**	**0.14**	**1.59**	**0.13**	**0.23**	**0.11**	-	**0.10**
	±0.03	**±0.02**	**±0.01**	**±0.04**	**±0.01**	**±0.03**	**±0.01**	-	**±0.02**
WHO	-	0.5-2.0	0.05	0.8	-	0.4	-	-	60

Mean values in the same column followed by the same superscript letters are not significantly different ($p<0.05$). BDL- Below detection limit

Significantly positive and negative correlation was observed between different elements in water and fish samples as shown in Table 5. The results showed that the relationship among the determined elements were significant correlations, between the lake and fish species. This strong correlation could be attributed to their common source in the anthropogenic emission to the dams.

Conclusion

The heavy metal concentrations in water were relatively high as compared to levels in tissues of fish species, the results revealed absence of any reliable interspecies differences in the content of determined metals in fish tissue. Furthermore, the two fishes tend to accumulate heavy metals and thus, they may be considered as useful species for monitoring pollution of dams and other water body.

The quantities of heavy metals in fish head, gill, muscle and liver measured in this study provide baseline information on concentrations and distribution of heavy metals in the two fish species (pylodictis - FHF and parachanna sp. - SHF) from osara dam.

Some of the determine metals in the parts of the fishes may not be harmful to consumers because the observed values of heavy metals were below the permissible limits issued by WHO for human consumption however, elements like Cr and Fe call for concerned.

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