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RESEARCH ARTICLE

An Evaluation of Ag, Fe, Co and Mn Concentrations in Water, Sediment, and Fish from the Onitsha Segment of the River Niger

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Abstract

This research work determined the concentration of silver (Ag), iron (Fe), colbalt (Co) and manganese (Mn) in fish, sediment and water collected from three sites of River Niger. In the experimental design, the fish samples were collected using cast nets which were thrown by the fisher men and withdrawn by the means of line attached to its opening. The sediment and water samples were collected with bowl and kept inside a metal free stopper bottle. The heavy metal concentrations were then determined using Atomic Absorption Spectrometer (AAS 240 FS). Manganese was not detectable in sediments, water and fish from the Bridgehead site. Iron, Manganese in sediments and water collected from Otuocha were higher when compared to other sites. Silver concentrations were the highest in sediment, water and fish from Bridgehead. Heavy metals studied were detectable in fish, water and sediments samples indicating the river is polluted by these metals.

Keywords: *Heavy metals, sediment, water, fish concentration, accumulation, manganese, silver, cobalt, iron*

Introduction

The contamination of the water bodies as a result of pollution has posed greater challenge to the survival of the aquatic animals putting them in danger of death and bio-system malfunctions. The water and its environment are polluted via industrial, agricultural, commercial and household wastes (Ekubo and Abowel 2011). Pollutants are directly or indirectly channeled into water bodies thereby polluting it (Inyinbor *et al*., 2018). These pollutants deposit heavy metals such as Cu, Mn, Fe, Ag, Co, Cd and Cr into the water bodies. Heavy metals are characterized by their high atomic mass and their high density and they usually occur in low concentration with density of at least 5gcm-3 (Koller and Saleh, 2018). Copper, zinc or selenium are essential trace elements, with functions indispensable for various biological process necessary for entire human metabolism (Pavelková *et al*., 2018). Cobalt serves as a central atom in cobalamin vitamin B12 complex, which is a major player in the reductive branch of the propionic acid formation pathway (Stower *et al*., 2014), while iron, zinc, tin, lead, copper and tungsten have important technological benefits (Koller and Saleh, 2018). A lot of heavy metals act as the central atom of artificial designed bioinorganic catalyst for special chemical bioformation (Terfassa *et al*., 2014). Other heavy metals are precious noble elements and these include gold, silver, iridium, rhodium or platinum (Rap and Reddi, 2000). Heavy metals such as mercury, cadmium, arsenic, chromium, thallium and lead are toxic even at their low concentrations (Duruibe *et al*., 2007).

Heavy metals accumulation in the environment has been attracting increasing attention from both researchers and policy makers because of their toxicity and persistence in the environment and subsequent accumulation in aquatic habitat (Brunner *et al*., 2008), and ultimately to humans and animals. Aquatic animals such as crab, fish, seal, oyster, shark, octopus, sea urchin, sea anemone, dolphins, and the aquatic plants such as water hyacinth, water lettuce, water lilies, cattail arrowhead, parrot feather, giant salvinia accumulate pollutants including heavy metals arising from various sources (Gado *et al*., 2003). Sediments usually act as reservoir of these pollutants, interact directly with the environment, this can serve as an important indicator of the effects caused by pollution and human activities (Sodrzeieski *et al*., 2019).

There are several rivers in Africa including River Niger. The river Niger is the principal river of western Africa, extending over 2,500 miles (about 4,180km) (Berton *et al*., 2022). It runs in a crescent through Guinea, Mali, Niger, on the border with Benue and the through Nigeria discharging through a massive delta, known as the oil Rivers, into the Gulf of Guinea. The Niger is the third largest river in Africa exceeded only by the Nile and the Congo rivers (Mahe *et al*., 2013). This study was aimed at assessing the accumulation of some heavy metals in the fish, sediments and water from the Onitsha segment of the river Niger so as to assess the anthropogenic activities within the area.

Methods

Collection of water and sediment samples

The water and sediment samples were collected from the sampling location by submerging the sample bottle at about 0.5ft below the water surface and transferring the water into stopper bottle which is metal free.

Collection of the Fish

The fish samples were collected using cast nets which were thrown by the fisher men and withdrawn by the means of line attached to its opening. The fish caught by the net were collected, washed, weighed and preserved in refrigerators for a day before analysis. The fishes were brought out and the flesh extracted.

Determination of heavy metal concentrations in the water sample

The digest of the test sample was assayed for the presence of heavy metals using atomic absorption spectrophotometer spectra AA model number 240FS under the appropriate wavelength and detection limit for each heavy metal. The process of sample analysis involves the following, placing the diluted extracts on the bench. The atomic absorption spectrophotometer machine was switched on and set to the required wavelength which is determined by the heavy metal being assayed. The appropriate lamp which is determined by the heavy metal was placed in the appropriate place in machine. A tube from the machine was inserted into the instrument. The machine was then set to take the absorbance as well as the concentration which is displayed on the screen at the front of the machine.

Result

Table 1 Concentrations of Co, Mn, Fe and Ag in Fish from the Sampling Sites

Heavy metals	*Atani*	*Bridgehead*	*Otuocha*	*WHO STD*
Co	*0.787 ± 0.146*	*0.077 ± 0.179*	*0.629 ± 0.008*	*5.59*
Mn	*0.254 ± 0.718*	*0.00 ± 000*	*5.904 ± 2.619 21.*	*21.20*
Fe	*2.397 ± 0.634*	*0.00 ± 0.198*	*47.12 ± 0.785*	*161.16*
Ag	*0.503 ± 0.457*	*0.729 ± 0.001*	*0.036 ± 0.074*	*NA*

Fe and Mn concentrations were higher at Otuocha while cobalt was highest at Atani Ag highest at, Bridgehead. Guidelines: WHO, 1989 and 2003., NA-Not Available A tube from the machine was inserted into the instrument. The machine was then set to take the absorbance as well as the concentration which is displayed on the screen at the front of the machine.

Table 2 Concentrations of Co, Mn, Fe and Ag in water from the Sampling Sites

Heavy metals	*Atani*	*Bridgehead*	*Otuocha*	*WHO STD*
Co	*0.506 ± 0.052*	*0.071 ± 0.183*	*0.665 ± 0.018*	*2*
Mn	*2.118 ± 0.600*	*0.00 ± 000*	*13.780 ± 3.507*	*0.5*
Fe	*3.684 ± 0.236*	*0.707 ± 0.302*	*48.77 ± 0.382*	*0.3*
Ag	*0.497 ± 0.462*	*0.781 ± 0.036*	*0.026 ± 0.081*	*0.1*

Concentrations of Fe, Mn and Co were highest in Atocha while Ag was highest concentration at the Bridgehead. Guidelines: WHO, 1989 and 2003.

Table 3 Concentrations of Co, Mn, Fe and Ag in Sediments from the Sampling Sites

Heavy metals	*Atani*	*Bridgehead*	*Otuocha*	*WHO*
Co	*0.437 ± 0.101*	*0.139 ± 0.135*	*0.635 ± 0.004*	*NA*
Mn	*1.423 ± 0.108*	*0.00 ± 000*	*6.773 ± 1.447*	*2000*
Fe	*3.966 ± 0.436*	*0.138 ± 0.100*	*48.80 ± 0.403*	*50000*
Ag	*0.464 ± 0.485*	*0.668 ± 0.044*	*0.362 ± 0.157*	*NA*

Fe, Mn and Co concentrations were highest in Otuocha while Bridgehead had highest concentration of Ag**.** Maximum allowable limit of heavy metals concentrations in soil (mgkg´-1) by World Health Organisation (WHO), (Chioma *et al*., 2014). NA-Not available.

Discussion

The concentration of heavy metals in fish, water and sediments for the three sites are presented in table 3.1-3.3. The heavy metal concentration obtained from Otuocha was found to be greater than all the concentration from other sites in both fish and water except for silver (Ag) which was less in sediment, water and fish compared to the other sites.

Silver was least in Otuocha in water, fish and sediments compared to Atani and Bridgehead. Bridgehead has the highest concentration of Ag in water, fish and sediments. Pure silver is a white, lustrous, soft, very ductile, and malleable; and an excellent conductor of heat and electricity (Nair and Ravichandran, 2018). Sources of silver are lead, zinc, gold and copper ore deposits (John *et al*. 2018). The most important ore mineral of silver is argentite (Ag2S, silver sulfide) (Mikhlin *et al*., 2011). Free Ag+ ion is a surface-active toxicant that does its damage by binding to specific sites on or inside the gills (Zhang *et al*., 2016). The toxic effect it results is the inhalation of bronchial Na+, K+, ATpase activity which leads to blockage of active Na+ and Cl- uptake across the gills (Völker *et al*., 2013). The resulting net loss of ions leads to a complex stress response in which the fish may eventually die from circulatory failures (Schreck and 2016)).

Cobalt concentration from Otuocha in fish was also found to be less than that from Atani. Cobalt is a cofactor of vitamin B12 beneficial for humans, which is essential for human health (González-Montaña *et al*., 2020). Cobalt enhances red blood cell production and thus is employed in treatment of anaemia with in pregnant women (Bhadra and Deb, 2020). However, excess concentrations of cobalt may be injurious to human health (Onakpa *et al*., 2018). Inhalation of excess amount of cobalt through air we experience lung effects, such as asthma and pneumonia (D’Amato *et al*., 2015). Other health effects from high concentrations of cobalt are vomiting and nausea, vision problems, heart problems, thyroid damage (Redzuan *et al*., 2023). Plants bioaccumulate very small particles of cobalt predominantly in the fruits and seeds and upon consumption humans accumulate these cobalt particles (Mahey *et al*. 2020).

Manganese was totally absent in Bridgehead both sediment and fish and water. There was complete absence of manganese in fish, water and sediments from Bridgehead. The value of manganese obtained from the present work in sediment of Atani, Bridgehead and the manganese concentration in this work were found to be below WHO standard except that obtained from Otuocha. Manganese sources include pyrolusite (MnO2) and rhodochriste (MnCO3) (Kusumaningrum *et al*., 2018), and has health effects, environmental effects and effects on the aquatic organisms (Jabeen and Chaudhry, 2010).

There were only trace concentrations of iron in fish from Bridgehead. But high concentration of iron was observed in Otuocha sediments, water and fish Iron plays a role in oxygen transports from lungs to tissues in human makes it an impotent element (Tiimub and Afua, 2013). Iron come from various sources and causes conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues (Anusha and RajaMurugadoss, 2014). Chronic inhalation of excessive concentrations of iron oxide fumes or dusts may result in development of a benign pneumoconiosis (Safinejad *et al*., 2019).

Conclusion

The work showed that heavy metals accumulated in the fish, water and sediments from the three sites investigated. These accumulations in the river could be due to agricultural waste, industrial activities, commercial waste products, household wastes or other anthropogenic sources. Efforts should therefore be made by agencies at curtailing the release of these waste products into the river that pollutes the water bodies to reduce the danger pollution poses to the aquatic health and wellbeing of the aquatic inhabitants and ultimately to humans.

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