International Journal of Scholarly Research in
Science and Technology
Journal homepage: https://srrjournals.com/ijsrst/
ISSN: 2961-3337 (Online)

(RESEARCH ARTICLE)

An evaluation of concentrations of arsenic, nickel, cadmium and chromium from the Onitsha segment of the River Niger

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International Journal of Scholarly Research in Science and Technology, 2023, 02(02), 016–021

Publication history: Received on 08February 2023; revised on 29April2023; accepted on 01May 2023

Article DOI: https://doi.org/10.56781/ijsrst.2023.2.2.0022

Abstract

This study was carried out to determine the concentration of arsenic, nickel, cadmium and chromium in the water, sediments and fish from Atani, Bridgehead and Otuocha segments of river Niger. The results indicated that arsenic concentration in the water, sediments and fish from the three segments were highest compared to other heavy metals analysed. Chromium was not detectable in the water, sediments and fish samples from the three segments. The order of the concentrations of the heavy metals from this results showed that in all the segments (As>Ni>Cd>Cr). Heavy metals accumulated in the water, sediments and fish which indicate contamination of the river and the need to control the source of pollution of these water bodies.

Keywords: Concentration; Heavy metals; Cadmium; Chromium; Nickel; Arsenic; River Niger

1 Introduction

Heavy metals are among of the major pollutants of water bodies. They are distinguished by their high atomic mass and high density (Koller and Saleh,2008). Heavy metals enter into water bodies via dumping of waste into and by the sides of water bodies or via agricultural waste, applied fertilizers and herbicides, industrial wastes run-off during rainfall (Raymond*et al*., 2011). Several heavy metals such as copper, manganese, iron, silver, cobalt, cadmium, chromium, arsenic, nickel, lead have been used as indicators in monitoring the pollution of the water bodies (Vetrimurugan*et al*., 2017).

The release of these harmful substances into the water leads to pollution which makes the water bodies foul and filthy (Schwarzenbach*et al*., 2010). Even in their low concentrations, pollution by heavy metals is toxic to the aquatic animals (Gheorghe*et al*., 2017).The pollution of aquatic water by heavy metals and successive uptake in the aquatic food chain poses high hazard to human population (Obaroh*etal*., 2015). Heavy metals interfere with the normal functioning of the immune, reproductive and neurological processes and may increase the susceptibility of aquatic animals to various diseases by (Edori*etal*.,2020).

Fish is one of the aquatic animals that are normally utilized by humans for purpose using flesh or oil obtained from it (Jayathilakan*et al*., 2012). Sediments, water and fishhave been shown to accumulate heavy metals studies (Rajeshkumar*et al*., 2018). Fish can metabolize xenobiotic and bioaccumulate pollutants directly from polluted water and sediments by diffusion through the gill and skin, or they may ingest metals with their food (Sononee*t al*., 2020); thus they provide anexcellent indicator for assessing aquatic toxicity and waste water quality (Al-Sabtri*etal*., 1995,

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Minissi*etal*., 1996; and Frank *etal*., 1991). This study aimed tothe concentration of arsenic, cadmium, nickel and chromium in water, sediments of River Niger at Atani, Bridgehead and Otuocha locations.

2 Materials and Method

2.1 Collection of Water and Sediment Samples

The water and sediment samples was 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.

2.2 Collection of the Fish

The fish samples were collected using cast nets which were thrownby 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.

2.3 Determination of Heavy Metal Concentrations in the Water Sample

The digest of the test sample were 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.

3 Results

Table 1 Heavy metal concentrations in fish, water and sediments from Atani

Heavy Metals	Fish	Water	Sediments
Cd	0.027 ± 0.018	0.013 ± 0.007	0.037 ± 0.008
Ni	1.807 ± 0.359	0.146 ± 0.057	1.359 ± 0.029
Cr	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
As	3.206 ± 0.491	3.785 ± 0.788	4.899 ± 0.142

Table 2 Heavy metal concentrations in fish, water and sediments from Bridgehead

Heavy Metals	Fish	Water	Sediments
Cd	0.019 ±0.012	0.018 ± 0.003	0.026 ± 0.000
Ni	1.121 ± 0.127	0.015 ± 0.036	1.372 ± 0.029
Cr	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
As	3.674 ± 0.160	5.457 ± 0.394	6.077 ± 0.691

Table 3 Heavy metal concentrations in fish, water and sediments from Otuocha

Heavy Metals	Fish	Water	Sediments
Cd	0.024 ± 0.016	0.011 ± 0.002	0.016 ± 0.007
Ni	1.016 ± 0.201	0.038 ± 0.020	1.355 ± 0.032
Cr	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
As	4.703 ± 0.568	5.478 ± 0.409	4.271 ± 0.586

Table 4 Interpretation of Results

Order of heavy metals in the three segments (Atani, Bridgehead and Otuocha: same order for the three.	Order of heavy metal concentration in sediments, fish and water from the three segments.	Comparison of heavy metals from the three segments
Fish: As>Ni>Cd>Cr	Cd Atani: Sediments> fish> water Bridgehead: Sediments> fish> water Otuocha: Fish> Sediments> water	Cd Sediments: A>B>O Water: B>A>O Fish : A>O>B
Water: As>Ni>Cd>Cr	Ni Atani: fish > sediments> water Bridgehead: Sediments> fish> water Otuocha: Sediments> fish> water	Ni Sediments: B>A>O Water: A>O>B Fish: A>B>O
Sediments: As>Ni>Cd>Cr	Cr Absent in sediments, water and fish from Atani, Bridgehead and Otuocha	Cr Absent
	As Atani: Sediments> water> fish Bridgehead: Sediments> water> fish Otuocha: water> fish> sediments	As Sediments: B>A>O Water: O>B>A Fish: O>B>A

Note: A means Atani, B means Bridgehead and O means Otuocha.

4 Discussion

Bridgehead has highest concentration of arsenic (As) in sediments compared to other heavy metals in the study. The concentration of As in sediments from bridgehead was also found to be greatest compared to As in water, Sediments and fish from Atani and Otuocha. The order of the concentration of the heavy metals from this result showed in all segments (As>Ni>Cd>Cr(ND)). From this study, the results suggested that fish from Atani accumulated the highest amount of Nickel compared to other Ni concentration in the three segments. Though Cd concentration was moderate compared to As and Ni, it was observed that highest concentration was in sediments from Atani.

Chromium was totally absent from the water, sediments and fish from the three segments. Chromium is a toxic heavy metal which is found in environment in different oxidation states ranging from -2 to +6. But the most stable forms are trivalent and hexavalent chromium (Kirti *etal*., 2015). Human health is adversely affected due to the exposure of chromium and these health effects are categorized in two types, carcinogenic and non-carcinogenic (Guertin, 2004). The results obtained from water, sediments and fish is not line with the results presented by Özturk(2009)but is similar to the findings of Karadede and Ünlü, 2020 and Ozturk *etal*., 2004 in both sediments and water.

Human beings are exposed to Ni mainly via oral ingestion through water and food as nickel may be a contaminant in drinking water and food (Sinircropi*etal*., 2012). Depending on quantity and duration of exposure to nickel, nickel being an immunotoxic and carcinogen agent can cause a variety of health effects, such as contact dermatitis, cardiovascular

disease, asthma, lung fibrosis, and respiratory tract cancer (Chen *etal*., 2017). Accumulation of nickel and nickel compounds in the body through chronic exposure may be responsible for a variety of adverse effects on the health of human beings, such as lung fibrosis, kidney and cardiovascular diseases and cancer of the respiratory tract (McGregor *etal*., 2000, Seilkop*etal*.,2003).

Long-term exposure to cadmium through the air, water, soil, and food leads to cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular, central and peripheral nervous, and respiratory systems (Mehrdad *etal*.,2017). Cadmium affects cell proliferation and differentiation by interacting with DNA repair mechanism, the generation of reaction oxygen species (ROS) and the induction of apoptosis (Rani *etal*., 2014). Cadmium binds to the mitochondria and can inhibit both cellular respiration and oxidative phosphorylation at low concentration (Patrick, 2003). It also depletes reduced glutathione (GSH) and enhances ROS production and inhibits enzymes like: catalase, manganese-superoxide dismutase and copper/zinc-dismutase (Filipic, 2012). This work showed that the result obtained for Cd concentration in fish was below standard by (UNEP, 1985) which is 0.3 and also standard by EC, 2015 which is 0.05.

Arsenic is a natural component of the earth's crust and is widely distributed throughout the environment in the air, water and land. It is highly toxic in its inorganic form(WHO, 2018). Inorganic arsenic is a confirmed carcinogen and is the most significant chemical contaminant in drinking-water globally (Chung*et al*., 2014). Inorganic arsenic compounds (such as those found in water) are highly toxic while organic arsenic compounds (such as those found in seafood) are less harmful to health (WHO, 2019). Vomiting, abdominal pain and diarrhoea, numbness and tingling of the extremities, muscle cramping, skin lesions and hard patches on the palms and soles of the feet (hyperkeratosis), skin cancer, and death, in extreme case are some of the symptoms accompanying accumulation of arsenic(Kochubovski *et al*., 2022). Arsenic is also associated with adverse pregnancy outcomes and infant mortality, with impacts on child health (Quansah *etal*., 2015).

5 Conclusion

It was shown from this study that there were bioaccumulation of heavy metals in fish, sediments and fish.The contamination of the water bodies via industrial, agricultural, domestic sources should be monitored and regulated.

Compliance with ethical standards

Acknowledgments

The researchers wish to acknowledge Springboard Laboratory Awka where this research was carried out and members of staff of Applied Biochemistry of Enugu State University of Science & Technology.

Disclosure of conflict of interest

There is no conflict of interest.

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