Quantifying and Evaluating Heavy Metal Content Ballast Contaminated River in Nigeria Port Authority (NPA) Warri Delta State.

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Abstract

The impacts of ballast water on the river and surrounding environment were investigated by measuring the concentration of heavy metals Co, Cd, Cu, Pb, Ni, Cr, and Fe (Mglg) in the sediment and water of the NPA river in the Nigeria Port Authority, Warri South Local Government Area. These metal concentrations fall between 0.06 and 1.70 mg/C in water and 0.04 and 4.62 mg/l in sediment, respectively. The concentration level of heavy metals in water follows the patterns Fe>Pb>Ni> and Cr>Cu>Co, whereas the sediments follow the patterns Fe>Pb>Cr>Cu>N>Co>. The Abraka River's non-ballast impacted water was used to create the value that served as the baseline values. In order to manage and mitigate the risk associated with these contaminants, decision-making processes are aided by the presence of heavy metals in the water and sediment in ballast water. These elements also assist in establishing standards and guidelines that safeguard human health and preserve the ecological integrity of marine ecosystems.

Keywords: Ballast water, Sediment, Water heavy metals, Contamination.

1. Introduction

Ballast water from ships in the maritime environment is a primary way that invasive species are transported into new environments. Water pollution from home, agricultural, and industrial activities has led to the loss of the ecological cycles balance (MPA, 2022). In order to give draft and stability when a ship is operating, ballast water is required. Managing the detrimental effects of invasive aquatic species' migration in ship ballast water transfer is a challenge for the maritime industry (Bailey, 2015). They have significant concern in the worlds shipping industries and one of the solutions by IMO (2018) for managing this negative impact by spread of invasive aquatic species in ship ballast water transfer (Eke, 2015), although there are challenges hindering the Ballast Water Management systems (BWMS) compliance of shipping operators in Nigeria from installation and environmental challenges (Siynal, et al, 2020). The ballast water form causes deterioration to the ecological balance and threatens living organisms due to transfer of invasive marine species into the new environment (David et al (2013). In addition to the translocation of microorganisms, the movement of organic and inorganic matter and sediment present in the ballast water is also a critical factor in spreading pollution and damaging ecological balance (UNAL, 2023).

Geological, climatic seasonal and environmental conditions have an influence on seawater quality, that is determined by turbidity salinity, temperature, dissolved oxygen (DO), polycyclic aromatic hydrocarbon (PAHs) and heavy metals e.g. cobalt (Co), Chromium (Cr) Nikel e.g. Cobalt (Co), Pb and marine species. The persistent and high toxicity of heavy in seas (oceans) has made heavy metals priority pollutants. An understanding of the changing distribution and concentration of heavy metals and their compounds is necessary for environmental management. (O Wamah, 2013) determine the heavy metal concentration in a river impacted with petroleum in the Niger Delta region of Nigeria. Umudi (2018) investigated the characteristic of Ogulaha/Escavos river pollutant content find reported the distribution of heavy metals along the coastal water. The indiscriminate discharge of ballast water by the shipping companies into the environment constates one of the main factors of degradation in the aquatic and terrestrial ecosystem (Kairy et al, 2023). Heavy metal monitoring in the coastal area is an essential part of pollution study (Linal, 2023).

Elimination process of metals is worsened by lack of natural elimination process, bioaccumulation would make it shift from one component within the aquatic environment. Through food chain transfer toxicological risk is possible (Koffi, 2014). Adsorption, accumulation and content ration of metals in bottom sediments are expected to be higher than in the water to cause secondary pollution. Sediments are repository for heavy for heavy metals and their cumulative behaviour. (Vijayan, 2020). Metal poisoning from food and its stuff, toxicity from ballast water can lead to neurological diseases, Kidney diseases, Liver diseases, respiratory illness etc. NPA river which holds the ships with ballast water usually generate effluent and discharge it into the river which is a natural receptor (Yung, et al 2022). Heavy metals present in ballast water is toxic to marine organisms, disrupting their ecological balance and potentially impacting human activities as fishing and tourism (Stephan, 2015). If humans consume seafood contaminated with high levels of heavy metals, it can lead to adverse health effects, such as neurological disorders organ damage and developmental issues. Sediments can serve as a long-term source of contamination, releasing heavy metals into the water column over time (Lovra, 2017). Assessing heavy metal in ballast water and sediments helps identify potential sources of contaminating evaluate the effectiveness of pollution control measures and inform decision – making process for managing and mitigating the risk associated with these contaminants for integrity of the ecosystem. It is therefore important to monitor the limits of heavy metals in the ecosystem, so that an approximated measure of the hazard potential can be attained (Kairu, 2023). Which is an estimation of its effect type after exposure to heavy metals. The intent of this research was to obtain information on the distribution and concentration of heavy metals as a result of ballast water impacted on it.

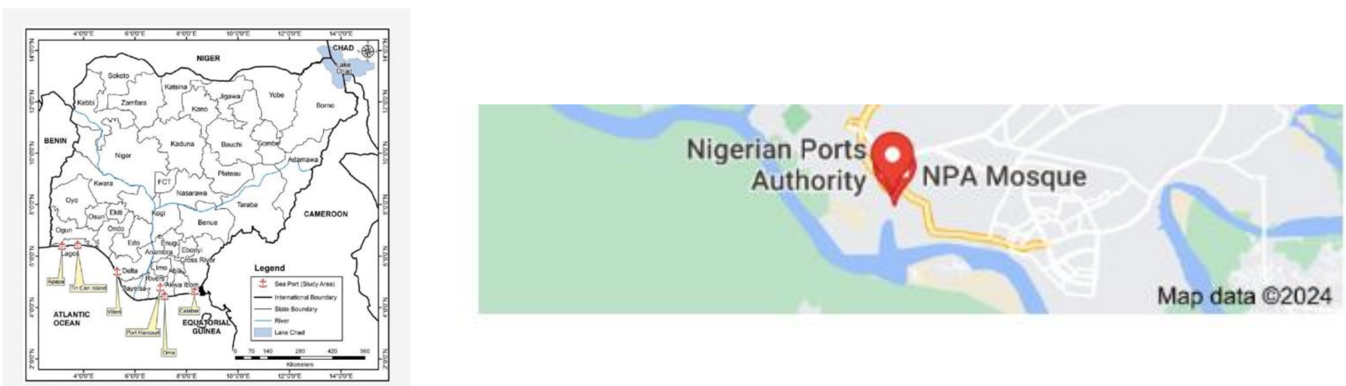

Figure 1: Showing the sampling site

1.1 Study Area

Nigeria Port Authority in Delta State, is located along Warri Warri South Local Government Arae River Lying on Longitude 5^0 45^0 E and latitude 5.30^0 N as shown in fig. 1 it reaches out to fresh water with dense vegetation of forest and lower down with mangrove vegetation in brackish water dominated with red and white mangrove of annual, rainfall of about 3000nm with tropical humidity. It experiences wet season of April -November and dry season of December-March. Activities in this area include but not limited to trading, fishing, bathing, swimming, offloading of cargoes.

2. Materials and methods

Four sampling sites along the river was used for collection of samples, at strategics points were the ships are anchored and ballast water is been discharged. Sampling was done four months during the wet season and four months during the dry season. April, June, August and September while that for dry season was December, January, February and march. A composite sample of water at a dept of 10cm was taken as a representative of each site. It was collected counter currently in a well labelled poly ethene container which have been rinsed with acidified water. They were carefully stopped to avoid air contacting with air already rinsed with acidified water.

They were transported to the laboratory and stored at 4^0cin a refrigerator prior to chemical analysis. The samples of sediments were pre-treated before final analysis, using standard methods (APHA, 2017). The sample method was done for water and sediment from Abraka river used as control since it's a non-oil producing (Community) river.

The samples were analyzed using GBS spectral 10 Atomic Absorption spectrophotometer with a acetylene/air flame. The concentration of Cd, Co, Cr, Ni and Pb in water, and sediments were determined from ballast water impacted from NPA water side.

3. Results and discussion

Analysis was performed using analysis of variance and random block design for comparison of mean to give room for heavy metal comparison in both water and sediments in both polluted and non-polluted water.

Table I: Concentration of heavy metals in water and sediments from ballast impacted river (NPA) Warri during the dry season.

	Site A		Site B		Site C		Site D	
Parameter mgil	**Water Mean + SD**	**Sediment Mean + SD**	**Water SD Meant**	**Sediment + SD**	**Water Mean + SD**	**Sediment Mean + SD**	**Water Mean + SD**	**Sediment Mean + SD**
Co	0.12+0.001	0.60+0.001	0.14+0.001	0.71+0.001	0.16+0.001	0.61+0.001	1.30+0.002	1.31+0.001
Cd	0.35+0.001	1.20+0.001	0.49+0.002	0.56+0.001	0.43+0.001	0.64+0.002	0.61+0.001	0.12+0.001
Cu	0.45+0.001	0.91+0.001	0.35+0.001	0.96+0.001	0.30+0.001	1.20+0.001	0.23+0.001	0.10+0.001
Pb	0.81+0.002	1.42+0.001	0.69+0.001	1.42+0.001	0.79+0.002	1.96+0.002	0.15+0.001	0.29+0.002
Ni	0.39+0.002	1.30+0.001	0.51+0.001	1.4+0.003	0.59+0.001	1.02+0.001	0.71+0.002	0.91+0.001
Cr	0.46+0.001	0.71+0.001	0.50+0.001	0.89+0.002	0.28+0.001	0.90+0.001	0.51+0.001	1.32+0.001
Fe	1.19+0.001	4.62+0.001	1.70+0.002	4.20+0.002	1.40+0.002	2.50+0.002	0.20+0.003	2.21+0.001

Results are expressed as mean + standard Deviation of Six determinations of heavy metals in (mglg)

Table 2: Concentration of heavy metals in water and sediments from ballast impacted river (NPA) Warri during the raining season.

	Site A		Site B		Site C		Site D	
Parameter mgil	**Water Mean + SD**	**Sediment Mean + SD**	**Water SD Meant**	**Sediment Mean + SD**	**Water Mean + SD**	**Sediment Mean + SD**	**Water Mean + SD**	**Sediment Mean + SD**
Co	0.12+0.001	2.90+0.001	0.08+0.001	0.02+0.001	1.30+0.002	2.00+0.002	1.42+0.002	2.50+0.002
Cd	0.10+0.001	0.51+0.001	0.06+0.001	0.04+0.001	0.33+0.001	0.71+0.001	0.31+0.001	0.81+0.001
Cu	0.39+0.001	1.17+0.001	0.41+0.001	0.16+0.001	0.50+0.001	1.12+0.001	0.54+0.001	1.24+0.001
Pb	0.90+0.002	0.70+0.001	0.18+0.001	0.26+0.001	0.69+0.002	1.60+0.001	1.10+0.001	1.82+0.001
Ni	0.31+0.002	0.49+0.001	0.20+0.001	0.07+0.003	0.24+0.001	1.19+0.001	0.31+0.001	1.21+0.001
Cr	0.32+0.001	0.40+0.001	0.18+0.002	0.21+0.001	0.21+0.001	0.60+0.002	0.26+0.001	0.82+0.002
Fe	1.20+0.003	0.50+0.001	1.14+0.001	3.30+0.002	0.11+0.001	0.41+0.001	0.19+0.001	0.62+0.001

Results are expressed as mean + standard Deviation of Six determinations of heavy metals in (mglg)

Table 3: Concentration of selected heavy metals in water and sediment from non ballast water impacted river (Abraka) during the dry season.

	Site A		Site B		Site C		Site D	
Parameter mgil	**Water Mean + SD**	**Sediment Mean + SD**	**Water SD Meant**	**Sediment Mean + SD**	**Water Mean + SD**	**Sediment Mean + SD**	**Water Mean + SD**	**Sediment Mean + SD**
Co	0.03+0.001	0.10+0.001	0.05+0.001	0.07+0.001	0.04+0.001	0.06+0.002	0.08+0.001	0.09+0.001
Cd	0.06+0.001	0.05+0.001	0.03+0.002	0.06+0.001	0.03+0.001	0.04+0.002	0.05+0.001	0.06+0.001
Cu	0.12+0.001	0.15+0.001	0.10+0.001	0.18+0.001	0.07+0.001	0.22+0.001	0.09+0.002	0.25+0.001
Pb	0.21+0.002	0.22+0.001	0.16+0.001	0.28+0.001	0.19+0.002	0.20+0.003	0.23+0.002	0.24+0.003
Ni	0.08+0.002	0.09+0.001	0.05+0.001	0.62+0.003	0.06+0.001	0.06+0.001	0.07+0.001	0.09+0.001
Cr	0.18+0.001	0.30+0.001	0.14+0.001	0.27+0.002	0.18+0.001	0.30+0.001	0.20+0.001	0.22+0.001
Fe	1.21+0.002	0.34+0.001	0.18+0.002	0.34+0.002	0.30+0.001	0.29+0.002	0.30+0.001	0.35+0.002

Results are expressed as mean of Six determinations of heavy metals in (mglg)

Table 4: Concentration of heavy metals in water and sediments from non- ballast water impacted river (NPA) Abraka during the raining season.

	Site A		Site B		Site C		Site D	
Parameter mgil	**Water Mean + SD**	**Sediment Mean + SD**	**Water SD Meant**	**Sediment Mean + SD**	**Water Mean + SD**	**Sediment Mean + SD**	**Water Mean + SD**	**Sediment Mean + SD**
Co	0.03+0.001	0.04+0.002	0.02+0.002	0.18+0.002	0.13+0.001	0.07+0.001	0.17+0.002	0.20+0.001
Cd	0.005+0.001	0.07+0.001	0.02+0.002	0.20+0.003	0.12+0.001	0.05+0.001	0.10+0.001	0.30+0.001
Cu	0.01+0.001	1.06+0.001	0.01+0.001	0.09+0.003	0.03+0.001	0.03+0.001	0.41+0.001	0.06+0.001
Pb	0.10+0.002	0.20+0.001	0.19+0.001	0.24+0.001	0.20+0.002	0.18+0.001	0.24+0.001	0.28+0.001
Ni	0.07+0.002	0.10+0.001	0.04+0.001	0.07+0.001	0.02+0.001	0.07+0.001	0.04+0.001	0.17+0.001
Cr	0.13+0.001	0.20+0.001	0.15+0.001	0.04+0.001	0.01+0.001	0.15+0.001	0.01+0.001	0.26+0.001
Fe	0.15+0.002	0.15+0.001	0.13+0.002	0.01+0.001	0.02+0.001	0.20+0.001	0.04+0.001	0.30+0.001

Results are expressed as mean of Six determinations of heavy metals in (mglg)

Completely randomized block design (CRIB) Was used for analysis of variance for the comparison of the means. This is flexible for comparison of heavy (concentration) in both water and sediment in ballast water impacted and non-impacted river and sediments.

Tables 1 and 2 depicts the concentration of heavy metals in water and sediments during rainy and dry season in samples collected from NPA river in Warri. The levels were significant ($p<0.05$), it was higher in sediment than water, since sediment is the sink for heavy metals. In the case of Table 3 and Table 4, which shows the level of heavy metals in sediment and water from Abraka (Ethiope east) which is not impacted with ballast. There was significant difference (Pco.os) in that water compared with that impacted by non-ballast water. Higher in water and sediment in impacted and non-impacted water and sediment. In all the fables from 1-4 site B has relatively higher concentration of heavy metals than the other most of the vessels, which is the off-loading point.

Ballast water includes heavy metals in water and sediments in Niger delta as documented (Giri, 2023) and showed a higher concentration of heavy metals in polluted water than non-polluted water. the results shows that heavy metals in sediment were higher than water, hence the button sediment are repository of heavy metals and possible incidence of ballast water spillage. (Asia, 2007), higher concentration of these metals in water and sediments from ballast water impacted environment was due to exposure of ballast water effluent in the cause of off/loading in these sites. (Jiangliang, et al 2023). Analysis of variance show that there is a significant difference in the individual heavy metal concentration and also a significant difference in the level of these concentration in the sediment and water samples impacted with ballast water and non-ballast water impacted. And no significant difference in the level of these heavy metal concentration in the sediment and water samples collected from the non-ballast impacted river, pointing to the fact in the absence of anthropogenic pollution, (Akporido,2015) the levels of heavy metals in water and sediments that their concentrations are almost the same. An indication of pollution was shown that the level of heavy metals Lead, nickel, copper, chromium and calcium were above WHO recommended standard for surface water.

4. Conclusion

The result of heavy metals (Pb, lead) is the highest which is a source of danger posed on the consumption of water, seafood for different purposes. Conclusion. The level of heavy metals determined in this study is an indication of heavy metal in the ecological immediate environment were vessels discharged their ballast water. Government should take appropriate measures by checking the discharge of ballast water into the environment and constant monitoring of the river and ecological material should be done especially at night when eyes are off the vessels.

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