**Faculty of Natural and Applied Sciences Journal of Scientific Innovations**
**Print ISSN: 2814-0877 e-ISSN: 2814-0923**
www.fnasjournals.com
**Volume 4; Issue 2; October 2023; Page No. 72-76.**

# ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES AND HEAVY METALS POLLUTION IN ANDONI ESTUARY OF RIVERS STATE, NIGERIA

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## Abstract

The study was on the assessment of physicochemical properties and heavy metals concentration in the sediments of Andoni Estuary. Samples were collected at five stations: Station 1 (Agan-asuk), station 2 (Atasuk-ile), station 3 (Otutibi), station 4 (Ama-Amaramu) and station 5 (Ibot-inyon), once quarterly for a period of one year between April 2021 to March 2022. The various physicochemical variables were analyzed in the laboratory following the normal APHA procedures. The following heavy metals Cadmium, (Cd), Lead (Pb) Copper (Cu), Mercury (Ag) and Nickel (NI) were analyzed using an atomic absorption spectrophotometer, to determine their concentration in the water. The result obtained in this study showed that the Physicochemical properties investigated showed a very high level of variation among the parameters. pH value ranged between 1.2 to 7.31 which is within the WHO limit of 6.5 to 9.5. The contamination factor of the individual heavy metals in Sediment samples were as follows; Cd varied <0.01 – 0.02, Pb varied from 1.3-9.4, Cr was between 23 - 40, Ni was between 21.1 – 24.1, Zn varied between 57 - 158, and Cu varied from 13.2 – 21.9. When compared to the contamination and pollution intervals as well as the interpretations in the WHO permitted limit, these results are greater. It was determined that the current level of concentrations of heavy metals that were measured in the Andoni Estuary were typically greater than the set allowable limit as suggested by WHO. This was the conclusion that was reached**.**

**Keywords:** Pollution, Heavy Metals, Bioaccumulation, Sediments, Physicochemical properties

## Introduction

Heavy metals can accumulate in the sediment layers of rivers and have negative effects on the environment for nearby residents and the water's quality. They can be present in any environment due to natural or human-caused causes (Demirak et al., 2006). The toxicity and carcinogenicity of heavy metals, in addition to the health effects they can have, have been documented (Acosta et al., 2015). According to Bing et al. (2016), heavy metals may not represent or pose harm to the environment when they are present in quantities that are within the natural permissible limits. Heavy metals are found in their naturally occurring state in the crust of the planet. Rocks are carried by runoff from the topsoil and deposited in the bottom sediment as a consequence of their breakdown and disintegration. This process occurs as a result of the rock's disintegration. In addition to heavy metals being discharged into the river for natural reasons, Xia et al. (2018) found that heavy metals may also be introduced into the sediment by human activities such as the expansion of metropolitan areas, the mechanisation of transportation systems, and the generation of electricity. The distribution of heavy metals in the aquatic environment is complicated by several factors, one of which is stormwater runoff, which does not get nearly enough attention. Studies have shown that when rainfall travels over the surface of the earth, it carries with it heavy metals that have been produced as a byproduct of a wide range of human activities. These activities include material wear and tear, corrosion, roof runoff, and fuel burning. rainfall also carries these heavy metals with it.

Public health studies have shown that heavy metals are significant pollutant intermediates in aquatic environments (Khaled et al., 2012). This is because they can cause a variety of ailments, and when they are released, they get deposited on sediment, at which point, depending on the parameters of the environment, they may ultimately become immovable. Sometimes only very small levels of heavy metals are discovered. Immobilisation within the sediment may be caused by several different processes, including re-suspension, absorption, precipitation, and co-precipitation with other elements in the form of oxides and hydroxides (Mohiuddin et al., 2010; Awofolu et al., 2005). These processes also go through sophisticated creation procedures

Heavy metals don't break down in the body, so they can be concentrated in the food chain. As a result, most of the time, their toxic effects are felt or seen far away from the pollution source. Heavy metals have been linked to several diseases in humans, animals, and plants, particularly when present in high concentrations (Saha & Hossain, 2011). Petroleum and related businesses are a major source of pollution in Nigeria's Niger Delta Region. The intricacy of the oil extraction process is further increased by the present growth of artisanal refining, which has taken over the different rivers in the area. According to Ekpete et al. (2019), the development of trash that is discharged into the environment without following the set standards is related to the uncontrolled manufacture of refined petroleum products. The bulk of pollution is caused by businesses such as the oil and petrochemical sectors. Heavy metals can accumulate in the tissues and sediment of aquatic creatures if waste that has not been adequately removed from the aquatic environment can enhance the value of heavy metals over their natural value. This may be the consequence of waste that has not been properly removed from the aquatic environment. According to Uluturhan et al. (2011), increasing concentrations of heavy metals in sediment and water signal a hazard to the surrounding ecosystem. These metals also have a detrimental impact on human health since they are absorbed by the body via dietary sources. The contamination or pollution of any aquatic environment's sediment, which is the last repository of contaminants or pollutants in any waterbody, determines the information on the pollution state of the environment (Schleiss et al., 2016). Sediment is the final repository of contaminants or pollutants in any water body. According to research carried out by Ekpete et al. (2019), heavy metals that have been retained or collected in sediment may be re-suspended back into surface water in the event of ecological disturbances or turbulence. This would be detrimental to the ecosystem.

To effectively monitor and recover an aquatic system's integrity, the sediment quality must be sufficiently safeguarded. This applies to all aquatic systems. According to Issa and colleagues (2011), this will make an even more significant contribution to the protection of aquatic, wild, and human life. The ultimate sink for pollutants in aquatic systems is sediment, which is both a vital component of the aquatic environment and the final sink for contaminants. According to Issa et al. (2011), a wide variety of aquatic plants and animals make use of it as a home, a source of food, a spawning site, and a nursery. As a consequence of this, the objective of this study was to assess the concentration of heavy metals in the Andoni Estuary, which is located in the state of Rivers in Nigeria**.**

## Materials and Methods

This study was conducted in the Andoni Local Government Area of Ekede Creek in Rivers State, Nigeria. The Andoni River is a tributary that flows into the Atlantic Ocean at 4.48114 North latitude and 7.43177 North longitude. Within the Creek's stretch, samples were collected at five stations: station 1 (Agan-asuk), station 2 (Atasuk-ile), station 3 (Otutibi), station 4 (Ama-Amaramu), and station 5 (Ibot-inyon). The Ugama Ekede people of Rivers State's Andoni Local Government Area are highly religious and have long been known for their fishing and hunting. The ancient plant Lympa, the native mangrove, and the adjacent rain forest, home to numerous wild animals like elephants, monkeys, antelopes, and others, define the region. Five sampling stations were established at 100m intervals after a reconnaissance survey was undertaken by walking down the creek bank. The survey was to identify and locate suitable sampling points. Sample for this study were collected in five stations once quarterly for I year between April 2021 to March 2022. The reason for the quarterly sample collection is to allow for seasonal influence on the physicochemical properties of the water.

The water sample was collected using 500ml plastic containers with screw caps. The collection of water samples was done during the daytime and at low tide. The samples were collected just a few centimetres below the water surface at each of the five stations respectively by dipping or immersing the container at a depth of about 10 – 20cm. The sample was moved to the laboratory in Ice Park within 24 hours for both tests of heavy metals and physicochemical parameters. As was stated before, the purpose of the research was to investigate the short-term shifts in the concentrations of heavy metals in the bottom sediments at each of the five locations. To accomplish this goal, sediments were collected from the topographic surface of the stations. According to Burden (2002), current pollutants deposit themselves mostly on surface sediments. Throughout the whole sampling period, the sediment samples were collected at each station within about one square metre of fixed sites. This was done so that the sampling would remain consistent.

The river bottoms were the starting point for collecting the three duplicate surface sediment samples. Each sample was taken from the top one centimetre of the surface depth. Approximately 250 grams of sediments were collected from each of the sites. These sediments were then put in self-sealing bags that had been tagged in advance, and they were transported to the laboratory, where they were stored in the refrigerator until they were sieved and separated. To avoid the desorption of heavy metal compounds that had been adsorbed to the sediments (Klein, 2014), the water that was present in the sediment samples was appropriately decanted before they were packaged for transport to the laboratory. Each sample of sediment was first passed through a wet sieve with 212 m mesh using DI water. This was carried out on the very next day after the sample had been completed. Before and throughout the process of sieving, the sediment samples were sorted to eliminate any undesirable material. This included shell pieces, creatures found along the shore, and big rock particles. To aid the mechanical separation of smaller particles from bigger particles during the sieving process, sediments were agitated with DI water while contained inside a sieve. This was done. The sieved sediments were dried entirely in an oven at a temperature of 800 degrees Celsius (Burden, 2002). Particle size was more than 212 micrometres. To get a composite sample, the samples of dried sediment were first properly combined before being disaggregated carefully using a ceramic pestle. The samples of ground sediment were sieved once more with a mesh size of 75 m, and then they were placed in plastic vials to be preserved until they were tested**.** The following heavy metals were analysed using atomic absorption spectrophotometer, Cadmium, (Cd), Lead (Pb) Copper (Cu), Mercury (Ag) and Nickel (Ni). Statistical analysis was done using descriptive and inferential statistics (ANOVA).

**Results**

**Table 1 Physicochemical Properties of Water Across Stations**

| Parameter | Mean | F(Sig) | Remark |
|---|---|---|---|
| $P^H$ | 6.75±1.98 | 1.004(0.435) | NS |
| Salinity | 51.5±0.52 | 0.087(0.985) | NS |
| TDS ( mg/l) | 777.2±34.11 | 0.809(0.538) | NS |
| Turbidity | 7.167±0.16 | 0.936(0.469) | NS |
| Total Hardness (mg/l) | 390.56±23.22 | 0.098(0.981) | NS |
| Total Alkalinity (mg/l) | 40.56±1.34 | 1.143(0.374) | NS |
| BOD (mg/l) | 17.21±0.16 | 1.057(0.411) | NS |
| Temperature | 27.1±1.14 | 1.005(0.216) | NS |
| Dissolved Oxygen | 19.6±4.9 | 3.871(0.024) | S |

Table 1 presents the physicochemical properties of the water. It showed the mean values for each of the properties. It revealed that the mean result for analysis of variance of $P^H$ was 6.75±1.98 (F=1.004; p>0.005), TDS was 777.3±34.11mg/l (F=0.809; p>0.005), turbidity, 7.167±0.16 (F=0.936; p>0.005). Total hardness, 390.56±23.22mg/l (F=0.098; p>0.005), BOD, 17.21±0.16 (F=1.057; p>0.005), temperature, 27.1±1.14 (F=1.005; p>0.005).

**Table 2: Concentrations of heavy metals in water sediments**

| Location | Concentration (µg g-1 dry wt) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Cd** | **Cu** | **Cr** | **Ag** | **Ni** | **Pb** | **Zn** |
| **Station 1** | 0.02±0.00 | 19.7±0.5 | 36.5±0.4 | 1.6 ± 0.1 | 20.2± 0.3 | 3.7± 2 | 158± 4 |
| **Station 2** | <0.01 | 13.2±0.1 | 30±1 | 0.36± .02 | 24.1± 0.4 | 2.4± 1 | 126± 3 |
| **Station 3** | <0.01 | 21.9±0.2 | 30± 1 | 1.52± .03 | 21.4± 0.4 | 9.4± 0.3 | 112± 1 |
| **Station 4** | <0.01 | 19.8±0.5 | 23± 1 | 0.41± 0.02 | 21.1± 0.5 | 1.3± 1 | 99± 1 |
| **Station 5** | <0.01 | 13.3±0.5 | 40± 2 | 0.93± 0.04 | 22.0± 0.3 | 0.7± 0.2 | 57± 1 |
| **F** | 9.173** | 246.48** | 1.143 | 0.809 | 46.638** | 1.411 | 1.002 |
| **P-value** | 0.000 | 0.000 | 0.374 | 0.538 | 0.000 | 0.266 | 0.351 |

Table 2 presents the concentration of heavy metal in water sediments across the five stations. It showed that Cd is highest in station 1 (0.02±0.00), and Cu has its highest concentration in station 3 (21.9±0.2). Cr had its highest concentration at station 5 (40± 2). Ag is highest in station 5 (0.93± 0.04), and Ni has its highest concentration in station 2. Pb is highest in station 3(9.4± 0.3) and Zn had its highest concentration in station 1(158± 4). The result showed that Cr, Ag, Pb and Zn had pe values greater than 0.05 while Cd, Cu and Ni had p-values less than 0.05.


*Cite this article as*:
Dandison, A.B. (2023). Assessment of physicochemical properties and heavy metals pollution in Andoni Estuary of Rivers State, Nigeria. *FNAS Journal of Scientific Innovations,4*(2), 72-76.

## Discussion

Physicochemical properties investigated in this study showed a very high level of variation among the parameters. pH value ranged between 1.2 to 7.31 which is within the WHO limit of 6.5 to 9.5. However, the pH value recorded in this study did not conform to the findings of Vincent-Akpu et al. (2015) who in their Assessment of physicochemical properties and metal contents of water and sediments of Bodo Creek, Niger Delta, Nigeria reported a pH value range of 8.8 to 8.9. Furthermore, Vincent-Akpu et al. (2015) also reported a spatial variation in BOD to range between 13 to 19 mg $L^{-1}$ which is consistent with the range of 17.2 to 19.85 recorded in this study and also within the WHO limit of 100.

Also, Woke et al. (2016) in their Assessment of physicochemical properties and metal contents of water and sediments in the Andoni River, Niger Delta, Nigeria reported a salinity range of 2,580 to 16,200 mg $L^{-1}$ which is in tandem with the salinity range of 50.1 to 53.1 reported in this study. Although Bodo Creek is very close to the Andoni estuary, the differences in the salinity range recorded for both studies could be attributed to the season in which the studies were carried out as Vincent-Akpu et al. (2015) also pointed out that the mean values of salinity, temperature and pH showed a gradual increase from September until January. Furthermore, The TDS range of 700 to 830 observed in this study which fell within the WHO limit of 1,500 did not conform to the findings of Sanchez-Marina and Beiras (2008) who reported a range value of 3, 070 to 188,000. The total Hardness range of 350 to 437 reported in this study which was found to be above the WHO limit of 300 was within the range of 151 to 453 reported by Vincent-Akpu et al. (2015) in their study.

Other physicochemical parameters reported in this study include Turbidity which ranged between 4.9 and 42 which is above the WHO limit of 5 and Alkalinity which ranged between 38 and 45 which is within the WHO limit of 120. Water temperature in this study ranged between 26.7 $^{0}$C to 27.8 $^{0}$C, which is within the range typical for the Niger Delta region as the exact temperature depended on the time of day and the sunlight absorbed by the water. This assertion is in line with the values and conclusions reached by Vincent-Akpu et al. (2015) in their study. Furthermore, dissolved oxygen mean values recorded in this study ranged from 4.7 to 5.5 mgL-1 which is in agreement with the findings of Omotoso (2005).

The following is a breakdown of the contamination factors for each of the different heavy metals found in sediment samples: The values for Cd ranged from 0.01 to 0.02, the values for Pb ranged from 1.3 to 9.4, the values for Cr ranged from 23 to 40, the values for Ni ranged from 21.1 to 24.1, the values for Cu ranged from 13.2 to 21.9, the values for Zn ranged from 57 to 158, and the values for Cu ranged from 13.2 to 19.8. When compared to the contamination and pollution intervals as well as the interpretations in the WHO acceptable limit, these numbers are excessive. This observation is higher than the observation of PLI made by Mortuza and Al Misned (2017) in sediments from the Red Sea coast of Jizan, Saudi Arabia, where PLI values were as low as 0.06 and those of Mandeng et al. (2019) in sediments collected from two divisions in a river in the Abiete-Toko gold region, Southern Cameroon, but either lower, within the range, or higher than the values observed in sediments from different stations in two notable streams

## Conclusion

The current level of the concentrations of the heavy metals that were assessed in the Andoni Estuary was generally higher than the established permissible level that was recommended by WHO as such, the concentrations of these metals were within values that showed a stressed sediment environment, therefore, the environment requires constant monitoring to prevent a sudden rise in the general heavy metal content in the sediment, looking at the present activity that is within the area thus, it is recommended that it be done so to prevent a sudden rise in general heavy metal content.

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