**Assessment of heavy metals, physiochemical parameters in water effluent of an aluminium company on the environment in Nigeria**

**ABSTRACT**

The environmental impact of wastewater discharge is crucial for evaluating its potential impacts on soil quality, water resources, ecosystems, and human health. Wastewater contains various contaminants, including heavy metals, nutrients, organic pollutants, and pathogens, which can lead to soil degradation, groundwater contamination, and ecological imbalances if not properly managed. This study adopts a mixed-methods approach combining quantitative and qualitative methods to ensure a comprehensive risk assessment. Key methodologies include physicochemical analysis and comparing results with the NESREA acceptable limits. Results of the contamination/pollution index showed that soils in the study area were very slightly contaminated with Chromium Cr, Lead (Pb), and Aluminium (Al). In contrast, wastewater was slightly contaminated with copper cu and nickel (Ni). The contamination level in the study area can be described as being very slightly to slightly contaminated and hence, does not pose any serious environmental concern to plants, man, and the well-being of the environment as it stands presently. To safeguard the health of living organisms in the surface water, this study recommends further treatment of the wastewater before discharge for environmental sustainability. Proper remediation of the soils should be carried out before any cultivation of crops is done on this soil to avoid bioaccumulation of toxic elements. and enlightenment should be carried out to inform the operators of this industry on the need to ensure effective treatment of the wastewater effluents

Keywords: Environmental Impact, Wastewater Discharge, Remediation, Soil Contamination, Sustainable Management

**Introduction**

Industrial development plays a significant role in national economic growth; however, it often comes at an environmental cost. In Nigeria, Africa’s most populous country (Reed & Mberu, 2014), the aluminium industry has emerged as a major contributor to industrial growth. However, it is often associated with the release of effluents that contain harmful substances such as heavy metals and other pollutants. These effluents can infiltrate surface and groundwater systems, degrade soil quality, cause ecological imbalance, and pose several environmental risks to agricultural produce, aquatic life, and public health when not properly managed or treated (Chinedu & Chukwuemeka, 2018); (Sardar *et al*., 2013); (He *et al*., 2005; Suruchi & Khanna, 2011).

In Abia State, which is home to over 4 million people (Abia Statistics, 2022), the surge in industrial activities has raised concerns over environmental degradation, especially in areas where untreated effluents are discharged into rivers and streams. Such untreated discharge contains contaminants such as chromium (Cr), lead (Pb), aluminium (Al), copper (Cu), and nickel (Ni) are known for their persistence in the environment and their tendency to accumulate in biological tissues over a long period (Iwegbue *et al*., 2013). These substances can alter the chemical composition of water bodies and affect physicochemical parameters such as pH, electrical conductivity, dissolved oxygen, and temperature, all of which are essential for maintaining aquatic ecosystem health (Gbarakoro *et al*., 2020; Kaur & Brraich, 2021).

Prolonged exposure to such contaminants has serious environmental and health consequences in humans. Studies have shown that heavy metals retained in sediments and aquatic organisms can become more concentrated as they move through the food chain (World Health Organisation, 2007), which increases the risks for both wildlife and humans. In communities near industrial areas in Abia State that rely on local water sources for drinking, agriculture, and domestic use, this contamination poses a great risk to food security, crop yields, including chronic health problems. These include liver and kidney damage, neurological and developmental effects on fetuses, infants and children, and blood pressure increase in adults (Chidugu-Ogborigbo *et al*., 2025)(Suruchi & Khanna, 2011; World Health Organisation, 2007).

In response to these public health and environmental concerns, the quality of industrial effluents, which is indispensable in promoting sustainable practices and achieving water safety and ecological resilience, needs to be assessed. This work examines the concentrations of heavy metals and key physicochemical parameters in wastewater discharged from an aluminium company in Abia State. It compares observed values with regulatory limits set by the National Environmental Standards and Regulations Enforcement Agency (NESREA) and evaluates pollution levels and their corresponding environmental implications. It further provides recommendations for improved water treatment practices and regulatory enforcement.

**Study Area**

The study area is Aba North Local Government in Abia State, Nigeria, with over 107,488 people. The region makes up around 60% of Aba's urban area (FGN, 2006). It encompasses places like Ariaria, Umuola Egbelu, and Ogbor Hill. It is situated at latitude 50 7'N and longitude 70 22'E in southeast Nigeria. The research area is located in southeast Nigeria's humid tropical and rainforest region. The pattern of rainfall distribution is similar to what is seen in southern Nigeria. The area's regime is bimodal and rainfall peaks in July and September, with a ‘little dry season’ in between. March marks the start of the rainy or wet season, which lasts until October or early November. The wet season lasts for at least seven months. The months of December through February span the dry season. Abia State receives an average of 2550 to 2751 mm of rainfall annually. 32ºC is the temperature (Ajiere S.I. & Weli V.I. 2018).

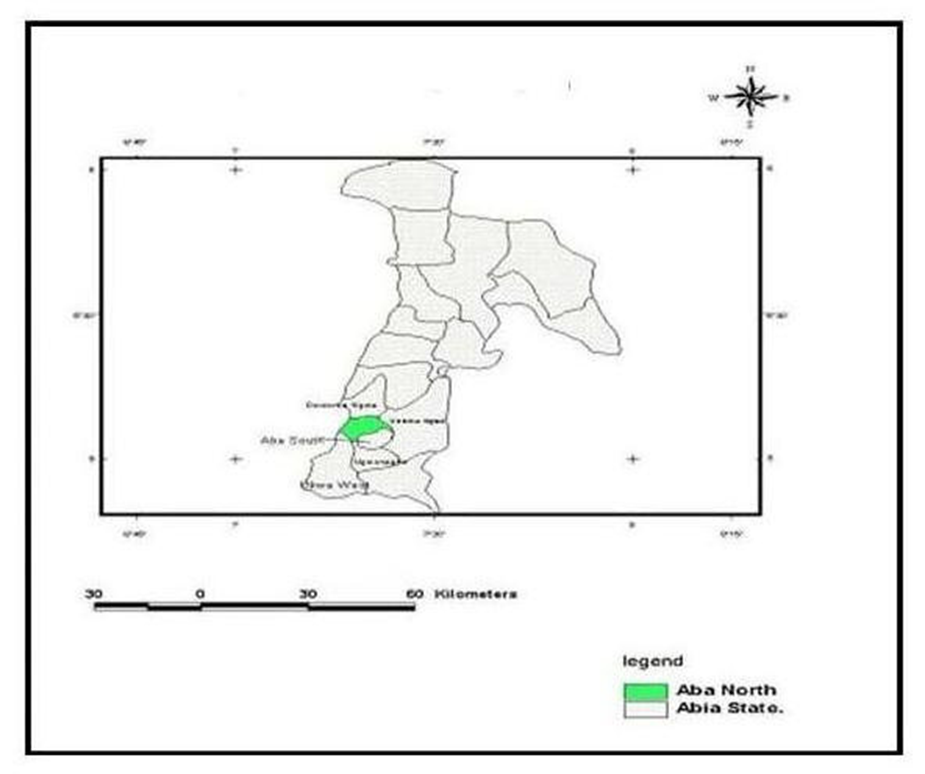


Figure 1. Map of Abia State showing Aba, the study area (source: John 2013)

**2.0 Literature review**

2.1 Wastewater Management Practices in Abia State, Nigeria

Wastewater or water effluent management remains a significant environmental and public health challenge in Abia State, particularly in industrial hubs like Aba. The state's rapid industrialization and urbanization have not been accompanied by adequate infrastructure for wastewater treatment. As a result, effluents from manufacturing companies—including aluminum production facilities—are frequently discharged directly into open drains and water bodies without sufficient treatment (Nwachukwu & Mbanaso, 2012). The wastewater discharged from households and industries continues to be a critical issue (Adewumi & Oguntuase, 2016; Amaefule *et al*., 2023), leading to environmental degradation, health impacts, and economic risks. Wastewater treatment plants (WWTPs) are an important part of wastewater management; it has had substantial environmental and economic impacts on receiving water bodies. The overall cost and effluent quality of WWTPs depend heavily on the influent type, the presence of priority pollutants, the treatment technology used, and the required effluent quality for discharge or reuse. (García *et al*.,2021) In Nigeria, the effectiveness of the different Wastewater Treatment technologies varies depending on the treatment technique used and the facility's treatment capabilities. Despite the efforts and options obtainable today, untreated wastewater discharged into the environment poses significant challenges, leading to several health and environmental issues (Ado *et al*., 2015; Amaefule *et al*., 2023).

In the context of integrated water resources management and wastewater management practices, it's crucial to develop and implement impact evaluation methods. These methods should effectively capture the complexities of water-related impacts associated with wastewater treatment and discharges through identification, description, and quantification, while also being methodologically simple (Adeleke *et al*., 2022. The methods should accurately describe, compare, and prioritize impacts across various environmental compartments and/or treatment processes to enable treatment process evaluation or site comparison (Noya *et al*., 2018). The industrial operations are very important in waste management practices; some industries in Abia State lack in-house effluent treatment plants (ETPs). Industries either channel their wastewater into municipal systems, discharge it untreated into natural water bodies, or rely on makeshift sedimentation tanks that do little to remove heavy metals and harmful chemicals (Okafor *et al*., 2015). Compliance with national effluent discharge standards enforced by NESREA is often low due to inadequate monitoring and enforcement mechanisms (NESREA, 2011). The Ministry of Environment in Abia State has developed policies aimed at improving environmental sanitation and promoting safe waste disposal. However, implementation has been hindered by a lack of funding, skilled personnel, and political will (Ike *et al*., 2018). While NESREA provides national environmental standards, enforcement at the state level remains weak, leaving gaps in the control of industrial discharges.

2.2 Impact of Wastewater Effluent on Soil for Agricultural Use

The reuse of treated wastewater for agricultural irrigation is gaining global attention as a sustainable water management strategy, particularly in arid and semi-arid regions. While wastewater effluent can be a valuable source of water and nutrients, its application has complex effects on soil quality, structure, and long-term fertility.

Positive mpacts

Several studies highlight the agronomic benefits of wastewater reuse. Treated effluent often contains significant amounts of nitrogen, phosphorus, and potassium, which can reduce dependence on synthetic fertilizers and improve soil fertility (Toze, 2006). Organic matter in effluent may also enhance soil structure, increase water retention capacity, and support microbial activity (Qadir *et al*., 2007). An experimental design was carried out in the semi-Arid region where the researcher investigated the impact of irrigating potato (Solanum Tuberosum) and corn (Zea mays) with tertiary-treated (TW) and secondary-treated (SW) wastewater compared to freshwater, over two years, and results shows that TW is a sustainable alternative water source that enhances crop yields and improves soil quality. (Lena *et al*, 2025)

Negative Impacts

However, the uncontrolled use of poorly treated or untreated effluents poses environmental risks. High salinity and sodium content can cause soil salinization and sodicity, impairing soil permeability and structure (Ayers & Westcot, 1985). Additionally, wastewater may contain heavy metals such as cadmium, lead, and chromium, which accumulate in the soil and potentially enter the food chain (Kiziloglu *et al.,* 2008). The risk of pathogen contamination from effluent use also presents a serious public health concern, especially when used on crops consumed raw (WHO, 2006).

Soil Degradation and Monitoring

Long-term use can lead to soil degradation, particularly in systems without regular monitoring. Elevated Electrical Conductivity (EC) and Sodium Adsorption Ratio (SAR) levels are common indicators of soil stress due to effluent irrigation (Rusan *et al.,* 2007). Effective soil and water quality monitoring, along with appropriate effluent treatment, is critical to ensure sustainable reuse practices. While wastewater effluent can provide substantial agricultural benefits, its use must be governed by stringent treatment standards and soil monitoring to prevent environmental degradation. Integrated wastewater management and awareness of long-term soil impacts are essential for sustainable agricultural productivity.

2.3 Impact of Wastewater on Aquatic Ecosystems

Wastewater discharge is one of the most significant environmental stressors affecting aquatic ecosystems worldwide, comprising domestic, industrial, and agricultural effluents. untreated or inadequately treated wastewater introduces a complex mix of organic and inorganic pollutants into rivers, lakes, and oceans, disrupting ecological balance and biodiversity. One of the primary effects of wastewater discharge is eutrophication, a process driven by excess nutrients, particularly nitrogen and phosphorus. These nutrients stimulate excessive growth of algae, leading to algal blooms that deplete oxygen in the water when they die and decompose. This condition, known as hypoxia, creates "dead zones" where most aquatic life cannot survive. The Gulf of Mexico’s hypoxic zone, primarily fueled by agricultural runoff and wastewater from the Mississippi River, is a well-documented example (Rabalais *et al*., 2002). Moreover, wastewater often contains pathogens, heavy metals, and endocrine-disrupting chemicals, which can be toxic to aquatic organisms. (Baker *et al*., 2016).Pharmaceuticals and personal care products, now recognized as emerging contaminants, interfere with the reproduction, growth, and behavior of fish and invertebrates even at low concentrations (Kümmerer, 2009). Heavy metals like mercury and cadmium accumulate in the food chain, affecting predator species and posing risks to human health through seafood consumption (Ali *et al*., 2019).

Wastewater also alters the physical and chemical characteristics of water bodies, such as pH, temperature, and turbidity. These changes can modify habitat suitability, causing shifts in species composition and loss of sensitive species (EPA, 2012). Invasive species may outcompete native ones under altered conditions, further degrading ecosystem integrity. Effective wastewater treatment and management, including the adoption of sustainable practices like green infrastructure and constructed wetlands, is critical to mitigate these impacts. Policies promoting nutrient removal and stringent effluent standards are essential to safeguard aquatic ecosystems and the services they provide.The discharge of wastewater poses a multifaceted threat to aquatic environments. Addressing it requires a coordinated effort in science, policy, and public engagement to restore and preserve water quality and biodiversity.

**3.0 Research Methodology**

The study employs a mixed-methods approach, combining quantitative and qualitative methods to ensure a comprehensive risk assessment. The Primary Data were discharged water and soil samples. A soil auger was used to collect soil samples from the point of discharge of wastewater. The soil samples were packaged in a polyethylene bag, labeled, and sent to the laboratory for determination of the concentration level of heavy metals and physicochemical parameters. Wastewater Samples were collected at multiple discharge points, following standardized protocols (APHA, 2017). The parameters tested include pH, turbidity, heavy metals (Al, Pb, Cd, Hg), total suspended solids (TSS), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) (ISO 5667-10:2020).

**3.1** **Contamination / Pollution Index**

The contamination / Pollution index is as defined by Lacatusu .2000.

C / P Index = Concentration of metals in soil / Target value

The target value is a reference value of metals as obtained using the standard table formulated by National Environmental Standards and Regulations Enforcement Agency (NESREA), for maximum allowable concentration of metals in the soil (NESREA, 2021) The NESREA, target values considered here are: Cu (36 mgkg-1); Ni (35 mgkg-1); Pb (85 mgkg-1); and Zn (50 mgkg-1). C / P index values less than one define contamination ranges, while values greater than one define pollution (Lacatusu, 2000). Thus, National Environmental Standards and Regulations Enforcement Agency (NESREA), “First Eleven Gazetted Regulations Federal Republic of Nigeria Official Gazette”

<0.1 Very Slight contamination

0.10 -0.25 Slight contamination

0.26 - 0.50 Moderate contamination

0.51 - 0.75 Severe contamination

0 .76 - 1.00 Very severe contamination

1.1 - 2.0 Slight pollution

2.1 - 4.0 Moderate pollution

4.1 - 8.0 Severe pollution

8.1 - 16.0 Very severe pollution

> 16 Excessive pollution

Determination of Contamination Factor (CF) for the wastewater. Contamination factor (CF) shows the man-made input in elemental pollution and is usually used to measure the overall contamination of water (Bhuiyan *et al*., 2010). CF is calculated by dividing the concentration of heavy metal in the wastewater sample by the reference

concentration. CF =𝐶𝑖 𝐵𝑖

Ci is the concentration of the examined heavy metal, and Bi is the geochemical background value of that metal. The contamination grades in an increasing order of contamination are rated from 1 to 6 (0 = none, 1 = none to medium, 2 = moderate, 3 = moderate to strong, 4 = strongly polluted, 5 = strong to very strong, 6 = very strong) (Varol, 2011).

1. **Results and D****iscussion**

4.1Concentration Level of Parameters for Soil Sample

The result of Table 1 depicts the concentrations of the selected heavy metals (Zn, Pb, Cu, Cr, Al, and Ni) in the soil from wastewater discharge points.

Table 1: Concentration Level of Parameters for Soil

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameters | Sample Code | **Soil** | **NESREA** | **EPA** |
|  | Method |  |  |
| pH | EPA 9045D | 6.38 | 6.5-8.5 | NS |
| Organic Matter  Content, % | USEPA 9060A | <0.10 | NS | NS |
| Chromium, Cr, mg/kg | USEPA 7000B | <0.001 | 100 | NS |
| Copper, Cu, mg/kg | USEPA 7000B | 0.236 | 50 | NS |
| Lead, Pb, mg/kg | USEPA 7000B | <0.001 | 50 | NS |
| Aluminum, Al, mg/kg | USEPA 7000B | <0.001 | NS | NS |
| Nickel, Ni, mg/kg | USEPA 7000B | 0.012 | 50 | NS |
| Total Bacteria Count,  CFU/g | SPREAD PLATE | 3.6 X 105 |  |  |
| NS- Not Stated  NESREA COPPER FOR WATER 1.0mg/L |  |  |  |  |
| Author's work, 2025 |  |  |  |  |

The pH level in Table 1 and Figure.2 gives a value of 6.38 for soil from the wastewater discharge area, which is slightly acidic, indicating that the soil is suitable for crop, while the NESREA permissible limit ranges from 6.5 to 8.5 based on local factors and specific purposes. Generally, in agricultural practice, the pH level is expected to be between 6.0- 8.5, while the Environmental Protection Agency does not specify any specific limit for soil.

The Organic matter content level in Table.1 shows a value of <0.10, indicating that the soil has very poor organic material. NESREA and EPA do not have a standard limit for Organic matter content. However, a soil with an organic matter content of <0.10% shows that it lacks basic nutrients to grow healthy plants, as organic matter is a vital source of nourishment for crops; hence, this soil may not be good enough for the planting of crops.

Chromium concentration level in Table 1 shows a value of <0.00mg/kg, while the permissible limit by NESREA is 100mg/kg. The value falls below the permissible limit, which shows that the soil is not contaminated by chromium. EPA did not give a guideline for chromium in soil, as the acceptance level is dependent on the uses of such soil. For example, residential soil is to have approximately 100mg/kg. If the concentration level of chromium is higher than 100mg/kg, it could cause a serious risk to plants, animals, and humans.

The Copper concentration value of 0.236mg/kg is below the NESREA permissible limits of 50mg/kg, which shows that the soil is not contaminated with copper, hence it is safe. EPA, however, does not have a general standard limit for copper in soil, as it varies between

residential and industrial soil.

Copper is required by plants in a small amount, but it becomes a problem when it s too low, especially for crops that may need it for biological processes. Lead concentration level shown in Table 1 is <0.001, which is far below the permissible limit of NESREA at 50 mg/kg. This shows that the soil from this study is not contaminated with lead (Pb). Table.1 shows the aluminum concentration level in the sample collected to be <0.001. Neither NESREA nor EPA has set standards for aluminum in soils, as aluminum is a naturally occurring element found in soils. The concentration of aluminum in the soil is often influenced by the pH value of the soil. If the pH of the soil is low, then aluminum concentration will become of concern. Nickel concentration values, as shown in Table 1, are 0.012mg/kg, which is below the permissible limit of 50mg/kg given by NESREA, showing that the soil in the study area is not contaminated by nickel. EPA does not have limits for nickel in soils, as it varies between residential and industrial areas. When nickel is high in soil, it can have adverse impact on root growth, ability of plants to take in nutrients and general stunted growth Table 1 reveal a total bacteria count of 3.6 X 105 showing that the soil in the study area has a healthy level of bacteria activity as the bacteria count is neither too low nor too high. This is a good indication of nutrient cycling and the fertility of the soil. Generally, all the parameters assessed in the study area were below the permissible limits of NESREA, indicating that the soil is not contaminated with any of the heavy metals analyzed.

Total Bacteria Count, CFU/g Nickel, Ni, mg/kg

Aluminum, Al, mg/kg Lead, Pb, mg/kg

Copper, Cu, mg/kg Chromium, Cr, mg/kg Organic Matter Content, % pH

7

6

5

4

3

2

1

0

Soil

Concentration level of Soil Parameters

Figure 2: Concentration level of Soil Parameters in the study samples

### **Contamination / Pollution (C/P) Index of the studied soils**

According to the ratings postulated by Lacatusu (2000), soils in the study area were very slightly contaminated with Chromium Cr, Lead (Pb), and Aluminum (Al), while soils in the study area were slightly contaminated with copper, cu and Nikel (Ni). Generally, the contamination level in the study area can be described as being very slightly to slightly contaminated and hence, does not pose any serious environmental concern to plant, man and the well-being of the environment as it stands presently.

4.2Concentration level of heavy metals and physicochemical parameters for water sample.

The datasets in Table 2 show the concentration level of the various water parameters assessed in the study area. The pH of the data shows a pH of 10.8 from the wastewater discharge; the guideline given by NESREA specifies that the pH of wastewater discharge should be between 6.0-9.0. This clearly shows that the wastewater discharge from the study location is above the stipulated value of NESREA for wastewater discharge and hence could adversely affect aquatic organisms in the water body that this water is being discharged into, and consequently affect the water quality. The findings from this work is in disagreement with the result from a study conducted by Sumaila *et al.* (2023) in wastewater obtained from ceramic industry, where the pH of the wastewater was below the permissible limit and safe to be discharged as they were within the permissible ranges (5.5 - 8.5) set by (WHO, 2011).

Table 2: Concentration level of heavy metals and physiochemical parameters for water sample

|  |  |  |
| --- | --- | --- |
| Parameter mg/L | Sample Code | Wastewater |
|  | Methods |  |
| pH | APHA 4500-H+-B | 10.08 |
| Total Suspended Solids, TSS | APHA 2540-D | 6.00 |
| Biological Oxygen Demand,  BOD | APHA 5210-B | 3.6 |
| Chemical Oxygen Demand | APHA 5220-C | 44.00 |
| Nitrate, NO3 | APHA 4500-NO3- -E | 0.863 |

|  |  |  |
| --- | --- | --- |
| Phosphorus | APHA 4500-PO4 2- -E | 0.273 |
| Potassium, K | APHA 3111-B | 1.488 |
| Chromium, Cr | 0.008 |
| Copper, Cu | <0.001 |
| Lead, pb | <0.001 |
| Aluminum, Al | <0.001 |
| Nickel, Ni | <0.001 |

Authors' Work, 2025.

Table 2 shows the value of Total Suspended Solids to be 6.00mg/L. The standards for wastewater set by NESREA depend on the type of activities. For the food and beverage industry, it is 25mg/L, while for pharmaceutical and chemical industries, it is 10mg/L. Therefore, our samples' concentration for Total Suspended Solid is below the stipulated NESREA limit. For Biological Oxygen Demand, it shows a value of 3.6mg/L for the wastewater, which is below the NESREA stated limit for both the food and beverage industry and the chemical or pharmaceutical industry, which is between 25mg/L and 35mg/L. This shows that the pollution level of BOD is low and hence is not capable of causing oxygen depletion in the river. The study shows that, Chemical Oxygen Demand (COD) concentration is 44.00mg/L in the sampled water, the NESREA stated limit for wastewater ranges between 40mg/L to 80mg/L for chemical and other industries. Our sample value of 44.00mg/L means that the wastewater requires more treatment because if it is discharged into surface water like this, it will deplete the oxygen that is in the water, although this value is not so high to create a problem, especially for a large water body that is large.

Nitrite concentration level in the sampled wastewater shown in Table.2 is 0.863mg/L, which is higher than the limit to be 0.2mg/L given by NESREA for wastewater water showing that this wastewater is contaminated with nitrite. However, this level of concentration could cause problems to aquatic organisms; hence, this wastewater requires more treatment before discharge. table 2 shows the phosphorus concentration value in the waste water is 0.273mg/L which is capable of affecting the surface water that this waste water is being discharged into as phosphorus can cause eutrophication in water bodies that can reduce the quality of the water therefore, there is need for further treatment of this waste water before discharge. This finding is in agreement with the study conducted by Okereke, Ogidi, & Obasi in 2016, who affirmed that eutrophication is capable of causing Algal clumps, odours, and discoloration of the water.

The concentration level of Chromium in the waste water is 0.008mg/L, as shown in Table 2, NESREA is 0.1 mg/L, which shows that the concentration level of chromium in our sampled water is low.

The concentration value of copper is <0.001 from the wastewater collected from the discharge point. This value is lower than the NESREA value of 1.0 mg/L for wastewater.

Similarly, the lead value for wastewater collected for the study shows a value of <0.001, signifying no contamination. Aluminum exhibited a similar character with values of <0.001, which is lower than the NESREA value of 5.0mg/L

Nickel value (<0.001) from discharged waste water is also lower than NESREA value of 0.2mg/L.

Generally, the heavy metals analyzed, Chromium, lead, copper, nickel and aluminum were below the permissible limit. This study is in agreement with the study conducted by Hussaini, Ali & Abdullahi (2021) in Kano who found that the Concentrations of Cr, Ni and Pb for site A, B, C and control sample were below the maximum acceptable limits.

0

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Concentration level

Figure 3: Concentration level of Parameters in wastewater sample from the study area

### Determination of contamination factor (CF) from wastewater water Formula for Contamination Factor (CF)

**CF=**𝐶𝑜𝑛𝑐𝑒𝑛𝑡𝑟𝑎𝑡𝑖𝑜𝑛 𝑜𝑓 𝐶𝑜𝑛𝑡𝑎𝑚𝑖𝑛𝑎𝑛𝑡 𝑖𝑛 𝑡ℎ𝑒 𝑤𝑎𝑠𝑡𝑒𝑤𝑎𝑡𝑒𝑟

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Table.3: Contamination factor of wastewater

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Concentration in**  **wastewater mg/L** | **NESREA Limits**  **mg/L** | **Concentration Factor CF** |
| Chromium (Cr) | **0.008** | **0.05** | **0.16** |
| Copper (Cu) | **<0.001** | **1.0** | **<0.001** |
| Lead (Pb) | **<0.001** | **0.01** | **<1** |
| Aluminum (Al) | **<0.001** | **0.2** | **<0.005** |
| Nickel (Ni) | **<0.001** | **0.1** | **<0.01** |
| Nitrite NO3 | **0.863** | **0.2** | **4.315** |

Authors' Work, 2025.

From our calculation of the contamination factor in Table.3, the wastewater is slightly contaminated with chromium, with a contamination factor of 0.16. Copper, lead, nickel,

and aluminum is also slightly contaminated. On the other hand, nitrite showed a severe pollution with a contamination factor of 4.315; hence, the need to ensure that the wastewater is further treated to remove nitrite before discharge.

**Conclusion & Recommendations**

The Assessment of heavy metals, physiochemical parameters in water effluent of an aluminum company on the environment by using wastewater samples and soil samples, which was compared to the NESREA and EPA permissible limits. Generally, most of the parameters assed were below the NESREA permissible limits for wastewater, but the pH of 10.8 from the waste water discharge, was higher than the guideline given by NESREA as 6.0-9.0, showing that the wastewater discharge from the study location is above the stipulated value of NESREA for wastewater discharge and hence could adversely affect aquatic organism in the water body that this water is being discharged into and consequently affect the water quality. In addition, results of the contamination/pollution index showed that soils in the study area were very slightly contaminated with Chromium Cr, Lead (Pb), and Aluminum (Al). In contrast, wastewater in the study area was slightly contaminated with copper (cu and Nickel (Ni). Generally, the contamination level in the study area can be described as being very slightly to slightly contaminated and hence, does not pose any serious environmental concern to plants, humans, and the well-being of the environment as it stands presently.

Based on findings, this study recommends the following

1. To safeguard the health of living organisms in the environment, the Government should invest in modern wastewater treatment infrastructure and monitor pre-treatment of industrial effluents before discharge for environmental sustainability

2. The study recommends that proper remediation of the soils should be carried out before any cultivation of crops is done on the soil to avoid bioaccumulation of toxic elements.

3. Proper enlightenment should be carried out to inform the operators of this industry of the need to ensure effective treatment of the wastewater effluents.

4. Public-private partnerships (PPPs) can be explored for constructing centralized treatment plants

**Declaration of Competing Interest**

The authors are declaring that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

**References:**

Abia (State, Nigeria) - Population Statistics, Charts, Map and Location. (n.d.). Retrieved June 6, 2025, from <https://www.citypopulation.de/en/nigeria/admin/NGA001__abia/>

Adeleke, O., Akinlabi, S. A., Jen, T. C., & Dunmade, I. (2022). Environmental impact assessment of the current, emerging, and alternative waste management systems using life cycle assessment tools: a case study of Johannesburg, South Africa. Environmental Science and Pollution Research, 29(5), 7366-7381.

Adewumi, J. R., & Oguntuase, A. M. (2016). Planning of Wastewater Reuse Programme in Nigeria.Consilience,15, 1–33.

Ado, A. Tukur, A., Gumel, M., Muhammad, A., Habibu, S., & Koki, I. (2015). A Review on Industrial Effluents as Major Sources of Water Pollution in Nigeria. Chemistry Journal, 1(5), 159–164.

Ajiere, S.I. and Weli, V.E. (2018) “Spatial Analysis of Rainfall and Temperature Regimes over the selected state of South Eastern Nigeria Implication for agricultural practices” Journal of Natural Science Research Vol 8. No.8.20l 8. Available

Ali, H., Khan, E., & Ilahi, I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. Journal of Chemistry, 2019. https://doi.org/10.1155/2019/6730305

APHA (2017). Standard Methods for the Examination of Water and Wastewater (23rd ed.). Washington DC: American Public Health Association.

Amaefule, E.O. Anyanwu, S.A., Abuka, C.O., Nwaogazie, F.O., Nwabuko, C.N., & Chiemela, C.D. (2023). Water and Wastewater Treatment in Nigeria: Advancements, Challenges, Climate Change and Socioeconomic Impacts. Path of Science, 9(8) 2010–2031. doi: 10.22178/pos 95-7. ISSN 2413-9009

Ayers, R. S., & Westcot, D. W. (1985). Water quality for agriculture (Vol. 29). FAO Irrigation and Drainage Paper.

Baker, D. B., et al. (2016). "Effects of wastewater treatment plant effluent on the water quality of receiving streams." Environmental Monitoring and Assessment, 188(4), 225.

Bhuiyan M.A.H., Suruvi N.I., Dampare S.B., Islam M.A., Quraishi S.B., Ganyaglo S., Suzuki S.

Investigation of the possible sources of heavy metal contamination in lagoon and canal water in the tannery industrial area in Dhaka, Bangladesh Environ. Monit. Assess., 175 (2011), pp. 633-649

Chidugu-Ogborigbo, R. U., Sunday Nkopuyo, U., Hodges Nikolas, J., & Barker, J. (2025). Bioaccumulation and genotoxic effect of heavy metal pollution in marine sponges from the Niger Delta. Marine Pollution Bulletin,211 https://doi.org/10.1016/J.MARPOLBUL.2024.117386

Chinedu, E., & Chukwuemeka, C. K. (2018). Oil spillage and heavy metals toxicity risk in the Niger Delta, Nigeria. Journal of Health and Pollution, 8(19). https://doi.org/10.5696/2156-9614-8.19.180905/ASSET/8811ADDE-73E4-4DE1-8522-A7BD8EC9DE26/ASSETS/GRAPHIC/I2156-9614-8-19-180905-F08.PNG

EPA. (2012). Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater. U.S. Environmental Protection Agency. https://www.epa.gov

Ezekwe, C.I., & Ofoegbu, G.I. (2010). Groundwater pollution from domestic waste disposal in southeastern Nigeria. Environ. Monitor. Assess., 170(1), 153–162.

Federal Government of Nigeria (2006). 2006 Population Census. National Bureau of Statistics, Abuja

García Villena, E., Gracia Villar, S., Dzul López, L. A., Álvarez, R. M., Delgado Noya, I., & Luís Vidal Mazón, J. (2021). Approach to a project framework in the environment of sustainability and corporate social responsibility (csr): case study of a training proposal to a group of students in a higher education institution. Sustainability, 13(19), 10880.

Gbarakoro, S. L., Gbarakoro, T. N., & Eebu, W. L. (2020). Impact of Industrial Effluent Discharge on the Physico-chemical Properties of Aleto Stream, Eleme, Rivers State, Nigeria. Annual Research & Review in Biology, 35(1), 79–89. https://doi.org/10.9734/ARRB/2020/V35I130183

He, Z. L., Yang, X. E., & Stoffella, P. J. (2005). Trace Elements in Agroecosystems and their Environmental Impacts. Journal of Trace Elements in Medicine and Biology, 19(2–3), 125–140. <https://doi.org/10.1016/J.JTEMB.2005.02.010>

Hussaini A. Ali A.F and Abdullahi B.A (2021). Effects of Using Industrial Wastewater For Irrigation On Heavy Metals In Soils And Crops: A Case Of Kano Metropolis, Nigeria.

J. Chem. Soc. Nigeria, Vol. 46, No. 6, pp 0931 – 0939

Ike, C.C., Ugwu, K., & Agbo, K.E. (2018). Urban waste management in Nigeria: A case study of Abia State. J. Environ. Sci. Eng. B, 7(1), 31–42.

Iwegbue, C., Bassey, F., Tesi, G., Nwajei, G., & Tsafe, A. (2013). Assessment of Heavy Metal Contamination in Soils around Cassava Processing Mills in Sub-Urban Areas of Delta State, Southern Nigeria. Nigerian Journal of Basic and Applied Sciences, 21(2). https://doi.org/10.4314/NJBAS.V21I2.2

Kaur, N., & Brraich, O. S. (2021). Impact of industrial effluents on physico-chemical parameters of water and fatty acid profile of fish, Labeo rohita (Hamilton), collected from the Ramsar sites of Punjab, India. Environmental Science and Pollution Research International, 29(8), 11534. https://doi.org/10.1007/S11356-021-16429-2

Kiziloglu, F. M., et al. (2008). Effects of wastewater irrigation on soil and cabbage-plant chemical properties. Journal of Plant Nutrition and Soil Science, 171(3), 385–392.

Kümmerer, K. (2009). The presence of pharmaceuticals in the environment due to human use–present knowledge and future challenges. Journal of Environmental Management, 90(8), 2354-2366. <https://doi.org/10.1016/j.jenvman.2009.01.023>

Lacutusu, R. (2000). Appraising levels of soil contamination and pollution with heavy metals. In Heinike H. J.,.Eckselman W., Thomasson A.J., Jones R.J.A., Montanarella L. and Buckeley B.(eds.). Land information systems for planning the sustainable use of land resources. European Soil Bureau Research Report No. 4. Office of Official Publication of the European Communities, Luxembourg, pp 393-402. Machender, G., Dhakate, R., P

Lena Abou Jaoude, Farah Kamaleddine, Rania Bou Said, Rabi H. Mohtar, Razan Dbaibo, Sandra F. Yanni, Treated wastewater reuse and its impact on soil properties and potato and corn growth, Science of the Total Environment, Volume 958,2025,178130, ISSN 0048-9697,https://doi.org/10.1016/j.scitotenv.2024.178130.(https://www.sciencedirect.com/science/article/pii/S0048969724082883)

NESREA (2011). National Environmental (Sanitation and Waste Control) Regulations. National Environmental Standards and Regulations Enforcement Agency, Abuja.

Nigeria Exports of Aluminum (NEA) - 2025 Data 2026 Forecast 1996-2023 Historical. Retrieved June 6, 2025, from https://tradingeconomics.com/nigeria/exports/aluminum

Noya, I., Inglezakis, V., González-García, S., Katsou, E., Feijoo, G., & Moreira, M. T. (2018). Comparative environmental assessment of alternative waste management strategies in developing regions: A case study in Kazakhstan. Waste Management & Research, 36(8), 689- 697

Nwachukwu, M.A., & Mbanaso, E.O. (2012). Wastewater management in Nigeria: Problems and prospects. African Journal of Environmental Science and Technology, 6(2), 77–84.

Okafor, B.O., Opara, A.I., & Uchegbu, M.N. (2015). Evaluation of industrial wastewater management in Aba Metropolis, Abia State. J. Waste Manag. Dispos., 1(2), 29–36.

Okereke, J.N., Ogidi O.I and Obasi K.O (2016). Environmental and Health Impact of Industrial Wastewater Effluents in Nigeria - A Review. Int. J. Adv. Res. Biol. Sci. (2016). 3(6): 55-67.

Qadir, M., et al. (2007). Agricultural use of marginal-quality water—opportunities and challenges. Advances in Agronomy, 96, 197–258.

Rabalais, N. N., Turner, R. E., & Wiseman Jr, W. J. (2002). Gulf of Mexico hypoxia, aka "The dead zone". Annual Review of Ecology and Systematics, 33(1), 235-263. https://doi.org/10.1146/annurev.ecolsys.33.010802.150513

Reed, H. E., & Mberu, B. U. (2014). Capitalizing on Nigeria’s demographic dividend: reaping the benefits and diminishing the burdens. Etude de La Population Africaine = African Population Studies, 27(2), 319. https://doi.org/10.11564/27-2-477

Rusan, M. J. M., Hinnawi, S., & Rousan, L. (2007). Long-term effect of wastewater **irrigation of forage crops on soil and plant quality parameters. Desalination, 215(1-**3), 143–152.

Sardar, K., Ali, S., Hameed, S., Samar, S. A., Muhammad, F., Shakoor, B., Aslam, S., Hafiz, B., Tauqeer, M., Afzal, S., Fatima, S., Shakoor, M. B., Bharwana, S. A., & Tauqeer, H. M. (2013). Heavy Metals Contamination and what are the Impacts on Living Organisms. 2(4), 172–179. [www.gjournals.org](http://www.gjournals.org)

Sumaila, A, Onyirioha, N. N , Erhabor, D. O. , Muhammad, H. B. , Sumaila, A. O (2023). Pollution Assessment of Selected Heavy Metals in Wastewater obtained from West African Ceramic Company Ajaokuta, Nigeria. Conference: Maiden food safety and nutrition summit At Kebbi state

Suruchi, & Khanna, P. (2011). Assessment of heavy metal contamination in different vegetables grown in and around urban areas. Research Journal of Environmental Toxicology, 5(3), 162–179. https://doi.org/10.3923/RJET.2011.162.179

Toze, S. (2006). Reuse of effluent water—benefits and risks. Agricultural Water Management, 80(1-3), 147–159.

Varol, M. (2011) Assessment of heavy metal contamination in sediments of the Tigris River (Turkey) using pollution indices and multivariate statistical techniques. Journal of Hazardous Material, 195, 355 – 364.

WHO (2006). Guidelines for the safe use of wastewater, excreta, and greywater. Volume 2: Wastewater use in agriculture. Geneva: World Health Organization.

World Health Organisation. (2007). Health Risks of Heavy Metals from Long-Range Transboundary Air Pollution Joint WHO Convention Task Force on Health Aspects of Air Pollution, 2–144. www.euro.who.Int