Gombe Journal of Geography and Environmental Studies (GOJGES)

Vol. 3 No.3 Dec. 2023

e-ISSN: 2714-321X

p-ISSN: 2714-3201

http://www.gojgesjournal.com

PHYSICO-CHEMICAL EVALUATION OF ETCHE RIVER IN THE NIGER DELTA AREA OF NIGERIA

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Abstract

The physico-chemical characteristics of Etche River, located in Rivers State, were investigated across different seasons. The study area is a vast theatre for multiple petroleum development and cottage industry activity. Water samples were collected during the dry and wet seasons, from six sampling points, and two samples along the river course. Grab (Catch) water sampling method was used in the collection of water samples into PVC and Biological Oxygen Demand (BOD) bottles, during the two different seasons. Water samples were carefully labelled and kept cool at 4 degrees Celsius. We used standard equipment to measure water temperature, acidity (pH), and how well electricity can pass through the water (conductivity). We also tested for dissolved oxygen, total alkalinity, and free carbon dioxide using established scientific procedures. (Eaton and Franson, 2005). Differences exist in the observed physico-chemical properties of water samples collected during the two seasons. For instance, during the wet season, the levels of magnesium, Calcium, and pH were 72.22(mg/l), 297.3 (mg/l), and 5.07 respectively, while values for the dry season were 63.19(mg/l), 260.1 (mg/l) and 6.11 respectively. The concentration of total dissolved solids (TDS) in water samples from both seasons surpassed the guidelines set by the Federal Environmental Protection Agency. Copper was detected in the water at concentrations of 0.06 to 0.09 milligrams per litre. The study revealed the disposal of industrial, commercial, and domestic waste in Etche River. Recommendations include controlling both point and non-point sources of pollution in Etche River.

Key Words: Seasonal variation, Surface water, Physico-chemical Parameters, Niger Delta Area

1. Introduction

Nigeria's Niger Delta has been an area of great concern for environmental activists for decades due to widespread environmental problems exacerbated by anthropogenic activities, including problems caused by the exploration and development of oil resources on which Nigeria depends heavily. The area is at high risk of flooding, is crossed by numerous rivers, and has been subject to several instances of pollution from crude oil spills. The many rivers that flow through Nigeria's Niger Delta play a vital role in the local ecosystem and support the livelihoods of many communities. As with many river systems in rapidly developing regions, understanding their physicochemical properties is essential to assess their condition and sustainability. The objective of this study is to provide a comprehensive assessment of the physical and chemical properties of the Etche River. By analysing these factors we aim to gain insight into the current state of the river, possible sources of pollution and their impacts on the ecosystem. This study will not only contribute to the scientific understanding of the Etche River but also serve as the basis for informed management and conservation strategies to ensure the preservation of this important water resource for future generations.

Over the decades, there has been a wealth of literature on the physicochemical and bacteriological aspects of natural and drinking water quality (Inah et al (2022), Oluwande et al (1980), Esreyet al (1985), Sharma et al (1995), Esrey (1996), Smith et al (2000), Dwivedi and Pandey (2002), WHO (2002, 2004a and 2004b), NWP (2002), Ashbolt (2004), Begum et al (2004), Turgeon et al (2004), Eaton and Franson (2005), Chowdhury et al (2006), Ayse et al (2008), Bhuiyan and Gupta (2007), Naik and Wantaneeo (2009)). (2008), Schmidt and Esa (2008), Aina (1996). 1980), Amadiet al (1989), Imoke (2012), Udom et al, Ugbaja and Edet (2004), Igbokwe (2005), Badmus (2008) and Rimonson (2008), Adejuwon (2012) and many others papers however provide vivid evidence of local water problems in Nigeria. Water is one of the most important natural resources on earth and therefore one of the most important. Water is needed in rural and urban areas for domestic, industrial and agricultural purposes. Sources include rivers, streams, ponds and wells (Adejuwon and Adelakun, 2012).

Rivers are strategically important waterways around the world and represent important water resources for various purposes, and the selection of the Etche River for this study is justified by the fact that many oil exploration and extraction activities are carried out in the community. It flows through. Water bodies such as the Etche River are constantly used as reservoirs for untreated water and poorly treated wastewater from industrial activities.

This can render the water body unusable for both primary and secondary uses. One of the most serious crises in Etche communities is lack of adequate drinking water. In Rivers State in general, drinking water supply is one of the biggest problems due to environmental pollution. The plight of Etche communities in Rivers State due to the impact of resource exploration and exploitation on their physical and cultural environment and future has been well documented by both Naagbanton (1999) and Nwokogba (2013).
Nwokogba (2013) specifically states that the major freshwater rivers in the region are Otami Oche, Oguche and Imo Rivers. He noted that agriculture is an important occupation for the Etche people. This explains why Etche is popularly referred to as the “breadbasket” of Rivers State. However, the discovery and development of huge reserves of crude oil and natural gas has had adverse effects on the environment especially in areas such as Agbada, Imo River, Nkari, Otamiri, Oyigbo North and Umuetchem.

Currently, the presence of pipeline networks, flow stations and gas processing plants has marred the aesthetics of the area. He added that according to the most pessimistic estimates, Etche is the third largest producer of crude oil and gas in the state. He noted that oil and gas activities have various negative and unavoidable impacts on the human environment. He lamented the situation in which Etche has borne the brunt of the impacts of oil spills and spills, severely affecting agricultural and residential areas and groundwater levels; freshwater pollution in rivers; gas flaring that has caused acid rain and reduced crop yields; insecurity and violent clashes; uncertainty; and health risks. In particular, he noted that eight known large-scale oil spills have been recorded in Etche, apart from numerous wastewater releases into rivers. In developing countries, as has happened in this study, as industrial geography develops over the last decade, there is a need to focus more on the socio-economic, biophysical and health impacts of industrialization, rather than focusing only on traditional theories of rent and location economics, to ensure that the best interests of the local community are brought about.

Industrial site siting in Africa has been largely politicized, with little concern for the immediate and long-term impacts on local communities. Against this background, the need for studies on the impact of anthropogenic activities on the aquatic environment in rural areas such as Etche, where large-scale agricultural activities, as well as large-scale industrial and oil extraction activities, are carried out, cannot be overemphasized. Such research is also necessary and urgent, as growing oil industry activity has been linked to numerous conflicts, devastating poverty, massive oil theft and spills, and high levels of environmental pollution.

Etche River, a vital artery of the conflict-ridden oil-rich Niger Delta region in Nigeria, flows through the Etche Local Government Area (LGA) of Rivers State. Situated between Longitude 60°55'00" and 70°08'15" East and Latitude 4°53'30" and 5°12'15" North, the river bisects the LGA and serves as a significant source of the nation's petroleum resources. The Etche area, encompassing both Etche and Omuma LGAs, is bordered by Ohaji/Egbema and Ngor Ogbala LGAs of Imo State to the north, Omuma LGA to the east, Oyigbo and Obio/Agbor LGAs to the south, and Ikwerre LGA to the west. According to Nwokogba (2013), Etche's landmass spans approximately 97,500 hectares (376.5 square meters), and the total population is estimated to be around 600,000. Table 1 presents some communities within the study area, while Figure 1: shows Etche River and surrounding communities.

Table 1. Some communities within the Study Area

S/N	Community	Villages
1	Chakota	Igbo, Ikwerengwo , Umueze , Umuechem, Umusalem, Eguri, Okoroagu Umuaria
2	Nchokoche	Umuanyagu, Chokoche, Odogwa, Umuakuru, Edegelem
3	Okomoko	Amaato, Ulakwo, Odufo

Source: Researcher’s Fieldwork (2012)

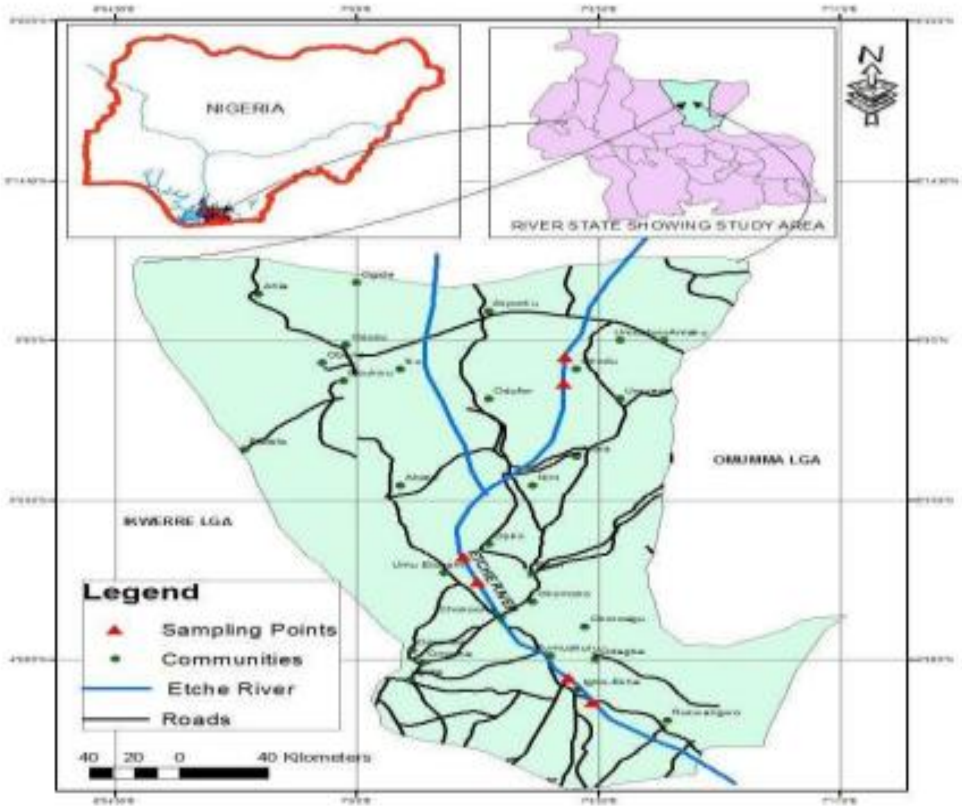

Figure 1: The study area-Etche River and the communities
Source: Department of Environmental Resource Management GIS Lab (2012)

2. Methods

Six sampling stations were strategically selected along the Etche River's course for this study. Employing a systematic random sampling technique, surface water samples were collected at approximately one-kilometer intervals along each river section: upper, middle, and lower. A Global Positioning System (GPS) device was used to precisely locate these sampling points, ensuring their identification in future seasons. Water samples were gathered during two distinct seasons: May for the dry season and October for the rainy season. Collections were conducted during the morning hours between 8:30 AM and 11:30 AM, using one-liter sterile plastic bottles. Samples were immediately transported to the laboratory for analysis.

A total of twelve water samples were collected: two samples from each of the six sampling points across the three river courses. Samples were collected in both PVC and Biological Oxygen Demand (BOD) bottles. All samples were meticulously labeled and stored at 4°C. Water Temperature (T), pH, and Electrical Conductivity (EC) were measured using a mercury bulb thermometer, pH meter, and Conductivity-total dissolved solids (TDS) Meter, respectively. Dissolved Oxygen (DO), Total Alkalinity (TA), and free Carbon Dioxide (CO2) were analyzed using standard methods outlined by the American Public Health Association

(APHA) (2005). The results were compared against the standard values set by the Federal Environmental Protection Agency (FEPA), now known as NESREA. All samples were clearly labeled with the corresponding site number. Samples were refrigerated between 1°C and 4°C to prevent freezing and were analyzed within six days of collection. In-situ analyses were conducted for pH, Dissolved Oxygen (DO), and Electrical Conductivity (EC).

Preparing for water sample collection involved several crucial steps to ensure accuracy and safety. Essential equipment, including sterilized sampling containers, gloves, a sampling pole, and labels, was gathered, and a field notebook was prepared for recording details. The research team evaluated weather and river conditions to confirm stable conditions and avoid sampling during times of floods or high turbidity. Safety protocols were strictly adhered to by wearing protective gear and assessing sampling sites for potential hazards such as strong currents or wildlife. Sampling locations were carefully chosen in areas with continuous flow, avoiding stagnant zones and riverbanks. Samples were collected using a sampling pole or, when necessary, by indigenous swimmers. Care was taken to ensure that containers were submerged without disturbing sediments. The containers were filled to approximately 90% capacity, sealed, and labeled with pertinent information.

Post-sampling procedures included recording any abnormal observations and transporting samples in coolers with ice packs to preserve their integrity. Waste was disposed of responsibly, and reusable equipment was thoroughly cleaned and disinfected to prevent cross-contamination. All sample information was meticulously documented for future reference. These sampling processes and regulations were consistently followed throughout both the dry and wet season sampling procedures.

3. Results

Etche River Water Samples' Physico-Chemical Properties Tables 2 (physical parameters) and 3 (chemical parameters) give the averages of the comprehensive analysis results for all six surface water samples collected throughout each season. As a result, the average values obtained from the water analysis were contrasted with the Federal Environmental Protection Agency's (FEPA, 1998) permitted limits. The average pH values of the water samples for both seasons fall between 6.50 and 8.50, which is within the range of WHO requirements, according to the results of the water analysis. During the wet season, the average pH of all three samples is 5.67, whereas during the dry season, it is 6.11. Compared to the wet season, the dry season had a higher pH level.

The pH of a solution is the concentration of hydrogen ions, expressed as a negative logarithm," states the Government of Western Australia (2009:16). It shows the degree of acidity or alkalinity in a given solution, such water. A pH of 7 indicates neutrality for an aquatic body or sample; lower pH values indicate rising acidity. In additiona, solutions with a pH higher than 7 indicate an increasing amount of alkalinity. The bioavailability of heavy metals and other possible toxicants are significantly impacted by pH level. With values of 12.30 ms/cm and 10.77 ms/cm, respectively, the average level of electrical conductivity (EC) was high during the wet season and low during the dry season. It is interesting to note that the Western Australian Government (2009: 14) added an explanation of how the EC test measures the electrical conductivity of water. This is mostly dependent on how many ions or other charged particles are present in the water.

Table 2 Physical parameters of water samples in comparison with the FEPA standard

S/N	Parameters	Wet Season	Dry Season	FEPA
1	Electricity conductivity (ms/cm)	12.30 10.77 N/A	10.77	N/A
2	Total Dissolved solid (TDS) (mg/L)	61.54	53.84	N.A
3	Odor	Fouling	Fouling	N.A
4	Total Suspended Solid (TSS)(mg/L)	31.0	29	30
5	pH	5.67	6.11	6-9
6	Turbidity (FTU)	81	28	<10

FTU= Formuzin Turbidity Units; N/A=Not available Source: FEPA (1998) and Researchers' Fieldwork (2013)

Table 3: Chemical Parameters of Water Samples and FEPA Limits

S/N	Parameters	Wet season	Dry season	FEPA limits
1	Calcium(mg/L)	297.3	260.1	200
2	Magnesium (mg/L)	71.22	63.19	200
3	Sulphate (mg/L)	619.2	541.8	500
4	Nitrate(mg/L)	4.012	0.688	10
5	Phosphate(mg/L)	0.019	0.016	5
6	Copper (mg/L)	0.09	0.06	1.5

Source: FEPA (1998) and Researchers' Fieldwork (2013)

If low values are observed, it indicates that the water body is of high quality and has low nutrient levels. The opposite is true for higher values. This is a common scenario in areas where fertilizers are used in agriculture and eutrophic conditions have occurred. However, electrical conductivity tests usually cannot indicate the specific ion composition and concentration present in a water body. The average Total Dissolved Solids (TDS) value of the analysis showed a value of 61.54 mg/L during the rainy season and a lower value of 53.84 mg/L during the dry season. This gives an average of 57.69 mg/I for both seasons. Total suspended solids (TSS) is defined as the percentage of total solids in a water sample that are retained by glass fibre filters (GF/C) with pore sizes greater than 2 µm. The mean river water temperature was similar in both seasons, ranging from 26.7°C to 26.0°C. These values are below the FEPA limit of 35-40°C. The importance of the temperature range has been explained by the Government of Western Australia (2009).

The Institute found that water temperature regulates the rates of various biochemical reactions that affect water quality through dynamics of heat sinks such as those occurring in fluctuating solar radiation, re-radiation, evaporative cooling and thermal transfer, cooling of water from power plants, inflows and groundwater discharges. The average values of Total Suspended Solids (TSS) were higher in the rainy season and lower in the dry season. The average values of Total Suspended Solids (TSS) are 31.0 mg/l and 29 mg/l in the rainy and dry seasons respectively. This indicates that the TSS in the rainy season water samples is above the FEPA limit of 30 mg/L while the values in the dry season are below the FEPA standard. Turbidity was low at 28 FTM in the dry season and high at 81/FTM in the rainy season. The turbidity values recorded in both the samples were above the FEPA recommended limit.

This suggests the presence of biodegradable substances, bacteria, and decomposition processes. The average calcium content of the water samples was higher in the rainy season at 297.3 mg/L and 260.1 mg/L in the dry season. Similarly, the magnesium content was higher in the rainy season and lower in the dry season. The sulfate content was higher in the rainy season at 619.2 mg/l and lower in the dry season at 541 mg/l. This may be explained by the fact that agricultural activities requiring the use of fertilizers during the rainy season may result in nutrients being washed into the river from extensive agricultural land, thereby increasing the levels of certain chemical elements.

It could have been logically assumed that during the rainy season, the large amount of precipitation would result in significant dilution and therefore a decrease in the concentration of chemical elements. The nitrate concentration was almost the same at all sampling sites, being 4.012 mg/l in the rainy season and 4.688 mg/l in the dry season. Phosphate levels were almost the same in both seasons, 0.019 mg/l in the rainy season and 0.016 mg/l in the dry season. Water samples from both seasons showed copper values of 0.09 mg/l in the rainy season and 0.06 mg/l in the dry season.

4. Discussion

Pollution has led to elevated levels of certain chemical components in the water body. Significant quantities of industrial and residential chemical and organic waste have been discharged into the river, resulting in a concentration of pollutants. As noted by Sahni and Yadav (2012), pollutant-laden water bodies are reservoirs of contamination, rendering them unsuitable for aquatic biota, aquaculture, and other purposes.

Inadequately managed effluents from both indigenous and multinational petroleum exploration companies and domestic and agricultural wastes have shown a strong potential for eutrophication in the Etche River. This is evident in the gradual spread of algae populations and high concentrations of certain parameters, such as calcium, magnesium, and sulfates. Compared to the FEPA norm of 1998, the Total Dissolved Solid (TDS) levels in the water samples from both seasons were significantly elevated. This high TSD could be attributed to erosion from the landward site and was higher in the rainy season than in the dry season. Additionally, the calcium concentration of the samples exceeded the FEPA's stipulated limit of 200 mg/L.

Uncontrolled effluents from oil companies and domestic and agricultural wastes have contributed to eutrophication in the Etche River, characterized by a spreading algae population and high concentrations of certain parameters. The Total Dissolved Solid (TDS) levels in the water samples were significantly higher than the FEPA standard of 1998, potentially due to erosion from the landward site. The TSD was higher in the rainy season compared to the dry season, and the calcium content exceeded the FEPA's specified limit.

Elevated concentrations of parameters beyond expected limits directly and indirectly impact both abiotic and biotic components of aquatic ecosystems. Several studies have corroborated this assertion, as evidenced by the algae bloom in the Etche River. Parameters such as Dissolved Oxygen, temperature, and BOD reflect the dynamics of living organisms, including the metabolic and physiological behavior of aquatic ecosystems (Singh and Mathur, 2005). As confirmed by Godhantaram and Uye (2003), water, the most precious resource on earth, plays a crucial role in the distribution of organisms. Fresh water contains various microorganisms, and the quality of water through physicochemical parameters affects the species composition, abundance, and productivity of aquatic life (Raibole and Singh,

2011). While some organisms can tolerate pollution, others are highly sensitive to changes in conditions. The concentration of chemical parameters in the Etche River not only affects its suitability for domestic use but also impacts other living biota, as confirmed by other researchers.

Conclusion

Analysis reveals significant seasonal variations in water quality regarding physical and chemical parameters. Conductivity, TDS, and TSS were slightly higher during the wet season, while Turbidity, calcium, magnesium, and sulfates were considerably higher during the same period. Moreover, several parameters, including TDS, turbidity, TSS, and electrical conductivity, exceeded the FEPA limits, indicating a significant deviation from national standards. Calcium, magnesium, and sulfates were also above the expected limits, suggesting that runoff from the land during the wet season contributes to pollutant loads directly entering the river.

The physio-chemical properties of the Etche River in the Niger Delta highlight the substantial impact of petroleum resource exploitation on this vital water body. The analysis reveals significant alterations in water quality parameters, including elevated levels of hydrocarbons and heavy metals, directly linked to oil extraction and processing activities. These changes have far-reaching implications for human health, with increased incidences of waterborne diseases and potential long-term health risks.

The degradation of water quality also has a detrimental effect on local livelihoods, particularly for communities relying on fishing and agriculture. Contamination of aquatic ecosystems disrupts fish populations and damages crops, leading to economic losses and food insecurity. Furthermore, indirect socio-economic consequences, such as reduced property values and increased healthcare costs, further exacerbate the challenges faced by these communities.

Addressing these issues requires a multi-faceted approach, including stringent regulatory measures, effective remediation strategies, and comprehensive health and economic support programs. Collaboration among policymakers and stakeholders is essential to implement sustainable practices and ensure that the benefits of petroleum exploitation do not come at the expense of riverine communities' health and well-being. Only through a concerted effort can the balance between resource extraction and environmental stewardship be achieved, fostering a healthier and more resilient future for the Niger Delta region.

5. Recommendations

Based on the findings of the study and given the river's significance to the local population, it is imperative to ensure the long-term sustainability of Etche River and its ecosystem by implementing the following recommendations:

1. **Research and Monitoring:** Conduct research on the river's morpho-adaptive characteristics and ecology to inform management decisions. Regularly monitor human activities affecting the river and strictly prohibit the discharge of pollutants.

2. **Waste Management:** Improve household waste disposal practices and impose penalties for illegal dumping. Provide alternative water sources, such as free public water, to reduce reliance on the river.
3. **Integrated River Management:** Adopt an integrated approach to river management for sustainable use.
4. **Community Engagement:** Educate the community about river conservation and engage them in conservation efforts.
5. **Regulatory Frameworks:** Strengthen regulations related to industrial discharges and land use, with strict penalties for violations.
6. **Infrastructure Investment:** Invest in waste management infrastructure to ensure proper treatment and disposal of waste.
7. **Sustainable Agriculture:** Promote sustainable agricultural practices that minimize runoff and reduce chemical use.
8. **Monitoring Systems:** Establish comprehensive monitoring systems to track water quality, biodiversity, and ecological changes.
9. **Local Governance:** Empower local government bodies to take an active role in river management and conservation.
10. **Community-Based Resource Management:** Involve local stakeholders in decision-making processes to enhance ownership and accountability.
11. **Economic Alternatives:** Create alternative livelihoods for communities affected by river pollution to reduce dependence on harmful activities.
12. **Riparian Buffer Zones:** Establish and maintain vegetative buffer zones along the riverbanks to protect water quality and ecological health.

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