ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES OF WATER FROM ELEME RIVER, SOUTH-SOUTH NIGERIA

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ABSTRACT

This study evaluated the physicochemical characteristics of water from the Eleme river in Rivers State, South-South Nigeria, to assess the water quality in the river. To determine pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), dissolved oxygen (DO), five-day biochemical oxygen demand (BOD_5), total organic carbon (TOC), chloride ion (Cl^-), calcium ion (Ca^{2+}), magnesium ion (Mg^{2+}), and potassium ion (K^+) using their standard methods, water samples were collected at two different points: station 1 (S1) and station 2 (S2). The results show that EC (1221, 1410 $\Omega^{-1}cm^{-1}$), TSS (312.78, 372.01 mg/l), DO (6.09, 5.95 mg/l), Cl^- (1056.41, 1056.89 mg/l) and K^+ (15.24, 14.84 mg/l) for S1 and S2 respectively were observed to be above the permissible limits recommended by some government regulatory bodies. pH of the water from S1 and S2 are 6.10 and 6.72 respectively which indicates that S1 water is below the permissible limits while S2 water is within the limits and TDS (611.09, 619.90 mg/l) for S1 and S2 respectively were within the permissible limits while TS (923.87, 991.00 mg/l), BOD_5 (4.87, 4.92 mg/l), TOC (190.41, 112.01 mg/l), Ca^{2+} (30.90, 38.22) and Mg^{2+} (23.71, 28.41 mg/l) for S1 and S2 respectively were below the permissible limits. The study has shown that large volumes of untreated industrial effluents and toxicological chemicals released into the Eleme river were the primary cause of pollution loading, which was attributed to EC, TSS, DO, Cl^-, and K^+.

***Keywords*:** Physicochemical parameter; Water quality, Permissible limit, Government regulatory bodies, Eleme river

INTRODUCTION

Water resources are seriously threatened by poor agricultural drainage from rivers and pollution caused by human activity [1, 2]. Anthropogenic sources, such as solid wastes, oil spills, and gaseous emissions [6], as well as untreated industrial effluents, improper home waste disposal, and agricultural runoff, are the main causes of surface water pollution and deteriorating water quality [3-5].

Given that oil exploration sites in Nigeria are known to be surrounded by coastal regions, surge effluents from produced water by refinery facilities constitute an intolerable threat to communities along the coastal boundaries of the Eleme River [7]. These people whose major occupations are mainly fishing, lack knowledge of the level of risks they are exposed to due to lack of confirmed results concerning water quality in their environment.

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Everyone has the right to drink clean, safe water, according to a July 2016 UN General Assembly declaration [8]. Since human activity and climate change are drastically changing the hydrological cycle, the degradation of water quality has drawn attention worldwide as a key issue for the sustainable development of humanity. Monitoring the physicochemical water quality parameters is crucial for assessing the ecosystem, hydrochemistry, ecology, and water environment as well as for restoring water quality [9–11].

The significant geographic and temporal variation observed in rivers and streams has been documented by numerous researchers, with a focus on the physicochemical dynamics of these waterways. Numerous rivers worldwide have had their differences in water quantity and quality well studied. For example, Rahman *et al.* [12] examined the physicochemical characteristics of water in Bangladesh's Turag River and how they changed with the seasons; Singh *et al*. [13] studied the physicochemical characteristics of water samples from the Manipur river system, India; Bilewu *et al*. [14] assessed the physicochemical parameters in particular water bodies in the states of Oyo and Lagos; and Ejiogu *et al*. [15] investigated the concentrations of polycyclic aromatic hydrocarbons and various refinery oil parameters on the Eleme River, Port-Harcourt, Nigeria.

To inform the public, especially the residents of Eleme who rely on the river's water for drinking and other household activities, about the extent of contamination of the Eleme river by some chemical and biochemical contaminants as a result of refinery activities around the river, and to encourage the government to enact policies towards mitigating the inherent risks associated with oil exploration and exploitation in the area, the current study attempts to characterize the trends in physicochemical properties of water from the Eleme river in Eleme, Rivers State, South-South Nigeria.

MATERIALS AND METHODS

The Study area

The Eleme River is situated in Eleme town in Eleme Local Government Area (LGA) of Rivers State, South-South Nigeria. Eleme has 190,884 residents according to the 2006 census, living in an area of 138 km^2. One of the twenty-three LGAs that comprise Rivers State, Eleme is located between longitudes 7' and 7' 35'' East of the Meridian and latitudes 4' 60'' and 4' 35'' North of the equator [15]. As of 2005, Eleme was home to two of Nigeria's four petroleum refineries. Onne, a well-known town in Eleme with a variety of businesses, is also home to the largest seaport in West Africa and one of Nigeria's busiest seaports [16].

The GIS position map places Eleme, the host town of the Indorama Petrochemical Company in Nigeria, 1.4 kilometers from Rumukrushi town,

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which is primarily a residential area without a history of oil exploration and exploitation. The sampling points are indicated on the research area map in Figure 1.

Sample collection and preparation

Two sampling stations were selected along the river: Station 1 is located upstream, and Station 2 is downstream. The method of sample collection used by [17, 18] with modifications was employed. Three sampling sites were picked from each station, and six samples were collected from each of the three sites, giving a total of 18 samples. This resulted in a total of 32 samples from the two stations. At each sampling location, water was collected at a water depth of approximately 10-20 cm and stored in clean polyethylene bottles that had been pre-washed with HNO_3 and thoroughly rinsed with deionized water. The 18 samples from each station were then homogenized to get a composite sample of each station. An alkaline potassium iodide solution was added after sampling to protect the water samples against pathogenic or fungal attacks. The bottles were sealed, appropriately labeled, and then transported to the laboratory, and stored in the refrigerator until analysis.

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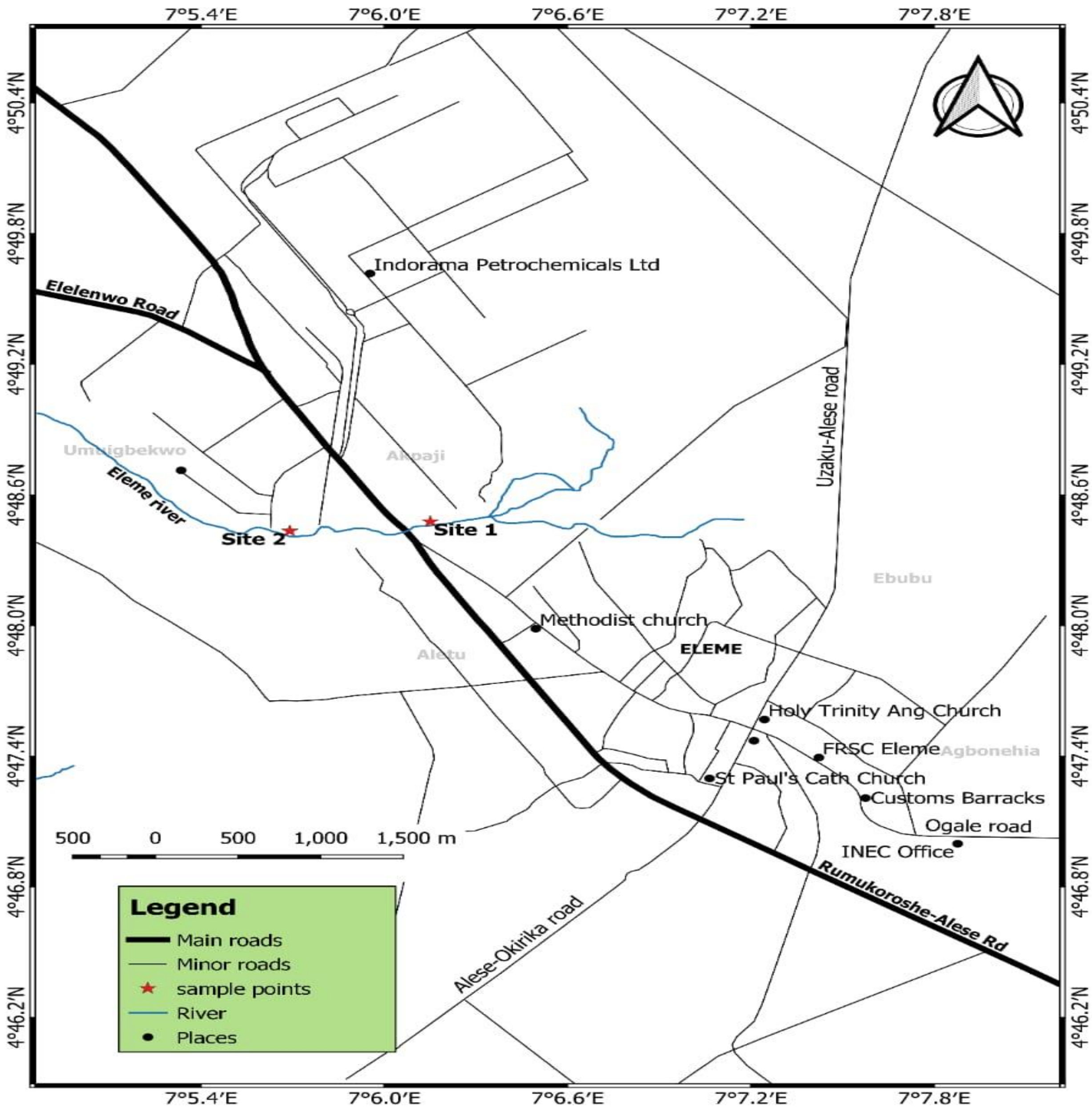

Fig 1: Map of the study area showing sampling points

Determination of Physicochemical Properties of the Water Samples from Eleme River

Twelve parameters were determined using methods described previously for pH [19], electrical conductivity [20], total dissolved solids [21], total suspended solids [21], total solids [20], dissolved oxygen [20], biochemical oxygen demand [22], total organic carbon [23], Cl^- [19], Ca^{++} [19], Mg^{++} [19] and K^+ [19].

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RESULTS AND DISCUSSION

Physicochemical properties of Eleme River water

The water in S1 and S2 had pH values of 6.10 and 6.72, respectively, indicating somewhat acidic water. S2 water is within the allowable level, but S1 water is below it. Flood discharges around sites 1 and 2 may be the cause of the slight pH level difference between them. Acidic precipitation-induced floods (runoff) introduce a variety of organic and inorganic chemical pollutants into surface water, changing the system's water chemistry, particularly the pH [24]. The normal pH range for surface water systems is from 6.5 to 8.0 while that for surface water systems is from 6.5 to 8.5. Thus, the mean pH values of the water at the two sites, as indicated in Table 1, were within the acceptable range for several purposes, including irrigation, residential and recreational uses [25].

Electrical conductivities of 1221 and 1410 (Ω^{-1} $^{Cm-1)}$ for S1and S2 respectively are higher when compared with the standards suggested by [25-29]. The obtained results exceeded the permissible limits reported by DoE [25] in terms of drinking (700 Ω^{-1}cm-^{1}) and irrigation (1 000 $\Omega^{-1\ Cm-1}$) water. The higher conductivity of the water can be attributed to the nature of the contaminants in the water, such as oil and other recalcitrant, which may contain higher acidic contents (oleic and benzoic acids), as opined by Saalidong *et al*. [30]. As a result, the water was unfit for residential uses, drinking, and agricultural purposes (Table 1).

Natural sources, wastewater, municipal and agricultural run-off, and industrial effluents are all sources of TDS in bodies of water. The maximum TDS concentrations for drinking water are 600, 500, and 600 mg/L, respectively, according to [26–29]. As can be seen in Table 1, the TDS levels for the two sites were therefore higher than the allowable limits. Thus, it may be stated that the water from the Eleme River is unfit for domestic purposes such as bathing and drinking but appropriate for irrigation purposes [25].

Stations 1 and 2 have total suspended solids of 312.78 and 372.01 mg/L, respectively, which are higher than the values recommended by [25–28. The greater TSS concentrations in this study may have resulted from the industrial wastewater that dropped straight into the river through pipelines, canals, open drains, etc. that contaminates the river water. The TSS values in the current study were much greater than the drinking standard according to the recommendations by [25–28] (Table 1).

Table 1 shows that the total solids produced in this investigation are marginally below the WHO standard. These outcomes are consistent with those that Valerro [31] reported. These solid particle components of the water can be caused by eutrophication of water bodies, volcanic

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eruptions in the waterbed, weathering of rocks, and human activities like quarrying.

Table 1: Mean values of the physicochemical properties of Eleme River water at the two stations

Parameters	Station 1	Station 2	Recommended limits
pH	6.10[Y]	6.72 [Y]	6.5-8.5[a, b, c, d]
EC ($\Omega^{-1}cm^{-1}$)	1221	1410	700[a], 1 000[c, d]
TDS Concentration (mg/L)	611.09 [Y]	619.90 [Y]	1 000[a], 600[b, c], 500[d]
TSS Concentration (mg/L)	312.78	372.01	150[a], 10[b, c]
TS Concentration (mg/L)	923.87 [Y]	991.00 [Y]	1000[c]
DO Concentration (mg/L)	6.09	6.23	4-6[a], 6[b, c]
BOD_5 Concentration (mg/L)	4.87 [Y]	4.92 [Y]	< 6.0[b, c], 50[a]
TOC Concentration (mg/L)	190.41 [Y]	112.01 [Y]	300[c]
Cl^- Concentration (mg/L)	1056.41	1056.89	150-600[a, b], 250[c, d]
Ca^{2+} Concentration (mg/L)	30.90 [Y]	38.22 [Y]	75[c]
Mg^{2+} Concentration (mg/L)	23.71 [Y]	28.41 [Y]	50[c]
K^+ Concentration (mg/L)	15.24	14.84	5[c]

Note: "a", "b", "c", and "d" denote DoE [25], DPHE [26], WHO [27, 28], and USEPA [29], respectively; and "Y" denotes that water quality parameters meet standards.

According to Table 1, the average DO values for water in S1 and S2 are 6.09 and 6.23 mg/L, respectively. The above values are higher than the acceptable bounds suggested by [25–28]. Hart and Zabbey [32] and Davies et al. [33] also noted a similar pattern for the trans-Amadi (Woji) stream in Port Harcourt, Rivers State, Nigeria. The following DO concentration guidelines are supported: 5 mg/L for industrial uses, 4-5 mg/L for entertainment, 4-6 mg/L for fish and domesticated animals, and 6 mg/L for drinking water [25–28]. Therefore, the water from the Eleme River was practically unfit for such uses.

The BOD_5 quotients of the water at stations 1 and 2 were found to be 4.87 and 4.92 mg/mL, respectively, which is less than the allowable limit specified by [25–28]. When Edori and Nna [34] examined effluents at discharge locations into the new Calabar River, they found average BOD_5 values of 4.92 mg/L; these findings are consistent with the findings of this investigation.

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Water from stations 11 and 2 had TOC concentrations of 190.41 and 112.01 mg/L, respectively, which is less than the WHO standard. A mean TOC of 190 mg/L was reported by Nafsin and Li [35] in their investigation, which compared favourably with this study at station S1. In a different study, Sobczak and Rosińska [23] found that the average TOC levels in water reservoirs in Poland and Germany's Rhine River were, respectively, 8.75 mg/L and 4.13 mg/L. Their findings, however, run counter to the findings of this study.

In comparison to the limitations suggested by [25–29], the amounts of chlorine reported in the two stations (1056.41 mg/L for S1 and 1056.89 mg/L for S2) are extremely high. According to DoE [25] and WHO [27], the acceptable limits of Cl^- concentration in surface water for human consumption are 150–600 mg/L and 250 mg/L, respectively. Chlorinated pesticides and pollutants released from nearby mills and enterprises could be the sources of the chloride found in the water of the Eleme River [9].

Magnesium (23.71 mg/L for S1 and 28.41 mg/L for S2) and calcium (15.24 mg/L for S1 and 14.84 mg/L for S2) recorded in the current investigation are lower than the standard recommended by WHO while potassium values of 15.24 and 14.84 mg/L for SI and S2 respectively, are high compared to the WHO standard.

Probably, this work, to the best of our knowledge except that of Ejiogu et al, [15] on PAHs and sundry parameters, is likely the first of its kind carried out on the Eleme River as literature is scarce on studies about the river. As a result of this research, people in Eleme and its environ are more aware of the poor water quality they consume. The study also highlights how dire the people's circumstances are and how urgent it is for the government to provide alternate sources of potable water. Exposure to chemical and biochemical contaminants via drinking water may expose people in such an environment to developing certain illnesses in their lives if the water sources are not monitored periodically.

CONCLUSION

The concentrations of TSS, DO, Cl^- and K^+, and EC values were above the permissible limits (EC 1221, 1410 $\Omega^{-1}cm^{-1}$), pH of the water indicates that S1 water is below the standard limit while S2 water is within the limit. TDS, TS, BOD_5, TOC, Ca^{2+} and Mg^{2+} aligned with the permissible limits. The substantial volume of untreated industrial effluents and toxicological chemicals released into the river seems to be the primary cause of the pollution loading, which is attributed to EC, TSS, DO, Cl^-, and K^+ concentrations. This study suggests that station 2 has higher concentrations than station 1 in all the parameters except TOC and calcium ion concentrations because station 2 is the point where effluents from industries are most likely to contaminate the river. Hence, there

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is a need for proper monitoring of waste disposal and sustainable remediation options.

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