

## Assessment of physicochemical parameters of water from two selected Rivers (Ekrekana And Iwofe creeks) in Rivers State, Nigeria

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### Abstract

The assessment of physicochemical parameters provides a fundamental and quantitative foundation for evaluating the health, quality, and dynamics of an environmental system. The study was designed to assess the physicochemical parameters of Ekrekana and Iwofe Creeks in Rivers State, Nigeria. Surface water samples for physicochemical analysis were collected monthly for dry season and wet season using pre-washed plastic containers. Physico-chemical parameters such as; pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, turbidity, temperature, dissolved oxygen (DO), biological oxygen demand (BOD)<sub>5</sub> and chemical oxygen demand (COD) were evaluated and used for analysis. pH, EC, TDS, and temperature were measured in-situ using a portable handheld pH/EC/TDS/temperature meter. At the laboratory, (DO) was analysed using the Winkler's method, BOD<sub>5</sub> was analysed in the dark at 20°C for 5 days. All other parameters were analysed based on standard methods as described by The American Public Health Association (APHA). Results showed that at Ekrekana, Iwofe, and Opobo, the pH was 6.89, 7.35, 6.54, respectively, for the wet season, and 6.72, 5.64, and 7.28, respectively for the dry season.

DO were as follows: (Ekrekana: 6.04, Iwofe: 7.15, Opobo: 5.24 mg/L), for wet season, (Ekrekana: 5.42, Iwofe: 7.10, Opobo: 5.01 mg/L) for dry season; BOD recorded thus: (Ekrekana: 3.57, Iwofe: 3.69, Opobo: 3.24 mg/L) for wet season, (Ekrekana: 3.21, Iwofe: 3.60, Opobo: 3.10 mg/L) for dry season; EC was: (Ekrekana: 4213, Iwofe: 5241, Opobo: 3240 µS/cm) for wet season, (Ekrekana: 3863, Iwofe: 4812, Opobo: 301 µS/cm) for dry season; TDS: (Ekrekana: 10872, Iwofe: 12184, Opobo: 8029 mg/L) for wet season, (Ekrekana: 9342, Iwofe: 1184, Opobo: 7780 mg/L) for dry season; the Salinity records were: (Iwofe: 6861 for wet, 6234 for dry) with Ekrekana and Opobo showing lower and less variable values. For Turbidity: (Ekrekana: 23.19, Iwofe: 32.98, Opobo: 8.93 NTU) for wet season, (Ekrekana: 18.21, Iwofe: 27.38, Opobo: 8.04) for dry season; Temperature: (30.63 to 31.29°C) for wet season and (31.23 to 31.03°C) for dry season. The results showed that Ekrekana and Iwofe show greater degree of water quality impairment relative to the control, attributed to anthropogenic or natural input such as runoff, organic pollution, or saline influence. Parameters such as DO, BOD, EC, turbidity, and pH showed statistically significant differences across sites and seasons, indicating real spatial and seasonal variability. The study recommends continued monitoring and potential remediation at Ekrekana and Iwofe to control sources of pollution.

**Keywords:** Physicochemical, Parameters, Season, Pollution, Fluctuation, Water, River system.

### Évaluation des paramètres physicochimiques de l'eau de deux rivières sélectionnées (criques Ekrekana et Iwofe) dans l'État de Rivers, Nigéria

#### Résumé

L'évaluation des paramètres physicochimiques fournit une base fondamentale et quantitative pour évaluer la santé, la qualité et la dynamique d'un système environnemental. L'étude a été conçue pour évaluer les paramètres physicochimiques des criques Ekrekana et Iwofe dans l'État de Rivers, au Nigeria. Des échantillons d'eau de surface pour l'analyse physicochimique ont été collectés mensuellement pendant la saison sèche et la saison humide à l'aide de contenants en plastique préalablement lavés. Les paramètres physico-chimiques tels que le pH, la conductivité électrique (CE), les solides dissous totaux (SDT), la salinité, la turbidité, la température, l'oxygène dissous (OD), la demande biologique en oxygène (DBO<sub>5</sub>) et la demande chimique en oxygène (DCO) ont été évalués et utilisés pour l'analyse. Le pH, la CE, les SDT et la température ont été

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mesurés in situ à l'aide d'un appareil portatif combiné pH/CE/SDT/température. Au laboratoire, l'OD a été analysée par la méthode de Winkler, la DBO5 a été analysée à l'obscurité à 20°C pendant 5 jours. Tous les autres paramètres ont été analysés selon les méthodes standards décrites par l'American Public Health Association (APHA). Les résultats ont montré qu'à Ekrekana, Iwofe et Opobo, le pH était respectivement de 6,89 ; 7,35 ; 6,54 pour la saison humide, et de 6,72 ; 5,64 ; 7,28 pour la saison sèche.

Les valeurs d'OD étaient les suivantes : (Ekrekana : 6,04 ; Iwofe : 7,15 ; Opobo : 5,24 mg/L) pour la saison humide, (Ekrekana : 5,42 ; Iwofe : 7,10 ; Opobo : 5,01 mg/L) pour la saison sèche ; la DBO enregistrée était : (Ekrekana : 3,57 ; Iwofe : 3,69 ; Opobo : 3,24 mg/L) pour la saison humide, (Ekrekana : 3,21 ; Iwofe : 3,60 ; Opobo : 3,10 mg/L) pour la saison sèche ; la CE était : (Ekrekana : 4213 ; Iwofe : 5241 ; Opobo : 3240  $\mu$ S/cm) pour la saison humide, (Ekrekana : 3863 ; Iwofe : 4812 ; Opobo : 301  $\mu$ S/cm) pour la saison sèche ; les SDT : (Ekrekana : 10872 ; Iwofe : 12184 ; Opobo : 8029 mg/L) pour la saison humide, (Ekrekana : 9342 ; Iwofe : 1184 ; Opobo : 7780 mg/L) pour la saison sèche ; les enregistrements de salinité étaient : (Iwofe : 6861 pour la saison humide, 6234 pour la saison sèche), Ekrekana et Opobo montrant des valeurs plus faibles et moins variables. Pour la Turbidité : (Ekrekana : 23,19 ; Iwofe : 32,98 ; Opobo : 8,93 NTU) pour la saison humide, (Ekrekana : 18,21 ; Iwofe : 27,38 ; Opobo : 8,04) pour la saison sèche ; Température : (de 30,63 à 31,29°C) pour la saison humide et (de 31,23 à 31,03°C) pour la saison sèche. Les résultats ont montré qu'Ekrekana et Iwofe présentent un degré plus élevé de dégradation de la qualité de l'eau par rapport au site témoin, attribué à des apports anthropiques ou naturels tels que le ruissellement, la pollution organique ou l'influence saline. Des paramètres tels que l'OD, la DBO, la CE, la turbidité et le pH ont montré des différences statistiquement significatives entre les sites et les saisons, indiquant une réelle variabilité spatiale et saisonnière. L'étude recommande une surveillance continue et une éventuelle remédiation à Ekrekana et Iwofe pour contrôler les sources de pollution.

Mots-clés : Physicochimique, Paramètres, Saison, Pollution, Fluctuation, Eau, Système fluvial.

يُوقر تقييم المعايير الفيزيائية والكيميائية أساساً علمياً كياً ومهما لتقويم صحة وجودة وديناميكيات النظام البيئي. وقد صُممت هذه الدراسة لتقييم المعايير الفيزيائية والكيميائية لحوزري إكركانا (Ekrekana) وإيوفي (Iwofe) في ولاية ريفرز، نيجيريا. جُمعت عينات المياه السطحية للتحليل الفيزيائي والكيميائي شهرياً خلال موسمي الجفاف والأمطار باستخدام أوعية بلاستيكية مغسولة مسبقاً. وتم تقييم وتحليل معايير فيزيائية وكيميائية مثل: الأثر الهيدروجيني (pH)، والتوصيلية الكهربائية (EC)، والمواد الصلبة الذائبة الكلية (TDS)، والملوحة، والعمارة، ودرجة الحرارة، والأكسجين الذائب (DO)، والطلب الحيوي على الأكسجين (BOD<sub>5</sub>)، والطلب الكيميائي على الأكسجين (COD). قيسَت قيم pH و EC و TDS و درجة الحرارة ميدانياً باستخدام جهاز محمول لقياس pH/EC/TDS/الحرارة. وفي المختبر، جرى تحليل الأكسجين الذائب (DO) باستخدام طريقة وينكلر (Winkler)، كما جرى تحليل الطلب الحيوي على الأكسجين (BOD<sub>5</sub>) في الظلام عند درجة حرارة 20°م لمدة خمسة أيام. أما بقية المعايير فقد خُلَّت وفق الطرق القياسية كما وردت في إرشادات الجمعية الأمريكية للصحة العامة (APHA). أظهرت النتائج أن قيم الأثر الهيدروجيني في إكركانا وإيوفي وأوبوبو (Opobo) خلال موسم الأمطار بلغت على التوالي: 6.89، 7.35، 6.54، بينما كانت خلال موسم الجفاف 6.72، 5.64، 7.28 على التوالي. سُجِّلَت قيم الأكسجين الذائب (DO) كما يلي: خلال موسم الأمطار (إكركانا: 6.04، إيوفي: 7.15، أوبوبو: 5.24 ملغم/لتر)، وخلال موسم الجفاف (إكركانا: 5.42، إيوفي: 7.10، أوبوبو: 5.01 ملغم/لتر). أما الطلب الحيوي على الأكسجين (BOD<sub>5</sub>) فكانت قيمه خلال موسم الأمطار: (إكركانا: 3.57، إيوفي: 3.69، أوبوبو: 3.24 ملغم/لتر)، وخلال موسم الجفاف: (إكركانا: 3.21، إيوفي: 3.60، أوبوبو: 3.10 ملغم/لتر). وبلغت التوصيلية الكهربائية (EC) خلال موسم الأمطار: (إكركانا: 4213، إيوفي: 5241، أوبوبو: 3240 ميكروسيمز/سم)، وخلال موسم الجفاف: (إكركانا: 3863، إيوفي: 4812، أوبوبو: 301 ميكروسيمز/سم). كما سُجِّلَت قيم المواد الصلبة الذائبة الكلية (TDS) خلال موسم الأمطار: (إكركانا: 10872، إيوفي: 12184، أوبوبو: 8029 ملغم/لتر)، وخلال موسم الجفاف: (إكركانا: 9342، إيوفي: 1184، أوبوبو: 7780 ملغم/لتر). أما الملوحة، فقد سُجِّلَت في إيوفي بقم بلغت 6861 خلال موسم الأمطار و6234 خلال موسم الجفاف، في حين أظهرت إكركانا وأوبوبو قمتاً أقل وتبايناً محدوداً. وبالنسبة للمعارة، فقد بلغت خلال موسم الأمطار: (إكركانا: 23.19، إيوفي: 32.98، أوبوبو: 8.93 وحدة NTU)، وخلال موسم الجفاف: (إكركانا: 18.21، إيوفي: 27.38، أوبوبو: 8.04 وحدة NTU). وتراوحت درجات الحرارة بين 30.63 و31.29°م خلال موسم الأمطار، وبين 31.03 و31.23°م خلال موسم الجفاف. وأظهرت النتائج أن إكركانا وإيوفي تعانين من درجة أعلى من تدهور جودة المياه مقارنة بالموقع المرجعي، ويُعزى ذلك إلى مدخلات بشرية أو طبيعية مثل الجريان السطحي، أو التلوث

العضوي، أو التآثرات الملحية. كما أظهرت معايير مثل الأكسجين الذائب (DO)، والطلب الحيوي على الأكسجين (BOD)، والتوصيلية الكهربائية (EC)، والعمارة، و pH ففوقاً ذات دلالة إحصائية بين المواقع والمواسم، مما يدل على وجود تباين مكاني وموسمي حقيقي. وتوصي الدراسة باستمرار المراقبة وتنفيذ إجراءات معالجة محتملة في إكوكانا وإيوفي للسيطرة على مصادر التلوث.

## الكلمات المفتاحية: الخصائص الفيزيائية والكيميائية، المعايير، الموسم، التلوث، التذبذب، المياه، النظام النهري.

### Introduction

The physicochemical characteristics of river ecosystems in Nigeria necessitate an examination of the principal water quality indicators of riverine waters. These parameters are crucial for evaluating the ecological health and appropriateness of the river for aquatic organisms, human utilization, agricultural practices, and the maintenance of ecological equilibrium. Commonly assessed physicochemical variables in river systems in Nigeria encompass temperatures, pH, electrical conductivity (EC), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), sulphate (SO<sub>4</sub>), nitrate (NO<sub>3</sub>), total hardness (TH). These indicators provide insights into various factors, including temperature variations, acidity or basicity, organic load, nutrient concentrations, and the presence of particulate matter in the water.

Temperature affects the metabolic rates of aquatic organisms and the solubility of gases while pH indicates the acidity or alkalinity which influences chemical reactions and organisms health. Electrical conductivity measures water's ability to conduct electricity, related to ion concentration and salinity. Dissolved oxygen is crucial for respiration of fish and microorganisms; low DO indicates pollution. Biological oxygen demand (BOD) and chemical oxygen demand (COD) estimates the organic pollution load and oxygen consumption potential. Total dissolved solids (TDS) and total suspended solids (TSS) affect turbidity and water clarity while, nutrient like nitrate and sulphate impact eutrophication potential. Hardness measures calcium and magnesium content, affecting water chemistry and usage.

Researches on river systems have revealed a significant correlation between seasonal variations and anthropogenic activities on various water quality parameters. Some of these studies identified a range of detrimental human-induced factors, including urban runoff, industrial discharges, agricultural

effluents, and domestic wastes, all of which contribute to degradation of water quality in these vital ecosystems. The impact of such activities often results in substantial deviations from the recommended water quality standards establish by standard bodies like World Health Organisation (WHO). These deviations are worrisome as they pose serious concern to both human health and aquatic biodiversity (Tula *et al.*, 2023; Akinyemi *et al.*, 2014).

Monitoring of physicochemical parameters such as pH, DO COD, BOD, EC, nutrient and heavy metal contents – is of paramount importance. Such monitoring not only aids in effective environmental management but also serves as a crucial mechanism for pollution control. Regular assessment and analysis of these parameters allows for the identification of pollution sources and the formulation of strategies to mitigate their effects. Consequently, the sustainable utilization of Nigeria's river resources hinges on comprehensive and on-going monitoring efforts, which can help ensure the protection of public health and the preservation of the ecological integrity of these waterways. It is essential that stakeholders including government agencies, environmental organizations, and local communities collaborates to implement robust monitoring frameworks to curb the deteriorating conditions caused by human activities. In doing so, more sustainable approach to manage Nigeria's vital water resources can be established, benefiting both present and future generations.

A systematic approach is essential in river monitoring, as the quality of water at any point is influenced by the entire upstream watershed, including land use, geology, and human activities (Lord *et al.*, 2009). In Penchala River, Malaysia, water quality was reported to have declined from "good" at the upstream sites to distorted in the middle/downstream urban sections by using integrated biomonitoring and water quality index (Mahazar *et al.* 2013). Nayak *et al.* (2018) used water

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quality index (WQI) to evaluate key physicochemical parameters of the Brahmani River, India. Their findings showed that WQI ranged from good to poor across stations. A study at the Bhairab River, Bangladesh on key physicochemical parameters such as TDS, EC, BOD, COD, DO, turbidity, pH, and salinity revealed that high WQI (957) indicates water is unsuitable for drinking; though suitable for irrigation and fisheries (Biswas *et al.*, 2021). In a related study, Hassan *et al.* (2020), investigated 30 parameters of water including 11 heavy metals (Cr, Pb, Ni, CU, zn, Cd, etc.), BOD, TDS, and EC in the Dhaleshwari River, Bangladesh. Their study noted that Tannery industrial pollution; central effluent treatment plant was not fully effective at the time of the study. Furthermore, Cr concentration was seen to exceed standards in winter. Forecasting was used for pollution trends from 2000 to 2024 at the Yamuna River, India. Increasing trends in total coliform, temperature, TDS, and hardness was reported at the river which pose serious concerns on river systems within the area (Sharma *et al.*, 2020).

Multiple Nigerian Rivers have been studied for physical and chemical parameters reflecting seasonal variations, urbanization, and industrial impact. For

### The Study Area

Rivers State is one of the core Niger Delta states and lies within latitude 4°30'0"N – 5°15'00"N and longitude 6°30'00"E – 7°0'00"E (Ahuchaogu *et al.*, 2025). Formed on the 27<sup>th</sup> day of May 1967, and bordered by Imo and Anambra State to the north, Abia and Akwa-Ibom State to the east, Bayelsa and Delta State to the west (Figure 1). The State capital, Port Harcourt is a metropolis that is considered to be a commercial nerve centre of the Nigerian oil industry (Amaechi, 2009; Rivers State Government, 2010). Rivers State is home to lots of Rivers and Creeks with several mangrove swamps, tropical rainforest, vegetation and numerous networks of roads (Ahuchaogu *et al.*, 2025). The State is known to experience a tropical monsoon climate characterized by high temperatures, humidity, and significant rainfall throughout the year. The mean annual temperature ranges from 25°C to 28°C. During the hottest months (February to April), though temperatures can reach up to 32°C or higher (Ogba, 2013). Rainfall in the State ranges from 2000mm to 4000mm, and due to its coastal location

example, the Otamiri River in Imo State showed contamination from urban runoff, industrial waste, agricultural input, and domestic sewage affecting pH, DO, BOD, COD, nutrients and solids (Iheagwam and Ezenwaji, 2024). Similarly, Woji creek in Rivers State exhibited statistically significant changes in physicochemical parameters over time, reflecting diverse pollution sources affecting sulphur, nitrogen compounds, and heavy metals. At local Nigerian Rivers, a comparative study across five rivers (Ele, Fada, Olugbu, Ubu, Ukwaka) at Umudim Nnewi, Anambra State, Nigeria indicated variations in parameters such as pH (noting acidity in some rivers), total dissolved solids, electrical conductivity, and temperature. Some rivers exhibited values suggesting potential water quality degradation likely tied to human influence (Obasi *et al.*, 2024). The overall trend in these case studies emphasize that river water physicochemical parameters are significantly influenced by natural seasonal changes and increasing anthropogenic pressures such as urbanization, agriculture and industry. These impacts manifest in altered pH, DO, nutrient enrichment, and solid content often surpassing recommended environmental standards.

and abundant rainfall, the state witnessed high humidity levels throughout the year with relative humidity exceeding 80% particularly during the wet season (Efe and Weli, 2015). Rivers state experiences typically two seasons namely wet season and dry season. The wet seasons occurs from March to November and is characterized by heavy rainfall, increased cloud cover, and slightly lower temperatures whereas, the dry season is marked by reduced rainfall, higher temperatures, and increased sunshine hours. However, variations in seasons occur such that even during the dry season, some amount of rainfall still occurs (Akpodiogaga and Odjuga, 2010). The state receives an average of 1500 to 2000 hours of sunshine annually with sunshine duration typically shorter during the wet season due to increased cloud cover (Efe and Weli, 2015).

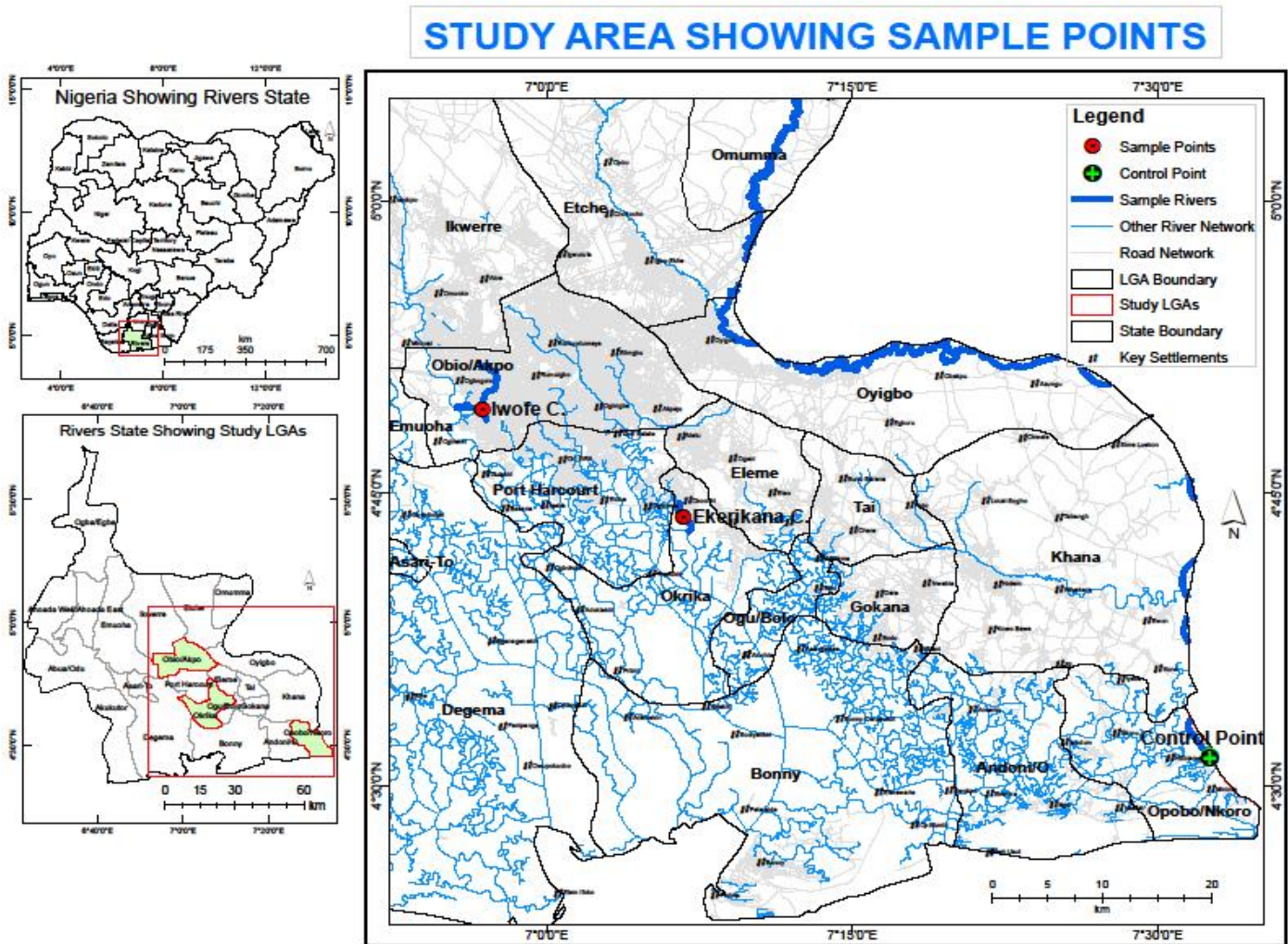
The state has an estimated area of 11,077km<sup>2</sup> and ranked 26<sup>th</sup> in terms of size with an estimated human population of 9,898,470 (MINA Ijaw Population Report 2024 Estimate). Rivers State is the 4<sup>th</sup> most populous state in Nigeria being home to many ethnic groups including Ikwerre, Etche, Ndoki, Asa, Ogba, Ekpeye, Degema, Ogoni, Ijaw and Kalabari. The

state is linguistically diverse with 30 indigenous languages being said to be spoken in Rivers State including Andoni-Obolo, Ibani, Ijaw, Ekpeye, Ikwerre, Ogba, Abua, Ogoni, and Kalabari (The Language of Rivers State of Nigeria, 2021). The study area features Okrika Local Government Area and Obio-Akpor Local Government Area of Rivers State (Figure 1).

Okrika Local Government Area of River State is one of the 23 LGAs in the state, located in the southern part of the state, in the Niger Delta region of Nigeria and bounded by Eleme LGA to the North, Tai LGA to the East, Bonny River which leads to the Atlantic Ocean to the South and Port Harcourt to the West (Figure 1). The area is characterised by a mix of land and water bodies, including creeks, swamps, and island. The terrain (Okrika LGA) is low-lying, typical of the Niger Delta region. The major water bodies in the area include the Bonny River and the Okrika Creek. According to the 2006 population census data, the population of Okrika LGA was 222,026 (National Population Census, 2006). Major settlements in the area include Okrika town being the administrative headquarters, Ibaka, Ogoloma and Ogbogbo. Okrika LGA is strategically important due to the presence of oil and gas facilities including the Port Harcourt Refinery Company (PHRC). The area features a jetty that serves as a mirror port, which facilitates trade and transportation. Okrika's economy remains strongly tied to aquatic resources and traditional fishing practices, though environmental

degradation from oil exploration has impacted the livelihood of the area (City People Magazine, 2012). Obio-Akpor Local Government Area just like Okrika LGA is located in the southern part of Rivers State. Obio-Akpor is bounded to the north by Ikwerre LGA, to the east by Etche LGA, to the south by Port Harcourt LGA and to the west by Emuoha LGA (Ref. Figure 1). The area covers approximately 260 km<sup>2</sup>. The projected area population of the area in 2020 was put at 742,238. The predominant occupation of the indigenous people are farming, fishing and trading while, the major religion is Christianity with few adherent to African Traditional Religion ([https://rsphcmb.rv.gov.ng/health\\_facilities\\_cl/obio-akpor/](https://rsphcmb.rv.gov.ng/health_facilities_cl/obio-akpor/)). The area is predominantly low-lying with some parts being swampy, typical of the Niger Delta region. The area occupies a mainland position immediately north and east of Port Harcourt City, with a more varied terrain that includes urban areas, freshwater swamps, and tropical rainforest zones (Rivers State, Nigeria, 2022). The major water bodies in the area are the New Calabar River which flows through parts of the LGA. Some of the major settlements in its urban areas include Rumuola, Rumuobiakani, Rumuogba, Rumuomasi, Rumuokoro and Rumuodumaya being the LGA headquarters. Economically, Obio-Akpor is home to several industries and is considered one of the industrial hubs of Rivers State. It hosts lot of oil and gas companies and related service providers. Due to its closeness to Port Harcourt, the state capital, Obio-Akpor has experienced rapid urban growth and development owing to the influx of industries in the area.

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**Figure 1: Study Area Showing Iwofe and Ekrekana Creeks**

### **Surface Water Sampling**

Surface water samples for physicochemical parameters were done following the methods used in the works of Ahuchaogu, Deekor and Iwuoha (2025). Samples were collected in the morning hours (8.30am – 10am). Surface water samples were collected from each of the two (2) selected river systems (Ekrekana and Iwofe) and a control point at Opobo Water Channel on monthly bases (Figure 1). Water samples were collected during dry season between November 2023 to January 2024 (dry season) while, water samples for the wet season months were done between August to October 2023 (wet season). Samples were collected from the first 20-25cm of the water column using a plastic container. Prior to sampling, the plastic containers were washed thoroughly and rinsed using the river water before using it to collect the river water to be analysed. Eight (8) water physico-chemical parameters were evaluated and used for determining the concentration

of water physicochemical parameters like; pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, turbidity, temperature, dissolved oxygen (DO), biological oxygen demand (BOD)<sub>5</sub>. Upon collection, pH, conductivity, total dissolved solid and temperature were measured In-Situ with the help of a portable handheld pH/EC/TDS/temperature meter. The rest of the water samples were then stored in cold packed ice to maintain the chemical properties of the water sample, and then transported to the laboratory within 24 hours after collection. At the laboratory, Dissolved oxygen (DO) was analysed using the Winkler's method after adding fixatives. Separate samples were collected, incubated in the dark at 20°C for 5 days after which biological oxygen demand (BOD<sub>5</sub>) was analysed. All other parameters were analysed based on standard methods as prescribed by The American Public Health Association (APHA). Containers used for sampling include, dark coloured reagent bottles (70 ml) for the

collection of dissolved oxygen (DO) and biochemical oxygen demand (BOD). Plastic containers (1 litre can) were used to collect water for physicochemical analysis. The sampling containers were properly dried, corked with covers, well labelled and stored in

cool box under laboratory condition a day before the sampling date. The physico-chemical parameters of the samples were presented in mean and standard deviation.

**Results**

**Table 1: Physico-chemical Parameters of Ekrekana Creek, Iwofe, and Opobo Water Channels, Rivers State, Nigeria**

Parameter	Ekrekana		Iwofe		Opobo Channel	Water	P-Value
	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	
pH	7.22±0.47 <sup>a</sup>	7.09±0.31 <sup>a</sup>	7.02±0.31 <sup>a</sup>	7.15±0.25 <sup>a</sup>	6.64±0.01 <sup>a</sup>	6.67±0.34 <sup>a</sup>	.793
DO (mg/L)	7.25±0.86 <sup>a</sup>	7.58±0.62 <sup>a</sup>	7.52±0.36 <sup>a</sup>	6.86±0.50 <sup>a</sup>	5.20±0.11 <sup>a</sup>	5.31±0.00 <sup>a</sup>	.195
BOD (mg/L)	3.89±1.04 <sup>a</sup>	4.09±0.72 <sup>a</sup>	4.04±0.41 <sup>a</sup>	3.75±0.68 <sup>a</sup>	3.01±0.31 <sup>a</sup>	3.44±0.00 <sup>a</sup>	.856
EC (µS/cm)	23.70±7.29 <sup>a</sup>	22.89±7.40 <sup>a</sup>	21.68±7.40 <sup>a</sup>	24.48±8.02 <sup>a</sup>	21.68±7.40 <sup>a</sup>	24.48±8.02 <sup>a</sup>	.931
TDS (mg/L)	11670.00±375.21 <sup>a</sup>	11463.33±373.627 <sup>a</sup>	10826.67±3690.71 <sup>a</sup>	12343.33±4002.02 <sup>a</sup>	430.02±0.01 <sup>a</sup>	456.02±0.03.02 <sup>a</sup>	.920
Salinity (0/000)	14.26±5.25 <sup>a</sup>	13.82±4.83 <sup>a</sup>	12.74±4.48 <sup>a</sup>	15.00±5.34 <sup>a</sup>	12.74±4.48 <sup>a</sup>	15.00±5.34 <sup>a</sup>	.889
Turbidity (NTU)	16.30±9.44 <sup>a</sup>	16.30±10.81 <sup>a</sup>	17.38±11.87 <sup>a</sup>	18.67±16.86 <sup>a</sup>	8.27±11.23 <sup>a</sup>	8.92±0.11 <sup>a</sup>	.986
Temperature (°C)	31.04±1.51 <sup>a</sup>	31.03±1.76 <sup>a</sup>	31.11±1.95 <sup>a</sup>	31.88±2.44 <sup>a</sup>	30.15±1.41 <sup>a</sup>	30.17±0.01 <sup>a</sup>	.845

Source: Nti, Okechukwu, Ukaoma, Ogbuagu, and Akpovbovbo (2025)

**Table 2: Seasonal Variation of Physico-chemical Parameters of Ekrekana Creek, Iwofe, and Opobo Water Channel, Rivers State, Nigeria**

Parameter	Wet Season			Dry Season			P-Value
	Ekrekana	Iwofe	Opobo Water Channel	Ekrekana	Iwofe	Opobo Water Channel	

**Assessment of physicochemical parameters of water from two selected Rivers (Ekrekana And Iwofe creeks) in Rivers State, Nigeria**

	(Control)			(Control)			
pH	6.89±0.25	7.35±0.1 1	6.54±0.51	6.72±0.18	7.28±0.11	5.64±0.32	.723
DO (mg/L)	6.04±0.68	7.15±0.0 1	5.24±0.44	5.42±0.12	7.10±0.21	5.01±0.00	.043
BOD (mg/L)	3.57±0.68	3.69±0.8 1	3.24±0.00	3.21±0.42	3.60±0.11	3.10±0.07	.007
EC (µS/cm)	4213.97±7.78	5241±1.2 2	324.01±0.02	3863±0.34	4812±0.00	301.00±0.02	.350
TDS (mg/L)	10872.50±37 83.20	12184.50 ±1733.10	80.29±0.2 3	9342.00±31 32.00	11184.10±1027. 22	78.00±0.2 2	.348
Salinity	4625±5.08	6861.09± 0.44	193.00±0.01	3746±1.23	6234±0.88	80.00±0.0 4	.408
Turbidity (NTU)	23.19±14.22	31.92±9. 33	8.30±0.30	21.28±14.2 2	27.38±8.33	8.01±0.30	.009
Temperature (°C)	30.63±2.09	31.29±0. 01	29.01±0.3 1	31.23±2.09	31.00±0.00	31.03±0.0 3	.356

Source: Nti, Okechukwu, Ukaoma, Ogbuagu, and Akpovbovbo (2025)

**Discussion**

***Physico-chemical Parameters of Ekrekana, Iwofe, and Opobo Water Channels of Rivers State***

***Temperature***

The temperature range recorded in the study could be attributed to the influence of climate change and global warming on the creek. However, this value is slightly within the WHO permissible limit for the survival of aquatic organisms. This high temperature may be linked to the impact of organic matter and other wastes which decompose and eventually increase the heat retention capacity of the water thereby increasing the temperature of the water. The findings from the study is slightly higher than the findings of Davies *et al.* (2018) That reported temperature ranging from 26.77 - 28.07 and 26.37 - 27.13°C in dry and wet seasons respectively at Orashi, Rivers State, though this temperature range might bring about the invasion of alien species or adversely affect biodiversity (Angaye and Mieyepa, 2015). In contrast, the findings disagreeD with Ansa (2005) WHO which documented a temperature range between 25.9°C and 32.4°C. and Zabbey and Hart (2005) who reported a range between 25.8°C to 30.4°C along Woji Creek. The spatial variation observed in the present study may be due to difference in degrees of runoffs, ambience, organic

and other anthropogenic activities going on around the stations investigated.

***Turbidity***

The high turbidity value of 18.67±16.86 NTU recorded in Iwofe Creek could be due to the tidal activities of the river as well as the influx of water run-offs into the creek. This also means that there was no sufficient photo-penetration into the water column which is necessary for the survival of its constituent organisms. Though turbidity value was higher than the 8 NTU recommended by WHO (2011), these values were however, inconsistent with earlier values recorded by Davies (2009) which documented turbidity values of 21.60±6.20 NTU in their study. Turbidity being a function of the amount of colloidal materials in water especially persistent clay particles (Mallin *et al.*, 1999), findings from the study reflected little suspended particles. This suggests that there was sufficient photo-penetration into the water column which was necessary for the survival of its constituent organisms (Deekae *et al.*, 2010). In contrast, the turbidity values obtained in this study is inconsistent with the findings of Garricks (2008) in the lower Sombreiro River (1.7-2.0 (1.8±0.09) NTU and attributed it to minimal input of materials capable of affecting the cloudiness of the river.

### **pH**

pH of the present study showed variation between acidic and alkaline extremes. This value could be due to the estuarine nature of the creek as a result of the mixing activities of salt and fresh water at the creek. The level of pH observed in this study could be also hinged on anthropogenic activities including dredging at the Elechi-Bonny link road, influx of agro-chemicals into the creek and death of aquatic biota resulting from decayed aquatic biota. The pH range observed in this study was higher than 5.02 - 6.63 observed by Davies *et al.* (2018) at the Orashi River. The pH range of the present study is consistent with the results of Wokoma and Njoku (2016) who reported a mean pH value of  $7.51 \pm 0.02 - 7.90 \pm 0.02$ . The wide pH range observed in the present study may be detrimental for the survival of aquatic lives because most marine organisms including shrimps do not tolerate wide variations of temperature Wokoma and Njoku (2016). However, the pH range observed in the present study also lies within the 6.5 - 8.5 range of World Health Organization (WHO) standard for drinking water and water intended for aquatic life and recreational activities (WHO, 2002). The results showed that the study sites are brackish or marine, as freshwaters of the Niger Delta have been shown to be acidic with pH range of 5.5 - 7.0 (Chindah and Braide, 2003) even though it is said to be below the reports of lower Bonny River by Chindah *et al.* (2006) with a pH range of 8.18 - 8.68.

### **Dissolved oxygen**

Dissolved Oxygen was shown to be within acceptable limits which imply that sufficient entrance of air into the river and as such the creek could allow a larger diversity of aquatic biota. The DO concentration reported in this study was higher than an earlier value recorded by Davies (2009) which had an overall value of  $5.35 \pm 1.36$  mg/L and is within the range recommended for fish production (5 - 75 mg/L) (Kutty, 1987; Anyawu, 1988). The DO value showed higher concentration than an earlier findings of Erondu and Chindah (1991b) in New Calabar (5.0-7.0 mg/L); Hart and Zabbey (2005) in Woji creek (1.6-10.1 mg/L), Adeniyi (1986) in the Bonny estuary (freshwater section) 1-4.0 mg/L and Garricks (2008) for the lower Sombreiro river (6.8-7.0 mg/L). The dissolved oxygen level observed in this study could be connected with biotic and abiotic sources such as vegetation cover, biological oxygen demand, phytoplankton development and size of the creek and wind action (Kutty, 1987). The findings of this research therefore suggest that the creeks contain

adequate dissolved oxygen for fish production. The results of this study however differed from the findings of Arimoro and Ohimain *et al.* (2013). Water with biochemical oxygen demand less than 4 mg/L are termed reasonably clean and unpolluted, while water with concentration greater than 10 mg/L are considered polluted since they contain large amount of degradable organic materials (Ohimain *et al.*, 2012). The concentration of biochemical oxygen demand recorded in this study could also explain low level of dissolved oxygen recorded thus, indicating deteriorating water quality and probably resulted from the death and decay of aquatic macrophyte, increased active organic decomposition in the bottom sediment and the absence of flow-induced turbulence which normally enhances oxygen dissolution in water, this was also observed by Ohimain *et al.* (2014). The BOD concentration recorded in this study was also within acceptable limits. This implies that the aquatic ecosystems investigated had enough air for biodegradation of organic matter in the river. Davies (2006) reported that a high BOD load constitutes huge threat to aquatic environment by depressing the dissolved oxygen level which in turn affects aquatic organisms. River systems with BOD levels less than 4 mg/L are considered clean but those with concentrations greater than 10 mg/L are regarded as polluted as they contain large amounts of degradable organic material (McNeely *et al.*, 1978).

### **Total dissolved solids**

The high TDS recorded in the study areas indicate massive dissolved solids which could be attributed to the influence of water run-offs and other materials into the river. Total dissolved solids are the inorganic matters and small amounts of organic matter, which are present as solution in water. These values were above the standard or allowable value of the TDS set by NDWQS 1000 mg/L (Ministry of Health Malaysia, 2004).

### **Seasonal Variation of Physico-chemical Parameters of Ekrekana Creek, Iwofe, and Opobo Water Channel, Rivers State, Nigeria**

The seasonal variation in physicochemical parameters for Ekrekana, Iwofe, and Opobo Water Channel in Rivers State, Nigeria, revealed substantial hydrological and ecological shifts between the wet and dry seasons. These changes are closely linked to rainfall patterns, runoff, dilution effects, and anthropogenic influences in the Niger Delta region.

## Assessment of physicochemical parameters of water from two selected Rivers (Ekrekana And Iwofe creeks) in Rivers State, Nigeria

The physicochemical parameters (pH, DO, BOD, EC, TDS, salinity, turbidity, temperature) shift considerably between the wet and dry seasons:

pH which showed slightly acidic to neutral in the wet season, with lower values in the dry season, especially in Opobo Water Channel (pH 5.64), was likely due to increased concentration of acids as dilution by rainwater decreases. The higher DO recorded during the wet season may be due to rain-induced aeration. Lower values in the dry season can be linked to increased temperatures and reduced mixing, which favors oxygen depletion. This pattern is significant for aquatic health as oxygen availability drops in the dry season, risking hypoxia. The wet season brings increased nutrient and pollutant loading (Via runoff, organic matter, ion), but flushes and aerates systems, supporting DO concentrations and facilitating natural microbial degradation processes. The dry season reduces these inputs and physical mixing, concentrating pollutants, reducing DO, and presenting higher risk of hypoxia or eutrophication, especially in more impacted channels. Nweke-Maraizu et al. (2023) noted that wet season brought higher turbidity and dissolved nutrients; dry season showed lower DO, mirroring ecological risks and the need for season-aware pollution control at the Okrika segment of the Bonny River. The higher concentrations of BOD in the wet season signify increased organic matter from surface runoff; BOD decreases in the dry season due to reduced inflow of organic materials. Higher BOD, turbidity, and ion

### Conclusion

The seasonal variation seen in Ekrekana, Iwofe, and Opobo Water Channels thus aligns with broader hydrological, ecological, and pollution dynamics in southern Nigeria's aquatic ecosystems, confirming the critical need for annual cycles to be incorporated into water quality assessment, pollution control and

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load in wet season, lower DO in dry season, supporting the general regional trend (Onyenecherer & Chukwukere, 2019). This relationship indicates greater pollution risk during rainfall events. Electrical conductivity (EC) and total dissolved solids are highest in the wet season from increased runoff that brings ions and sediments, but substantial evaporation or retention in the dry season limits these measures despite continued anthropogenic pollutant influx in Iwofe. Seasonal variations saw significant shifts in EC, DO, BOD and turbidity with higher values in the wet season owing to rainfall-driven pollutant and sediment runoff, supporting findings from Ekrekana, Iwofe, and Opobo Water channel (Akintoye et al., 2014). Salinity at Iwofe river system records elevated concentration year-round, possibly because of tidal influence and less freshwater mixing, while Ekrekana and Opobo show less marked changes. Wet season dilution can lower salinity, while dry season concentration increases it. The higher turbidity in the wet season could be as a result of rainfall that suspends sediments, with markedly lower dry-season concentration where water clarity improves. The salinity and turbidity data also revealed how estuarine dynamics and anthropogenic influences combine with seasonal hydrology to shape riverine habitat characteristics and macroinvertebrate community structure. Temperature remained generally high and stable across seasons, typical for the tropics; impacts biological productivity and pollutant breakdown rates.

conservation efforts. The study therefore recommends effective monitoring to account for seasonal peaks in organic and inorganic pollution during the wet season, and risk of oxygen depletion during the dry season.

### Competing interest

The authors declare that they have no competing interests.

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