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SEASONAL VARIATIONS IN PHYSICOCHEMICAL PARAMETERS AND NUTRIENTS IN FIVE COWRIES CREEK NIGERIA: IMPLICATIONS FOR AQUACULTURE

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ABSTRACT
Aquaculture development in estuarine systems depends on maintaining good water quality, and transparency is a key indicator of trophic status. This study evaluated the suitability of Five Cowries Creek, Lagos for aquaculture by characterizing seasonal and spatial variability in transparency and key water quality variables. Twenty sampling stations across three zones were monitored over a 24-month period (November 2023–November 2025), with emphasis on dry (March) and wet (July and November) seasons. Physicochemical parameters were measured in situ, while nutrients and chlorophyll-a were analyzed in the laboratory. Seasonal means showed consistently adequate oxygenation for finfish culture (DO 6.02 ± 0.54 mg L^{-1} in the dry season; 6.41 ± 0.47 mg L^{-1} in the wet season), while wet-season runoff markedly increased turbidity (23.41 ± 0.82 vs. 13.93 ± 15.33 NTU) and nutrient enrichment (PO_4^{3-} 4.82 ± 6.22 vs. 3.37 ± 4.68 mg L^{-1}), coinciding with reduced transparency (58.71 ± 1.31 vs. 113.56 ± 46.57 cm) and episodic extremes (turbidity >60 NTU; Secchi depth ~30–36 cm; PO_4^{3-} >14 mg L^{-1}; NH_3 up to 0.71 mg L^{-1}; NO_3^- up to 11.81 mg L^{-1}; NO_2^- up to 0.591 mg L^{-1}). PCA explained 84.71% of the total variance (PC1 50.43%, PC2 19.74%, PC3 14.54%) and resolved dominant gradients driven by the clarity oxygenation versus turbidity phosphate axis, nitrogen speciation (ammonia nitrate opposition), and redox-linked internal nutrient processing. Overall, Five Cowries Creek can support aquaculture, but wet-season turbidity and nutrient pulses elevate eutrophication and localized oxygen-stress risk; the dry season represents the optimal production window.

Keywords: Water quality, Secchi disk, transparency, physicochemical parameters, Five Cowries Creek

INTRODUCTION

Aquaculture, defined as the controlled breeding, rearing, and harvesting of aquatic organisms, has emerged as one of the fastest-growing food-production sectors globally (FAO, 2022). Its development is largely driven by the need to supplement capture fisheries and satisfy the rising global demand for fish and other aquatic products (Food and Agriculture Organization, 2020). As the world's population continues to grow and wild fish stocks become increasingly strained, aquaculture has the potential to meet the ever-expanding need for protein source (Ruben *et al*., 2025). However, the success of aquaculture operations is intimately tied to the quality of the water in which these organisms are farmed. Water quality is a complex of parameters influenced by a variety of factors (Boyd, 2015; FAO, 2020) and Secchi disk measurements are among the most widely used methods to assess water clarity (Son *et al*., 2025). This is particularly important because water clarity is a strong and indirect indicator of the trophic status and overall health status of an aquatic ecosystem (Siddiqui *et al*., 2021).

Five Cowries Creek, located in Lagos, Nigeria, offers a compelling case study for evaluating the suitability of local water bodies for aquaculture. The creek has long been subject to human activities, such as urban runoff and industrial discharges, which have significantly impacted its water quality (Akinnigbagbe *et al*., 2025).

Previous studies, on Five Cowries creek by Adekoya and Makanjuola (2020), revealed elevated turbidity levels largely due to sedimentation caused by runoff. Olufemi *et al*. (2022) examined the relationship between turbidity and other critical water quality parameters, including dissolved oxygen and nutrient concentrations.

High turbidity, can limit light penetration and disrupt oxygen exchange, and further create a hostile environment for aquatic life. It also has the ability to hinder aquaculture productivity. Further investigations by Chukwu *et al*. (2021) and Akinnigbagbe *et al* (2025) underscored the role of industrial discharges in exacerbating the turbidity problem, emphasizing the need for stricter waste management practices to protect water quality in the creek.

Given the vital role of Secchi disk measurements in monitoring water clarity and its subsequent impact on aquaculture, this study aims to evaluate the suitability of Five Cowries Creek for aquaculture operations. Specifically, the study will analyze nutrients, transparency and some physicochemical parameters data collected over two years to assess water quality in the creek. The research objectives are to measure and analyze transparency, nutrient concentrations and dissolved oxygen levels that are essential for aquaculture, and to provide recommendations for improving water quality management practices to enhance the creek's potential for aquaculture.

MATERIALS AND METHODS

Study area

Five Cowries Creek is located in Lagos State, southwestern Nigeria, forming part of the Lagos Lagoon

Complex, an extensive coastal lagoon system along the Gulf of Guinea. The creek lies approximately between 6°25′–6°28′ N latitude and 3°23′–3°26′ E longitude and connects the Lagos Lagoon to the Atlantic Ocean. It is an estuarine system characterized by the mixing of freshwater inflow from inland sources with saline water from the ocean, resulting in a brackish and highly dynamic aquatic environment (Oladipo and Onyema, 2007; Food and Agriculture Organization, 2020). The creek flows through densely populated urban and semi-urban areas of Lagos, including Ikoyi, Victoria Island, Lekki, and Lagos Island, where land use is dominated by residential, commercial, transportation, and recreational activities.
The region experiences a tropical climate characterized by two main seasons: a wet season from April to October and a dry season from November to March. Temperatures generally range between 25°C and 32°C, with high humidity and intense rainfall during the wet season (Nigerian Meteorological Agency, 2022). Five Cowries Creek supports artisanal fishing activities that provide livelihood and food resources for surrounding communities. The creek also serves as an important aquatic habitat supporting diverse estuarine organisms within the Lagos Lagoon ecosystem (Onyema, 2014). Hydrologically, the creek is influenced by tidal exchanges from the Atlantic Ocean, which enhance water circulation and maintain a brackish environment suitable for various aquatic species. For the purpose of this study, the creek was divided into three zones (Zone A, B and C) to facilitate spatial assessment of water quality conditions across the study area (Figure 1).

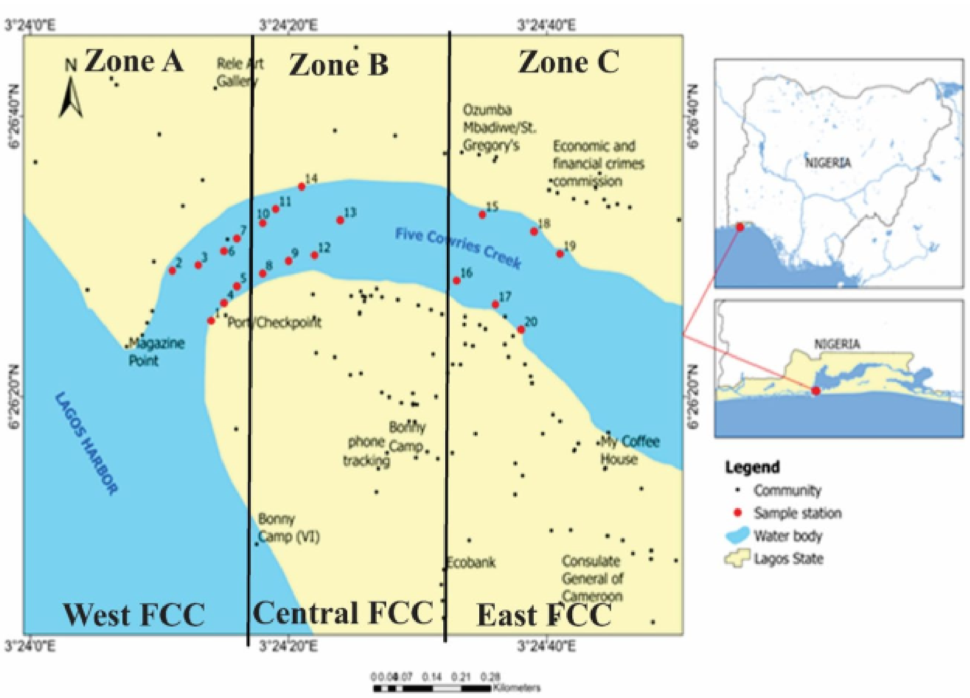

Fig. 1: Map of the study area subdivided into zone A (located at the west of Five Cowries creeks, FCC), Zone B (at the middle of FCC) and Zone C (East of FCC). Adapted from Akinnigbagbe *et al.* (2025)

Zone A
Located in the western section of the creek near Lagos Lagoon, this zone experiences an influx of water from the lagoon and fuel discharge from local transportation activities.

Zone B
Situated in the central part of the creek, this zone is characterized by discharges from an overhead bridge, floating toilets, and marine debris.

Zone C
Found in the eastern section, this zone is the farthest from Lagos Lagoon. It is affected by residential effluents, marine debris, and fuel discharge from flying boats.

Transparency Measurement
Secchi disk readings were taken at the 20 locations in Five Cowries Creek to measure water transparency. The Secchi disk, a simple circular disk typically 8 inches in diameter with alternating black and white quadrants, was lowered into the water until it was no longer visible to the observer by unwinding a calibrated line to which it is attached. The disc is then raised until it reappears. The average of the depth of the water where the disk disappears and reappears is the Secchi disk reading (Zar, 2010).

Sampling Locations and Frequency

Sampling locations were selected based on factors such as proximity to the shoreline, variations in water depth, and areas considered suitable for potential aquaculture activities. The distribution and description of the sampling stations across the three zones are as presented by Akinnigbagbe *et al*. (2025). In total, 20 sampling stations were established to represent the diverse ecological conditions within the creek. Physicochemical parameters were monitored bi-monthly over a 24-month period; however, for the present study, only data from March (dry season) and July and November (wet season) between 2023 and 2025 were analyzed. This is to match the months with data on nutrient concentrations.

Collection of water samples, Nutrient concentrations and selected physicochemical parameters

The dissolved oxygen and turbidity were conducted directly aboard the Nigerian Institute for Oceanography and Marine Research (NIOMR) research-boat, using Hanna HI-9828 multiparameter probe. Samples meant for chlorophyll-a and nutrient analyses were collected using a Niskin bottle and transferred into 2-L containers. Nutrients were analyzed during the month of March, to represent dry season, and July to represent wet season. Perchloric acid was immediately added to fix the nutrients on the field, and the samples were stored in ice chests, labeled Stations 1 to 20. The samples were then transported to the laboratory of the Department of Physical and Chemical Oceanography, Nigerian Institute for Oceanography and Marine Research, Lagos, Nigeria. Nitrite and nitrate concentrations were determined using the standard pink azo-dye method, while phosphate levels were analysed using the molybdenum blue method in accordance with AFNOR standards (ISO 7890–3; T 90015 and T 90023). Prior to analysis, the water samples were filtered through Whatman GF/C filter paper (0.45 µm). All procedures adhered to the precision standards outlined by the USGS (2018).

Data analysis

The measured physicochemical variables and water transparency were analysed using Principal Component Analysis (PCA) to explore their interrelationships and relative contributions to overall water quality variability. Multivariate analysis was performed with PAST version 4.03 (statistical software for Windows), and statistical significance was evaluated at the 5% probability level ($p < 0.05$). Mean concentrations of the measured parameters were subsequently compared with guideline values recommended by the Federal Environmental Protection Agency (FEPA, 1991) and the World Health Organization (WHO, 2004).

RESULTS

Monthly Variability of Dissolved Oxygen, turbidity and nutrient concentrations in Five Cowries Creek

Monthly monitoring of Five Cowries Creek revealed clear seasonal variability, with dissolved oxygen highest during the month of March (up to 6.74 mg/L) and turbidity peaking in the month of November (up to 39.12 NTU) table 1. Nutrient concentrations, particularly nitrate and phosphate, were elevated during November (NO_3^- up to 9.09 mg/L; PO_4^{3-} up to 11.63 mg/L), while transparency was greatest in the month of March (167.23 cm) and lowest in the months of July and November (≈45–60 cm), indicating reduced transparency.

Table 1: Monthly variation of Dissolved Oxygen, turbidity and nutrient concentrations in Five Cowries Creek (Mean ± SD)

Month	DO (mg/L)	Turbidity (NTU)	NH_3 (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	PO_4 (mg/L)	Secchi (cm)
Nov-23	5.17 ± 0.38	6.66 ± 1.23	0.027 ± 0.020	9.09 ± 1.16	0.112 ± 0.025	0.80 ± 0.13	102.35 ± 17.62
Mar-24	6.17 ± 0.63	4.11 ± 3.63	0.081 ± 0.205	2.47 ± 1.20	0.069 ± 0.034	0.23 ± 0.28	167.23 ± 16.42
Jul-24	6.74 ± 0.23	23.99 ± 1.63	0.074 ± 0.151	6.63 ± 1.30	0.093 ± 0.017	9.20 ± 2.02	57.63 ± 5.56
Nov-24	5.83 ± 0.20	39.12 ± 13.40	0.012 ± 0.027	1.26 ± 0.38	0.054 ± 0.068	11.63 ± 1.59	45.30 ± 8.03
Mar-25	6.66 ± 0.23	5.35 ± 0.88	0.029 ± 0.053	2.89 ± 0.63	0.052 ± 0.013	0.32 ± 0.79	149.60 ± 18.14
Jul-25	6.07 ± 0.20	22.83 ± 6.06	0.024 ± 0.009	4.06 ± 1.78	0.032 ± 0.010	0.43 ± 0.09	59.78 ± 7.26
Nov-25	6.26 ± 0.15	14.41 ± 1.32	0.060 ± 0.025	8.50 ± 1.92	0.370 ± 0.121	3.88 ± 0.71	103.30 ± 18.02

Note: Values represent mean ± standard deviation (SD) calculated from 20 sampling stations. Dissolved oxygen (DO), turbidity, ammonia (NH_3), nitrate (NO_3^-), nitrite (NO_2^-), phosphate (PO_4^{3-}), and water transparency (Secchi depth) were measured during seven sampling campaigns between November 2023 and November 2025

Seasonal and Spatial Variability of Dissolved Oxygen, turbidity and nutrient concentrations in Five Cowries Creek

Seasonal variation was observed in dissolved oxygen (DO), turbidity, nutrient concentrations (NH_3, NO_3^-, NO_2^-, PO_4^{3-}), and water transparency (Secchi depth) between November 2023 and November 2025, table 2. Dry season months recorded lower turbidity and higher Secchi depth, whereas wet season months showed higher turbidity and reduced water transparency. Seasonal averages indicated higher mean values of turbidity and nutrients during the wet season, while Secchi depth values were higher during the dry season. Dissolved oxygen values were slightly higher during the wet season. Seasonal mean values and standard deviations are presented in Table 2.

Table 2: Seasonal mean (± general trend) of water quality parameters in Five Cowries Creek (2023–2025)

Season	DO (mg L^{-1})	Turbidity (NTU)	NH_3 (mg L^{-1})	NO_3^- (mg L^{-1})	NO_2^- (mg L^{-1})	PO_4^{3-} (mg L^{-1})	Secchi Depth (cm)
Dry Season	6.02 ± 0.54	13.93 ± 15.33	0.042 ± 0.071	4.84 ± 3.76	0.131 ± 0.143	3.37 ± 4.68	113.56 ± 46.57
Wet Season	6.41 ± 0.47	23.41 ± 0.82	0.049 ± 0.035	5.35 ± 1.82	0.063 ± 0.043	4.82 ± 6.22	58.71 ± 1.31

Notes: Values represent seasonal mean ± standard deviation derived from monthly averages across 20 sampling stations between November 2023 and November 2025.

Dissolved Oxygen and Turbidity Dynamics

Dissolved oxygen concentrations ranged from 4.6–5.95 mg L^{-1} in November 2023 to 7.2 mg L^{-1} in July 2024. Wet season sampling periods, particularly July 2024 and July 2025, generally recorded DO values above 6.5 mg L^{-1}.Turbidity varied substantially across the sampling period. Dry season values ranged from 1.7–7.9 NTU during November 2023 and March 2024. Higher turbidity values were recorded during wet season months, reaching 65.1 NTU in November 2024, with replicate values up to 61.6 NTU.

Nutrient Concentrations and Seasonal Enrichment Patterns

Ammonia (NH_3) concentrations were generally low, with dry season values frequently below 0.05 mg L^{-1}. The highest concentration recorded was 0.71 mg L^{-1} in July 2025. Nitrate (NO_3^-) concentrations were detected throughout the study period, with peak values of 11.81 mg L^{-1} in July 2025 and 11.45 mg L^{-1} in November 2025.Nitrite (NO_2^-) concentrations were lower than nitrate but showed occasional peaks, with the maximum value of 0.591 mg L^{-1} recorded in July 2025. Phosphate (PO_4^{3-}) concentrations varied widely, with the highest value exceeding 14 mg L^{-1} in November 2024.

Water Transparency (Secchi Depth) and Optical Conditions

Transparency values showed substantial variation across seasons. Maximum transparency reached 195 cm in March 2024, with similarly high values recorded during March 2025. The lowest values ranged from 30–36 cm in November 2024.

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was applied to identify the dominant environmental gradients controlling variability in dissolved oxygen (DO), turbidity, ammonia (NH_3), nitrate (NO_3^-), nitrite (NO_2^-), phosphate (PO_4^{3-}), and transparency in Five Cowries Creek (Table 3 and Figure 3). The first three principal components (PC1 to PC3) had Eigen values > 1 and together accounted for 84.71% of the total variance, with PC1 showing 50.43%, PC2 19.74%, and PC3 14.54% respectively.

Table 3: Principal Component Loadings of Water Quality Parameters in the Study Site

Parameters	PC1	PC2	PC3
DO	0.44817	0.049461	-0.33564
Turbidity	-0.45531	-0.3354	0.02758
NH_3	-0.1518	0.70494	0.311
NO_3	0.18165	-0.60302	0.50186
NO_2	0.35023	0.11662	0.62571
PO_4	-0.45225	0.073236	0.35802
SD	0.45674	0.074334	0.1353

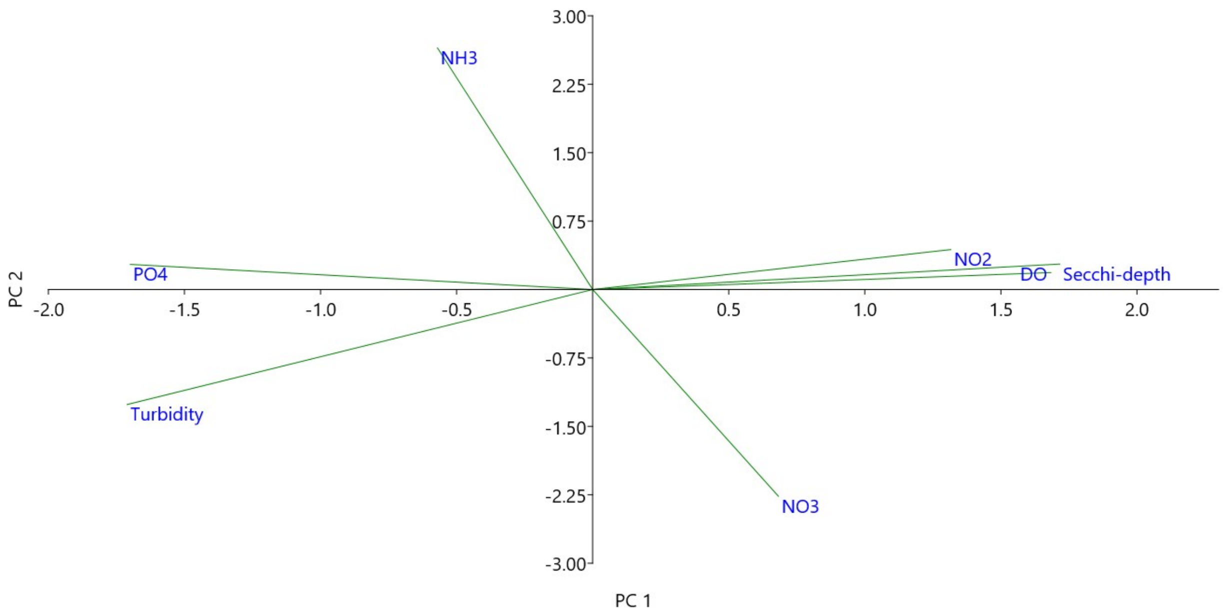

Fig. 3: PCA analysis of dissolved oxygen (DO), turbidity, nutrients (NH_3, NO_3^-, NO_2^-, PO_4^{3-}), and water transparency (Secchi depth) in Five Cowries Creek, Lagos, Nigeria, across dry (November, March) and wet (May, July, September) seasons from November 2023 to November 2025

DISCUSSION

The physicochemical characteristics of Five Cowries Creek between November 2023 and November 2025 revealed marked seasonal variability associated with the dry (March) and wet (July and November) seasons .These seasonal dynamics have direct implications for the suitability of the creek for aquaculture development.

Dissolved oxygen (DO) concentrations in Five Cowries Creek ranged from 4.45 to 7.20 mg L^{-1}, with slightly higher values generally observed during wet-season sampling periods. Most measurements exceeded the 5 mg L^{-1} threshold commonly recommended for sustaining healthy fish growth and aerobic aquatic life, indicating that the creek possesses generally suitable oxygen conditions for fish culture. Similar DO ranges have been reported for tropical estuarine and lagoon systems used for aquaculture and fisheries production in West Africa and other tropical coastal environments (Boyd *et al*., 2020; Badiola, *et al*., 2021and FAO, 2022). However, the spatial distribution of sampling stations indicates that oxygen conditions are not uniform across the creek, partly reflecting variations in human activities, shoreline proximity, and hydrodynamic flushing. Sampling stations located closer to densely urbanized shorelines and areas with higher organic inputs occasionally recorded lower DO concentrations, particularly during transitional seasonal periods. Such conditions may result from localized organic matter loading and microbial respiration, which can increase oxygen demand in nearshore waters (Paerl *et al*., 2021). Stations within Zone C, which are generally farther from intensive shoreline disturbances and benefit from better water circulation and tidal exchange, are likely to provide more stable dissolved oxygen conditions. In contrast, stations in Zone A, located closer to areas with higher anthropogenic activities such as urban runoff and boat traffic, may experience greater fluctuations in oxygen availability. For aquaculture development, Zone C is therefore recommended as the most suitable zone for fish culture operations, particularly for cage or pen systems that depend on natural water exchange. Locating aquaculture facilities in well-flushed sections of the creek would help maintain adequate oxygen supply and reduce the risk of localized oxygen depletion associated with organic waste accumulation.

Turbidity exhibited strong seasonal control, with low values during the dry season and pronounced increase during the wet season, sometimes exceeding 60 NTU. This increase corresponded with a marked decline in Secchi transparency (from >150 cm in the dry season to as low as 30–60 cm in the wet season). The inverse relationship between turbidity and transparency indicates increased sediment and organic matter input during rainfall events, which reduces light penetration and possibly limits primary production (Lee, *et al*. 2024 and Mustapha, 2024). For aquaculture, moderate turbidity can be beneficial by reducing predator risk and moderating light stress on fish, but persistently high turbidity may impair feeding efficiency of visual feeders and clog gills in sensitive species (Lunt and Smee 2015; Boyd and Tucker 2012; Utne-Palm 2002). Similar seasonal turbidity patterns have been observed in tropical creeks connected to urbanized catchments in West Africa, where wet-season runoff increases suspended sediment and organic matter, degrading water clarity and temporarily constraining fish growth conditions (Nwankwo, 2014; Akinnigbagbe *et al.*, 2025). In Five Cowries Creek (Southwest Nigeria), turbidity increases significantly during the wet season due to runoff and sediment input, exceeding standard thresholds and correlating with reduced light penetration and potential stress on aquatic organisms, including fish (Akinnigbagbe *et al.*, 2025). Comparable seasonal turbidity spikes linked to rainfall and runoff have also been documented in other West African tropical waterways, such as the Badagry and Bodo creeks, where wet-season inputs of suspended sediments and pollutants similarly reduce water clarity and can affect fish habitat quality (Elegbeleye *et al.,* 2019). Compared with relatively clearer brackish systems used for aquaculture in parts of Southeast Asia (Mekong Delta canals, Mutea *et al.*, 2021), Five Cowries Creek shows greater wet-season turbidity stress, highlighting the need for seasonal management strategies to mitigate sediment-driven water quality degradation and support sustainable fish production.

Nutrient concentrations, particularly nitrate (NO_3^-) and phosphate (Po_4^{3-}), were substantially higher during the wet season, with phosphate occasionally exceeding 10 mg L^{-1}. These elevated values point to strong anthropogenic nutrient inputs, likely from urban runoff, domestic wastewater and shoreline activities (Abdulkabir *et al.,* 2025; Ezeabasili *et al* 2018). While moderate nutrient enrichment can enhance natural productivity and food availability for filter feeders and detritivorous fish, excessive nutrient loading increases the risk of eutrophication and algal blooms, which may subsequently lead to hypoxia during bloom decay (FAO, 2016). Compared with nutrient concentrations reported for less impacted aquaculture friendly lagoons such as the Volta system in Ghana where nitrate in the surface waters of Lake Volta has been reported at relatively low concentrations (≈0.51–0.82 mg L^{-1} NO_3^--N and 0.34–0.41 mg L^{-1} PO_4^{3-}-P) reflecting oligotrophic conditions (Ofori-Danson and Ntow, 2005) or managed shrimp ponds in Southeast Asia, where nitrate and phosphate in well managed ponds typically remain below ≈1–3 mg L^{-1} (nitrate up to ~2.1 mg L^{-1} and dissolved reactive phosphorus <1.2 mg L^{-1} in Pulau Pinang shrimp ponds; Burford *et al*. 2003), the levels observed here are markedly higher, underscoring the need for targeted nutrient management strategies The observed nutrient levels in this study exceed coastal water quality targets recommended by the United States Environmental Protection Agency, USEPA (2022), suggesting that uncontrolled intensification of aquaculture could exacerbate nutrient pollution in the study area.

This high cumulative variance indicates that water quality dynamics in the creek are largely structured by three dominant hydro-biogeochemical processes namely: (i) a hydrological dilution runoff and sediment resuspension process controlling water clarity and oxygenation (Pc1); (ii) nitrogen transformation and speciation driven by organic matter inputs and nitrification ammonification dynamics (PC2); and (iii) internal biogeochemical processing associated with localized redox conditions and nutrient regeneration (PC3) which is a pattern comparable to multivariate assessments of tropical urban lagoons and estuarine systems elsewhere (Oladipo *et al.,* 2019; Ajao and Oyewo, 2020; Akpabio *et al.,* 2022).

Pc1, which explains more than half of the total variance (50.43%), is characterized by strong positive loadings of transparency (0.4567) and dissolved oxygen (0.4482), and strong negative loadings of turbidity (–0.4553) and phosphate (–0.4523). This component represents a clarity–oxygenation gradient opposed to turbidity and nutrient enrichment. The inverse relationship between turbidity and Secchi depth reflects the expected optical response of the water column. When turbidity is high, light penetration is reduced, so the Secchi disc disappears at a shallower depth (low Secchi depth). When turbidity is low, the water is clearer, light penetrates deeper, and the Secchi disc can be seen at a greater depth (high Secchi depth) (Golubkov, 2023). The positive loading between dissolved oxygen and transparency is an indication that clearer water allows more sunlight penetration, which enhances photosynthesis and phytoplankton biomass, and aquatic plants, leading to increased oxygen production (Zhang *et al.,* 2025). The opposing behavior of dissolved oxygen and phosphate suggests anthropogenic phosphate input affecting dissolved oxygen dynamics in the Five Cowrie creek. Similar PCA structures have been reported in Lagos Lagoon and other tropical estuarine systems, where runoff-driven sediment and nutrient loading during the wet season reduces water transparency and promotes oxygen depletion through enhanced microbial respiration (Ajao and Oyewo, 2020; Adekanmbi *et al.,* 2021).In Five Cowries Creek, this gradient supports earlier seasonal observations that increased surface runoff introduces suspended particles and nutrients, suppresses light penetration, and potentially depresses oxygen levels through elevated biological oxygen demand. From an aquaculture perspective, the PC1 gradient highlights the importance of maintaining low turbidity and adequate oxygenation to support primary productivity and fish health, as reduced transparency can limit phytoplankton photosynthesis and impair visual feeding in cultured species (Boyd, 2020).

Pc2 accounts for 19.74% of the total variance and is dominated by a strong positive loading of ammonia (0.7049) and a strong negative loading of nitrate (–0.6030). This axis reflects nitrogen speciation dynamics, representing spatial and/or temporal variability in nitrification processes. The opposing relationship between ammonia and nitrate indicates differential nitrogen transformation states within the creek, influenced by localized organic inputs, wastewater discharge, and oxygen availability. Similar nitrogen gradients have been observed in urban creeks and peri-urban lagoons in West Africa, where zones receiving fresh organic matter exhibit elevated ammonia, while better-flushed and more oxygenated areas favor nitrate formation through nitrification (Akpabio *et al.,* 2022; Okoye *et al.,* 2023). In Five Cowries Creek, areas impacted by residential effluents, floating toilets, and bridge-related discharges likely contribute to elevated ammonia concentrations via organic matter mineralization. This has direct implications for aquaculture development, as unionized ammonia is toxic to fish and shellfish, particularly under warm tropical conditions and elevated pH, and may constrain site suitability for intensive culture without adequate water exchange or treatment (Boyd, 2020).

Principal Component 3 (Pc3): Internal Biogeochemical Processing and Redox Variability explains 14.54% of the variance and shows strong positive loadings for nitrite (0.6257), moderate positive contributions from nitrate (0.5019) and phosphate (0.3580), and a moderate negative loading for dissolved oxygen (–0.3356). This structure reflects intermediate nitrogen transformation processes and localized redox variability. The prominence of nitrite suggests zones where nitrification may be incomplete or where fluctuating oxygen conditions regulate microbial pathways. The inverse association with dissolved oxygen further supports the role of microbial respiration and organic matter degradation in structuring this component. Comparable patterns have been reported in shallow estuarine creeks and mangrove-fringed lagoons, where fine-scale hydrodynamics and organic loading promote localized hypoxia and altered nutrient cycling (Oladipo *et al.,* 2019; Adekanmbi *et al.,* 2021). Unlike PC1, which is driven largely by hydrological forcing and external inputs, PC3 reflects internal biogeochemical regulation within the creek. This underscores the importance of micro-scale ecological processes in shaping nutrient dynamics and oxygen conditions, with implications for aquaculture carrying capacity and ecosystem resilience.

CONCLUSION

This study assessed water quality dynamics in Five Cowries Creek, Lagos, across three zones and two seasons (2023–2025) to evaluate aquaculture suitability. Dissolved oxygen remained above 5 mg L^{-1}, indicating generally favorable conditions, with Zone C showing greater stability due to better tidal flushing, while Zones A and B reflected stronger anthropogenic influence. Clear seasonal contrasts were observed, with the dry season characterized by low turbidity and high transparency, and the wet season by elevated turbidity, reduced light penetration, and increased nutrient concentrations, particularly nitrate and phosphate. These conditions heighten eutrophication risk and may constrain productivity. Overall, Zone C in the dry season is most suitable, while wet-season aquaculture requires careful management and monitoring.

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