*West African Journal of Life Sciences. Available online at***http://www.wajls.com** ISSN (Print): 2992-5150. *Volume 2; Issue* 1: pages 25-37

Full Length Research

Physicochemical Limnology and Seasonal Water Quality Dynamics of Igbidin Stream in Edo State, Nigeria.

Omoruyi, O. A and Ibhasabiemo, F. O

Department of Plant Science and Biotechnology, Faculty of Life Sciences, Ambrose Alli University, Ekpoma

***Corresponding Author:** osasere.omoruyi@aauekpoma.edu.ng Tel+2348055656885

ABSTRACT

This study investigated the physicochemical limnology and seasonal water quality dynamics of Igbidin Stream in Edo State, Nigeria. Monthly water samples were collected from three stations between January and June 2018, spanning both dry and wet seasons. Parameters analyzed included temperature, pH, turbidity, color, total dissolved solids (TDS), conductivity, alkalinity, total hardness, calcium, magnesium, nitrate, and phosphate. The results revealed marked seasonal variations, with elevated turbidity (up to 21 NTU), conductivity (up to 207.5 µS/cm), and TDS (up to 125 mg/L) during the dry season. Colour values peaked at 99 PtCoU in February, far exceeding WHO limits. Nitrate and phosphate concentrations remained generally low, with nitrate ranging from 0.005 to 0.053 mg/L and phosphate from 0.19 to 0.46 mg/L, although phosphate occasionally surpassed ecological thresholds. The pH showed significant seasonal fluctuation, peaking at 10.7 in April. The physical pollution index (PPI) remained above 1 throughout the study, indicating consistent pollution, particularly in the dry season. Water Quality Index (WQI) values showed significant spatial and temporal variation, with April exhibiting the poorest quality (mean WQI: 116.8), classifying the water as unsuitable for drinking. In contrast, June showed the best quality (mean WQI: 16.28), rated as excellent. Stations 1 and 2 were more affected by pollution, likely due to nearby anthropogenic activities such as farming, while Station 3 exhibited relatively stable and better water quality. The findings underscore the need for seasonal monitoring, targeted pollution mitigation, and provision of water treatment interventions, especially during high-risk months.

Keywords: Water Status, Polution, Water Body, Fresh Water, Water Chemistry, Aquatic Health.

Received May 31, 2025

Received in Revised form, June 20, 2025

Accepted June 22, 2025

Available Online: June 23, 2025

W. Afr. J. Life Sci. 2(1): 25-37

INTRODUCTION

Freshwater ecosystems are among the most dynamic and ecologically significant components of the natural environment, serving as critical habitats for aquatic organisms and vital resources for human societies, (Ekhator and Omoruyi, 2020). Streams, in particular, function as integral parts of watershed systems, regulating hydrological cycles, supporting biodiversity, and providing water for domestic, agricultural, and industrial uses. However, the quality and ecological integrity of these systems are increasingly threatened by both natural climatic variations and human-induced pressures, such as land-use changes, pollution, and unregulated resource extraction. Consequently, the study of stream limnology—especially the physicochemical characteristics of freshwater bodies—has become essential for sustainable water management and ecological conservation.

Physicochemical limnology examines the chemical and physical properties of inland waters and their seasonal dynamics, which are crucial indicators of environmental quality and aquatic health, Dwivedi, (2017); Dutta and Biswas (2023). Seasonal variations in parameters such as temperature, pH, dissolved oxygen, conductivity, turbidity, and nutrient concentrations significantly influence biogeochemical processes and the composition of aquatic communities. Numerous studies across diverse climatic zones have documented the seasonal fluctuation of these parameters and linked them to both natural cycles (e.g., rainfall, temperature shifts) and anthropogenic activities (e.g., agriculture, urban runoff, effluent discharge). However, many streams in sub-Saharan Africa, including those in Nigeria, remain under-researched despite their importance for ecosystem services and human livelihoods. While numerous studies have examined the physical and chemical properties of freshwater bodies across Nigeria (Ipeaiyeda and Onianwa (2011); Udebuana et al. (2014); Dirisu and Olomukoro (2015); Ekhator, et al. (2015); Omorogieva et al. (2016); Talabi et al. (2016); Oboh and Agbala (2017); Yusuf et al. (2017); Zaky and Okpanachi (2017); Egun and Ogiesoba-Eguakun (2018); Iyam et al. (2019); Oseji et al. (2019); Ogbodo et al. (2020); Imoobe and Aganmwonyi (2021); Ogbeibu, and Oriabure (2023); Edosomwan et al. (2024); Avoseh, et al. (2024); Okoye and Ogbebor, 2024), no documented research has specifically addressed the physico-chemical characteristics and water quality of the Igbidin Stream. This lack of empirical data represents a significant gap in our understanding of the ecological status and environmental dynamics of this particular freshwater system.

Edo State, located in the humid tropics of southern Nigeria, contains a network of streams that are increasingly exposed to varying environmental stressors. Yet, detailed investigations into their physicochemical status and seasonal water quality dynamics are limited. In response to this gap, the present study aims to assess the physical, chemical limnology and seasonal water quality of Igbidin stream in Edo State. By integrating field measurements and laboratory analyses across wet and dry seasons, the study establishes baseline water quality conditions, evaluate temporal trends, and identify potential environmental stressors. This multidisciplinary approach is intended to inform water resource management, ecological monitoring, and policy decisions in the region, while also contributing to broader scientific discussions on freshwater ecosystem dynamics under changing environmental conditions.

MATERIALS AND METHOD

Study Area

The study was conducted at Igbidin Stream (figure 1), located in Ozalla, one of the four clans in Owan West Local Government Area, Edo State, Nigeria (coordinates: 6°48′0″N, 6°1′0″E). The stream originates from a rock outcrop, with water channeled through a bamboo structure. Three sampling stations were established along the stream course using a global positioning system (GPS) device (Garmin eTrex 10 GPS Receiver).

Station 1: Near the source, primarily used for drinking, cooking, and bathing (N $06^0 47.968$ E$006^0 01.761$).

Station 2: A transit point for farmers (N $06^0 47.971$E$006^0 01.761$).

Station 3: Commonly used for laundry and bathing (N $06^0 47.959$E$006^0 01.753$).

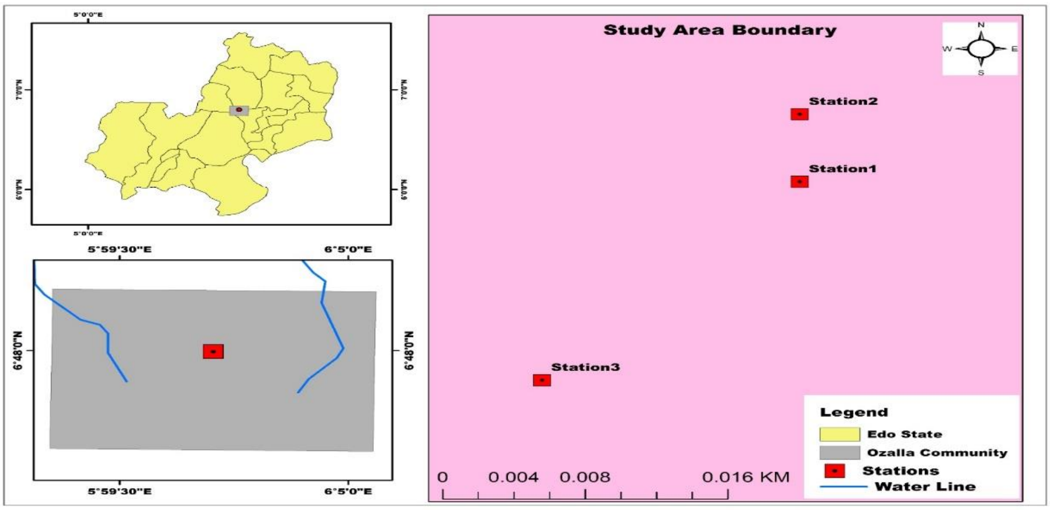

Figure 1: Map of study area

Sampling Procedure

Monthly sampling was carried out from January to June 2018 covering both dry (January–March) and wet (April–June) seasons. Water samples were collected at each station using two liters sample bottles and transported in an ice chest to the laboratory for analysis.

Physical and Chemical Analyses

Water Temperature: Measured *in-situ* using a mercury-in-glass thermometer. Total alkalinity was determined by titrimetric method (APHA, 2005). Colour (PtCoU) was assessed with a HACH DR 2000 spectrophotometer at 455 nm. Turbidity (NTU) was measured using the HACH DR 2000 spectrophotometer at 450 nm. Total Dissolved Solids (TDS, mg/L) and Conductivity (µS/cm) were determined using a HACH CO150 meter. pH was measured on-site using a HANNAH field pH meter.

Total Hardness (mg/L): Determined by titrating 50 mL of the sample with 0.8 M EDTA using ManVer 2 indicator and ammonium buffer. Calcium (mg/L) was determined by titration using CalVer 2 indicator and KOH buffer. Calcium concentration was calculated as: Calcium (mg/L) = Ca Hardness (mg/L as $CaCO_3$) × 0.40. Magnesium (mg/L) was estimated using the formula:

Magnesium (mg/L) = (Total Hardness - Calcium Hardness as $CaCO_3$) × 0.842 × 0.29.

Phosphate (PO_4^{3-}, mg/L): Analyzed with a HACH DR 2000 spectrophotometer at 890 nm using PhosVer 3 reagent. Nitrate (NO_3^-, mg/L): Determined spectrophotometrically at 507 nm using NitraVer 6 and NitraVer 3 reagents.

Pollution and Water Quality Indices

Physical Pollution Index (PPI)

The Physical Pollution Index (PPI) was calculated following Boluda et al. (2002):

using the formulae:

$$PPI = \frac{\left(^{pH}/_{9}\right)+\left(^{Hardness}/_{45}\right)+\left(^{EC}/_{3}\right)+\left(^{Turbidity}/_{30}\right)+\left(^{TDS}/_{1,440}\right)}{5}$$

Where: PPI = Physical pollution index

EC = Conductivity

TDS= Total dissolved solids

Water quality classification based on pollution index standards

Water Quality Index (WQI) Assessment

In this study, eight key physicochemical parameters (pH, TDS, Total hardness, Calcium, Magnesium, Nitrate, Conductivity and alkalinity) were selected to evaluate the water quality using the Water Quality Index (WQI) approach. The index was derived following the drinking water quality standards set by the World Health Organization (WHO, 2011) and the Indian Council of Medical Research (ICMR, 1975). The computation followed the Weighted Arithmetic Index method originally proposed by Brown et al. (1972), and is represented as:

$$WQI = \sum W_i Q_i$$

Where:

W_i denotes the relative weight assigned to the ith parameter

Q_i represents the quality rating for the ith parameter

The weight W_i was obtained using the formula:

$$W_i = w_i / \sum w_i$$

where w_i is the unit weight of the ith parameter, which is inversely related to its standard permissible limit (S_i), calculated as:

$$w_i = K / S_i$$

Here, K is a constant of proportionality determined by:

$$K = 1 / \sum(1 / S_i)$$

The sub-index or quality rating (Q_i) for each parameter was computed using the equation:

$$Q_i = 100 \times [(V_i - V_o) / (S_i - V_o)]$$

where:

V_i is the observed concentration of the ith parameter at a sampling site

V_o is the ideal value for that parameter in potable water

S_i is the standard permissible value for the parameter

Ideal values (V_o) were considered as zero for most parameters except for pH, which was taken as 7.0, in accordance with the values suggested by Tripaty and Sahu (2005).

Table 1: Water quality index classification and water quality status as per Weighted Arithmetic Water Quality Index (WAWQI) method:

Water quality index classification	Water quality status
0 to 25	Excellent water quality
26 to 50	Good water quality
51 to 75	poor water quality
76 to 100:	very poor water quality
> 100:	Unsuitable for drinking.

RESULTS

Physical and Chemical characteristics

Turbidity levels (figure 2a) ranged from 0 to 21 NTU. The lowest mean value (0.7 NTU) was recorded in March, while the highest (8.0 NTU) occurred in May. Station 3 recorded the peak turbidity in May (21 NTU), indicating significant particulate input during this period. TDS values (figure 2b) varied between 5 mg/L and 125 mg/L across stations. The monthly mean TDS peaked in February (66.33 mg/L), with the highest individual value at Station 3 (125 mg/L). March and April recorded relatively lower means of 22.0 mg/L and 11.33 mg/L respectively.

Conductivity values (figure 2c) ranged from 9.6 µS/cm (March, Station 1) to 207.5 µS/cm (February, Station 3). The highest monthly mean was in February (116.57 µS/cm), while the lowest occurred in April (24.07 µS/cm). Alkalinity ranged (figure 2d) from 5 to 15 mg/L, with the highest mean in February (13.33 mg/L) and the lowest in March and May (6.67 mg/L each). Values remained fairly consistent across stations and months.

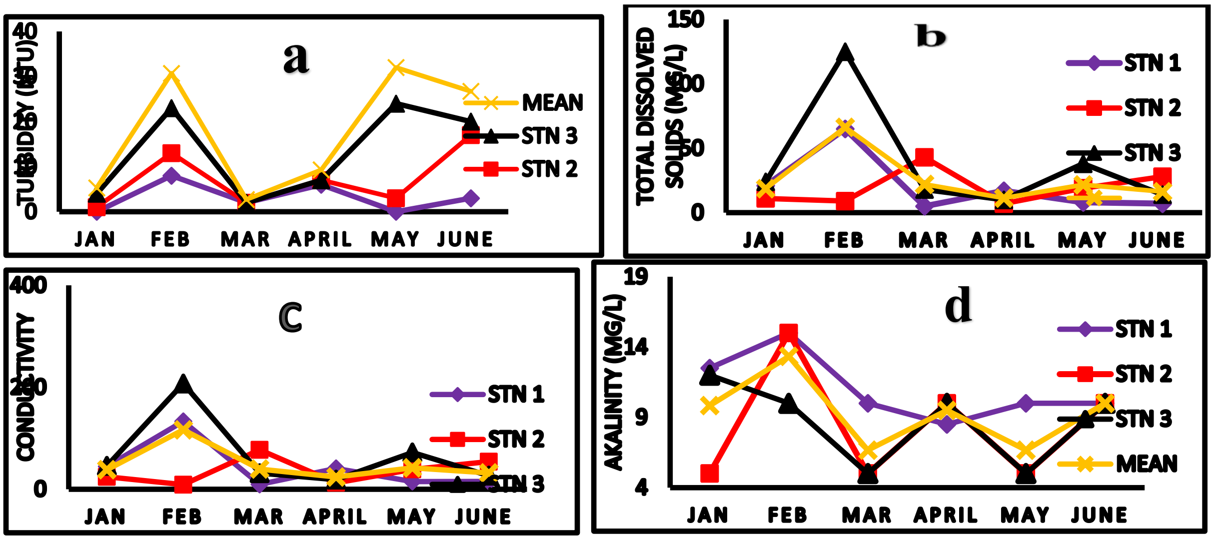

Figure 2: Monthly Variation of (a): Turbidity, (b): Total Dissolved Solids, (c): Conductivity and (d): Akalinity in Igbidin Stream

The colour (figure 3b) of the stream water varied widely, with values between 0 and 99 PtCoU. The mean colour value was highest in February (47.00 PtCoU), with a notable spike at Station 3. March and April recorded the lowest mean colour values of 10.67 PtCoU and 4.33 PtCoU respectively. Nitrate concentrations (figure 3a) were low throughout the sampling period, ranging from 0.005 to 0.053 mg/L. The highest monthly mean was recorded in February (0.0227 mg/L), while the lowest occurred in March (0.0057 mg/L). Phosphate concentrations (figure 2c) ranged from 0.19 to 0.46 mg/L. January recorded the highest monthly mean (0.37 mg/L), while February had the lowest (0.25 mg/L). The highest individual value (0.46 mg/L) occurred at Station 2 in January.

Total hardness values (figure 3d) ranged from 7.5 to 20 mg/L. The highest monthly mean was observed in January (15.83 mg/L), and the lowest in June (10.83 mg/L. Calcium hardness (figure 4a) ranged from 5 to 12.5 mg/L, with January and February recording the highest monthly means (9.17 mg/L). Magnesium hardness (figure 4b) varied from 2.5 to 10 mg/L, with the highest mean in January (6.67 mg/L). Calcium concentrations (figure 4c) ranged from 2 to 5 mg/L, with January and February having the highest mean values (3.67 mg/L). Magnesium concentrations (figure 4d) varied from 0.61 to 2.44 mg/L, with the highest mean in January (1.63 mg/L).

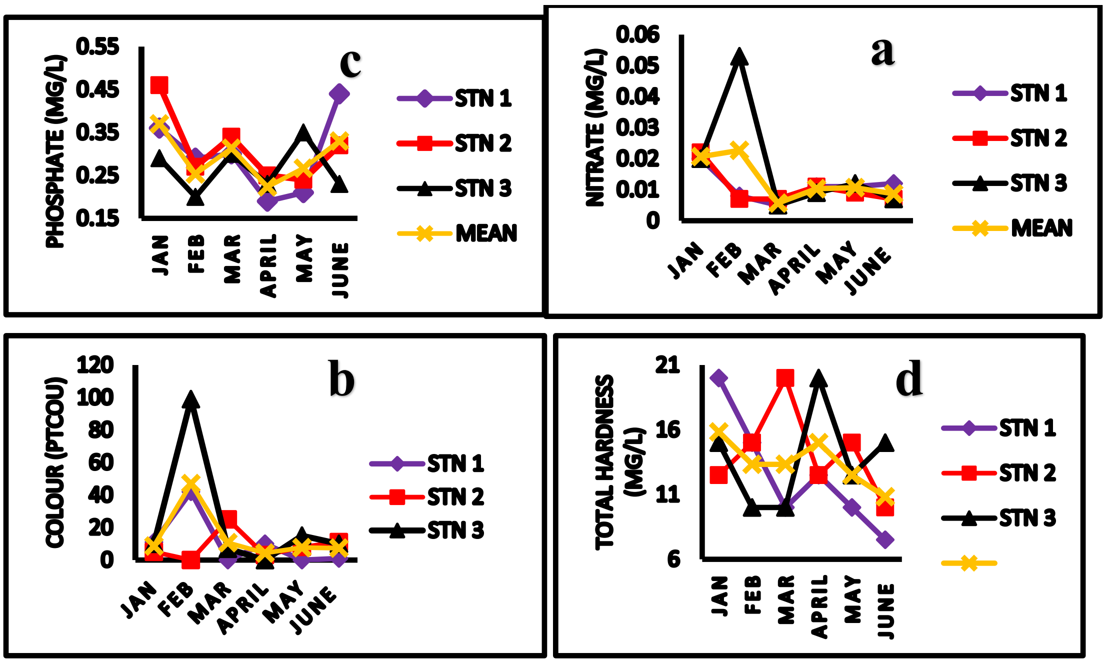

Figure 3: Monthly Variation of (a): Nitrate, (b): Colour, (c): Phosphate and (d): Total Hardness in Igbidin Stream

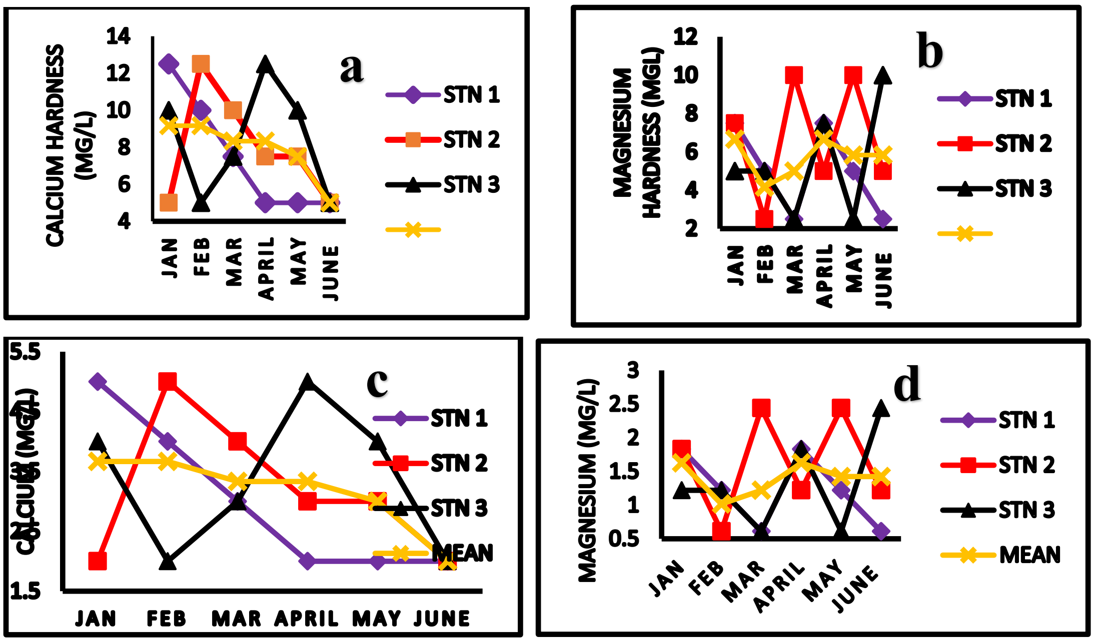

Figure 4: Monthly Variation of (a): Calcium Hardness, (b): Magnesium Hardness, (c): Calcium and (d): Magnesium in Igbidin Stream.

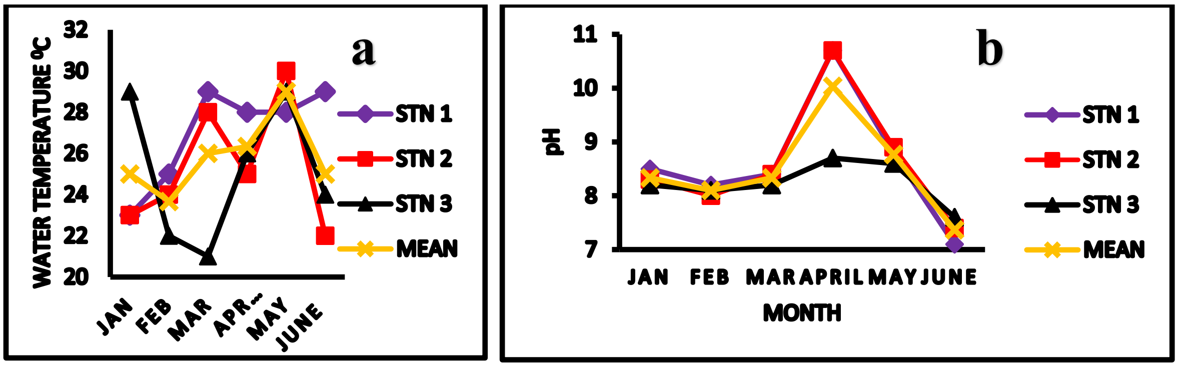

Figure 5: Monthly Variation of (a): Water Temperature, (b): pH in Igbidin Stream

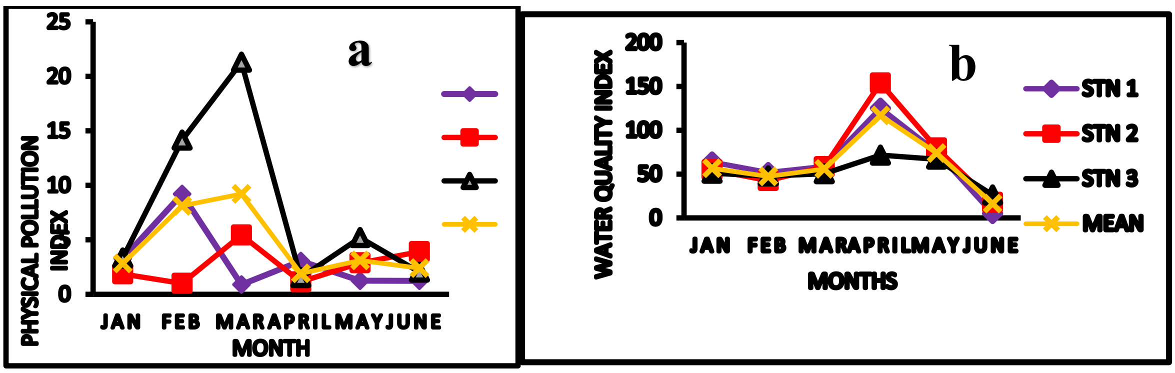

Figure 6: Monthly Variation of (a): Physical Pollution Index, (b): Water Quality Index in Igbidin Stream

Water temperatures (figure 5a) fluctuated between 21°C and 30°C. May had the highest mean temperature (29°C), while February had the lowest (23.67°C). Station 3 recorded the lowest temperature of 21°C in March. The pH values (5b) ranged from 7.1 to 10.7. The highest monthly mean was recorded in April (10.03), and the lowest in June (7.37). All three stations recorded a sharp increase in pH in April, with Stations 1 and 2 reaching 10.7.

Pollution and Water Quality Indices

Monthly variations in Igbidin stream physical pollution index are illustrated in Figure 6a. The physical pollution index values decreased from January to June, with mean values of 2.82 in January, 8.11 in February, 9.21 in March, 1.91 in April, 3.11 in May, and 2.4 in June.

The water quality index (WQI) values (figure 6b) for three stations along a stream revealed that, station 1 recorded WQI values ranging from 4.96 (June) to 124.99 (April). The lowest WQI in June suggests excellent water quality, while the April value indicates water unsuitable for drinking. Station 2 showed similar variability, with WQI values between 17.75 (June) and 153.77 (April). As with Station 1, water quality improved considerably in June but declined sharply in April. Station 3 exhibited the most stable trend, with WQI values ranging from 26.12 (June) to 71.63 (April). Unlike Stations 1 and 2, this station did not exceed the threshold for unsuitability but showed poor to good quality throughout the period.

The monthly mean WQI across all stations showed a clear seasonal pattern: poor water quality in January to March (mean: 55.8–56.5), unsuitable water quality in April (mean: 116.80), very poor in May (mean: 73.97), and excellent water quality in June (mean: 16.28).

DISCUSSION

The results from the six-month physicochemical and water quality assessment of the Igbidin Stream reveal important insights into the stream's water quality, its ecological health, and its suitability for domestic and agricultural use, benchmarked against World Health Organization (WHO) guidelines.

The observed turbidity values were generally low, except for peaks at Station 3 in May (21 NTU) and February (10 NTU). According to WHO standards, turbidity should not exceed 5 NTU for safe drinking water. Exceedances in certain months indicate the presence of suspended solids likely from surface runoff, soil erosion, or anthropogenic activities. A similar phenomenon was reported by Imoobe and Koye (2011). Ecologically, increased turbidity can impair photosynthesis in aquatic plants and affect fish feeding efficiency. Although not chronically high, turbidity fluctuations suggest periodic stress to aquatic habitats. This finding contrasts with the results of Edosomwan et al. (2024), who reported turbidity ranges of 0.32–0.77 NTU and 0.53–0.87 NTU in the Ibiekuma and Ogidikpe streams, respectively.

TDS values remained within WHO's acceptable range (<600 mg/L for drinking water), peaking in February (mean: 66.33 mg/L). Similarly, conductivity values ranged from 9.6–207.5 µS/cm, far below the WHO threshold of 1400 µS/cm. Relatively low values of conductivity and total dissolved solids (TDS) were also observed by Dirisu and Olomukoro (2015). According to WHO, water with TDS below 1000 mg/L is safe for irrigation and household use WHO (2008). Thus, the stream water is safe for agriculture and domestic purposes. However, peaks in conductivity may signal episodic influxes of pollutants, potentially altering the ionic composition of the habitat and stressing sensitive aquatic species. The correlation between TDS and conductivity also reflects occasional solute influxes, possibly from domestic wastewater or agricultural inputs. A correlation and similar trend between TDS and conductivity was also observed in the River Ule, Edo State, by Ekhator and Omoruyi (2018a).

Alkalinity levels were low (5–15 mg/L), suggesting limited buffering capacity. This is contrary to the finding of Oseji et al. (2019) in Illushi river Edo state with a range of 20-50mg/l. Streams with low alkalinity are vulnerable to pH fluctuations, which can affect both ecological and water use stability. This vulnerability was evident in April, when pH spiked to a mean of 10.03, significantly above the WHO recommended drinking water range. This observation contradicts the findings of Ekhator and Omoruyi (2018b), who reported relatively stable pH values in the River Ule, Edo State. WHO recommends a pH range of 6.5–8.5 for drinking water. The observed pH in April (10.7) exceeds this range and may be unsuitable for domestic consumption without treatment. Similarly, pH values above 9 can affect the availability of nutrients in irrigation water and increase ammonia toxicity in aquatic environments. Most aquatic organisms thrive in the range of 6.5–8.5, and deviations can disrupt enzyme activity, reproduction, and survival, particularly in sensitive species. Water colour values varied significantly, with a high value of 99 PtCoU in February (Station 3), exceeding WHO's acceptable threshold of 15 PtCoU. High colour values can indicate organic pollution from decaying vegetation, sewage, or industrial effluent. Apart from aesthetic concerns, coloured water may also be associated with microbial contamination and reduced light penetration in the water column, thus hindering aquatic plant growth.

Nutrient concentrations were consistently low across all stations. The low nitrate concentration observed in this study aligns with the findings of Imoobe and Koye (2011) in the Eruvbi stream, Edo State, but contrasts with those of Avoseh et al. (2024), who reported higher concentrations (2.2–4.45 mg/L) in the Obazagbon River. Nitrate levels remained below 0.05 mg/L, well under the WHO limit of 50 mg/L, indicating minimal risk for methemoglobinemia or nutrient pollution. Phosphate concentrations were below the ecological threshold for eutrophication (0.1 mg/L in flowing waters) in some months but exceeded this in January and June. Elevated phosphate, even at low levels, may stimulate algal blooms under certain conditions, leading to oxygen depletion and ecological imbalance. The phosphate concentration in Igbidin stream, ranging from 0.19 to 0.46 mg/L, was significantly lower than the 0.6 to 1.2 mg/L reported by Avoseh et al. (2024) in the Obazagbon River.

Total hardness values (7.5–20 mg/L) classify the stream as "soft water," which, while not harmful, may reduce taste acceptability and plumbing durability.

Calcium and magnesium concentrations were also low, consistent with the hardness data. Such low concentrations pose no threat to human health and are acceptable for irrigation. However, ecologically, they may limit the growth and reproduction of organisms that rely on these minerals, such as crustaceans and mollusks. Total hardness recorded in Igbidin stream was less than what observed in Edion River (20.09 to 40.90 mg/l) and Omodo River (17.00 to 36.10mg/l), Dirisu and Olomukoro (2015). The stream's temperature ranged between 21°C and 30°C, typical of tropical systems. These temperatures are suitable for most aquatic organisms but may influence oxygen solubility. The warmer months (April to June) may experience decreased dissolved oxygen, potentially stressing aquatic fauna, especially fish. From a domestic and irrigation standpoint, water temperature does not significantly affect usage but may encourage microbial growth if water is stored improperly.

Physical pollution index was higher in the dry season and lower in the raining season. This is typical of the finding of Ekhator and Omoruyi (2018b) in Warri River. All Physical pollution index value obtained during the study were greater than one (<1). This indicates pollution in Igbidin stream Boluda et al. (2002). One of the most effective method to assess water quality and ecological status of a water body is by quantifying its physicochemical parameters, Ustaoglu et al. (2020); Ariza-Restrepo et al. (2022).

The Water Quality Index (WQI) assessment of the Igbidin Stream reveals notable spatial and temporal variations in water quality, with significant implications for public health, ecosystem sustainability, and land use planning.

The highest WQI values were observed in April (mean: 116.80) at all stations, with values at Station 1 (124.99) and Station 2 (153.77) exceeding the WAWQI threshold (>100), classifying the water as unsuitable for drinking. These peaks correspond with the onset of the rainy season in southern Nigeria, which typically begins in late March or early April. The heavy rainfall likely mobilized contaminants from surrounding land, including: Fertilizers and pesticides from nearby farmlands, human and animal wastes from open defecation or poorly managed latrines, sediments and debris from eroded surfaces and unpaved roads. Such runoff can elevate nutrient loads, turbidity, organic matter, and microbial contaminants, drastically reducing water quality. The observation of water quality ranging from very poor to unsuitable for drinking was also reported by Imoobe and Aganmwonyi (2021).

In contrast, June recorded the best water quality (mean WQI: 16.28), especially at Stations 1 and 2, which fell into the "excellent" category. This value contrasts with the finding of Okoye and Ogbebor (2024), who reported a range of 59.32-79.72 across ten water bodies in Edo State. This improvement may be due to dilution effects from sustained rains flushing the stream system and reducing pollutant concentration. However, Station 3 remained relatively stable throughout, never exceeding the "poor" category, suggesting natural resilience possibly due to vegetation cover, riparian buffers, or limited exposure to pollution sources.

Stations 1 and 2 exhibited more pronounced fluctuations and higher peak WQI values, indicating their vulnerability to anthropogenic impacts. This may reflect: Proximity to intensive farming, where agrochemical use is common, location near settlements or markets with potential for direct waste discharge, Areas with open grazing or poultry activities, which can increase nutrient and pathogen inputs. On the other hand, Station 3's more consistent water quality suggests either less disturbed land use or better natural filtration by surrounding vegetation. This spatial variability points to the need for localized management approaches tailored to land use intensity and hydrological features of each station's catchment area.

Periods of very poor or unsuitable water quality—especially in April and May—pose serious public health risks for communities relying on the stream for drinking, cooking, or bathing. Risks include: Waterborne diseases such as cholera, typhoid fever, and dysentery, exposure to nitrates or agrochemicals, which are harmful to children and pregnant women, parasitic infections, particularly if the stream is used without treatment. Okoye and Ogbebor (2024) also reported very poor water quality status in the Eruvbi, Igue-Edo, Okhuaihe, and Ugonoba rivers.

The presence of excellent water quality in June does not negate these risks, as microbial contamination (often unassessed in WQI) can persist even in visually clean water. Therefore, continuous microbial analysis and community awareness programs are essential to guide safe water practice. April and May should be flagged as high-risk months, requiring preemptive public health advisories and temporary restrictions on direct domestic water use without treatment. Land management strategies should prioritize soil conservation, riparian reforestation, and runoff diversion techniques, especially upstream of Stations 1 and 2. Local governments should support the installation of water treatment facilities or provision of household filtration devices during critical periods.

CONCLUSION

The physicochemical assessment of Igbidin Stream revealed significant seasonal and spatial variations in water quality, with higher pollution levels recorded during the dry season. Elevated turbidity and pH, values, especially in April and May, indicate anthropogenic stressors such as runoff, effluents, and agricultural inputs. WQI analysis highlighted April as the most critical month, with water at Stations 1 and 2 deemed unsuitable for drinking. Conversely, June reflected improved quality due to dilution by rainwater. These findings stress the importance of continuous monitoring, public health advisories during critical periods, and localized land-use management. Implementation of basic water treatment and riparian conservation measures is essential to protect the ecological integrity and safe use of the stream.

REFERENCES

American Public Health Association (APHA). (2005). *Standard methods for the examination of water and wastewater* (19th ed.). American Public Health Association.

Ariza-Restrepo, J. L., Rodríguez-Díaz, Y. J., & Oñate-Barraza, H. C. (2022). Water quality indices (WQI) and contamination indices (WPI): A bibliographic review. *Tecnura*, *27*(77). https://doi.org/10.14483/22487638.2005

Avoseh, D. O., Okanlawon, T. S., Ekozin, A. A., Okanlawon, K. P., & Olatunji, E. O. (2024). Assessing the water quality of River Obazagbon, Edo State, Nigeria using physicochemical and bacteriological parameters. *Pollution, Bioremediation & Biodegradation Journal*, *5*(1), 180020.

Boluda, R., Quintanilla, J.F., Bonilla, J.A., Saez, E. & Gamon, M. (2002). Application of the microtoxic test and pollution indices to study of water toxicity in the Albufera natural park Valencia, Spain. *Chemosphere*, *46*, 335-369

Brown, R. M., McClelland, N. I., Deininger, R. A., & O'Connor, M. F. (1972). Water quality index – crossing the physical barrier. *Proceedings of the International Conference on Water Pollution Research*, *6*, 787–797.

Dirisu, A. R., & Olomukoro, J. O. (2015). Investigation of water quality of two rivers in Agbede – wetlands in Southern Nigeria. *Global NEST Journal*, *17*(3), 451–462.

Dutta, T., & Biswas, S. K. (2023). Analysis of water pollution with special reference to physio-chemical parameters and its corresponding impact on social being. *Man, Environment and Society*, *4*(1), 1–22. https://doi.org/10.47509/MES.2023.v04i1.01

Dwivedi, A. K. (2017). Research in water pollution. *International Research Journal of Natural and Applied Sciences*, *4*(1), 118–142.

Edosomwan, E. U., Odiana, S., & Ogboghodo, N. (2024). Water quality assessment of two perennial streams in a rainforest region of Nigeria. *DUJOPAS*, *10*(1a), 129–134.

Egun, N. K., & Ogiesoba-Eguakun, C. U. (2018). Physicochemical and water quality index analysis of the Okhuaihe River, Edo State, Nigeria. *African Journal of Aquatic Science*, *43*(4), 345–351.

Ekhator, O., Opute, F. I., Akoma, O. C., & Mensah, J. K. (2015). Water quality assessment of Osse River, Edo State, Nigeria, using physicochemical parameters. *BIU Journal of Basic and Applied Sciences*, *1*(1), 88–102.

Ekhator, O., & Omoruyi, O. A. (2018a). Phytoplankton response to anthropogenic and recreational activities in the watershed of a resort centre in Edo State, Southern Nigeria. *Tropical Journal of Natural Product Research*, *2*(6), 262–270. https://doi.org/10.26538/tjnpr/v2i6

Ekhator, O., & Omoruyi, O. A. (2018b). Application of water pollution indices in the comparative assessment of two rivers in the Niger Delta Region of Southern Nigeria. *FUPRE Journal of Scientific and Industrial Research*, *2*(1), 88–108.

Ekhator, O., & Omoruyi, O. A. (2020). Algae as bioindicators in the determination of water quality of Warri/Forcados estuary, Niger Delta, Southern Nigeria. *African Journal of Phycology*, *1*, 1–6.

Imoobe, T. O. T., & Koye, P. I. O. (2011). Assessment of the impact of effluent from a soft drink processing factory on the physico-chemical parameters of Eruvbi Stream, Benin City, Nigeria. *Bayero Journal of Pure and Applied Sciences*, *4*(1), 126–134.

Imoobe, T. O. T., & Aganmwonyi, I. (2021). Impact of oil pollution on the water quality of Ekehuan River, Edo

State, Nigeria. *Research Journal of Biotechnology and Life Science*, *1*(1), 1–17.

Indian Council of Medical Research (ICMR). (1975). *Manual of standards of quality for drinking water supplies* (Special Report No. 44).

Ipeaiyeda, A. R., & Onianwa, P. C. (2011). Pollution effect of food and beverages effluents on the Alaro River in Ibadan City, Nigeria. *Bulletin of the Chemical Society of Ethiopia*, *25*(3), 347–360.

Iyama, W. A., Edori, O. S., & Ede, P. N. (2019). Physicochemical assessment of surface water quality around the Sagbama Creek water body, Bayelsa State, Nigeria. *Global Journal of Science Frontier Research: B Chemistry*, *18*(2), 1–10.

Oboh, I. P., & Agbala, C. S. (2017). Water quality assessment of the Siluko River, Southern Nigeria. *African Journal of Aquatic Science*, *42*(3), 279–286.

Ogbeibu, A. E., & Oriabure, P. A. (2023). Assessment of the water quality of the Benin River, Southern Nigeria, prior to the seaport development project. *Journal of Water Resource and Protection*, *15*, 597–610. https://doi.org/10.4236/jwarp.2023.1511033

Ogbodo, C., Wuana, R., Itodo, A. U., & Eneji, I. S. (2020). Physico-chemical parameters and water quality index of water in the lower Usuma dam, FCT, Nigeria. *International Journal of Geography and Environmental Management*, *6*(2), 86–95.

Okoye, G. U., & Ogbebor, J. U. (2024). Physicochemical limnology and water quality assessment of ten surface water bodies in Edo State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *28*(9), 2927–2936.

Omorogieva, O. M., Imasuen, O. I., Isikhueme, M. I., Ehinlaye, O. A., Anegbe, B., & Ikponmwen, M. O. (2016). Hydrogeology and water quality assessment (WQA) of Ikhueniro and Okhuahe using water quality index (WQI). *Journal of Geology, Environment and Earth Science*, *6*(3), 1–10.

Oseji, M., Uwaifo, O. P., & Omogbeme, M. (2019). Assessment of physical and chemical characteristics of surface water from River Niger, Illushi, Edo State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *23*(1), 195–199.

Pandey, B. W., Ranjan, O. J., Srivastava, A., & Prasad, A. B. (2017). Water pollution and its impact on human health: A case study of Allahabad City, Uttar Pradesh. *International Journal of Interdisciplinary Research in Science and Culture*, *3*(1), 14–25.

Standard Organisation of Nigeria (SON). (2007). *Nigerian standard for drinking water quality*. Lagos, Nigeria.

Talabi, A. O., Ojo, O. F., Ajayi, C. A., Olaolorun, O. A., & Afolagboye, O. L. (2016). Hydrochemistry and environmental status of River Owan water, Edo State, Nigeria. *Journal of Environment and Earth Science*, *4*(5), 1–15.

Tripaty, J. K., & Sahu, K. C. (2005). Seasonal hydrochemistry of groundwater in the barrier spit system of the Chilika Lagoon, India. *Journal of Environmental hydrology*, *13*: 1 – 9.

Udebuana, O. O., Akaluka, C. K., & Bashir, K. M. I. (2014). Assessment of physico-chemical parameters and water quality of surface water of

Iguedo River, Ovia South-West Local Government, Edo State. *Journal of Natural Sciences Research*, *4*(24), 12–21.

Ustaoglu, F., Tepe, Y., & Taş, B. (2020). Assessment of stream quality and health risk in a subtropical Turkey river system: A combined approach using statistical analysis and water quality index. *Ecological Indicators*, *113*, 105815. https://doi.org/10.1016/j.ecolind.2019.105815

World Health Organization (WHO). (2011). *Guidelines for drinking-water quality* (4th ed.). WHO Press.

World Health Organization (WHO). (2008). *Guidelines for drinking-water quality: Incorporating 1st and 2nd addenda.* (3rd ed.). WHO Press.

Yusuf, O. A., Adewole, H. A., & Olalaye, V. F. (2017). Assessment of the water quality of Saba River, Osogbo, Nigeria. *Notulae Scientia Biologicae*, *9*(2), 188–195.

Zaky, S. K., & Okpanachi, I. Y. (2017). The effects of effluent discharged from bottling companies on algal composition in Kakuri Stream, Kaduna, Nigeria. *Nigerian Journal of Basic and Applied Science*, *27*(1), 25–33.