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Research

Physico-chemical Assessment of Agbabu Water, Oluwa River, Odigbo Local Government Area, Ondo State, Nigeria

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Highlights

- Assessed physico-chemical status of Agbabu Water in Oluwa River, Ondo State.
- Samples collected monthly (June–Nov 2024) and analysed using APHA standards.
- Measured values: temp (26–32°C), DO (1.2–3.8 mg/L), EC (18–105 µS/cm), etc.
- Station A had highest values; differences across stations not significant ($p < .05$).
- All parameters within safe limits; regular monitoring recommended.

Abstract

Agbabu Water, Oluwa River, serves artisanal fishing, ferrying, and domestic purposes in Odigbo Local Government Area (OLGA), Ondo State, Nigeria. The river is subjected to bitumen spills and the discharge of domestic and agricultural wastes, which may negatively affect water quality and aquatic biota. Despite increasing anthropogenic pressures, limited studies have examined the river's limnology and biodiversity. Extensive bitumen spillage and uncontrolled waste discharge have pollution implications, altering the ecological balance and destroying aquatic habitats. This study aimed to investigate the physico-chemical parameters of Agbabu Water to provide baseline data for effective environmental management. Monthly surface water samples were collected from the Oluwa River over six months (June 2024 to November 2024). Physico-chemical parameters were analysed using standard procedures as outlined by the American Public Health Association (APHA, 2005). Results revealed temperature values between 26.0–32.0°C; transparency (1.0–8.0 m); alkalinity (14.0–25.0 mg/L); electrical conductivity (18–105 µS/cm); dissolved oxygen (1.2–3.8 mg/L); sulphate (0.0–4.0 mg/L); and total dissolved solids (18–36 mg/L). The downstream station (Station A) recorded the highest values for most parameters. However, no statistically significant differences ($p < .05$) were observed across stations. All measured parameters were within the acceptable limits for drinking and aquatic life as prescribed by national and international standards. It is recommended that regular monitoring and enforcement be undertaken by relevant government agencies, public health authorities, and local leaders.

Keywords: Physico-chemical, Dynamics, Agbabu Water, Oluwa River.

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1.0 Introduction

The quality of water used for drinking, irrigation, industrial processes, or recreation must meet specific standards based on physical, chemical, and biological characteristics (Gore, 1985). Water is an essential component of the biosphere, fundamental to life, and its usability depends on its intended purpose. The introduction of foreign substances into water bodies can lead to pollution or may serve as nutrients for aquatic microorganisms (Boukori et al., 1999). Water is considered polluted when its physical and chemical properties are altered in ways that adversely affect aquatic life (Eletta, 2007).

Among pollutants, heavy metals—introduced through anthropogenic activities such as mining and the discharge of untreated industrial effluents—are particularly concerning (Amman et al., 2002). Water bodies are often used as sinks for waste, under the erroneous assumption that aquatic ecosystems have an unlimited self-purification capacity (Fakayode, 2005; Adeogun et al., 2011).
Rapid population growth, urbanisation, and industrialisation have had significant impacts on both water quantity and quality (Herschy, 1999). Additionally, seasonal and climatic variations influence the physico-chemical properties of surface water. The growing demand for water has led to increased research into water quality criteria (World Health Organization [WHO], 1966).

1.1 The objectives of this study were to:

1. Assess the extent of human-induced stress on Agbabu Water over the years.
2. Evaluate selected physico-chemical parameters of Agbabu Water.

1.2 Justification

Agbabu Water, Oluwa River, is used extensively for artisanal fishing, sand mining, transportation, and domestic purposes. It also serves as a dumping site for domestic and industrial wastes, including bitumen spills. These challenges are exacerbated by the proliferation of urban and industrial developments along the riverbanks. Despite the evident anthropogenic pressures due to the rapid expansion of Agbabu town and its environs, information on the river's limnology is sparse. This study provides crucial baseline information for impact assessments, planning, and policy implementation aimed at monitoring and sustainable development.

2.0 Materials and Methods

2. 1 Study Area

Agbabu Water, part of the Oluwa River, is located in Odigbo Local Government Area, Ondo State, Nigeria. It lies at coordinates 6°35'0" N, 4°50'0" E (see Figures 1.1 and 1.2).

2.2 Vegetation

The vegetation includes floating macrophytes such as duckweed (*Lemna spp.*), water lettuce (*Pistia*), and water hyacinth (*Eichhornia crassipes*). The riverbanks are characterised by rooted trees and dense undergrowth including *Rhizophora racemosa*, *Avicennia germinans*, *Mariscus alteriflorus*, and *Paspalum orbiculare*.

Figure 1.1: Map of Ondo State Showing Study Area (Agbabu)

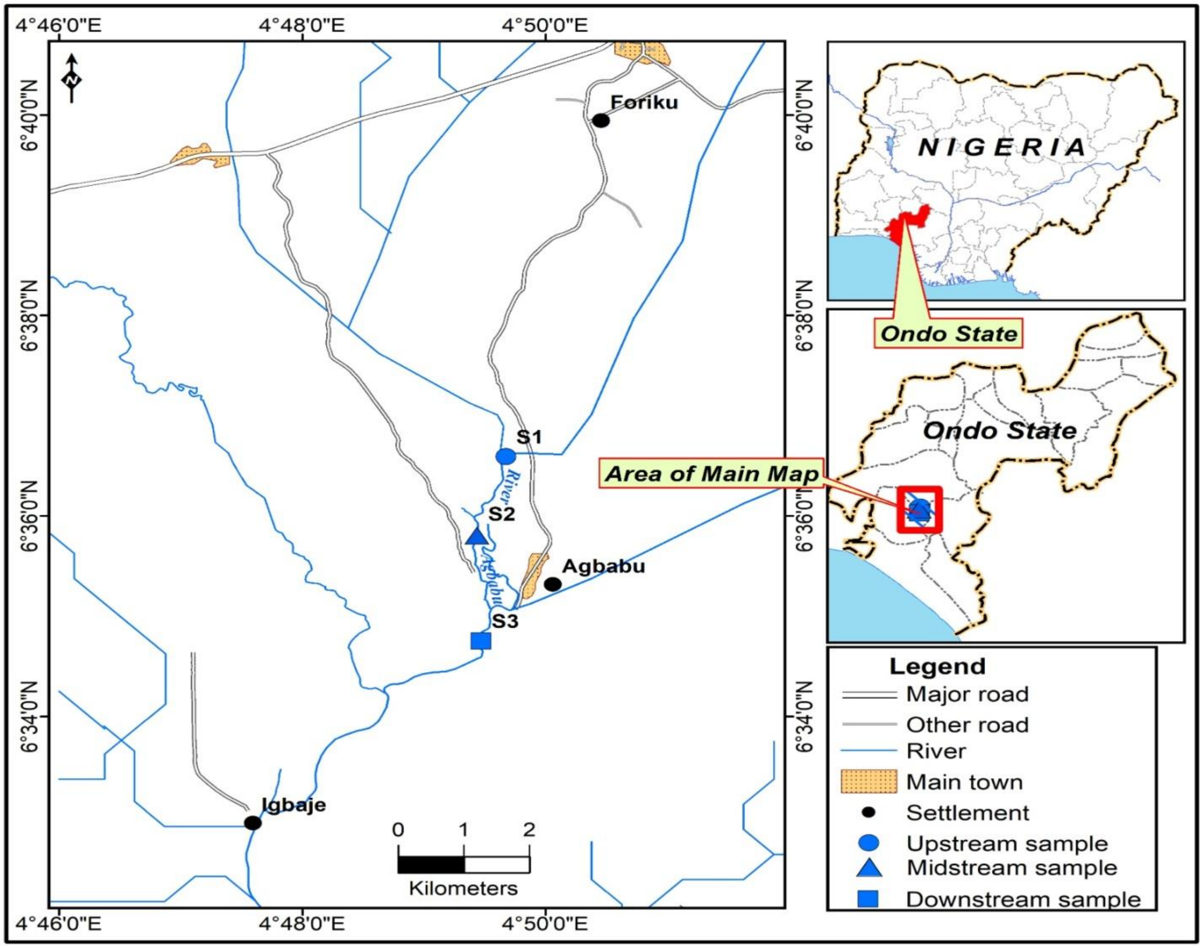

Figure 1.2: Map of Agbabu Showing Sampling Points

2.3 Sampling Stations

Three sampling stations were established: upstream, midstream, and downstream. The distance between the upstream and midstream stations was approximately 1,000 metres, and the same distance separated the midstream and downstream stations.

2.4 Sampling Techniques

Sampling was conducted from June to November 2024, covering both rainy and dry seasons. Each station was sampled between 08:00 and 18:00 hours to minimise diurnal variation. Surface water samples were collected for physico-chemical analysis.

2.5 Physico-chemical Parameters

Water samples for physico-chemical analysis were collected from a depth of approximately 0.5 m below the surface of the river at all sampling sites, with two replicates taken per site. All containers used for sampling were thoroughly washed with a non-phosphate detergent, rinsed with tap water, and subsequently with distilled water to avoid contamination. Containers were appropriately labelled in the field.

2.5.1 Temperature

Air and surface water temperatures were measured using a mercury-in-glass thermometer graduated in degrees Celsius (°C). The thermometer was first allowed to stabilise in the atmosphere for 5 minutes to obtain the air temperature, and then immersed in the surface water to measure water temperature.

2.5.2 Dissolved Oxygen (DO)

Water samples for dissolved oxygen were collected in 250 ml glass specimen bottles, filled underwater to avoid air bubble entrapment. After collection, the bottles were gently reopened, and 1 ml each of Winkler's Solution A (manganous sulphate) and Solution B (alkaline iodide) were added using a pipette. The bottles were stoppered carefully and shaken gently by rotating and inverting several times for about 10 seconds. Samples were transported to the laboratory for analysis. Dissolved oxygen concentration was determined using the iodometric titration method described by Golterman et al. (1978), with results expressed in milligrams per litre (mg/L).

2.5.3 Biochemical Oxygen Demand (BOD_5)

Samples for biochemical oxygen demand were collected in 250 ml black glass bottles, filled underwater without trapping air bubbles. The samples were incubated in the dark for five days at 20°C. At the end of the incubation period, the samples were fixed with Winkler's reagents A and B, carefully stoppered, agitated, and transported to the laboratory. BOD concentrations were determined using the Winkler iodometric titration method as described by Golterman et al. (1978), and reported in mg/L.

2.5.4 Hydrogen Ion Concentration (pH)

In the laboratory, the pH of each water sample was determined using a 510 model pH meter. The glass electrode of the meter was immersed in the sample, and the pH reading was recorded (APHA, 1995).

2.5.5 Transparency

Transparency was measured in situ using a calibrated Secchi disc. The depth at which the disc disappeared and reappeared was noted, and the average of these two depths was taken as the transparency reading. Results were expressed in metres (m).

2.5.6 Conductivity

Electrical conductivity was measured in the laboratory using a Jenway Conductivity Meter (Model 4071). The electrode was immersed in the water sample and the conductivity value recorded in microsiemens per centimetre (µS/cm), following the method described by APHA (1995).

2.5.7 Total Dissolved Solids (TDS)

To determine TDS, 100 ml of the water sample was filtered using Whatman T50 filter paper. The filtrate was evaporated to dryness in a pre-weighed crucible at 105 ± 2°C until a constant weight was achieved. After cooling in a desiccator, the crucible was reweighed. TDS values were calculated and expressed in mg/L, following the procedure of APHA (1995).

2.5.8 Alkalinity

Alkalinity was determined using the LaMotte Freshwater Aquaculture Test Kit (Model AQ-2). Results were expressed in milligrams per litre (mg/L) as calcium carbonate ($CaCO_3$).

2.5.9 Sulphate

Sulphate concentrations in the water samples were determined using the colorimetric method as described by Golterman et al. (1978). Results were expressed in mg/L.

2.6 Statistical Analysis

1. Descriptive statistics, including means and standard deviations, were used to summarise the physico-chemical data across all sampling sites and seasons.
2. Variations across the sampling stations, as well as seasonal differences, were examined using descriptive statistical methods.

3.0 Results

3.1 Physico-chemical Parameters of Agbabu Water, Oluwa River

The results of the physico-chemical parameters of Agbabu Water, Oluwa River, are presented in Table 1.1. Seasonal variations (Mean ± S.E.) of physico-chemical parameters from June 2024 to November 2024 are shown in Table 1.2.

3.1.2 Water Temperature

Water temperature ranged between 24.0°C and 30.0°C. The downstream station recorded the highest mean temperature (27.3 ± 0.39°C), while the lowest mean was recorded upstream (26.5 ± 0.37°C) and midstream (26.6 ± 0.38°C) (Table 1.1). Seasonal mean water temperatures were 25.9 ± 0.17°C in the rainy season and 28.6 ± 0.19°C in the dry season (Table 1.2).

3.1.3 Transparency

Transparency values ranged from 1.0 m to 8.0 m. The lowest mean was observed downstream (3.5 ± 0.42 m), while midstream recorded the highest (4.6 ± 0.42 m) (Table 1.1). Seasonal means were 4.49 ± 0.32 m during the rainy season and 2.82 ± 0.23 m in the dry season (Table 1.2).

3.1.3 pH

pH values ranged between 6.0 and 9.0. The upstream station had the lowest mean pH (7.0 ± 0.24), and the downstream station had the highest (7.7 ± 0.24) (Table 1.1). Mean seasonal pH was 7.86 ± 0.15 in the rainy season and 6.44 ± 0.07 in the dry season (Table 1.2).

3.1.4 Total Dissolved Solids (TDS)

TDS ranged between 18 mg/L and 105 mg/L. The upstream station recorded the lowest mean value (23.6 ± 2.11 mg/L), while the downstream station had the highest (35.1 ± 2.73 mg/L) (Table 1.1). Seasonal means were 31.8 ± 2.23 mg/L (rainy) and 33.9 ± 2.64 mg/L (dry) (Table 1.2).

3.1.5 Total Solids (TS)

Total solids ranged from 20 mg/L to 100 mg/L. The lowest mean value was observed upstream (52.6 ± 5.52 mg/L), and the highest downstream (65.4 ± 5.19 mg/L) (Table 1.1). Seasonal means were 71.08 ± 2.76 mg/L (rainy) and 33.9 ± 2.64 mg/L (dry) (Table 1.2).

3.1.6 Conductivity

Conductivity values ranged from 18 µS/cm to 105 µS/cm. The upstream station recorded the lowest mean (33.5 ± 3.94 µS/cm), while the downstream station recorded the highest (48.3 ± 6.28 µS/cm) (Table 1.1). Seasonal means were 48.8 ± 3.87 µS/cm in the rainy season and 25.3 ± 1.27 µS/cm in the dry season (Table 1.2).

3.1.7 Alkalinity

Alkalinity ranged from 14 mg/L to 25 mg/L. The lowest mean was recorded upstream (18.9 ± 0.46 mg/L), and the highest downstream (21.7 ± 0.59 mg/L) (Table 1.1). Seasonal means were 20.3 ± 0.43 mg/L (rainy) and 20.1 ± 0.52 mg/L (dry) (Table 1.2).

3.1.8 Dissolved Oxygen (DO)

DO ranged between 1.2 mg/L and 4.0 mg/L. The lowest mean was observed downstream (2.4 ± 0.20 mg/L), while the upstream station recorded the highest (3.1 ± 0.14 mg/L) (Table 1.1). Seasonal means were 2.95 ± 0.11 mg/L (rainy) and 2.65 ± 0.20 mg/L (dry) (Table 1.2).

3.1.9 Biochemical Oxygen Demand (BOD)

BOD ranged from 1.4 mg/L to 3.8 mg/L. The lowest mean was recorded upstream (2.0 ± 0.17 mg/L), and the highest downstream (2.4 ± 0.18 mg/L) (Table 1.1). Mean BOD was 1.98 ± 0.09 mg/L in the rainy season and 2.84 ± 0.17 mg/L in the dry season (Table 1.2).

3.1.10 Sulphate Ions

Sulphate concentrations ranged from 0.0 mg/L to 4.0 mg/L. The lowest mean value was observed upstream (1.6 ± 0.21 mg/L), and the highest downstream (2.4 ± 0.21 mg/L) (Table 1.1). Seasonal means were 2.65 ± 0.13 mg/L (rainy) and 0.86 ± 0.13 mg/L (dry) (Table 1.2).

Table 1.1: Physico-chemical parameters (Mean±S.Eand Range) of Agbabu water, Oluwa River from June, 2024 to November, 2024.

S/N	Parameters	Upstream Mean ±SE	Midstream Mean ± SE	Downstream Mean ± SE	OVER ALL Mean ± SE	Range	F	P
1.	Water temperature (°C)	26.5 ±0.37	26.6 ±0.38	27.3 ±0.39	26.8 ± 0.22	24 – 30	1.604	0.21
2.	Transparency (m)	3.6 ±0.41	4.6 ±0.42	3.5 ±0.42	3.9 ± 0.25	1.0 – 8.0	2.247	0.116
3.	Dissolved oxygen (mg/L)	3.1 ±0.14	2.9 ±0.14	2.4 ±0.20[b]	2.8 ± 0.10	1.2 - 4.0	3.844	0.028*
4.	Biochemical oxygen demand (mg/L)	2.0 ±0.17	2.2 ±0.16	2.4 ±0.18	2.2 ±0.10	1.4 - 3.8	1.884	0.162
5.	pH	7.0 ±0.24	7.3 ±0.22	7.7 ±0.24	7.3 ± 0.14	6.0 – 9.0	2.439	0.097
6.	Conductivity (µs/cm)	33.5 ±3.94	41.1 ±4.98	48.3 ±6.28	41.0 ±3.01	18 – 105	2.080	0.135
7.	Alkalinity (mgcaco$_3$/L)	18.9 ±0.46	19.9 ±0.59	21.7 ±0.59	20.2 ±0.33	14 – 25	7.070	0.001*
8.	Total Dissolved Solid (mg/L)	23.6 ±2.11	25.5±3.10	35.1 ±2.73	28.0±1.67	14- 60	5.238	0.009*
9.	Total Solid (mg/L)	52.6 ±5.52	58.0 ±5.19	65.4 ±5.19	58.7 ± 3.14	20 – 100	1.419	0.251
10.	Sulphate (mg/L)	1.6 ±0.21	2.2 ±0.32	2.4 ±0.21	2.05 ± 0.15	0.0 – 4.0	2.753	0.73

* =significant at p<0.05

Table 1.2: Seasonal variation (Mean±S.E) of Physico-chemical parameters for Agbabu water, Oluwa River from June, 2024 to November, 2024

S/N	Parameters	Rainy season Mean ±SE	Dry season Mean ± SE	t_{value}	Significance
1.	Water temperature (°C)	25.9 ±0.17	28.6 ±0.19	-9.48	(.000) Sig
2.	Transparency (m)	4.49 ±0.32	2.83 ±0.23	3.39	(.001) Sig
3.	Dissolved oxygen (mg/L)	2.95 ±0.11	2.65 ±0.20	1.36	(.180) NS
4.	Biochemical oxygen demand (mg/L)	1.98±0.09	2.84 ±0.17	-4.66	(.000) Sig
5.	pH	7.86±0.15	6.44±0.07	6.12	(.000) Sig
6.	Conductivity (µs/cm)	48.8 ±3.87	25.3 ±1.27	4.21	(.000) Sig
7.	Alkalinity (mg/L)	20.3 ±0.43	20.1 ±0.52	0.19	(.849) NS
8.	Total Dissolved Solid(mg/L)	31.8±2.23	20.7±0.88	3.44	(.001) Sig
9.	Total Solid (mg/L)	71.08±2.76	33.9 ±2.64	8.54	(.000) Sig
10.	Sulphate (mg/L)	2.65 ±0.13	0.86 ±0.13	8.41	(.000) Sig

NS = Not significant P>0.05 Sig = Significant P<0.05,

4.0 Discussion

4.1 Water Temperature

Water temperature at the Agbabu downstream station (27.3±0.39°C) was higher compared to the upstream station (26.5±0.37°C). This increase could be attributed to the decomposition of organic matter discharged into the downstream section of the river. Similar elevated temperatures at points of organic waste discharge have been reported by Olaniyan (2010) and Tyokumbur et al. (2002) in the Owena River, Ondo, and Awba Stream, Ibadan, respectively. The mean temperature recorded in the present study falls within the national and international limits of 30.00°C–35.00°C for aquatic organisms (World Health Organization [WHO], 1998; Federal Environmental Protection Agency [FEPA], 1991).

4.2 pH

The pH values ranged from slightly acidic to weakly alkaline, with mean values of 7.0±0.24, 7.3±0.22, and 7.7±0.22 for the upstream, midstream, and downstream stations, respectively. Lower pH values were recorded in the dry season (6.44±0.07), while higher pH values occurred in the rainy season (7.86±0.15). pH is a critical parameter in water quality assessment, as it influences many biological and chemical processes involved in water supply and treatment (Chapman & Kimstach, 1992). According to Chapman and Kimstach (1992), the pH of natural water typically ranges from 6.0 to 9.0. The pH values recorded at all stations were within both national and international limits, indicating that pH conditions were suitable for aquatic life.

4.3 Conductivity and Total Dissolved Solids (TDS)

In natural waters, conductivity measures the ability of water to conduct an electrical current and is usually related to the concentration of total dissolved solids (TDS) (Boyd, 1979; Chapman & Kimstach, 1992). Conductivity at the upstream station (33.5±3.94S/cm) was lower than at the midstream (41.1±4.98S/cm) and downstream (48.3±6.28S/cm) stations. These values were higher than the range of 31–131S/cm recorded by Adebisi (1981) in the upper Ogun River. A similar trend of rising conductivity during the dry season and decreasing during the rainy season was observed. This could be due to increased evaporation, resulting in higher ion concentrations from reduced water volume, as also reported by Ogbeibu and Egborge (1995) in the Okomu Forest Reservoir.

TDS values followed a similar pattern to conductivity, with values of 23.6±2.11mg/L, 25.5±3.10mg/L, and 35.1±2.73mg/L for the upstream, midstream, and downstream stations, respectively. The variations in conductivity and TDS between the upstream and downstream stations may be due to anthropogenic waste deposition by residents around the downstream station. Many households in the area lack toilet facilities and practice open defecation (locally termed “shot put”), contributing significantly to environmental pollution. In contrast, TDS values at the upstream station reflected minimal pollution from human activities. The TDS and conductivity values recorded at all stations remained within the national and international limits of 200mg/L and 1000S/cm, respectively (FEPA, 1991).

4.4 Dissolved Oxygen (DO)

Dissolved oxygen (DO) refers to the amount of molecular oxygen dissolved in water. It is produced through photosynthesis and consumed during respiration and the decomposition of organic matter (Michaud, 1991; Moore, 1989). DO is essential for all aquatic organisms, including those responsible for natural water purification. Its concentration varies with temperature, salinity, turbulence, photosynthetic activity, and atmospheric pressure. Oxygen solubility decreases with rising temperature and salinity. In freshwater, DO at sea level ranges from 15mg/L at 0°C to 8mg/L at 25°C (Chapman & Kimstach, 1992).

In this study, mean DO values were 3.1±0.14mg/L (upstream), 2.9±0.14mg/L (midstream), and 2.4±0.20mg/L (downstream). Fluctuations in DO levels may be attributed to waste input and biological activities that modulate various environmental factors, as observed by Boyd (1979), Cole (1975), and Chapman and Kimstach (1992). Similar seasonal DO extremes have been reported in the Ogun River (Adebisi, 1981), Nun River (Yakubu et al., 1998), and Aiba Reservoir (Atobatele & Ugwumba, 2008), and were linked to algal blooms, photosynthesis, run-off, and turbulence. DO values reported in this study were below the WHO (1998) threshold for the protection of aquatic life.

4.5 Biological Oxygen Demand (BOD)

The highest and mean BOD_5 values at the downstream station were below the upper limits of 5□mg/L and 10mg/L, as stipulated by FEPA (1991) and WHO (1998). Lower BOD values were recorded during the rainy season (1.98±0.09mg/L) compared to the dry season (2.84±0.17mg/L) in Agbabu. This may be attributed to the dilution effect of rainfall on organic matter.

BOD_5 serves as an indicator of organic pollution by measuring the amount of oxygen consumed during the biological decomposition of organic matter into inorganic compounds (Abowei & Sikoki, 2005). Similar elevated BOD levels at points of human sewage discharge have been reported by Yakubu (2004) in the Awba Stream, Ibadan, and by Olaniyan (2010) in the Owena Reservoir, Ondo.

5.0 Conclusion and Recommendations

This study provides valuable baseline information on the physico-chemical characteristics of Agbabu Water, Oluwa River, highlighting the influence of anthropogenic activities on water quality. The downstream section exhibited elevated pollution levels, largely due to bitumen spillage and the direct discharge of human waste, revealing the environmental risks associated with using natural water bodies as waste disposal sites.

To safeguard the river’s ecological integrity and public health, it is recommended that regular water quality monitoring be conducted by environmental agencies. Community sensitisation campaigns should be implemented to raise awareness about the impacts of pollution, while the provision of sanitation facilities is essential to reduce faecal contamination. In addition, enforcement of environmental policies and investment in water management infrastructure by government and stakeholders are crucial. Further research is also necessary to track seasonal variations and assess long-term changes in the river’s ecological health.

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Data availability statement

Data will be made available on request.

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Conflict of Interest

There is no Conflict of Interest.