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Research Article

The Physicochemical Dynamics of Epie Creek, Yenagoa, Bayelsa State, Nigeria

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Abstract— The Physicochemical Dynamics of Epie Creek, Yenagoa, Bayelsa State was investigated. This was done to measure the degree of direct and indirect human impacts on receiving systems of Epie creek, Bayelsa State. Physicochemical samples were collected for analyses once monthly from Four (4) stations for twelve (12) consecutive months between April 2021 and March 2022**.** Samples were collected between the hours of 08:00hrs to 12:00hrs during each sampling day using standard techniques. Physicochemical samples were analyzed for Biochemical Oxygen Demand (BOD_5), Dissolved Oxygen (DO)**,** Alkalinity, Temperature, pH and Electrical conductivity (EC). Means and standard deviation were calculated for all physicochemical variables for both dry and wet seasons. Physicochemical data were subjected to analysis of variance (ANOVA) at the 95% confidence limit (P=0.05) in order to check the sources of variability and similarities in the measured values at stations within seasons. T-test was employed to determine the degree of variability of physicochemical parameters between seasons. This was aided by the SPSS® 20.0 statistics tool kit. Results indicate that all the physicochemical parameters were within the internationally permissible threshold for physicochemical parameters in fresh water. There were significant differences (P<0.05) of certain physicochemical parameters between the wet and dry seasons and between stations. It can be concluded that Epie creek in not under any immediate threat of pollution and the current practices around the creek be sustained or improved upon.

Keywords— Physicochemistry, Dynamics, Epie creek, Yenagoa, Bayelsa State, Nigeria.

1. Introduction

Yenagoa, the capital city of Bayelsa State is unique in several ways. It is touted as the unannounced capital of the ijaw nation and the most homogeneous assemblage of all ijaw people. Situated several meters below sea level, it is endowed with several creeks and creeklets within its boundaries and other neighbouring cities. Due to its low lying topography, it is perennially flooded both from seasonal rains and from over-flow from river banks and creeks. The impact on these floods on the lives and livelihood of the people can better be imagined. Worse still, receding flood waters gather into nearby rivers and creeks, carrying with them all the leeched materials of both harmful chemicals and nutrient rich materials from land and their riparian catchments. Such materials are limitless in its diversity. These could include sewage from broken down sewers, waste oils from workshops, industrial chemicals from stores and all sorts of waste materials from households.

Epie creek plays a strategic role in the lives of the people of Bayelsa state and is one of the receiving water bodies in the Niger Delta. It is greatly under studied and under reported in scientific literature. There is therefore a critical need to study some of its limnological characteristics as to gauge the environmental health of this all important water body. This will provide information for future planning and for safe guarding the ecosystem.

In this study, Section 1 contains the introduction of the work with vital background of the subject matter. Section 2 contains the related works of previous scholars concerning the research topic Section 3 contain the methodology, materials and methods employed in the research. Section 4 contains the result and discussions of the research. Section 5 concludes the research work with future directions.

2. Related Work

Bilewu et al [1] assessed the physicochemical parameters in selected water bodies in Oyo and Lagos States. The study was conducted to gauge the conditions of these frequently used water bodies. The locations were selected based on surrounding population and activities. Sampling was done in the months of April and June, 2021. The physicochemical parameters analysed were pH, electrical conductivity (EC), salinity, total dissolved solids (TDS), chloride, biochemical oxygen demand (BOD) and dissolved oxygen (DO). The result revealed that average salinity value ranged between 0.2675 ± 0.14 mg/L (UI) and 0.6735 ± 0.22 mg/L (Berger). These values are quite high and significant when compared to the threshold level of 0.0000001 mg/L. Comparing the three sampling points, the samples obtained from Awba Dam at the University of Ibadan seem to have the better quality in relative terms. This follows from the BOD and TDS values of 3.75 ± 0.28 mg/L and 259.7 ± 156.89 mg/L respectively. This study shows that the mismanagement of our waters through unrestrained and unrestricted dumping of contaminants into it has caused these water bodies to have poor quality and should not be used for the purpose of consumption unless properly treated.

In another study, Omoboye et al [2] investigated the water quality and plankton composition of Owalla Reservoir, Osun State, Nigeria, from October 2012 to November 2013 with a view to providing baseline information on limnology of the reservoir. Seven sampling stations (designated Stations 1-7) were established as representatives of the zones and regions of the reservoir and sampling was conducted quarterly. At Stations 1 and 3, only surface water samples were collected while water samples were collected from the surface, mid-depth and close to the bottom at other stations. Samples for total plankton and physico-chemical water quality were analyzed using standard methods. The result of the study showed that mean dissolved oxygen (P<0.001), biochemical oxygen demand, conductivity, pH (P<0.001), and alkalinity were higher at the surface of the reservoir. As regards seasonal variation, alkalinity, biochemical oxygen demand had the higher mean values during the rainy season. Also, acidity, dissolved oxygen, and pH showed significantly (P<0.001) higher values during the rainy season. One hundred and thirty seven (137) taxa of phytoplankton and 39 taxa of zooplankton were recorded from the reservoir. The horizontal pattern of variation showed an increase in the mean abundance of most of phytoplankton groups from inflow to the dam area while vertical variation showed a decrease in mean abundance from surface to the bottom of the reservoir. Most of the phytoplankton and zooplankton taxa were more abundant during the dry season than in the rainy season.
The study concluded that all the monitored physico-chemical water quality parameters were within the guide level range as of the World Health Organisation (WHO) for drinking water. Owalla Reservoir is qualitatively rich in both phytoplankton and zooplankton and the reservoir can support a viable aquatic community and sustainable fishery production.

3. Experimental Method/Procedure/Design

Study Area
Epie creek is a lotic, non-tidal fresh water environmental unit. It is situated in Yenagoa, in Yenagoa local government area of Bayelsa State in the Niger Delta. The creek lies between longitude 6^0 19' to 6^0 25'E and latitude $4^0$59' to 05^0 05'N. The location of the sampling site is at Igbogene,Etegwe,Akenfa and Agudama all in Yenagoa.

3.2 Description of Sample Stations

After a study of the peculiarities of the creek, 4 sampling zones were established to reflect the different forms of land uses in the catchments and reflect stations upstream and downstream of the catchments.

3.2.1 Station 1

This station is located far most downstream of the creek at Igbogene. The station is located at latitude 5^0 2' 19.59''N and longitude $6^0$24' 8.94.''E. The station has an elevation of 3m. Station 1 is situated at the bridge head near a refuse disposal site adjacent to a make-shift meat market.

Plate 1: Station 1 at Igbogene,-Epie, Yenagoa

3.2.2 Station 2

Station 2 is also situated at Etegwe. It is located at longitude $6^0$23' 55.67''E and latitude $5^0$1' 31.161''N. The station has an elevation of 2m. This station is up stream penultimate to station 1. It is situated at a creek crossing point where passengers are ferried across using canoes. It has notable features such as floating aquatic weeds and vegetation in the adjacent catchments.

Plate 2: Station 2 at Yenegwe Epie, Yenagoa.

3.2.3 Station 3

This station is situated at Akenfa Epie at longitude $6^0$23' 16.83''E and latitude $5^0$0' 29.34''N. This station lies at an elevation of 3.0m. This station is situated at a shore protection site near a refuse dump site. It is characterized by relatively clearer water surface but with plentiful amounts of floating aquatic macrophytes present in the creek.

Plate 3: Station 3 at Akenfa-Epie, Yenagoa

3.2.4 Station 4

This station is situated almost at the end of all sampling stations. It is up stream of stations 1, 2 and 3. It is also located at Agudama-Epie at longitude $6^0 22'$ 35.314''E and latitude $4^0 59'$ 13.395''N. The station has an elevation of 5m. This station 4 is at a wooden foot bridge crossing point of the creek. There are sparse distributions of aquatic plants in that area.

Plate 4: Station 4 at Agudama-Epie, Yenagoa

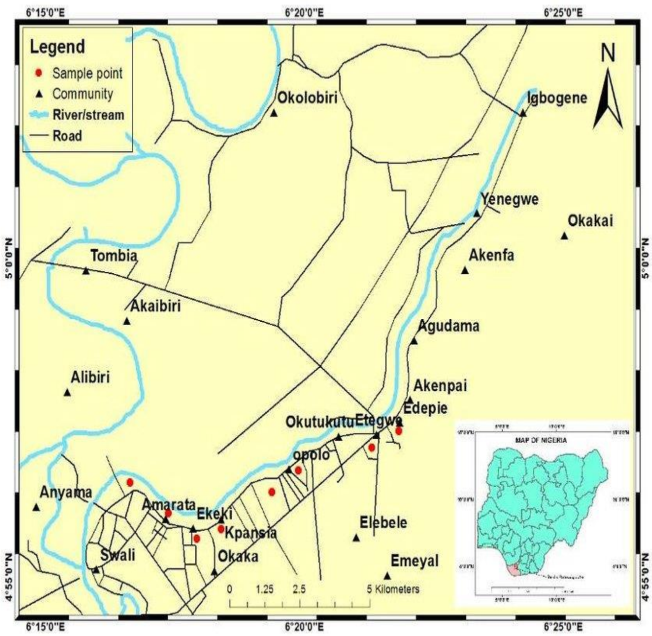

Figure 1 Map of Nigeria showing Bayelsa State & Epie Creek in Yenagoa (Source: Oborie and Nwankwoala, [3])

3.3 Collection of Samples

Limnological samples were collected in triplicates once monthly for twelve consecutive months between April 2021 and March 2022 from each sampling station.

Samples were collected between the hours of 08:00hrs to 12:00hrs during each sampling day.

3.3.1 Physico-chemical Samples

3.3.1.1 Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (D0)

Dark labeled reagent bottles were used to collect water samples from the sampling stations. BOD and DO samples were collected by completely immersing the bottles into the water and then allowed to fill. 2mls each of Winkler I and Winkler II reagents were added to the DO sample bottles and then shaken to mix properly and then corked. BOD samples were stored in dark containers and then transported to the laboratory and kept for five days before fixing with Winkler I and Winkler II reagents.

3.3.1.2 Alkalinity, Temperature: pH: Electrical conductivity (EC).

Water samples for the above physicochemical parameters were collected from the sampling stations using one litre plastic containers. The plastic containers were dipped into water to collect sub-surface water samples in each of the 4 sampling stations.

3.3.1.3 Dissolved Oxygen (DO)

Dissolved oxygen was measured by the use of the Winkler Iodometric method. This method is based on the oxidizing properties of oxygen. To the collected water sample in a glass bottle, divalent manganese solution was added. Due to the fact that dissolved oxygen rapidly oxidizes an equivalent amount of manganese hydroxide to hydroxides of higher valency states in the presence of iodide ions and acidification. The oxidized manganese reverses to the divalent state with the liberation of iodine equivalent to the original D.O content. The iodine is then titrated with a standard thiosulphate (sio_3). The titration end point is then read off visually from the dissolved oxygen meter.

3.4.1.2 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD_5) was determined after the samples were incubated in the dark for five days. The Dissolved Oxygen content of the samples was determined using the above Winkler Iodometric method.

The BOD_5 was then determined from the calculation below:

$$BOD_5 = DO – DO_5 \quad (1)$$

3.4.1.3 pH: Temperature: Electrical conductivity.

The above physicochemical parameters were measured insitu by the use of a U_{10} Horiba water checker. This was done by introducing water at each station into the metal container of the equipment. The probe of the U_{10} Horiba water checker was then put into the container and the water checker then switched on to measure each parameter one at a time. The readings of each parameter are displayed electronically on a display screen as a bright red light.

3.4.1.4 Total Alkalinity

The determination of total alkalinity involved the titration of 50ml of the water samples in the laboratory. To the 50ml water samples 5 drops of methyl orange indicator with 0.02N H_2SO_4 solution was added. Total alkalinity was thus calculated using the formula:

$$\frac{A \times N \times 50000}{\text{Sample volume in ml}} \qquad (2)$$

Where A = Volume of acid used in titration.
N = Normality of standard acid solution.
The detection limit is 1.0mg/l as $caco_3$ [4].

4. Results and Discussion

The results of the investigation of Epie Creek are presented below:

4.1.1 Physicochemical Parameters.

The mean seasonal variations of the physicochemical parameters of Epie creek; Temperature, pH, Dissolved Oxygen (D.O), Electrical Conductivity (EC), Alkalinity and Biochemical Oxygen Demand (BOD_5)are presented in Tables 1 to 3.

The mean physicochemical parameters of Epie creek in wet season is captured below in Table 1. All physicochemical parameters of pH, DO, EC and BOD_5 showed no significant difference ($P>0.05$) between stations. However, Alkalinity value were not significantly different ($P>0.05$) between stations 1, 2 & 3 but significantly different ($P<0.05$) in Station 4.

Table 1: Mean Physicochemical parameters in Wet Season

Parameters	Station1	Station 2	Station 3	Station 4
Temp.	27.26^{a} ± 0.75	27.24^{a}±0.67	26.80^{a} ± 0.53	26.96^{a} ± 0.65
pH	6.21^{a} ± 0.47	6.30^{a} ± 0.32	6.62^{b} ± 0.35	6.29^{a} ± 0.35
DO	6.41^{a}±0.52	6.33^{a}±0.62	6.17^{a}±0.74	6.09^{a}±0.63
EC	48.03^{a}±1.05	48.46^{a}±1.06	49.05^{a}±1.74	48.74^{a}±1.58
Alkalinity	20.05^{a}±1.71	19.98^{a}±1.09	19.69^{a}±1.98	21.37^{b}±0.57
BOD_5	2.92^{a}±0.50	2.99^{a}±0.54	2.87^{a}±0.42	2.89^{a}±0.49

Data represents Means± Standard deviation. Means with the same letter superscript (a,b) of the same parameter are not significantly different

Table 2: seasonal variations of Physicochemical parameters in all Stations

Parameters	Station1	Station 2	Station 3	Station 4
Temperature	28.35^{a} ± 0.56	28.57^{a}±0 .23	28.50^{a} ± 0.36	28.26^{a} ± 0.46
Ph	4.94^{a}±0.64	5.23^{a}±0.41	5.12^{a}±0.43	5.59^{b}±0.40
DO	5.13^{a}±5.88	4.43^{b}±5.54	4.78^{c}±5.59	4.65^{bc}±5.49
EC	53.76^{a}±3.15	53.92^{a}±2.67	52.0^{a}±1.63	54.13^{a}±4.58
Alkalinity	23.25^{a}±1.03	22.36^{a}±1.11	25.10^{b}±2.66	21.87^{a}±1.45
BOD_5	2.17^{ab}±0.18	2.08^{a}±0.13	2.16^{ab}±0.28	2.46^{b}±0.55

Table 3 below show divergence and statistically different values in seasonal data in all measured parameters except in pH & Alkalinity which was not significant seasonally across stations

Parameters	Seasons	Station1	Station 2	Station 3	Station 4
Temperature	Wet season	27.26^{a} ± 0.75	27.24^{a}±0.67	26.80^{a} ± 0.53	26.96^{a} ± 0.65
	Dry season	28.35^{a} ± 0.56	28.57^{b}±0.23	28.50^{a} ± 0.36	28.26^{a} ± 0.46
pH	Wet season	6.21^{a} ± 0.47	6.30^{a} ± 0.32	6.62^{a} ± 0.35	6.29^{a} ± 0.35
	Dry season	4.94^{a}±0.64	5.23^{a}±0.41	5.12^{a}±0.43	5.59^{a}±0.40
DO	Wet season	6.41^{a}±0.52	6.33^{a}±0.62	6.17^{a}±0.74	6.09^{a}±0.63
	Dry season	5.13^{a}±5.88	4.43^{b}±5.54	4.78^{b}±5.59	4.65^{b}±5.49
EC	Wet season	48.03^{a}±1.05	48.46^{a}±1.06	49.05^{a}±1.74	48.74^{a}±1.58
	Dry season	53.76^{b}±3.15	53.92^{b}±2.67	52.0^{a}±1.63	54.13^{b}±4.58
Alkalinity	Wet season	20.05^{a}±1.71	19.98^{a}±1.09	19.69^{a}±1.98	21.37^{a}±0.57
	Dry season	23.25^{a}±1.03	22.36^{a}±1.11	25.10^{a}±2.66	21.87^{a}±1.45
BOD_5	Wet season	2.92^{a}±0.50	2.99^{a}±0.54	2.87^{a}±0.42	2.89^{a}±0.49
	Dry season	2.17^{b}±0.18	2.08^{b}±0.13	2.16^{a}±0.28	2.46^{a}±0.55

Data represents Means± Standard deviation. T-test indicate that seasonal means with the same letter superscript (a,b) of the same parameter/station are not significantly different

4.2 Discussion of Results

The study investigated the physicochemical parameters of surface water in Epie creek, Yenagoa over a period of one year. The physicochemical variables evaluated are temperature, pH, dissolved oxygen (DO), electrical conductivity, alkalinity and biochemical oxygen demand (BOD_5).

The result of the study demonstrates variations among the physicochemical attributes between stations and seasons. Some of the results obtained are in conformity with the results of previous scholars [5], [6], [7], while others are in disagreement with the works of other scholars done in the Niger Delta and in the Diaspora.

There was a higher amount of dissolved oxygen content in the wet season than in the dry season. As wet season DO ranged between 6.09mg/L to 6.41mg/L. While dry season DO ranged from 4.43mg/L to 5.13mg/L. The dissolved oxygen range in this study is within the acceptable ranges and display significant temporal differences. The spatial difference in dissolved oxygen values was however not significant ($P<0.05$) in the wet season but was significantly different in most of the stations in the dry season (Tables 1 & 2).

The higher amounts of dissolved oxygen in the wet season can be explained by increase in the agitation of the surface water within the creek channel due to channel precipitation and run-off discharges as a result of rainfall. Also, dissolved oxygen is dependent on water temperature and decreases as water temperature increases. DO is essential to all forms of aquatic life and varies with temperature, turbulence, atmospheric pressure and photosynthetic activity of algae and plants. Therefore, the relative lower level of DO in the dry season could also be partly due to increase in temperature of the creek.

The reason for the similarity in dissolved oxygen content across stations in this study may be as a result of the fact that Epie creek is a lotic water body with moderate currents that make uniformity in parameters possible.

Higher DO values of between 8.25 mg/L to 9.93 mg/L were reported by previous scholars for Woji Creek and Okpoko River in the Niger Delta area of Nigeria. [8], [9], [10]. This exceeds all the values recorded in this study.

The biochemical oxygen demand (BOD_5) also showed similar seasonal trends as dissolved oxygen. This implies that BOD_5 levels were relatively higher in the wet season than in the dry season (Table 3).Wet season values ranged from 2.87mg/L to 2.99mg/L while dry season values ranged between 2.08mg/L to 2.46mg/L. Higher BOD_5 concentrations in the wet season may be attributed to increased input or import of decaying organic matter, humus nutrient load and dead macrophytes, through surface runoff from swamps into the river, requiring oxygen for their biodegradation [11, 12]. Generally, BOD_5 depends on temperature, extent of biochemical activities, concentration of organic matter and such other related factors. This is also indicative of higher organic content of the creek during the wet season [13]. Also, the high concentration of BOD_5 seem to follow the depth profile theory, implying that water bodies of low depth are more disturbed, resulting in higher BOD_5 concentration [14].

The range of BOD_5 levels (2.08mg/L - 2.99mg/L) obtained for both seasons is below values indicative of pollution (<10mg/L). This is similar to the observations of Ekeh & Sikoki [15] whom obtained values of 1.32 mg/L– 6.8mg/L in New Calabar River but differ with the values obtained by Ubong & Gobo [16] who found significantly higher values.

The BOD_5 of unpolluted waters is less than 1.00mg/L; moderately polluted (BOD_5 2.0 – 9.0mg/L) while heavily polluted waters have BOD_5 more than 10.0mg/L [17]. Therefore, the mean BOD_5 range values for both wet and dry seasons (2.08mg/L - 2.99mg/L) of Epie creek indicates that the water may be considered as fairly clean or moderately polluted. One reason for this moderate pollution may be as a result of refuse dump as seen in station 1 at Igbogene, station 3 at Akenfa and the runoff of flood waters or storm sewage.

Higher temperatures were recorded in the dry season than in the wet season. Temperature ranged between 26.0^0c to 27.26 ^{0}C in the wet season and 28.26^0C to 28.57 ^{0} C in the dry season. This finding disagrees with earlier reports of 25 to 27.8^0C in the Niger Delta waters [18]. However, the result agrees with the reports of Hart & Zabbey [8] (25.8 to 30.4^0C), Chindah et al [19] (26 °C and 30.5 °C), Zabbey [20] (26.3 °C and 30.4 °C) and Abowei & George [10] (27 - 31^0C) because of extremely higher maximum temperature ranges.'

There was therefore a slight increase in temperature between the wet and dry seasons. The relatively small variation range in temperature conforms to the result of Ajao [21] in his work on temperature. A similar result was observed by Onyema and Popoola [22]. They agreed that temperature is a stable environmental factor in the shallow brackish environments of West Africa, and it is most unlikely that this variation in temperature constitutes an important ecological factor in this area.

The observed seasonal variation is directly attributed to the climate of the study area which is usually characterized by a hot dry season and cold wet season [23], [24].

This study also observed that there are no significant difference ($P<0.05$) in temperature between stations during same seasonal confines. This is in agreement with the findings of Alagoa and Wokoma [25] who observed no significant seasonal variations between temperatures of stations in Taylor creek, Bayelsa State. Negligible temporal and spatial variations have also been observed by previous scholars [26], [27,] [28]. This may be due to the fact that Epie creek is a lotic water body with moderate currents, making mixing of water effective and continuous.

pH levels recorded in this study ranged from 6.21 to 6.62 in the wet season and between 4.94 to 5.59 in the dry season. This implies that the creek is more acidic in the dry season. A pH range of 6.5 - 8.5 is permissible according to the WHO [29]. Therefore the creek presents pH values which fall below the suggested limit for survival of fish and other useful biota. This finding is in disagreement with the findings of Alagoa and Wokoma [25] who observed greater acidity and lower pH values in the wet season compared to the dry season of Taylor creek, Bayelsa State. One reason for this trend may be the fact that plants grow more during the dry season with increased sun shine. Therefore, tannins from roots of plants growing in streams and creek catchments have been known to impact on water acidity by reducing pH [30].

The alkalinity of a creek is a reflection of its carbonate and bicarbonate profile [31]. The Alkalinity observed in the creek in the wet season was lower than that obtained in the dry season. Wet season Alkalinity ranged between 19.69mg/L to 21.37mg/L while the dry season Alkalinity ranged between 21.87mg/L to 25.10mg/L.

The range of the total alkalinity obtained in this study (19.6mg/L to 25.10 mg/L $CaCO_3$) compares favorably with the range given by Gupta & Gupta, [32] that waters having hardness values of 15 mg/L or above are satisfactory for the growth of fish while values less than 5 mg CaCO3/L equivalent cause slow growth, distress and eventual death of fish. Likewise, Alkalinities at or above 20 mg $CaCO_3$/L trap free CO_2 and increase the concentrations available for photosynthesis because phytoplankton use mainly free CO_2 in photosynthesis indicating a well buffered water body. Therefore, the alkalinity range recorded during this study period can adequately support phytoplankton productivity.

The electrical conductivity of Epie creek in the wet season ranged between 48.03 to 49.05ms/m which was lower than that of the creek in dry season (52.0 to 54.13ms/m). At low levels of electrical conductance, major ions may determine the nature of the fauna [33]. Conductivity of freshwater varies between 50 to 1500 ms/m [34], but some polluted waters reach 10,000 ms/m. Therefore the EC obtained in this study falls within the recommended normal.

5. Conclusion and Future Scope

5.1 Conclusion

The application of physicochemical investigation to determine the ecological status of water bodies is standard practice. This study therefore has employed the use of physicochemical parameters dynamics as tools to assess the wellbeing of Epie creek. The result of physicochemical parameters investigated in this study show that there was no significant difference between parameters in the wet season except for Alkalinity which was different in only station 4. However, there were significant differences in all physicochemical parameters measured in the dry season except EC values which were not significantly different in all stations. There was divergence in seasonal values in all parameters except in pH & Alkalinity which was not significant seasonally across stations. However, there are no established trends in these differences from station to station as we move down the creek. It is observed that all physicochemical parameters are within the international permissible limits of water for fresh water environment. This is therefore suggestive that the physicochemical parameters of the water were satisfactory during the period of the study. This study therefore opines that flood waters or intrusions of pollutants into lotic waters hardly impact on the well being of these aquatic systems

2 Future Scope

The future scope of this work will be the measurement of biotic parameters alongside the physicochremical parameters. This will provide information on how physicochemical parameters impact biological systems in aquatic systems.

This will provide a clearer picture on the ecology of the creek and the overall aquatic health of Epie creek which can be extrapolated to other receiving water bodies in the Niger Delta.

Data Availability

Primary data were collected from field sources while secondary data were collected easily from internet sources from e-libraries.

Conflict of Interest

The authors hereby affirm that there is no conflict of interest between the authors in the design and execution of this research work

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Authors' Contributions

The research was jointly designed by the authors. Oweifa, Munasuonyo Domokuma was engaged with the collection of samples and measurements of all parameters while Alagoa, Koru Joe did all statistical procedures and the drafting of the manuscript for publication.

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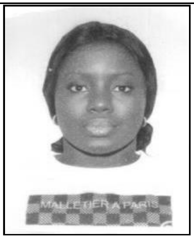

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