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MULTIVARIATE ANALYSIS AND WATER QUALITY INDEX ASSESSMENT OF RIVER ADOFI, SOUTH-SOUTH NIGERIA

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ABSTRACT

Water plays a vital role in ensuring food production, maintaining public health, promoting education, and fostering peaceful coexistence among citizens of any nation. The rapidly growing global population has made it essential to verify the quality of water sources before use. This study presents a multivariate analysis of the water quality status of Adofi River. Water samples were collected monthly (December 2020 to November 2021) from three stations along the river, selected based on human activities. The results showed that water temperature ranged from 26-30 ºC, water depth from 59.0 to 154.4 cm, Dissolved Oxygen (5.4 - 9.8 mg/L), Biochemical Oxygen Demand (2.0 – 8.0 mg/L), pH from 2.1 to 7.4, electrical conductivity from 102.0 to 132.4 µS/cm, acidity from 48.0 to 86.0 mg/L, alkalinity from 150.0 to 280.0 mg/L, Total Dissolved Solids from 80.0 to 135.0 mg/L, phosphate from 1.0 to 3.0 mg/L, sulphate from 20.4 to 52.0 mg/L, and nitrate from 14.5 to 26.4 mg/L. Sulphate, acidity, alkalinity, and water depth varied significantly ($p < 0.05$) between the stations. Principal Component Analysis revealed that PC1 accounted for 89.491% of the variation in the river's water quality. The scatter plot indicated a positive correlation of station 1 with TDS, water depth, BOD, pH, and D.O., station 2 with acidity, and station 3 with phosphate, nitrates, and water temperature. The water quality index results showed that water quality across the three stations ranged from poor to very poor, making it unfit for drinking purposes, and indicated disturbances from both anthropogenic and agricultural sources within and outside the river system. This study emphasises the need for mitigation strategies to address anthropogenic and agricultural activities in the watershed.

Keywords: Adofi, River, Water quality index, Principal Component Analysis, ANOVA

INTRODUCTION

Water is perhaps the most popular naturally occurring resource, utilized by all organisms, including humans, for achieving the basic requirements for survival (Effendi *et al.,* 2015), and play a significant role in food production, maintaining proper health, education, and assuring peaceful coexistence of citizens of any nation (National water Policy, 2004). The bulk of the global water supply is preserved in glacial ice, groundwater, and saltwater found in the ocean, leaving a negligible quantity of freshwater, which is utilized for most human activities (Wu *et al.,* 2021). The over-dependence on these surface freshwater sources for domestic and industrial processes has resulted in deterioration in the quality of associated water bodies, an increase in the incidence of water-borne diseases, and scarcity in the availability of good quality water for consumption by humans and other life-forms (Iloba *et al.*, 2021 and Jehan *et al.,* 2020). The challenge posed by utilizing polluted water to meet the water needs of individuals is profound, especially in the developing countries of the world; in Asia, Latin America and Africa, huge budgetary allocation is reserved for the treatment of water-borne diseases, as well as the provision of pipe-borne water supply to the population (Effendi, 2016). The periodic monitoring of water from multiple sources to determine its quality and subsequent use has been globally accepted as an important protocol in efficient water management (Iloba *et al.*, 2021). Water monitoring protocols have employed various processes, including chemical, biological, and physical processes.

Principal component analysis (PCA) and water quality index (WQI) were selected for their robustness in integrating multiple parameters and comparing against WHO standards. A water quality index is a computational method of determining the quality of a water source by aggregating various components of the water quality into a single index that sufficiently describes its quality. This is a highly reliable tool in water monitoring, as numerous indices have been developed and adopted globally for use by researchers and water managers, and have been extensively applied in determining various river water qualities around the globe (Kachroud *et al.,* 2019; Ewaid *et al.,* 2020; and Uddin *et al.,* 2021A key component of the National water Policy (2004), is the need for periodic assessment of Nigerian surface and groundwater quality, in line with environmental standards, and to prevent pollution and over-exploitation.). River water generates the most attention in terms of quality management due to its proximity to human settlements, accessibility, and the cheap cost of harvesting and most importantly, exposure to contaminants from various sources. Adofi River has been an important source of water for domestic, recreational and agricultural use for the communities within the watershed and a place of ancestral worship for many generations. Previous studies have concentrated on the upper and middle sections of the river (Ikomi et al., 2003; Arimoro 2009; iloba and Akawo, 2013; Akporido *et al.,* 2019; and Akawo and Ikomi, 2023), while studies on the lower section of the river were lacking or scanty. This study aims to "Assess water quality status of lower River Adofi, South-south Nigeria using Multivariate Analysis and water quality index".

MATERIALS AND METHODS

Description of Study Area

The study area and sampling stations are detailed in Akawo and Ikomi, (2023). River Adofi (fig.1) is a first-order river that originates from Ejeme-Unor in the Aniocha South Local Government Area of Delta State, flowing through Ejeme-

Aniogor to Utagba-Uno and Ossissa in Ndokwa West and Ndokwa East Local Government Areas of Delta State, Nigeria. The river is highly significant to the communities within its watershed, as it is the sole river draining this region, providing water for domestic and agricultural purposes. Adofi River flows southward to Utagba-Uno and then turns southeast to Ossissa, where it joins the Ase River.

It lies within the dense and thick tropical rainforest, at a terrain elevation estimated at 22m above sea level. The vegetation here consists of floating plants such as Pistia spp., *Azolla africana, and Nymphacea lotus;* the submerged plants include *Vossia cuspidata, Ludwigia spp., Salvinia nymphellula, Hydroles glabra, Echinochloa stagnina, Echinochloa pyramidalis, Oryza barthi, Phragmites karka, Polygonum lanigerum, Leersia virginica, Leersia oryzoides,* and *Puerarus lanceolatus*. Fishes found in the river *include Bagrus bayad, Oreochromis niloticus, O. aureus, Gymnarchus niloticus,* and some members of the families Mokuchidae and Clariidae etc. Anthropogenic activities include fishing, washing of clothes, bathing, fermentation of cassava, lumbering, and others.

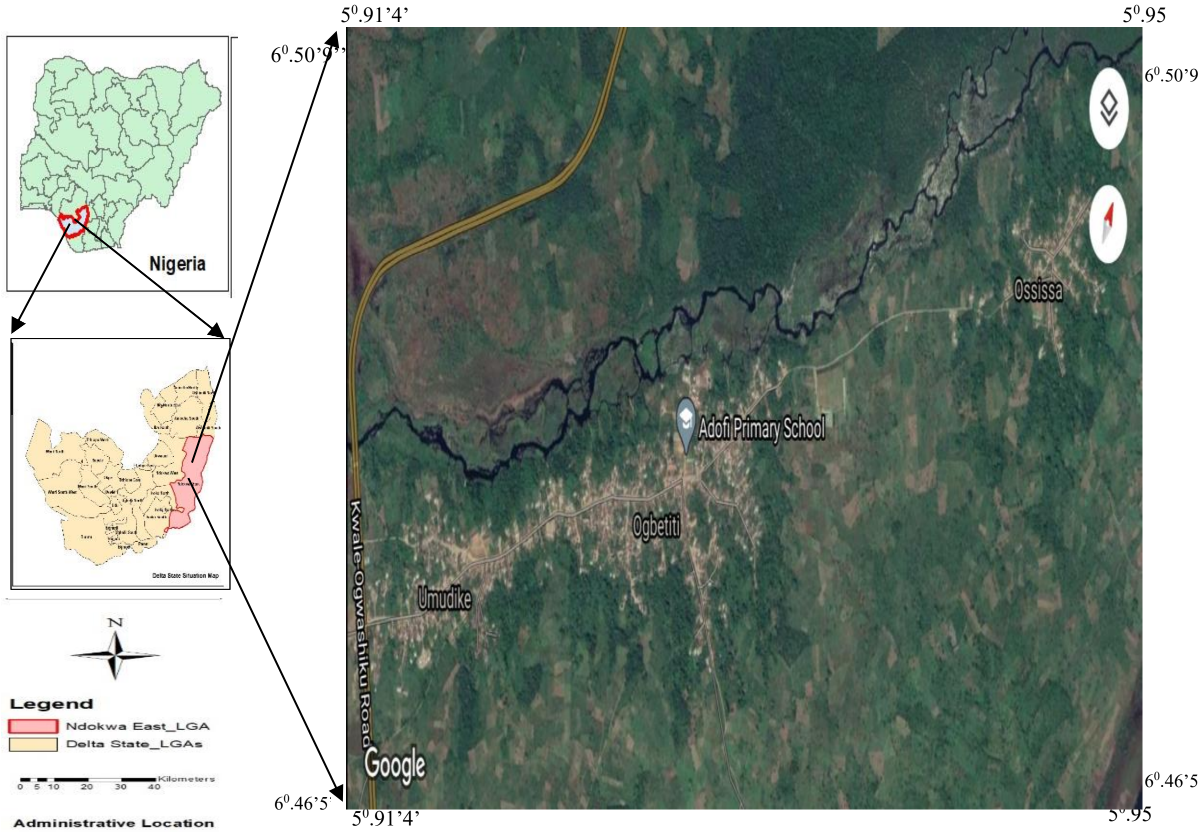

Figure 1: Map showing the sampling stations of River Adofi, South-south Nigeria. Source. Akawo and Ikomi, (2023)

Description of Sampling Sites

Station 1: This station is located at Umudike on long. 5.914, and lat. 6.465 around the eastern fringes of Ossissa town. The bottom sediment is mostly sandy, especially along the main river channel, however on the fringes of the river, it is dominated by silt and plant matter. Compared to the two other stations, this station is the least impacted by human activities, which are limited to swimming, laundry, and water abstraction for domestic and industrial purposes. This station is further characterised by rich littoral and truly aquatic macrophytes, ranging from floating plants such as *Pistia* sp., *Azolla africana, and Nymphacea lotus,* to submerged plants *including Vossia cuspidata, Ludiogia* sp., *Salvinia nymphelluda, Hydroles glabra, Echinochloa stagnina, Echinochloa pyramidalis, Oryza barthi, Phragmites karka, Polygonum lanigerum, Leersia virginica, Leersia oryzoides, and Pyereus lanceotus.*

Station 2: This is at Ogbe-Etiti, behind Adofi Primary School, on long. 5.928 and lat. 6.484, and approximately 3km away from Station 1. Station 2 is a backwater region cut off from the main water channel by a large aquatic forest, hence it is characterised by reduced flow velocity, greater depth. The sediment is predominantly silt and plant matter; however, there is no marginal vegetation due to unstable soil resulting from canoe anchorage. There exists the presence of overhanging trees, and submerged plants *include Vossia cuspidata, Ludiogia* sp., *Salvinia nymphelluda, Hydroles glabra, Echinochloa stagnina, Echinochloa pyramidalis, Oryza barthi, Phragmites karka, Polygonum lanigerum, Leersia virginica, Leersia oryzoides, and Pyereus lanceotus.* This station is subjected to increased human interaction as the fermentation of cassava, anchorage for canoe, fishing, fetching of water for drinking and swimming are some of the noticeable activities taking place here.

Station 3: This is the deepest of the three stations and it is located at longitude 5.950 and latitude 6.509, about 2km away from the mouth of the river, where it empties into the Ase River and 3.5Km from station 2. Like station 2, this is a backwater zone, with sparse marginal vegetation and overhanging trees the visible water bottom has notable patches of debris from plant remains, possibly washed down from the riparian zone vegetation by the receded river. The vegetation here consists of floating plants such as *Pistia* sp., *Azolla africana, Nymphacea lotus,* while Rafia palm occurred as part of the emergent vegetation. The water is used as a source for drinking, washing, swimming, anchorage, cassava fermentation, and a point of religious activities for local folks that worship the River deity. The riparian zone and adjourning land are used for agricultural activities, as they serve as farmlands for local cassava farmers.

Sampling Method

The stations were sampled every month for twelve (12) months between 7.30 am – 11.00 am, to collect water samples for Physicohemical parameters. Water samples for the determination of physicochemical parameters of Adofi River were collected in acid-washed polyethene containers that were first rinsed with water from the river. The collected samples were preserved by adding 3.3 ml of HNO_3 and placed in an ice chest and transported to the laboratory of the Department of Animal and Environmental Biology, Delta State University, Abraka. The samples were analysed for various physical and chemical parameters within 48 hours of collection. The water samples were analysed for eleven physicochemical parameters: temperature, water depth, Dissolved Oxygen (DO), Biochemical oxygen demand (BOD), Electrical Conductivity (EC), Total dissolved solids (TDS), pH, phosphate, nitrate, sulphate, alkalinity, and acidity. DO and BOD were determined by Winkler's method, alkalinity and acidity (Titrimetric method with 0.02N, Sulphuric acid, and Sodium hydroxide, respectively) as described by the American Public Health Association (APHA, 2017). EC, TDS, and pH were determined in situ using Hanna USA H19829 Multiparameter meter, temperature (mercury in glass thermometer), Water depth (meter rule), Phosphate (spectrophotometric method), Nitrate (Devarda's alloy method) and Sulphate (Indirect EDTA titration with $BaCl_2$) as described by (APHA, 2017).

Data Analysis

The results were subjected to descriptive statistics to establish the means, range and standard deviation of each parameter using Microsoft Excel 2016. One-way ANOVA was used to ascertain if there are significant differences ($p < 0.05$) in the stations, while Turkey's honest significant difference (HSD) test was used to identify the source of the significant differences. The level of variation of each parameter was determined by transforming the mean values of each parameter log(x+1) and subjected to principal component analysis (PCA) and cluster analysis using PAST statistical software version 4.05 (Hammer *et al.,*2001).

Water Quality Index

The water quality status was determined by adopting the weighted arithmetic mean water quality index (WAMWQI) method originally proposed by Horton (1965) and applied by Anyanwu and Ukaegbu, (2019), Iloba *et al.*, (2021), Iloba *et al.,* (2022) and Soueilim *et al.,* (2025). The water quality index was calculated using the formula:

$$WQI_A = \sum_{i=1}^{n} w_i q_i \,/\, \sum_{i=1}^{n} w_i \quad (1)$$

where,

i. n is the number of variables or parameters,
ii. wi is the relative weight of the ith parameter and,
iii. qi is the water quality rating of the ith parameter.

The unit weight (wi), of the various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters.

$$Wi = 1/Si, \text{and } K = \text{constant given as; } K = 1/\sum 1/Si \quad (2)$$

$$qi = 100\,[(Vi - Vid)\,/\,(Si - Vid)] \quad (3)$$

where:

i. Vi is the observed value of the *ith* parameter,
ii. Si is the standard permissible value of the ith parameter and,
iii. Vid is the ideal value of the ith parameter in pure water.

All the ideal values (Vid) are taken as zero for drinking water, except pH and dissolved oxygen are 7 and 14.6, respectively (Tripathy and Sahu, 2005).The following nine parameters - dissolved oxygen (D.O.), biochemical oxygen demand (BOD), electrical conductivity (EC), total dissolved solids (TDS), alkalinity, pH, phosphate, sulphate, and nitrate perceived to have the most impact on the water quality, was used for the calculation of WQI.

Table 2: Weighted Arithmetic Water Quality Index Method, Water Quality Rating

WQI Value	Rating of water quality	Grading
0 – 25	Excellent water quality	A
26 – 50	Good water quality	B
51 – 75	Poor water quality	C
76 -100	Very Poor water quality	D
100 – Above	Unsuitable for Drinking Purpose	E

Source Tyagi et al., (2013)

RESULTS AND DISCUSSION

Physico-Chemical Parameters

An interplay between geophysical conditions and anthropogenic activities in and around the watershed is manifested in the physico-chemical condition of the aquatic ecosystem, and as well as its water quality (Iloba *et al.*, 2021). All the measured water parameters of the Adofi river were within the standard limits provided by FEPA, (2023), NIS, (2015) and WHO, (2017), except B.O.D. and Alkalinity (Table 3).

Table 3: Mean± Standard Deviation Values of Physico-Chemical Parameters of Adofi River (Minimum and Maximum Values in Parentheses)

Parameter	Umudike	Ogbetiti	Umueze	F-value	P-value
Air Temperature (ºC)	28.25±1.14 (27.0-30.0)	29±1.28 (27.0-31.0)	29.5±1.38 (27.0-32.0)	2.944	0.0666
Water Temp. (ºC)	27.17±1.12 (26.0-29.0)	27.92±1.24 (26.0-30.0)	28.17±1.19 (26.0-30.0)	2.319	0.1142
pH	6.97±0.31 (6.4-7.4)	6.43±1.39 (2.1-7.3)	6.73±0.17 (6.4-6.9)	1.278	0.292
Dissolved Oxygen (mg/L)	8.8±1.04 (7.0-9.8)	7.97±0.90 (6.2-9.0)	8.17±1.29 (5.4-9.4)	1.903	0.1651

Parameter	Umudike	Ogbetiti	Umueze	F-value	P-value
BOD (mg/L)	5.15±1.57 (3.1-8.0)	4.18±1.41 (2.2-6.5)	4.64±1.19 (2.0-5.4)	1.459	0.2471
Water Depth (cm)	138.01±11.16 (124.0-154.2)	68.58±8.39** (59.0-77.8)	72.18±6.92** (64.0-79.6)	226.5	*5.30E-20
Alkalinity (mg/L)	235.83±28.11 (180.0-280.0)	202.08±24.63** (150.0-220.0)	186.25±5.69** (180.0-195.0)	16.16	*1.28E-05
Conductivity (µS/cm)	116.43±9.89 (102.0-132.4)	116.65±3.82 (112.0-122.0)	118.43±4.58 (110.0-124.5)	0.3249	0.7249
Acidity (mg/L)	66.83±2.98 (60.0-70.0)	72.25±11.66 (55.0-86.0)	62.33±8.12** (48.0-70.0)	4.211	*0.0235
TDS (mg/L)	109.75±23.48 (80.0-135.0)	100.58±11.50 (84.0-118.0)	114.67±13.87 (94.0-130.0)	2.101	0.1385
Phosphate (mg/L)	2.00±0.45 (1.2-2.4)	1.9±0.52 (1.0-2.4)	2.24±0.68 (1.0-3.0)	1.161	0.3257
Sulphate (mg/L)	46.44±5.58 (38.0-52.0)	33.76±1.87** (30.8-36.0)	31.14±6.89** (20.4-38.0)	29.33	*4.79E-08
Nitrates (mg/L)	20.85±2.14 (17.0-23.0)	20.47±0.75 (19.0-21.5)	22.33±4.09 (14.5-26.4)	1.601	0.2169

*P<0.05= significant difference; **sources of variation between stations; P>0.05=No significant difference

The monthly temperature values recorded in River Adofi ranged between (26-30) ⁰C and (27-32) ⁰C, for water and air respectively, throughout the sampling period as seen in Tab. 3. The temperature ranges for both air and water were within the ranges previously reported by Ikomi *et al.,* (2003), (24-30) ⁰C, Iloba and Akawo, (2013), (22-30) ⁰C and Nwabueze and Ekelemu, (2021), (27-30) ⁰C all in the Adofi river. The water depth (59.0 – 154.4) cm in this study was of a similar range to the (35.25-128.26) cm by Nwabueze and Ekelemu (2021), but lower than the (3.02-5.7) m reported by Ikomi *et al.* (2003) in Adofi River. This difference, spatial and temporal, could be attributed to increased surface runoff and siltation of the river channel, as well as differences in sampling stations. There was a notable increase in water depth during the rainy season, attributed to the increased volume of rain (Edegbene and Omovoh, 2014).

The dissolved oxygen values (5.4-9.8) mg/L were high, slightly higher than the acceptable limit of dissolved oxygen needed to support aquatic life. Slightly lower values (2.98-8.13) mg/L and (2.6-6.00) mg/L have been reported by Nwabueze and Ekelemu, (2021) and Iloba and Akawo, (2013) respectively, in the Adofi river. High dissolved oxygen values in water bodies are an indication of good water quality and are necessary for the sustenance of life forms in the aquatic environment Bhatti and Latif, (2011). The values of dissolved oxygen recorded could be attributed to the combined effect of increased photosynthesis from the numerous submerged macrophytes in Adofi River, increased flow and resultant freshwater mixing. This agreed with Ikomi *et al.,* (2003) in Adofi River and Niusha *et al.,* (2014) in Jajroud River, Iran, who associated increased dissolved oxygen levels during the rainy season with the combined effects of heavy rainfall, higher flowvelocity and improved freshwater mixing. The BOD values record in this study ranged from 2.0-8.0 (mg/L). It was higher than (1.05-3.00)mg/L reported earlier in the same river by Iloba and Akawo, (2013), but have a lower mean value 5.15 mg/L compared to the 7.26 mg/L by Nwabueze and Ekelemu, (2021) in the same river. These differences could be a result of the spacial and temporal differences in these studies. High ranges of BOD levels recorded in this study have been reported by Mohammed *et al.,* (2020) in the Moussa stream. According to Nwabueze and Ekelemu, (2021) and Arimoro *et al.,* (2008), high BOD in such rivers occurs when a heavy downpour of rain leads to heavy runoffs, leading to nutrient enrichment from anthropogenic and agricultural wastes into the river. This study agrees with Ikomi *et al.,* (2003) and Akawo and Ikomi, (2023), since the Adofi River is located in the Niger Delta area associated with continuous rainfall year-round and heavy surface runoffs into the river. This type of runoff increases the nutrient load and solid deposit into the river resulting in high B.O.D levels. This gives an indication of the pollution status of the Adofi River and the values reported in this study classify the river as "moderately polluted" Edokpayi *et al.,* (2010) and Anyanwu *et al.,* (2022). The pH values (2.11-7.4) varied from acidic to slightly alkaline. This range of values (5.00-7.11) has also been reported by Ikomi *et al.,* (2003) and Iloba and Akawo, (2013) in Adofi River, and elsewhere by Edegbene *et al.,* (2014) in Owan River. This observation agrees with that of Edegbene *et al.,* (2014) in the Owan River and Iloba et al., (2018) in Agbhara-Otor River; tropical forested water bodies are characterized by low pH due to the presence of humic substances, as well as the inflow of organic matter from the riparian zones. According to Akawo *et al*., (2021), the sampled sites of the Adofi River have numerous aquatic macrophytes in and around the river, as well as the fermentation of cassava in stations 2 and 3, which will contribute to the breakdown of the fermentation products and a more acidic pH of the water body. Previous studies indicated that the Adofi river had low alkalinity levels (0.41-1.00)mg/L by Ikomi *et al.,* (2003) and Iloba and Akawo, (2013). This study however recorded high levels (150-280) mg/L of alkalinity beyond the standard limit permissible 200 mg/L in drinking water according to NIS (2015). The alkalinity levels were higher than values recorded by Arimoro *et al.,* (2015) in the Orogodo River, Iloba and Arebun, (2020) in Agbhara-Otor River and Anyanwu *et al.,* (2022). High Alkalinity has been associated with the presence of bicarbonates, organic acids, hydroxides, phosphate and borates in the riparian basin drained by the river, Iloba and Arebun, (2020) and Adejuwon and Akinola, (2025), as well as the high buffering of the Adofi River. Hamid *et al.,* (2020) and Umoren et al., (2024) associated high alkalinity with improved primary production, abundance of submerged macrophytes, algal blooms, higher dissolved oxygen values and impaired water quality. This is consistent with the conditions recorded in Adofi river during this study.

The values of TDS and electrical conductivity were regarded as excellent by Souelim et al., (2025) and are lower than the standards set by SON and WHO, respectively, John et al., (2025). Similar findings have been reported earlier by Niusha et al., (2014), Iloba et al., (2021), and Iloba et al., (2022), who associated high TDS and conductivity levels with the combined effects of high temperatures, which lead to greater evaporation of water and a higher incidence of storm runoff (Akawo et al., 2021) during both the dry and wet seasons. Although the levels of phosphate, nitrate, and sulphate were within the limits for drinking water quality (John *et al.,* 2025), they were higher than previously reported in Adofi River by Ikomi *et al.,* (2003) and Iloba and Akawo (2013), but within the range observed by Mohammed *et al.,* (2020) and Arimoro (2015), who linked high nutrient levels in rivers to surface runoff from farmlands in the riparian zone, laden with fertilisers, faecal droppings, and other organic matter from anthropogenic activities within the watershed. The studied section is heavily impacted by agricultural activities, with large deposits of cassava peels along the riverbanks at stations II and III, cassava fermentation, fish landing, and open defecation in the riparian forest, all of which provide a reservoir of nutrients transported back into the water body via surface runoffs or underground leaching.

Principal Component Analysis (PCA)
The relationship between factor weight values of observed factors and the principal components is presented in Table 4. The PCA selected two principal components (1 and 2). The PC1 accounted for 89.49% of the variability noted in Adofi river, with high positive loading for water depth (0.83), moderate positive loading for Alkalinity (0.24) and Sulphate (0.44). On the other hand, PC2 explained 10.51% of the in this study. PC2 was associated with strong positive loading for phosphate (0.51), weak positive loading factors for BOD (0.32), and TDS 0.41), while Nitrates was associated with low positive factor loading (0.272). Acidity (-0.46) had a moderate negative loading factor while Alkalinity (-0.261) and Sulphate (-0.26) were associated with moderate negative factor loadings. From table 4; the variability associated with PC1, can be associated with the natural or geogenic conditions of the river, while the variability of PC2 is associated with agricultural activities in and around the river.

Table 4: PCA Loading Factors, Eigenvalues and Percentage of Variations of Principal Components in Adofi River

	PC 1	PC 2
Water Temp.	-0.03892	0.028816
pH	0.071671	0.1399
Dissolved Oxygen	0.10696	0.074154
B.O.D	0.19371	0.31949
Water Depth	0.82999	0.13619
Alkalinity	0.23954	-0.26046
Conductivity	-0.01149	0.04744
Acidity	-0.00659	-0.45936
TDS	0.028042	0.40716
Phosphate	-0.03652	0.51324
Sulphate	0.4415	-0.2636
Nitrates	-0.03001	0.27145
Eigenvalue	0.041476	0.004871

Station 1(Umudike) correlated positively with TDS, water depth, BOD, pH, and Dissolved oxygen and negatively with sulphate and alkalinity (Fig. 2). Station2 (Ogbe-etiti) correlated negatively with acidity, while station 3(Umueze) correlated with phosphate, nitrates, and water temperature.

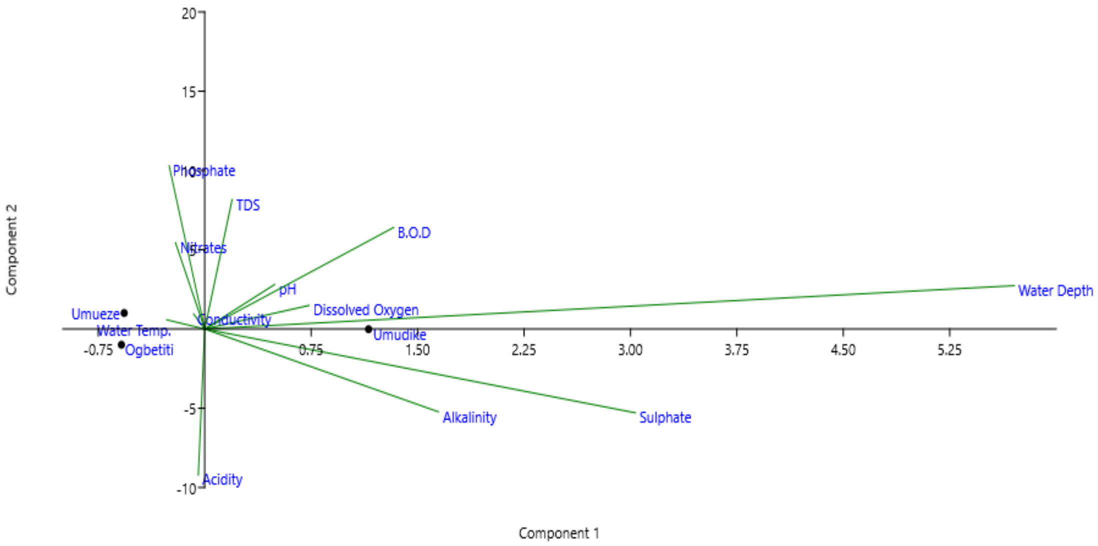

Figure 2: PCA Plot of Adofi River Based on the Physico-chemical Parameters Obtained for the three Stations

Water Quality Index Analysis (WQIA)
The result of the water quality index analysis was presented in Table 5. It showed that during the rainy season, the values were 90.27 (station 1), 68.54 (station 2), and 77.90 (station 3), while in the dry season, it was 62.96 (station 1), 72.22 (station 2), and 64.67 (station 3). According to Tyagi *et al.,* (2013), Adofi river is classified as very poor (station 1) poor (stations 2 and 3) during the rainy season, while it was classified as

poor in all the stations during the dry season, indicating the presence of pollution activities from both anthropogenic and natural sources within and outside the river system. The seasonal variation in the pollution status especially in station 1, is attributed to the impact of greater runoff due to heavier rains during the rainy season.

Table 5: Water Quality Status of Adofi River Using the Weighted Arithmetic Mean Method (WAMWQI)

Parameters	Wi	Dry season			Rainy season		
		Station 1 (wiqi)	Station 2 (wiqi)	Station 3 (wiqi)	Station 1 (wiqi)	Station 2 (wiqi)	Station 3 (wiqi)
pH	0.1393	2.6293	-2.8793	-2.8793	2.3221	-6.8675	-1.393
DO (mg/L)	0.2368	15.7875	18.0086	18.0086	12.8275	14.8	13.8054
BOD (mg/L)	0.3381	32.9288	46.8505	38.158	60.5679	46.6578	51.4878
Alkalinity (mg/L)	0.0099	1.8288	1.6019	1.5128	2.0625	1.7325	1.5593
Conductivity (µS/cm)	0.0012	0.0134	0.0138	0.014	0.0145	0.0142	0.0145
TDS (mg/L)	0.0024	0.0467	0.048	0.0507	0.0586	0.0486	0.0594
Phosphate (mg/L)	0.2368	8.288	7.2461	8.5722	10.7507	10.7507	10.7507
Sulphate (mg/L)	0.0118	0.5021	0.3829	0.3092	0.5939	0.4142	0.4257
Nitrate (mg/L)	0.0237	0.9362	0.9504	0.9324	1.076	0.9897	1.185
Σwiqi		62.961	372.222	64.677	90.274	68.540	77.895
WQI=Σwiqi/ΣWi		62.961	372.222	64.677	90.274	68.540	77.895

According to Tyagi *et al.,* (2013), the water quality of the Adofi River is poor, as there was not much improvement in the water quality between the various seasons, especially in stations 1and 2, which were reported to have poor water quality. Station 1, had a slightly worse condition as the quality index shifted from poor in the dry season to very poor in the rainy season. This may be associated with an increase in surface runoff and influx of nutrients into the river as the rain begins to fall more frequently. Similar water quality conditions have been reported by Iloba *et al.,* (2021) in the Anwai river. According to Ataguba and Brink (2021) and Wali *et al.,* (2020), high alkalinity and TDS values in water sources increase its hardness and reduce its quality. Iloba *et al.,* (2021) related increased B.O.D and Phosphate values in water to nutrient enrichment from anthropogenic activities in the river catchment area and season. In this study, increased water volume and territory during the rainy season into previously terrestrial areas will lead to an increased nutrient loading into the river, causing a corresponding increase in phosphate, BOD., alkalinity and TDS levels in the Adofi River. These changes potentially increased the pollution level in the river particularly station 1, resulting in a shift from poor water quality to very poor water quality noted.However, this studies aligns with Tyagi et al., (2013), who acknowledged the subjecticeness of weight allocation in WAMWQI, as these predefined weights creates doubt in the quality status of water sources.

CONCLUSION

This study highlighted that the physicochemical parameters of Adofi River is within limits acceptable in drinking water quality, except for B.O.D and Alkalinity. Despite this, the water quality index revealed that Adofi River water quality is poor and unfit for drinking purpose. The (wi.qi) of BOD and phosphates, in the analysis of water quality index, were very high, thus highlighting the impacts of agricultural activities on the river catchment and storm water runoff on this important river. The outcome of this study provides impetus to develop water quality management strategies to improve the water quality of Adofi river. There is also an urgent need for an extensive WQI study which will include analysis of the heavy metals component of the sediment and water of Adofi river, as well as, the addition of more sampling stations. These will be in addition to the provision of stringent monitoring or discontinuation of the discharge of agricultural waste into this river.

LIST OF ABBREVIATIONS

Dissolved Oxygen (DO), Biological oxygen demand (BOD), Electrical Conductivity (EC), Total dissolved solids (TDS), Water Quality Index (WQI), Nigerian Standard for Drinking Water Quality (NSDWQ), Federal Environmental Protection Agency (FEPA), and World Health organization (WHO).

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