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Upshots of Surface Water Quality on the Incidence of Water-Borne Disease Cases in Communities Along River Ase in Southern Nigeria

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ABSTRACT

In Southern Nigeria, there is the problem of inadequate access to safe drinking water and the incidence of water-borne diseases that reduce vitality and economic productivity. It is on this premise that the paper assesses the upshots of surface water quality on the wide range of water-borne disease cases in the study area. The study employed an experimental and expost facto research design. A surface water sample from each of the six communities along River Ase was analyzed for physicochemical and bacteriological quality parameters using standard procedures for twelve months. The resulting data were compared to the WHO recommended limits and the suitability of the surface water for residential use was determined using the water quality index. In addition, health records of persons diagnosed and treated for water-borne diseases were collected from limited health record centers in the study communities to determine those impacted by water-borne diseases. Data were analyzed using descriptive statistics and multiple regression statistical techniques to test the posited hypothesis (H_o). The results showed that there is variation in the water quality of the river. The posited hypothesis showed that 51% of the incidence of water-borne diseases was significantly dependent on the quality of water at $P > 0.05$. Also, the WQI indicated that the water quality fell between bad and medium (42.80 - 58.05), indicating that the water should be treated before consumption. The study, therefore, recommends the testing of the water periodically to safeguard human health.

INTRODUCTION

Water that is easily accessible and safe is essential for maintaining public health. Water is a chemical substance composed of hydrogen and oxygen and covers 71 percent of the earth's surface (Dingman, 2002). It is found mainly in oceans, seas, rivers, and lakes with 1.6 percent of it below ground in aquifers and 0.001 percent in the air as vapor, clouds, and precipitation (Gallant, 2002). Oceans hold 97 percent of surface water, glaciers, and polar ice caps 2.4 percent, and other land surface water such as rivers, lakes, and ponds 0.6 percent (Dingman, 2002). Water on earth moves continually through a cycle of evaporation or transpiration, precipitation, and runoff, usually reaching the sea as surface water. Surface water is the most often used source of water supply for the majority of people in developing countries around the world, especially Africa and Nigeria in particular, where most of the Nigerian rural communities are supplied with surface water in one way or the other (Oladeji et al., 2021). They get their water primarily from there.

The amount as well as the quality of water from the land surface water, such as the river, varies seasonally. Although the water is so murky during the rainy season that it is dubious to use it for human use, both rural and some urban areas rely on it (Dzavi et al., 2021; Iro & Chukwudi, 2009). In the last century, freshwater usage has amplified six-fold globally, and since the 1980s, it has grown at a rate of roughly 1% yearly, according to the UNESCO 2021 World Water Development Report. However, with the rising water demand, water quality is facing severe challenges all over the world as a result of urbanization, agriculture, and industrialization (Halder & Islam 2015; Kaur et al., 2021; Xu et al., 2022).

Industries discharge hazardous wastes into aquatic environments during and after industrial production without sufficient treatment, resulting in water pollution (Chen et al., 2019; Chowdhary et al., 2020; Wu et al., 2020). With the increase in urbanization, wastewater from households has gradually increased. This from time to time finds its way into surface water bodies and leads to pollution (Lin et al., 2022). Also, agricultural activities through the use of pesticides, soil additives, nitrates, and phosphorus have polluted water bodies (Moss 2008; Parris, 2011; Lu et al., 2015). All these activities have contributed to environmental pollution and degradation, which harms the rivers and oceans that support life and, eventually, human health, and long-term societal progress (Wu et al., 1999; Lai 2017; Xiao et al., 2019; Ustaoglua et al., 2020; Lin et al., 2022).

Many researchers have stated that unsafe water poses serious health risks to humans resulting in waterborne diseases such as typhoid, diarrhea, dysentery, cholera, skin diseases amongst others (Ferreccio et al., 2000; Vladeva et al., 2000; Bartlett, 2003; Zhang et al., 2003; Fong and Lipp, 2005; Jorgenson, 2009; Kazi et al., 2009; Yau et al., 2009; Zhitkovich, 2011; Ebenstein, 2012; Khan et al., 2013; Lin et al., 2013; Ahmed and Ismail, 2018; Schullehner et al., 2018; Tseng et al., 2018; Kaur et al., 2019; Landrigan et al., 2019; Xu et al., 2019; Arif et al., 2020; Hanif et al., 2020; Magdaraog et al., 2022). A recent review by Lin et al., 2022 further found that drinking water quality in developing nations is perturbing. Water pollution continues to be the primary cause of morbidity and mortality due to its detrimental effects on health in developing nations.

The challenges posed by waterborne diseases will magnify in the future due to an ever-increasing population that needs to share in the already insufficient and poorly managed water resources. Therefore, assessing surface water quality is crucial to healthy living and sustenance of man on the earth's surface, especially for the realization of sustainable development goals. This underscores the need for this research. The study, therefore, assessed the upshots of surface water quality on the incidence of the wide range of waterborne disease cases in the study area. The posited hypothesis (Ho) was generated.

Ho: The wide range of waterborne disease cases is not significantly dependent on the water quality in the study area.

MATERIALS AND METHODS

Study Area

The study area is River Ase, and it includes six communities (Asaba-Ase, Ivorogbo, Igbuku, Kwale, Osemele, and Obikwele) situated alongside the river's flow in Southern Nigeria. River Ase flows into the Forcados River around the River Niger. According to Federal Surveys, Nigeria, Sheet 78, 1970, River Ase is situated roughly around latitudes 5°17' and 5°53' North of the Equator and longitudes 6°17' and 6°31' East of the Greenwich Meridian. The river traverses the Niger Delta Region of Southern Nigeria's freshwater swamps and marshy woods. The water from the river is used for domestic purposes-bathing, washing, drinking, transportation, fishing, and other agricultural activities by the people of the area.

Study Design

The study adopted experimental and expost-facto designs. The experimental design involved the field and laboratory components, while the expost-facto design established a relationship between the physicochemical and biological parameters of the water, the calculated water quality index (WQI), and the upshots of water pollution (if any) on the health of the people.

Study Population

Persons diagnosed and treated for water-borne illnesses in the study area. Total sampling was employed in the study due to the limited water supply and health record centers in the study area. The study site was chosen purposively since it serves as the principal water supply for so many communities. River Ase was categorized into three sections namely the upstream, midstream, and downstream. A simple random sampling technique was used to select two communities surrounding each section, for a total of six communities selected for the study. A water sample was collected from each of the six communities that represent the sampling points along the river course from January 2021 to December 2021. A total of seventy-two water samples were collected, analyzed, and used for the study. Total sampling was used to select the hospitals, health centers, and local government headquarters within these communities to participate in the study.

Data Collection Methods

Health records from hospitals, health centers, and local government headquarters within the study communities were used to get information on persons diagnosed and treated for water-borne diseases, for a period of six years (the year 2015 - 2021), to determine those impacted by water-borne diseases. Direct field collection of water samples from the surface and sub-surface of the river was the method adopted. The collection of the water samples was done between the hours of 7 am and 9 am to reduce the impact of temperature on the samples collected. The water samples were collected using a sterilized 2-litre plastic can fitted with an information tag for identification. The plastic can were securely corked, and stored in iced containers before transporting them to the laboratory for analysis. This process was done within six hours of the water samples collection.

Determination of Physiochemical and Bacteriological Quality

The parameters pH, electrical conductivity, temperature, TDS, DO, nitrate, COD, alkalinity, phosphate, HCO3, chloride, sulfate, fecal coliform, sodium, calcium, and zinc were analyzed using the standard methods developed by the American Public Health Association (APHA, 1998). The results obtained were compared with the World Health Organization standard for drinking water quality.

Statistical Analysis

The proposed hypothesis was tested using multiple regression analysis, while the water quality index (WQI), which evaluates whether or not water quality is suitable for home use (Asadi, Vuppala & Reddy, 2007), was chosen for the research. A mathematical equation that assigns a numerical value to the characteristics of waterbodies is created by combining data from several water quality parameters (Yogendra and Puttaiah, 2008). Sixteen parameters were employed in this study to calculate the Water Quality Index (WQI). The World Health Organization-approved standards for drinking water quality were used to determine the WQ1. The WQ1 of the water samples was determined using the weighted arithmetic index approach recommended by Akoteyon et al., (2011) and Brown et al., (1972). The following formula was used to determine the additional quality rating or sub-index (qn):

Qn = 100 (Vn-Vio) / CSn-Vn) ………………… (1)

Where:

Qn = nth water quality parameter's quality rating;

Vn = estimated nth parameter value at a specific sampling point;

Sn = standard value of the nth parameter that is acceptable;

Vio = the nth parameter's optimal value in pure water.

An inversely proportionate value to the suggested standard value Sn of the associated parameter was used to compute the unit weight.

Wn = K / Sn ………………………………… (2)

Where:

Wn = the nth parameter's unit weight;

Sn = the nth parameters' standard value;

K = Proportionality constant.

The unit weight and quality rating were aggregated linearly to determine the overall WQI =

WQI = ∑qn Wn/∑Wn ………………………… (3)

Where:

WQI= Water quality index;

∑ = summation;

Qn = quality rating for the nth water quality parameter;

Qn = unit weight for the nth parameters

The calculated values and spatial distribution of the WQI throughout the River Ase's path, community by community are presented in tables and discussed.

RESULTS AND DISCUSSION

Table 1 shows the results of some major physico-chemical and biological constituents of the surface water at Asaba-Ase. The results revealed that electrical conductivity has the highest mean value (68.99us/cm), followed by coliform count (52.40/100) and chemical oxygen demand (COD) (45.02mg/l); while zinc has the lowest recorded mean value (0.22mg/l). The largest standard variation was seen in Electrical conductivity (22.46us/cm). This is followed by coliform count

(19.85/100), while zinc recorded the least value of 0.04mg/1 (Table 2).

On the pattern of relative variation, the results of the coefficient of variation (C.V %) showed that all the examined water variables are heterogeneous. Furthermore, all the examined water parameters are within the maximum permissible limit of WHO standards for drinking water quality.

Furthermore, the outcomes of the Asaba-Ase water quality index computation are displayed in Table 2. The result shows that Asaba-Ase has a water quality index of 45.43. According to Brown et al., (1972), and as stated by Ohwo (2009), this status implies that the water is bad and may not be too suitable for human intake, as shown in Table 3 and Table 4.

By implication, the high amount of coliform recorded as shown in Table 1 poses a health risk when the water is consumed by the people. Water-borne illnesses like cholera, typhoid, dysentery, and diarrhea could arise as a result, affecting the local population.

Table 1. Results of Physico-Chemical and Biological Analysis (Asaba-Ase)

S/N	Field code Asaba-Ase	pH	Elec. Conduc. (us/cm)	Temp (^oC)	TDS (mg/l)	DO (mg/l)	$N0_3N$ (mg/l)	COD (mg/l)	Alkali (mg/l)	Total Phosp (mg/l)	HCOs (mg/l)	CL^{-1} (mg/l)	So_4 (mg/l)	Coliform (Count/100)	Na (PPM)	Ca (PPM)	Zn (PPM)
1.	January	7.20	91.43	27.30	42.00	7.10	3.73	20.30	19.00	3.90	22.15	12.15	8.15	30.00	15.10	8.05	0.20
2.	February	6.95	80.20	27.15	40.00	7.00	3.50	20.15	18.00	4.00	15.10	10.30	7.15	25.00	15.05	8.00	0.25
3.	March	7.05	75.10	27.30	35.00	7.15	3.15	25.10	17.00	4.15	15.10	10.30	8.00	27.00	14.10	7.45	0.20
4.	April	7.12	48.56	26.80	25.32	4.00	0.04	62.00	18.00	0.54	22.00	6.00	3.00	75.00	12.21	3.90	0.25
5.	May	7.15	40.45	26.85	26.30	4.15	0.05	60.00	18.00	0.55	25.00	5.00	3.15	70.00	12.00	3.50	0.22
6.	June	7.10	38.40	27.00	27.10	4.20	0.07	55.00	17.00	0.45	25.00	4.15	2.45	60.00	11.20	3.40	0.20
7.	July	7.20	37.40	27.15	27.40	4.15	0.10	50.15	18.00	0.42	24.00	4.00	2.30	65.00	12.00	3.45	0.25
8.	August	7.45	52.30	27.90	31.10	40.00	0.12	65.00	18.00	0.40	21.00	3.75	2.15	70.00	13.00	3.15	0.20
9.	September	7.44	91.69	28.20	48.21	3.00	3.90	60.00	20.00	4.30	24.40	11.50	8.00	72.00	19.30	8.22	0.25
10.	October	7.45	90.50	27.50	45.30	7.20	4.00	37.20	21.00	4.50	24.50	12.00	8.20	42.00	18.50	8.25	0.24
11.	November	7.40	91.45	27.40	46.03	7.35	3.75	64.00	22.00	4.30	24.20	11.50	8.10	68.00	17.40	8.03	0.20
12.	December	6.95	90.40	26.90	44.00	7.20	4.00	21.30	20.00	4.20	24.10	12.00	8.40	25.00	18.02	8.10	0.22
	$\bar{x}$	7.21	68.99	27.29	36.48	5.54	2.20	45.02	18.83	2.64	22.63	8.57	5.75	52.42	14.82	6.13	0.22

Source: Fieldwork, 2021.

Table 2. Statistics of Physico-Chemical and Biological Parameters and Calculated WQ1 at Asaba-Ase

Parameters	Mean ± SD	CV (%)	WHO STD	Observed Value	Standard Value (sn)	Unit Weight (wn)	Quality Rating (qn)	Wnqn
pH	7.21 ± 0.17	2.4	6.5-8.5	7.21	8.5	0.118	16.28	1.92
EC	68.99 ± 22.46	32.55	100	68.99	100	0.01	68.99	0.69
Temperature	27.29 ± 0.16	0.61	29.8	27.29	29.8	0.034	91.58	3.11
TDS	36.48 ± 0.16	22.88	500	36.48	500	0.002	7.29	0.014
DO	5.54 ± 1.66	29.94	5	5.54	5	0.20	110.8	22.16
Nitrate	2.20 ± 1.81	82.40	10	2.20	10	0.10	22	2.20
COD	45.02 ± 5.18	11.51	100	45.02	100	0.01	45.02	0.45
Alkalinity	18.83 ± 1.56	8.41	100	18.43	50	0.02	37.66	0.75
Phosphate	2.64 ± 1.84	69.85	100	2.64	100	0.01	2.64	0.026
HCO_3	22.63 ± 2.74	12.12	50	22.63	50	0.02	45.26	0.90
Chloride	8.57 ± 3.44	40.90	250	8.57	250	0.04	3.42	0.13
Sulphate	5.75 ± 2.69	46.84	200	5.75	200	0.005	2.87	0.014
Coliform count	52.40 ± 19.85	37.88	5	52.40	5	0.01	10.48	10.48
Sodium	14.80 ± 2.76	18.63	200	14.80	200	0.005	7.40	0.037
Calcium	6.134 ± 2.24	36.64	75	6.13	75	0.013	8.17	0.106
Zinc	0.22 ± 0.04	20.16	3	0.22	3	0.33	7.33	2.42
						$\sum$Wn=1		$\sum$Wnqn = 45.43
WQ1=$\sum$qnwn/$\sum$Wn=45.43								

Source: Fieldwork, 2021.

Table 3. Water Quality Index Categories

Water Quality Index	Description
0-25	Very bad
25-50	Bad
50-70	Medium
70-90	Good
90-100	Excellent

Source: Ohwo (2009), after Brown et al (1972).

Table 4. Classification of water quality index (WQ1), Community by Community along the course of River Ase

S/N	Communities	0-25 Very Bad	25-50 Bad	50-70 Medium	70-90 Good	90-100 Excellent
1	Asaba-Ase	-	45.43	-	-	-
2	Ivorogbo	-	44.15	-	-	-
3	Kwale	-	42.80	-	-	-
4	Igbuku	-	46.30	-	-	-
5	Obikwele	-	-	58.05	-	-
6	Osemele	-	-	54.92	-	-

Source: Fieldwork, 2021.

At Ivorgbo, coliform count had the highest mean of 64.92±25.05 count/100; then followed by electrical conductivity at 64.65±0.44us/cm. However, zinc had the lowest mean of 0.85±0.024 ppm identified in the area (Table 5). However, all recorded values are within the WHO permissible water quality standard for drinking water except dissolved oxygen (DO) and coliform count. The computed water quality index (44.15), as given in Table 6, indicates that the water is unfit for drinking unless additives are added to purify it.

Table 5. Result of Physico-Chemical and Biological Analysis (Ivorogbo)

S/N	Field Code Ivorogbo	pH	Elec. Conduc. (us/cm)	Temp (^oC)	TDS (mg/l)	DO (mg/l)	$N0_3N$ (mg/l)	COD (mg/l)	Alkali (mg/l)	Total Phosp (mg/l)	HCOs (mg/l)	CL^{-1} (mg/l)	So_4 (mg/l)	Colifom (Count/100)	Na (PPM)	Ca (PPM)	Zn (PPM)
1.	January	7.30	85.00	26.90	41.20	6.70	3.40	17.15	14.00	4.50	18.20	10.30	8.10	35.00	15.20	7.10	0.21
2.	February	7.15	75.15	27.00	41.20	6.80	3.30	18.00	13.00	4.30	18.00	9.15	8.12	35.00	15.20	7.20	0.15
3.	March	7.12	70.10	28.15	40.15	6.90	3.20	19.75	14.00	4.45	16.10	10.00	8.10	32.00	14.20	7.10	0.20
4.	April	7.20	44.30	26.70	24.16	3.40	0.05	32.00	26.00	2.30	32.03	6.00	4.00	92.00	12.15	1.75	0.15
5.	May	7.25	37.20	26.80	24.15	3.45	0.10	35.00	25.00	2.15	35.04	5.00	3.45	91.00	12.00	1.95	0.16
6.	June	7.30	39.00	26.30	24.15	4.15	0.15	35.00	30.00	2.00	32.15	5.16	3.40	75.00	12.30	2.00	0.15
7.	July	7.25	38.00	27.10	25.15	4.05	0.20	31.00	29.00	2.15	31.02	5.12	3.45	70.00	11.45	2.15	0.20
8.	August	7.00	50.15	26.90	36.00	3.15	0.21	30.00	25.00	2.00	26.00	4.25	3.15	86.00	11.30	2.14	0.21
9.	September	6.91	81.96	26.80	45.74	1.60	3.40	30.00	15.00	3.70	18.30	10.00	8.00	90.00	15.32	6.90	0.18
10.	October	6.95	82.92	25.40	40.75	6.00	3.45	20.15	15.00	4.00	18.32	10.20	8.00	62.00	15.35	7.00	0.20
11.	November	7.00	85.00	26.00	42.30	6.30	3.30	32.00	16.00	4.25	17.30	9.50	8.15	85.00	16.04	7.15	0.21
12.	December	7.30	87.00	26.30	41.10	6.40	3.40	17.52	15.00	4.30	18.20	10.20	8.20	25.00	16.20	7.20	0.20
	$\bar{x}$	7.14	64.65	26.70	35.50	4.91	2.01	26.89	19.75	3.34	23.39	7.91	6.17	64.92	13.89	4.97	0.85

Source: Fieldwork, 2021.

Table 6. Statistics of Physico-Chemical and Biological parameters and Calculated WQ1 at Ivorogbo

Parameters	Mean ± SD	CV (%)	WHO Std	Observed Value	Standard Value (sn)	Unit Weight (wn)	Quality Rating (qn)	Wnqn
pH	7. 14 ±0.28	32.02	6.5-	7.14	8.5	0.118	10.29	1.21
EC	64.65 ± 20.09	31.08	100	64.65	100	0.01	64.65	0.647
Temperature	26.7 ± 0.44	1.60	29.8	26.7	29.8	0.034	89.60	3.046
TDS	35.5 ±8.13	22.90	500	35.50	500	0.002	7.10	0.0142
DO	4.91 ± 1.72	35.11	5	4.91	5	0.20	98.20	19.64
Nitrate	2.01 ± 1.59	79.1	10	2.01	10	0.10	20.10	2.01
COD	26.89 ± 7.28	27.06	100	26.89	100	0.01	26.89	0.269
Alkalinity	19.75 ±6.31	31.20	50	19.75	50	0.02	39.50	0.79
Phosphate	3.34 ±1.06	31.70	100	3.34	100	0.01	3.34	0.0334
$HC0_3$	23.39 ± 6.93	29.62	50	23.39	50	0.02	46.78	0.9356
Chloride	7.91 ± 2.40	30.34	250	7.91	250	0.04	3.164	0.127
Sulphate	6.71 ±2.30	37.22	200	6.71	200	0.005	3.355	0.0168
Coliform Count	64.92 ± 25.05	38.59	5	64.92	5	0.01	1298.40	12.98
Sodium	13.89 ±1.81	13.00	200	13.89	200	0.005	6.945	0.0347
Calcium	4.99 ±2.51	50.60	75	4.97	75	0.013	6.627	0.086
Zinc	0.185 ±0.024	13.15	3	0.186	3	0.33	6.167	2.035
						∑Wn= 1		∑Wnqn= 45.43
WQ1=∑qnwn/∑Wn=45.43								

Source: Fieldwork, 2021.

Kwale's average water quality in Tables 7 and 8 varies from 0.76 mg/L in terms of phosphate to 28.76°C of temperature. Given that all of the water parameters under investigation are heterogeneous, regular water monitoring is necessary, as evidenced by the overall trend of the coefficient of variation (C.V.%). Additionally, the quality of every surface water tested at Kwale is within the WHO's allowable level for the quality of drinking water.

Furthermore, Kwale's computed water quality index (42.80) is between 25 to 50, which Brown et al., (1972) classified as “bad” for drinking (Ohwo, 2009). The calculated water quality index further corroborates the analyzed physicochemical parameters of the river with respect to the WHO standard for drinking water quality. However, pH concentration in the area should be reduced with the addition of alkaline materials.

Table 7. Result of Physico-Chemical and Biological Analysis (Kwale)

S/N	Field Code Ivorogbo	pH	Elec. Conduc. (us/cm)	Temp (^oC)	TDS (mg/l)	DO (mg/l)	$N0_3N$ (mg/l)	COD (mg/l)	Alkali (mg/l)	Total Phosp (mg/l)	HCOs (mg/l)	CL^{-1} (mg/l)	So_4 (mg/l)	Colifom (Count/100)	Na (PPM)	Ca (PPM)	Zn (PPM)
1.	January	5.92	20.66	28.90	10.70	7.00	3.10	3.46	0.00	0.66	0.00	4.00	0.90	1.00	5.50	2.00	3.34
2.	February	6.00	20.61	28.60	9.76	6.90	3.20	13.40	0.00	0.52	0.10	3.46	0.86	1.00	6.00	2.50	3.42
3.	March	6.10	21.42	28.00	9.42	7.00	3.10	3.42	0.26	0.46	0.09	2.42	0.74	1.40	6.00	2.15	3.30
4.	April	6.90	39.20	28.20	21.01	4.80	0.80	10.20	18.00	0.90	21.96	7.00	4.00	2.20	2.50	2.80	1.12
5.	May	7.00	40.20	28.30	21.00	4.50	0.85	12.88	16.00	0.86	20.90	7.24	4.24	3.90	2.46	2.48	1.00
6.	June	6.69	42.43	28.20	20.00	4.40	0.81	12.40	15.00	0.75	20.96	7.30	5.00	3.00	2.31	2.30	1.00
7.	July	7.01	40.46	28.00	16.00	4.20	0.82	10.46	16.00	0.70	15.46	6.44	5.02	2.00	2.04	2.14	1.00
8.	August	6.56	18.00	29.00	11.00	3.20	0.42	10.20	15.00	0.86	16.00	5.24	4.24	3.00	2.04	1.46	1.05
9.	September	6.40	18.00	30.20	11.10	2.80	0.03	10.10	14.00	0.90	17.08	5.00	2.00	2.00	4.20	3.50	1.25
10.	October	6.45	18.20	29.68	9.20	6.90	0.03	7.05	15.00	0.96	18.00	6.00	2.20	1.00	4.00	3.40	1.20
11.	November	6.42	17.62	29.04	9.00	6.82	0.02	10.00	14.00	0.84	16.00	6.14	2.10	2.80	3.75	3.20	1.22
12.	December	5.90	20.22	29.00	8.10	6.85	0.01	3.50	7.00	0.76	8.00	5.20	2.00	1.60	4.01	3.40	1.20
$\bar{x}$		6.45	26.42	28.76	13.02	5.45	1.10	8.92	10.86	0.76	12.87	5.45	2.78	2.08	3.73	2.66	1.69

Source: Fieldwork, 2021.

Table 8. Statistics of Physico-Chemical and Biological Parameters and Calculated WQ1at Kwale

Parameters	Mean ± SD	CV (%)	WHO Std	Observed Value	Standard Value (sn)	Unit Weight (wn)	Quality Rating (qn)	Wnqn
pH	6.451± 0.310.61	4.8	6.5-8.5	6.45	8.5	0.118	126.83	4.166
EC	26.42 ± 10.0912.58	38.19	100	26.42	100	0.01	26.42	0.264
Temperature	28.76 ± 0.660.03	2.29	29.8	28.76	29.8	0.034	96.51	3.281
TDS	13.02 ±4.816.03	36.94	500	13.02	500	0.002	2.604	0.005
DO	5.45 ±1.53 1.86	28.07	5	5.45	5	0.20	109	21.80
Nitrate	1.10 ±1.221. 19	110.91	10	1.10	10	0.10	11.00	1.10
COD	9.92 ± 3.53	39.57	100	8.92	100	0.01	8.92	0.089
Alkalinity	10.86 ±6.69	61.60	50	10.86	50	0.02	21.72	0.434
Phosphate	0.76 ±0.17	22.37	100	0.76	100	0.01	0.76	0.0076
$HC0_3$	12.87 ± 5.49	42.66	50	12.87	50	0.02	25.74	0.515
Chloride	5.45 ±1.492.30	27.34	250	5.45	250	0.04	2.18	0.0872
Sulphate	2.78 ±1.55	55.76	200	2.78	200	0.005	1.39	0.00695
Coliform Count	2.08 ± 0.88	42.31	5	2.08	5	0.01	41.6	0.042
Sodium	3.73 ±1.440.89	38.61	200	3.73	200	0.005	1.865	0.0093
Calcium	2.66 ± 0.59	22.18	75	2.06	75	0.013	2.747	0.036
Zinc	1.68 ±0.96	57.14	3	1.68	3	0.33	54.33	17.93
						∑Wn= 1		∑Wnqn=42.80
WQ1=∑qnwn/∑Wn=42.80								

Source: Fieldwork, 2021.

The temperature at Igbuku had the highest mean of 27.96 ±1.01°C, then nitrate had the lowest mean of 0.98±1.09 mg/L recorded in Igbuku. Due to the heterogeneity of all the investigated values of the parameters, routine water monitoring is necessary. Additionally, as seen in Tables 9 and 10, every measure of water quality examined, with the exception of pH, falls within the WHO guidelines for drinking water quality. Furthermore, as Table 10 illustrates, the computed water quality index value of 46.30 is within the 25–50 range that is classified as "bad". This suggests that, other than water treatment done to raise the pH content of the water, the water is not fit for consumption.

Table 9. Result of Physico-Chemical and Biological Analysis (Igbuku)

S/N	Field Code Ivorogbo	pH	Elec. Conduc. (us/cm)	Temp (°C)	TDS (mg/l)	DO (mg/l)	$N0_3N$ (mg/l)	COD (mg/l)	Alkali (mg/l)	Total Phosp (mg/l)	HCOs (mg/l)	CL^{-1} (mg/l)	SO_4 (mg/l)	Colifom (Count/ 100)	Na (PPM)	Ca (PPM)	Zn (PPM)
1.	January	5.85	20.42	28.70	10.64	7.20	3.07	13.50	0.10	0.59	0.01	4.05	0.82	0.00	5.36	2.64	3.32
2.	February	5.90	19.46	28.54	10.04	7.02	2.60	3.26	0.10	0.56	0.01	5.06	0.96	0.40	5.34	3.20	3.26
3.	March	5.95	20.42	28.01	9.64	6.96	2.64	3.24	1.25	0.59	0.01	6.42	0.53	0.00	6.10	3.16	3.25
4.	April	7.36	34.60	28.00	20.30	5.00	0.80	10.20	26.00	0.69	30.10	6.12	4.00	1.00	2.40	2.76	0.66
5.	May	7.20	34.10	29.00	22.30	4.79	0.82	12.82	25.00	0.69	29.42	6.24	4.06	2.00	2.36	2.74	0.65
6.	June	7.10	25.26	28.60	21.04	4.76	0.83	11.46	24.00	0.94	30.21	6.15	4.04	1.00	2.40	2.52	0.58
7.	July	7.15	41.69	29.00	20.16	4.50	0.72	10.46	22.00	0.96	22.60	6.24	3.20	2.00	2.00	2.16	1.36
8.	August	6.40	19.00	27.00	11.10	4.20	0.21	5.21	20.00	0.46	15.00	6.00	5.04	2.00	3.00	3.20	0.76
9.	September	5.30	19.00	27.00	11.10	4.85	0.01	6.31	11.00	0.85	14.00	4.00	2.01	0.00	4.45	3.45	1.20
10.	October	5.35	20.00	27.00	9.05	8.40	0.02	6.42	11.02	0.86	13.00	4.00	6.01	2.40	4.45	3.46	1.24
11.	November	5.42	16.04	26.00	9.05	8.75	0.03	5.06	10.20	0.70	12.00	5.00	5.01	3.00	4.45	3.24	1.20
12.	December	5.45	17.42	28.70	7.10	8.30	0.04	3.45	5.00	0.54	6.02	4.25	3.20	1.00	5.25	3.24	1.20
	$\bar{x}$	6.20	24.78	27.96	13.46	6.23	0.98	7.62	12.97	0.67	14.37	5.29	3.24	1.23	3.96	2.98	1.56

Source: Fieldwork, 2021.

Table 10. Statistics of Physico-Chemical and Biological and Calculated WQ1 at Igbuku

Parameters	Mean ± SD	CV (%)	WHO Std	Observed Value	Standard Value (sn)	Unit Weight (wn)	Quality Rating (qn)	Wnqn
pH	6.20 ± 0.79	12.7	6.5-8.5	6.20	8.5	0.118	-34.78	-4.10
EC	24.78 ±7.34	29.60	100	24.47	100	0.01	24.78	0.25
Temperature	27.96 ±1.01	3.60	29.8	27.96	29.80	0.034	93.83	3.19
TDS	13.46 ±5.42	40.27	500	13.46	500	0.002	2.69	0.005
DO	6.23 ± 1.63	26.16	5	6.23	5	0.20	124.6	24.92
Nitrate	0.98 ±1.09	111.2	10	0.90	10	0.10	9	0.90
COD	7.63 ± 3.67	48.16	100	7.62	100	0.01	7.62	0.076
Alkalinity	12.97 ± 9.64	74.3	50	12.97	50	0.02	25.94	0.52
Phosphate	0.67 ±0.12	17.91	100	0.67	100	0.01	0.67	0.007
$HC0_3$	14.37 ±11. 13	77.43	50	14.37	50	0.02	28.74	0.50
Chloride	5.29 ± 0.98	18.53	250	5.29	250	0.004	2.116	0.008
Sulphate	3. 24 ±1.73	53.40	200	3.24	200	0.005	1.62	0.008
Coliform Count	1.23 ±0.99	80.49	5	1.23	5	0.01	24.6	0.25
Sodium	3.96 ±1.39	35.10	200	3.96	200	0.005	1.98	0.010
Calcium	32.98 ± 0.42	13.42	75	2.98	75	0.013	3.97	0.05
Zinc	1.56 ±1.02	65.38	3	1.56	3	0.38	52	19.76
						∑Wn= 1		∑Wnqn=46.3
WQ1=∑qnwn/∑Wn=46.30								

Source: Fieldwork, 2021.

Obikwele’s average water quality varies from 0.12±0.17 mg/L in terms of phosphate to 27.43±0.36°C of temperature as shown in Tables 11 & 12. Additionally, every parameter of water quality studied in Table 12 falls within the guideline limits of drinking water quality recommended by WHO. Also, table 12's computed water quality index result of 58.05 falls into the “medium” range of 50 to 70, indicating that the water is fairly safe for drinking.

Table 11. Result of Physic-Chemical and Biological Analysis (Obikwele)

S/N	Field Code Obikwele	pH	Elec. Conduc. (us/cm)	Temp (^oC)	TDS (mg/l)	DO (mg/l)	$N0_3N$ (mg/l)	COD (mg/l)	Alkali (mg/l)	Total Phosp (mg/l)	HCOs (mg/l)	CL^{-1} (mg/l)	SO4 (mg/l)	Colifom (Count/ 100)	Na (PPM)	Ca (PPM)	Zn (PPM)
1.	January	5.83	10.87	28.80	5.89	12.00	1.40	1.26	0.00	0.05	0.00	3.00	0.90	0.00	2.30	1.80	1.87
2.	February	5.70	10.90	28.70	5.70	12.30	1.45	1.35	0.05	0.03	0.00	2.75	0.92	0.00	2.20	1.82	1.85
3.	March	5.90	12.00	27.10	6.05	12.40	1.25	1.30	2.10	0.02	0.02	2.72	0.90	0.00	2.10	1.50	1.80
4.	April	7.10	14.50	26.70	9.10	6.80	0.02	6.12	25.00	0.02	30.50	2.00	1.00	3.00	1.04	1.40	1.12
5.	May	7.20	14.75	26.90	9.20	7.00	0.03	6.00	26.00	0.04	33.40	2.20	0.99	2.80	1.00	1.36	1.10
6.	June	7.25	14.90	27.00	9.30	7.15	0.02	6.00	27.24	0.04	32.40	2.21	1.00	0.00	1.02	1.46	1.10
7.	July	7.30	15.00	27.10	9.45	8.00	0.01	5.00	28.00	0.06	30.00	2.21	0.96	0.00	1.00	1.40	0.96
8.	August	7.42	15.22	27.25	9.55	9.00	0.02	5.81	27.00	0.04	29.00	2.20	0.86	1.00	0.96	1.20	0.94
9.	September	7.40	14.95	27.20	10.50	8.00	0.01	6.15	26.00	0.05	26.00	2.10	0.76	2.75	0.69	1.01	1.20
10.	October	5.95	11.07	27.25	6.00	11.45	1.06	1.20	1.75	0.47	0.01	3.25	1.00	0.00	2.15	1.07	1.84
11.	November	6.00	11.25	27.60	5.90	12.30	1.23	1.22	2.10	0.52	0.03	3.00	0.95	1.00	2.20	1.70	1.74
12.	December	5.82	10.86	27.50	5.00	12.00	1.20	1.20	0.00	0.06	0.01	3.04	0.92	0.00	2.25	1.72	1.80
	$\bar{x}$	6.57	20.17	27.43	7.64	9.87	0.64	3.55	13.77	0.12	15.11	2.56	0.93	0.88	1.58	1.45	1.44

Source: Fieldwork, 2021.

Table 12. Statistics of Physico-Chemical and Biological parameters and Calculated WQ1 at Obikwele

Parameters	Mean ± SD	CV (%)	WHO Std	Observed Value	Standard Value (sn)	Unit Weight (wn)	Quality Rating (qn)	Wnqn
pH	6.57 ± 0.74	11.26	6.5-8.5	6.57	8.5	0.118	-22.78	-2.63
EC	13.37 ±1.84	13.76	100	13.37	100	0.01	13.37	0.133
Temperature	28.03 ± 0.59	2.10	29.8	27.43	29.8	0.034	92.05	3.13
TDS	13.54 ±5.26	38.85	500	7.64	500	0.002	1.528	0.0031
DO	9.87 ±2.27	22.99	5	9.87	5	0.20	197.4	39.48
Nitrate	0.64 ± 0.63	98.44	10	0.64	10	0.10	6.4	0.64
COD	3.55 ±2.31	65.07	100	3.55	100	0.01	3.55	0.0355
Alkalinity	13.77 ±12.8	92.96	50	13.72	50	0.02	27.54	0.551
Phosphate	0.12 ±0.17	141.67	100	0.12	100	0.01	0.12	0.0012
$HC0_3$	15.11 ±15.20	100.60	50	15.11	50	0.02	30.22	0.604
Chloride	2.56 ± 0.41	16.02	250	2.56	250	0.004	1.024	0.041
Sulphate	0.93 ± 0.07	7.53	200	0.93	200	0.005	0.465	0.0023
Coliform Count	0.88 ±1.19	135.23	5	0.88	5	0.01	17.60	0.18
Sodium	1.58 ±0.62	39.24	200	1.58	200	0.005	0.79	0.004
Calcium	1.45 ±0.28	19.31	75	1.45	75	0.013	1.933	0.025
Zinc	1.44 ±0.39	27.08	3	1.44	3	0.33	48	15.84
						$\sum Wn = 1$		$\sum Wnqn=58.05$
$WQ1=\sum qnwn/\sum Wn=58.05$								

Source: Fieldwork, 2021.

Tables 13 and 14 revealed that the mean water quality in Osemele varies from 0.12±0.14 mg/L in terms of phosphate to 27.65±0.59 °C in temperature. Additionally, every water quality parameter that was looked at was found to be within the WHO's acceptable water quality limits. Also, the computed water quality index value of 54.92 is categorized as "medium" according to the water quality index categories, falling between 50 and 70. Since all of the physicochemical and bacteriological characteristics of the water samples tested in the area meet the WHO criteria for drinking water quality, the estimated WQI is supported by the fact that the water in the area is safe for drinking.

Table 13. Result of Physico-Chemical and Biological Analysis (Osemele)

S/N	Field Code Osemede	pH	Elec. Conduc. (us/cm)	Temp (°C)	TDS (mg/l)	DO (mg/l)	$N0_3N$ (mg/l)	COD (mg/l)	Alkali (mg/l)	Total Phosp (mg/l)	HCOs (mg/l)	CL^{-1} (mg/l)	SO_4 (mg/l)	Colifom (Count/100)	Na (PPM)	Ca (PPM)	Zn (PPM)
1.	January	5.80	10.80	28.75	5.80	11.15	1.35	1.20	0.00	0.06	0.00	2.80	0.72	15.00	1.95	1.82	0.92
2.	February	5.90	12.00	28.72	5.75	12.10	1.40	1.21	0.00	0.12	0.02	2.15	0.82	5.00	2.00	1.75	1.00
3.	March	6.25	12.75	28.00	5.95	13.00	0.82	1.32	6.50	0.05	0.20	2.20	0.85	5.00	1.75	1.70	1.00
4.	April	7.25	14.75	26.90	9.02	6.50	0.04	5.92	21.00	0.02	35.10	2.25	1.00	4.00	1.05	1.44	1.20
5.	May	7.24	14.90	27.00	9.05	6.75	0.03	6.20	24.00	0.12	34.14	2.24	1.21	2.00	1.04	1.33	1.22
6.	June	7.25	14.90	27.00	9.21	7.02	0.03	5.92	25.10	0.03	32.60	2.20	0.95	1.60	1.10	1.32	1.24
7.	July	7.10	14.78	26.90	10.00	8.15	0.01	6.00	27.80	0.05	31.40	2.15	0.72	1.20	1.06	1.14	1.01
8.	August	7.22	14.85	27.16	9.75	7.25	0.04	5.92	26.75	0.01	30.04	2.04	0.92	3.25	0.92	1.10	0.76
9.	September	7.20	14.70	27.40	10.76	7.20	0.03	5.75	23.00	0.02	22.00	2.32	0.84	3.77	0.98	1.20	1.46
10.	October	6.12	12.00	27.60	5.92	13.15	1.66	1.40	0.92	0.46	0.04	2.70	0.82	5.00	2.42	1.70	1.26
11.	November	5.85	10.90	27.62	5.82	13.15	1.05	1.30	0.75	0.35	0.04	2.00	0.85	0.00	2.15	1.77	1.25
12.	December	5.75	10.70	28.72	4.82	12.00	1.30	1.22	0.05	0.20	0.03	2.10	0.62	10.00	2.00	1.80	1.00
	$\bar{x}$	6.58	13.17	27.65	7.65	9.79	0.65	3.61	12.99	0.12	15.47	2.26	0.89	4.65	154	1.51	1.11

Source: Fieldwork, 2021.

Table 14. Statistics of Physico-Chemical and Biological parameters and Calculated WQ1 at Osemele

Parameters	Mean ± SD	CV (%)	WHO Std	Observed Value	Standard Value (sn)	Unit Weight (wn)	Quality Rating (qn)	Wnqn
pH	6.58 ± 0.62	9.42	6.5 - 8.5	6.58	8.5	0.118	-21.88	2.58
EC	13.17 ±1.77	13.44	100	13.17	100	0.01	13.17	0.13
Temperature	27.65 ± 0.59	2.13	29.8	27.65	29.8	0.034	92.79	3.15
TDS	7.65 ± 2.06	26.93	500	7.65	500	0.002	1.53	0.0031
DO	9.79 ± 2.70	27.58	5	9.79	5	0.20	195.8	39.16
Nitrate	0.65 ± 0.64	98.46	10	0.65	10	0.10	6.5	0.65
COD	3.61 ±2.35	65.10	100	3.61	100	0.01	3.61	0.036
Alkalinity	12.99 ±11. 84	91.15	50	12.99	50	0.02	25.98	0.52
Phosphate	0.12 ±0.14	116.67	100	0.12	100	0.01	0.12	0.0052
$HC0_3$	15.47 ±15.71	101.55	50	15.47	50	0.02	30.94	0.62
Chloride	2.26 ±0.26	11.50	250	2.26	250	0.04	0.904	0.036
Sulphate	0.89 ± 0.085	9.55	200	0.89	200	0.005	0.445	0.0022
Coliform Count	4.65 ± 3.97	85.38	5	4.65	5	0.01	93	0.93
Sodium	1.54 ±0.52	33.77	200	1.54	200	0.005	0.77	0.0039
Calcium	1.51 ±0.24	15.89	75	1.51	75	0.013	2.01	0.026
Zinc	1.11 ±0.15	13.50	3	1.11	3	0.33	37	12.21
						$\sum Wn = 1$		$\sum Wnqn = 54.92$
$WQ1 = \sum qnwn / \sum Wn = 54.92$								

Source: Fieldwork, 2021.

From January to December 2021, treated instances of water-borne illnesses such as diarrhea, typhoid, cholera, and dysentery were acquired from the local government headquarters in Kwale as well as the health facilities at Ivorogbo, Iselegu, Uzere, Kwale, and Obetim-uno. Some of the communities studied such as Asaba-Ase, Obikwele, and Osemele have no health centers; while the health center at Igbuku is not functioning. However, cases of water-borne illnesses in these areas were culled from case files of residents who sought care at the closest health facility. In such vein, case files of persons from Asaba-Ase who visited Uzere for treatment were analyzed. In the same way, case files of persons from Obikwele and Osemele who visited Iselegu and Obetim-uno health centers for treatment were analyzed. At Ibrede, which is the nearest health center to Igbuku, case files of persons from Igbuku were separated and analyzed for water-borne illnesses.

A total of 252 patients out of 1,267 registered patients received treatment for water-borne illnesses (cholera, typhoid, dysentery, and diarrhea) at the health facilities from January 2021 to December 2021. In the case of cholera, no one received treatment, however, twenty-five people—ten from Asaba-Ase, three from Ivorogbo, and twelve from Kwale—were treated for typhoid. A total of 36 patients were treated for dysentery, out of which Asaba-Ase had 24 patients, Kwale (9), and Igbuku had 3 patients. In the case of diarrhea, a total of 191 patients were recorded. Out of these numbers, 23 patients were from Asaba-Ase and 15 patients were from Ivorogbo. Others include 49 cases from Kwale, 83 cases from Igbuku, 12 cases from Obikwele, and 9 cases from Osemele as shown in Table 15.

Table 15. Total Number of Patients treated for water-borne diseases (cholera, typhoid, dysentery, and diarrhea) in the area

Communities	Total Number of Patients who visited the Centre	Cholera	Typhoid	Dysentery	Diarrhea
Asaba-Ase	181	-	10	24	23
Ivorogbo	367	-	3	-	15
Kwale	361	-	12	9	49
Igbuku	268	-	-	3	83
Obikwele	61	-	-	-	12
Osemele	29	-	-	-	9
Total	1,267	-	25	36	191

Source: Health centers at Uzere, Ivorogbo, Kwale, Ibrede, Iselegu, and Local Government headquarters (Office of the National Programme on Immunization, 2021).

Among all recorded cases of water-borne illnesses, Asaba-Ase accounted for 57 cases (2.18%), Ivorogbo for 18 cases, (0.69%), Kwale for 70 cases (2.72%), Igbuku, for 86 cases (3.30%), Obikwele for 12 cases (0.46%) and Osemele for 9 cases (0.34%), as shown in Table 16.

Table 16. Treated cases of water-borne diseases in the area

Communities	Cholera	Typhoid	Dysentery	Diarrhea	Total	Percentage	WQ1 of sampled communities
Asaba-Ase	-	10	24	23	57	2.18	45.43
Ivorogbo	-	3	-	15	18	0.69	44.15
Kwale	-	12	9	49	70	2.72	42.80
Igbuku	-	-	3	83	86	3.30	46.30
Obikwele	-	-	-	12	12	0.46	58.05
Osemele	-	-	-	9	9	0.34	54.92

Source: Fieldwork, 2021.

However, there are disparities in recorded incidence of water-borne illnesses between places with high levels of water quality parameters and those with low levels of water quality parameters. Put differently, locations exhibiting elevated levels of water quality parameters over the acceptable threshold typically have a higher incidence of water-borne illnesses (relative to the total number of patients who sought for care in the health facility). This matches the estimated water quality index (WQ1) of the local sampling communities that were observed. Thus, there are fewer incidences of water-borne illnesses at Osemele and Obikwele, with WQ1 values of 54.92 and 58.05, respectively, with 9 and 12 patients, respectively. Whereas WQ1 values of 46.30 and 42.80 were recorded for 86 patients and 70 patients, respectively, in localities like Igbuku and Kwale, 18 and 57 patients, respectively, at Ivorogbo and Asaba-Ase, had WQ1 values of 44.15 and 45.83.

This implies that, communities located upstream of the river, like Obikwele and Osemele, tend to record fewer cases of water-borne diseases as a result of lesser pollutants in their water samples than communities located downstream, like Asaba-Ase and Ivorogbo, and in the middle of the river, like Kwale and Igbuku. Nonetheless, the WQ1 value of Kwale in the middle portions of the river is less than the WQ1 values found in the upstream portion. This is most likely the effect of industrial activity brought on by nearby businesses and the oil prospecting industry. Thus, it suggests that the water contains higher concentrations of pollutants, which is why there have been more occurrences of water-borne illnesses reported at Kwale and Igbuku. Additionally, in Asaba-Ase and Ivorogbo, lower WQ1 values found in the river's lower course corresponded to increased incidence of water-borne illnesses.

Test of Hypothesis

The hypothesis that the variety of water-borne illnesses (cholera, typhoid, dysentery, and diarrhea) in the region is not substantially influenced by the river's water quality was tested using multiple regression. The four water-borne illnesses (diarrhea, typhoid, cholera, and dysentery) that have been linked to the study area were investigated. The water-borne illnesses were the independent variables (X1..........X4), and the various communities' computed water quality indexes (WQI) were the dependent variables (Y).

HO: The diversity of water-borne illnesses (diarrhea, typhoid, cholera, and dysentery) that have been linked to the study area is not significantly dependent on the river’s water quality.

Table 17. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.714[a]	.510	.359	5.44913	1.181

a. Predictors: (Constant), diarrhea, cholera, dysentery, typhoid

b. Dependent Variable: WQI

The association between water quality and water-borne illnesses is demonstrated by Table 17's model summary, which explains that 51% of the water-borne illnesses (cholera, typhoid, dysentery, and diarrhea) that are common in the region are caused by the river's water quality.

Thus, the coefficient of determination

R = (0.714)2 x 100

R = 0.510xl00

R = 51%

The results of a comparable study conducted along the Amassoma River in Southern Nigeria by Nwidu et al., (2008) are supported by this discovery. Also, this finding backs up previous studies by Ferreccio et al., 2000; Vladeva et al., 2000; Bartlett, 2003; Zhang et al., 2003; Fong and Lipp, 2005; Jorgenson, 2009; Kazi et al., 2009; Yau et al., 2009; Zhitkovich, 2011; Ebenstein, 2012; Khan et al., 2013; Lin et al., 2013; Ahmed and Ismail, 2018; Schullehner et al., 2018; Tseng et al., 2018; Kaur et al., 2019; Landrigan et al., 2019; Xu et al., 2019; Arif et al., 2020; and Hanif et al., 2020 that have stated that unsafe water poses negative health effects to humans, among others things. In contrast, 49% of the cases may be related to drinking contaminated water from shallow wells (Ushurhe and Origho, 2009; Oloruntoba and Olannye, 2019); boreholes (Ohwo, 2009; Olannye et al., 2017; Oloruntoba and Olannye, 2019); eating contaminated food and improper sewage disposal (Udoh et al, 1987).

CONCLUSION

The study showed variation in all the parameters of the water samples collected and analyzed in line with WHO standards for drinking water quality along the course of the river. The study identified the factors responsible for the variation in water quality in the parameters examined as the variation in the concentration of pH along the course of the river is attributable to the effects of decayed vegetal matter and industrial activities. Also, variation in temperature of between 27.24oC and 28.18oC recorded in the area is a result of the forested and industrial nature of the catchment area. Thus, the variation in TSS from 4.5mg/l to 13.62mg/l is a result of the effect of erosion, stormwater run-off, and industrial discharges caused by heavy rainfall in the area. The study also identified the contamination of the river by human and animal matter as factors responsible for variation in fecal coliform in the area. Also, industrial wastewater generation and the use of detergents for laundry activities were identified in the study as factors responsible in the amount of zinc in the water samples analyzed. The investigation in the area also showed that there was a wide range of water-borne disease cases; as diarrhea recorded the highest number of cases, followed by typhoid and dysentery.

The study revealed that areas of high levels of water quality parameters above the acceptable threshold for drinking water quality recorded more cases of water-borne diseases than areas of low levels of water quality parameters. The implication of this is that the quality of water is a determinant of waterborne diseases and hence being responsible for waterborne diseases in the area. The calculated results of the WQ1 varies between 42.80 to 58.05. that is from bad to medium. Thus, areas that have low WQI recorded high incidences of waterborne diseases, while areas that recorded high WQ1 recorded low cases of waterborne diseases. The study also showed that the results of the posited hypothesis indicated a significant relationship between the river's water quality and the incidence of typhoid, dysentery, and diarrhea in the area. However, with improved planning, monitoring, and education, we can rise up to the challenge of water pollution and waterborne diseases for healthy living and sustainable development in Nigeria and the world in general.

In light of the study's findings, a number of recommendations were made: (1) The adoption of corresponding water management policies such as the monitoring of all human activities, and risk assessment of watercourses and catchment areas, so as to lessen the negative effects of water pollution on public health; (2) Periodically, epidemiological studies should be conducted to develop guidelines for household water quality that are both health-friendly and appropriate for the general public; (3) Domestic water especially surface water should be treated before use; (4) Health education be carried out, especially environmental education to educate residents on how to protect the water and the water courses. This will go a long way in enhancing public health awareness among the people and users of surface water.

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