Assessment of Water Quality of Aba River in Aba Area, Southeastern Nigeria, Using Water Quality Index Technique

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Abstract

Water is one of the 'essentials' for the sustenance of life on earth. Its availably and potability is of uttermost importance to human and environmental health as well as resource and environmental management. Water quality assessment is the evaluation of the physical, chemical and biological state of the water using result from measured Physico-Chemical and biological water quality parameters to ascertain the natural state of the water, effect of anthropogenic activities in the water, and its potability for various usage. Water Quality Index (WQI) is a mathematical approach of calculating a single value from multiple test results (Olubukola et al., 2021); it is a single value that classifies an assessed water as either, excellent, good, poor, very poor or unfit for certain purposes. In this study, the assessment of water quality of Aba River in Aba area, South-eastern Nigeria, was done using Water Quality Index (WQI) technique. Water samples were collected for analysis from seven sampling points along Aba River where major anthropogenic activities of concern happen on a regular basis starting from the headwater of the Aba River which was located during reconnaissance field survey. Fifteen (15) water quality parameters were analyzed including the following: pH, Temperature (T), Electrical Conductivity (EC), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD5), Total Dissolved Solid (TDS), Nitrate (NO3-), Potassium (K), Phosphate (PO4-^{3}), Total Hardness (TH), Calcium (Ca), Magnesium (Mg), Sodium (Na), Copper (Cu) and Total fecal Coliform, (TFC). Using Weighted Arithmetic Water Quality Index (WA-WQI), water quality index was calculated for the 7 sampling points based on insitu and laboratory measured concentrations of the above-mentioned water quality parameters. WQI of Aba River ranges from 76– 126 with an overall WQI of 87 and thus classified as very poor water quality. Following Federal Ministry of Environment (FMnEnv) and World Health Organization (WHO) standards and unsuitable for drinking. Evaluation for irrigation suitability shows the following irrigation indices: SAR = 0.11, MH = 49, KH = 0.1, SSP = 54. These values indicate that the water could be used for irrigation purposes.

Key Words: *Surface Water, anthropogenic, pollution, Physico-Chemical, parameters, water quality.*

1.0. INTRODUCTION

Of all the natural resources at man's disposal, water is the most abundant (Smith et al 2006). Interestingly also, 70 percent of the human body and 60 to 70 percent of plant cells comprise of water (Smith et al.; 2006). Thus, water is indispensably essential for human living and wellbeing, as well as sustenance of animals and plants, and ensuring a balanced and functional ecosystem. Water is one of the essential natural resources that have unprecedented socio-economic value and health implications. Without water, existence of man would be threatened (Zhang 2017). Water is very vital for the survival of any form of life (Ibiam et al, 2024). World Health Organization, WHO (2018) reports that close to 2 billion of the world's population drink water with fecal contamination and suffer consequent health complications, most of which are fatal. Sustainable Development Goal number six (SDG6) puts premium on the need for accessibility of potable water for all, globally (United Nations, UN, 2018; Suneela et al. 2020).

Availability and accessibility of water mostly determine human settlement and siting of commercial and industrial establishments in a region (Ibiam et al.; 2024). Most industrial and commercial activities require heavy volume of water as well as generate incredible tons of wastewater and effluent. And for the most part, surface water (Rivers, streams, and lakes) serves both as source of water supply and point of discharge and disposal of industrial effluents, wastewater, sludge and semisolid-wastes from industrial processes and operations. The thick concentration of industries and commercial establishments along River banks, rising growth in human population, urbanization and corresponding anthropogenic activities have become alarming and issue of grave concern. Consequently, most Rivers of the world, especially those that transverse commercial cities and highly industrialized regions have become heavily polluted and/or contaminated, mostly by wastewater from such industries. This situation is worsened by the fact that these industrial and domestic wastewaters are discharged into the surface water without any form of wastewater treatment as most cities and industries do not have standard sewerage system, sewage regulations, and/or wastewater treatment plants.

Aba River, Southeastern Nigeria is the only River in the commercial City of Aba, Abia State, Nigeria. Aba River is typical of a River that runs through thickly populated, commercial and industrial city; over laden with the impact of multiple degrading anthropogenic activities in and around it. Aba River used to be the surest source of potable water for those living around it in the 1970s. It even blossomed with aquatic lives before the wake of industrialization in the city of Aba (Nwazue 2021). Regrettably, no one currently drinks from Aba River, even the poorest of Aba inhabitants. The most use that the Aba River water serves dwellers of communities in Aba region are commercial operations such as 'car-wash', laundry, washing of rugs, farmhouses (pig farm, goat farm), slaughterhouses (abattoirs), slaughtered meats, swimming, transportation across banks, and discharge point for industrial effluents, commercial and domestic/sanitary wastewater; these degrading river water use pose major environmental, ecological, and health risk with detrimental impact. Figure 1(a,b and c) show a bit of the numerous polluting anthropogenic activities in and around the Aba River which have heavily impacted adversely on its water quality and potability for drinking and other domestic usage.

2.0. STUDY AREA DESCRIPTION

2.1. Location And Climate

Aba River is located in the popular, populous commercial city of Aba, Abia State, Southeastern Nigeria. Aba City lies along the west bank of the Aba River at the intersection of roads leading to Port Harcourt, Owerri, Umuahia, Ikot Ekpene, and Ikot-Abasi (Hoiberg, Dale, 2010). Aba City of Abia State Nigeria is located in the Southeastern region of Nigeria. Southeastern Nigeria covers an area of 76,358km² east of the lower Niger and south of the Benue valley.

Aba City became a collection point for agricultural products following construction of a British-made railway running through it to Port Harcourt. Aba is a major urban settlement and commercial center in its region, which is surrounded by small villages and towns. The indigenous people of Aba are the Ngwa. Aba is well known for its craftsmen and is the most populous city in Southeastern Nigeria. As of 2016, Aba had an estimated population of 2,534,265, making it the biggest city in South Eastern Nigeria (Abia, state, Nigeria - Populations; 2016).

Aba river is the major drainage system in Aba and environs. Most of the industries in Aba Town are located within the watershed of Aba river. Aba river has an average discharge of 5.20m^3/s and depth that varies between 0.5m and 8m (Okeke et al., 2005).

Peaks of rainfall occur in the months of July and September (312mm and 399mm, respectively), with a little dry spell in August generally known as "August Break" (Nigerian Meteorological Agency, 2007; Okeke et al., 2016).

The Aba River is the only surface water in Aba City of Abia State, Southeastern Nigeria. Aba River is a tributary of Imo River that runs through the city of Aba, Nigeria. Its headwater is within Isiala-Okpu and Mgboko-Umuette autonomous communities Osisioma Ngwa LGA in the Ngwa heartland (Ezeigbo, 1989) and during my reconnaissance survey, I was able to locate the source of the River which also serves as my Control, SW0. The River is a spring that comes from under the ground, however the exact spot of the spring cannot be access due to the presence of pythons that habit the riparian zone of the Headwater.

Aba River is popularly known as "Waterside" (Nwazue; 2021). The whole stretch of Aba River extends from its headwater through to where it joins the Imo River, a total distance of 50,845 meters. The whole stretch of Aba River lies within Latitude 5°10'30''N to 4°51'0'' of the

Figure 1(a,b and c)

equator and longitude 7°19’30’’E to 7°30’0’’E of the Greenwich Meridian, a distance that extends across Aba area to some parts of Ukwa East, and Port Harcourt in Rivers State, Nigeria. However, water samples for this study was collected from 7 sampling points within latitudes 5°4’30’’N to 5°10’30”N of the equator and Longitude 7°21’0”E to 7°24’0’E of the Greenwich Meridian as shown in figure 2, the location map of the study area. Aba has a relatively flat coastal terrain, with the average relief of about 54m above sea level (Njoku et al. 2013). The low-lying plain is the inland extension of the Coastal Plain from the Bight of Benin (Amadi et al., 2013). Due to the topography of the study area, the Aba River flows in the North-South direction where it joins the Imo River and then the Atlantic Ocean (Nwankwoala et al., 2017; Ezeigbo 1989; Uma, 1989; Amadi et al,, 2010). The study area is within the humid tropical rainforest climate zone of south-eastern Nigeria. The rainfall regime is bimodal. Rainfall usually peaks in July and September with scanty days of no rain and a usual rainfall ‘break’ popularly referred to as ‘August Break’ (Ogbonna et al., 2016).

This ‘break’ in rainfall normally lasts for two weeks. However, in recent times, it tends to extend more than the traditional two weeks with a mix of sun and ‘harmattan wind’. The rainy or wet season begins by late February and lasts till October or early November (Ogbonna et al; 2016). Mean annual rainfall of Abia State is between 2550mm and 2890 mm (Uma, 1989; FGN, 2003). Most parts of the area are flooded during the rainy season due to poor drainage system and construction. The dry season in the area is from November to March and is characterized by dry, cold and windy weather, with little or no rainfall (Onyeagocha, 1980).

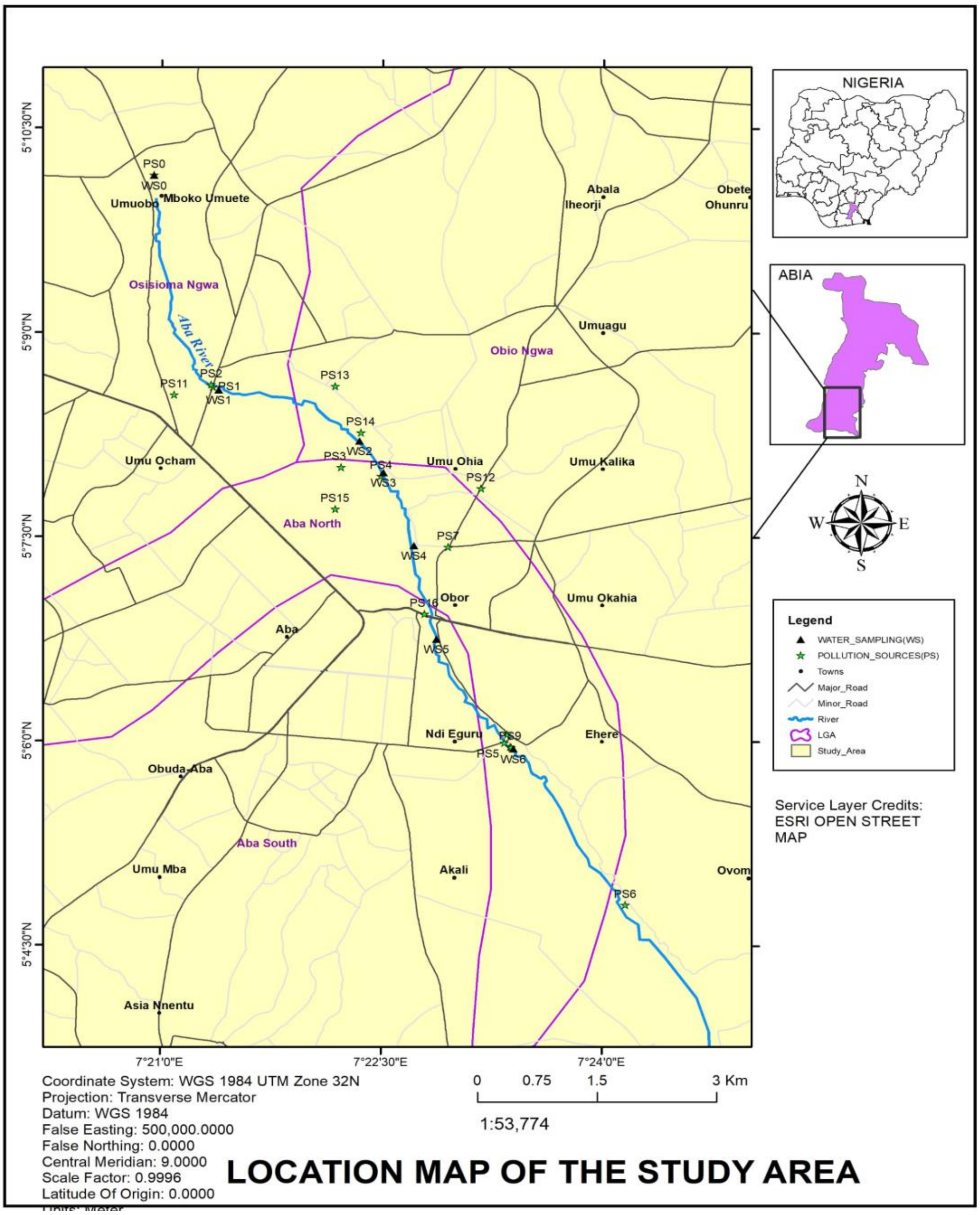


Figure 2: Location map of Study Area showing ABA RIVER, sampling points, and major sources of pollution of the Aba River; World Geodetic System (WGS) 1984; Environmental System Research Institute (ESRI) 2024.

Due to climate change, there has been changed in seasons of highest and lowest temperature. In recent times, the temperature is highest between November and February (though with a few very cold days of harmattan in between and lowest between April and June due to the rainy season. Palm trees, Raffia palms, bananas, plantain, cassava, yam, cocoyam and maize are grown abundantly in the area. The abundant rainfall and high temperature in the area favor their growth. The vegetation appears more forest-like along River channels and due to intense farming in the area, grasses are taking over the original tropical forest characteristic of the area (Amadi et al., 2013).

2.2. Geology of The Study Area

The geology of Nigeria shows that the study area is within the Niger Delta basin as seen in figure 3.

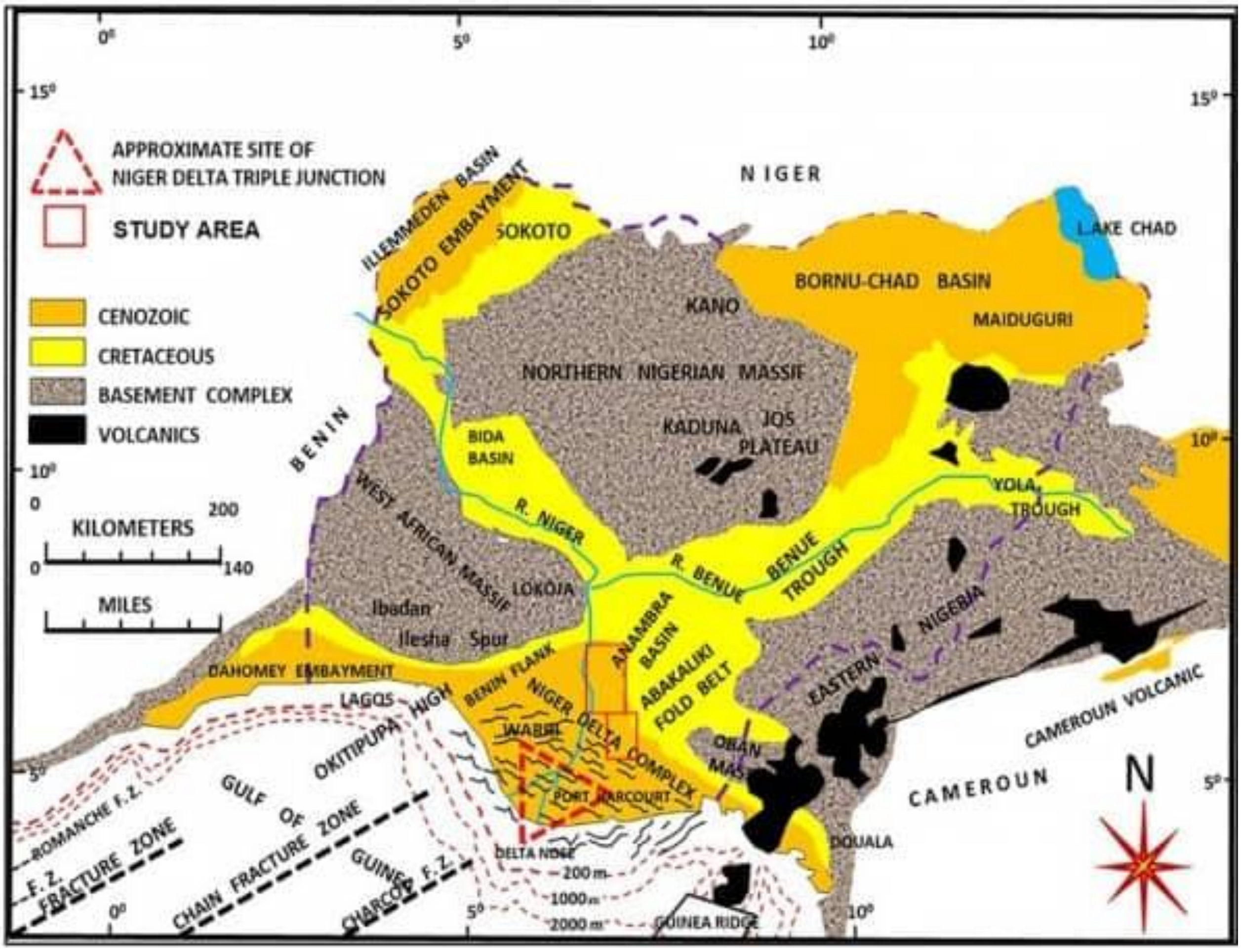


Figure 3: Geologic Map of Nigeria showing its Sedimentary Basins (modified after Murat, 1972). Source: Ekwenye et al. (2020)

Geographically, the Niger Delta Basin/Complex is found in the Gulf of Guinea between latitudes 3º and 6°N and longitudes 5º and 8°E as shown in figure 3 (Nwajide, 2013). The Niger Delta Basin, a Cenozoic clastic build-out overlays older transgressive Paleocene prodelta sedimentary Benue Trough and Anambra Basin, covering a total area of over 256,000 km² (Adegoke et al., 2017; Izah et al., 2022). Niger Delta Basin comprise of the following geologic formations: Akata, Agbada, and Benin Formations, all of which were deposited in sequence at various ages; the Akata Formation is Paleocene, the Agbada Formation Eocene and then the Benin Formation Miocene to recent (Izah et al., 2022). Table 1 shows the stratigraphy of the Niger Delta Basin and Southeastern Nigeria.

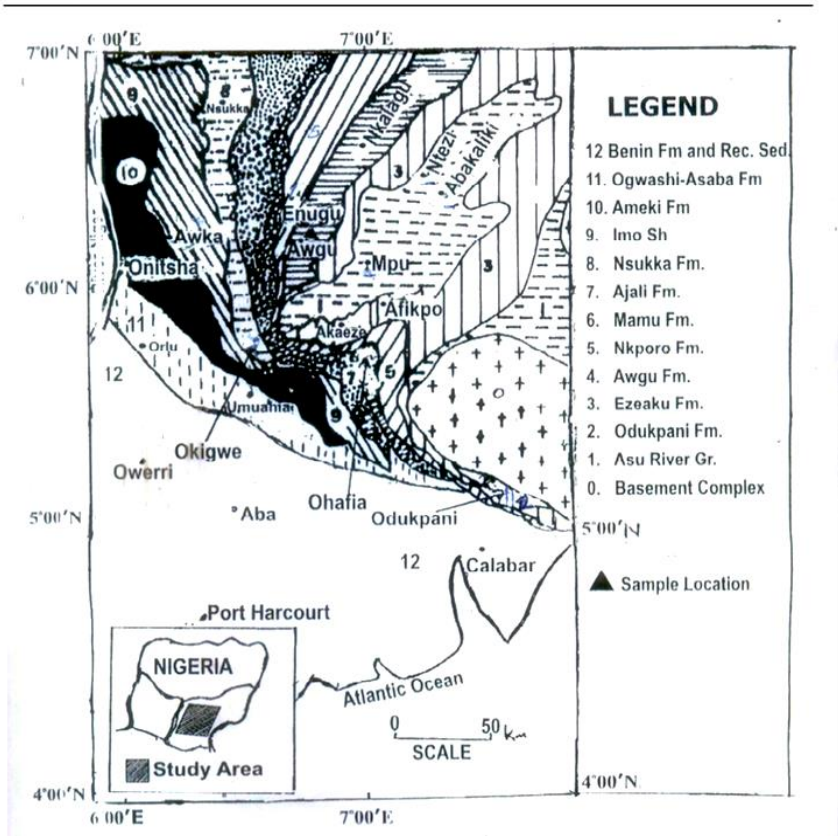


Figure 4: Regional Geologic map of Southeastern Nigeria; Source: Eldosouky et al., 2022

Figure 4 is the geologic map of the study area that captures the Niger Delta Sediment. The Benin Formation is composed mostly of high resistant fresh water bearing continental sand and gravel with clay and shale intercalations (Onyeagocha, 1980; Agharanya, DIM; 2018). The general thickness of the Benin Formation is variable and ranges from 200 m at the North-East end to about 2000 m at the South-west (Avbovbo, 1978). Figure 5 is the geologic map of Study Area showing the Aba River.

Due to the Formation (Benin Formation) of the Aba River, the River remains a constant source of 'sharp sand' for various building and civil engineering operations in Aba region and beyond which is one of the anthropogenic activities that has badly defaced and polluted Aba River. The River is basically recharged by precipitation and groundwater (Uma, 1989) such as the groundwater spring from where the River originates.

Table 1: Summary of the Stratigraphic Sequence of Southeasthern Nigeria (Okeke and Okogbue, 2010; Ken-Onukuba, et al, 2021)

AGE	FORMATION	LITHOLOGICAL CHARACTERISTICS
Recent	Recent Sediments	Alluvium/Deltaic Plains
Miocene – Recent	Benin Formation	Unconsolidated sandstone with lenses of clay
Oligocene - Miocene	Ogwashi-Asaba Formation	Unconsolidated sandstone, Mudstone, Clay and Lignite Seams
Eocene	Ameki Formation	Grey to green argillaceous sandstone, shale and limestone units
Paleocene	Imo Formation	Fine textured dark-grey shale with arenaceous sandstone member
Maastrichtian	Nsukka Formation Ajali Formation Mamu Formation	Alternating sequence shale, sandstone and coal seams. Friable sandstone with Iron stains Alternating sequence of sandstone, claystone and shale with coal seams
Campanian	Nkporo Formation/Enugu Shale	Dark grey shale with clayey Mudstone and Shale with thin beds of Sandstone
Santonian	Awgu Formation	Bluish grey Shale with intercalations Sandstone and shaly limestone
Turonian	Ezeaku Formation (Ezeaku Shale)	Black shale with clay and sandtone lenses
Albian	Asu River Group	Black shale and sandstone
Precambrian	Basement Complex	Older Granite and Gneiss

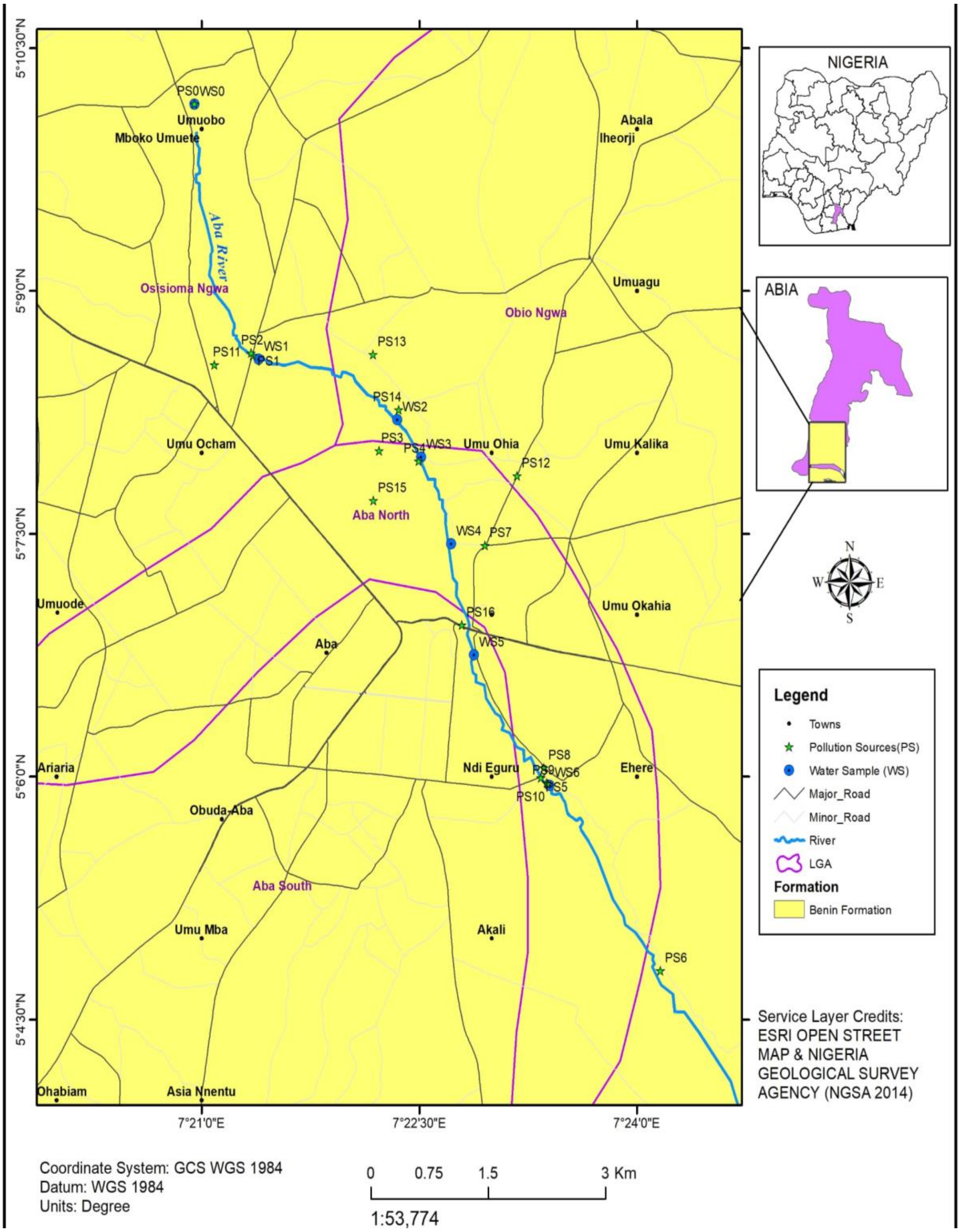


Figure 5: Geologic Map Of The Study Area showing Aba River; Geographic Coordinate System (GCS) 1984, World Geodetic System (WGS) 1984, Environmental System Research Institute (ESRI) 2024, & Nigeria Geologic Survey Agency (NGSA) 2014

3.0. MATERIALS AND METHODS

3.1. Field Study/Sample Collection

Reconnaissance survey of the study area in this research was first done, a procedure that revealed a lot of details of Aba River such as the rate and degree of the anthropogenic activities that go on in and

Around the River. This field study also enabled the identification of important pollution spots along the River where samples for water quality parameter analysis were collected. The location map and topographic map of the study area were both prepared for the coordinate data collected via GPS Map camera during the field survey. Figure 5(a,b) below show the headwater of Aba River as discovery during reconnaissance survey.

Figure 6 (a and b): Photos showing the Headwater of Aba River with its location coordinates.

Water samples were collected from the seven sampling points already indicated on the location map of Aba River under standard practice and regulation. Water samples were collected by the River bank of each sampling point. Sampling bottles and containers were dipped in water and samples collected in a way that didn't allow bubbles of atmospheric oxygen to enter the container, especially the samples for BOD and COD analyses. Containers and bottles of collected water samples were stored temporarily in an ice cooler while in the field and quickly moved to the fridge in the laboratory for analyses. This procedure is important to ensure that the water is in its original state at the time of laboratory analyses. Some parameters were also measured insitu while water samples were being collected; water parameters such as temperature, pH, and DO and the rest were analyzed in standard laboratory under standard conditions. All physicochemical parameters were analyzed using APHA (2005) standard analytical method.

3.2. Laboratory Test On Water Sample

Materials include water containers of water sample collection (a set of 7 containers (1litter each), another set of 7 water containers (2litter each), a set of 7 dark bottles (500m/l each) for BOD analysis), big-sized cooler with ice blocks to keep the collected samples at 2-5°C as part of the preservation technique before moving them to the laboratory, pen, exercise book, GPS map camera to get photos, longitude, latitude and elevation of each sampled point. Other materials include Dissolved Oxygen Analyzer/Meter for dissolved oxygen measurement, Turbidity Meter, thermometer for temperature, pH Meter for pH measurement, thermometer for temperature measurement, Conductivity Meter for electrical conductivity measurement, and N4s UV- Visible Spectrophotometer for Sodium analysis. The rest of the materials and methods used for the analyses of the 32 water quality parameters in the quality assessment of Aba River is summarized in the table 2 below. Excel 2007 was used for all mathematical and statistical computations.

Table 2: Summary of Materials and Methods used for laboratory analysis in this study

PARAMETERS	UNIT	METHOD
PH		Potentiometric
Temperature, (T)	°C	Electrode thermometer
Electrical Conductivity, (EC)	µS/cm	Potentiometric
Dissolved Oxygen, (DO)	mg/l	Electro-membrane
Biochemical Oxygen Demand, (BOD_5)	mg/l	Incubation & Electro-membrane
Chemical Oxygen Demand, (COD)	mg/l	Titrimetric
Total Dissolved Solid, (TDS)	mg/l	Gravimetric
Nitrate, (NO_2-)	mg/l	UV Spectrometric
Nitrite, (NO_3-)	mg/l	Diazotization
Potassium, (K)	mg/l	Tetraphenylborate
Phosphate, (PO_4^{-3})	mg/l	Ascorbic acid
Total feacal Coliform, (TFC)	cfu/ml	Spread Plate
Calcium Hardness, (CH)	mg/l	EDTA Titrimetric
Total Hardness, (TH)	mg/l	EDTA Titrimetric
Magnesium Hardness (MH)	mg/l	EDTA Titrimetric
Calcium, (Ca)	mg/l	EDTA Titrimetric

Table 3: Names of Water Sampling (WS) Points and Coordinates of Aba River as shown on the map in figure 2

Names of points	Point No.	Location ID	Latitude (°) N	Longitude (°) E	Elevation (m)
Headwaters/Control	1	WS0	5.16918	7.34919	43
Okpu Umuobo Bridge	2	WS1	5.14296	7.35655	36
Glass Industry area	4	WS2	5.13674	7.37249	34
Ohuru Isimiri UmuOhia	4	WS3	5.13287	7.37522	31
Hill Top by PZ	5	WS4	5.12396	7.37867	29
Aba River Layout	6	WS5	5.11251	7.38128	28

Emelogu/Slaughter	7	WS6	5.09909	7.38999	22

3.3. Calculation of Water Quality Index (WQI) For Surface Water Quality Assessment

Water quality issues are complex and diverse, and deserve urgent global attention and action (Breabăn et al, 2012). The characteristics of water are defined by its composition and are commonly referred to as water quality (Olubukola et al, 2021). Water quality is generally defined as "the chemical, physical and biological characteristic of water usually in respect to its suitability for a designated use" (John, et al. 1997). Water quality assessment can be defined "as the evaluation of physical, chemical and biological state of the water in relation with the natural state, anthropogenic effects and future uses" (Chapman, 1996). The assessment of water quality, usually carried out by determining its physico-chemical and biological properties or parameters against a set of standards, is used to determine whether the water is suitable for consumption or safe for the environment. Data obtained from water quality assessment and monitoring supplies empirical evidence needed for health and environmental decision making (Olubukola et al. 2021)). Water quality values also serve as significant and sensitive indicators of changes in the physical, chemical or biological composition of the overall water status, a knowledge useful in water management (Cambers et al, 2005).

Basically, WQI is a mathematical approach of calculating a single value from multiple test results (Olubukola et al., 2021). Horton first developed Water Quality Index (WQI), a mathematical method of computing a single value that represents the water quality of a whole water body out of multiple water quality parameter values (Horton, 1965) gotten from laboratory measurements and analyses of varying samples of the water under study. In this study, weighted arithmetic water quality index (WAWQI) method is used to calculate the water quality index of the Aba surface water. Laboratory results gotten from the analyses of the sampled water parameters and WQI realized for each parameter is compared to the Federal Ministry of Environment (FMnEnv) and World Health Organization Water Quality Standard for each tested water parameter to assess its potability. The Weighted arithmetic water quality index (WAWQI) method is a good analytical tool for water quality index assessment of surface water (Patki et al, 2022; Islam, et al, 2020). WQI is calculated by averaging the individual index values of some or all of the parameters within five water quality parameter categories that depict the pollution level or status of the water:

1. Water clarity: turbidity (NTU) and/or Secchi disk depth (meters or feet);
2. Dissolved oxygen: Dissolved oxygen concentration (mg/l);
3. Oxygen demand: biochemical oxygen demand (mg/l), chemical oxygen demand (mg/l) and/or total organic carbon (mg/l);
4. Nutrients: total nitrogen (mg/l), and/or total phosphorus (mg/l); and
5. Bacteria: total coliform (per mg/l) and/or fecal coliform (per mg/l).

The WAWQI method (Horton, 1965) used in this study consist of 4 steps, which are as follow:

1. Select parameters to measure the surface water quality.

2. Quality rating scaled for each parameter;
3. Calculation of the unit weight (Wi) where Wi is inversely dependent upon the standard value (Si) of the parameters recommended (using FMEnv. -WQS)
4. Calculation of the overall WQI by summing the sub-index value.

The following procedure and equations are used to calculate the WQI:

-Each water quality parameter's unit weight (Wi) is computed using:

$Wi = K/Si$ …………. (1) (Abualhaija et al, 2021; Tokatli, 2020),

where Wi is the unit weight of ith parameters; K is a proportionality constant, and Si is the standard value of each parameter (Patel et al. 2023).

$K=1/\Sigma\ (1/Si$ ………… (2)

-Each parameter's quality rating scale (Qi) is calculated using:

$Qi = 100(Vi - V0/Si - V0)$ ……………… (3)

-The quality rating or sub index corresponding to ith parameter is the measured value of this parameter in River under study with respect to its permissible standard value (Patel, et al; 2023). The quality rating scale for pH is determined thus:

$Qi = (Vi - 7/Si - 7)$ ……….(4)

where Vi is the measured value for the ith analyzed parameter and Vo is the ideal value of the parameter. Vo for pH and DO are 7 and 14.6 respectively and 0 for all other parameters. The WQI is then determined by:

$SIi = \Sigma WiQi\ /\Sigma Wi$ ………… (5)

$WQI = \sum SIi$ …………….. (6)

where SIi is the sub-index of the ith parameter and i represents the number of parameters taken into consideration. WQI is the sum of rating and weightage of all the parameters (Tripathi, et al. 2019).

Table 4: Classification of Water Quality based on Weighted Arithmetic WQI Method (Jhamnani et al, 2009)

WQI	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	Unsuitable for drinking	E

4.0 RESULT AND DISCUSSION

4.1. Table of Measured Laboratory Result Of water Quality Parameter Of Aba River

Parameter	**Unit**	**FMnE.Std. (2011)**	**WHO/EU STD (2011/2008)**	**Minimum**	**Maximum**	**Mean**
PH		6.5-8.5	6.5-8.5	4.95	6.1	**5.71**
Temperature, (T)	°C	20-30	20-30	9.01	29.75	**26.17**
Electrical Conductivity, (EC)	µS/cm	1000	1000.00	21.	81.5	**42.071**
Dissolved Oxygen, (DO)	mg/l	7.50	5.00	3.85	9.05	**5.78**
Biochemical Oxygen Demand, (BOD_5)	mg/l	NS	5.00	1.45	4.8	**3.45**
Total Dissolved Solid, (TDS)	mg/l	500	500.00	13.65	53.48	**27.43**
Nitrate, (NO_3^-)	mg/l	50	50.00	0.39	1.6	**0.98**
Potassium, (K)	mg/l	10	50.00	8.83	19.17	**14.13**
Phosphate, (PO_4^{-3})	mg/l	5	5.00	6.67	34.59	**18.87**
Total Hardness, (TH)	mg/l	150	150.00	11.65	27.2	**20.53**
Calcium, (Ca)	mg/l	200	200.00	1.86	4.84	**3.4**
Magnesium, (Mg)	mg/l	200	0.10	0.95	3.47	**2.115**
Sodium, (Na)	mg/l	200	50.00	0.22	0.96	**0.71**
Copper, (Cu)	mg/l	1	2.00	0.002	0.01	**0.0073**
Total feacal Coliform, (TFC)	cfu/ml	0	0	20000	2.09×10^6	**532857.14**

The result of the analysis of 15 water quality parameters of Aba River shows high values of Phosphate, fecal coliform, title dissolved solid, high acidity, potassium, magnesium, and low amount of dissolved oxygen in the river all of which are indication of water pollution due to reckless and unregulated anthropogenic activities in and around the Aba River.

4.2. Water Quality Index

The WQI of Aba River was determined using the Weighted Arithmetic Water Quality Index formula as shown in equations 1-6.

Table 6: Overall Water Quality Index of Aba River

PARAMETERS	Unit	FMnEnv Standard Value (S*i*) (2011)	WHO/ EU STD (2011/ 2008)	MEAN VALUES (V*i*)	1/S*i*	Unit Weight (Wi) = K/S*i*	Quality Rating (Q*i*) (V*i* - Vo/S*i* - Vo) X 100 (Vo = 0	Sub Index (W*i* x Q*i*)
PH		6.5	6.5-8.5	5.71	0.15	0.083	258	21.41
Temperature, (T)	°C	30	20-30	26.17	0.03	0.018	87.23	1.57
Electrical Conductivity, (EC)	µS/cm	1000	1000.00	42.07	0.001	0.0005	4.21	0.002
Dissolved Oxygen, (DO)	mg/l	7.5	5.00	5.78	0.13	0.072	124.23	8.95
Biochemical Oxygen Demand, (BOD_5)	mg/l	NS	5.00	3.45	0.2	0.108	69	7.452
Total Dissolved Solid, (TDS)	mg/l	500	500.00	27.43	0.002	0.001	5.49	0.006
Nitrate, (NO_3^-)	mg/l	50	50.00	0.98	0.02	0.011	1.96	0.022
Potassium, (K)	mg/l	10	50.00	14.13	0.1	0.054	141.3	7.63
Phosphate, (PO_4^{-3})	mg/l	5	5.00	18.87	0.2	0.108	377.4	40.76
Total Hardness, (TH)	mg/l	150	150.00	20.54	0.007	0.004	13.69	0.06
Calcium, (Ca)	mg/l	200	200.00	3.4	0.005	0.003	1.7	0.005
Magnesium, (Mg)	mg/l	200	0.10	2.12	0.005	0.003	1.06	0.003
Sodium, (Na)	mg/l	200	50.00	0.71	0.005	0.003	0.36	0.001
Copper, (Cu)	mg/l	1	2.00	0.001	1	0.54	0.1	0.054
Total feacal Coliform, (TFC)	cfu/ml	0	0	532857.1	-	-	-	-

K= 1/1.837 = 0.54; WQI = 87.93/1.01; WQI = 87

In this study, the overall Water Quality Index was calculated using the mean value of the following 16 water quality parameters from the 7 sampling points: PH, Temperature(°C), Electrical Conductivity(µS/cm), Dissolved Oxygen, (mg/l), Biochemical Oxygen Demand(mg/l), Total Dissolved Solid(mg/l), Nitrate (mg/I), Potassium(mg/l), Phosphate (mg/l), Total Hardness (mg/l), Calcium (mg/l), Magnesium(mg/l), Sodium (mg/l), Copper(mg/l), and Total Fecal Coliform(cfu/ml). The overall WQI is found to be 87 an index that indicates that Aba River water quality is very poor based on WAWQI rating standard as shown in table 4 according to Jhamnani et al (2009).WQI of Aba River ranges from 76– 126 with an overall WQI of 87 and thus classified as very poor water quality following Federal Ministry of Environment (FMnEnv) and World Health Organization (WHO) standards and unsuitable for drinking. The water quality of Aba River is a reflection of degrading unregulated anthropogenic activities in and around the river, especially industrial effluents discharge and wastewater from commercial areas, municipal wastewater and municipal solid wastes dumpsites leachate all discharged into the Aba River besides the daily intensive sand dredging activities in the river.

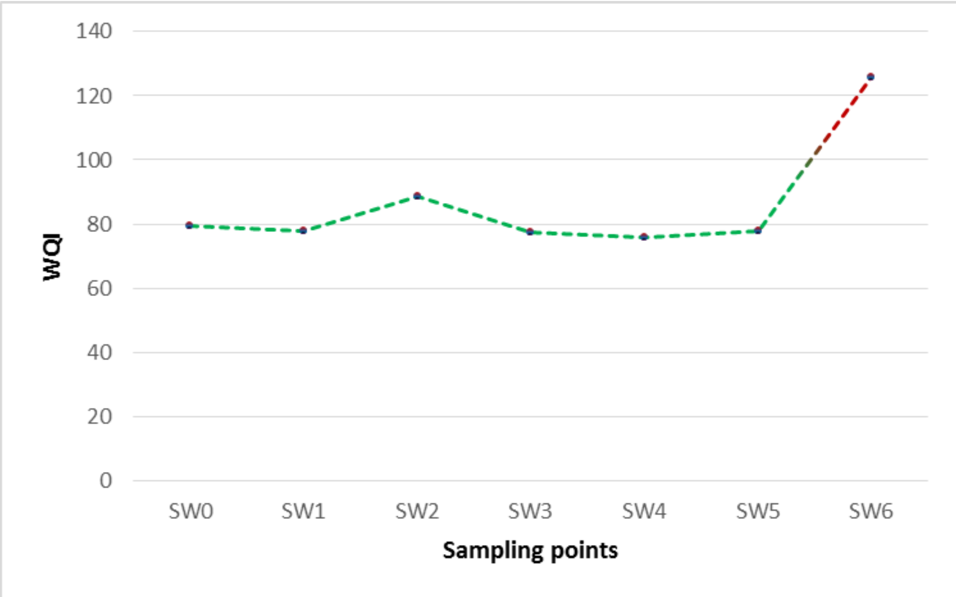


Figure 7: A graph of WQI trend across the 7 sampled points

The graph of WQI trend across the 7 sampled points in Aba River, which cover the Aba metropolis, shows at a glance the water quality status of Aba River. Base on the water quality classification criteria shown in Table 4, the water quality status of Aba River is very poor with WQI of all 7 sampled points in a range between 76-126 and average WQI value of 87 as shown in Table 6.

Table 7: Summary of WQI calculated for each of the 7 sampled points along Aba River.

Sample Points	Location I.D	Location Name	Longitude (N°)	Latitude (E°)	Elevation (M)	Description &anthropogenic activities	WQI	Rating
1	SW0	Umuimo St, Aba	5.169129	7.34921	43	Spiritism activities/'sacrifices', cow rearing	80	Very poor
2	SW1	Okpu Umuobo	5.14334	7.35609	38	Car-wash, rug-wash, bathing, swimming, domestic wastewater discharge, storm/urban runoff, Cow grazing.	78	Very poor

3	SW2	Glass Ind. Road Umuohia	5.1367	7.3725	34	Aba Malt Plant effluent discharge, dump site, animal farm,	89	Very poor
4	SW3	Ohuru Isimiri	5.13286	7.37524	31	Domestic wastewater discharge, boat transportation, swimming, bathing	77	Very poor
5	SW4	PZ	5.12399	7.37867	34	PZ wastewater, boat transportation	76	Very poor
6	SW5	Aba River Layout	5.11253	7.381286	22	Domestic wastewater, 7up company effluent, tie/dye, urban runoff	78	Very poor
7	SW6	PFG (Slaughter)	5.099125	7.38999	22	Slaughter, meat roasting, blood wash-off, heaps of black soot, dump site, bathing, swimming, urban runoff, sanitary wastewater	126	Unsuitable for drinking

4.3.Water Assessment for Irrigation Purpose

There are four major water quality indices used to determine and rate the suitability of water for irrigation, they are as follow: Magnesium Hazard (MH), Soluble Sodium Percentage (SSP), Kelly Ratio (KR) and Sodium Adsorption Ratio, (SAR). In irrigation water quality rating, four major cations are analyzed: Calcium ion ($Ca^{2}+$), Magnesium ion ($Mg^{2}+$), Sodium ion ($Na+$), and Potassium ion ($K+$); these were all analyzed from the measured concentrations of water parameters in this study. The concentration of these cations in a given water determines the extent of its reaction with the ions trapped in soil water which in turn determines the interaction of water with the crop.

4.3.1. Magnesium Hazard (MH)

One important index that measures the suitability of water for irrigation purpose is the Magnesium Hazard. High Magnesium level in water retards plant growth and productivity (Ajayi and Okeke 2024;Eyankware, et al, 2020). MH value above 50 is considered unsuitable and unsafe for use in plant irrigation while MH values with 50 are considered suitable. Using data from Aba River sample analysis, calculation for MH was done using the following formula:

$$MH = \left(\frac{Mg^{+}}{Ca^{2+} + Mg^{2+}}\right) \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Table 8: MH-SurfaceWater Classification For Irrigation

MH Range	Zone	Sample No.	% Value	Class of water
<50	SWO-SW6	1-7	48.5	Suitable
>50				Unsuitable

MH is 48.5 <50 and safe and suitable for irrigation.

4.3.2. Soluble Sodium Percentage (SSP)

Soluble sodium percentage measures the quantity of sodium that can dissolve in a water body. SSP level above 50 is considered unfit for irrigation, while values below 50 are safe for irrigation use. SSP is calculated using the following formula:

$$SSP = \left(\frac{Na^{+} + K^{+} \times 100}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}}\right) \ldots . (8)$$

Table 9: SSP- Surface Water Classification for Irrigation

SSP Range	Zone	Sample No.	% Value	Class of water
<50	SW0-SW6			Suitable
>50		1-7	54.2	Unsuitable

In this study, SSP value is calculated to be 64.5 > 50, thus, considered unsafe for use.

4.3.3. Kelly's Ratio (KR)

KR is another useful tool in evaluating the quality status of surface water and its appropriateness for use in irrigation (Akakuru et al., 2022; Ajayi and Okeke, 2024). Surfacewater with High level of Sodium usually has KR value greater than one. The value of soluble sodium in this study is 0.69, a value less than 1 also, the value of KR in this study is 0.1, which is also less than one, thus water is suitable for irrigation. KR value less than one is suitable for irrigation. KR is calculated using the following formula:

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}} \ldots \ldots \ldots \ldots (9)$$

Table 10: KR Surface Water Classification for Irrigation

KR Range	Zone	Sample No.	Value	Class of water
<1	SW0-SW6	1-7	0.1	Suitable

>1				Unsuitable

4.3.4. Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio (SAR) is a water quality parameter for evaluating the suitability of surface water for irrigation purpose. Sodium adsorption ratio is a value that shows the concentration of sodium (Na) in surface water with in relation with calcium (Ca) and magnesium (Mg) (Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture). SAR is given by the formula (Ajayi and Okeke 2024):

$$SAR = \frac{Na^+}{\frac{\sqrt{Ca^{2+}+Mg^{2+}}}{2}} \text{........ (10)}$$

where sodium, calcium, and magnesium all have their units as milliequivalents/liter.

The idea of SAR assesses the impact and importance of sodium on soil aggregates stability. SAR is an important water quality parameter in water quality assessment especially when the soil on which the water would be used is sodium-affected. Sodium and potassium ions facilitate the dispersion of clay particles. This implies that high value of SAR in a water used in irrigation will negatively impact on the ability of such soil to form stable aggregates, thus, loss of soil structure and tilth. Application of water with high SAR over a sustained period of years will lead to the displacement of calcium and magnesium in such soil, which in turn leads to low infiltration and permeability of the soil to water, and consequently low crop yield. Table 11 gives the SAR rating scale for irrigation.

Table 11: Irrigation water quality values at different sampling points of Aba River.

Irrigation Parameters	**SSP(%)**	**SAR**	**MH(%)**	**KR**
Sampling Pt1	48.3	0.03	70.3	0.03
Sampling Pt2	63.7	0.2	38.9	0.23
Sampling Pt3	42.1	0.11	58.7	0.08
Sampling Pt4	58.6	0.1	47.2	0.08
Sampling Pt5	72.3	0.15	28.1	0.14
Sampling Pt6	60	0.08	44.1	0.07
Sampling Pt7	38.3	0.12	44.2	0.09
Mean	54.76	0.11	47.36	0.10
Average water class	Unsuitable	Excellent	Suitable	Suitable

Table 12: Sodium Hazard Classes based on Sodium Adsorption Ratio (SAR) (After Wilcox, 1995).

Sodium Hazard class	**SAR**	**Description of quality**	**Study Samples**	**Remarks**
S1	<10	Excellent	(0.08-0.20) 1,2,3,4,5,6,7	All the samples
S2	10-18	Good	-	
S3	18-26	Doubtful	-	
S4	>26	Unsuitable	-	

Table 13 Water quality based on Magnesium Hazard (MH) (Szabolos and Dorab, 1964)

MH (%)	**Description of water quality**	**Study Samples**	**Remarks**
<50	Suitable	1,3,4,5,6 (28.10-47.20)	5 samples
>50	Unsuitable	2,7 (58.70, 70.30)	2 samples

Table 14 Water Quality based on Soluble Sodium Percentage (SSP, (After Wilcox, 1995)

SSP (%)	**Description of water quality**	**Study Samples**	**Remarks**
<50	Suitable	1,3,7 (38.3-48.30)	3 samples
>50	Unsuitable	2,4,5,6 (58.60-72.30)	4 samples

Table 15 Water Quality based on Kelly Ratio (KR)

KR	**Description of water quality**	**Study Samples**	**Remarks**
<1	Suitable	1,2,3,4,5,6 (0.03-0.23)	All samples
>1	Unsuitable	-	-

4.4. Interpretation To the Measured Physico-Chemical Parameters Concentrations in Aba River

Out of the analyzed 16 water quality parameters used for water quality index assessment in this study, a few parameters stood out in concentration and in ways that affected the other parameters.

4.4.1. TDS, EC, and Temperature

Total Dissolved Solids (TDS) is the total concentration of dissolved substances in water. TDS constitute of inorganic minerals elements and little quantity of organic matter. Inorganic minerals commonly found dissolved in water include: calcium, magnesium, potassium and sodium, all of which are cations, and anions such as carbonates, nitrates, bicarbonates, chlorides and sulfates. Dissolved solids can produce hard water or soft water depending on the predominant minerals dissolved in such water. Dissolved Solid could be as a result of solution and carbonation, a reaction between water and limestone, feldspar etc., due to weathering, from inorganic substances that contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur, and other minerals; or anthropogenic activities such as farming with mineral-rich fertilizer, discharge of industrial effluents into the River, runoff flow through organic sources like leaves, silt, plankton, sewage etc. High TDS value signifies the presence of harmful contaminants like iron, manganese, sulfate, bromide and arsenic, in such water.

In this study, the average TDS value is measured to be 27.4mg/l with its maximum value as 53.5mg/l at sampling point 7. From the measured mean values of Calcium (Ca), Sodium (Na), Potassium (K) and Magnesium (Mg) which are: 3.4mg/l, 0.71mg/l, 14.13mg/l, 2.12mg/l respectively, it is obvious that the TDS value at sampling point 7 is due to anthropogenic activities. Also, at sampling point 7, the Phosphate level is the highest, with a concentration of 34.6mg/l (a value 7times more than FMnEnv permissible standard) while at sampling point 1(control), Phosphate is measured to be 17.9mg/l. More significantly, the concentration of Phosphate at sampling point 7 is anthropogenic, which further explains the TDS level (53.5mg/l) at sampling point 7 since the measured concentrations of Na, Ca, K, and Mg are very little. At sampling point 7, abattoir (slaughter house), vegetable and food market, dumpsite, bone-ash heaps, black soot heaps, urban runoff, sanitary wastewater, bathing, and swimming are all human activities that regularly go on in the area. All these human activities are enough sources of dissolved solid in the River at that point.

Consequently, when surface water dissolves mineral salt, they become ionizer with either a positive charge as cation or negative charge as anion, thus causing a rise in EC, as shown in figure 9. In this study, the average electric conductivity (EC) is 27.43us/cm and 81.5uS/cm at sampling point 7 which is considerably significant and could be explained by the high level of TDS at this point due to all the anthropogenic activities in and around the River at this point. However, the water remains electrically neutral even with increased solute concentration and significant electric conductivity level because concentrations of each cation and anion remain constantly equal in the River.

Temperature is also a factor that influences TDS, with high dissolved solute concentration, temperature seems to increase which also reduces dissolved oxygen and affects aquatic life in the water environment. Both low and high TDS concentration in a water body may limit the growth and sustenance of aquatic life. The presence of salts in concentrated level and in extreme cases can make the water hypertonic and lead to dehydration the skin of aquatic animals by osmosis which could result to death and in extreme cases extinction of certain species.

High level of dissolved ions could also affect water pH and consequently, overall water quality and make the aquatic environment inhabitable for aquatic life. In this study, the average pH of the Aba River is 5.7, 5.0 at sampling point 6 and 5.5 at sampling point 7.

4.4.2. DO, COD and BOD

Aquatic lives do not breathe in oxygen gas, because of their anatomy, they are created with a mechanism that enables them use oxygen dissolved in the water of their habitat. Dissolved oxygen (DO) is the amount of oxygen in a water body accessible to fish, and all other aquatic lives in the aquatic environment. There is a level of dissolved oxygen that cannot sustain aquatic life; the life of fish cannot be sustained in a water whose dissolved oxygen lower that 5 mg/l (Bozorg-Haddad et al, 2021).The prescribed standard for DO according to FMnEnv is 7.5mg/l, however, in this study, the average DO is 5.8mg/l, with a maximum value of 9.1mg/l at sampling point 2 where tiny fishes swimming around the River bank were sighted; 3.9mg/l at sampling point 1 and 4.5mg/l and point 7 where there was no sight of fish. Low level of dissolved oxygen in water is a sign of pollution and/or contamination; a crucial parameter in water quality assessment, aquatic environmental management. Dissolved oxygen also varies with temperature and elevation. Cold water tends to have higher DO value than warm water, thus, the lower the temperature, the higher the DO, while the lower the altitude, the higher the DO at a constant temperature (Omid et al., 2021). High temperature decreases oxygen solubility in water. From the analysis in this study, the highest value of DO record was 9.1mg/l at point 2 with lowest recorded temperature value of 9°c as shown in figure 8; the graph of temperature and DO across the 7 sampling points. The presence of organic waste, mostly domestic and animal sewage, industrial waste, slaughterhouse sewage and crop wastewater, drastically reduce the DO content of water. Wastes with the most oxygen demand are organic wastes and industrial wastes (Omid et al., 2021). The presence of high bacterial count reduces the dissolved oxygen level in a body of water.

Biochemical oxygen demand (BOD) mg/l is the quantity of dissolved oxygen required by aerobic organisms to breakdown organic matter present in a given water sample at a given temperature, usually 20°C, and over a specific time frame, usually 5 days, (Kaiser, 1998), that is way BOD is correctly written as BOD5. BOD is a water quality parameter which reliably measures the degree of organic pollution of a water body. It then follows that if a water has high organic matter content, the BOD would be high leaving the water with little or no dissolved oxygen (Parween et al., 2022). In this study, the values of BOD and DO in sampling point 1 for instance are 1.5mg/l and 3.85mg/l respectively, both are the lowest values for these parameters across the 7 sampling points; these low values for BOD^5 and DO are simply a function of the high presence of fecal coliform with a value of 2.0×10^4. /Cm, Total Dissolved Solid, 13.7mg/l, Aluminum, 43.2mg/l and Chromium, 0.41mg/l.

BOD analysis has striking similarity with chemical oxygen demand (COD) analysis; both parameters evaluate the organic compounds content of water; though COD analysis measures everything that can be chemically oxidized, BOD measures the amount of oxygen demanded by organisms to breakdown organic matters specifically (Prabagar et al., 2023). High value of COD in a water sample signifies that such water has higher quantity of oxidizable material in it, in which case, the water will have reduced dissolved oxygen levels, a condition that has severe adverse impact on such aquatic environment and could be lethal to the aquatic life in it. Figure 9 is a graph of COD and DO across the 7 sampling points; the high values of COD across the points show corresponding low DO values.

In this study, also at sampling point 1, COD is as high as 96mg/l, a value explainable by the high amount of chemicals and heavy metals prevalent at this point: Aluminum 43.2mg/l (216times larger than permissible limit of 0.2mg/l), Phosphate 18mg/l (3.6times more than permissible limit of 5mg/l), Arsenic 0.13mg/l (13times higher than permissible limit of 0.01mg/l), Zinc 0.37mg/l (37times higher than permissible limit of 0.01mg/l), Cadmium 0.33mg/l (110times larger than permissible limit of 0.003mg/l), Iron 3.44mg/l (11.5times bigger than permissible limit of 0.3mg/l), Mercury 0.02mg/l (20times higher than permissible limit of 0.001mg/l) and Chromium 0.41mg/l (13.7 times more than permissible limit). These values indicate that Contamination Factor (CF) of these metals are very high.

4.4.3. Phosphate (PO_4^{3-})

In this study, the level of phosphate is alarmingly high. Phosphate $PO^{-3}{}_4$ forms when Phosphorus, a naturally occurring rock mineral which is soluble in water, dissolves in water. Phosphates exist in three forms: orthophosphate, metaphosphate (or polyphosphate) and organically-bound phosphate (Fadiran et al, 2008). Orthophosphates are produced by natural processes, but certain anthropogenic activities can be sources of introduction of Phosphate into a River system; such activities include: discharge of partially treated and untreated sewage, application of Phosphate-bases fertilizers and runoff from agricultural sites into the River.

In the case of this study, the phosphate level, a mean value of 18.87 mg/l, is majorly influenced by anthropogenic activities along the stretch of the River, especially around sample point 7 where the slaughter is located with a maximum phosphate value of 34.6mg/l and water quality index (WQI) of 126. The presence of Phosphate in sampling point 1, as well as other sampling points, is likely due to presence of animal manures (wastes from cow and humans) and fertilizers (washouts from agricultural lands and soil erosion) as non-point pollution sources. Phosphorus is an important element needed for plant growth. Phosphate easily accumulates by biological uptake, absorption, and mineralization in soil and River sediments, inducing growth of plankton and aquatic plants, a condition known as eutrophication.

Excessive presence of nutrients such as nitrates and phosphates in River, and River sediment result in eutrophication, excessive production of plants and algal blooms which upsets the ecosystem of the River; Phosphate is a nutrient that encourages rapid growth of microorganisms (Kimbell et al., 2023). In this circumstance, there is of necessity, decomposition of the excess organic matter in the water which drastically reduces the dissolved oxygen content of the water making the River anoxic, that is very low in dissolved oxygen. This is typified in the Aba River with high phosphate level. The mean (average) dissolved oxygen (DO) content of Aba River is 5.78mg/l, and 4.5mg/l at the sampling point with the highest Phosphate value of 34.6mg/l, values lower than the FMnEnv dissolved oxygen prescribed standard of 7.5mg/l. The sources of Phosphorus at Sampling point 1 are likely to be animal manures (wastes from cow and humans) and fertilizers (washouts from agricultural lands and soil erosion) (Fadiran et al., 2008) as non-point pollution sources, even at the headwaters/spring section of the river under study. High concentration of phosphate in surface water is a treat to the existence of fishes in a river. With consequent algae bloom which die off due to reduced dissolved oxygen and are in turn decomposed in the water by microorganisms which as well use up available oxygen in the water, fishes have little or no dissolved oxygen available for their survival in such surface water (Badamasi et al., 2019).

4.4.4. pH

The pH of a water body is the measure of the acidity or otherwise alkalinity of the water. pH is estimated as the most important physicochemical parameter that influences the concentration, character and impact of other water quality parameters and hydrogeochemical parameters in water bodies (Weiner, 2008). Acid-base reactions, solubility reactions, oxidation-reduction reactions and complexations are chemical processes that are generally determined by the concentration of hydrogen ions concentration (pH) in water (Saalidong et al., 2022). Very high or very low pH makes water unsuitable for certain purposes. For surface water, its pH value ranges between 6.5 and 8.5 which is within the range for most water quality standards. The lower the value of pH of a water the more acidic it is, while the higher the pH value of a water, the more alkaline it is. The pH is a surface water could be regulated by natural factors such as the chemical composition of its aquifer bedrock or rock it flows through, whether it is basic, or acidic. For instance, when acidic water flows through limestone, it neutralizes. Also, the presence of excessive plants growing in or along a River can significantly impact on the acidity of the River. Plants release carbon dioxide, when they die off and decay, which reacts with water to form carbonic acid with lowers the pH of the water. Conversely, a number anthropogenic activities could as well impact greatly on the pH of surface water such as: industrial operations, municipal solid waste mismanagement, sewage mismanagement, wastewater mismanagement and indiscriminate discharge, industrial chemical pollution, acid rain, etc.

Increase in pH value of a water environment can be lethal to lives in the ecosystem such as fishes and other aquatic lives (Weiner, 2008; Saalidong et al., 2022). Aquatic life is hypersensitive to changes in pH, temperature and other water parameters. In this study, the average pH of the sampled points is 5.7 with lowest value as 5.0 at sample point 6, an area characterized by tie and dye activities. Aba River was known to flourish with fishes but the polluting anthropogenic activities that go on in the since urbanization and industrialization made the water less habitable for most species of aquatic lives. It is also important to note that acidic water is synergistic. This implies that when a surface water is both acidic and contain high concentration of heavy metals such as aluminum, mercury etc., the impact of the acid-metal combination becomes more fatal to both human and aquatic life than the impact if each parameter (pH, and heavy metals) were separated or acted independent of the other. In the same vein, alkaline water with a pH greater than 8.0 has its own adverse effect, one of which is disinfection difficulty. Bar charts representing the trend of Physico-Chemical parameters across the 7 sampling points in Aba River and their relationship with each other is shown in figures 8, 9,10.

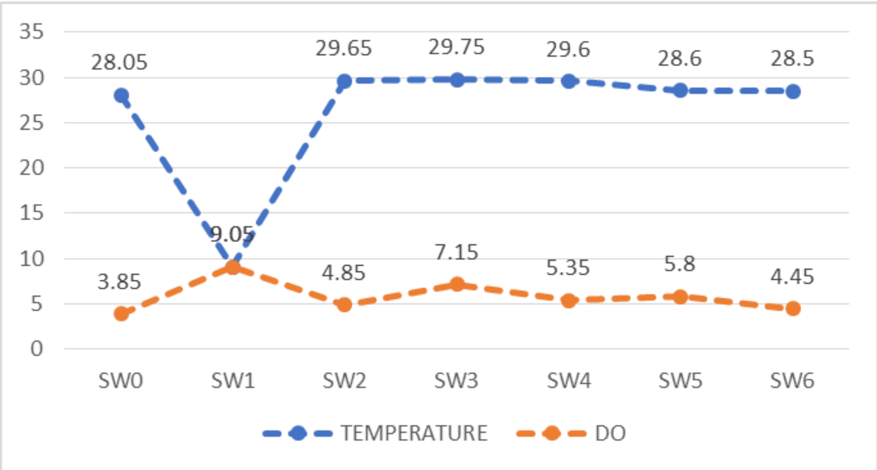


Figure 8: A graph of dissolved oxygen and temperature across the sampled points.

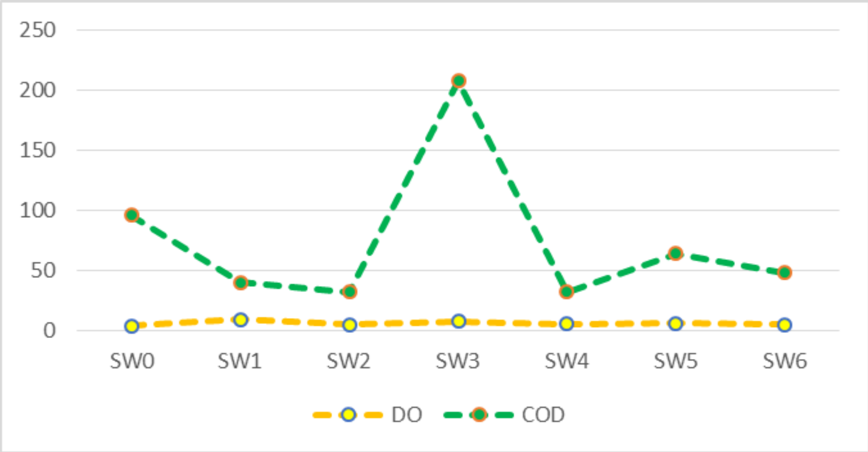


Figure 9: A graph of DO,COD across the sampled points.

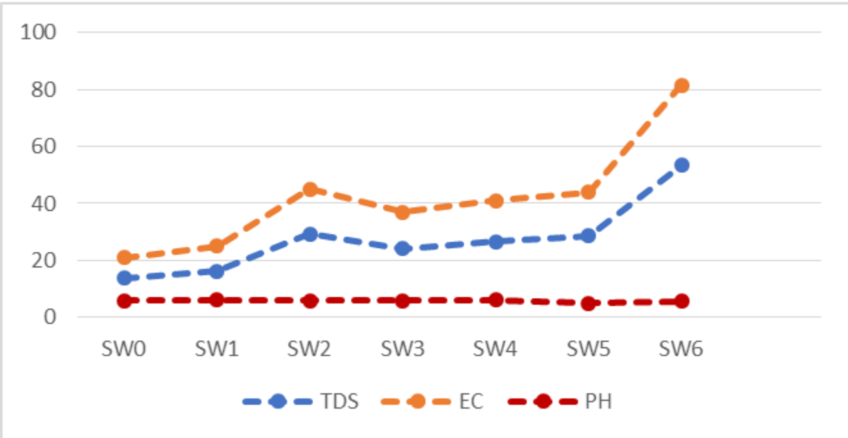


Figure 10: A graph of TDS, EC and pH across the sampled points.

4.4.5. Coliform Bacteria

Coliform bacteria basically are found in feces of humans, mammals and other warm-blooded animals. The presence of coliform bacteria in water shows that there is the likelihood of presence of pathogens in the water environment (Li, et al., 2019). Three known groups of coliform bacteria are:

Total Coliform: This is a collection of various types of bacteria.

Fecal Coliform: This is a subgroup of total coliform found in abundance in human and animal intestines and thus found in their feces (Varol et al., 2023). Its presence in water implies high risk of presence of pathogens.

E. Coli: This is a subgroup of fecal coliform found mostly in human and animal intestines. If presence in water indicates recent contamination with feces. It could be harmless but some strains of E.Coli such as E. coli O157:H7 found in cattle feces can impact detrimentally on human health (Minnesota Department of Health, 2019).

4.5. Physico-Chemical Parameters: Environmental and Health Impact

The assessment of Aba River in this study shows that it is good for use in irrigation. However, the health implications and risk that can accrue upon usage of the River water considering the level of pollution and contamination of the River as shown in the result of its quality assessment in this study poses enormous and grave environmental and health concern.

Fecal coliforms, phosphate and nitrate pollution and contamination are not just major concern and cause of environmental pollution in surface water bodies, they as well present serious health risk to humans (Sánchez-Araujo, et al., 2024), and the ecosystem. The issue of fecal coliform, as one major cause of surface water pollution, has remained a grievous problem in surfacewater quality and potability worldwide.

Nitrate is taken to be a non-carcinogenic water pollutant (Pasupuleti et al, 2022), however, ingestion can lead to a wide range of medical conditions such as: methemoglobinemia in infants' miscarriages, birth complications, increased risk of hemolytic anemia, esophageal cancer and stomach cancer, ulcerations and teratogenic effects (Ayejoto et al, 2024; Isiuku et al, 2020; Ji et al., 2022).

Research also shows that when nitrate gets ingested into the human system, it can undergo certain biochemical reactions such as reduction reaction that reduces nitrate to nitrite which could react with certain digestive enzymes known as amines; a reaction that could lead to the formation of nitrosamines which is a carcinogenic compound (Isiuku et al 2020). A major public health risk of nitrogen and phosphorus ingestion is their capacity to aid Enterococcus faecalis, a gastrointestinal bacterium, form resistance to antibiotics (Xiao, et al, 2024) leading to prolonged suffering of gastrointestinal infections which could be lethal.

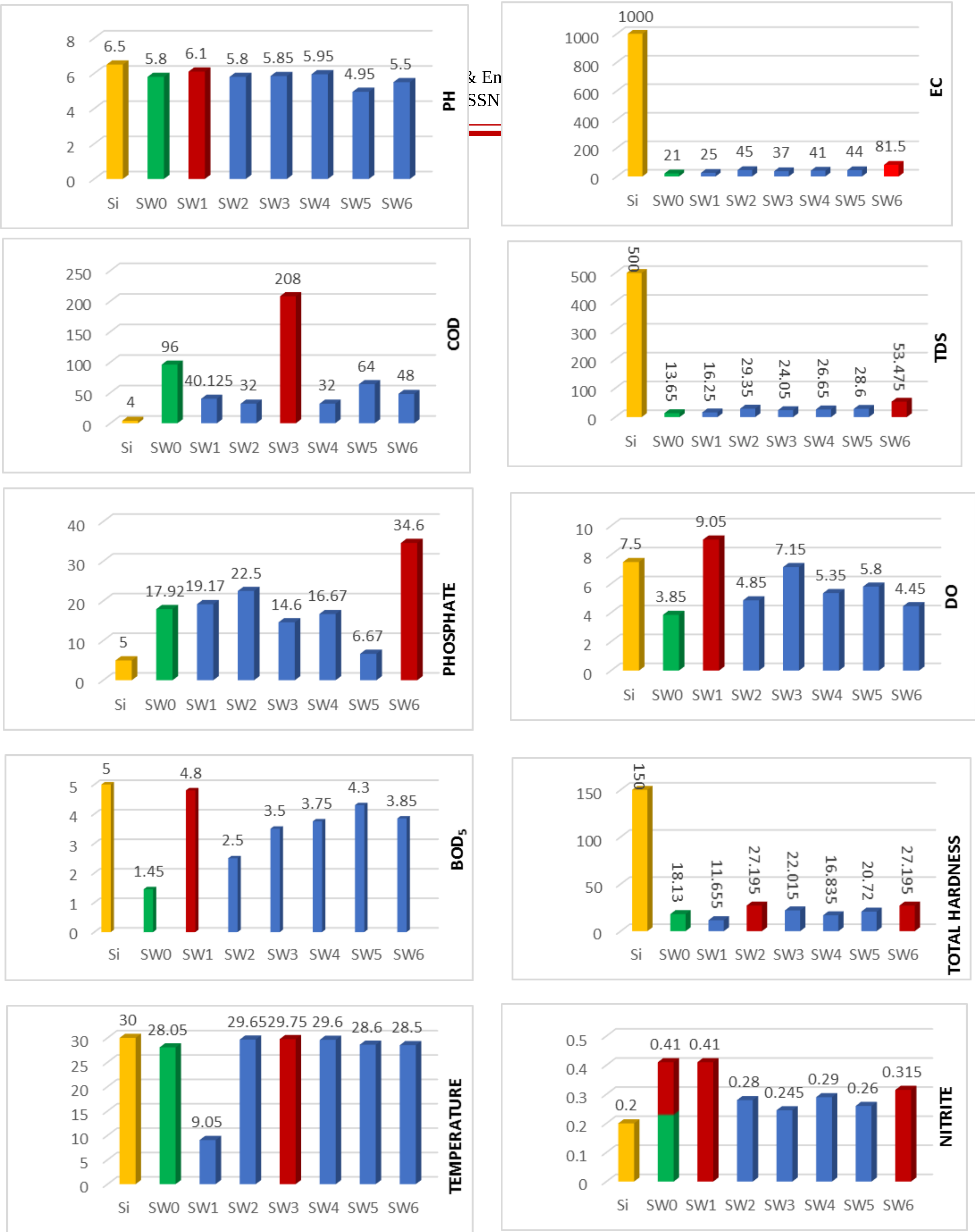
Phosphates are not toxic to human and animal life except when present in concentration way higher that recommended standard. Phosphate concentration in surface water above recommended standard could result into parasitic infections (Sánchez-Araujo et al, 2024; Contreras et al, 2021). Ingestion of water or food with extremely high level of phosphate could induce digestive problems.

Nitrate and phosphate can be ingested orally by drink the water, or eating food made from crops grown on heavy nitrate and phosphate soil. These elements in high concentration can also enter the body through skin contact (Sáez-Huamán et al., 2023; Sánchez-Araujo et al., 2024).

The knowledge and sight of all the water polluting anthropogenic activities that daily go on in Aba River have ruled out its usage as source of drinking water or domestic source of water supply. The most usage of the Aba River water is for swimming, in-River-bathing, washing of roasted skin of cow (kpọmọ), goat and pig of cloths, rugs, cars, industrial source of water supply, agricultural source of water supply, animal farm source of water supply and discharge point for industrial effluents from companies situated around the River, all of which further degrade the Aba River water quality. Hence the most likely means of human ingestion of the Aba River water is firstly through skin contact.

From the result of the analysis in this study, the concentration levels of nitrate and nitrite are within the specified of the Federal Ministry of Environment (FMnEnv) standard. But, the concentration level of Phosphate is way above FMnEnv recommended standard for phosphate which is 5mg/l. The mean value of Phosphate for the 7points sampled in this study is 18.87mg/l and a maximum value of 34.6mg/l. Hence, phosphate is one of the hazards in Aba River with the potential to cause great adverse impact of human and environmental health.

Figures 11 are bar-charts representation the distribution of the measured Physico-Chemical parameters of Aba River across the 7 sampling points.



FMEnv Standard Control Maximum Value Other Values.

Figure 11: Distribution of Physico Chemical Parameters across the seven sampled points in Aba River

5.0 CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Surface Water pollution is mostly caused by anthropogenic activities and unregulated use of surface water for various human activities. The poor water quality of Aba River starting from sampling point 1 (headwater) is highly influenced by the high concentration of phosphate, low pH, high Total dissolved solid, Electrical conductivity and fecal coliform found in it. High water quality index at sampling point 1 is both anthropogenic and geogenic; anthropogenic in sense that there are surprisingly, human and animal activitiesaround and in the headwater region of Aba River that introduce pollutants and contaminants into the river even at the headwater; such activities include cattle grazing, farming, 'spiritist' activities (sacrifices, etc.) and dredging. Cattle rearers bring their cattle to graze around the headwater and as well drink water from the headwater area of river to the extent accessible, noting also that the river is not deep at the headwater. These cattle mess the ground with their hoofs, feces and urine. Surface runoff also carry farm yard pollutants and contaminants into the river at the headwater as well as the other points in the river. Also, the activities of reptiles at the inaccessible area of the headwater could have effect on the water quality of the river at sampling point 1. On the other hand, the high-water quality index at the headwater could be due to natural environment such as the presence of laterite in the area. Almost at all points down the stretch of Aba River are anthropogenic activities, especially, industrial activities, that load the River with pollutants and contaminants thereby making the water unfit for drinking and domestic activities.

The grave impact of surface water pollution on the environment, ecosystem and human's health should inspire feasible but stringent measures of regulating all polluting anthropogenic activities in and around the River.

5.2. Recommendations

Based on the findings of this study, I recommend the following:

1. That the Abia State Environmental Protection Agency, Ministry of Works, Ministry of Health, and law enforcement agencies activate/propound and enforce environmental protection and management laws that ensure that solid wastes and liquid wastes from Aba metropolis as well as industries sited in the area do not end up in the river.
2. That the government of Abia State should instill strict regulations on dredging business along the river. Also, policies concerning wastewater treatment of industrial effluents before discharging them into the river should be made and enforced.
3. That Aba Town Planning authority together with the Ministry of Works and Infrastructure beginning a re-channeling of Aba urban drainages to stop them from emptying their content into the river.

4. That wastewater treatment plants be built in Aba City. This will also go a long way in stopping or at least minimizing the introduction of harmful substances into the river, thus allowing the river enough time to rejuvenate and enough time to self purify itself, a process known as self purification of river.

5. That public health enlightenment campaign be carried out to clearly enlightened the public on the health and environmental implications of mismanagement of the river.

6. That prompt clean up exercises be carried out in and around the river, clearing out the refuse dumpsites along the stretch of river.

7. That small scale purification methods especially water boiling should be used to treat the water before domestic usage.

8. Regulation on use of phosphate and nitrate based fertilizer to reduce nutrient concentration in the river thereby reduce eutrophication.

9. Relocation or strict regulation of the operations of the animal farms and abattoir located by the river.

10. The Aba River could be dredged, cleaned bank, and facilities that make for tourists attraction built by the river bank which could also serve the purpose of revenue to the state government.

11. That the headwater, especially, be protected from the activities of herdsmen and their herd (cows) that come to graze and drink water at the headwater where they also defecate and mess up with their hooves.

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