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Assessment of the Physicochemical-Water Quality Parameters of a Tropical River in Aragba, Delta State, Nigeria

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Abstract: *Over time, studies have shown that the physical and chemical composition of any water body shows its integrity index. The present study investigated the limnological integrity of Aragba River for eight (8) weeks at three designated sites using standard techniques. Physical variables were air (21-34°C) and water(20.5-31°C) temperatures, conductivity(23.5-35.2µS/cm), Total Dissolved solids(11-20mg/L) and chemical; Alkalinity(10-20 mg/CaCO$_3$), Acidity(146-556 mg/CaCO$_3$), Chloride(11.5-32mg/L), CO$_2$(2.05-3.89mg/L), Phosphate(0.01-0.5mg/L), Potassium (111-534mg/L) characteristics measured a good quality river. These attributes fluctuated daily within and across the stations within acceptable configurations. Changes occurred in most chemical than physical variables; pH tilted towards acidity; water temperature associated with other variables. The limnological integrity of Iyikpesu River is still intact, despite the enormous human activities and its use for economic development is therefore highly recommended rather than use for silages.*

Keywords:*Limnology, Water quality, Iyikpesu River, Aragba, Nigeria.*

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I. Introduction

Water is to aquatic organisms, just like terrestrial environment is to terrestrial organisms. Water quality is a characteristic of the vast number of substances in dissolution. Water is, therefore, seen as a fundamental element that symbolises all liquid substances. The non-separable nature of lives from water is hypothesised by without water life cannot exist. Hence water is hugely vital for the survival of aquatic lives and humankind (Vidokovic, 2007). Water is nature's asset and has attracted man's exploitation for both natural and artificial aquatic ecosystems (Edogbolu and Alele-Wokoma 2007). As such, water exposed to intensive human, industrial and municipal wastes/pollution, resulting in an unhealthy environment and human afflicted diseases transmissions (Ayandiran et al., 2018). As scarce resources, water is a relatively valuable resource; its care and management are of significant priority. Its pivotal role in tourism, agriculture, and food pursuit and livelihood sustainability of water is worldwide (Mugagga and Nabaasa, 2016). Researchers had reported the importance of water and how extensively water quality has contributed to fish health, yield and management as well as employment (Abolude et al., 2012, Naik, et al., 2015). Thus Ait-Kadi (2016) noted that water is the heartbeat of every enduring development and as such has been prioritised in the United Nations 2015 Development Agenda (WWAP, 2015). Water is, therefore, a bridge, livelihood, social, economic development masonry.

Aquatic habitats are of diverse types, and its constituents and components are also as variable as the water bodies, yielding diversities in nature, diversity composition and productivity (Machowski and Noculak 2014). The components of water bodies depend on the ability of water to ensure dissolution and ionisation of substances which impacts the unique physical and chemical attributes that birthed the kinds of aquatic ecosystems. In these habitats, incredible varieties of species (both plants and animals) also adapt and live in the different parts of these environments (Salmaso and Mosello, 2010). Naturally, biotas and water (environment) are in conflicts, particularly in environments modified or changed by man's activities (Akpan, 2006; Biachi and Morrison, 2018). Water is so significant and valuable to man, even in their wasteful forms with treatment (WWDR, 2017).

For over two decades, there have been assertions on the need to monitor and conserve water quality and their resources. Excellent performances exist in fisheries, water supply and other essential activities in countries where water resources are harnessed and used profitably. This process involves the assessment of the physical and chemical parameters in water bodies in place of impacting changes on the vulnerable biotic community responsive to deteriorated water quality due to pollution (Wetzel, 2001; Erhunmwunse et al. 2013). Despite oodles of water bodies in Nigeria, most water bodies in Nigeria are losing their potentials with their opulent resources rather than ameliorate our shortfall economy. The development of most developed world country is grossly associated with their water resources. Impracticable development is the outcome of enormous human activities. Without water then, Nigeria needs to take a clue from such nations and pay attention to her immerse water resources, to become economically emancipated.

Nigeria is still at data gathering, and infancy stage of water quality assessments studies and little has been used to provide ecological services. The neglect of our water bodies is a fast guaranteed corridor to continuous failure and prolonged abject poverty. It is in this regard that this research was developed to add and to document the physicochemical factors and potentials of this overlooked water body at Aragba used as silages. The current study examines the limnological integrity of a small tropical stream in Aragba, Delta state, Nigeria. The study takes into account the changes in selected water quality parameters that may constitute the studied water body due to environmental pollution.

II. Materials and Methods

Study location

The study was conducted in a local stream in Aragba, Delta state(Figure 1). Aragba is 121 sq. Km area of land located in the Delta south senatorial zone of Delta state in Ughelli North Local Government Area, south-south, Nigeria. Geographically, Aragba is relatively humid in climate, located in latitude 5.72955 of the equator and longitude 6.13852 of the Prime Meridian. It is mostly forest in nature and covered with mosaic grassland/shrubland, tropically of a monsoon climate of the short dry season.

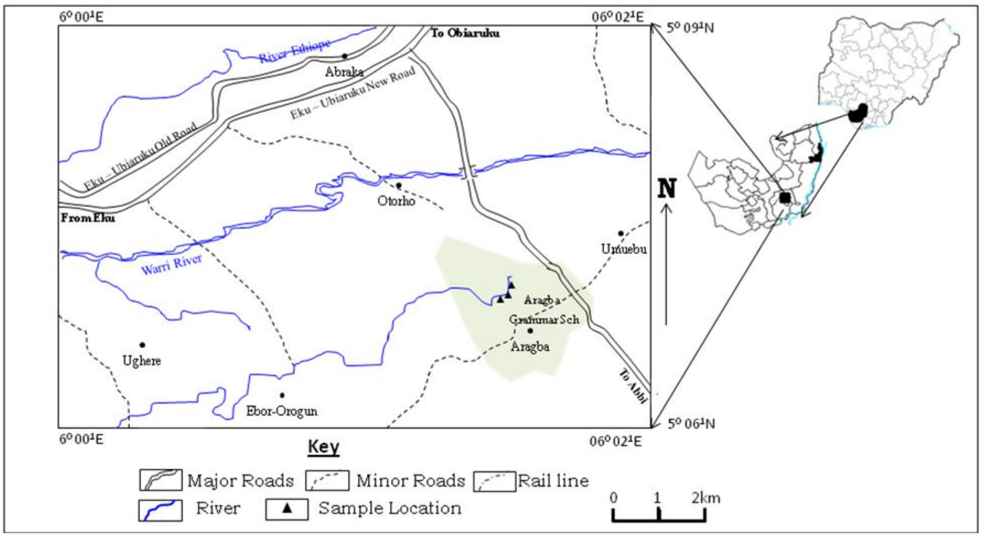

Figure no 1. Location of Aragba in Ughelli North Local Government Area, Delta, Nigeria

III. Study Design

The study investigated the physicochemical parameters of the Aragba stream at different stations. Three (3) sampling sites (Stations) in the river were chosen; Station 1 was the deepest while Station2 was situated mid-stream, and Station 3 was the shallowest with high human impacts. From these Sites, water samples were taken, and the measured physicochemical parameters were Air and water Temperatures, Alkalinity, Acidity, dissolved oxygen, Total Dissolved Solids, Conductivity, pH, Turbidity, Phosphorous, CO_2, Potassium, Chloride and biochemical oxygen demand as described in APHA, 1990 and Wetzel and Likens, 1991

Sampling Techniques

Three sampling stations were randomly selected, and the numbers assigned. Water samples were analysed using standard techniques. Air and water temperatures were determined using mercury in glass thermometer (0°C to 100°C). The thermometer was first stabilised before use. Water Turbidity levels were measured with the Digital Turbidity meter (Labtech). Surface water pH was got with a digital pH meter (Labtech AVI-65). Employing a portable digitise conductivity/TDS meter (DDB 303A), Electrical conductivity was also obtained. The digital conductivity/TDS meter (DDB 303A) was also employed for the measurements of Total Dissolved Solids (TDS) in sampled stations. Dissolved oxygen was determined with a digital DO meter (Labtech). Alkalinity determined titrimetrically using methyl orange as indicator. Chloride was determined by the argenometric method using silver dichromate as the indicator.

Statistical Approach

The physicochemical variables were analysed and expressed as Mean ± SD (standard deviation). Dissimilarities between and among mean variables were computed by the one-way analysis of variance (ANOVA) using PAST 2000. The confidence level for all statistical based calculations was at p values < 0.05.

IV. Results and Discussion

In contemporary times the physicochemical status of freshwater is considered a prime factor in accessing water quality for multi-purported purposes; in drinking, irrigation, fisheries, and even public purpose.

In modern times much has been documented on the importance of water quality. Understanding the intricate processes that interplay to improve water quality to sustain/underwrite its multifunctional nature is therefore applicable to this study. These water variables and their dependence on life processes make it desirable to view water as having an environment. Water quality variables in Figure no's 2 to 13 reveal the limnological status at the various stations.

Knowledge on the nature and behaviour of water bodies (the structure and function of aquatic ecosystems) is fundamental to answering hugely pondered questions on ecology, water resources and water quality (Abujam et al., 2011). The quality of any aquatic system expressed its biological composition; the physical state of the water, its chemical composition, and the descriptions of aquatic organisms including species diversities. This study substantiates the many relationships between the physicochemical variables in water bodies (Tables1, 2 and 3). Foremost (are of great importance) in the management strategies of aquatic lives and ecosystems in totality (Matta et al., 2018). Comparing the ionic compositions in the current study at different days bore small differences across stations. The depth of our study sites makes it synonymous to a lake like an environment, with rooted macrophytes inferring a productive system (Yang et al., 2018), from its bounty zooplankton component provided by Iloba, (2014) (Nabila et al., 2014).

Figure 2 and 3 compares air (21-34°C) and water temperatures (20.5-31°C) for sampled stations in the course of the study. The higher mean values of air and water temperatures were observed towards the last days of April (April 20th – May 28th) and early days of May (May 6th – 10th) in station 3 respectively. Whereas, no statistically significant difference was seen in air and water temperatures of station I (20.5-31.0±2.96°C) and station II (20.5-30.0±2.79 °C) upon comparison ($p \geq 0.05$). As a rule, atmospheric and water temperature pivot on the geographic area plus the atmospheric conditions such as rainfall, humidity, cloud cover, wind velocity. The study further corroborates the conjoint behaviour of the atmospheric and water temperature (Bello et al., 2017). These meteorological conditions may be responsible for the changes seen in air and water temperatures across sampled stations.

Furthermore, it may affect the physicochemical variates and so the water quality. The air and water temperature dependent agree with those of Ojutiku and Kolo (2016). They observed that in the tropics, water temperatures are high all the year-round—the reported differences in air temperature between rainy and dry seasons appreciably affected water temperatures. The twain (air and water temperature range) befits the advisable limits. The twain (air and water temperature range) behoves the advisable values for aquaculture as reported by Dupree and Hunner (2014). They observed that warm water fish grow best at temperatures of between 25^{0}C and 32^{0}C, positioning the studied sites suitable for aquaculture usage (Bhatnagar and Devi, 2013). The routinely tropical temperature observed in this study will expedite the removal of accumulated litter in the sites, through decomposition and biogeochemical pathways (Lintern et al., 2018); accompanied by agitation and influx of water (Dupree and Hunner, 2014).

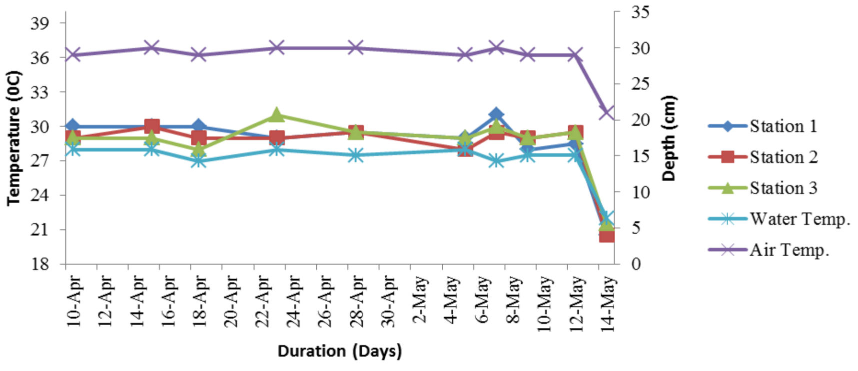

Figure no 2: Compares air and water temperatures with depths of sampled stations

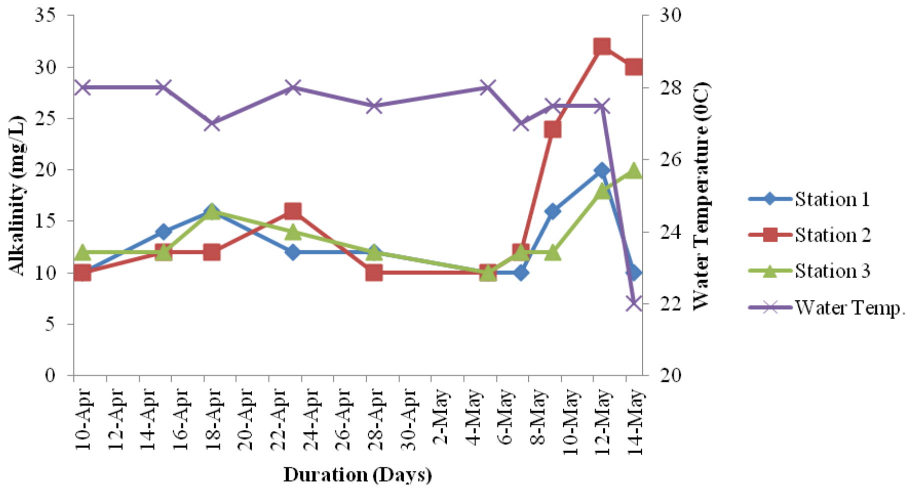

Figure no 3: Compares alkalinity level with water temperature across sampled stations

Again from figure 3 and 4, changes in alkalinity (10-32mg/$CaCO_3$) and acidity (146-556 mg/$CaCO_3$) levels due to changes in water temperatures were observed across sampled stations. Seen here was astatistically significant increase in alkalinity across stations (Figure 4), with station 2 showing the highest mean value in the first two weeks of April than any other stations. Here, alkalinity was observed to increase with increased temperature across sampled stations, peaking high (pH = 14) on April 18th (for station 1) as water temperature rosefrom 10^{o}C to 15^{o}C. This increase accompanied by a swift reduction (in station 2) in water temperature (1.0°C) decrease (to as low as 27^{0}C -28^{0}C) between 24th and 28th of April. Variation in alkalinity (10-32mg/$CaCO_3$) across sampled stations ranged from 10.0-20.0mg/L in station1 with a mean value of 13.0±3.43 mg/$CaCO_3$. Station 2 had a range of 10.0-32.0 mg/$CaCO_3$, and averaged between 16.8 ± 8.60 mg/CaCO3; whereas, Station 3 had a value of 10.0-20.0 mg/$CaCO_3$ with a mean value of 13.8±2.57mg/L. Alkalinity variation is indicative that the river falls within the acidic range and has a tremendous cushioning/modulating effects to outside interferences. Its monthly resiliency was significantly higher than in the Yobe River (Badejo et al., 2017).

The value recorded for water pH showed that the water was acidic for Stations 1, 2 and 3 with mean values of 5.6, 5.6 and 5.6, respectively (Fig. 5).The result compares well with that reported in the study of Iloba (2012) and Amitaye (2014) who found acidicpH of 6.3 and 6.5, respectively in River Ethiope, Delta State. Likewise, Ikomi and Arimoro (2014) published a slightly acidic pH of 4.6 - 6.4 range in the River Ethiope. These are reflective of the attribute of rainforest water bodies.

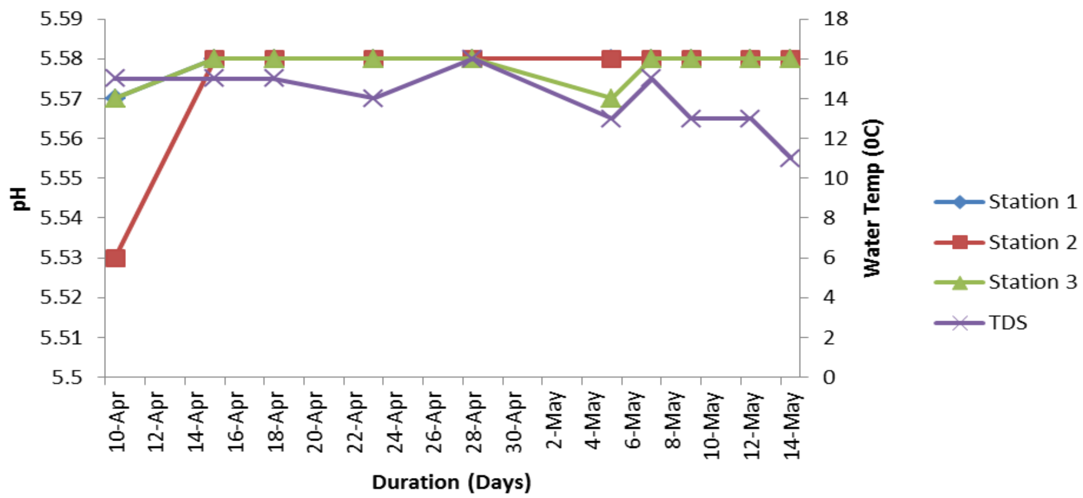

Figure no 5: Changes in pH occasioned by changes in water temperature across sampled stations

Figure 6 shows the observed level of acidity ranging from 146-502 mg/$CaCO_3$, an important indicator of water quality for sampled stations in studied water.

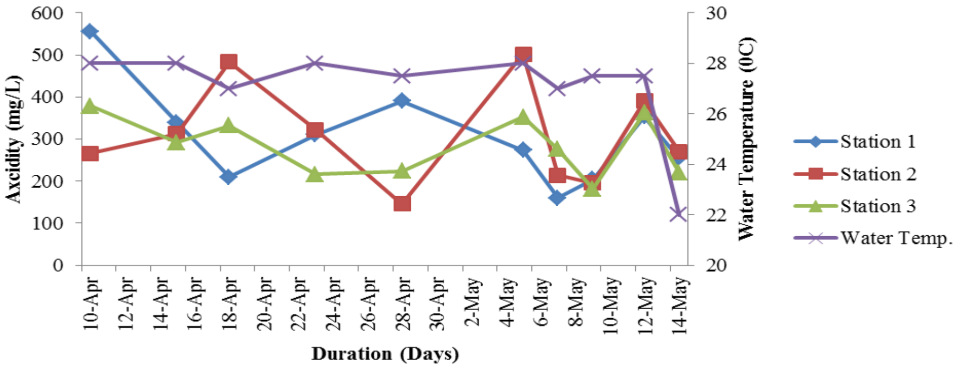

Figure no 6: Compares acidity levels with water temperature across sampled stations

Visible here are durational differences in levels of acidity between stations, with station 1 experiencing the lowest acidity between 6th and 8th day of May while peaking on April 10th. Stations 2 and 3 showed least acidity values on April 28th and May 10th, being highest on May 4th to May 6th, and May 12th respectively. Chemically, the registration of less than 6.4 hydrogen ion concentration (pH) is an indicator of carbonic acid-driven alkalinity. This pH range further predetermines the relatively high acidity noted in the present study (Rogowski and Stewart, 2016). Again, the alkalinity and acidity buffering effects will foster fish rearing and its general usage.

From figure 7, a statistically significant difference (p-value = 0.01353 at $p < 0.05$) was observed for total dissolved solids (TDS) (11-20mg/L) across sampled stations in Aragba stream. More important was the higher level of TDS seen in station 1(11-20±2.49mg/L) than any other sampled stations (11-18mg/L). The obvious reason for this is not far-fetched, possibly owing to the proximity of station 1 (than other stations) to the substratum. Here, maximum TDS was seen on April 14th for station 1, with average minimum TDS on May 14th. Low TDS in this study illustrates the slow dissolution of organic matter through autolysis and likely formation of amorphous carbon. The solids will not favour the growth of filter and amorphous filter feeders. The low nature of TDS noted makes the water good for fish culture and domestic use with minimal treatment and management.

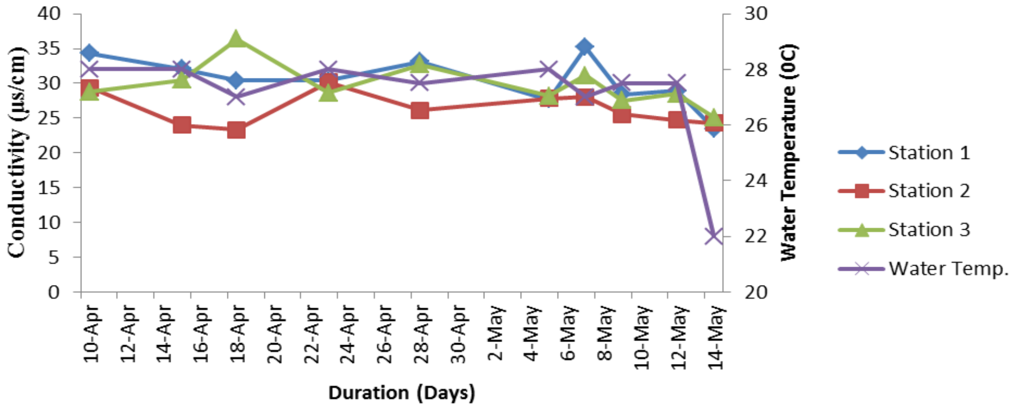

Figure no 7: Changes in total dissolved solids with temperature across sampled stations

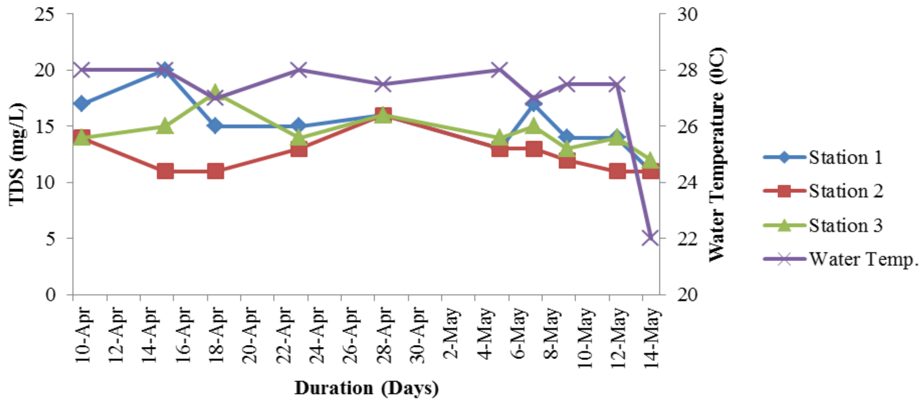

Figure no 8: Temperature-dependent changes in electrical conductivity across sampled stations

For electrical conductivity (figure 8), a statistically significant increase was observed (at p <0.05) amidst sampled stations (23.3-35.2) (p-value = 0.013) as water temperatures increased. This variation in conductivity (µS/cm) with respect to changing water temperature (in the sampling stations) ranged from 23.5-35.2µS/cm in station 1, which had a mean value of 30.4±3.49µS/cm, followed by 23.3-30.2µS/cm(26.32±2.39µS/cm) and 25.1- 32.7(29.7±3.13µS/cm) for stations 2 and 3 respectively. The highest conductivity value (35.2µS/cm) was seen in station 1, while the lowest value (23.3µS/cm) was in station 2.

Compared to the study of Ikhuoriah and Oronsaye (2016), these results were lower with reported conductivity value of 62.03-70.11 µS/cm. Conductivity is a function of the ionic strength of the water body, primarily determined by the presence and levels of concentration of sodium and magnesium ions and to some extent calcium ions. The low values highlight low values in alkalinity impacting ions. These ions help buffer the effect of bicarbonate and carbonate ions, thus maintaining the pH values. These values were far below WHO a maximum limit of 1000µS/cm (Bhatnagar and Devi, 2013).

Figure 9 shows changes in turbidity (16.1-68mg/L) and total dissolved solids (TDS)(11-20NTU) in respect to changes in Temperatures across sampled Stations. Here, turbidity was seen to vary (across stations) (16.1-86.0NTU) with temperature. Though the same cannot be said for TDS levels (11.0-20.0mg/l), the highest turbidity was in station 1 in the first and last days of sampling. In contrast, the lowest turbidity values were seen in station 3. Thus, the current study revealed that all the physical and chemical parameters (except turbidity and water temperature) showed no significant difference across the three (3) sampling stations.

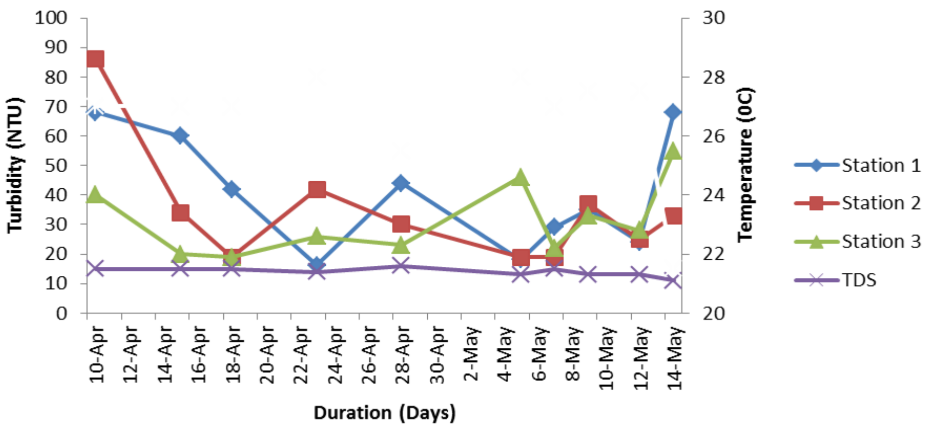

Figure no 9: Changes in turbidity and total dissolved solids due to changes in temperatures in sampled stations.

Similarly, Figure 10 reports the effect of temperature changes on dissolved oxygen (DO) concentration across Sampled Stations. The study noted low oxygen values (0.25-2.8mg/L). Station 1 had a higher mean value (0.90mg/L) of dissolved oxygen than other stations II (0.89 ±0.72) and III(0.7±0.46). As water temperature increased peaking highest in the 10th day of April (2.35 mg/L) than other studied days.

Tentatively, dissolved oxygen decreased with increased water temperature across stations, returning a statistically insignificant difference (p >0 .05 = 7.5) within groups (stations). Dissolved oxygen is crucial to run the basal metabolic processes of most aquatic organisms.

Dissolved oxygen is an essential parameter for the survival of fishes and other aquatic organisms as such the studied river will be excellent for aquaculture. Dissolved oxygen could be responsible for the sustenance of many chemical reactions required for proper water functioning (Mustak and Ersanli, 2015), thus contributing to its water quality integrity. Studies of Ojutiku and Kolo (2016) on water quality parameters of Agaie-Lapai dam in Niger State showed that the dissolved oxygen ranged from 3.8 –5.15mg/L, with temperature from 24.6 –29.0^{0}C. The present study water variables did not change in concordance with Ojutiku and Kolo's report. Thus, it was not within the tolerable limits.

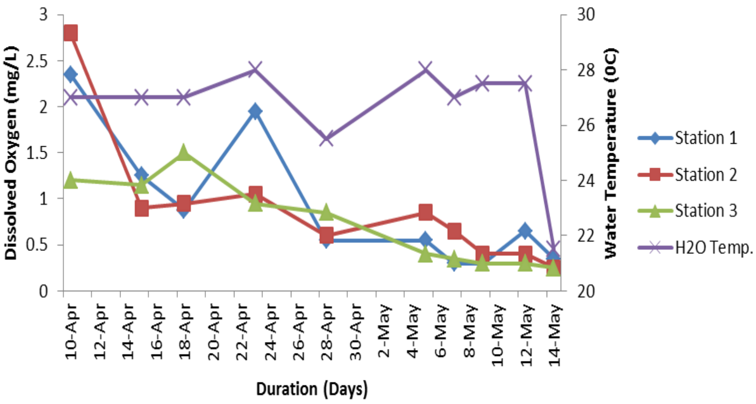

Figure no 10: Temperature-dependent changes in dissolved oxygen concentration across sampled stations

Of all environmental pollutants, studies have shown metals to pose significant potential toxic effect on the bioaccumulation of dissolved oxygen in the aquatic ecosystems (Wen et al. 2017). Among implicated aquatic parameters, dissolved oxygen is reportedly the most important. It is vital to aquatic fauna, playing an essential role in the respiration processes of aquatic lives. Predictably, the gross oxygen-deficient noted by the present study typifies the present organic load of the study sites (self-observation). Upon organic load withdrawal by human agents and management as well as with its lotic nature, would restore adequate oxygen necessary for good water quality and thus for aquatic life. (Yakubu et al., 2000).

The carbon dioxide production in the studied sites with amazingly high organic load was low (2.05-3.89mg/L) (Fig.11). Possibly the carbon dioxide output may have been drastically affected by emission to the outside or its utilisation through photosynthesis higher than its contribution through aeration and respiration (Stanley et al., 2017). The former will mean bounty for aquatic production (Salgado et al., 2018) while the latter result in suffocation and thus will require mechanical aeration (Iloba, 2014).

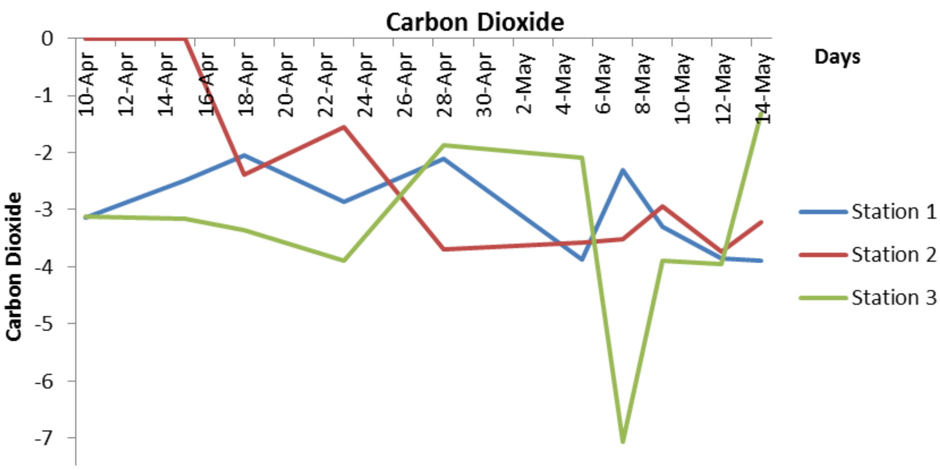

Figure no 11: Changes in Co_2 concentrations across sampled stations

Similarly, deficiency in phosphate (0.01-0.53mg/L) (Fig. 12) noted currently is worrisome as the magnitude of primary production in an aquatic ecosystem is dependent on nutrients, phosphate naturally limited (Friedland et al., 2012). The status of chloride ions (11.53-32mg/L) was within allowable limits. It will promote the multiplicity potentials of the aquatic organisms, including natural food in fish (Matta, 2018). The low

Chlorides values (Fig.13) in the present study reflect the Benin formation composition of this region sediment, majorly sand and few intercalated (Iloba, 2012; Obiadi and Obiadi, 2016). The insignificant chloride level indicates low mineralisation in the system since the Chloride index is for primary production indicators in the aquatic ecosystem (Matta, 2018).

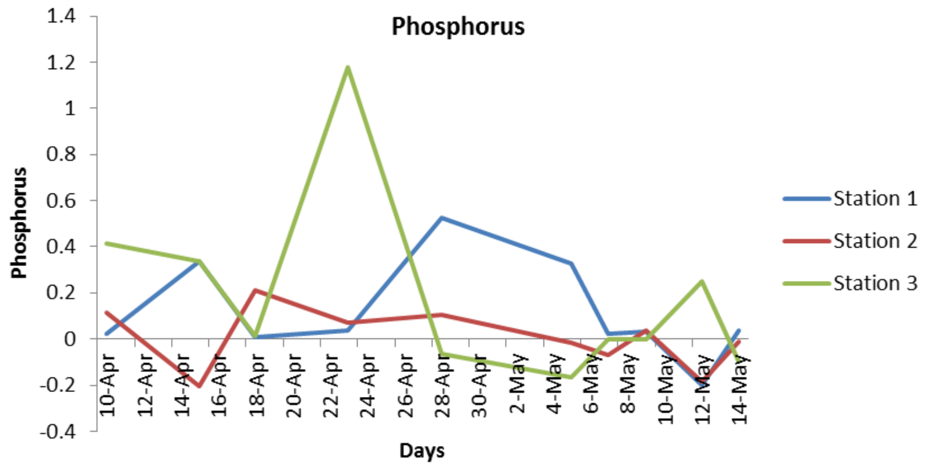

Figure no 12: Changes in Phosphate ion Concentrations across Sampled Stations

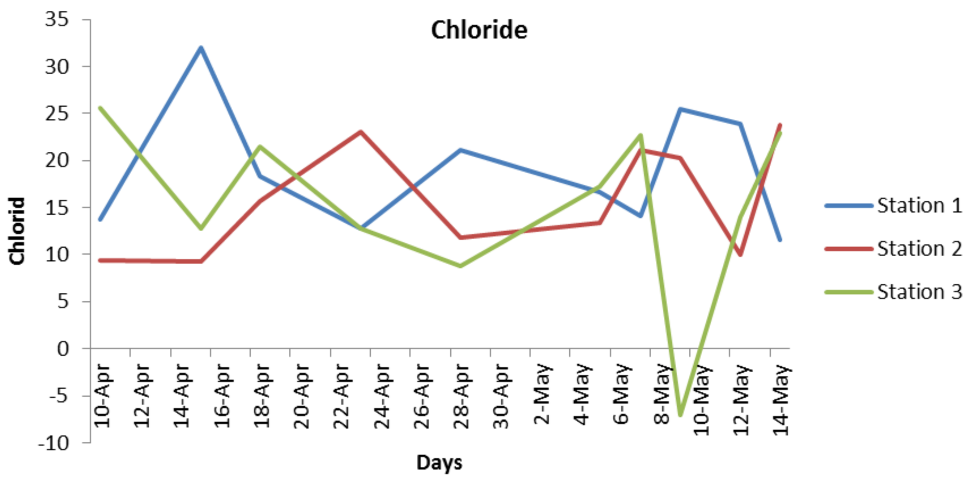

Figure no 13: Changes in chloride ion concentrations across sampled stations

The water quality parameters in the present study highly interact besides conductivity with air temperature and dissolved oxygen, respectively. Such collaborations or interdependence underwrites the resultant water quality, functioning and the integrity of Aragba River (Lintern et al., 2018). The present study revealed strong associations between parameters. Limnologically, every factor has an independent role. Nevertheless, at the same time the final effect is the actual result of the interactions of all the factors; serving as a basis for the richness or otherwise biological productivity of this aquatic environment (Davies et al., 2018).

V. Conclusion

This small river in Aragba (Iyikpesu) though neglected with all silages, is still good. Reviving, restoring and maintaining this water body and the likes will help the nation reduce its overbearing dependence on oil.

Table no 1: Correlation coefficients for the water variables in station 1

	Air Temp.	H_2O Temp.	Alkalinity	Acidity	DO	TDS	Conductivity	pH	Turbidity	Phosphorous
Air Temp.	1									
H_2O Temp.	0.930372	1								
Alkalinity	0.715684	0.92003	1							
Acidity	0.877667	0.985942	0.957029	1						
DO	0.99663	0.954189	0.764248	0.910741	1					
TDS	0.868615	0.984613	0.962976	0.999608	0.903216	1				
Conductivity	0.435727*	0.731062	0.939342	0.808734	0.499426*	0.820125	1			
pH	0.689105	0.905015	0.99882	0.947413	0.740283	0.954132	0.951257	1		
Turbidity	0.867686	0.984938	0.963669	0.999025	0.901993	0.999312	0.821408	0.955219	1	
Phosphorous	0.592122	0.84277	0.984268	0.895347	0.646246	0.90399	0.980609	0.988648	0.906276	1

Table no 2: Correlation coefficients for the water variablesin station 2

	Air Temp.	H_2O Temp.	Alkalinity	Acidity	DO	TDS	Conductivity	pH	Turbidity	Phosphorous
Air Temp.	1									
H_2O Temp.	0.981731	1								
Alkalinity	0.964865	0.98141	1							
Acidity	0.98423	0.999105	0.983277	1						
DO	0.942585	0.967438	0.902304	0.963369	1					
TDS	0.856624	0.849624	0.932517	0.85709	0.694259	1				
Conductivity	0.971949	0.997132	0.975438	0.996893	0.972826	0.836672	1			
pH	0.768829	0.818205	0.698912	0.808951	0.927785	0.394137*	0.82914	1		
Turbidity	0.924342	0.925725	0.978355	0.930748	0.804447	0.983827	0.91528	0.544058*	1	
Phosphorous	0.829776	0.807307	0.897848	0.818768	0.643153	0.990625	0.79386	0.328395*	0.967604	1

Table no 3: Correlation coefficients for the water variablesin station 3

	Air Temp.	H_2O Temp.	Alkalinity	Acidity	DO	TDS	Conductivity	pH	Turbidity	Phosphorous
Air Temp.	1									
H_2O Temp.	0.995101	1								
Alkalinity	0.953001	0.975568	1							
Acidity	0.896508	0.930987	0.987515	1						
DO	0.992943	0.999013	0.975267	0.93295	1					
TDS	0.961801	0.933993	0.834409	0.743023	0.931473	1				
Conductivity	0.7972	0.84507	0.941459	0.981309	0.846844	0.602579	1			
pH	0.975686	0.989508	0.9894	0.965569	0.99231	0.887014	0.897832	1		
Turbidity	0.976863	0.956275	0.869468	0.784416	0.953126	0.99629	0.652877	0.912507	1	
Phosphorous	0.974371	0.983785	0.98644	0.962746	0.985189	0.884469	0.897459	0.99495	0.907455	1

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