

ASSESSING THE PHYSICO-CHEMICAL PROPERTIES OF ALETO RIVER, ELEME, RIVERS STATE FOR FISH PRODUCTION

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ABSTRACT

This study was carried out to examine the Physico-chemical parameters of Aleto River, Rivers State. Monthly data were collected from November 2020 to February 2021. The Physico-chemical parameters were determined using standard ecological analytic procedures. Results were subjected to analysis of variance (ANOVA) with Turkey's Honestly Significant Difference (HSD) post-hoc test at 95% confidence interval to determine the significance of differences in mean values. The results showed upstream, midstream and downstream mean temperatures (27.65 ± 0.6 , 28.78 ± 0.58 , 29.28 ± 0.89), pH (7.59 ± 0.35 , 7.28 ± 0.24 , 7.4 ± 0.34), total dissolved solids (112.83 ± 74.8 , 169.95 ± 181.55 , 213.7 ± 168.67), biochemical oxygen demand (1.45 ± 0.22 , 0.7 ± 0.33 , 2.4 ± 0.53) and salinity (37.93 ± 27.36 , 52.79 ± 40.53 , 22.62 ± 13.98). These are suitable for fish production. Dissolved oxygen (4.08 ± 0.64 - 5.18 ± 0.05 mg/l) was below the permissible limit while electrical conductivity (197.28 ± 150.39 - 483.4 ± 280.44 µs/cm) was above the permissible limit of WHO and Federal Ministry of Environment. The study concludes that the river was suitable for fish production and domestic use. However, due to industrial effluent discharge and anthropogenic activities in and around the river, mitigation and regular monitoring of the river are therefore recommended.

Key Words: Aleto River, physico-chemistry, effluent discharge, fish production.

INTRODUCTION

Life without water is impossible as it is significantly important for all living creatures on earth, at least in the form of moisture. Though more than 70% of the earth is covered with water, access to quality and safe water is challenging to most organisms as water sources are constantly being polluted (Chidozie and Nwakanma, 2017). Pollution of the aquatic environment by inorganic chemicals is a major threat to water quality, aquatic life, and organisms depending on water directly for drinking sources and indirectly through bio-accumulation. Their direct toxicity to man and aquatic organisms, and the indirect toxicity through their accumulation in the aquatic food chain are issues of serious concern (Adesuyi *et al.*, 2016). Anthropogenic influence on the aquatic ecosystem, however, has increased the rate of contamination of the ecosystem than it would have occurred naturally (Bhat *et al.*, 2019). Such interactions were triggered by a rapid increase in human population size, urbanization of settlements, and industrialization to tackle the needs of mankind (Chandan *et al.*, 2017; Setia *et al.*, 2020). Contamination of the aquatic environment and fluvial ecosystems are of public concern due to the non-degradability, accumulation, and toxicity of several potentially toxic pollutants (Li *et al.*, 2019).

The estuaries are marked with rapid changes in physico-chemistry due to the influx of fresh water into the marine. Such spatial variations maybe seasonal or irregularly unpredictable as a result of the unchecked point source introduction of pollutants into an aquatic environment. Pollution, among other things, is known to alter the Physico-chemical parameters of water bodies (Gbarakoro *et al.*, 2020). The physico-chemistry of an aquatic

environment entails its physical characteristics like colour, temperature, turbidity, currents, depth, and flow of the water body; in addition to chemical characteristics which are reflections of the soil and rocks the water has been in contact with, such as total suspended solids, salinity, electrical conductivity, hydrogen ion concentration and concentration of solutes. These parameters are indicators of water quality (Faiza *et al.*, 2018) and also reflect the type and diversity of aquatic biota (David, 2014).

Aquatic biota is influenced in number and diversity by food availability, spawning areas, and the physico-chemistry of the water. Physico-chemical parameters of water bodies directly affect the survival, fecundity, and breeding of fishery resources as niche, foraging activities, metabolism, and physiology are dependent on the water environment for optimal functions (DPR, 2002). Current (Bob-Manuel, 2006), temperature (Komi and Sikoki, 2013), salinity (Edokpayi, 2005), dissolved oxygen (Jingxi *et al.*, 2020), total dissolved solids, conductance, pH (Zhang *et al.*, 2015), biochemical oxygen demand and nutrients (Vincent-Akpu and Offiong, 2019) make up important limiting factors in the viability of ichthyofauna production in inland and flowing waters.

Dissolved oxygen plays the role of regulating metabolic activities of organisms, consequentially governing the metabolism of the biological community as a whole, and is used as an indicator of the trophic status of water (Kidu *et al.*, 2015). However, its requirements for any fish species vary with age, temperature, and concentration of minerals in the water (Dastagir *et al.*, 2014). In estuaries, pH ranging from 8-9 is appropriate for the survival and growth of

indigenous fish species (Water Watch/Namoi CMA, 2013). Temperature changes are known to influence the life cycle (Water Watch/Namoi CMA, 2013), rate of development, parasite infestation, fecundity, movement, and migratory patterns of aquatic organisms including fish (Komi and Sikoki, 2013). Total dissolved solids concentration below 200 mg/L promoted even healthier spawning conditions (Deepak and Singh, 2014). The electrical conductivity of water is directly proportional to its dissolved mineral matter content.

Fish species show a difference in preference to water quality for optimal growth and fecundity (Kausar and Salim, 2006). However, there are narrow limits in physico-chemistry for which fin and shellfishes thrive in their natural environments (Bartholomew, 2010). These limits have been studied and published by national and international regulatory bodies for policymaking and in sustainable management of affected environments. Since the level of the physico-chemistry of the Aleto River is not clear, this study aims to provide empirical evidence of these parameters in line with regulatory standards and their support for artisanal and commercial fish production.

MATERIALS AND METHODS

Study Area

Aleto Stream is a tributary of the Imo River and lies between latitude 4°50'0" North of the equator and longitude 7°10'0" East of the Greenwich meridian in Eleme Local Government Area of Rivers State, Nigeria. Its seasons and climate conditions have been duly reported by Nigeria

Meteorological Agency (NIMET, 2009). The upper part of the stream extends from Imo River and meanders through Oyigbo and Agbonchia. This upstream reach, particularly Agbonchia, is freshwater with forest vegetation comprising of various palms and aquatic macrophytes such as *Lemna* and *Pistia* species. Downstream, the creek extends to Akpajo and is linked to the Okrika arm of the Bonny River estuary. Vegetative cover is comprised of *Avicennia africana*, *Rhizophora racemosa*, *Acrostichum* spp, and other mangrove types. The river is unidirectional with two tidal flows, high tide, and low tide. It is fresh water at the upper reaches but brackish downstream.

The study divided Aleto River into three stations to compare differences in the physico-chemistry of the River. Station one is recognized as downstream. It is also the discharge point of the wastewater coming from surrounding industries. The major activity going on here is the commercial dredging of sand.

Station two is a distance away from station one and is recognized as the midstream. Ferns and mangroves make up the vegetative cover here. The main activity going on is the dredging of sand and artisanal fishing.

Station three is upstream of station two. Aquatic macrophytes and mangroves make up the flora at the shoreline. The station is characterized by human settlement and activities such as fishing, overhung public latrines where human faecal wastes are discharged into the river directly, and the presence of a local cow skin/meat processing establishment.

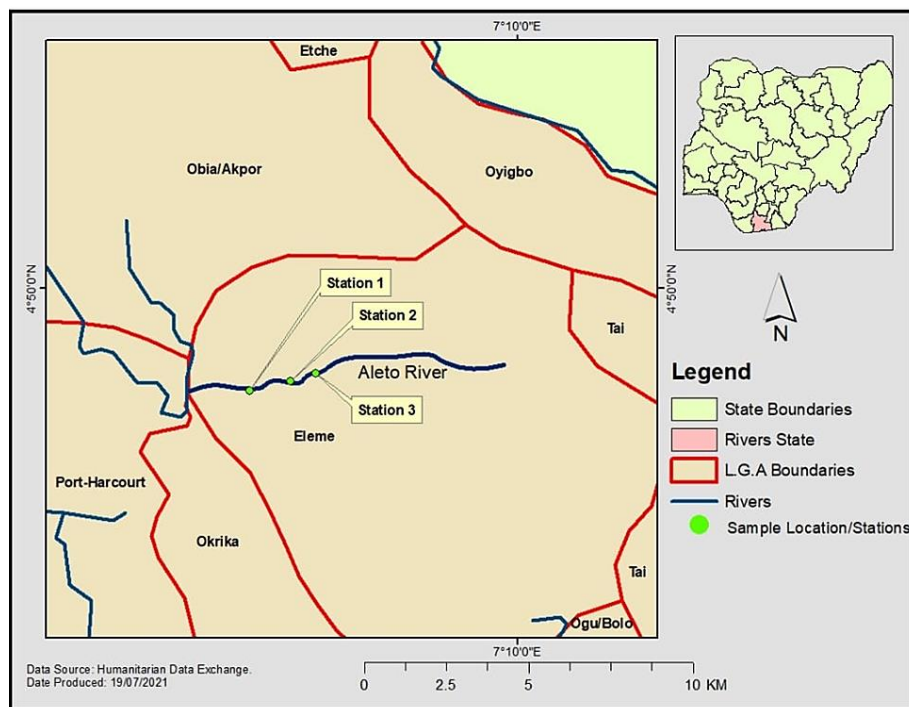


Figure1: Map showing the study area of Aleto River in Rivers State.

Analysis of Physico-Chemical Parameters

The Physico-chemical parameters studied in the Aletto River were temperature, salinity, hydrogen ion concentration (pH), total dissolved solids, electrical conductivity, dissolved oxygen, and biochemical oxygen demand. Temperature, hydrogen ion concentration (pH), total dissolved solids (TDS), electrical conductivity (EC) were analyzed in-situ using a multi-meter water checker (ultra-meter 11 6PFC). The ultra-meter was calibrated with the sensor storage solution. The water checker was rinsed five times to ensure that no substance was in the equipment. The water sample was poured into the water checker and the button for the parameter to be analyzed was turned on and the reading was recorded. It was repeated in triplicates and the mean values were calculated.

Dissolved oxygen was analyzed in-situ with a PRO DO METER (Digital Professional Series YS1Dissolved Oxygen Meter). The probe of the meter was inserted 10-15cm into the stream and the meter was switched on. The value was recorded when the reading was stable. The same was done in triplicate and the mean values were calculated. Salinity was analyzed in the laboratory using Sper Bench-Top Water Quality Meter (860033) Model. Water samples were taken from the three stations

into three plastic bottles and stored in a cooler for laboratory analysis. In the laboratory, the water quality meter was calibrated and the probe of the meter was inserted into a 'PYREX' 400ml beaker containing water sample, and the salinity button was switched and allowed to stabilize for ten minutes. The same was repeated in triplicates and the mean value was calculated and recorded. Biological oxygen demand (BOD) was analyzed ex-situ using standard methods (APHA, 1998).

STATISTICAL ANALYSIS

The analysis of variance (ANOVA) with Turkey's Honestly Significant Difference (HSD) post-hoc test was used to determine significant differences in the Physico-chemical properties of Aletto River at the different sampling stations. The probability level was set at 0.05. All statistical calculations were carried out using IBM SPSS Statistics 20.

RESULTS

The results of the Physico-chemical parameters (Temperature, pH, Salinity, Electrical conductivity and Total Dissolved Solids) are presented in the table below.

Table 1: Mean and Standard deviation of Physico-chemical parameters across the stations in comparison to international and national standards.

Parameters	Downstream (Min-Max) $\bar{x} \pm SD$	Midstream (Min-Max) $\bar{x} \pm SD$	Upstream (Min-Max) $\bar{x} \pm SD$	WHO (2011)	FMEnv (2002)
Dissolved oxygen (mg/l)	4.3-5.8 4.08±0.64	4.6-4.7 4.65±0.05	5.1-5.2 5.18±0.05	5	6.8
Temperature (°c)	27.2-28.6 ^a 27.65±0.6	28.1-29.4 ^b 28.78±0.58	28.3-30.1 ^b 29.28±0.89	30	20-33
Conductivity (µs/cm)	22.7-410.0 197.28±150.39	41.1-755.0 327.53±299.22	54.6-768.0 483.4±280.44	600	Na
Total dissolved solids (ppm)	30.3-224.0 112.83±74.8	39.5-462.0 169.95±181.55	32.5-375.0 213.7±168.67	500	Na
pH	7.24-8.12 7.59±0.35	7.01-7.62 7.28±0.24	7.08-7.80 7.4±0.34	6.5-8.50	8.5
Salinity (mg/l)	1.52-63.50 37.93±27.36	3.16-90.10 52.79±40.53	0.37-33.70 22.62±13.98	250	Na
BOD (mg/l)	1.2-1.7 ^a 1.45±0.22	0.4-1.2 ^a 0.7±0.33	1.6-2.9 ^b 2.4±0.53	10	4.0

Values with different superscripts are statistically significant at p<0.05. pH – Hydrogen ion concentration; BOD - Biological Oxygen Demand; WHO (2011) - World Health Organization; FMEnv- Federal Ministry Of Environment National Environmental (Surface Water And Ground Water Quality Control) Regulations, 2002; na – not available; °C – degree Celcius; mg/l – milligram per liter; ppm – parts per million; µs/cm – microSiemens per centimeter; pH – Hydrogen ion concentration

Dissolved oxygen in Aleto River was between 4.08 ± 0.64 downstream and 5.18 ± 0.05 at upstream. Temperature decreased progressively from upstream to downstream with values ranging between $29.28 \pm 0.89^\circ\text{C}$ and $27.65 \pm 0.6^\circ\text{C}$. Hydrogen ion concentration (pH) ranged from 7.28 ± 0.24 at midstream to 7.59 ± 0.35 at the downstream of the river. The salinity value of the study area is highest (52.79 ± 40.53) at midstream and lowest (22.62 ± 13.98) at upstream. Electrical conductivity increases progressively from 197.28 ± 150.39 at downstream to 483.4 ± 280.44 at upstream. Total dissolved solid was between 112.83 ± 74.8 and 213.7 ± 168.67 . BOD value was least (0.7 ± 0.33) at midstream and highest (2.4 ± 0.53) at upstream.

DISCUSSION

Temperature

Temperature decreased progressively from upstream to downstream with values ranging between $29.28 \pm 0.89^\circ\text{C}$ and $27.65 \pm 0.6^\circ\text{C}$. Ogbonna (2014) recorded a similar result in selected rivers in Port Harcourt Metropolis in the Niger Delta of Nigeria. The difference in temperatures in the study area was due to the enormous activities going in the stream as well as its morphometric characteristics. An increase in temperatures has been reported by Ayode and Olusegun (2012) in Ogbere River to be caused by a large number of suspended solids from cassava peels and domestic wastes.

Hydrogen ion concentration

Hydrogen ion concentration (pH) ranged from 7.28 ± 0.24 at midstream to 7.59 ± 0.35 at the downstream of the river. The values are within the WHO (2011) limits of 6.5-8.50 for aquatic life. Kidu *et al.* (2015) stated that pH monitoring is essential for the assessment of aquatic ecosystem health especially fisheries, irrigation, and drinking water sources, industrial discharges, and surface water runoff since pH indicates the intensity of the acidic or basic character of a solution and is controlled by the dissolved chemical compounds and biochemical processes in a water body. The pH of freshwater is decreased following a decrease in pH of rainwater and runoff containing a high concentration of carbon (IV) oxide caused by gas flaring (Beetseh and Ichakpa, 2015), while wastewater, particularly those that contain detergents and soap-based products also change water pH to alkaline (Nouken *et al.*, 2016).

Salinity

Salinity is one of the important factors which profoundly affect the abundance and distribution of animals in estuaries and freshwaters. Salinity hampers with osmoregulation and the

development of fish eggs. The salinity value of the study area is highest (52.79 ± 40.53) at midstream and lowest (22.62 ± 13.98) at upstream. The variations in values may be due to a reduction in effluent mixing, industrial and domestic discharge. Komi and Sikoki (2013) posit that salinity in the Andoni River system is influenced by the volume of precipitation and quantity of runoff water into the water body.

Electrical Conductivity

Electrical conductivity, a measure of water capacity to conduct electric current, increases progressively from 197.28 ± 150.39 downstream to 483.4 ± 280.44 upstream which is lower than the WHO limit (600) for the inland freshwater system. The influx of sewage systems would raise the conductivity because of the presence of chloride, phosphate, and nitrate. Similarly, low flow of water, reduced volume, and stagnation of water are causative agents of high electric conductance (Zebib and Teame, 2017). On the contrary, oil spills would lower the conductivity (EPA, 2012). Raji *et al.*, (2015) reported quite lower values in River Sokoto in Northwestern Nigeria.

Total dissolved solids

Vincent-Akpu and Offiong (2019) attributed total dissolved solutes of a natural water body to the salt intrusion of organic sources such as leaves, silt, and plankton from the sea, as well as industrial wastes and sewage. From the study, the total dissolved solid was between 112.83 ± 74.8 and 213.7 ± 168.67 but within WHO limits of 500. Total Dissolved Solids (TDS) in freshwater bodies change due to industrial effluents discharge (Phyllis and Lawrence, 2007). Imoobe and Oboh (2003) and Olele and Ekelemu (2008) stated the higher TDS value in water bodies during the dry season may be due to the evaporation of water leaving a higher concentration of salt within a smaller volume of water.

Dissolved oxygen

The diversity of species, pattern of recruitment into maturity, reproductive and hatching success, change in abundance and embryonic development are the indirect effect of dissolved oxygen on fish production in addition to suffocation and loss of appetite (Clark, 1996).

Dissolved oxygen in Aleto River was between 4.08 ± 0.64 downstream and 5.18 ± 0.05 at upstream. At the downstream of Aleto River, dissolved oxygen was below the maximum tolerance level for fish (5mg/L) reported by Jingxi *et al.* (2020). This study does not affirm the findings of Kuligiewicz *et al.*, (2015) that dissolved oxygen in an aquatic system is inversely related to the water's temperature since temperature increased progressively as dissolved oxygen.

Biochemical oxygen demand

Biological oxygen demand measures the amount of oxygen required by bacteria for breaking down to simpler substances of the decomposable organic matter present in any water, wastewater, or treated effluent. Alteration in BOD levels is directly proportional to the quantity of decomposable matter in a water body but inversely proportional to available dissolved oxygen (TVA, 1995). An increase in BOD concentration may cause the death of some aquatic organisms such as fish and increase eutrophication (Chandan *et al.*, 2017). BOD value was least (0.7 ± 0.33) at midstream and highest (2.4 ± 0.53) at upstream. This study is consistent with the postulation of Arimoro and Ikomi (2008) from their findings at Orogodo River in the Niger Delta Region that increases in the levels of nitrates and phosphates reduce the level of oxygen but increase the level of Biological Oxygen Demand (BOD). The statistical significance in the rise in BOD at the upstream may be due to effluent and domestic discharge from the traditional cow skin processing establishment upland and direct sewage disposal systems at the shoreline.

CONCLUSION

The physico-chemistry of the river captured by this study is mostly within international and local limits for fish production and domestic water use (WHO, 2011a; FMEnv. 2002). The few exceptions were observed in electrical conductivity and dissolved oxygen which was below limits. The overall physicochemical parameters showed that the river was suitable for fish production. The study, however, recommends an assessment of the stress levels of individual Physico-chemical properties of the Aleto River to specific commercial and local fish species. Remediation of the stretch of Aleto River and implementation of laws to prohibit the direct and indirect discharge of untreated, mistreated, and mal-treated disposal of any kind of waste from large industries to traditional activities; like open-defecation into the water and local meat processing slab which make up the primary and secondary sources of alterations in the health status of the river system.

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