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PHYSICO-CHEMICAL PARAMETERS OF THE LOTIC SYSTEM IN THE DERIVED SAVANNA, CROSS RIVER STATE, NIGERIA

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Abstract

The study was carried out to determine the Physico-Chemical parameters in the lotic system of the Derived Savanna, Cross River State, Nigeria. The study areas were Ogoja, Yala, Bekwara, Obudu and Obanliku Local Government Areas with each divided into four sampling points totaling twenty (20). Data of Physico-Chemical parameters of the lotic system were collected during the dry and rainy seasons from January to December, 2022. Temperature, pH and conductivity were measured using multipurpose thermos-scientific orion meter. Dissolved oxygen was measured with dissolved oxygen meter. Salinity was measured using hand held refractometer. Turbidity was measured using turbidimeter. The data were analyzed using descriptive statistics and ANOVA. The result of physico-chemical parameters showed that temperature ranged (27.1±0.67 - 28.0±0.46 ºC), this was highest in Akorshie River in Obanliku with mean values 28.0 ±0.46ºC and lowest in Kigbe Stream in Obudu with mean values 27.1 ±0.67ºC. The pH ranged (8.28±0.36 - 8.87±0.29), highest in Abebe Stream in Obudu with mean values 8.87±0.29 and lowest in Ranch Stream in Obanliku with mean values 8.28±0.36. The turbidity ranged (18.2±0.25 - 18.7±0.35 NTU) highest in Nwol River in Ogoja with mean values 18.7±0.35 NTU and lowest in Buabia Stream in Obudu with mean values 18.2 ± 0.25NTU.Salinity ranged (-66.5±0.81‰ -68.3±1.53 ‰) highest in Kigbe Stream in Obudu with mean values -68.3±1.53 ‰ and lowest in Basun River in Obudu with mean values -66.5±0.81‰. Dissolved Oxygen (5.13±0.47 - 6.19±0.45mg/l) highest in Okpoku River in Yala with mean values 6.19±0.45mg/l and lowest in Ibil River in Ogoja with mean values 5.13±0.47 mg/l. Conductivity (64.35 ±1.02 - 73.2±0.99 µs/cm) was highest in Bansara River in Ogoja with mean values 73.2±0.99 µs/cm and lowest in Onyinne Stream in Bekwara with mean values 64.35 ±1.02 µs/cm. The ranged of values were within WHO acceptable limits for clean tropical freshwater bodies. It is recommended that further studies be carried out on the lentic system of the derived savanna.

Keywords: Physico-Chemical,Temperature,pH,Conductivity,Dissolvedoxygen,salinity, turbidity.

INTRODUCTION: The river system constitutes a major source of fresh water supply. This comprises of both main course and the tributaries carrying the one-way flow of a significant load of matter in dissolved and particulate phases from natural and anthropogenic sources. Distribution of aquatic resources like fish and other aquatic animals is governed largely by variation in physico-chemical parameters of a specific water body (Ndome, Mowang, Okorafor, and Nkereuwem, 2014). It is recorded that above fifty different types and 80% of diseases like diarrhea, skin diseases, malnutrition, cancer and 50% of child deaths are caused by drinking of polluted water around the world (UN-Water, 2013; Lin *et al.*, 2022). Monitoring of physico-chemical parameters in aquaculture cannot be over underscored, for fish life and the lives of other animals are solely reliant on these limitations. Toxicity of certain chemical to fish and other aquatic organisms is governed by the physico-chemical parameters (GlennDombeck, 2005). Water temperature is one of the most important factors of the aquatic ecosystem. Temperature affects other important factors of the aquatic ecosystem such as the amount of oxygen that can dissolve in water and the rate of photosynthesis by algae and larger aquatic plants (Michand, 1991). The metabolic rate of aquatic organisms depends on temperature, and the sensitivity of organisms to toxic wastes, parasites and diseases (GlennDombeck, 2005). This is because every reaction in organisms is regulated by enzymes which function best at temperatures typical for the organism in which they are found (Michand, 1991; GlennDombeck, 2005). The pH of water refers to the amount of H^+ or OH^- (Hydrogen or hydroxyl ions) present. The operation of most biological processes is limited to a pH range of 6.5 to 8.5, outside this range, biological activities decline or cease (Pillay, 1992; Lind, 1997; Windelspecht and Harris, 2001). The pH value is influenced by changes in carbon dioxide, carbonates and bicarbonates system. At higher rates of photosynthesis, pH increases to a high level by afternoon and hydroxyl alkalinity is produced. Due to high rates of photosynthesis and the concurrent use of free carbon dioxide and bicarbonates from euphotic zone, pH increases ($CaCo_3$ is precipitated). At high temperatures, solar radiation accelerates photosynthesis, which in turn increases carbon dioxide absorption, thus altering the bicarbonates equilibrium and producing OH which in turn raises the pH (Branco and Senna, 1996; Dublin-Green, Ayinla, and Ogori, 2003). Bilewu, Ayanda and Ajayi (2022) studied the assessment of physicochemical Parameters in selected water bodies in Oyo and Lagos States. The reported that the physicochemical parameters analyzed were pH, electrical conductivity (EC), salinity, total dissolved solids (TDS), chloride, biochemical oxygen demand (BOD) and dissolved oxygen (DO). Average salinity value ranged between 0.2675 ± 0.14 mg/L (UI) and 0.6735 ± 0.22 mg/L (Berger). These values are quite high and significant when compared to the threshold level of 0.0000001 mg/L. Of the three sampling points, the samples obtained from Awba Dam at the University of Ibadan seem to have the better quality in relative terms. This follows from the BOD and TDS values of 3.75 ± 0.28 mg/L and 259.7 ± 156.89 mg/L respectively. This study shows that the mismanagement of our waters through unrestrained and unrestricted dumping of contaminants into it has caused these water bodies to have poor quality and should not be used for the purpose of consumption unless properly treated. The presence of aquatic plants that take in some of these pollutants and release oxygen may also help improve quality. Suresh, Bharati, Durgesh and Bhoopendra (2022) reviewed on the Physicochemical Parameters of Water Concerning their Effect on Biotic Population. They reported that it is necessary to know details about different physicochemical parameters such as temperature, total hardness (TH), pH, sulphate, phosphate, nitrate, chloride, fluoride, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total alkalinity and total dissolved solids (TDS) used for testing of water quality. Heavy metals such as Pb, As, Cr, Fe, Hg, Cd etc. are of exclusive crisis because they make water unfit for domestic usage or long-term poisoning of aquatic organisms. In our present review we have collected the water analysis records with physicochemical parameters which will help in further research activities and maintaining the purity of water.

According to Akin-Oriola (2003), the pH of water shows variability from season to season in aquatic systems in both tropical and temperate regions. Natural waters exhibit wide variations in relative acidity and alkalinity, not only in actual pH values but also in the amount of dissolved material causing the acidity or alkalinity. The concentration of these compounds and the ratio of one to another determine the actual pH and the buffering capacity of a given water body (Wetzel, 2001). Shwetanshumala and Sharma (2020) studied the Physicochemical characteristics of water at Nandeshwar Dam, Udaipur, Rajasthan. The maximum air temperature was 42.10ºC in May. The observations of air temperature had a positive significant relationship with water temperature, pH, bicarbonate, alkalinity, EC, nitrate-nitrogen. The surface water temperature variation was between 16.30–30.60ºC. The observations on water temperature had a positive significant relationship with air temperature, pH, EC and negative correlation with DO. Surface water pH variations between 7.13–8.53. Depth of visibility during the study period was found to range from 34.47–63.27 cm. The observations on the depth of visibility had positive significant relationship with pH, DO, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, nitrate-nitrogen, orthophosphate and negative correlation with EC. The DO, total alkalinity, EC and TDS of surface water showed variations between 7.07–9.07 mg/l, 75.13–101.27 mg/l, 0.133–0.480 mS cm-l, 85.33–309.33 mg/l during the study period. Nitrate-nitrogen in the surface water ranged between 0.043–0.099 mg/l during the study period. Sarma *et al.* (2017) made a study to analyze the Water Quality Index (WQI), analysis of variations of Water Quality Index parameters along the Kolong river Nagaon, Assam. The seasonal changes of physicochemical characteristics of Kolong river were also analyzed. In this study, river samples were collected and analyzed from 7 different study sites for 6 different times from October 2016 to February 2017. The physicochemical parameter of water like turbidity, pH, iron, nitrate, fluoride, hardness, chloride, manganese was analyzed. The WQI value of these samples ranged from 134.64–565.58, which showed that water in all the spots was unsuitable for drinking. Thus, the river needs a proper treatment to conserve this water body from future contamination with pollutants.

The existence of some pollutants can lead to varying pH values, like oxides of sulphur and nitrogen which are converted to nitric and sulphuric acids, especially when calculated and documented continuously, together with the electrical conductivity of a water body (Moisès, Kgabi and Lewis, 2020). Electrical Conductivity (EC) is determined by the number of solids that are dissolved in water. It is affected by temperature and rainfall between seasons (Odhiambo and Gichuki, 2000; Akin- Oriola, 2003). Electrical conductivity varies from time to time in aquatic systems within the same or different seasons (Chapman and Kramer, 1991; Akin-Oriola 2003; Chindah and Braide, 2004). The measurement of water's ability to conduct electricity is called conductivity or specific conductance and is measured in micro-mhos per centimeter or micro-siemens per centimeter. Different aquatic systems have different electrical conductivities. Electrical conductivity varies between and even within water bodies, sometimes even within the same water body, different points or areas may have different electrical conductivities. Soft water has less dissolved salts (ions) and therefore less electrical conductivity when compared to hard water.

The Ryder (1965) equation shows a clear relationship between Total Dissolved Solid (TDS) and EC which is always positive Henderson and Welcomme, 1974). Rainfall, interacting with the atmosphere, vegetation, rocks and soil is the major source of dissolved solids in streams. Dissolved Oxygen (DO) is the amount of oxygen gas dissolved in a given quantity of water at a given temperature and atmospheric pressure, it is expressed in parts per million, percentage saturation or milligram per liter (Master *et al*., 1998; Branco and Senna, 1996). Waters of consistently high dissolved oxygen are usually considered healthy and stable aquatic ecosystem capable of supporting many different kinds of aquatic organisms. Oxygen saturation percentage is influenced by phytoplankton densities and organic matter decay (Branco and Senna, 1996). Dissolved oxygen in water comes from the atmosphere, waves on lakes and slow-moving rivers and tumbling waters, and fast-moving rivers. Sudden and gradual depletion in dissolved oxygen can cause major shifts in the kinds of aquatic organisms, from pollution-intolerant species (Chindah and Braide, 2004). Singh (2020) observed that the temperature of water samples has been found between 28–30ºC near industrial area of Pali, Rajasthan. Minimum value was observed in January (18.4ºC) and maximum was documented in June (38.5ºC). The pH value ranged between 7.5–9.5 in water samples which indicated alkaline character of water chiefly due to carbonate and bicarbonate. DO value indicated high pollution level as it was very less than the required amount (2–4 mg/L) of oxygen to sustain life. The total hardness values were found in range of 206–332 mg/L. The greatest value was found in May and lowest in January. Highest recorded value of BOD was 704 mg/L in the month of January and least value was 330 mg/L observed in month of May. Recorded value of EC, TDS and TSS was ranged from 7250–17800 Ω/cm, 2754–4220 mg/ L, 510–838 mg/L. Chloride concentration value ranged between 1435–1885 mg/L. Highest concentration was observed in June and the lowest recorded value of chloride was in January. CO2 concentration was measured in range of 138–349 mg/L, whereas Bicarbonate concentration was found maximum in April (258 mg/L) and minimum in February (129 mg/L). The study area covers Ogoja, Yala, Bekwarra, Obudu and Obanliku Local Government Areas which represents the derived savanna region of Cross River State.

Materials and Methods.

Geographical Location: The five Local Government Areas are all in the Northern Senatorial District of Cross River State. Ogoja LGA lies geographically in latitude 6º30'N and longitude 8º40'E, Yala lies geographically in latitude 6º42'N and longitude 8º36'E, Bekwara lies geographically in latitude 6^0 48^1& 6^037^1 North and longitude 8^0 50^1 & 9^010^1 East, Obudu lies geographically in latitude 6^042^1 & $6^0.26^1$ North and 9^010^1 & 9^012^1 East and Obanliku lies geographically in 6.5344^0N, and 9.3229^0E (Fig. 1).

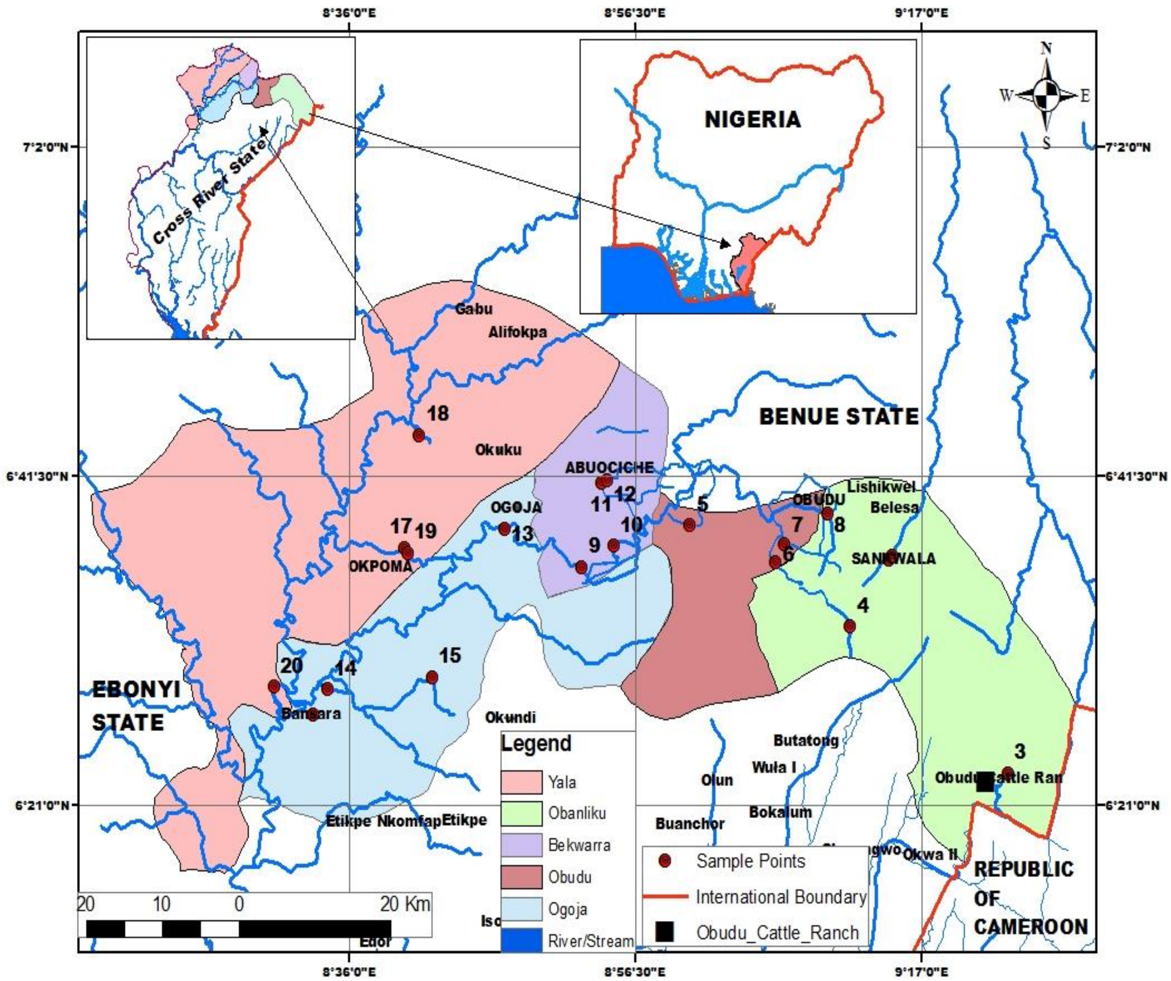

Fig.1.Study area showing the location of the sampling stations in the derived savanna.

Measurement of some physico-chemical parameters: Water quality parameters such as Dissolve Oxygen (DO), Temperature (ºC), Negative Logarithm of the Hydrogen ion Concentration (pH), Conductivity, Turbidity, and Salinity were measured insitu. Measurement was done using standard measuring instruments as stated below.

Temperature: The temperature of the water was measured with a multipurpose thermo scientific Orion meter. The meter was calibrated to a buffer (Zero) before dipping the end probe into the water. The temperature was recorded in degree Celsius (ºC) immediately the meter reading was stable/constant.

pH: The pH was also measured with the same multipurpose thermos scientific Orion meter. The meter was set to pH calibrated to a buffer (Zero), the probe was then dipped into water sample to cover the probe length and allowed to adjust to a given stable number.

Dissolve Oxygen: The dissolve Oxygen was measured by dissolve oxygen meter model DO-5509. The meter was calibrated to Zero and the probe dipped in water to cover the probe length. The display was allowed to show a stable maximum value. The display was then recorded in mg/l.

Conductivity: Conductivity was also measured with multipurpose thermos scientific Orion meter. The meter was set to conductivity and calibrated to Zero, the probe was then dipped into water sample to cover the probe length and allowed to adjust to a given stable maximum number which was recorded in micro Siemens per centimeter (µs/cm).

Turbidity: Turbidity was measured in nephelometric turbidity units (NTU) with an instrument called turbidimeter. The meter was supplied with three sample bottles with containing clear, cloudy and opaque liquids. These were used in comparing with the study water sample and recorded.

Salinity: The salinity was measured by a Hand Held Refractometer model REF104. The meter was calibrated to Zero and the probe dipped in water to cover the probe length. The display was allowed to show a stable maximum value. The display was then recorded per thousand (‰).

Results: Table 1 shows the parameters concentrations of the lotic system sampled between January and December, 2022. The values obtained for the water samples are compared with the World Health Organization (WHO) limits for unpolluted water. The analysis of variance showed no significant differences (P>0.05) in all the parameters.

The physico-chemical parameters in Ogoja lotic system during the period were temperature in Abakpa 27.9 ±0.45 ºC, Ibil 27.6 ± 0.50 ºC, Bansara 27.2±0.27 ºC and Nwol 27.6±0.42 ºC. The pH 8.79±0.56 in Abakpa, 8.60±0.85 in Ibil, 8.38±0.71 in Bansara and 8.83±0.64 in Nwol. The turbidity in Abakpa, Ibil, Bansara and Nwol were 18.3±0.13 NTU, 18.3±0.23 NTU, 18.3±0.26 NTU and 18.7±0.35 NTU respectively. While the salinity was 67.7'±0.26‰ in Abakpa, 67.4'±0.44‰ in 67.8'±0.54‰ in Bansara and 67.5'±0.67‰.The Dissolved Oxygen in Abakpa, Ibil, Bansara and Nwol during the study period were 5.29±0.36 mg/l, 5.13±0.47 mg/l, 6.16±0.53 mg/l and 6.08±0.51 mg/l respectively. Finally, the conductivity recorded were Abakpa 62.6 ± 1.21 µs/cm, Ibil 69.0±5.03 µs/cm, Bansara 73.2 ± 0.99 µs/cm and Nwol 71.3±3.75 µs/cm (Table 1).

TABLE 1: DETERMINATION OF MEAN±STANDARAD DEVIATION OF VARIATIONS IN THE PHYSICO-CHEMICAL PARAMETERS OF THE LOTIC SYSTEMS IN THE REGION.

Sampling stations	Temp.	pH	Turbidity	Salinity	Dissolved Oxygen	Conductivity
		Ogoja				
Abakpa	27.9±0.45	8.79±0.56	18.3±0.13	-67.7±0.26	5.29±0.36	62.6±1.21
Ibil	27.6±0.50	8.60±0.85	18.3±0.23	-67.4±0.44	5.13±0.47	69.0±5.03
Bansara	27.2±0.27	8.38±0.71	18.3±0.26	-67.8±0.54	6.16±0.53	73.2±0.99
Nwol	27.6±0.42	8.83±0.64	18.7±0.35	-67.5±0.67	6.08±0.51	71.3±3.75
		Yala				

Eja	27.7±0.47	8.63±0.37	18.7±0.29	-67.1±0.34	6.03±0.30	71.98±4.03
Okpoku	27.7±0.25	8.47±0.63	18.6±0.13	-67.3±0.73	6.19±0.45	71.38±3.29
Iboko	27.4±0.45	8.55±0.38	18.4±0.34	-67.4±0.71	5.93±0.42	70.88±3.79
Yahe	27.7±0.23	8.69±0.41	18.4±0.31	-67.9±0.80	6.01±0.63	68.95±3.56
			Bekwara			
Ochagbe	27.9±0.48	8.36±0.42	18.5±0.24	-67.0±0.63	5.99±0.28	65.47±4.63
Amange	27.8±0.32	8.57±0.37	17.9±0.52	-67.7±0.79	5.79±0.17	65.57±4.29
Onyinne	27.8±0.28	8.83±0.27	18.5±0.25	-67.0±1.18	6.00±0.19	64.35±1.02
Okogor	27.8±0.46	8.86±0.52	18.3±0.17	-67.3±0.54	5.77±0.27	66.10±4.35
			Obudu			
Abebe	27.8±0.32	8.87±0.29	18.4±0.13	-66.9±0.46	5.87±0.17	71.80±4.94
Buabia	27.3±0.29	8.65±0.48	18.2±0.25	-67.4±0.63	5.62±0.27	72.53±5.16
Kigbe	27.1±0.67	8.55±0.35	18.4±0.29	-68.3±1.53	5.71±0.39	70.42±4.73
Basun	27.5±0.38	8.43±0.28	18.5±0.22	-66.5±0.81	5.76±0.50	70.95±4.57
			Obanliku			
Urie	27.5±0.14	8.68±0.21	18.4±0.20	-67.2±0.55	5.95±0.44	65.91±3.98
Akan	27.5±0.35	8.54±0.32	18.3±0.13	-66.8±0.87	5.68±0.08	68.45±5.21
Ranch	27.4±0.23	8.28±0.36	18.2±0.26	-67.1±0.65	5.63±0.31	72.72±4.77
Akorshie	28.0±0.46	8.48±0.12	18.6±0.12	-67.3±0.78	5.75±0.28	64.92±2.13

In Yala lotic system during the period were temperature in Eja 27.7± 0.47ºC, Okpoku 27.7 ± 0.25ºC, Iboko 27.4 ± 0.45ºC and Yahe 27.7 ± 0.23ºC. The pH 8.63 ± 0.37 in Eja, 8.47 ± 0.63 in Iboko and 8.69 ± 0.41 in Yahe. The turbidity in Eja, Okpoku, Iboko and Yahe were 18.7±0.29 NTU, 18.6±0.13 NTU, 18.4 ± 0.34 NTU and 18.4 ± 0.31NTU respectively. While the salinity was 67.1'±0.34‰ in Eja, 67.3' ± 0.73 ‰ in Okpoku, 67.4' ± 0.71‰ in Iboko and 67.9'±0.80 ‰ in Yahe. The Dissolved Oxygen in Eja, Okpoku, Iboko and Yahe during the study period were 6.03±0.30mg/l,6.19±0.45 mg/l, 5.93±0.42 mg/l and 6.01±0.63 mg/l respectively. Finally, the conductivity recorded were 71.98±4.03μs/cm in Eja,71.38±3.29μs/cm in Okpoku, 70.88±3.79 μs/cm in Iboko and 68.95±3.56μs/cm in Yahe (Table 1). The physico-chemical parameters in Bekwarra lotic system during the period were temperature 27.9±0.48 ºC in

Ochagbe, 27.8±0.32ºC in Amange, 27.8±0.28ºC in Onyinne and 27.8±0.46ºC in Okogor. The pH in Ochagbe 8.36±0.42, in Amange 8.57±0.37, in Onyinne 8.83±0.27 and in Okogor 27.8±0.46. The turbidity was 18.5±0.24 NTU in Ochagbe, 17.9±0.52 NTU in Amange, in Onyinne 18.5±0.25 NTU and in Okogor 18.3±0.17 NTU. While the salinity was 67.0'±0.63 ‰ in Ochagbe, 67.7'±0.79 ‰ in Amange, 67.0'±1.18 ‰ in Onyinne and 67.3'±0.54‰ in Okogor. The Dissolved Oxygen in Ochagbe, Amange, Onyinne and Okogor during the study period was 5.99±0.28mg/l, 5.79±0.17mg/l, 6.00±0.19mg/l and 5.77±0.27mg/l respectively. Finally, the conductivity recorded were 65.47±4.63µs/cm, 65.57±4.29µs/cm, 64.35±1.02 µs/cm and 66.10 ± 4.35 µs/cm respectively (Table1).

In the same vein in Obudu lotic system during the period were temperature 27.8±0.32ºC in Abebe, 27.3±0.29ºC in Buabia, 27.1±0.67ºC in Kigbe and 27.5±0.38ºC in Basun. The pH 8.87±0.29 in Abebe, 8.65±0.48 in Buabia, 8.55±0.35 in Kigbe and 8.43±0.38 in Basun. The turbidity in Abebe, Buabia, Kigbe and Basun were 18.4±0.13 NTU, 18.2±0.25 NTU, 18.4±0.29 NTU and 18.5±0.22 NTU respectively. While the salinity was 66.9'±0.46‰ in Abebe, 67.4'±0.63‰ in Buabia, 68.3'±1.53‰ in Kigbe and 5.76'±0.50 ‰ in Basun.The Dissolved Oxygen in Abebe, Buabia, Kigbe and Basun during the study period were 5.87±0.17 mg/l, 5.62±0.27mg/l, 5.71±0.39mg/l and 5.76±0.50mg/l respectively. Finally, the conductivity recorded were Abebe 71.80±4.94µs/cm, Buabia 72.53±5.16µs/cm,Kigbe 70.42±4.73µs/cm and Basun 70.95±4.57 µs/cm (Table 1). Finally, in Obanliku lotic system during the period was temperature in Urie 27.5±0.14ºC, Akan 27.5±0.35ºC, Ranch 27.4±0.23ºC and Akorshie 28.0±0.46ºC. The pH in Urie 8.68±0.21, in Akan 8.54±0.32, in Ranch 8.28±0.36 and 8.48 in Akorshie. The turbidity in Urie, Akan, Ranch and Akorshie were 18.4±0.20 NTU, 18.3±0.13 NTU, 18.2±0.26 NTU and 18.6±0.12 NTU respectively. While the salinity was 67.2'±0.55‰ in Urie, 66.8' ± 0.87‰ in Akan, 67.1'±0.65 ‰ in Ranch and 67.3'±0.7‰ in Akorshie.The Dissolved Oxygen in Urie, Akan, Ranch and Akorshie during the study period were 5.95±0.44mg/l, 5.68±0.08mg/l, 5.63±0.31mg/l and 5.75±0.28 mg/l respectively. Finally, the conductivity recorded were 65.91±3.98µs/cm in Urie, 68.45±5.21µs/cm in Akan, 72.72±4.77 µs/cm in Ranch and 64.92±2.13 µs/cm in Akorshie µs/cm (Table 1).

Discussion: Physical and chemical parameters which tend to influence species diversity, distribution and abundance in the aquatic environment are of utmost importance. On this note, the physico-chemical parameters of the derived savanna, Cross River State, Nigeria are quite moderate in their concentrations and can be tolerated by almost all freshwater organisms. Temperature showed little variation of 27.1±0.67^{0}C to 28.0± 0.46^{0}C in all the sampling stations of all the two local government areas. This might be as a result of the time and atmospheric condition in which the water temperatures were tested. According to Sawyer *et al*., (1994); Adebowale *et al*., (2008) the variation in water temperature is mainly related with the temperature of the atmosphere and weather conditions. This finding is also in agreement with the findings of Ndome *et al*., 2014 which ranged was between 25.20 to 26.50^{0}C in Tinapa lake, Calabar. The average temperatures of ranged 27.1±0.67^{0}C to 28.0± 0.46^{0}C in the lotic system were within the WHO permissible limits of temperature in aquatic environment. The temperature is in line with Michand (1991) who recommended temperature range of 21^{0}C to 31.9^{0}C for tropical fishes. The Statistical analysis (ANOVA) reveals no significant differences (P > 0.05) in temperatures across the sampling stations in the two local government areas. The pH range of 7.33 to 9.57 in this study favoured the occurrence of freshwater organisms. From this study, the pH in all the sampling stations in Ogoja and Yala, were not above WHO standards for survival of most fresh water organisms. This is in tandem with the findings of Kalyoncu *et al*., (2008) who reported that pH values of between 7.84 and 7.38 in streams in Turkey supported a good number of different molluscs. Adebowale *et al*., (2008) attributed variation in pH to exposure of water body to atmosphere, biological activities and temperature changes, in Ondo State, Nigeria. Surface run off, pesticides and decaying vegetation also produce low pH waters, which can retard snail growth by increasing the rate of calcium dissolution (Hunter, 1990). The pH value of water is related to a large number of substances and is therefore a good indicator of the quality of the water. The Statistical analysis (ANOVA) reveals no significant differences (P > 0.05) in pH across the stations in all the five local government areas.

Turbidity is a measure of the transparency of water body. Turbidity is the decrease of ability of water to transmit light ray normally caused by either suspended colloidal materials of various size, coarse dispersion, and organic matters in the form of planktons. Turbidity is also seen as an opaque or unclear appearance imparted to water by the presence of suspended foreign particles (soil, plankton, etc.). Turbidity can also be viewed as the measure of the clarity of water. The resultant effect of its inability to transmit light tells on the colour of the water (Onuoha and Nwadukwe 2001). The turbidity of 5NTU is reveals clear waters, 55 NTU reveals Cloudy waters and 500NTU above opaque. Most importantly, turbidity above 15 NTU is detrimental for drinking waters and recreational purposes. In this study the turbidity ranged between 18.3±0.13NTU and 18.9±0.52 NTU. This might be as a result of the agricultural activities taking place in the zone. According to Fast (1983) turbidity arising from organic suspense are caused by run off from unstabilized water shed such as cropped land, road, constructions and source of water. This range is not conducive for drinking waters but can support the growth of freshwater snails. Some sampling stations in Ogoja, Bekarra, Obudu and Obanliku showed greenish and clear waters at some points. This may be due to the presence of planktons and high productivity. The statistical analysis (ANOVA) reveals no significant differences (P > 0.05) in turbidity across the stations in all the five local government areas. The salinity in this study ranged between -66.8±0.87‰ and -68.3±1.53‰ this may be due to the fact that the study was conducted in lotic freshwater systems. This is in line with < 0.5‰ WHO standard for salinity in freshwater habitat. Studies have shown that freshwater snails are salinity intolerance (Gillis, 2011; Ertan and Ali, 2014; Blackeslee *et al.*, 2013). Impacts of salinity on the reproduction of freshwater unionids show a decrease in glochidia viability in the freshwater mussel *Lampsilis fasciola* (Gillis, 2011). Another recent experimental study on the effects of salinity on mussel was on the multiple life stages of a common freshwater mussel, *Elliptio complanata* which demonstrated that low levels of salinity could have a dramatic effect on the reproduction, physiology and survival of this species (Blakeslee *et al*., 2013). Ertan and Ali (2014) exposed freshwater mussel (*Unio crassus*) to some concentrations of salinity, at the end of the experiment all mussels were dead. Thus, the low salinity in the area influences the distribution and abundance of the freshwater mollusc species. The Statistical analysis (ANOVA) reveals no significant differences (P > 0.05) in salinity across the stations in all the five local government areas.

The average DO obtain in this study ranged between 5.13±0.47 mg/l and 6.19±0.45 mg/l of the lotic system. This is an indication of good habitats for biodiversity of fresh water molluscs and other aquatic animals. Studies have shown that proper dissolved oxygen (DO) levels are essential for aquatic ecosystems. Mean DO values of 5.65mg/l and higher were reported to support high diversity of molluscs in stream waters (Kalyoncu *et al*., 2008). The DO value of 5.00 mg/l or greater has been considered good for healthy growth in fish. Low DO may be as a result from mild pollution or contamination. Chindah and Braide (2004) reported that a sudden and gradual depletion of dissolved oxygen can cause major shifts in the kinds of aquatic organisms; from pollution intolerant species to pollution tolerant species. The Statistical analysis (ANOVA) reveals no significant differences (P > 0.05) in DO across the stations in all the five local government areas. The electrical Conductivity showed a variation of 62.6±1.21 µs/cm and 73.2±0.99 µs/cm. Electrical conductivity varies from time to time in aquatic systems within the same or different seasons (Chapman and Kramer, 1991; Akin-Oriola 2003; Chindah and Braide, 2004). The measurement of water's ability to conduct electricity is called conductivity or specific conductance and is measured in micro-mhos per centimeter or micro-siemens per centimeter. Different aquatic systems have different electrical conductivities. Electrical conductivity varies between and even within water bodies, sometimes even within the same water body, different points or areas may have different electrical conductivities. Soft water has less dissolved salts (ions) and therefore less electrical conductivity when compared to hard water. The average values of Conductivity in this study can be considered low. Trivedy and Goyal (1986) reported higher ranges of 347 to 433 and 525 to 485 respectively. High values of EC indicate large quantity of dissolved mineral salts (Trivedy and Goyal, 1986). The conductivity of 50 to 500 µs/cm is favourable to all freshwater habitats. The conductivity in the present study was within the permissible limits of conductivity in freshwater system. The Statistical analysis (ANOVA) reveals no significant differences (P > 0.05) in conductivity across the stations in all the five local government areas.

Conclusion: The Physico-chemical parameters of the lotic system revealed that the system is not polluted. This is based on the ranged of values of the analyzed physico-chemical parameters which included temperatures ranged (27.1±0.67 - 28.0±0.46 ºC), pH ranged (8.28±0.36 - 8.87±0.29), turbidity ranged (18.2±0.25 - 18.7±0.35 NTU), Salinity ranged (-66.5±0.81‰ - -68.3±1.53 ‰).The dissolved oxygen (5.13±0.47 - 6.19±0.45mg/l), Conductivity (64.35 ±1.02 - 73.2±0.99 µs/cm). The analyzed physico-chemical parameters of the lotic system were within WHO acceptable limits for the survival of freshwater organisms with no significant differences (P > 0.05). Thus, physical and chemical parameters of the lotic system in the derived savanna Cross River State, Nigeria are not polluted. It is recommended that further studies be carried out on the lentic freshwater bodies in the region

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