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Physicochemical Parameters and Ichthyofaunal Composition of Streams in Ikono and Ibiono Ibom Local Government Area, Akwa Ibom State, Nigeria

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ABSTRACT: In this study, physicochemical parameters and ichthyofaunal composition of streams in Ikono and Ibiono Ibom Local Government Area, Akwa Ibom State were investigated for five months. The highest water temperature was recorded in January, 30.33±0.0157 °C, while the lowest was in March, 22.42±0.0700 °C, all in station 3. The highest pH was recorded in December, 7.58±0.0057, while the lowest was in February, 5.53±0.0067, all in station 3. The highest electrical conductivity was recorded in December, 271±1.0000 µS/cm, in station 2, while the lowest was recorded in March 51±0.0000 µS/cm in station 3. The highest dissolved oxygen 8.71±0.0258 mg/l, was in December, while the lowest was recorded in January 5.44±0.0059 mg/l all in station 2. The highest biochemical oxygen demand was recorded in February 5.89±0.0257 mg/l, in station 1 while the lowest was recorded in January, and 3.12±0.0000 mg/l in station 3. A total of 529 fish belonging to 10 Families and 11 species were recorded. Family Cichlidae consisting of *Chromidotililapia guentheri* and *Coptodon zillii* had the highest percentage abundance of 25%, while Family Mormyridae had the lowest percentage abundance of 2.26%. Family Claroteidae Consisting of *Chrysichthys nigrodigitatus* was the most abundant fish recorded in all stations. Ecological indices analysis such as Margalef's index (d) was highest, 1.786 in station 2, while the lowest, 1.175 in station 3. Shannon-weiners index (H) was highest, 0.9020 in station 1, while the lowest, 0.8493 was in station 2. Species evenness was highest 0.4103 in station 3, while the lowest 0.3846 was in station 1. Margalef's index and Shannon-weiners index did not show any significant difference ($p>0.05$) across all the stations, while equitability shows a significant difference ($p<0.05$) across all the stations. This study provides critical ecological baseline information on the physico-chemical parameter and ichthyofaunal composition of streams in Ikono and Ibiono Ibom and shows the impact of human activities which could threaten the sustainability of the streams and their resources.

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The importance of water to man and the world in general cannot be over-emphasized. Water is vital for the continuation of life in the universe. It provides habitat and nutrients for organisms that live in it. Biological and ecological variables play significant role in regulating ecosystem dynamics in the aquatic ecosystem which affect primary productivity, survival, and sustainability of species (Cousseau *et al.*, 2001). Physical and chemical factors act in synergy to determine biological adaptations and distribution of

species of both fauna and flora in the aquatic ecosystem which also affect the distribution of fishes (Elliot and Hemingway, 2002; Andem *et al.,* 2016; Bruno *et al.,* 2013). Water quality parameters such as temperature, pH, dissolved oxygen conductivity, and biochemical oxygen demand have considerable effects on aquatic life. This affects species composition and distribution, diversity, stability, reproduction, and physiological conditions (Bruno *et al.,* 2013; Akin *et al.,* 2005; Blaber, 2000). Therefore, scientific information on the relationship between ecological variables and the distribution of species is greatly important. In the tropical region of the world, there is increased concern about the incessant drying up of freshwater ecosystems and the loss of valuable species of fisheries.

Fisheries resources from freshwater ecosystems contribute significantly to the sustainability of both rural and urban communities. Unfortunately, fisheries resources in Nigerian waters are depleting due to over-exploitation and habitat destruction (Akin *et al.,* 2005; Andem *et al.,* 2016, Adakole *et al*., 2002).

Knowledge of species composition, diversity, and relative abundance of fisheries resources is critical for the general improvement of conservation policies and management strategies for commercial and ecological fisheries due to their high market demand, high nutritional value, and ecological relevance. Knowledge of ichthyofaunal composition is critical to estimating catch rates per unit effort (Holzloehner, 2007), migratory status and stock assessment, morphological and genetic diversity structure, and threatened and endangered species (Ahmad *et al.,* 2011).

Presently, there is sparse information on the physico-chemical parameters and ichthyofaunal composition of streams in Ikono and Ibiono Ibom in Akwa Ibom State Nigeria.

Therefore, the objective of this study is to investigate the physicochemical parameters and ichthyofaunal composition of streams in Ikono and Ibiono Ibom Local Government Area Akwa Ibom State Nigeria.

MATERIALS AND METHODS

Description of study area: This study was carried out in Ikono and Ibiono Ibom Local Government Area Akwa Ibom State on Latitude $05^0$22'' and $05^0$13'' N and longitude $07^0$46'' and $07^0$75''E in the tropical ecological zone of Nigeria (Figure 1). There are two marked seasons in this area. The wet season is between (April and October) and the dry season is between (November and March).

The mean annual rainfall data of the study area collected from the meteorological unit of the Department of Geography and Environmental Science, University of Calabar was between 150 and 200 cm. Three streams representing different sampling stations were chosen for this study. The emergent aquatic plants around the streams were *Echinochloa stagnina*, *Cyprus distans*, *Pistia stratiotes*, *Nymphaea lotus, Lemna paucicosta, Ipomoea aquatic, Mimosa pigra, Sacciolepis Africana and Ceratophllum demersum.* Station 1 was Nung Imo stream in Ikono local Government, located on latitude 05^0 14' N and Longitude 07^0 47' E, with 49 meters elevation.

Station 2 was Ikot Asifa Stream located on the boundary between Ikono and Ibiono Ibom Local Government, on latitude 05^0 08' N and longitude $07^0$50' E, with 31 meters elevation. Station 3 was Useh Ikot Ama Ama Stream in Ibiono Ibom Local Government, located on latitude $05^0$06'N and longitude $07^0$51'E. The related human activities in all the stations were mainly the washing of clothes and motorcycles, sand and gravel mining, gravel washing, hunting, agricultural activities, and artisanal fishing activities.

Sample collection: Fish samples were randomly collected two times a month in the three sampling stations from November 2014 to March 2015 within the hours of 08:00 to 10:00 am, and 05:00 to 07:00 pm from the landings of local fishermen.

The gear used by fishermen were traditional unbaited conical-valve basket traps, gill nets, cast nets, arrows, hook and line. Physico-chemical parameters such as surface water temperature, electrical conductivity, and pH were measured and recorded in situ using a glass thermometer, VOLTCRAFT WA-100ATC, and pH meter respectively.

Water samples were collected in sterilized containers in iced cold boxes and transported to the analytical laboratory of the Institute of Oceanography, University of Calabar. In the laboratory, DO, and BOD were analyzed using standard analytical methods for water analysis (Eaton and Franson, 2005). Fish samples were transported in an ice chest to the Department of Zoology and Environmental Biology University of Calabar for counting and identification using an identification guide of Nigeria freshwater fishes (Adesulu and Sydenham, 2007).

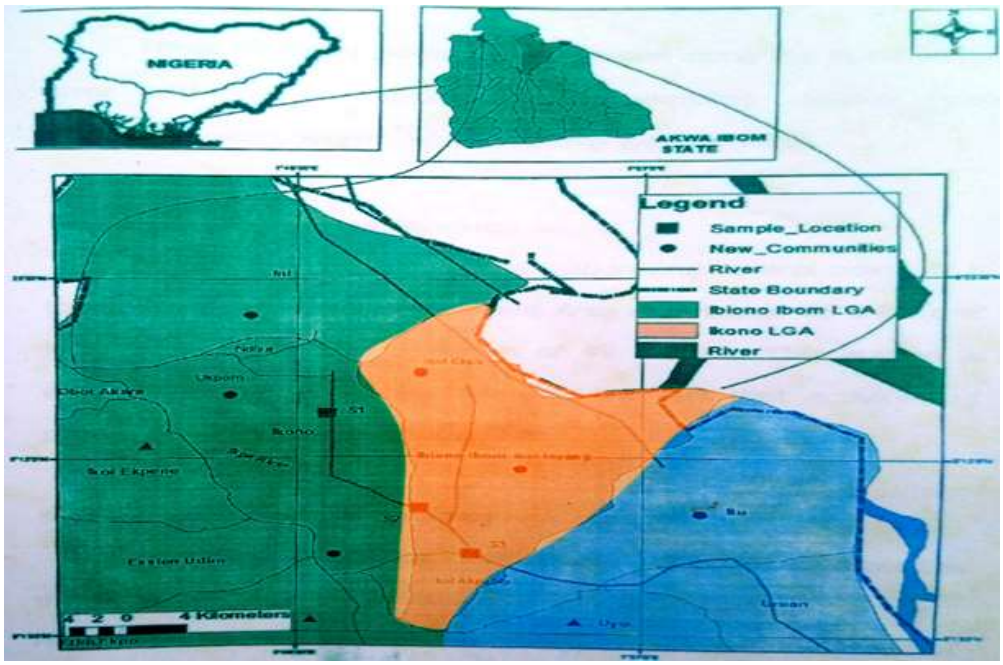

Fig 1: Map of the study area indicating sampling stations

Statistical Analysis: Data were subjected to One-way Analysis of Variance (ANOVA) using the SPSS statistical package (version 23) to compare variations in physico-chemical parameters and species composition among stations. Species abundance, Margalef's species diversity, and species evenness were estimated using PAST software (version 2.12) and Microsoft Excel 2013 was used for graphical illustration.

RESULTS AND DISCUSSION

Table 1 shows the mean values of physicochemical parameters of the three sampling stations used in this study. The highest water temperature was recorded in January, 30.33±0.0157 °C, while the lowest was in March, 22.42±0.0700 °C, all in station 3. The highest pH was recorded in December, 7.58±0.0057, while the lowest was in February, 5.53±0.0067, all in station 3. The highest electrical conductivity was recorded in December, 271±1.0000 µS/cm in station 2, while the lowest was recorded in March 51±0.0000 µS/cm in station 3. The highest Dissolved Oxygen was recorded in December, 8.71±0.0258, mg/l, while the lowest was recorded in January at 5.44±0.0059 mg/l all in station 2. The highest biochemical oxygen demand was recorded in February 5.89±0.0257 mg/l, in station 1 while the lowest was recorded in January, 3.12±0.0000 mg/l in station 3..

Table 1: Physicochemical Parameters Recorded during the study period November 2014 to March 2015 Parameter

Month	Stations	Water Temperature (°C)	pH	EC (µS/cm)	DO (mg/L)	BOD (mg/L)
November	1	28.31±0.0608^{a}	7.51±0.0110^{a}	92±0.0000^{b}	5.94±0.0115^{c}	2.31±0.0130^{b}
	2	28.52±0.3372^{a}	7.42±0.0157^{a}	100±0.0000^{a}	5.49±0.1762^{b}	2.86±0.0120^{a}
	3	29.11±0.0752^{a}	7.31±0.0231^{a}	101±0.0000^{a}	5.71±0.0257^{bc}	2.93±0.0100^{a}
December	1	26.72±0.4246^{a}	7.48±0.0067^{a}	271±1.0000^{d}	8.61±0.0158^{a}	3.24±0.0157^{a}
	2	24.45±0.0596^{a}	7.45±0.0115^{a}	260±0.0000^{c}	8.71±0.0258^{a}	2.27±0.0257^{b}
	3	26.13±0.0157^{b}	7.58±0.0057^{a}	270±1.0000^{d}	8.59±0.0115^{a}	3.24±0.0457^{a}
January	1	29.62±0.0120^{ab}	6.57±0.0068^{a}	115±0.0000^{a}	5.89±0.0068^{b}	3.67±0.0123^{b}
	2	28.70±0.0110^{a}	6.68±0.0100^{a}	124±0.5774^{b}	5.44±0.0059^{a}	3.79±0.0115^{b}
	3	30.33±0.0157^{b}	6.73±0.0257^{a}	117±0.0000^{a}	5.53±0.0057^{a}	3.12±0.0000^{b}
February	1	25.90±0.0257^{a}	5.62±0.0258^{b}	87±0.0000^{a}	7.76±0.0153^{b}	5.89±0.0257^{b}
	2	26.50±0.0257^{b}	5.68±0.0110^{a}	86±0.0000^{a}	8.31±0.0057^{b}	5.44±0.0057^{a}
	3	25.29±0.0058^{a}	5.53±0.0067^{b}	96±0.0057^{b}	8.90±0.0157^{c}	5.62±0.0100^{a}
March	1	23.43±0.0100^{b}	6.83±0.0057^{a}	52±0.0000^{a}	8.89±0.0519^{b}	5.43±0.0153^{a}
	2	24.32±0.0518^{b}	6.73±0.0210^{a}	52±0.0000^{a}	8.71±0.0100^{c}	5.47±0.0000^{b}
	3	22.42±0.0700^{b}	7.32±0.0058^{b}	51±0.0000^{a}	7.95±0.0058^{b}	5.33±0.0150^{a}

Values are expressed as means ± SEM (Means and Standard error of means). Means with different superscripts indicate significant differences at (P < 0.05).

Table 2: Fish abundance, composition, distribution, and number of individuals caught in the three sampling stations

Species identified	S1	%	S2	%	S3	%	Total	%
Characidae								
Alestes beremose	16	4.77	4	4.54	5	4.71	25	4.72
Cichlidae								
Chromidotilapia guentheri	67	20.00	19	21.59	13	12.26	99	18.70
Coptodon zillii	28	8.35	5	6.81	2	1.88	35	6.61
Clariidae								
Clarias gariepinus	37	11.04	6	6.81	5	4.71	48	9.07
Clarotidae								
Chrysichthys nigrodigitatus	75	22.38	25	28.40	27	25.47	127	24.0
Hemirhamphidae								
Hemirhamphus balao	31	9.25	14	15.90	5	4.71	50	9.45
Mochokidae								
Synodontis nigrita	11	3.28	-	-	13	12.26	24	4.53
Mormyridae								
Mormyrops engistroma	6	1.79	6	6.81	-	-	12	2.26
Netopteridae								
Papyrocranus guenthri	3	0.89	-	-	17	16.03	20	3.78
Osteoglossidae								
Heterotis niloticus	42	12.53	5	5.68	19	17.93	66	12.50
Sciaenidae								
Pseudotolithus elongatus	19	5.69	4	4.54	-	-	23	4.34
Number of species (S)	11	100.0	9	100.0	9	100.0	11	100.0
Number of Species (N)	335		88		106		529	
ANOVA	F	F-Crit	P-value	0.001	Inference	p<0.05 (S)		
	75.57	7.71						

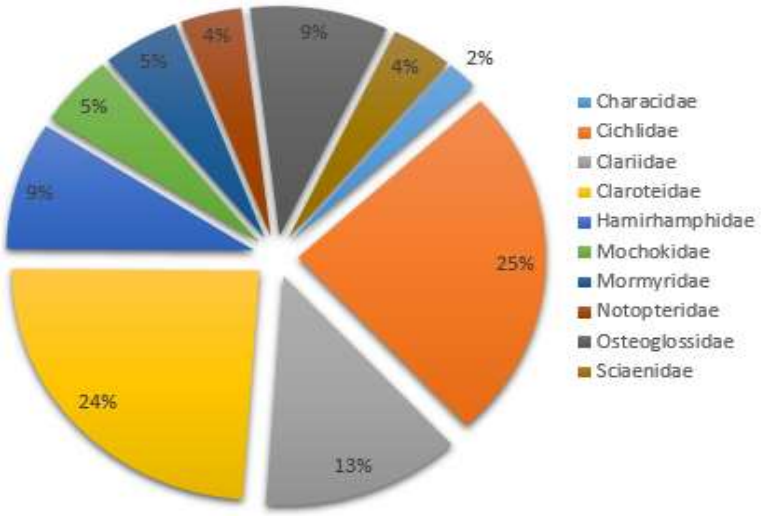

Fig 2: Percentage Composition of the fish family during the study period.

The relative abundance of the different fish taxa encountered at the three sampling stations is presented in Table 2. The percentage composition of the different fish fauna is shown in Figure 2. A total of 529 fish belonging to 10 families and 11 species were collected from the three sampling stations. Family Cichlidae and Clarotidae had the highest percentage of occurrence 25.0% and 24.0% respectively, while Mormyridae had the least 2.26%. *Chrysichthys nigrodigitatus* was the most abundant fish species recorded in all stations. Meanwhile, there was a significant difference of P< 0.05 in fish assemblage among all stations

Diversity Indices: The result of the diversity indices for the three sampling stations is presented in Table 3. Margalef's index (d) was highest, 1.786 in station 2, while the lowest, 1.175 was in station 3. Shannon-wieners index (H) the highest, 0.9020 was in station 1, while lowest 0.8493 was in station 2. Species evenness was highest 0.4103 was in station 3, while the lowest 0.3846 was in station 1. Margalef's index and Shannon-weiners index show a significant difference (p>0.05) across stations, while equitability shows a significant difference (p<0.05) across stations.

Table 3: Diversity indices for different sampling stations

Diversity indices	S1	S2	S3	F-values	*P*-Probability
Margalef's indices (d)	1.719	1.786	1.715	0.202	P>0.05 (NS)
Shannon-Weiner index (H)	0.9220	0.8493	0.9016	3.690	P>0.05 (NS)
Evenness (E)	0.3846	0.3865	0.4103	7.74*	P<0.05 (S)

*indicates significant different at a P<0.05, S = Significant, NS = Not Significant across all the stations.

The important ecological parameters such as environmental variables, habitat structures, and variations in climatic settings are critical ecological factors that determine organism's distribution and abundance in tropical aquatic ecosystems (Arunachalam, 2000). Remarkably, these are ecological indicators of habitat degradation (Ahmad *et al.,* 2011). However, we investigated the important environmental variables such as water temperature, pH, electrical conductivity, dissolved oxygen and biochemical oxygen demand, and ichthyofaunal composition of the three major streams in Ikono and Ibiono Ibom Local Government Area Akwa Ibom State in this study. Environmental variables such as temperature, pH, electrical conductivity, DO, and BOD are physico-chemical parameters routinely used as ecological indicators in water quality and habitat degradation studies (Adeogun *et al.,* 2011). This primary abiotic variable plays a critical role in controlling organisms' body physiology, life-history processes, development and reproduction, species composition, and abundance (Fauzia, and Khan, 2013, Ibor *et al.,* 2017). In this study, the highest water temperature value was recorded in January. In the tropical region, this is the peak of dry season months characterized by intensive sunlight and solar radiation. Therefore, since fish are poikilothermic animals, water temperature plays a significant role in regulating their internal body temperature and their general well-being. Temperature is highly considered when calculating fish longevity and natural mortality. The water temperature values recorded in all the stations were within the range of a tropical aquatic ecosystem (<40 °C) and this is consistent with the reports from fluvial tropical aquatic ecosystems in Nigeria (Fauzia, and Khan, 2013). The highest pH value was recorded in December while the lowest was in February all in station 3 Table 1. The pH values were within the acceptable range for the survival of organisms in freshwater ecosystems. A high electrical conductivity value was recorded in station 1 in December this may be due to the presence of mineral salt and organic ions in the stream. The lowest conductivity value was recorded in March on station 3. This result did not agree with the findings of (Andem *et al.,* 2016), in Ona River, Calabar River. Copp (2003), reported that fish body condition may be correlated with water conductivity because it revealed the status of organic contaminants in the water. The highest dissolved oxygen concentration recorded in this study was in station 2 while the lowest was recorded in January all in station 3. The highest BOD was recorded in station 1 in February while the lowest was recorded in January for station 3. Boyd, (1998) reported that dissolved oxygen and Biochemical oxygen demand are key environmental variables necessary for the growth, reproduction, and survival of freshwater fishes. According to the classification of BOD in aquatic bodies, unpolluted (BOD <1.0mg/L), moderately polluted (BOD <10.0mg/L) and heavily polluted (BOD >10.0mg/L) (Adakole *et al*., 2002). (BOD >1mg/L) can be caused by wastewater contamination and contaminants from other sources (UNESCO, WHO, and UNEP, 1998). Based on the above classification of BOD in aquatic bodies, the BOD of all the stations during the study period was less than 10 mg/l. This indicates a moderately polluted water body suitable for the growth, reproduction, and survival of fish. Herein, 11 fish species belonging to 10 Families were identified throughout this study. This revealed that the streams were not rich in species abundance and diversity. When compared with the findings of other studies. This may be due to the length of the study and the location of the study area. A list of African freshwater fishes Published by Boulenger (1916) consists of 976 species belonging to 185 genera and 43 species. NARESCON, (1992) reported more than 200 species of fisheries resources in Nigerian inland waters. They reported 100 species in Lake Kainji and 89 species in Lake Chad. In this study, members of the Family Cichlidae consisting of *Chromidotiliapa guentheri* and *Coptodon zillii* were the highest species recorded. The abundance of Cichlids in this study may be due to the availability of food materials, the nature of spawning and breeding grounds, and the prolific nature of their reproduction. All measures of community structure (species diversity, richness, and evenness) were generally high in the streams. This may be due to the morphology of the streams, the streams were characterized by a rocky stratum, interspaced by large boulders and shallow pools. However, increased aquatic ecosystem heterogeneity is usually associated with increased fish assemblage in the basin (Kadye and Marshal, 2006). Herein, station 1 had the highest number of fish Families and composition (10 and 11). Station 2 and Station 3 had 8 Families and 9 species each. These values showed increased diversity but low fish abundance. The higher species composition in station 1 may be due to low ecological disturbance in the

station. This observation may agree with the immediate disturbance hypothesis (IDH) which states that local species are maximized when ecological disturbance is neither too rare nor too frequent (Connell, 1978).

Conclusion: The study provides baseline information on physicochemical parameters and ichthyofaunal composition of the three major streams in Ikono and Ibiono Ibom Local Government Area Akwa Ibom State, Nigeria. It highlights the impacts of human activities in the streams on physicochemical parameters and ichthyofaunal composition, which have led to low species diversity and abundance. To preserve freshwater ecosystems and their resources effort should be made to encourage their restoration and management. Sand mining and related activities, using of harmful detergent and dumping of waste into freshwater bodies should be discouraged to enhance their sustainability.

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