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Assessment of Physico-chemical Parameters of Rivers Benue, Niger and their Confluence for Fish Production

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Abstract

The comparative analyses of the physico-chemical parameters of Rivers Niger, Benue and their confluence points were carried out for twelve months. Five sampling stations were located along River Niger, River Benue and their post confluence points. Water samples were collected from each of the sampling stations monthly from April 2016 to March 2017. The result showed significant variations ($p<0.05$) in the monthly mean values for all the physico-chemical parameters. Most of the physico-chemical parameters also displayed variations among stations- Rivers Niger, Benue, and their post confluence points but without significant difference except for air temperature, p^H and dissolved oxygen that had significant differences ($P<0.05$). The phosphate-phosphorus concentration were the same (0.1mg/L) for Rivers Niger, Benue, and their post confluence points. The effects of seasonal-variation were observed for all the physico-chemical parameter values, except for phosphate-phosphorus that again recorded equal values of 0.1mg/L each in both seasons. Some of the physico-chemical parameters measured (p^H, chloride, alkalinity, carbon–dioxide, total hardness and nitrate) were higher in dry season while parameters like air temperature, water temperature, transparency, conductivity and biological oxygen demand showed slightly higher concentration levels in wet season than in dry season in the five stations. Further studies on the biodiversity and microbial load of these water bodies are hereby recommended so as to have a proper understanding of pollution dynamics of these rivers.

Keywords:
Physico-chemical, Fish Production, River Benue

Introduction

Nigeria is undergoing massive population growth with daily springing up of industries and factories. Expansion of our farms to meet up food and raw material demands are responsible for high level of agricultural chemical, industrial wastes and sewage disposal into our river sources. This poses danger of dwindling availability of good quality fresh water and threaten fisheries production. Most Nigeria's freshwater are more prone to major agents of water pollution. Agricultural activities as a major source of pollution are usually located along river banks. Other major sources of river pollution are industries and domestic activities by the neighbouring communities because most rivers are easily accessible to waste disposal. The modern researches are more concerned about the quality and safety of our accessible water for the teeming population, but the major challenge in this area is the challenge of proposing all-encompassing criteria for water quality for specific uses. (Ajibade, *et al,* 2008).

Rivers Niger and Benue are observed to be used as depot for all sorts of waste and other pollutants especially the part of the river course used by the neighbouring communities. The quality of the water from these rivers could have been degraded every year as a result of human activities along the rivers course. There is high pressure of usage on these water bodies by the ever increasing population in the

area especially after the creation of Kogi State. A lot of farming activities are carried out along these rivers and their tributaries. Herbicides, chemicals and other organic fertilizers that are used for farming are washed down into the rivers which could be a source of potential pollution to these water bodies. Cattle and sheep were also observed using the water for drinking and grazing during dry seasons while local settlers use it to irrigate their farms. All sorts of domestic washings are also carried out on these rivers causing more pollution (Ajibade, *et al.,* 2008).

The ongoing dredging project on these rivers by the Federal Government has also affected the water depth, flowing rate, and the ecosystem of these rivers. The aquatic life is being destroyed and the underneath layers and sediments of the rivers is being pumped out during the dredging. These dredging activities is affecting the water turbidity, increasing the electrical conductivity and water hardness thereby lowering the quality of the water for human and animal use.

In view of the above sources of pollution and possible destruction of the aquatic life in these rivers, there is the need to asses and compare their effects on the quality of the water from River Niger, River Benue and the confluence points, for human use and for aquatic life in order to enact a sustainable management policy for these important water bodies.

Materials and Methods

This study covers Rivers Niger and Benue, the confluence points and after the confluence zones, with specific attention to the untreated water from these points. The area is known to witness heavy downpour of 500mm to 800mm as the annual average leading to the filling up of these rivers, while the dry season comes with dry harmattan. Lokoja is generally high in temperature and so the weather is hot, with a temperature range of 27^0C to 29^0C and sometimes more. The wet season begins towards the end of March and ends towards the end of October. The Niger River flows through many western African countries like Guinea, Mali, Niger, Benin, and Nigeria to the Gulf of Guinea. River Niger covers about 4, 180km in length to make it the third longest river in Africa, after the Nile and Congo Rivers. The size of the delta is nearly 190km which is the largest in Africa (Robert, 2009).

River Benue is a major tributary of River Niger in Nigeria. Its total course is about 1,400 km in length and it is almost navigable during the raining season. River Benue picks its source from the Adamawa plateau of Northern Cameroon from where it flows towards the western part of Cameroon into Nigeria through Jimeta, Ibi and Makurdi before joining River Niger at Lokoja to form a confluence (Wikipedia, 2012). Notable among River Benue tributaries are River Mayo Kebbi which links River Logone from the Chad Basin, Rivers Taraba and Katsina-Ala and River Gongola which links it at Makurdi (Wikipedia, 2012). River Benue is also of immense economic importance like River Niger in terms of its navigability for transportation of agricultural products, provision of fertile flood plains for cropping, fishing activities, cattle rearing along its course and for festivals by the natives.

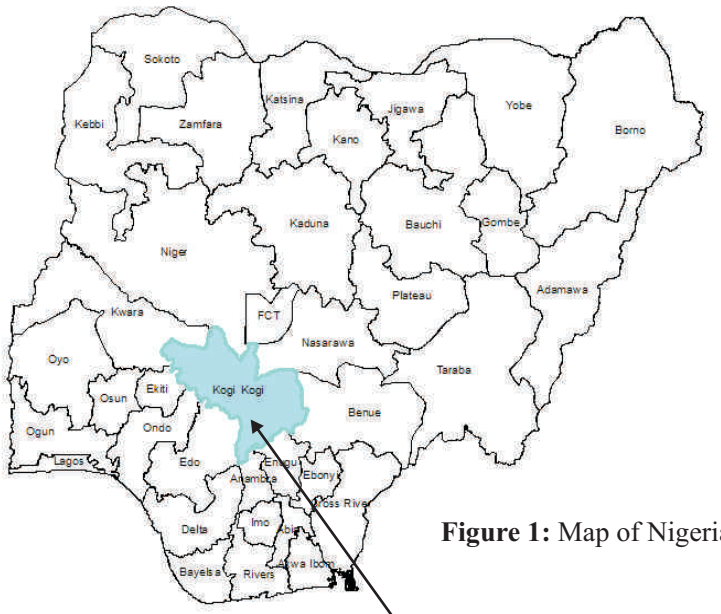

Figure 1: Map of Nigeria showing Kogi State

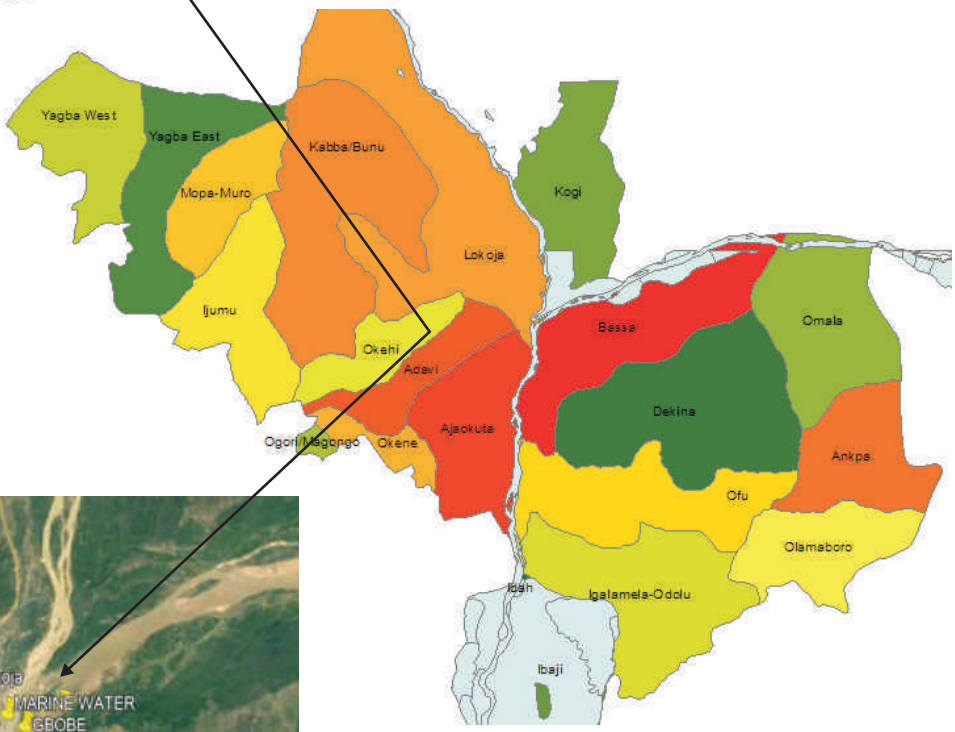

Figure 2: Map of Kogi State showing the Local Government Areas and Rivers Niger, Benue and their confluence points

Figure 3: Picture showing the topographical survey of the sampling stations

The meeting of the two largest rivers in West Africa - Niger and Benue at Lokoja lead to the formation of the popular Lokoja confluence. A lot of sediments, weathered materials, rock particles were flooded into this point by the two rivers.

Location of Sampling Stations

A total of five sampling stations were located along Rivers Niger and Benue, the confluence points and after the confluence points as follows, based on major anthropogenic activities around the sampling locations : (Stations 1-5 respectively).

Station 1: This station is located along the River Niger, around National Inland Waterways Authority office (NIWA) waterside in Marine yard, Lokoja. This is the parking yard where NIWA ships and boats are anchored. It also serves as base for the Nigeria Navy Force in Lokoja. The coordinates for this sampling station is Latitude: N 7º 47' 47.56" and Longitude: E 6º 44' 58.02".The distance from station 1 to Station 2 is about 3.13 km.

Station 2: This station is located along the River Benue around Gbobe fishing village. The population of the residents is about 80 to 100 people. Their major occupations are fishing, crop and livestock farming, petty trading and cattle rearing. The coordinate reading for Station 2 point is Latitude N 7º 47' 56.59" and Longitude E 6º 46' 39.66".From this point to Station 3 is about 2.36 km.

Station 3: This station is located at the point of River Niger-Benue Confluence where the two rivers meet. Different heights of water waves and turbulence were observed at this Station as the two big rivers collude here. The coordinate reading for this point at confluence is Latitude N 7º 47' 25.94" and Longitude E 6º 45' 29.18". The distance from Station 3 point to station 4 point is about 6.49 km.

Station 4: This is the station after the confluence point. It is about 2.02 km to the last sampling station point. It is popularly called Ganaja water side which coincides with the ferry/boat boarding station for passengers and vehicles crossing the water body from Lokoja/Ganaja to Shintaku village. A lot of water pollution activities like domestic and car washing, refuse dumping, cooking, cattle watering and riverside subsistence farming are observed here. It has coordinate reading of Latitude N 7º 43' 56.14" and Longitude E 6º 45' 6.10".

Station 5: This station is located far after the confluence point with about 8.51km distance from the confluence point. The sampling point is very close to Greater Lokoja water project after Ganaja waterside. It is the most recent water project by Kogi State Government to supply domestic water to the capital city. So there is continuous draining of water from this point into the processing plants/machines before pumping the water to the Lokoja metropolis. The coordinate reading for this point is Latitude N 7º 42' 50.81" and Longitude E 6º 44' 58.56"

Collection of Samples

Two samples of water were collected from each of the sampling stations identified above. The first set of water samples from each station were collected at the river bank while the second set of water samples were collected at the pelagic region (open water) with the means of a rented engine boat. These water samples for water quality analysis were collected in white plastic-stop cork containers of 50mls capacity each.

The physico-chemical parameters were determined using the methods of APHA, (1995).

Statistical Analysis

All data obtained were subjected to one-way analysis of variance (ANOVA) MINITAB VERSION 14.0, and the mean separated using Student new-man keul test.

Results

There were marked variations with significance difference ($p<0.05$) in the air temperature values among the five stations.

Table 1: Mean values of stations of physico-chemical parameters of Rivers Niger, Benue and their confluence points

Station/Parameter	River Niger ST1	River Benue ST2	Confluence Point ST3	Ganaja waterside ST4	After Greater Lokoja water plant ST5	SD
Air Temperature (^{0}C)	32.0^a ± 0.50	29.6^b ± 0.38	29.8^b ± 0.53	30.8^{ab} ± 0.05	29.6^b ± 0.38	±1.0
Water Temperature (^{0}C)	30.6^a ± 0.52	29.2^a ± 0.42	29.6^a ± 0.52	29.0^a ± 0.37	29.4^a ± 0.46	±0.6
P^H	6.7^b ± 0.05	6.9^{ab} ± 0.06	7.0^a ± 1.00	6.9^{ab} ± 0.06	6.9^{ab} ± 0.06	±0.1
Transparency (c m)	22.9^a ± 1.70	21.5^a ± 1.36	27.3^a ± 1.05	25.1^a ± 2.09	24.8^a ±1.98	±2.2
Conductivity(µmho/cm)	89.8^a ± 6.06	87.9^a ± 5.50	87.7^a ± 5.21	9.4^a ± 5.49	95.6^a ±6.92	±36.3
Dissolved Oxygen (mg/L)	10.4^{ab} ± 0.41	9.8^b ± 0.58	11.8^a ± 0.56	9.7^b ± 0.44	10.3^{ab} ± 0.56	±0.8
Biological Oxygen Demand (mg/L)	4.6^a ± 0.26	4.3^a ± 0.33	5.1^a ± 0.38	4.6^a ± 0.31	4.7^a ± 0.29	±0.3
Chloride (mg/L)	12.3^a ± 0.65	11.2^a ± 0.59	11.6^a ± 0.74	11.3^a ± 0.57	10.7^a ± 0.63	±0.6
Total Hardness (mg/L)	29.8^a ± 1.05	31.2^a ± 1.48	29.9^a ± 1.82	29.5^a ± 1.83	30.2^a ± 1.58	±0.7
Alkalinity (mg/L)	24.4^a ± 1.60	24.1^a ± 1.61	24.7^a ± 2.06	23.5^a ± 1.72	23.8^a ± 2.04	±0.2
Carbon dioxide (mg/L)	4.9^a ± 0.26	4.9^a ± 0.33	5.1^a ± 0.40	4.9^a ± 0.34	4.7^a ± 0.34	±0.1
Nitrate Nitrogen (mg/L)	0.3^a ± 0.03	0.3^a ± 0.04	0.5^a ± 0.05	0.1^a ± 0.05	0.2^a ± 0.05	±0.1
Phosphate Phosphorus (mg/L)	0.1^a ± 0.01	0.1^a ± 0.01	0.1^a ± 0.01	0.1^a ± 0.01	0.1^a ± 0.01	±0.0

Mean values on the same row carrying the same superscript letter were not significantly different ($P<0.05$)

Station 1 recorded the highest value of 32.0^{0}C while the least was observed in stations 2 and 5 (29.6^{0}C) each. Hydrogen ions (P^H values) as shown in Table 1 revealed that there were slight variations with marked significance difference among the five stations observed. Station 3 had the highest pH value of 7.0 while station 1 recorded the lowest among the stations (6.7).

Transparency values for all the stations ranged from 21.5cm observed in Station 2 to 27.3 cm in station 3. The variations in transparency levels among the stations were without significant difference. The conductivity values among the five stations also displayed variations but without significant difference. Station 5 recorded the highest presence of ions recording 95.6µmho/cm while Station 3 had 87.7µmho/cm as the lowest value of conductivity.

Dissolved oxygen levels among the stations were varied with significant difference. The values ranged from 9.7 mg/L in Station 4 to 11.8mg/L in Station 3.

Variations were also recorded in the B.O.D levels but without significant difference ($p<0.05$). Station 3 recorded 5.1mg/L as the highest while Station 2 had 4.3mg/L as the lowest B.O.D. among the five stations.

Chloride values recorded slight variations among the stations also without significant difference. The range observed for chloride values is from 10.7mg/L in Station 5 to 12.3mg/L in Station 1 ($P<0.05$). The highest value of total hardness was shown in Station 2 (31.2mg/L) while Station 3 recorded the lowest. All the five stations showed slight variations but without significant difference in total hardness values.

The alkalinity levels among all the stations also indicated variations but without significant difference. The concentration of alkaline salt was highest in Station 3 (24.7mg/L) while Station 4 had the lowest which is 23.5 mg/L.

The free carbon dioxide that dissolved in the water bodies observed also showed slight variations from one station to the other without significant difference. The highest value of carbon - dioxide was recorded in station 3 (5.1 mg/L), while the lowest was observed in Station 5 (4.7mg/L).

The readings recorded for Nitrogen in form of nitrates and ammonia was generally low in all the stations, with very slight variations and without significant difference. The Nitrogen levels ranged between 0.1mg/L in Station 4 and 0.3mg/L in stations 1 and 2.

Phosphate concentrations as recorded in all the five stations sampled, showed that the values were very low without any variations or significant difference. All the stations had 0.1mg/L of phosphate levels.

Bar charts (Fig 1 - 13) explains the variations of physico-chemical parameter values of each of the five stations sampled in the dry and wet seasons ($p< 0.05$).

The air temperature values were generally higher in each of the stations during the wet season than in the dry season. Station 1 recorded 33.3^{0}C as the highest in the wet season while the highest in the dry season was 30.8^{0}C both in station 1. All the stations showed variations in their air temperature levels in dry and wet seasons with significant difference (Fig.1). The lowest value (28.9^{0}C) was observed in Station 2 in dry season, while 30.1^0 C was the lowest in wet season at Station 3.

The water temperature values followed the same pattern of variation like the air temperature, showing higher value in each station in wet season than in dry season. Station 1 had the highest water temperature values in both dry and wet season – 29.4^{0}Cand 31.8^{0}C respectively (Fig. 2). The two seasons recorded variation in water temperature levels in all the stations but without significant difference in the dry season. 29.9^{0}C was the lowest in the wet season in Station 4 while stations 2 and 3 had the lowest value - 27.8^{0}C in the dry season.

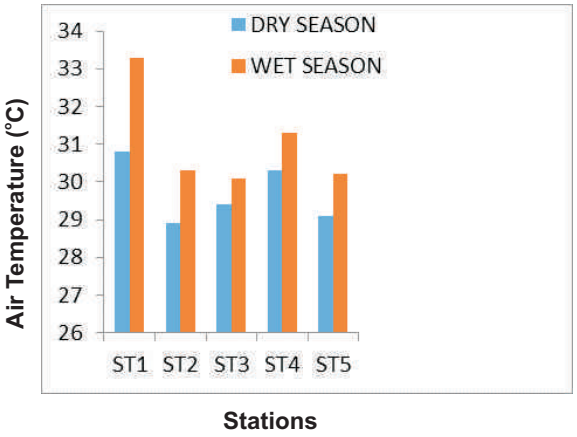

Figure 1: Seasonal variation of air temperature of River Niger, Benue and their confluence points

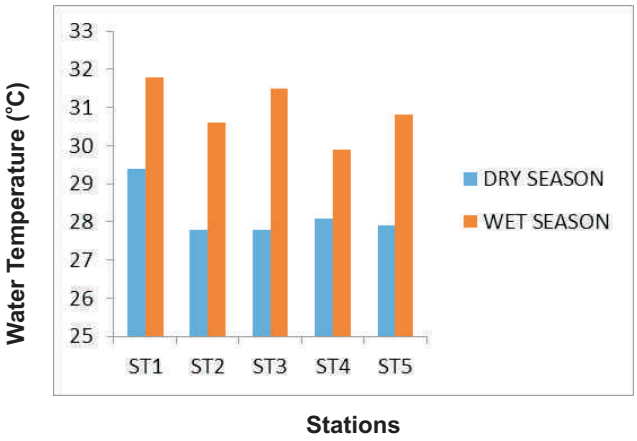

Figure 2: Seasonal variation of water temperature of River Niger, Benue and their confluence points

There were variations in the pH values in each of the station in both dry and wet seasons but without significant difference in the wet season (Fig. 3). The stations recorded higher pH values in the dry season than in wet season. The highest value (7.3) was observed in Station 3 during the dry season as against 6.9 recorded as the highest in the wet season from station 2.

Fig. 4 indicated the level of transparency in all the five stations during wet and dry seasons. Higher transparency values were observed in the wet season in each station than in the dry season without significant difference in the wet season. Station 4 had the highest transparency level of 31.6cm in wet season while the dry season had 22.8cm as its highest value in Station 5. Variations were also observed in the transparency levels in the two seasons but without significant difference in wet season.

Ions concentrations were more predominant in each of the stations in wet season than in dry season. The two seasons exhibited variations in their conductivity levels without significant difference in the dry season values. The highest conductivity value in the two seasons was 111.0µohms/cm in Station 5 in wet seasons while the lowest was 70.9µohm/cm in Station 2 in the dry season (Fig. 5).

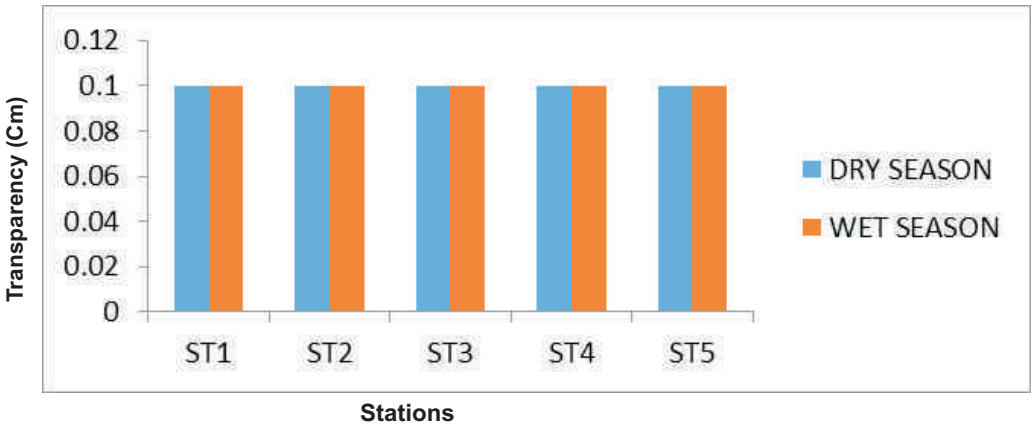

Figure 3: Seasonal variation of P^H of Rivers Niger, Benue and their confluence points

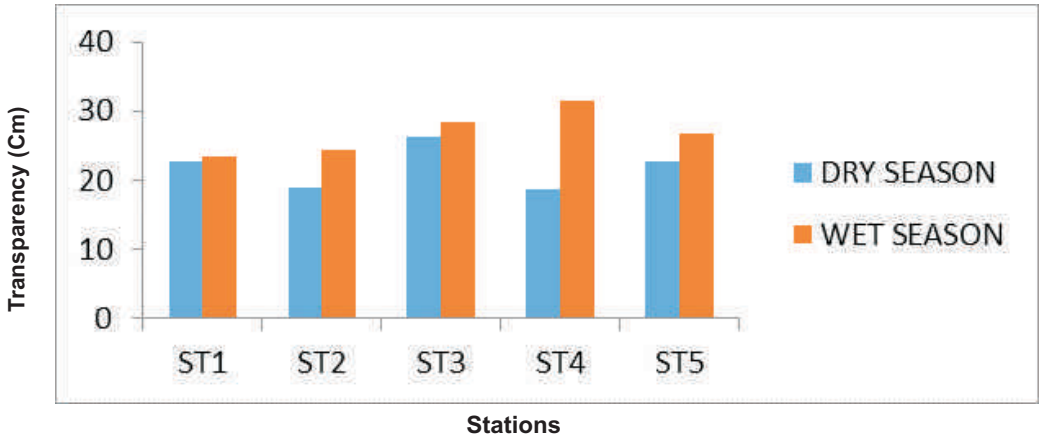

Figure 4: Seasonal variation of Transparency of Rivers Niger, Benue and their confluence points

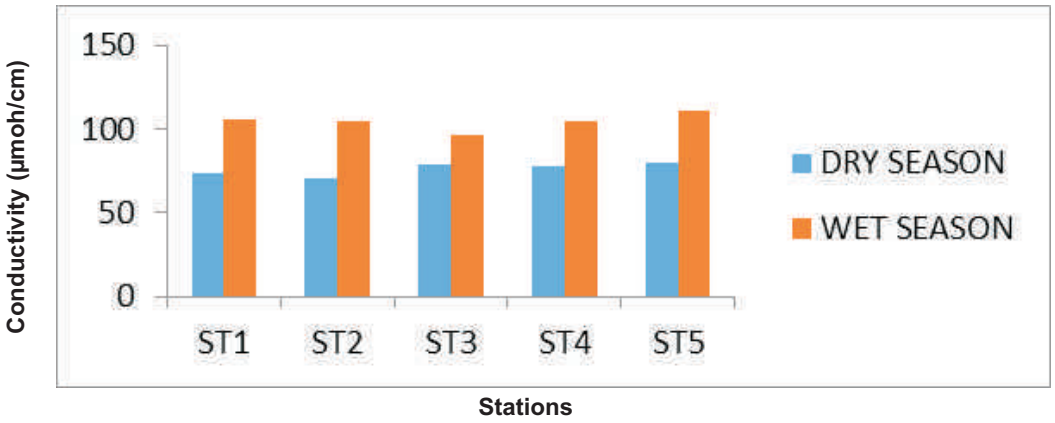

Figure 5: Seasonal variation of conductivity of Rivers Niger, Benue and their confluence points

Dissolved oxygen levels in each of the two seasons in each station varied with significant difference. It ranged from 9.5mg/l in Station 4 to 11.8mg/l in Station 3 in the dry season. The highest dissolved oxygen level in the wet season is 11.8 mg/L in Station 3 while the lowest is 9.0mg/l in Station 2 as showed in Fig. 6.

Fig. 7 indicated higher biological oxygen demand values in the wet season than in the dry season in each of the stations observed. Despite variations in the BOD in all the stations in the seasons, there was no significant difference recorded. The wet season recorded 5.3mg/l as the highest in Station 3 and 4 while the dry season recorded 4.9 mg/L in Station 3 as its highest BOD concentration level. The dry and wet seasons had 3.9 mg/l (Station 2) and 4.6mg/l (Station 2) as their lowest of BOD values respectively.

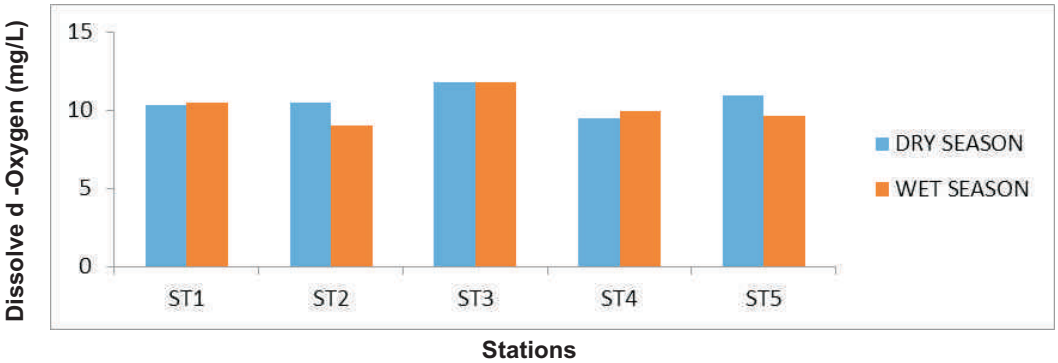

Figure 6: Seasonal variation of dissolved oxygen of Rivers Niger, Benue and their confluence points

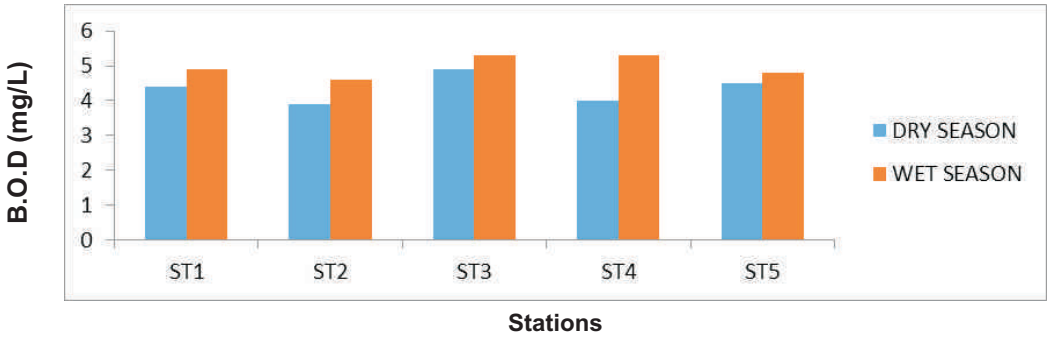

Figure 7: Seasonal variation of B.O.D of Rivers Niger, Benue and their confluence points

The chloride values in each station in the dry season were generally higher than its values in each of the stations in the wet season without significant difference in both seasons as well. Station1 in the dry season had 13.6 mg/L as its highest value while the highest in the wet season is 10.9 mg/L also in Station 1 as indicated in Fig. 8. In Station 5, the dry and the wet seasons respectively had11.9 mg/L and 9.5 mg/L as their lowest chloride level.

The dry and wet seasons showed slight variation in their calcium and magnesium carbonate levels in all the stations but without significant difference. The highest total hardness value in both seasons was 31.3 mg/Lin Station 2 in dry season and in Station 5 in wet season (Fig. 9).

The values for alkaline salts in the five stations in the dry season were far higher than that of the wet season without any significant difference in the dry season as shown in Fig.10. The highest alkalinity level in the wet season (18.7mg/L) was in Station 1 while that of the dry season (31.4mg/L) was in Station 5.

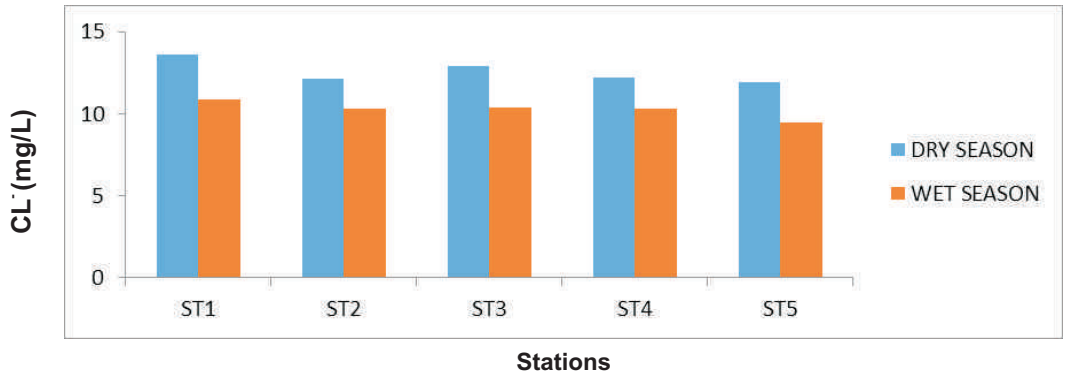

Figure 8: Seasonal variation of chlorides of Rivers Niger, Benue and their confluence points

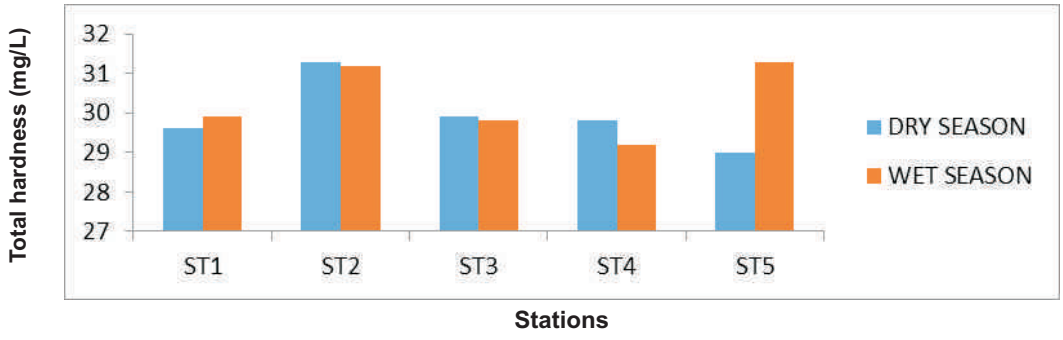

Figure 9: Seasonal variation of total hardness of Rivers Niger, Benue and their confluence points

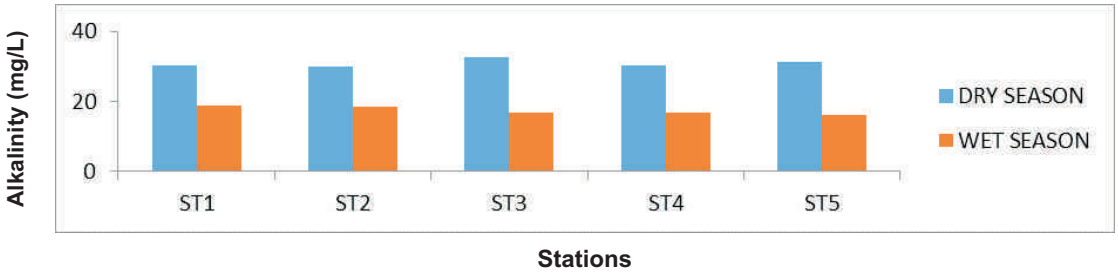

Figure 10: Seasonal variation of alkalinity of Rivers Niger, Benue and their confluence points

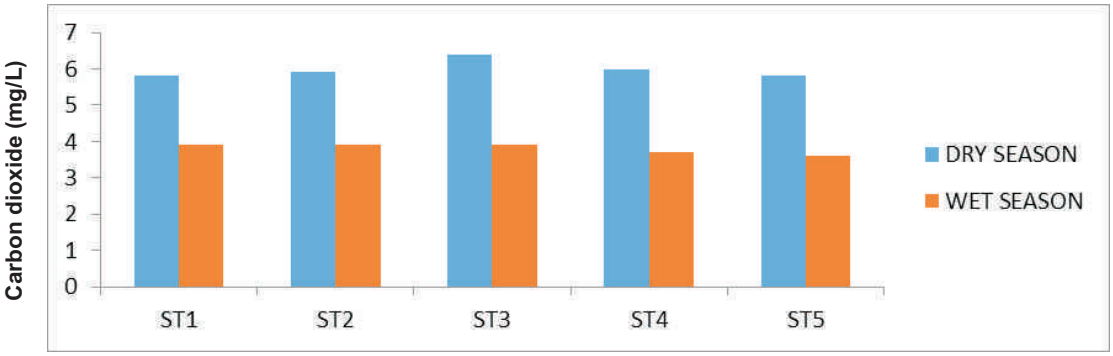

Figure 11: Seasonal variation of carbon dioxide of Rivers Niger, Benue and their confluence points

Fig. 11 indicated lower values of carbon dioxide in the wet season than in the dry season in each of the five stations. The lowest value in the dry season was 5.8 mg/L in stations 1 and 5 compared to the highest carbon dioxide values 3.9 mg/L observed in stations 1, 2 and 3 in the wet season. Despite the variations in the carbon dioxide values in both seasons, there was no significant difference in their values.

The nitrite concentration was generally low in both seasons in each of the stations observed. Despite no significant difference observed in both seasons, values in the dry season were higher than that of the wet season in each station. The highest nitrogen value in the dry season was 0.5 mg/L in Station 2 and 3 while that of the wet season was 0.3mg/L in Stations 1, 2, 3 and 5 as shown in Fig. 12. Fig. 13 indicated very low values of phosphate-phosphorous in all the Stations in both seasons. All the five stations observed had 0.1mg/ L value without significant difference in the wet season while the highest in the dry season was 0.12mg/L in Station 5. Stations 1- 4 recorded 0.09 mg/L as its lowest value in the dry season with slight significant difference.

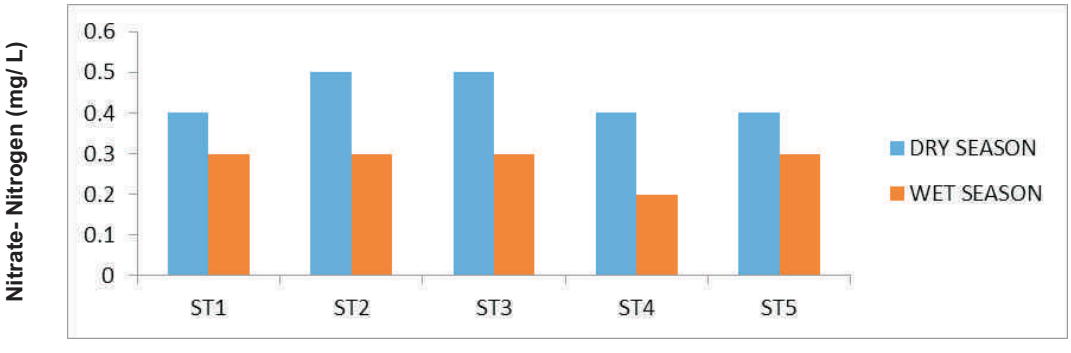

Figure 12: Seasonal variation of nitrate- nitrogen of Rivers Niger, Benue and their confluence points

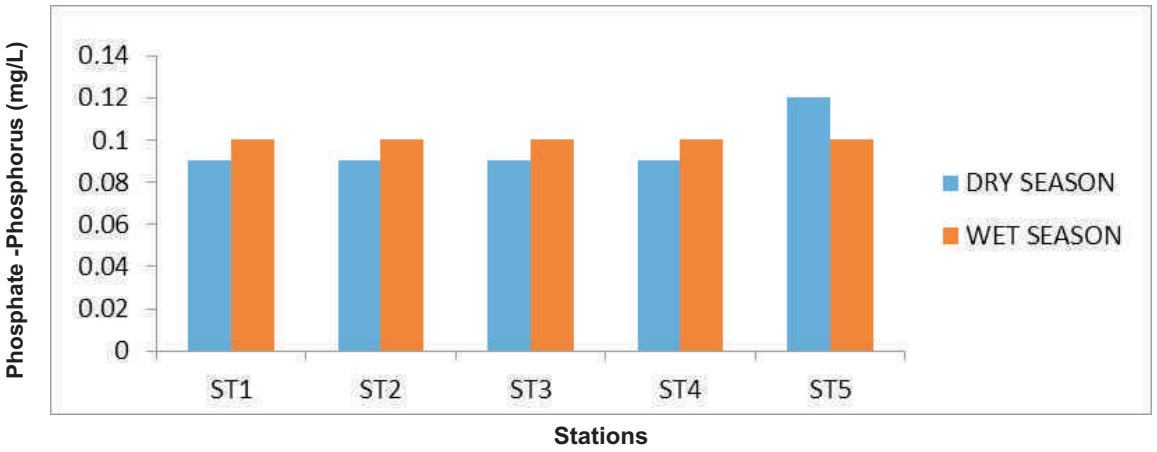

Figure 13: Seasonal variation of phosphate- phosphorus of Rivers Niger, Benue and their confluence points

Discussion

The air temperature range among the months in all the stations is from 27.0ºC to 35.0ºC and 24.5ºC to 36.0ºC for water temperature which is still within the permissible level for most freshwater fishes in the tropics. This assertion has also been reported about African water bodies by Kolo and Oladimeji (2004). All the temperature values of air and water observed during the sampled period still conformed to the report of Dupree and Hunner (1984) that warm water fish perform best at temperature range of 25^0C to 32^0C. The relatively high air and water temperature values seen in all the stations has been observed by Richard, 1992 that seasonal variation in natural water temperatures can be within the range of 0^0C– 30^0C or even higher. Okomoda, *et al* (2013) also attributed the high temperature readings to the warming effect of the solar radiation.

All the stations observed especially Rivers Niger and Benue respectively recorded pH range of (6.7-7.0) which is acceptable for fish survival at P^H range of 7.0-8.3 as asserted by WHO (2006). The confluence point is most turbid because it is a meeting point for both Rivers Niger and Benue which were grossly polluted with weathering debris, agricultural and domestic wastes. This is supported by Joseph (1997), who also observed that the river system is mostly prone to pollution because of their dynamic nature and easy exposure for the waste water disposal directly and indirectly. There is usually low volume of water and low flooding during the dry season with lesser human activities etc. on Rivers Niger and Benue, which may be responsible for clearer transparency records in the dry season than the records obtained in the wet season. The highest level of dissolved oxygen in August could be as a result of low temperature levels in the wet season as explained by Brown (2003), that the level of dissolved oxygen in rivers and smaller water bodies depend on the amount of water temperature and sediments in the streams, and the respiring rate or level of oxygen used by decaying organisms. It can be concluded that the physico-chemical parameters assessed fell within the acceptable level for fish production even though there is evidence of pollution in the rivers.

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