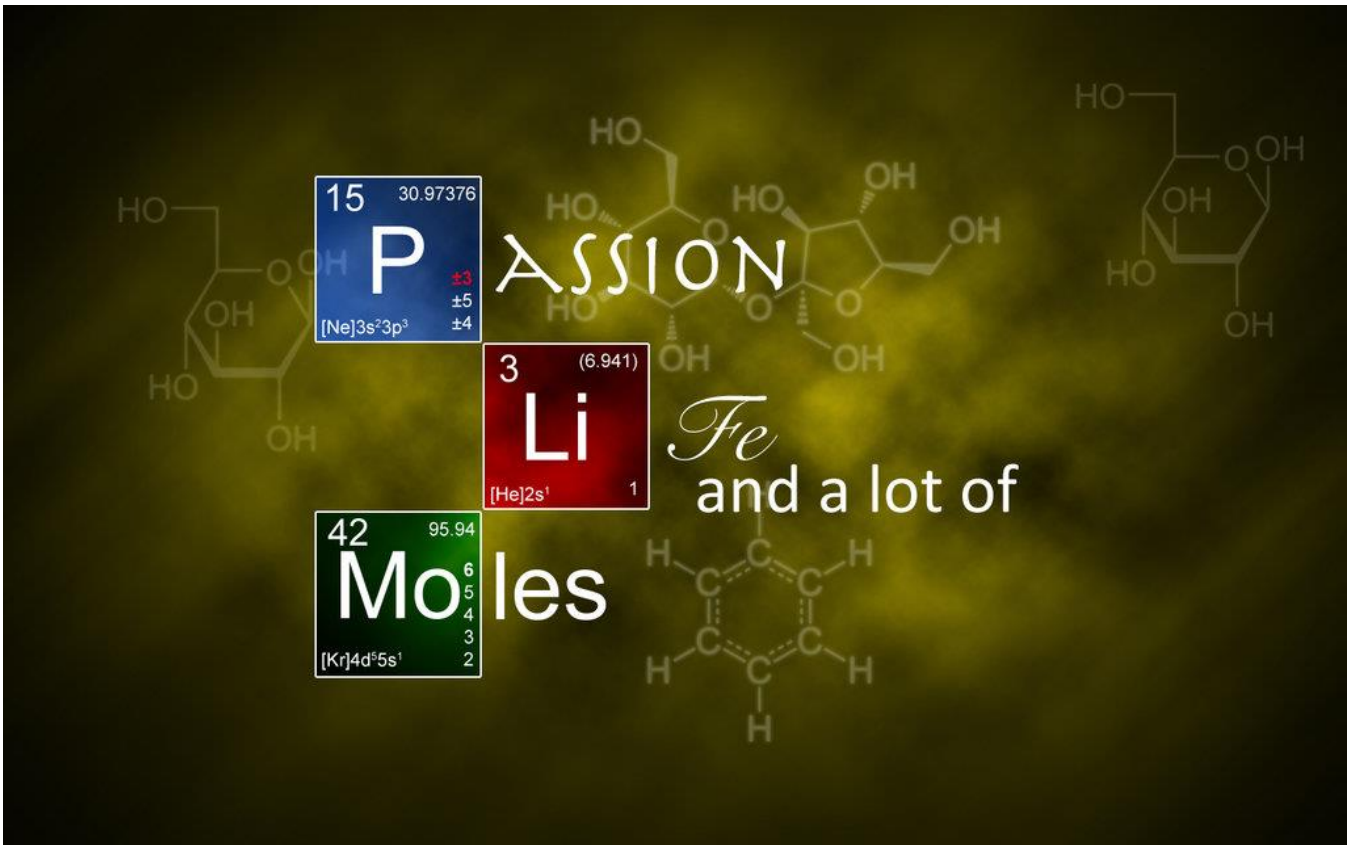

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SEASONAL VARIATION IN PHYSICO-CHEMICAL CHARACTERISTICS OF SELECTED RIVERS IN NORTH CENTRAL NIGERIA

RESEARCH ARTICLE

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ABSTRACT

Groundwater exploitation for rural water supply without adequate understanding of its chemistry and changes that may be induced by physical processes and anthropogenic activities may be counter-productive. Chloride, turbidity, total suspended solids (TSS), total dissolved solid (TDS), electrical conductivity, pH, hardness, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphates were determined. Electrical conductivity, Turbidity, TDS, TSS and pH were found to be between 48.4-74.0 (µS/cm), 12.0-90.0 (mgL^{-1}), 19.0-35.0(mgL^{-1}), 6.0-96.0 (mgL^{-1}), and 7.2-7.7, respectively, during the wet season. While during dry season, 63.8-74.2 (µS/cm), 7.0-59.0(mgL^{-1}), 20.6, -30.6 (mgL^{-1}), 5-62(mgL^{-1}) and 7.2-7.6 were observed for electrical conductivity, turbidity, TDS, SS and pH respectively. The lowest value of total hardness (8 mgL^{-1} $CaCO_3$) was recorded during wet season and the highest was 40.0 mgL^{-1} CaCO3. Higher values of total hardness 80.0-120.0 mgL^{-1} $CaCO_3$ were recorded during the dry season. DO, BOD and COD were found to range between 5.2-6.0(mgL^{-1}), 59-72(mgL^{-1}) and 118.0-144.0(mgL^{-1}) respectively during wet season, while 4.9-5.8(mgL^{-1}), 51.0-67.0(mgL^{-1}) and, 20.0-134.0(mgL^{-1}) were recorded during the dry season. Similarly, 1.5-1.9 mgL^{-1} and 0.96-1.36 mgL^{-1} were recorded for the wet and dry season respectively. The WQI (12.51) for the various rivers investigated revealed that the water are of poor quality for drinking purpose.

Key words: River, run-off, physic-chemical, water quality, pollution

INTRODUCTION

Many rivers/streams in the developing countries are heavily polluted due to anthropogenic activities, such as industrial and sewage discharges (Jonnalagadda *et al.,* 1991; Mathuthu *et al.,* 1993; Jonnalagadda and Nenzou, 1996a). The contamination of freshwater with a wide range of pollutants has become a matter of great concern over the last few decades, not only because of the threats to public water supplies but also the damage caused to the aquatic life (Canli *et al.,* 1998). Benue State like quite a number of states in Nigeria is faced with increasing pressure on water resources and the widespread, long-lasting water shortages in many areas are as a result of rising demand, unequal distribution and increasing pollution of existing water supply. The by-product of agricultural activities, urbanization and industrialization result in pollution and degradation of the available water resource (Waziri *et al*., 2009). It is important to analyse water to determine its suitability for drinking, domestic, industrial, and agricultural uses. It is also important in water quality studies to know the amount of organic matter present in the system and the quantity of oxygen required for stabilization of the water. The impact of organic pollutants on water quality in this work is expressed in terms of the Biochemical Oxygen Demand, BOD and Chemical Oxygen Demand, COD which all depend on the Dissolved Oxygen, DO. and Total Dissolved Solids; chloride, pH, Alkalinity, electrical conductivity, phosphate. TDS on the other hand are used to define the organic

content of the water. Several works on water quality have focused on the physicochemical characteristics of waters (Waziri *et al*., 2009; Hati *et al*., 2008; Izonfuo and Bareweni, 2001).

Scope of Study

The study covered two locations in the six states of Benue, Kogi, Kwara, Nassarawa, Niger and Plateau (i.e the North Central Geopolitical Zone of Nigeria). The monitoring will be carried out twice (i.e between August-September, 2011 for the rainy season and between February-March, 2012 for the dry season).

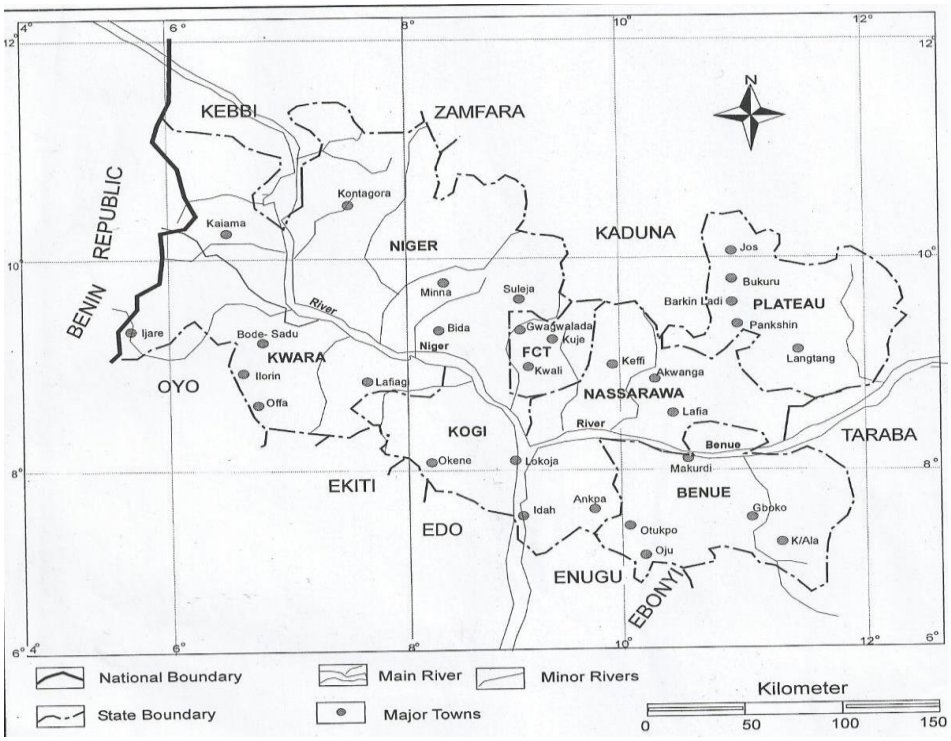

Figure 1: Map of North Central Nigeria Showing the Major and Minor Rivers.
Source: Longman School Atlas, 2003.

Table 1: Water Quality Parameters for September/October, 2011

Parameters	A	B	C	D	E	F	G	H	I	J	K	L
EC µs/cm	72.8	73.7	69.0	61.0	63.0	48.4	57.0	55.0	70.0	74.0	59.0	63.1
DO mg/L	5.4	5.4	5.5	5.2	5.4	5.2	6.0	5.2	6.0	5.6	5.5	5.2
BOD mg/L	67	70	66	61	64	65	63	60	59	62	72	70
COD mg/L	134	140	132	122	128	130	126	120	118	124	144	140
TH mg/L	80	60	80	60	40	60	60	60	60	80	60	80
Alkalinity mg/L	10.2	12.4	10.8	11.6	14.2	10.6	12.0	14.0	12.0	10.0	11.8	10.6
PO_4^{3-} mg/L	1.60	1.70	1.80	1.60	1.70	1.90	1.70	1.50	1.60	1.65	1.74	1.64
Cl^- mg/L	45.5	44.5	45.0	45.3	43.8	54.7	42.8	44.8	44.5	43.5	45.8	45.3
pH	7.5	7.2	7.5	7.4	7.6	7.6	7.6	7.4	7.6	7.7	7.4	7.2
Turbidity mg/L	39	41.0	24.0	86.0	41.0	90.0	22.0	27.0	42.0	21.0	12.0	29.0
TDS mg/L	34.0	35.0	33.0	19.0	21.0	23.0	24.0	28.0	29.0	26.0	22.0	30.0
TSS mg/L	23.0	20.0	18.0	30.0	75.0	81.0	6.0	74.0	8.0	19.0	20.0	96.0

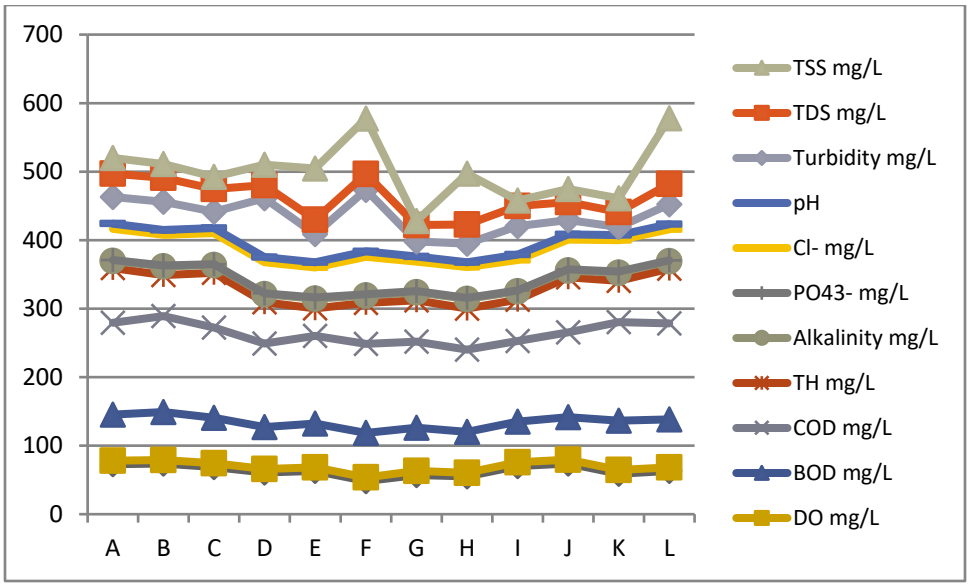

Figure 1: Physicochemical properties during the wet season

Table 2: Water Quality Parameters for Feb/March 2012

Parameters	M	N	O	P	Q	R	S	T	U	V	W	X
EC µs/cm	64.4	66.0	67.6	66.8	68.4	74.2	63.8	68.0	74.2	70.1	69.0	68.8
DO (mg/L)	5.3	5.3	5.1	5.4	4.9	5.3	5.4	5.8	5.4	5.1	5.3	5.4
BOD (mg/L)	64	67	61	59	58	60	60	57	51	57	60	65
COD (mg/L)	128	134	122	118	116	120	20	114	102	114	120	130
TH (mg/L)	100	100	100	80	100	120	100	100	120	80	80	80
Alkalinity	10.2	12.4	10.8	11.6	14.2	10.6	12.0	14.0	12.0	10.0	11.8	10.6
PO_4^{3-} (mg/L)	1.14	1.2	1.26	0.96	1.22	1.36	1.28	1.30	1.36	1.2	1.14	1.12
Cl^- (mg/L)	30.8	34.0	36.8	22.9	36.4	47.6	34.2	36.8	51.4	30.4	38.8	34.2
pH	7.2	7.6	7.6	7.5	7.6	7.4	7.4	7.6	7.6	7.4	7.5	7.4
Turbidity (mg/L)	24.0	19.0	20.0	33.0	14.0	28.0	59.0	24.0	45.0	42.0	7.0	10.0
TDS (mg/L)	20.6	28.2	29.0	27.2	28.4	24.0	24.8	26.0	22.8	30.6	28.4	27.8
TSS (mg/L)	23.0	20.0	46.0	43.0	17.0	17.0	62.0	23.0	48.0	30.0	5.0	17.l

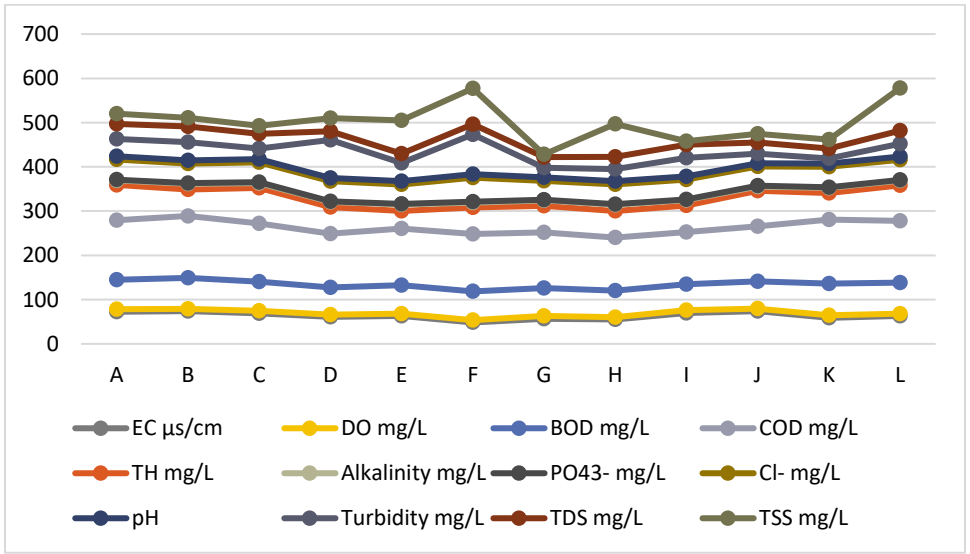

Figure 2: Physicochemical properties during the dry season

Table 3: Sample codes of sample locations

Sample States	Sample Locations	Sample Codes (Wet Season)	Sample Codes (Dry Season)	Intra State Sample Distance (km)
Benue	Wadata	A	M	7
	Wurukum	B	N	
Kogi	Confluence Hotel	C	O	10
	Lokoja Town	D	P	
Kwara	Jebba	E	Q	15
	Jebba Bridge	F	R	
Nassarawa	Yelwa	G	S	45
	Gudi	H	T	
Niger	Shiroro	I	U	120
	Kainji	J	V	
Plateau	Kalong	K	W	20
	Shendam Town	**L**	**X**	

Methodology

Water samples were collected in precleaned plastic containers from 12 sampling locations each during the wet and dry season spread across North Central Nigeria areas where human, animal and agricultural activities were high. Samples were collected on a seasonal basis i.e wet and dry seasons. The samples were analysed for DO, BOD, COD, and TDS using standard analytical techniques (Ademoroti, 1996; Radojevic and Bashkin, 1999; Sawyer *et al*., 1994).

BOD tests only measures biodegradable fraction of the total potential DO consumption of a water sample, while COD tests measures the oxygen demand created by toxic organic and inorganiccompounds as well as by biodegradable substances [Sawyer *et al*., 1994). Elevated BOD levels implies decrease in DO as the oxygen that is available in the water is being used by the bacteria resulting in the inability of fish and other aquatic organisms to survive in the river. TDS on the other hand is equally important in water quality studies, although there was no serious health effect associated with TDS ingestion in water but some regulatory agencies (FEPA, 1991; FME, 2001; NAFDAC, 2001) recommend a maximum TDS value of 500mg/L in drinking water supplies.

The COD was determined by titration with (0.25M) Ferrous sulphate, using 1:10 phenanthroline. At the end point blue green colour of contents changes to reddish blue. A blank was run simultaneously in similar manner. Turbidity, dissolved oxygen, chemical oxygen demand, and phosphate were determined using direct reading spectrophotometer (DR/2000) made by the HACH Company. Total dissolved solid and conductivity were determined using TDS kit model 50150 made by HACH. pH of was determined using a pH meter (model HI 8014) from HANNA Company. Water hardness was determined using Hardness EDTA titration. All the instruments were calibrated before use. While biochemical oxygen demand was determine using the mathematical expression. BOD mgL^{-1} = $DO_1 – DO_5$ /dilution factor

DO_1 = dissolved oxygen before incubation

DO_5 = dissolved oxygen after incubation for five days

Discussion

The physicochemical parameters during the wet season are shown in Table 1 while Table 2 shows the physicochemical parameters during the dry season.

Electrical conductivity: Electrical conductivity during the wet season range between 48.4 (E)-74.0 (J) µS/cm while the range was between 63.8 (S)-74.2 (R, U) µS/cm during the dry season.

DO: The maximum and minimum DO values during the wet season were 5.2 (D, F, H, L)-6.0 (G) mg/L respectively while the maximum and minimum DO values during the dry season were 5.8 (T) and 4.9 (Q) mg/L respectively.

pH: The pH range during the wet season was 7.2 (B, L)-7.7 (J) while the dry season range was between 7.2 (M)-7.6 (N, O, Q, T, U). These pH values fall within the WHO permissible limit of 6.5-8.0 for drinking water.

Total Hardness: From Table 1 it can be seen that the range of total hardness was 40 (E) - 80 (A, C, J, L) mg/L while the range during the dry season was 80 P, V, W, X) -120 (R, U) mg/L. These values fall below the WHO recommended limit of 200 mg/L in drinking water.

Cl^- : The maximum concentration of Cl^- in the wet season was 54.7 (F) mg/L while the minimum value under the same period was 42.8 (G) mg/L. In the same vein the maximum concentration of Cl^- in the dry season was 51.4 mg/L (U) while the minimum concentration was 22.9 mg/L (P). From the result it can be seen that the Cl^- values for both seasons are less than the WHO permissible Cl^- limit of 250 mg/L in drinking water.

Turbidity: The turbidity during the wet season range between 12.0 (K) – 90 (F) mg/L while the dry season range was 7 (W) – 59 (S) mg/L.

Alkalinity: Alkalinity values during the wet season were between 10.0 (J) – 14.2 (F) mg/L while the corresponding values during the dry season were 10.2 (M) – 14.2 (Q) mg/L.

PO_4^{3-} Similarly, the range of concentration of PO_4^{3-} during the wet season was 1.5 (H) - 1.9 (E) mg/L while the concentration ranged between 0.96 (P) – 1.36 (R, U) mg/L during the dry season portraying values that are below the regulatory limit of 5.0 mg/L set by FEPA.

TSS The maximum and minimum TSS values during the wet season were 81 (F) and 6.0 (G) mg/L respectively while the dry season maximum and minimum values of TSS were respectively 17.0 (Q, R) and 62.0 (S) mg/L. This shows that some sample locations presented values that are greater than the 30 mg/L permissible limit set by FEPA.

TDS: The TDS range during the wet season was 19 (D)-35 (B) mg/L while the dry season range was between 20.6 (M)-30.6 (V) mg/L. These TDS values fall within the FEPA permissible limit of 2000 mg/L for drinking water. From Table 1 it can be seen that the range of BOD was 59 (I) - 72 (K) mg/L while the range during the dry season was 51 (U) -67 (N) mg/L. These values are above the FEPA recommended limit of 30 mg/L in drinking water.

COD: The maximum value of COD in the wet season was 144 (K) mg/L while the minimum value under the same period was 118 (I) mg/L. In the same vein the maximum value of COD in the dry season was 134 mg/L (P) while the minimum concentration was 20 mg/L (S).

Water quality assessment using water quality indices

In total, the quality of the River of North Central Nigeria River waters was assessed work based on the prescribed format of CCME, 2001; the WQI value of 12.50 was calculated which corresponds to water of poor quality for drinking purpose. The ten indicator parameters used in the water quality assessment are as follows: pH, BOD, DO, COD, Alkalinity, Total hardness, phosphate, TSS, TDS, and electrical conductivity.

Statistical Analysis The statistical analysis of the result of physicochemical parameters was carried using SPSS statistical package. Analysis of variance ANOVA at each season at $p<0.05$ indicates significant difference in the result of physicochemical parameters between different parameters while within a physicochemical parameter, there is no significant difference between results at $p<0.05$. Post Hoc analysis on results between different physicochemical parameters shows that there is no significant difference in the results.

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