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An Assessment of the Effect of Seasonal Variation on the Physicochemical Parameters of River Niger around Lokoja, North Central Nigeria

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Abstract

The effect of seasons on the physicochemical parameters of water from River Niger was investigated. Surface water was collected at five sampling locations on River Niger and parameters such as temperature, electrical conductivity, pH, total dissolved solids determined in situ while other parameters were determined in the laboratory. Standard methods were used in the determination of physicochemical properties of the water and the values obtained were compared to WHO value. The results from the analysis for the wet and dry seasons respectively for the parameters were temperature: (27.31-28.13, 29.21-30.5 ^{o}C); pH (6.08-6.85, 6.72-6.99) ; Total hardness (37.20-40.52, 55.91-59.98 mg/L) ; Turbidity (24.50-26.00, 18.10-19.95 NTU); Electrical conductivity (12.32-15.42,6.31-8.31µS/cm); Total dissolved Solids (10.52-11.50, 7.15-8.97 mg/L); Dissolved Oxygen (6.30-7.21, 4.93-5.57 mg/L);Chemical Oxygen Demand (11.60-18.61, 3.59-13.13 mg/L); Sulphate (2.10-2.90, 3.20-4.98 mg/L) and Phosphate (0.85-0.98, 0.49-0.69 mg/L). The study ascertained that there are variations of these parameters with the seasons. Apart from turbidity in the wet season, dissolved oxygen and chemical oxygen demand in both seasons, all the other parameters were within the WHO acceptable limits. The study therefore indicates that chemical contaminations in the water sources are possibly from agricultural and other practices from the communities. Hence, the need for adequate treatment of the water from the river sources before they are put to use.

Keywords: Electrical conductivity, Physicochemical, Parameters, River, Seasonal, Variations

Introduction

The physicochemical parameters of water bodies show its suitability and quality for consumption by humans and the survival for the living organisms in it [1]. Investigating seasonal changes in surface water quality is vital in order to evaluate temporal

variations of the population of the river due to human activities and also natural inputs, this includes point and non-point sources [2]. Nutrients in surface water has been linked to land use activities, anthropogenic activities of point and non-point source of pollution are the main sources of nutrient enrichment of surface water.

The rapid increase in the world's population has pushed demand toward clean water globally despite the fact that rivers are used by different purposes by different sectors such as transportation, domestic water supply, agriculture e.tc, it has also been used for cleaning and dumping purposes [3]. Variation in physicochemical parameters of rivers is responsible for the distribution of organisms according to their adaptation, which allow them to survive in an ecosystem [4]. Water quality varies with seasons and these seasonal variations have both beneficial and negative effects [5]. The quality of surface water depends on physical, chemical, meteorological and chemical factors and it is also determined by the combination of all kinds of factors in various ways and intensities [6].

River Niger is one of the major rivers in Western Africa. Its water is used for irrigation, domestic uses and as a vital transportation artery. This research is aimed at studying the seasonal variations of the physicochemical parameters of River Niger at Lokoja from 5 sampling points with high anthropogenic activities.

Materials and methods

Study Area

Lokoja is a city in Nigeria, it lies at the Confluence of the Niger and Benue Rivers and it is also the capital city of Kogi State. The study was carried out in the portion of the lower river Niger that falls in Lokoja Local Government Area of Kogi State. The water samples were collected along Ganaja, Gadumo, Adankolo, Kpata and Kabawa which have the following locations respectively: 7^{o} 44' 15.702 "N and 6^{o} 44' 53.142 "E (Ganaja), 7^{o} 46' 47.004 "N and 6^{o} 44' 32.862 "E (Gadumo), 7^{o} 47' 28.164 "N and 6^{o} 44' 38.73 "E (Adankolo), 7^{o} 48' 30.222 "N and 6^{o} 44' 57.96 "E (Kpata), 7^{o} 49' 80.79 "N and 6^{o} 44' 56.946 "E (Kabawa). The wet season mostly begins from late April and end in late October. The dry season starts from November till March.

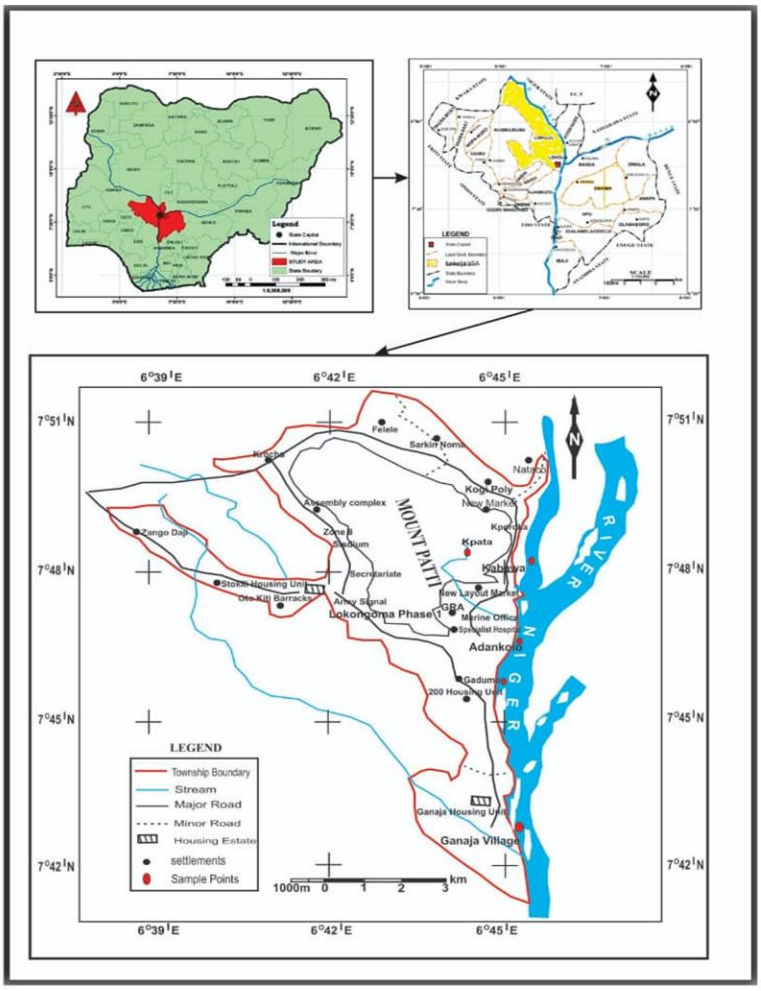

Fig. 1: Map of the study area

Sample collection

Water samples were collected during the dry season of December and wet season of July, the water samples were collected twice between 08:00 – 11:00 hours on each sampling day. Sampling involved collections from the five sampling stations of the River Niger along Lokoja River. The water sample for chemical parameters was collected in pre-cleaned 2L capacity plastic bottles. The bottles were rinsed thoroughly at the river bank using the river water.

Determination of Physicochemical parameters

The Temperature of the water sample was determined in situ using mercury in glass thermometer immediately at the site of collection and calibrated in degree Celsius, pH was measured using portable digital pen type pH Meter (pH-B600L,China) Electrical conductivity and Total

Dissolved Solids were determined using JENWAY Model 470 portable conductivity/TDS meter, UK). Other physicochemical parameters that were later determined in the preserved water samples were: total hardness by EDTA titrimetric methods (APHA, 1999) [7], Turbidity, dissolved oxygen (DO), Chemical oxygen demand (COD), Sulphate and Phosphate were determined by standard methods (APHA, 2002) [8]. All the chemicals used were of analytical reagent grade and obtained from British Drug House (BDH, London).

Result and Discussion

The results of the physicochemical parameters of River Niger along the sampling location in both Dry and Wet seasons are presented in Tables 1 and 2.

Table 1: Mean values of Physicochemical Parameters from locations on the River Niger (Wet Season)

S/N	Parameters	Adankolo	Ganaja	Gadumo	Kpata	Kabawa	Mean±SD	WHO, 2003[9]
1.	Temperature (°C)	28.13	27.31	27.95	28.01	28.05	27.89±0.33	29
2.	pH	6.57	6.59	6.80	6.85	6.08	6.56±0.30	6.50 – 9.00
3.	Hardness (mg/L)	40.52	38.32	39.10	37.20	38.40	38.71±1.22	300
4.	Turbidity (NTU)	25.48	26.00	24.50	25.30	25.78	25.41±0.58	25
5.	EC (µs/cm)	12.32	15.42	15.09	13.11	13.59	13.91±1.32	250
6.	TDS (mg/L)	10.95	11.31	11.50	10.52	10.69	10.99±0.41	500 – 1000
7.	DO (mg/L)	6.30	7.21	6.95	7.11	6.84	6.88±0.36	5.0
8.	COD (mg/L)	11.60	18.61	17.70	15.49	17.98	16.23±2.87	7.5
9.	Sulphate (mg/L)	2.82	2.10	2.95	2.65	2.90	2.68±0.35	400
10.	Phosphate (mg/L)	0.98	0.85	0.93	0.91	0.88	0.91±0.05	5.0

Temperature

The mean temperature values during wet season ranged from 27.31 °C – 28.13 °C and the dry season temperature ranged from 29.21 °C -30.53 °C. The highest temperature during the wet season was observed at Adankolo sampling location (28.13 °C) and the highest temperature during dry season observed at Ganaja sampling location (30.53 °C). The dry season values were generally higher compared to the wet season. The temperature range during wet season is within WHO maximum acceptable limit but the dry season values at Adankolo (30.24 °C), Ganaja (30.53 °C) and Gadumo (30.38 °C) Kpata (29.21 °C) and Kabawa (29.53 °C) were all above WHO maximum acceptable limits. Temperature is an important parameter affecting pH in aquatic environments and it is governed by physical, chemical and biological properties [10].

Table 2: Mean values of Physicochemical Parameters from locations on the River Niger (Dry Season)

S/N	Parameters	Adankolo	Ganaja	Gadumo	Kpata	Kabawa	Mean±SD	WHO, 2003[9]
1.	Temperature (^oC)	30.24	30.53	30.38	29.21	29.53	29.98±0.56	29
2.	pH	6.88	6.72	6.99	6.88	6.89	6.87±0.10	6.50 – 9.00
3.	Hardness (mg/L)	59.78	59.98	58.75	57.50	55.91	58.38±1.70	300
4.	Turbidity (NTU)	19.95	19.60	18.10	19.35	18.51	19.10±0.75	25
5.	EC (µs/cm)	7.30	6.31	7.00	7.98	8.31	7.38±0.79	250
6.	TDS (mg/L)	8.91	7.15	7.67	8.31	8.97	8.20±0.79	500 – 1000
7.	DO (mg/L)	5.29	5.44	5.57	4.93	5.19	5.28±0.25	5.0
8.	COD (mg/L)	6.09	6.58	3.59	11.06	13.13	8.09±3.90	7.5
9.	Sulphate (mg/L)	3.20	3.51	4.98	3.45	3.89	3.81±0.70	400
10.	Phosphate (mg/L)	0.65	0.52	0.66	0.49	0.69	0.60±0.09	5.0

pH

The mean pH values of water samples ranged from 6.08 (Kpata) – 6.85 (Kabawa) during the Wet season and 6.72 (Ganaja) – 6.99 (Kpata) during dry season. The overall mean pH value across the locations was found to be 6.87±0.10. These values are within the WHO standard acceptable limits. Also, the dry season values were generally higher than the wet season values. These variations between the dry and wet seasons might be due to low levels of water as a result of evaporation and high anthropogenic activities along the river bank. The results were comparable found to be comparable to results of a study carried out by Aremu *et al*., 2014[11] on streams from Okene having pH values of 6.50 and 7.03 in the dry and wet seasons respectively.

Total Hardness

Total hardness is due to the presence of bicarbonate, sulphate, chlorides and nitrates of calcium and magnesium. The total hardness values range from 37.20 mg/L (Adankolo) – 40.52 mg/L (Kpata) during wet season and 55.91 mg/L (Ganaja) – 59.98 mg/L (Kabawa) during dry season. The values were generally higher during dry season compared to wet season. These values were however lower than the maximum permissible limit hence the water from these sampling locations can support the growth and survival of biota living in the river along the sampling location. The values obtained from this study were found to be similar to that of the study conducted by Igbokwe *et al.,* 2021[4].The values were however far lower than results obtained in a study carried out by Oko *et al*.,2014[12] on underground waters in Wukari having mean values of 140 mg/L. This could suggest that depth may

also impact on the level of hardness observed for a water source.

Turbidity

In this study the mean turbidity values ranged from 18.10 (Gadumo) – 19.95 NTU (Adankolo) during dry season and 24.50 (Gadumo) – 26.00 NTU (Ganaja) during wet season. The wet season values are higher than the dry season values. The wet season values are above the permissible limit while the dry season values are below the permissible limit. The high turbidity values during rainy season might be due to higher flow rate that carry sediments and other materials to the river. Results from experiment carried out on River Nkomon by Silas *et al*. [13] also shows high turbidity during rainy season. During dry season, settlement of silt and clay result to low turbidity values, while during wet season silt, clay and other suspended particles contribute to high turbidity values [13].

Electrical Conductivity

The mean conductivity values for wet season ranged from 12.32 µs/cm (Ganaja) – 15.42 µs/cm (Adankolo) and the dry season values ranged from 6.31 (Kpata) – 8.31 µs/cm (Kabawa). The wet season values are higher than dry season values but the values are however within the permissible limits. High conductivity values are mostly associated with agricultural runoff, waste water, discharge from sewage and industries [14]. The result of this study (High Conductivity during rainy season) is in-line with a study conducted by Anhwange *et al.* [15].

Total Dissolved Solids

The total dissolved solids give an indication of the degree or dissolved substance [16]. The mean TDS values across the locations along River Niger ranged from 7.15 (Kabawa) – 8.97 mg/L (Ganaja) during dry season and 10.52 (Ganaja) – 11.50 mg/L (Kpata) during wet season. These values are within the permissible limit. The rainy season values are however higher than the dry season values. TDS in surface water originate from sewage, urban and agricultural run-off and industrial waste water [9].

Though studies have not proven that health implications are associated with drinking water with high concentration of total dissolved solids, the presence of dissolved solids in water may affect its taste [9]. TDS are relatively proportional to electrical conductivity since electrical conductivity is related to the number of dissolved solids [17]. The present study which is similar is to that conducted by Magaji and Adakayi [18] also indicated higher TDS during wet season.

Dissolved Oxygen

Dissolved oxygen is one of the most important parameters in determining the quality of surface water. DO affects the growth, survival, distribution, behaviour and physiology of aquatic organisms (Sale, 2020)[10]. Its deficiency affects the ecosystem of a river due to bioaccumulation and biomagnification (Silas et al., 2018)[14]. DO levels below 1ppm will affect fish while levels of 5 – 6 ppm are required by most fish population. In this study, the dry season mean values for DO ranged

from 4.93 (Kpata) – 5.57 (Gadumo) mg/L and the wet season mean values ranged from 6.30 (Adankolo) – 7.21 (Ganaja) mg/L. These values are however above the standard permissible limit in some locations. Wet season values were found to be higher than the dry season values and Silas *et al.* (2018)[14] also observed higher DO values during wet season as compared to dry season along Mkomon River which they attributed to the effect of temperature on the solubility of oxygen in the water. This study is in contrast with study carried out by Samfo *et al.* (2022)[19] which indicate higher DO during dry season along River Tordzie.

Chemical Oxygen Demand

COD is a pollution parameter indicating the level of organic pollution. This test allows for measurement of waste in terms of the total quality of oxygen required for oxidation to carbon dioxide and water [20]. During this investigation, a mean COD values of 3.59 (Gadumo) – 13.13 (Kabawa) mg/L was observed during dry season while during the wet season it was between 11.60 (Adankolo) – 18.61 (Ganaja) mg/L. The wet season values were higher than the dry season values. The result agrees with an earlier study carried out along River Benue by Akaahan and Azua, (2016)[21] . The values obtained in most of the locations were higher than the permissible values. The higher COD values indicate high organic pollution as well as presence of inorganic ions [22].

Sulphate

The mean concentration of sulphate from the study ranges from 3.20 (Adankolo) – 4.98 (Gadumo) mg/L during the wet season and 2.10 (Ganaja) – 2.90 (Kabawa) mg/L during the dry season across the locations. The wet season values were found to be higher than the dry season values and this study is in line with a study conducted by Simeon *et al.*, (2021) [23]. However, the values obtained are lower than the WHO limit. Sulphate is usually introduced into the river as a result of agricultural and domestic activities such as application of fertilizers which are transported by run off into the river and also due to sulphate -containing detergents used along the banks of the rivers.

Phosphate

Phosphate is one of the factors responsible for eutrophicaton in water. The highest mean phosphate value was observed during the wet season ranges from 0.85 (Ganaja) – 0.98 (Adankolo) mg/L and 0.49 (Kpata)–0.69(Kabawa) mg/L during dry season. Phosphate comes mostly from fertilizer application, pesticides, industries and detergents while natural sources include phosphate – containing rocks. This study agrees with a study conducted by Ugwu and Wakawa [24], which shows high phosphate content along River Usuma during wet season as compared to dry season. The values reported in the present study are however lower than reported in a study carried out by Aremu *et al*., 2017 [25] on Rivers at Wukari during wet and dry seasons.

Conclusion

The seasonal variation of physicochemical parameter was studied in this work at 5 sample points namely Ganaja, Gadumo, Adankolo, Kapta and Kabawa. The research ascertains that there is variation in these parameters with season. Some of the values obtained are lower than NSDWQ and WHO values while some values are higher than the acceptable values. The average value of chemical oxygen demand across the Rivers studied suggest levels of chemical contaminations from human activities especially during the wet season which should be adequately managed to forestall health effect associated with use of the River water sources. It is therefore recommended that they should be treated before use.

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