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Physicochemical Analysis of Bembal River Water in Lau Local Government Area, Taraba State, Nigeria

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Abstract
The study investigated various physicochemical parameters in the Bembal River, Lau, Taraba state, Nigeria over six months. The study was carried out in the Bembal River, which is located in the Lau local government area, Taraba state. Samples of water were taken fortnightly throughout six (6) months (i.e. from November 2023 to April, 2024) from 6 am local time. Water samples were collected and transported to the laboratory for physicochemical parameters. Results of the physiochemical parameters were in the range of 23.60 to 25.90°C (water temperature), 12.68 to 37.21cm (Transparency), 6.66 to 7.56 (pH), 83.00mg/L to 91.67mg/L (Total Alkalinity), 69.94 to 155.208 us/ cm (water conductivity), 5.30 to 17.46mg/l (free CO_2), 27.50 to 34.50mg/l (Nitrate), 118.22 to 145.12mg/l (Phosphate), 0.0054 to 0.069mg/l (Ammonia), 0.61 to 1.85mg/l (Dissolved Oxygen), 78.70 to 83.44mg/L (Dissolved solids), 3.14 to 4.081mg/L (Biochemical oxygen demand). All the physicochemical parameters showed significant differences in variability with the months ($P < 0.05$). Based on the findings for this study, the physicochemical parameters such as phosphate, free CO2, Ammonia, BOD and DO were recorded above the recommended limit, while the rest of the parameters were within the range. However, a routine monitoring of these parameters in this study area has to be carried out to ascertain the long-term impact of anthropogenic inputs to take remedial measures to ensure the good health of aquatic life.

Keywords: Physicochemical Parameters, Anthropogenic Activities, Assessment, Bembal River.

Introduction

Aquatic ecosystems are intricate environments consisting of a wide array of interacting factors, including physicochemical parameters and biological communities (Doe et al., 2018; Harrison et al., 2018). The physicochemical parameters of water, such as temperature, pH, dissolved oxygen, conductivity, and nutrient levels, play crucial roles in determining the overall health and functioning of these ecosystems. The assessment of physicochemical parameters is essential for evaluating the quality of water in aquatic ecosystems. These parameters provide valuable information about the physical and chemical characteristics of the water, which directly affect the survival, growth, and reproduction of aquatic organisms, including fish. For example, studies have shown that variations in water temperature and dissolved oxygen levels significantly influence the distribution and abundance of fish species (Doe et al., 2018). Nutrient concentrations, such as phosphorus and nitrogen, also play a role in fish biodiversity, with nutrient enrichment showing a negative correlation with fish species richness (Smith et al., 2019).
Several studies have highlighted the importance of monitoring and maintaining suitable ranges for temperature, pH, dissolved oxygen, and nutrient levels to sustain healthy fish populations (Jones et al., 2016; Smith & Johnson, 2017). However, this river is subject to various anthropogenic activities, including agricultural runoff, industrial discharges, and habitat degradation, which may impact water quality. Numerous studies have addressed the significance of factors such as temperature, dissolved oxygen, pH, and nutrient levels (Doe et al., 2018; Yan et al.,

2018; Smith et al., 2019). To effectively manage and conserve the Bembal River it is crucial to assess physicochemical parameters.

Materials and Methods

Study Area

The study was carried out in river Bembal which is located in Lau local government area, Taraba state. Lau is a Local Government Area in Taraba State, Nigeria. Its headquarters is in the town of Lau and the area is dominated by Bakula people. Lau Local government has a border with Ardo Kola, Jalingo, Yorro and Zing local governments of Taraba state. It also shares a border with Numan, Adamawa State. It has an area of 1,660 km2 and a population of 149,700 at the 2022 projection (Figure1).

Sampling Sites and Collection

Three sampling sites were established within River Bembal. The location of the sites were Agricultural activities (site i), Anthropogenic activities (Site ii), Fishing activities (Site iii). River Bembal Sampling Sites have the following Coordinates; site I (9.3289499^0N 11.4487^0E) , Site ii (9.3172903^0N 11.4218998^0E) and Site iii (9.3105097^0N 11.3944998^0E) respectively. The water samples were collected using 1 liter sampling bottles. The sampling was carried out from November 2023 to April 2024. The samples collected were carefully labeled and transported to the Laboratory for analysis.

Water Quality Analysis

The physicochemical parameters of the water (i.e water temperature, Transparency, pH, conductivity, total alkalinity, free carbondioxide, nitrate, phosphate, ammonia, total dissolved solids, Dissolved oxygen and biological oxygen demand) were analyzed using standard methods as described by APHA (1999).

Data Analysis

Physicochemical data, was subjected to one-way analysis of variance (ANOVA) for identification of significant variation (at 0.05) using SPSS, (graph pad distant window, 2020 and Excel window, 2020).

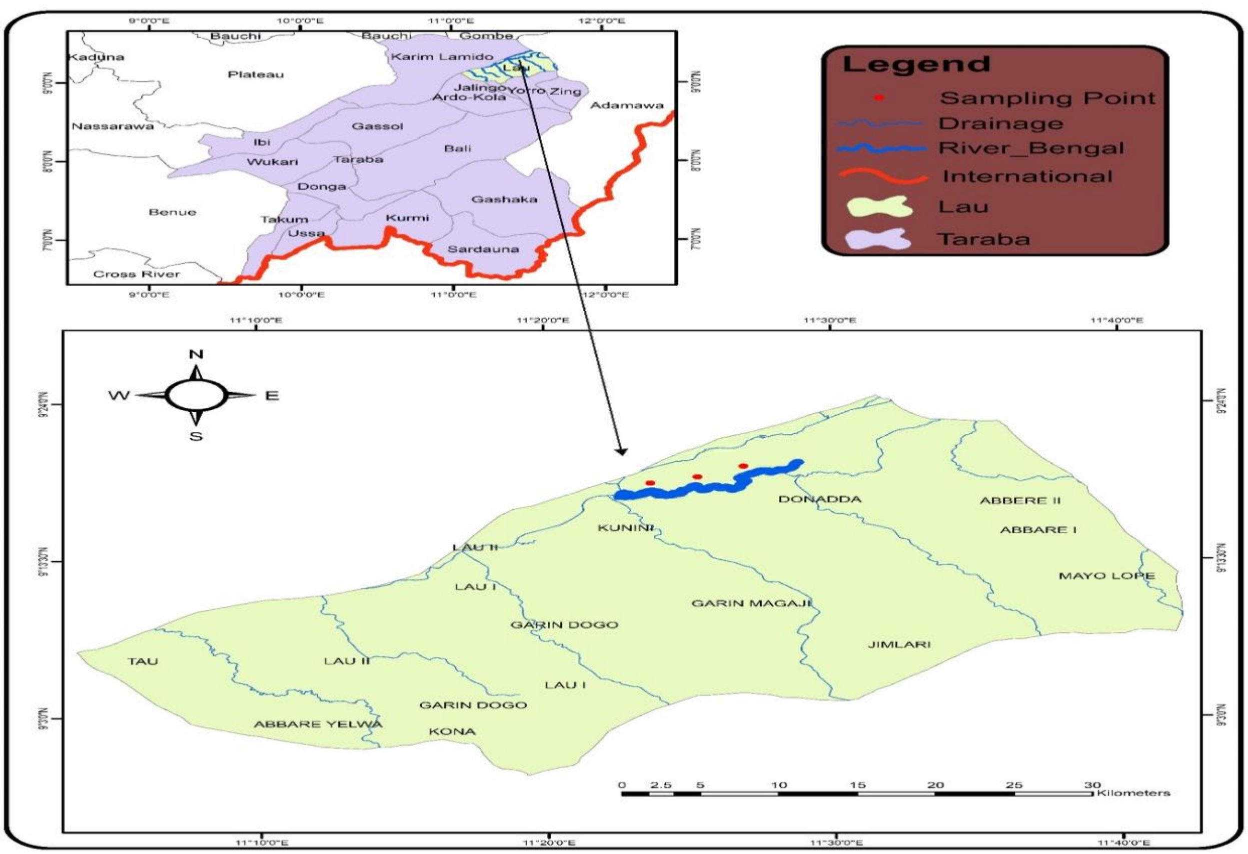

Figure 1: Showing the study area; Lau LGA showing River Bembal showing the Sampling Sites

Source: GIS Laboratory, Department of Geography Modibbo Adama University, Yola 2024.

Results

Physicochemical Parameters

The monthly mean of the physicochemical parameters of the Bambel River are presented in Table 1. The Mean monthly variations of water temperature ranged from 23.60°C in the month of November, 2023 to 25.90°C in the month of April, 2024. There was significant difference in variability in months ($p < 0.05$). The Mean monthly variations of transparency ranged from 12.68cm to 37.21cm in the months of April, 2024 and February, 2024 respectively. There was a significant difference in variability in months ($p < 0.05$). The Mean monthly variations of water conductivity ranged from 69.94us/cm in the month of April, 2023 to 155.208 us/ cm in the month of December, 2023. There was significant difference in variability in months ($p < 0.05$). The Mean monthly variations of water pH ranged from 6.66 in the month of April, 2024 to 7.55 in the month of March, 2024. There was a significant difference in variability in months ($p < 0.05$). The Mean monthly variations of total alkalinity ranged from 83.00mg/L in the month of March, 2024 to 91.67mg/L in the month of December, 2024. There was significant difference in variability in months ($p < 0.05$). The Mean monthly variations of free CO_2 ranged from 5.30mg/l in the month of December, 2023 to 17.46mg/l in the month of April, 2024. There was significant difference in variability in months ($p < 0.05$). The Mean monthly variations of nitrate ranged from 27.50mg/l in the month of March, 2024 to 34.50mg/l in the month of February, 2024. There was significant different in variability in months ($p<0.05$). The Mean monthly variations of phosphate ranged from 118.22mg/l in the month of April, 2024 to 145.12mg/l in the month of November, 2023. There was significant difference in variability in months ($p<0.05$). The Mean monthly variations of total ammonia ranged from 0.010mg/l in the month of April, 2024 to 0.069mg/l in the month of November, 2023. There was significant difference in variability in months ($p<0.05$). The Mean monthly variations of DO range from 0.61mg/l in the month of April, 2024 to 1.85mg/l in the month of December, 2023. There was significant difference in variability in months ($p<0.05$). The Mean monthly variations of total dissolved solids ranged from 78.70mg/L in the month of December, 2023 to 83.44mg/L in the month of April, 2024. There was significant difference in variability in months ($p<0.05$). The Mean monthly variations of biochemical oxygen demand ranged from 3.14mg/L in the month of April, 2024 to 4.081mg/L in the month of November, 2023.There was significant difference in variability in months ($p<0.05$).

Table 1. Mean Monthly of Physicochemical Parameters of Bembal River for the Month of November, 2023 to April, 2024

Parameters	November	December	January	February	March	April	Recommended limit	Reference
Temperature (°c)	23.60±1,04	24.17±1.43	23.85±1.39	25.48±1.46	25.44±1.46	25.89±1.47	20-30 °c	WHO, (2021)
Transparency(cm)	17.17±2.45	17.75±2.89	13.55±2.45	37.20±4.53	13.09±2.45	12.68±2.89	19.5-32.5	
Conductivity (µs/cm)	151.43±37.85	155.20±32.53	87.90±39.09	82.66±39.04	73.33±35.07	69.94±33.12	200-1000 µs/cm	
pH	7.33±0.45	6.99±0.24	7.24±0.45	7.34±0.64	7.55±0.45	6.66±0.24	6.5-8.5	
Alkalinity (mg/L)	85.49±6.40	91.67±9.32	85.05±8.58	87.83±8.21	83.00±6.73	85.66±8.11	200 mg/L	
Free CO_2(mg/L)	15.41±0.03	5.30±0.09	8.40±0.07	7.73±0.07	16.80±0.02	17.46±0.02	Below10-15mg/L	
Nitrates (mg/L)	29.10±4.00	34.16±4.31	30.63±4.00	34.50±5.18	27.50±4.31	33.06±4.00	50 mg/L	
Phosphate (mg/L)	145.11±9.16	137.95±13.30	140.47±9.17	140.33±9.34	132.11±13.30	118.22±12.37	1.0 mg/L	
Ammonia (mg/L)	0.06±0.06	0.04±0.03	0.05±0.06	0.04±0.03	0.05±0.06	0.01±0.03	0.02-0.05 mg/L	
Dissolved oxygen (mg/L)	1.28±0.45	1.85±0.44	1.41±0.42	1.67±0.41	0.82±0.92	0.61±0.35	5-7mg/L	
Total dissolved solids (ppm)	79.91±2.68	78.70±2.51	80.66±2.68	80.05±2.68	82.83±2.51	83.44±5.45	500 mg/L	
Biological oxygen demand mg/L	4.08±0.62	3.98±0.83	3.91±0.88	3.93±0.83	3.82±0.62	3.14±0.88	3-5 mg/L	

Discussion

The Mean monthly water temperature of the river fluctuated between 23.6°C and 25.9°C in November and April during the period of the research. The low water temperature recorded in the November of the dry season might be due to the characteristic pool dry North-East under wind known as harmattan between November and February while high temperature in April may be due to characteristic of hot weather in Taraba. This pattern of variation has similarly been reported in Northern Nigeria by Nababa, et al. (2024) in Gubi Reservoir. Adeyemi &Ibrahim. (2020) in the major rivers of Kainji Lake National Park and Eneogwe et al. (2022) in Kubanni Lake. The values of temperature observed are within the normal range of 8-30°C which fish are adapted in the tropics, which are the critical thermal, minimum and maximum respectively (Illing et al., 2020, WHO, 2021). The range of temperature recorded during the period of the research is almost in line with (26.0-29.0°C) obtained by Adeyemi and Ibrahim (2020) in Gbedikere Lake, Basssa, Kogi State and (25.8-28.0°C) recorded by Kefas et al. (2023) in Upper River Benue, Adamawa State respectively. The high temperature observed in this River could be due to the shallow nature of the River, which could be favourable to fish growth and development Woolway et al. (2020). Water temperature determines the concentration of many variables. As water temperature increases, the rate of chemical reactions generally increases together with the evaporation and volatilisation of substances. Increased temperature also decreases the solubility of gases, such as O_2, CO_2, N_2 and pH. The metabolic rate of aquatic organisms is also related to temperature and in warm waters, respiration rates increase leading to increased oxygen consumption and increased decomposition of organic matter Jabiol et al. (2020).

The Mean monthly transparency of the Bembal River was lowest in April and highest in December. The lower value recorded in April might be as a result of beginning of rainy season with corresponding high turbidity which might be attributed to increase in debris load. The high transparency mean value recorded in December could be due to absence of floodwater, surface run-offs and settling effect of suspended materials that followed the cessation of rainfall. The secchi disc depth is inversely related to turbidity and determines the conditions of availability of light in the water column to support photosynthesis by phytoplankton, and hence production (Golubkov & Golubkov, 2023). Higher turbidity increases water temperature because suspended particles absorb more heat; this, in turn reduces the concentration of dissolved oxygen because it reduces the amount of light penetrating the water, which reduces photosynthesis (Wotton, 2020). According to Schumann (2021) suspended materials can clog fish gills, reducing resistance to diseases and growth rates. Peschel and Aschemann-Witzel (2020) observed that decrease in water transparency reduces production of natural food in water

The Conductivity values recorded are in agreement with 499.44 µS/cm reported by Schumann (2021) in Bembal River and WHO, 2021. The high conductivity values recorded in December may be due to the fluctuation of Mean monthly values of pH around the neutral point of 7 recorded in the River and low transparency. The lower values recorded in April could be as result of dilution. Krishan et al. (2021) pointed out that ions were lower in the rainy season than in the dry season since conductivity declines in the wet periods as the concentration of salts becomes more dilute. Therefore, discharges can change the conductivity of a river because of their make-up. Anyanwu & Emeka (2020) stated that the very acidic (pH<4.5) or alkaline (pH>10) waters have appreciated higher conductivity values. Discharges could raise the conductivity because of the pressence of chloride, phosphorus and nitrate Gbarakoro et al. (2020). The Mean monthly variation of the pH values ranged from 6.66 in April to 7.55 in March. The recorded values fall within the EU recommended range of 6 to 9 for fisheries and aquatic life Baudron et al. (2020) and the WHO pH guideline (<8.0) for drinking water for effective disinfections with chlorine (WHO, 2021). The low mean pH recorded in April while the high pH observed in March could be as a result of complete dry season. Abubakar (2006) pointed out that low pH allows toxic elements and compound to become mobile and available for uptake by plants and animals. Schumann (2021) reported that pH is an important parameter in many ecological studies because there is a strong relationship between pit and the physiology of most aquatic organisms. WHO (2021) observed that extreme pH values outside the range of 6.5 to 9.0 stressed the physical system of most aquatic organism and reduced reproduction. The Mean monthly variations of total alkalinity ranged 83.00mg/L to 91.67mg/L during the period of the study which is higher than the 9.1 to 28.3 reported by Kefas et al (2023) in Upper River Benue and in line with the 84-128mg/l reported by Woolway et al, (2020) in river Suka. The pH values of 7 and above observed in the River show the high buffering capacity of the water body. The result also shows that alkalinity is high in the dry season. This could be due to low water levels with its stagnant concentration of salts. Adeyemi & Ibrahim (2020) recorded similar result for Dokowa Mine Lake. Schumann (2021) observed that the alkalinity buffering capacity in natural fresh water systems is due mainly to the presence of bicarbonate leached from the soils in rain water runs off. Woolway et al. (2020) also stated that increase pH values of water with high alkalinity (hard water) ranged from 8.5 upward.

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The Mean monthly variation of free CO_2, ranged between 5.30mg/l to 16.80mg/l. The low value of free CO, observed in December may be attributed to light intensity penetrating the clear water leading to photosynthesis while high CO_2, recorded in April could be as results of high temperature, low DO and dry season farming activities around the river which washed organic and inorganic chemicals into the water body. However, the values obtained were higher than recommended safety limit reported by Schumann (2021) & WHO (2021). Waters with high free CO_2 content may cause problem of kidney stone formation in fishes Jabiol et al. (2020). The Mean monthly nitrate fluctuations between the ranges of 27.50mg/l to 34.500mg/l is more than 0.44 to 1.21mg, reported by Abubakar (2006) in Lake Geriyo and lower than the values suggested by WHO (2021). The higher nitrates observed in February could be due to agricultural activities as well as the decomposition of organic matter. Eneogwe et al. (2022) made similar observations for Dokowa Mine Lake. Jabiol et al. (2020) stated that high nitrate concentration in lake is related to inputs from agricultural lands. Higher concentration of excess nitrate-nitrogen at 10mg/l or higher can cause low level of dissolved oxygen and become toxic to warm-blooded animals under certain conditions. The low values of total nitrate observed in the river might be due to the high concentration of dissolved oxygen recorded during the period of research. Schumann (2021) states that in well-oxygenated water, nutrient element form a bond with sediments that prevents their recycling. Nitrogen is an important source of nutrients for aquatic plants and animals Jabiol et al. (2020). Adeyemi & Ibrahim (2020) reported of its role in the formation of major constituents of protein.

The Mean monthly variation of phosphates ranged from 118.22mg/l to 145.12mg/l. This is at variance with 0.04 to 0.05mg/l reported by Woolway et al. (2020) in river Suka & WHO (2021). The low value recorded in April might be due to influx of water into the River as result of rain while the high value in December could be as results of reduced volume of water and agrochemicals used around the River in dry season farming. The concentration of phosphate also increases in dry season as the water volumes are decreasing. Nababa et al. (2024) made similar observations. Increase in phosphorus could be due to lower water hardness, thus less co-precipitation of phosphate with calcium carbonate, a phenomenon that has often been reported to occur in many lakes (Schumann, 2021). WHO (2021) stated that artificial sources of phosphorus include fertilizers, detergent, waste water, industrial effluent and animal faces amongst others. With increase in rains and accumulation of run-off water in river, it was observed that concentration of phosphorus increased, but the concentration of phosphorus recorded during period of the study was within safety limit of about or less than 1mg/l (WHO, 2021). The Mean monthly total ammonia variations ranged from 0.01mg/l to 0.0694mg/l is higher than 0.025mg/l recommended by Schumann (2021) and also in slightly higher than the values reported by WHO (2021). Ammonia in water is released as an end product of decomposition of organic matter and also as excretory product of some aquatic animal (Saxena, 2019). Ammonia is an important nutrient of phytoplankton (Philips, 2015). The high total ammonia observed during the period of the study might be due to decomposition of organic materials in River. Eneogwe et al. (2022) stated that ammonia could originate where the farm water supply is polluted with sewage, silage or other organic rich water. Golubkov & Golubkov, (2023) reported that high ammonia caused poor growth, increased susceptibility to disease and eventually death in fish.

Dissolved oxygen (DO) is a very important parameter of water quality and is an index of physical and biological processes going on in the water Nababa et al. (2024). The Mean monthly variation of the DO ranged from 0.61mg/l to 1.85mg/l. The Mean monthly value of DO observed during the period of study is lower than 12.02mg/l to 19.50mg/l as obtained by Abubakar (2006) in Lake Geriyo and the values of WHO (2021). The low DO observed during the period of research might be due to high CO_2, high temperature and decomposition of organic matter resulting in use of oxygen, while high DO in December could be as results of low temperature and high transparency observed. Jabiol et al. (2020) pointed out that apart from the photosynthetic activities which added to the maintenance of high oxygen levels, the cool wind action cause the water to mix thereby the phenomenon of bottom-up and top-bottom is enhanced. Super saturated oxygen conditions are caused by algal bloom while low oxygen (anoxic) conditions reduce the number of species being formed and frequently leads to the release of undesirable odours until aerobic or toxic condition develop Woolway et al. (2020).

The total dissolved solids (TDS) values ranges from 78.70 to 83.44mg/L during the period of research. The mean TDS values is within 27.60 to 114.67 mg/L observed by Emmanuel et al. (2017) and lower than 500 mg/L reported by WHO (2021). The TDS be observed during the period of the research might be due to reduced river flow and increased solute concentration. Human activities such as agriculture, industrial processes, and wastewater discharge can introduce additional dissolved solids into the river, leading to elevated TDS levels. Also, increased evaporation and plant transpiration can concentrate solutes in the remaining water, leading to higher TDS values. This agrees with the findings of Adebayo et al. (2015) who studied the physicochemical parameters of the Osun River in Nigeria and found seasonal variations in TDS levels, with higher values during the dry season. This aligns with the findings of this study, emphasizing the influence of hydrological conditions on TDS. Osibanjo et al. (2014) also investigated water quality in the lower Niger River and reported that human activities, such as industrial effluents, contributed to elevated TDS levels in certain reaches. This highlights the potential impact of anthropogenic activities on TDS concentrations. The mean values of biochemical oxygen demand (BOD) ranges between 3.14 to 4.08 mg/L during the period of research. The BOD observed is higher than 3.5 mg/L reported by WHO (2021). . Elevated BOD levels often indicate the presence of organic pollutants, such as domestic sewage, industrial effluents, or agricultural runoff. Microbial decomposition of organic matter consumes oxygen, leading to increased BOD values. Higher temperatures can accelerate microbial activity, resulting in elevated BOD levels. Variations in temperature, rainfall, and river flow can impact BOD levels. This finding agreed with Adebayo et al. (2015) who studied the physicochemical parameters of the Osun River in Nigeria, including BOD, and found seasonal variations with higher values during the dry season. This aligns with the potential impact of hydrological conditions on BOD levels. Osibanjo et al. (2014) also investigated water quality in the lower Niger River and reported the influence of human activities, such as domestic and industrial discharges, on BOD levels.

Conclusion

This study assessed the water quality of River Bembal, Lau, Taraba state, Nigeria. The results obtained from this water quality parameters of the measured physicochemical parameters are all within the permissible limits for water quality except for Phosphates, free co_2, Ammonia, BOD and DO. However, the River is moderately polluted , which required routine monitoring of these parameters in these study area has to be carried out to ascertain the long-term impact of anthropogenic inputs to take remedial measures so as to ensure the good health of aquatic life.

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