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Changes in Water Quality of Lotic Water Body Along River Hadejia, Hadejia Local Government Area of Jigawa State

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ABSTRACT
Water resources are vital to human survival and the functioning of aquatic ecosystems, yet they are highly vulnerable to degradation from anthropogenic activities. This study evaluated spatial variations in the water quality of River Hadejia, Jigawa State, Nigeria, using selected physicochemical parameters as indicators of ecological condition, pH, total dissolved solids, electrical conductivity, turbidity, dissolved oxygen, and biological oxygen demand (BOD) using standard analytical procedures. The data obtained were subjected to one-way analysis of variance (ANOVA) to determine differences among stations. The mean surface water temperature among the stations ranged from 22.3℃, 20.66℃ and 19.33℃ in station 1, 2 and 3 respectively. Station 2 has the highest mean value of 20.66℃ followed by station 1 and station 3 which has the lowest mean value, The mean value of Depth in Hadejia River during the period of study was found to range from 0.25m, 0.13m, and 0.15m in station 1, 2 and 3 respectively. The measure of hydrogen ion concentration (pH) mean values of Hadejia River ranged from 6.94 in station 1, 6.93 in station 2 and 6.51 in station 3. The results indicated no significant variation ($p > 0.05$) in pH, water depth, total dissolved solids, and biological oxygen demand across the sampling stations. However, significant differences ($p < 0.05$) were observed in water temperature, air temperature, turbidity, conductivity, and dissolved oxygen. Elevated turbidity levels and reduced dissolved oxygen concentrations suggest that the river is experiencing pollution stress, which may negatively affect habitat quality, biodiversity, and ecosystem services.

Keywords:
Lotic,
River Hadejia,
Physicochemical Parameters,
Water quality Assessment,
Sampling station

INTRODUCTION

Water is one of the most vital resources on the planet earth, without water, life cannot continue. Water plays a major role in supporting the human health and welfare. Around 780 million people do not have approach to pure and safe water and around 2.5 billion people do not have good sanitation. As a result, around 6–8 million people die each year due to water related diseases and calamity Suresh *et al.*, 2022). There are than fifty different types and 80% of diseases like diarrhea, skin diseases, malnutrition, cancer and 50%of child deaths are caused by drinking of polluted water around the world (UN-Water, 2013; Lin *et al.*, 2022). Water is a renewable natural resource that plays a fundamental role in sustaining life, supporting ecosystems, and driving socio-economic development (Khwakaram *et al*., 2012). Water is an essential requirement of human and industrial development but it is also one of the most delicate part of the environment (Das and Acharya, 2003, Hariam *et al.*, 2023).

The lack of strong enforcement of law and loose governance are the cause of deterioration of good water quality (Guptaa, 2009, Obialor, 2023)). Indicators for monitoring the upshot of wastewater discharges in aquatic ecosystems have include macro invertebrate assemblage (Elias *et al*., 2014; Chikodzi *et al*., 2017). Since they are less mobile found at the bottom of a stream and have short life cycles that authorize quick response for various environmental conditions (Dalu & Froneman, 2016). Rivers are the most significant natural water resources for human development, but they are polluted by indiscriminate sewage dumping, industrial waste,

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and a variety of human activities that change the physicochemical and microbiological quality of the water (Lulin *et al*., 2022). The importance of water to human beings cannot be overemphasized. A person may go longer without food, but not without water, which is needed for cooking, cleaning, sanitation, drinking, as well as growing crops and operating factories (Etim *et al*., 2013). As a result, it is critical to monitor and assess water quality as well as safeguard it from the various forms of pollution. Changes in land and water use have resulted from human population increase, posing a growing threat to biodiversity and ecosystem services (Lindborg, 2015; Selemani *et al*., 2018). Physicochemical and biological diversity are very important to the health of an aquatic ecosystem like rivers and other freshwater systems (Venkatesharaju *et al*., 2010, Siddiqi et al., 2025).

The physicochemical and biological water quality parameters changed from point to point and consequently affect macro invertebrates composition in a stream or river (Monoj & Padhy, 2013). Therefore, can be inferred the health of river between system and by checking the availability of certain macro invertebrates (Griffin *et al*., 2015). There is a high probability that the rising temperature due to climate change will negatively affect the water quality of river systems (FAO, 2018). The threat to water quality will be severe in Africa where annual stream flow is the lowest in the world as compared to other continents (Brooks *et al*., 2007).Groundwater in springs, wetlands and precipitation are sources of quality water in rivers and streams. However, water is being polluted by point and non-point anthropogenic sources consequently affecting the ecosystem resulting in loss of biodiversity and changes in species composition (Bhaskar & Dixit, 2013). Indeed, nutrient pollution from nitrates and phosphates is expected to increase in sub-Saharan Africa (UNEP, 2017) and hence the need to monitor the health of streams in these areas.

There is a growing global concern about deteriorating water quality caused by pollution from human settlements, agricultural and industrial activities, which is exacerbated by climate change that threatens to cause major alterations to the global hydrological cycle, and current ecosystem function (WHO, 2011). Freshwater resources in most parts of Africa are inadequately monitored, thereby hampering the development of indicators that decision-makers and water-resource managers need to assess progress towards sustainable water resource use (Hassan *et al.*, 2005; PACN, 2010; UN-Water, 2011, Ndubuisi and FNisafety 2025).

The destruction of forests and increasing population is expected to adversely impact heavily on the water flowing in the rivers and hence the need to study water quality of River Hadejia. Water quality deterioration greatly affects biotic communities and human health, pollution of water into the water body makes it detrimental to the health, safety of the public and the environment (Niculae *et al*., 2013, Singh et al., 2024). Kibri a*et al*., (2016) recommended that soil erosion and industrial wastewater furnish to produce heavy metals when discharged into rivers. Therefore, undertaking this study can provide scientific information on status of water quality in River Hadejia and to access ecological health condition of River Hadejia using physicochemical parameters.

MATERIALS AND METHODS

The study were conducted at river Hadejia, Hadejia River is located in Hadejia Local Government Area, Jigawa State, Nigeria, the River is located on Latitude (12^0 13' – 13^0 60' N and Longitude 9^0 22' – $11^0$00' E). It is a tributary of the Yobe River (KomaduguYobe) (Acremen, 2007). The Hadejia River splits into three channels in the Hadejia-Nguru Wetland (HNW): the Marma Channel which flows into Nguru Lake, the Old Hadejia River which joins up with the Jama'are River to become the Yobe River and the relatively small Burum Gana River. The total annual rainfall of Hadejia area is about 600mm. Most of the flow in the Hadejia River system is controlled by Tiga Dam and Challawa Dam (CGR, 2009).

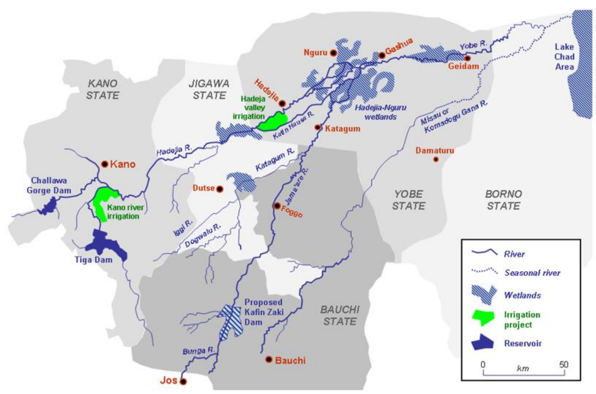

Figure 1: Map of the Study area showing the River Hadejia.

Source: Adopted from https://en.wikipedia.org/wiki/File:Yobe_river_catchment_area.png

Sampling Stations

For this study, three (3) well marked stations will be selected based on their distant and level of anthropogenic activities. The three stations were;

Station one (1) Gudiccin (Latitude 12°45'N and Longitude 10°05'E), have been characterized with less human activities such as washing compared to station 2 (Bakingada).

Station two (2) BakinGada (Latitude 12°44'N and Longitude 10°03'E), also been disturbed with human activities such as bathing, washing, fishing and also their resident.

Station three (3) MahucinSarki (Latitude 12°45'N and Longitude 10°02'E), is also characterized with activities such as open defecations, bathing, washing, heavy farming activity along the river bank.

Duration of the Study

This study was conducted for a period of one month i.e (April, 2025 – August, 2025), water samples are usually collected on Monday's in the morning between (10:00am – 11:30am) on a week in each three river stations.

Physicochemical Analysis

The physicochemical analysis carried out on the water samples included the pH, temperature, depth, Total Dissolved Solids (TDS), Turbidity, Conductivity, Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD), which were determined by standard methods (APHA, 1995). The temperature and depth were determined and recorded immediately at the site.

Determination of Physicochemical Parameters of the River

Temperature

The temperature of water at each sampling station was determined using mercury in glass thermometer dipped for 2-5 minutes in the water at a depth of 5 cm on each sampling day, while for the air temperature the thermometer was held at each station and the readings were recorded appropriately (APHA 1995).

Depth

The depth of water at each sampling station was measured using a rod stick. The rod stick was immersed in water until it touched the substratum. The reading was taken using tape and recorded in meters (APHA, 1995).

pH

The pH of the water was measured using pH meter (Model Hanna pH-25). PH meter was calibrated according to instructional manual provided by the manufacturer before measurement.

Turbidity

The turbidity of the water samples was measured using a portable turbidity meter (model WGZ-B). Each sample was poured in the sample holder and kept inside for few minutes. After achieving the reading stability, the value was recorded in Nephelometric Turbidity Units (NTU) (APHA 1995).

Conductivity

These were determined using the conductivity meter then the electrode of the conductivity meter was rinsed with distilled water and it was allowed to dry, and then it was submerged into a sample. The readings for conductivity were recorded appropriately in $\mu S/cm^{-1}$ using manual guide as a reference.

Dissolved oxygen (DO)

Digital dissolved Oxygen meter was used to determine the dissolved Oxygen, it was calibrated according to the instruction manual provide that the electrode of the dissolved oxygen meter was rinsed with distilled water and dipped into the beaker containing the sample water for about 2-3 minutes and readings was recorded in mg/L.

Total dissolved solid (TDS)

These was determined using the total dissolved solid meter, then the electrode of the meter was rinsed with distilled water and allowed to dry, and then it was submerged into a sample. The readings were recorded appropriately in ppm using manual guide as a reference.

Biological oxygen demand (BOD)

For biological oxygen demand, water sample was incubated for five days in cupboard and Dissolved oxygen was also determined after incubation. The difference between the initial value of dissolved oxygen and the value after incubation gave the value of the biological oxygen demand in the water sample (Mahar, 2003).

BOD_5 (mg/l) =dissolve oxygen (value at day 0) - dissolved oxygen (value at day 5) (APHA, 2005).

RESULTS AND DISCUSSION

Physicochemical Characteristics

Sampling stations and physicochemical parameters variation are shown in Table 1. Among all the physicochemical parameters used in this study four parameters shows no significance difference among sampling stations ($P>0.05$), while five shows significance difference among sampling stations ($p<0.05$).

However, pH, depth, total dissolved solids and biological oxygen demands shows no significance difference among sampling station ($p>0.05$). But parameters among water temperature, air temperature, turbidity, conductivity and dissolved oxygen there was significance difference ($p<0.05$) among all sampling stations. The mean surface of water temperature values among the sampling stations shows significance difference at 95% level of significance ($p<0.05$), air temperature shows significance difference among the H_2O sampling stations ($p<0.05$) as shown in table 1. The mean value of water pH in station 1, 293 was found no significance difference ($P>0.05$) between them as shown in (Table 1). The mean value of depth shows no significantly difference ($P>0.05$) in all stations (Table 1). There was significance difference in turbidity among the sampling stations ($p<0.05$) as shown in (Table 1). However, there was significance difference in H_2O conductivity between all the sampling stations (p<0.05). Statistically no significance difference (p>0.05) was observed in total dissolved solids between station 1,2,8,3 at 95% level of significance as shown in table 1. Also there was significant difference in dissolved oxygen (p<0.05). There was no significant difference (p>0.05) in the mean value of biological oxygen demand observed among all the sampling stations as shown in (Table 1).

Table 1 mean values of physicochemical parameters of the study stations of river Hadejia

Parameters	station 1	station 2	station 3	F-value	P-value
Temperature (ºC)	22.3± **5**.77	20.66±3.46	19.33±0.58	102.3	0.001
	(19.00-29.00)	(18.00-25.00)	(19.00-20.00)		
Air Temperature (ºC)	25.66±2.52	24.00±6.55	24.00±3.46	69.83	0.002
	(23.00-28.00)	(17.00-30.00)	(20.00-26.00)		
pH	6.94±0.12	6.93±0.20	6.51±0.31	187.5	0.09
	(6.83-7.06)	(6.70-7.08)	(6.16-6.73)		
Depth (m)	0.25±0.05	0.13±0.07	0.15±0.3	518.9	0.01
	(0.26-0.3)	(0.08-0.2)	(0.12-0.18)		
Turbidity (NTU)	184.43±8.36	154.33±15.9	183.73±14.1	251.5	0.02
	(178.5-194.0	(139.0-170.8)	(171.0-198.8)		
Conductivity (µS/cm)	14.4±0.9	15.6±0.52	16.62±0.72	518.9	0.01
	(13.5-15.3)	(15.3-16.2)	(16.2-17.46)		
Total Dissolved Solids	6.33±0.58	6.00±1.00	6.00±1.00	869.5	0.09
(TDA) (ppm)	(6 - 7)	(5 - 7)	(5 – 7)		
Dissolved Oxygen	4.93±1.50	4.27±0.58	3.87±1.55	50.8	0.002
(DO) (mg/L)	(3.7-6.6)	(3.6-4.6)	(2.6-5.6)		
Biological Oxygen Demand	2.00±0.89	1.5±0.56	1.37±1.63	2.6	0.1
BOD (mg/L)	(1.3-3)	(0.9-2)	(0.1-3.2)		

Spatio-Temporal Variation of Physicochemical Parameters in Hadejia River

Water temperature

The mean surface water temperature among the stations ranged from 22.3℃, 20.66℃ and 19.33℃ in station 1, 2 and 3 respectively. Station 2 has the highest mean value of 20.66℃ followed by station 1 and station 3 which has the lowest mean value. At the second week there was an increase in the mean values of surface water temperature but, decreases at week 3 as shown in Figure 2.

Air Temperature

The mean values of air temperature ranged from 25.66 ºC, 24.00ºC and 24.00ºC in station 1, 3 and station 2 respectively. The highest mean value of Air temperature was observed in station 1 followed by station 3 and station 2 which has the same value. The highest air temperature mean value was observed in the second week of station 2 and the lowest mean value of air temperature was observed in the third week of the same station as shown in Figure 2.

Depth

The mean value of Depth in Hadejia River during the period of study was found to range from 0.25m, 0.13m, and 0.15m in station 1, 2 and 3 respectively. The highest value observed was found to be in station 1 of week 2, followed by station 3of week 2 3 while station 2 in week 1 had the lowest depth value as shown in Figure 3.

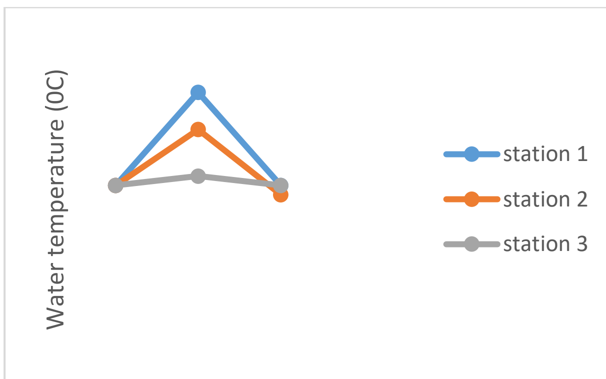

Figure 1 Water temperature variations among three sampling stations of River Hadejia

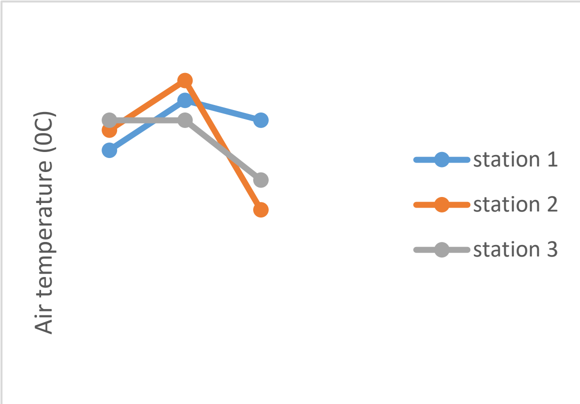

Figure 2.: Air temperature variations among three sampling stations of River Hadejia

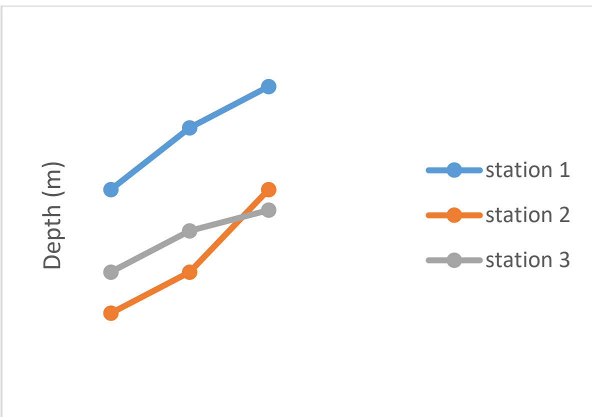

Figure 3: Showing depth variations among three sampling stations of River Hadejia

pH

The measure of hydrogen ion concentration (pH) mean values of Hadejia River ranged from 6.94 in station 1, 6.93 in station 2 and 6.51 in station 3. There is an increase in pH in the second week of station 1, but the mean values of pH decrease during the third week of the same station as shown in Figure 4.

Turbidity (NTU)

The mean values of Turbidity ranged from 184.43 in station 1, 183.73 in station 3 and 154.33 in station 2. The highest Turbidity was recorded in week 3 (198.8NTU) in station 3 then followed by 194,0NTU in station 1 of week 2 and the lowest was recorded in station 2 (139.0NTU) of week 1 as shown in Figure 5.

Conductivity

The mean values of Electrical conductivity ranged from 16.62 in station 3, 15.6 in station 2 and 14.4 in station 1. The highest Electrical conductivity value was recorded in week 3 (17.46µS/cm) in station 3, followed by week 2 and 3 also in station 3 and station 2 of week 1, then lowest value was recorded in week 3 (13.5µS/cm^{-1}) in station 1 as shown in Figure 6.

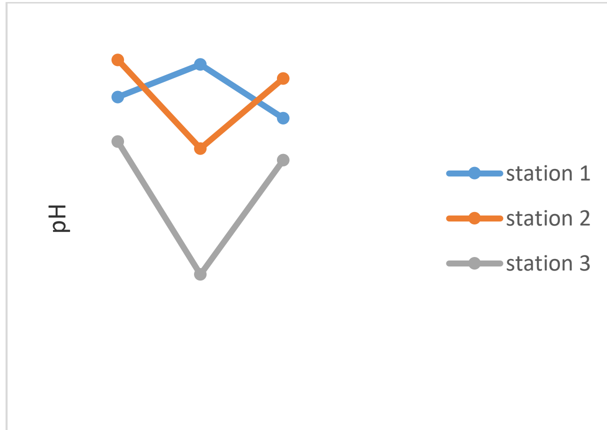

Figure 4: p H variations among three sampling stations of Hadejia River

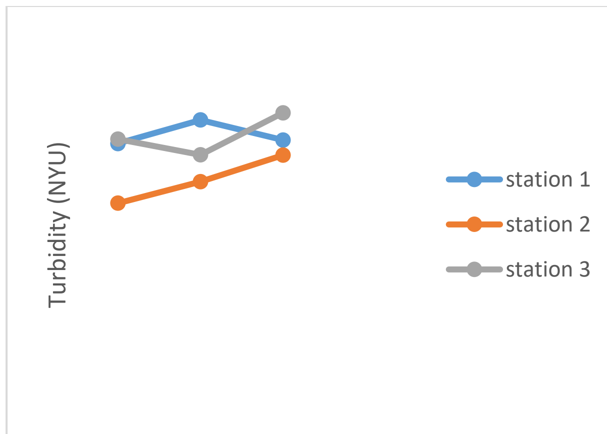

Figure 5: Turbidity variations among three sampling stations of Hadejia River

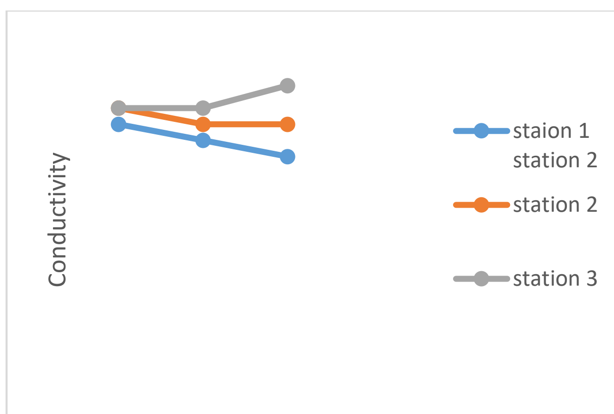

Figure 6: Showing conductivity variations among three sampling stations of Hadejia River

Dissolved Oxygen (DO)

The mean surface values of DO ranged from 4.93mg/L, 4.27mg/L, and 3.87mg/L in station 1, 2 and3 respectively. Station 1 of week 3 had the highest mean value, followed by week 2 of station3 then week 2 of station3 in as shown in Figure 7.

Total Dissolved Solid (TDS)

The concentration of total dissolved solids of Hadejia River during the period of study was found to range from 6.33, 6.00 and 6.00 in station 1, 2, and 3 respectively. The highest mean value was observed in week 3 of all the stations, also there are fluctuations in Total Dissolved Solids values during the second week of station 2 and 3, as shown in Figure 8.

Biological Oxygen Demand (BOD_5)

The mean value of biological oxygen demand of Hadejia River ranged from 2.00mg/L, 1.37mg/L and 1.5mg/L in station 1, 3 and 2 respectively, as shown in Figure 9. Station 3 of week 2 has the highest BOD value followed by station 1 of week 1, and the lowest value of BOD was found in week 3 of station 3 as shown in Figure 9.

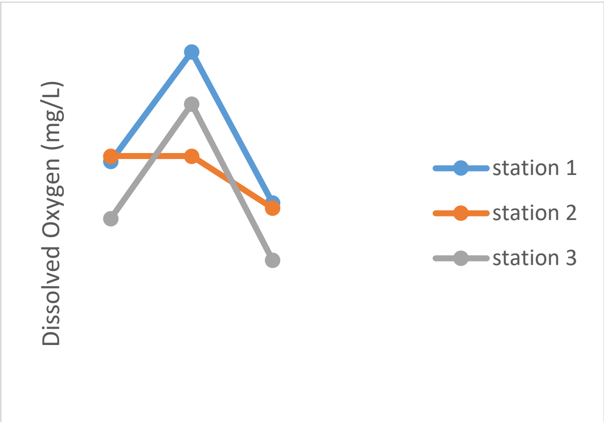

Figure 7: Showing Dissolved Oxygen variations among three sampling stations of river Hadejia

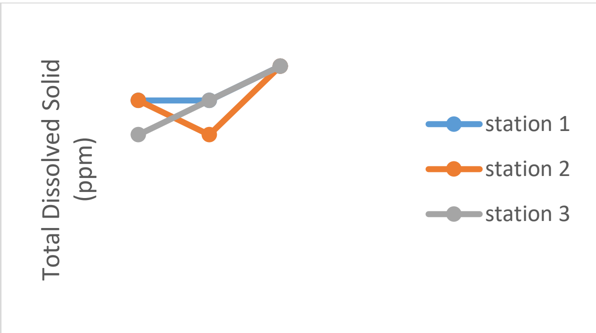

Figure 8: Total dissolved solids variations among three sampling stations of River Hadejia

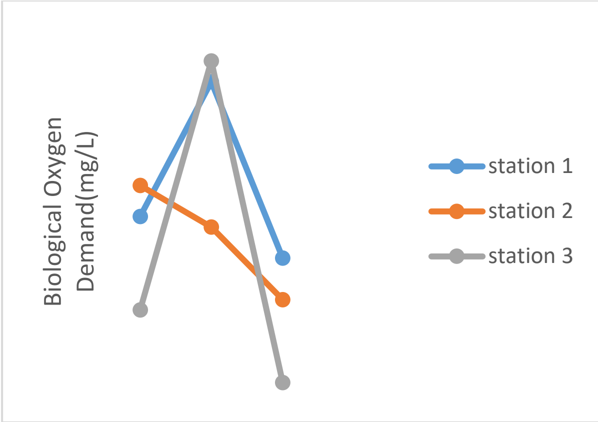

Figure 9: Biological Oxygen Demand variations among three sampling stations of Hadejia River

Water Physicochemical Parameters

Water physico-chemical parameters are important factors capable of exerting influences on the species diversity and composition of freshwater ecosystems (Sundermann *et al.*, 2013).The water surface temperature is the most vital parameter which controls in-born physical qualities of water. The temperature of Hadejia River varied from 18ºC to 29ºC. The highest temperature observed was in station 1 in week 2 while the lowest temp recorded was station 2 in week 3. The mean air and water temperatures obtained were typical of African tropical rivers (Masese *et al.*, 2009).Similar observation was also reported by Arimoro *et al.* (2007); Edokpayi *et al.*, (2000) and Edegbene and Arimoro (2012) in some selected river in southern Nigeria.

The result of the water pH in this study is in harmony with the research of Haruna, (2003) who reported that conducive surface water pH for aquatic life is in the range of 6.6 to 9.3. Similarly, the mean pH value of all sites were within the acceptable limit of 6.5 - 8.5 recommended for inland and drinking water quality (WHO, 2012).

The mean turbidity values obtained from the water samples of River Hadejia ranges from 154.33-184.43. This is exceedingly higher than the recommended guideline value of 5 NTU. Turbidity levels are dependent on the amount of suspended particles present in the water. Water turbidity is very important because the high turbidity is often associated with higher level of disease-causing microorganisms such as bacteria and other parasites (Shittu *et al.*, 2008, Hamisi 2024). The increase in mean values of the turbidity of the River Hadejia is an indication of pollution which enhances the increase in the number of pathogens.

Conductivity measures the total ionic composition of water and the overall chemical richness. The conductivity of water is a useful and accessible indicator of its salinity or total salt content (Oluyemi *et al.*, 2010). From present study, the mean conductivity values range between (14.4-16.62µS/cm) which shows a reflection of less amount of dissolved ions which shows the river is somewhat polluted. The conductivity observed in this study falls within the conductivity range for Nigeria inland water bodies as reported by Deeker *et al.*, (2010).

The lowest value of dissolved oxygen observed were station 3 in week 3 (2.6mg/L) and the highest is 6.6mg/L were station 1 in week 2. The decrease in DO value observed at some points may be due to discharge of organic wastes at such periods, which led to biological respiration and decomposition processes, which in turn reduced the concentration of DO in water bodies. This was agreed with the findings of Michael (2006), who reported that water with high organic or inorganic pollution may contain very little oxygen in them.

Biological oxygen demand (BOD) is a vital parameter that indicate the level of organic pollution in water quality (Jonnalagadda and Mhere, 2001). In this study the values of BOD range between 1.5mg/L-2.00mg/L. According to Adakole and Anunne (2003) classified using BOD of river as follows: unpolluted (BOD<1.0 mg/l), moderately polluted (BOD between 2-9 mg/l) and heavily polluted (BOD > 10.0mg/l i.e. it indicates organic matter is present and bacteria are decomposing this waste). Based on the previous classification, it can be interpreted that the Hadejia River is somehow unpolluted or moderately polluted.

Water that has decreased in quality is affected by anthropogenic activities along the river bank, such as defection in the riverbank, water dispose of domestic waste water into the river, bathing, washing, and latrine activities in the river.

CONCLUSION

The findings of this study indicate that River Hadejia is experiencing moderate water quality degradation, primarily driven by anthropogenic activities along its banks. High turbidity and reduced dissolved oxygen levels pose potential risks to aquatic life and ecosystem functioning. Frequent monitoring, public awareness, and enforcement of sustainable land-use practices are recommended to safeguard the long-term ecological health of the river.

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