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Assessment of Physical and Chemical Characteristics of Jebba Upper Basin on River Niger, North Central Nigeria

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ABSTRACT: Jebba Upper Basin upstream at Kainji, was constructed on River Niger in Nigeria during the last five decades mainly for hydropower generation, but receives pollutants through anthropogenic activities. This study assesses physical and chemical characteristics of Jebba upper basin on River Niger, North Central Nigeria using appropriate standard methods. The results show that the mean values of the physical and chemical parameters of water were: temperature (27.89±1.84 °C), pH (7.17±0.22), dissolved oxygen (6.35±0.91 mg/L), total hardness (42.33±32.89 mg/L), biological oxygen demand (2.85±1.07 mg/L), and conductivity (51.13±29.09 µs/cm). The result shows that temperature has significant positive (either at $r < 0.05$ and $r < 0.01$) association with Total Hardness (TH) (0.47), BOD (0.30) and NO_3^- (0.43) though inversely correlated with transparency (-0.29, $r > 0.05$). Total Hardness also have a positive correlation (0.52, $r > 0.05$) with nitrate. Spatial-temporal variations influenced by environmental factors were observed to impacted water quality parameters in the study area.

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Freshwaters (waters of rivers and stream) quality relies upon an expansive physical and chemical parameters such as temperature, colour, transparency, depth, hydrogen ion (pH), dissolved oxygen, BOD, conductivity, nitrate, phosphate, *etc* which are affected by interactions among environmental and human induced factors (Saeed, 2013). These physical-chemical parameters must be considered in determining freshwater quality because it greatly impacted the hydrological characteristics as well as biological productivity of the waters (Leibowitz *et al.*, 2018; Najafpour *et al.*, 2008). The regular and periodic changes in some environmental factors such as land-use, geological formation, vegetation, and season are eventually reflected in the water qualities which in turn have direct or indirect influence on the aquatic life (Arnous and Hassan, 2015; Saravanakumar *et al.*, 2008) because of their sensitivity to changes in their environment. However, the general admiration to sustained aquatic diversity has prompted to a development of research into water limnological characteristics as to provide information for rivers management. The species composition and density of aquatic life will be influenced not only by geographical locations but also by water quality of their habitats. This can in turn be adversely affected by

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human activities (Atobatele and Ugwumba, 2008). In recent times, Jebba Upper Basin water bodies probably receives pollutants through anthropogenic, arising from corrosion/abrasion of the ferrous steel material and additives in the lubricants and insulation used for auxiliary services on the turbine floor of the dam (Adelakun *et al*., 2013; Oyewale and Musa, 2006), sewage discharge and waste disposal from Power Holding Company of Nigeria and the riverine communities. Oli River also drains its waters into the basin with wide variety of waste from both agricultural and local mining activities. The resultant effect is that the associated fishery, the biota and the ecosystem upon which people depend for a living are in danger. However, little or no information is available on the effect these activities on the water quality status within Kainji-Jebba Upper Basin catchment ecosystem especially in relation to its river tributary. Research on the effects of pollution on physical and chemical of water bodies is of paramount significance in developing fresh water quality which play important role in ecosystem productivity. Therefore, this research work investigates the physical and chemical characteristics of Jebba upper basin on River Niger, North Central Nigeria.

MATERIALS AND METHOD

Study Area: Jebba Upper Basin dammed at Jebba (Lake) was formed in August 1983 designed to generate electricity, and it extends from the dam site at Jebba to southern tip of Kainji dam at Kainji. The lake is therefore unique as the first and the only man-made lake in Nigeria that has a direct in flow from another man-made lake located upstream to it. The lake is located in the northern hemisphere between latitudes 9°0′N and 9°55′N and longitudes 4°30′N and 5°00′E. The dam is about 3 kilometers upstream of Jebba town with tributaries which include Awun, Eku, Moshi and Oli rivers. It falls within the savanna zone but specifically Guinea savanna. Jebba Lake bounded on the eastern side by Niger state and on the west by Kwara state, and with a surface area of 303sq km is smaller than Kainji Lake. The total storage for Jebba Dam is 1× 109 m3. The predicted fish catch potential using primary productivity and morphoedaphic factors of Jebba lake was estimated at 909 – 1818 tons/annum (Adelakun, 2013; KLRI, 1983).

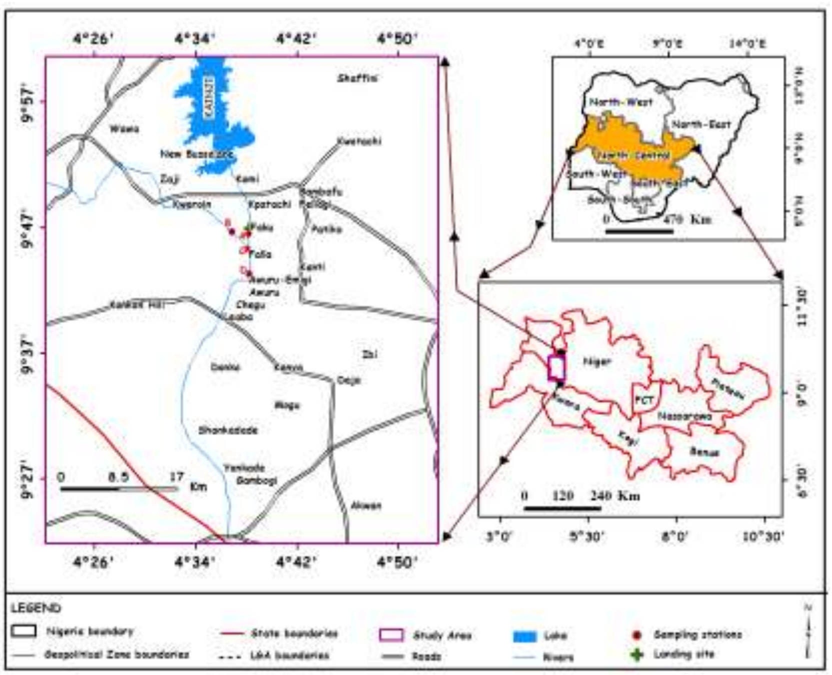

Fig 1: Map of the study areas on Jebba Upper Basin
Source: Adelakun, 2023

Water Sampling and Sample Preservation: Water samples were collected between 08:00 and 10:00hrs on each samplings days using one liter (1 L) sampling glassware bottles at 15cm below surface water at the designated four (4) sampling stations of about 2km intervals located from the upstream to downstream (A= Fakun, B= along Oli river, C = Confluence of Oli river with Jebba Basin, D = Awuru Emigi). Prior to sample collection, all the sampling bottles were thoroughly washed and sterilised; and before collection, the sample bottles were rinsed twice with the same water to be collected. After which each sample bottle was labelled with the date and collection station.

Until analysis, collected water samples for physical and chemical parameters (including total Biological Oxygen Demand, Total Hardness, Phosphate, and Nitrate) were stored at 4^0 C in the laboratory according to the standard method of the American Public Health Association (APHA, 1992). Temperature, pH, and Electrical Conductivity (EC) were measured in-situ with a Hanna combo probe meter (model: HI98129), Dissolved Oxygen was measured using a portable dissolved oxygen meter (model: ExStik DO600) while Secchi disc was used to determine both transparency and depth at the sampling stations. In the laboratory, the titrimetric method was used for the determination of Total hardness and BOD, while a spectrophotometer was used in the quantification of Nitrate and Phosphate present in the water samples.

Data Analysis: Descriptive statistics such as mean and standard error were used to describe each of the water quality parameters while Kruskall Wallis H was used to compare variations in physico-chemical characteristics between sampling stations. Pearson's Correlation (either at $r < 0.05$ and $r < 0.01$) analysis was used to assess the relationship between physicochemical factors. Differences were considered significantly at $p < 0.05$.

RESULTS AND DISCUSSION

The physical and chemical characteristics of water is an important part of environmental monitoring since it plays significant role in the distribution of aquatic organisms including fish and other ecosystem process. When water quality is poor as result of pollutants originating from anthropogenic activities, it affects not only aquatic life but the surrounding ecosystem as well (Häder *et al.*, 2020).

Water pollution are caused by improper handling of wastes such as domestic waste, wastewater from treatment plants, agricultural and plastic wastes, which all contribute to the poor water quality (Aryani *et al.*, 2021; Rakesh *et al.*, 2021). Particles on the surface water are usually very dependent on hydrohydynamic factors including temperature (Eamrat *et al.*, 2022; Kulkulka *et al.*, 2012), hence collecting metadata related to these factors is thus very important during pollution assessment in order to better interpret the results. The results of the physical and chemical parameters of water from Jebba Upper Basin are presented in Tables 1- 3.

There were spatial variations in the means of the studied parameters across the sampled stations. Analysis of variance (ANOVA) and Kruskal-Wallis H test revealed that except for water depth, transparency, and nitrate that showed significant variations at $p< 0.05$ (Table 1 and 3) in the four sampling stations, all other parameters showed no significant variations ($p> 0.05$). The highest surface water temperature of 28.22 ± 1.98 ^{0}C was recorded at station A, while the lowest value of 27.77 ± 2.04 ^{0}C was recorded at station C. Stations' surface water temperature ranged from 24.00 ^{0}C – 31.00 ^{0}C with an annual average mean of 27.89 ± 1.84 ^{0}C for the sampling year.

The mean river temperature at the four sampling stations, however, did not vary significantly (Kruskal-Wallis H test, $K = 0.83$, $p > 0.05$). Significant temperature changes can affect metabolic activities of aquatic organisms (Iwaliye *et al.*, 2021), as well as stress level and eventually lead to mortality (Phrompanya *et al.*, 2021). Generally, the Jebba Upper Basin temperature ranged is found within the permissible limit (WHO, 2008). The observed range is similar to other studies reported for tropical rivers (Eamrat *et al.*, 2022; Iwar *et al.*, 2021; Okafor *et al.*, 2021). Thus, the temperature range of the river is within the values considered favourable for aquatic ecosystem in the tropics (Halim *et al*., 2018).

The compositions of the river sediment have been noted to depend on ecological variables including depth (Thapa, 2022; Sekiranda *et al.*, 2004). The water level (Depth) has the highest mean at station A; (14.85 ± 3.50) m and ranges between 3.00 - 20.00 m during the sampling year.

The lowest mean depth of 5.55 ± 2.45 m was recorded at station C (confluence) due to heavy siltation associated with influxes of sediments entering the river system from river Oli drain at the confluence and moving down to station D. This is in consonance with Thapa (2022), who observed that heavy siltation associated to flood water could lead to the degradation of both the benthos community and water quality in freshwater environment.

Hence, the depth of the water decreases at the downstream (station D) during the study against the expected results that the depths of the river should have increased in the downstream direction as is always with other fast flowing rivers. Mean water depth, however, differed significantly along sampling stations Kruskal Wallis H test, $K = 0.00$; $p < 0.05$) (Table 1-3).

Table 1: Spatial variation in physical and chemical parameters of the study area

Parameters	Sampling stations			
	A	**B**	**C**	**D**
Water Temp.(°C)	28.22±1.96 (25.00-30.50)	27.87±1.60 (25.00-30.00)	27.77±2.04 (24.00-31.00)	27.89±1.84 (24.00-30.00)
Depth (m)	14.85±3.50[c] (9.50-20.00)	6.28.±1.41[a] (3.90-8.50)	5.55±2.45[a] (3.00-10.50)	8.73±2.11[b] (3.00-10.50)
Transparency(m)	0.89±0.54 [b] (0.22-1.70)	0.59±0.45 [ab] (0.15-1.60)	0.30±0.19 [a] (0.10-0.80)	0.53±0.31 [a] (0.20-1.20)
pH	7.17±0.24 (6.80-7.60)	7.17±0.20 (6.80-7.50)	7.20±0.25 (6.80-7.60)	7.17±0.22 (6.80-7.50)
D.O (mg/l)	6.38±0.82 (4.80-8.00)	6.68±0.79 (6.00-8.20)	6.13±1.37 (4.00-8.20)	6.20±0.46 (5.60-7.10)
Total Hardness (mg/l)	42.50±33.95 (10-110)	42.67±34.56 (10-100)	40.00±30.64 (10-110)	44.17±36.44 (5-110)
BOD (mg/l)	3.03±1.03 (2.00-5.00)	2.94±1.21 (1.10-5.00)	2.84±1.21 (1.00-4.80)	2.58±0.90 (0.80-4.00)
Elect. Conductivity (µs/cm)	49.92±25.30 (25.00-100.00)	55.42±31.13 (20.00-120.00)	50.27±32.23 (2.20-120.00)	48.92±30.66 (2.00-100.00)
Nitrate (mg/l)	9.58±3.83[a] (5.00-15.00)	11.50±2.40[a] (7.00-15.00)	11.75±4.20[a] (5.00-20.00)	14.58±2.81[b] (10.00-20.00)
Phosphate (mg/l)	0.04±0.01 (0.02-0.06)	0.05±0.02 (0.02-0.08)	0.05±0.02 (0.02-0.08)	0.06±0.02 (0.02-0.10)

NOTE: *Values are mean ± standard deviation (Range in parenthesis). Means without superscript are not significant different (p<0.05) while those with different superscripts are significantly different (p>0.05).*

Table 2: Annual mean physical-chemical parameters of the study area

Parameters	Annual Average Mean	Annual range (Min. – Max.)	Recommended Max. Permissible Limit (WHO, 2008)
Water Temp.(°C)	27.89±1.84	(24.00-31.00)	<40
Depth (m)	8.85±4.41	(3.00-20.00)	-
Transparency(m)	0.58±0.44	(0.10-1.70)	5
pH	7.17±0.22	(6.80-7.60)	6.5-8.5
D.O (mg/l)	6.35±0.91	(4.00-8.20)	5-7
Total Hardness (mg/l)	42.33±32.89	(5.00-110.00)	300
BOD (Mg/l)	2.85±1.07	(0.80-5.00)	2-5
Elect. Conductivity (µs/cm)	51.13±29.09	(2.00-120.00)	750
Nitrate (mg/l)	11.85±3.74	(5.00-20.00)	45
Phosphate (mg/l)	0.05±0.02	(0.02-0.10)	0.1

Note: Values are mean ± standard deviation (Range in parenthesis)

Table 3: Kruskal-Wallis Test for physical and chemical parameters across the sampling stations along Jebba Upper Basin

Parameters	Sampling stations					
	A	**B**	**C**	**D**	**Asymp. Sig.**	**Level of Sig.**
Water Temp.(°C)	27.71	24.04	22.96	23.29	0.83	NS
Depth (m)	41.58	15.92	13.21	27.29	0.00	S
Transparency(m)	33.67	25.00	13.92	25.42	0.01	S
pH	24.25	25.38	26.50	21.88	0.86	NS
D.O (mg/l)	24.92	30.54	21.92	20.63	0.30	NS
Total Hardness (mg/l)	24.67	23.58	25.25	24.50	0.99	NS
BOD (mg/l)	26.96	25.13	24.96	20.96	0.76	NS
Conductivity (µs/cm)	24.79	26.13	23.88	23.21	0.96	NS
Nitrate (mg/l)	16.96	22.46	23.71	34.88	0.01	S
Phosphate (mg/)	19.33	27.00	21.00	30.67	0.15	NS

**Note: S = p≤0.05, NS = p>0.05*

Transparency refers to the water clarity that influence light penetration into the water column of the river basin for optimum productivity (Ovie *et al.*, 2011). Transparency recorded in the study area show spatial disparity along the sampling stations and ranged between 0.10 m at station C and 1.70 m at station B during the study period (table 2 and 3). These correspond to annual mean transparency peak of 0.89 ± 0.54 m at the station B while station C witnessed a significantly (P<0.05) lower annual mean of 0.30 ± 0.19 m (Table 1). This trend show extensive turbid water and lower visibility observed in station C (which is a more shallow sampling station), could be primarily due to the fact that the station receives floodwater from river Oli thereby increasing the suspended solids load. This is in consonance with Eamrat *et al.* (2022) and Halim *et al.* (2018) whose reports stated that floodwater, siltation and erosion of riverbanks and agricultural farmland are the major causes of low transparency in freshwater environment. Moreover, low transparency has been reported as a major signs of microplastics abundance in polluted water (Eamrat *et al.*, 2022; Nanik *et al.*, 2021). pH which is usually monitored for assessments of aquatic ecosystem health to indicates the acidity and basic concentrations of a water body is controlled by the dissolved chemicals and biochemical processes in the environment (Mezgebe *et al*., 2015). It can exert considerable influence on chemical toxicity in a water body (Namieśnik and Rabajczyk, 2010).

The mean values of pH of the study area were generally stable between 7.17 ± 0.20 - 7.20 ± 0.25. Values of pH ranged from lowest 6.80 at all station during the sampling period to 7.60 recorded in station A and C (see table 2). The mean pH between stations during the study showed no significant difference and this could suggests that the water body was homogeneous in terms of pH, and this has been reported to be an indication of stability at all stations (Andem *et al.*, 2012). The total annual average pH of 7.17 ± 0.22 was recorded in the study area and found to be within permissible limit when compare with standard values from WHO (see table 3). However, both ANOVA ($p > 0.05$) and Kruskal-Wallis Test ($K = 0.86$, $p > 0.05$) show there is no significant differences in the mean values of water pH among sampling stations (see table 3). DO is an indispensable element to all forms of aquatic life (Abdel-Tawwab *et al.*, 2019). Hence, it is one of the key attributes that can reflect the healthiness of a river water ecosystem (Rouf *et al.*, 2022). Dissolved oxygen mean values varied between 6.13 ± 1.37 Mg l^{-1} at station C and 6.68 ± 0.79 Mg l^{-1} at station B (table 1) while total annual mean of DO in the study area was 6.35 ± 0.91 Mg l^{-1} (table 2). The values show no clear predictable spatial pattern though falls within the range reported in healthy water bodies (Komi and Sikoki, 2013; Mezgebe *et al.,* 2015) and higher that the values reported in polluted Ona river, Nigeria (Andem *et al*., 2012). Statistically, no significant variations were observed in the concentrations of dissolved oxygen (ANOVA and Kruskal-Wallis Test ($K = 0.30$, $p > 0.05$) among the sampling stations. However, the higher values of DO obtained in the study area may be due to water turbulence as a result of influx from the dam and frequent wind current in the water (Mohammed *et al.,* 2017). DO concentrations below 5mgl/L may adversely affect the functioning and survival of biological communities in river water (Sinha and Biswas, 2011). Numerous inorganic (mineral) substances are dissolved in water. Among these, calcium and magnesium along with their counter ion carbonate (CO^{3-2}) comprise the basis for the measurement of hardness (Halim *et al.*, 2018; Mezgebe *et al*., 2015).

Though station D relatively had the highest TH value averaging 44.17 ± 36.44 Mg l^{-1}, while station A and B recorded similar means of TH concentrations of 42.50 ± 33.95Mg l^{-1} and 42.67 ± 34.56 Mg l^{-1} respectively. The measured annual mean Total Hardness for the stations was 42.33±32.89 Mg/L. According to Mezgebe *et al*. (2015) and Soni *et al.*, (2013), water is classified into three different categories: soft water (0 to 75 Mg/L), moderately hard water (76 to 150 Mg/L) and hard water (151 to 300 Mg/L). Hence, Jebba Upper Basin can be considered as soft water and the recorded values of Total Hardness for all stations were below the permissible limit of (WHO, 2008). The variation the values recorded among the studied stations could be due to the diluting effect of floodwater entering the basin system during raining (Obhahie *et al.*, 2007) as well as discharge of water from the upstream dam. Biological oxygen demand (BOD) is directly correlated with abundance and distribution of several pollutants including microplastics (Eamrat *et al.*, 2022) hence, it is an important indices used in water quality management; measure of the concentration of organic matter present in any water (Mezgede *et al.*, 2015). The greater the decomposable matter present, the greater the oxygen demand and the greater the BOD values (Haider *et al*., 2013). The Biological-Oxygen Demand (BOD) concentrations were considerably lower in all sampling stations ranging from 0.80 to 5.00 Mg l^{-1} (see table 2) with maximum value recorded at station A (average mean of 3. 03 ± 1.03 Mg l^{-1} and monthly record between 2.00 – 5.00 Mg l^{-1}) while the lowest concentration of BOD was recorded at station D (2.58 ± 0.90 Mg l^{-1}). The Biological-Oxygen Demand (BOD) concentrations were considerably lower in all sampling stations. This could be attributed to little level of organic load in the water (Hussain *et al.*, 2021). The BOD values recorded in the study has been reported in rivers around the study area (Ajibade *et al.*, 2008) and within the maximum permissible level of 2-5 Mg/L (WHO, 2008). However, High BOD values in water bodies can cause serious dissolved oxygen depletion and death of aquatic animals in the receiving water bodies (Aniyikaiye *et al.*, 2019; Ubwa *et al.*, 2013). The Kruskall-Wallis H test, ($K = 0.76$, $p < 0.05$) revealed there was no significant difference among sampling stations.

Table 1 and 3 show that conductivity increased though insignificantly (Kruskall Wallis H test, K = 0.96, $p > 0.05$) between River Oli (station B) and confluence stations (C). Electrical conductivity (EC) of a water body is an important tool in the evaluation of water purity (Acharya *et al*., 2008). It is a numerical expression of an aqueous solution's capacity to carry an electric current (Halim *et al*., 2018). Conductivity had been reported to have important influence on pollutants distribution in urban canal water in Thailand (Eamrat *et al.*, 2022). The average mean value of 49.92 ± 25.30 µS cm^{-1} and 48.92 ± 30.66 µS cm^{-1} were recorded for sampling station A and D respectively at the River Basin. Wide range variation observed in electrical conductivity during the sampling period in this study could be due to content of available soluble ions during the particular sampling month (Marandi *et al.,* 2013), though the overall 51.13 ± 29.09 µS cm^{-1} recorded in this study was within the values for natural water (Baird and Bridgewater, 2017). Nitrates are products of oxidation of organic nitrogen by the bacteria present in soil and water where sufficient oxygen is present (Mezgebe *et al.*, 2015). Sinha nd Biswas (2011) reported that high concentration of nitrates is useful in irrigation but their entry into water resources increase the growth of nuisance algae, macrophytes and trigger eutrophication and pollution. The concentration of nitrate (NO_3^-) in the study ranged between 5 – 20 Mg l^{-1} between January and December with an annual mean concentration of 11.85 ± 3.74 Mg l^{-1} for the entire study area. Mean nitrate concentration of 9.58 ± 3.83 Mg/L, 11.50 ± 2.40 Mg l^{-1}, and 11.75 ± 4.20 Mg l^{-1} recorded for station A, B, and C respectively were significantly lower (Kruskall-Wallis H test, K = 0.01, $p < 0.05$) to 14.58 ± 2.81 Mg l^{-1} documented at station D. The increased usage of nitrogen-based fertilisers as well as the animal grazing and other agricultural wastes seems to have significantly contributed to the elevated nitrate levels in the river especially at station D where it is more prevalent. These high values of nitrate observed in study area correspond with the findings of Aganigbo *et al.* (2016) along Anambra Basin but lower to the nitrate levels reported for Tsaeda Agam River, Ethiopia (Mezgeb *et al.*, 2015). However, nitrate levels recorded for the study area did not exceed the limit recommended (WHO, 2008). Phosphorous is a limiting nutrient for algal growth and therefore controls the primary productivity of a water body (Khan and Jadhav, 2012). It is also an essential nutrient and another indicator of anthropogenic biological pollution in water bodies (Mezgebe *et al.*, 2015). The phosphate concentration recorded annually is between 0.02 and 0.10mgl/l. This values are relatively lower to 0.34 Mg/L to 1.65 Mg/L documented for Uramiriukwa river, Imo State, Nigeria (Verla *et al.*, 2018) and 5.53 Mg/L to 9.74 Mg/L for Agulu and Oguta rivers respectively in the South-Eastern, Nigeria (Isiuku and Enyoh, 2020). High concentrations of phosphate are largely responsible for eutrophic conditions in a water body (Moshoeshoe and Obuseng, 2018; Agbazue *et al.*, 2015). The present values along the Jebba Upper Basin are below 0.34 to 0.70 mg/L associated with eutrophication-related problems in tropical water systems (Mezgebe *et al.*, 2015).

Table 4: Matrix of correlation among physical and chemical parameters in the study area

Parameters	WT.	Depth	Transp.	pH	D.O	TH	BOD	Cond.	NO_3	PO_4
Water Temp.	1									
Depth	0.960	1								
Transparency	-0.292*	0.253	1							
pH	-0.262	-0.152	0.096	1						
D.O	-0.093	0.142	-0.010	0.027	1					
Total Hardness	0.470**	0.229	-0.555**	-0.327*	0.030	1				
BOD	0.302*	0.120	-0.343*	-0.045	0.597**	0.51**	1			
Conductivity	0.11	0.04	0.31*	0.05	0.34*	-0.37**	0.23	1		
NO_3^-	0.43**	0.11	-0.45**	-0.17	-0.17	0.52**	0.09	-0.34**	1	
PO_4	0.21	-0.05	0.07	0.12	-0.04	0.07	-0.11	0.14	0.45 **	1

**Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed)*
TH = Total Hardness; BOD Biochemical oxygen demand; Cond. = conductivity; Transp. = Transparency; WT = water temperature

Correlation Matrix of water physical and chemical parameters in the study area: Correlation between the variables of water quality across all the sampling stations in Jebba Upper Basin during the study period provides an indirect means of water quality monitoring. The Pearson's correlation co-efficient (r) indicated the relationship among the parameters in table 4. The result shows that temperature has significant positive (either at $r < 0.05$ and $r < 0.01$) association with TH (0.47), BOD (0.30) and NO_3^- (0.43). This implies that increase in water temperature will increase the level of water total hardness, nitrate and BOD in the study area since increasing temperature of water have a direct effect on the dissolution of substances including organic pollution due to the loads of wastes (Mezgebe *et al.*, 2015; Thirupathaiah *et al.*, 2012). The greater the decomposable matter present, the greater the oxygen demand and the greater the BOD values (Mezgebe *et al.*, 2015). This is contrary to observation from Ona River, Ibadan, Nigeria (Andem *et al.*, 2012) but the result is in consonance with study on Diyala River, Iraq (Hashim, 2017). The inverse (-0.29, r >0.05) relationship between water temperature and transparency could be as result of interference of suspended materials that limit the penetration of light in the water column hence necessitate the absorption of heat by the surface water. This aligned with Halim *et al*. (2018) who reported that the transparency of water was affected by many factors including suspended organic matter and intensity of light thereby increasing the surface water temperature. There is inverse association between temperature and pH. This is contrary to report of Hashim (2017) on Diyala River, however, current observation could be the effects of some ecological variables. Kumar and Bahadur (2009) reported that the variation in pH can be due to the exposure of river water to atmosphere, biological activities and temperature changes. Total Hardness positive correlation (0.52, r >0.05) with nitrate observed in the study had also been reported in water from Jaen district in Kano while direct relationship between nitrate and phosphate concentration conformed to observation from Isiuku and Enyoh (2020) in some rivers from South-Eastern Nigeria where increase in nitrate was reported with increasing phosphate. It could also be seen that the discharge of the sewage from both the domestic and Hydro Electricity Power stationed offstream at Kainji, could increase elemental salts concentration as so as increase of many pollutants concentration hence increases water hardness and BOD but consequently lowering the transparency.

Conclusion: There is spatial-temporal variation in the physical and chemical parameters of Jebba Upper Basin as observed from this study. The impact of the floodwater entering the river system from river Oli drain at the downstream was observed to significantly influence the basin water quality. However, effort should be geared towards maintaining standard environmental procedure to avert further pollution of the basin system.

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