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Assesment of some physico-chemical parameters of river katsina-ala at Buruku, Benue state, Nigeria

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Abstract
Physico-chemical parameters of River Katsina-ala at Buruku were investigated to assess the level of water pollution of the river which is a major tributary of River Benue in Nigeria. Monthly sampling from all the sampling stations was done for a period of 12 months (January to December 2016) between 7:00 and 11:00am. The water quality parameters studied include dissolved oxygen, water temperature, pH, alkalinity, total dissolved solids, Carbon dioxide, chloride, hardness, NH_3–Nitrogen, N-Nitrogen, biological oxygen demand, transparency and water depth. Standard methods were used to analyze the water samples collected. There was no significant difference in the mean location variation of all measured water parameters except dissolve oxygen (6.82±0.22, 6.01±24, 6.38±0.28 for stations A, B and C) hardness (25.17±1.93, 31.38±1.52, 28.08±1.36 for stations A, B and C) Biological oxygen demand (1.88±0.13, 2.57±1.13, 2.28±0.17for stations A, B and C) and Water Depth (0.94±0.04, 1.03±0.05, 0.91±0.03 for stations A, B and C). All the parameters measured were within the acceptable limit for drinking water and fish culture except Ammonia nitrogen (2.07±1.18) which was slightly above the safe standard by WHO and NIS indicating a slight pollution of the water body.

Keywords: physico-chemical parameters, river katsina-ala, Buruku

1. Introduction
Aquatic ecosystems such as rivers, dams and lakes provide livelihood for rural populations in many developing countries in Africa [1]. However, increase in population and urbanization has subjected such water bodies to various forms of degradation due to pollution [2]. Water is very important amongst the components of the ecosystem and its quality is defined in terms of the chemical, physical and biological contents. The water quality of rivers may change with the seasons and geographical areas, even when there is no pollution present. Water quality deterioration can occur both from natural sources, industrial, agricultural and domestic activities in the drainage basin of a water system [3]. Water quality is fundamental to the health and sustenance of aquatic ecosystems and hydrology. The adverse effects of these pollutants on human health, agricultural productivity, natural ecosystem and total environment are significant [4]. High levels of pollutants in river water causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), and hence make such water unsuitable for drinking.
Rivers serves as one of the major sources of water supply around the world. The continuous assessment and monitoring of water quality from rivers can be used to define existing conditions, detect trend and/or establish sources of pollution [3]. The anthropogenic discharges represent a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by climatic conditions [5]. Physico-chemical parameters and quantity of nutrients in water play an important role in the distribution and composition of phytoplankton in the aquatic habitat. Rivers are used for irrigation of agricultural lands, domestic, commercial, transportation and fishing purposes. They provide habitat for aquatic life especially fish. Rivers also have important social and economic benefits as a result of tourism and recreation [6]. Thus the continuous monitoring of the water quality is very important. This study focuses on investigating the physico-chemical parameters of River Katsina- ala at Buruku aimed at good management.

2. Materials and Methods
River Katsinna-ala is a river in central Nigeria and serves as a major tributary of river Benue in

Nigeria. The source of the river is found on the Bamenda high lands in north western Cameroon. It flows 200 miles (320km) northwest crossing in to eastern Nigeria just north of Gayama and passing the town of Katsina-ala before reaching the Benue River north east of Abinsi. The river is navigable for 90 miles (145km) below Katsina ala and is mainly found in Benue state of Nigeria after crossing the border between Nigeria and Cameroon before emptying its content into the river Benue (Fig. 1). The river is basically used for drinking, fishing, irrigation farming, transportation, and other domestic activities which informed the choice of the sample sites.

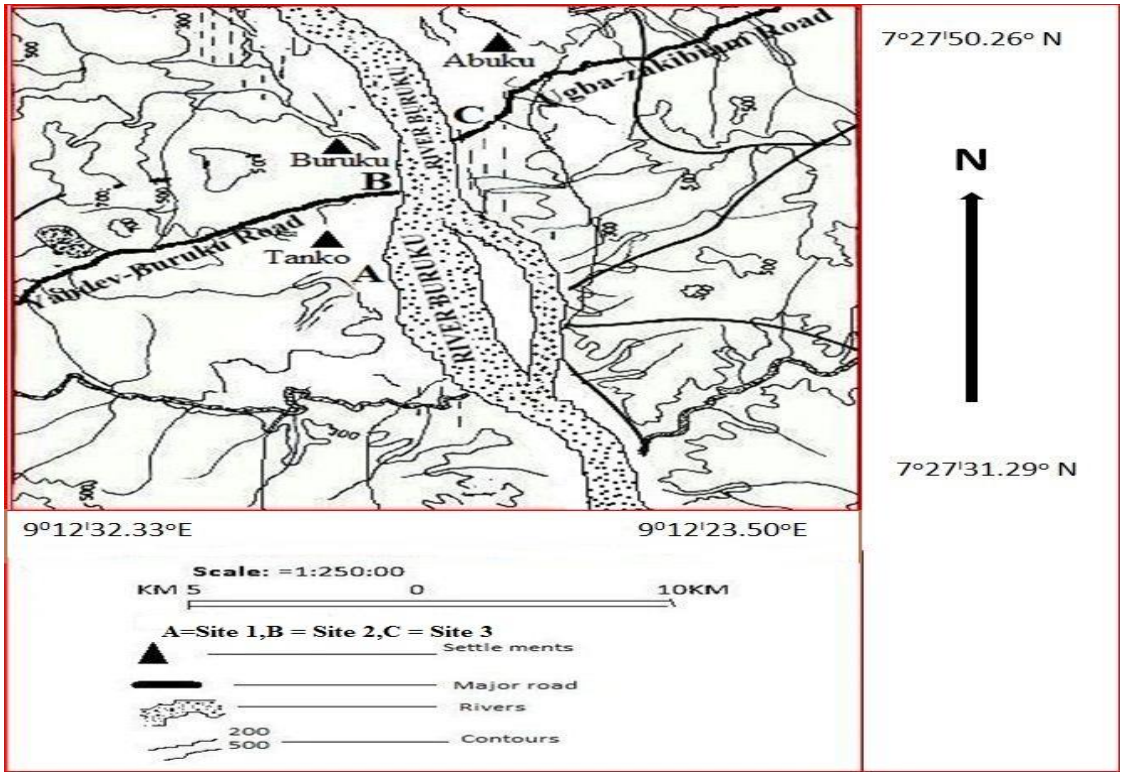

Fig 1: Map of River Katsina-Ala at Buruku

2.1 Water sample collection

A 12 month sampling was done between January and December 2016. Water samples were collected from three selected sampling sites namely: Tanko, (Site A), Buruku (Site B), and Abuku (Site C) at different points and depths for monitoring at regular monthly intervals (Fig. 1). Water samples were collected between the hours of 07:00 and 11:00am from each sampling site in 1-litre plastic containers. Prior to sample collection, the containers were washed with detergent and rinsed thoroughly to avoid any possible contaminant. The sampling bottles were immersed below the water surface at a depth of 20cm and filled to capacity, brought out of the water and properly closed. Dissolved oxygen (DO) and biochemical oxygen demand (BOD) were determined using a DO meter model: 5509. DO was taken on site by immersing the probes of the DO meter into the water body and allowed to stabilize for about 5 minutes and readings taken directly from the screen. In the laboratory the water sample collected was wrapped in a black polythene bag and incubated in the cupboard for 5 days. The probes of dissolve oxygen meter were immersed in the incubated water sample and left to stabilize for about five minutes and readings were taken directly from the screen and recorded as BOD (mg/l). Temperature, hydrogen ion concentration (pH) and Total dissolved solids (TDS) were measured using a PHT-027 Multi-parameter water quality monitor [7]. In each case the meter was set to read the parameter of interest at a time. The probes were immersed into the water sample and allowed to stabilize for about five minutes and readings were taken directly from the screen of the meter and recorded accordingly. Alkalinity, Free carbon dioxide, total hardness, chloride, Nitrite-Nitrogen and Ammonia-Nitrogen were determined using a fresh water aquaculture test kit [8]. Standard methods were employed following the procedure for titration in measuring each of the parameters. Transparency was determined using Secchi disc [9]; a metallic disc of 20cm in diameter with four quadrants of alternate black and white on the upper surface. The disc with centrally placed weight at the lower surface was suspended with a graduated cord at the center. Transparency was measured by gradually lowering the Secchi disc at respective sampling points. The depth at which it disappears in the water (X_1) and reappears (X_2) was noted. The transparency of the water body was computed as follows [9]:

$$\text{Transparency (Secchi Disc Transparency)} = (X_1 + X_2)/2$$

Where, X_1 = Depth at which Secchi disc disappears
X_2 = Depth at which Secchi disc reappears

Water depth was determined using a calibrated rod [10]. The rod was dipped into the water until it hit the bottom of the river at the sampling site. Readings were taken and recorded in meters. Data obtained was subjected to Analysis of variance using SPSS 17.0.

3. Results

3.1 Mean monthly water quality parameters

The mean monthly water quality parameters shows that DO was highest in the month of August (7.83±0.18mg/L) and

lowest in June (4.70±0.46mg/L). Air temperature was 29.17±0.17^{0}C in February and 25.20±0.25^{0}C in December while water temperature was 31.57±0.20^{0}C in April and 26.63±0.32^{0}C in July. The highest and lowest pH was 7.53±0.09mg/L and 5.10±0.06mg/L in March and December respectively. The highest value for TDS was 36.67±1.67mg/L which was recorded in August and September while the lowest value 20.00±1.00mg/L was recorded in May. CO_2 was highest in august (13.10±2.00mg/L) and lowest in March (0.73±0.09mg/L). Chloride was highest (45.67±5.78mg/L) in July and lowest (18.33±1.86mg/L) in November. The highest value for hardness was recorded in April (38.67±1.33mg/L) while the lowest value was recorded in November (17.33±1.76mg/L).NH_3-Nitrogen was at its peak in April (2.07±0.18mg/L) and minimum in February (0.20±0.00mg/L). BOD was lowest in February (1.60±0.21mg/L) and highest in September (2.87±0.15mg/L). The highest and lowest transparencies were recorded in the month of February (0.72±0.04cm) and August (0.25±0.01cm) respectively. Water depth was highest in the month of August (1.24±0.08m) and lowest in the month of March (0.78±0.03m).

Table 1a: Mean Monthly Water Quality Parameters of River Katsina-ala at Buruku

Month	Water Quality Parameters							
	DO	Air Temp	Water Temp	Ph	Alkalinity	TDS	CO_2	Chloride
January	6.80±0.31^{bc}	28.07±0.03^{c}	30.37±0.27^{e}	7.23±0.19^{cd}	57.33±6.74^{d}	31.67±1.67^{c}	1.83±0.43^{a}	23.33±2.03^{ab}
February	6.50±0.35^{b}	29.17±0.17^{d}	31.07±0.15^{ef}	7.46±0.09^{d}	42.67±1.45^{b}	30.00±0.00^{c}	0.77±0.03^{a}	22.33±1.45^{a}
March	6.63±0.38^{b}	29.00±0.15^{d}	31.27±0.15^{f}	7.53±0.09^{d}	40.00±1.00^{b}	25.33±0.33^{b}	0.73±0.09^{a}	21.33±0.88^{a}
April	6.77±0.47^{b}	28.97±0.09^{d}	31.57±0.20^{f}	6.49±0.16^{c}	61.67±4.91^{d}	45.00±0.00^{e}	9.00±1.73^{bc}	22.00±1.15^{a}
May	6.57±0.17^{b}	29.03±0.12^{d}	31.20±0.00^{f}	7.34±0.17^{d}	31.67±0.33^{a}	20.00±0.00^{a}	6.50±0.7^{6b}	27.33±8.35^{b}
June	4.70±0.46^{a}	26.37±0.27^{b}	28.03±0.20^{bc}	6.95±0.13^{c}	49.67±1.20^{c}	25.00±0.00^{b}	7.30±0.82^{b}	37.67±7.62^{cd}
July	6.00±0.12^{ab}	26.10±0.15^{b}	26.63±0.32^{a}	6.53±0.19^{c}	57.65±2.19^{d}	33.33±1.67^{cd}	12.53±1.82^{c}	45.67±5.78^{e}
August	7.83±0.18^{c}	26.47±0.18^{b}	27.53±0.34^{ab}	6.50±0.17^{c}	62.33±4.91^{d}	36.67±1.67^{d}	13.10±2.00^{c}	45.67±4.91^{e}
September	7.47±0.19^{c}	27.00±0.10^{b}	29.17±0.43^{cd}	6.03±0.09^{b}	50.67±0.88^{c}	36.67±1.67^{d}	9.27±1.04b^{c}	41.67±4.91^{de}
October	5.70±0.21^{a}	27.10±0.00^{b}	29.67±0.42^{d}	5.60±0.15^{ab}	41.00±1.15^{b}	31.67±1.67^{c}	6.87±0.38^{b}	33.33±2.67^{c}
November	5.93±0.26^{ab}	26.63±0.55^{b}	29.83±0.15^{d}	6.50±0.17^{c}	52.00±3.51^{c}	26.67±3.33^{b}	6.47±0.54^{b}	18.33±1.86^{a}
December	5.93±0.03^{ab}	25.20±0.25^{a}	27.47±0.24^{ab}	5.10±0.06^{a}	55.00±3.51^{c}	33.33±1.67^{cd}	2.37±0.33^{a}	21.00±3.61^{a}
P-Value	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*

Means in the same column with different superscripts differ significantly (p<0.05)

Table 1b: Mean Monthly Water Quality Parameters of River Katsina-Ala at Buruku

Month	Water Quality Parameters					
	Hardness	NH_3 Nitrogen	N- Nitrogen	BOD	Transparency	Water Depth
January	29.33±1.33^{b}	0.23±0.07^{a}	0.06±0.00^{ab}	1.77±0.22^{a}	0.66±0.03^{d}	0.93±0.03^{a}
February	29.33±0.67^{b}	0.20±0.00^{a}	0.05±0.00^{ab}	1.60±0.21^{a}	0.72±0.04^{e}	0.88±0.01^{a}
March	28.33±2.03^{b}	0.43±0.03^{bc}	0.03±0.01^{a}	2.13±0.09^{ab}	0.58±0.03^{c}	0.78±0.03^{a}
April	38.67±1.33^{c}	2.07±0.18^{d}	0.04±0.01^{a}	1.87±0.15^{a}	0.45±0.03^{b}	0.91±0.01^{ab}
May	27.67±3.84^{b}	0.37±0.08^{ab}	0.05±0.00^{ab}	2.53±0.57^{b}	0.39±0.02^{a}	0.93±0.01^{ab}
June	28.67±3.53^{b}	0.40±0.06^{b}	0.06±0.00^{b}	2.23±0.32^{ab}	0.35±0.02^{a}	0.94±0.02^{ab}
July	29.00±4.73^{b}	0.67±0.12^{c}	0.06±0.01^{b}	2.70±0.35^{b}	0.30±0.01^{a}	1.05±0.08^{b}
August	30.33±4.10^{b}	0.67±0.09^{c}	0.07±0.01^{b}	2.80±0.10^{b}	0.25±0.01^{a}	1.24±0.08^{c}
September	27.33±3.53^{b}	0.70±0.10^{c}	0.07±0.01^{b}	2.87±0.15^{b}	0.30±0.02^{a}	1.11±0.06b^{c}
October	25.00±1.73^{ab}	0.53±0.03^{c}	0.05±0.01^{ab}	2.37±0.15^{b}	0.33±0.04^{a}	1.01±0.05^{b}
November	17.33±1.76^{a}	0.33±0.07^{b}	0.04±0.00^{a}	1.67±0.18^{a}	0.57±0.03^{c}	0.80±0.03^{a}
December	29.33±1.20^{b}	0.27±0.03^{a}	0.04±0.01^{a}	2.33±0.15^{a}	0.57±0.03^{c}	0.99±0.06^{ab}
P-Value	0.02	0.00	0.00	0.01	0.00	0.00

Means in the same column with different superscripts differ significantly (p<0.05)

Table 2a: Mean location Water Quality Parameters of River Katsina-Ala at Buruku

Location	DO	Air Temp	Water Temp	pH	Alkalinity	TDS	CO_2	Chloride
A	6.82±0.22^{b}	27.48±0.37^{b}	29.63±0.53^{a}	6.64±0.26^{c}	47.92±2.37^{d}	29.58±1.99^{e}	4.96±0.89^{f}	34.00±4.52^{c}
B	6.01±0.24^{a}	27.38±0.46^{b}	29.48±0.49^{a}	6.70±0.21^{c}	54.33±3.88^{d}	33.00±2.06^{e}	7.26±1.45^{f}	30.33±3.07^{c}
C	6.38±0.28^{ab}	27.42±0.37^{b}	29.35±0.49^{a}	6.48±0.20^{c}	48.17±2.36^{d}	31.25±1.86^{e}	6.97±1.40^{f}	25.58±2.08^{c}
P-Value	*0.09*	*0.99*	*0.93*	*0.76*	*0.24*	*0.48*	*0.39*	*0.23*

*mean in the same column with different superscripts differ significantly

Table 2b: Mean location Water Quality Parameters of River Katsina-Ala at Buruku

Location	Hardness	NH_3 Nitrogen	N-Nitrogen	BOD	Transparency	Water Depth
A	25.17±1.93^{a}	0.53±0.13^{a}	0.05±0.00^{b}	1.88±0.13^{a}	0.49±0.04^{a}	0.94±0.04^{ab}
B	31.83±1.52^{b}	0.68±0.17^{a}	0.06±0.00^{b}	2.57±0.13^{b}	0.45±0.05^{a}	1.03±0.05^{b}
C	28.08±1.36^{ab}	0.52±0.14^{a}	0.05±0.00^{b}	2.28±0.17^{ab}	0.44±0.05^{a}	0.91±0.03^{a}
P-Value	*0.02*	*0.70*	*0.18*	*0.01*	*0.75*	*0.10*

*mean in the same column with different superscripts differ significantly

4. Discussion

River katsina-ala is predominantly the major source of natural water for the locals and provides a life support ecosystem for existed biodiversity in aquatic ecosystem [11]. The study shows significant difference in the physico-chemical properties of the river. There was a significant difference in the DO, Air

temperature, water temperature, pH, alkalinity, TDS, CO_2, chloride, hardness, NH_3-nitrogen, Nitrite-nitrogen, BOD, transparency and water depth at the three sampling sites.

4.1 Dissolved Oxygen (DO)

DO levels depends on whether the water is flowing, presence of rocks and other obstacles for water to flow over, population of plants growing on the water and temperature of the water. In the present study, DO was highest in the month of August (7.83±0.18mg/L) and lowest in June (4.70±0.46mg/L). This result is in agreement with the works of [12] and supported by [13] who also reported a higher DO range in the wet season. The higher DO recorded in August could be attributed to the high inflows of runoff water into the river and air-water interactions as a result of water turbulence associated with the engine boats and ferry movements. The DO value was within the acceptable range [14][15] for drinking water and fish production. There was no significant difference in DO Values across the three sampling sites.

4.2 Temperature

Temperature recorded a slight significant difference throughout the study period, except in the month of December where it recorded it minimum value. Although, air temperature affected the water temperature it was not directly proportional to the water temperature. Water temperature ranges from $26.63^{\pm}0.32^0$C to $31.57^{\pm}0.20^0$C, which is in agreement with [16] who reported that the temperature of inland waters in the tropics generally varies between 25^0C and 35^0C.

4.3 Hydrogen ions (pH)

The pH recorded ranges between $5.10^{\pm}0.06$ to $7.53^{\pm 0.09}$, which is within the range (6.5-9.0) recommended for optimum fish production by [14][15]. The present findings is also supported by [13][17], however, contrary to the works of [18] whose pH value was slightly above the optimum level. The low pH values as recorded in this study could be attributed to the influx, waste disposal and decay of debris in the area as well as imbalance level of H^+ inputs from surface runoffs during the rains. There was no significant difference in pH across the three sampling sites.

4.4 Alkalinity

Alkalinity is composed primarily of carbonates (CO_3) and bicarbonates (HCO_3) and it acts as stabilizer for pH [19]. There was a significant difference in the monthly variations of alkalinity. The highest value of alkalinity was recorded in the month of August ($62.33^{\pm}4.91$), which could be attributed to the inflow of water into the river from runoffs within the surroundings and the presence of CO_2 in the water. This finding is supported by [18] but contrary to the works of [20] [21], whose report shows a high alkalinity range. Generally, the present study revealed that alkalinity was within the permissible range of 20 to 150mg/L.

4.5 CO_2

There was a significant difference in the mean monthly values of CO_2 recorded. High level of CO_2 could situate the growth of some aquatic plants species in the present study, CO_2 and DO were highest in the month of August which is an indication that the two parameters are independent of each other. This is in agreement with the findings of [22] who reported CO_2 and DO as highest in the same month. The high level of CO_2 in August could be attributed to the influx of pollutants from runoffs, death and decay of plant debris and the carbon monoxide from the high activities of the ferries on the water body.

4.6 Hardness

Dissolved Calcium and Magnesium are the two most common minerals that make water hard. This study shows that water hardness ranges from $17.33^{\pm}1.76$ to $38.67^{\pm}1.33$mg/L which indicates that the water was slightly hard according to Fairfax water hardness scale. The water hardness value in this study is below the permissible limit, showing their suitability for drinking. This finding is supported by [23] but contrary to the works of [21] who reported a very high range of total hardness which is above the permissible range for drinking water [14, 15].

4.7 Chloride

Chloride in water originates from natural sources, sewage and industrial effluents, urban runoff and saline intrusion [14]. In this present study, the mean monthly chloride concentration ranges from $18.33^{\pm}1.86$(November) to $45.67^{\pm}5.78$(July) which is less than the permissible limit for drinking water. This finding is supported by the work [24][17] who recorded values lower than the permissible limits for drinking water. However [21], recorded chloride value above the permissible limit for drinking water. Seasonally, the value for chloride was highest in July (rainy season) and lowest in November (dry season) which is supported by [18]. Studies have shown that chloride concentration above 100mg/L in the water may burn the edges of the gills of fish with long term effect [17]. The mean monthly chloride values obtained in this present study are suitable for fish growth and for drinking. There was a significant difference in the concentration of chloride at the 3 sampling sites.

4.8 Ammonia nitrogen

Ammonia in water is an indicator of possible bacteria, sewage and animal waste pollution [14]. Certain bacteria oxidize ammonia rapidly to nitrite and nitrate in a process that involves DO. Ammonia been a source of nitrogen is also a nutrient for algae and other forms of plants life, thereby, overloading the natural water and causing pollution. Ammonia can block oxygen transfer in the gills of fish which is capable of causing immediate and long term gill damage. In this study, the highest value for ammonia nitrogen was $2.07^{\pm}$ 1.18 and the lowest value was $0.20^{\pm 0.00}$ which are higher than the permissible limit for drinking water, and could be attributed to anthropogenic activities that takes place in the river.

4.9 Nitrite-nitrogen

Nitrite-nitrogen is typically absent or present in water to a much lesser extent because it is rapidly converted to nitrate (NH_3) [14]. Nitrite (NO_2) enters the water through fertilizers, livestock and human waste associated with septic and municipal waste water system. Nitrite can produce a serious condition in fish called “brown blood disease”. It also reacts directly with haemoglobin in human blood and other warm blooded animals to produce methemoglobin, a condition that destroys the ability of red blood cells to transport oxygen [14]. In this present study, the highest value for nitrite-nitrogen is

0.07 $\pm$ 0.01 and its lowest value is 0.03$\pm$0.01mg/L which is below the permissible limit for drinking water.

4.1.1 BOD
BOD is a measurement of the amount of DO that is used by aerobic microorganisms when decomposing organic matter in water. BOD values in the river should be below 1mg/L, moderately polluted rivers may have a BOD value in the range of 2.8mg/L. Rivers may be considered severely polluted when BOD exceeds 8mg/L. This study reveals the highest value of BOD to be 2.87$\pm$0.15 and the lowest value to be 1.60$\pm$0.21. The range shows that the river is moderately polluted, and this finding is supported by [13].

4.1.2 Transparency
Water transparency is a characteristic of water that varies with the combined effect of colour and turbidity. It is the measure of the depth of light penetration into the water and it depends on the amount of particles in the water. Particles can be inorganic (sediments from erosion) or organic (algae, phytoplankton). This study reveals the highest transparency in February (0.72$\pm$0.04) and lowest in August (0.25$\pm$0.01). The high transparency in the dry season could be due to water stability, low suspended particles in the water and high light penetration into the water.

4.1.3 Water depth
Water depth measurement is a process of measuring and monitoring the depth of water. The highest water depth was recorded in August (rainy season) and lowest in March (dry season). The low water depth could be attributed to high water evaporation and low influx of water from rain and runoffs [10].

4.1.4 Conclusion
This study reveals that river Katsina-ala at Buruku is still suitable for drinking, domestic use and fish production as most of the physico-chemial parameters are within the acceptable standards by WHO and NIS. However, some physico-chemical parameters such as hardness, ammonia-nitrogen, BOD were slightly above the permissible limits by WHO and NIS which is an indication that the water is gradually being polluted. Further studies should be carried out on the river to determine the heavy metal pollution and the productivity of the river to ascertain its full potentials.

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