Aspects of Physico-Chemical Parameters of Bodna River in Kwali Area Council Abuja, Nigeria

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Abstract

In this study, the Bodna River was analyzed for some physicochemical parameters. The main aim of the study was to determine the effect of human activities on the physical, chemical and biological properties of the river, and to enhance systemable usage for conservation and management. The water quality parameters examined were Temperature, pH, Transparency, Salinity, Total dissolved solids (TDS), Dissolved oxygen (DO) and Electrical Conductivity (EC) for the four sampling stations from May 2018 to April 2019. There was no significant difference ($p>0.05$) in the pH values of the river ranging between (7.16 to 7.20) in all the sampling stations. The Analysis of Variance (ANOVA) showed significance differences ($p<0.05$) in other parameters across the months. The result showed that air temperature ranged from 32.10±0.73 to 36.15±0.17 ^{o}c, water temperature from 30.20±0.94 to 34.30±0.22^{o}c, transparency ranged from 5.9±0.61cm to 18.7±6.17cm, Salinity varied 2.08±0.06 to 3.15±0.50 mg/l. Total dissolved solid (TDS) was between 33.50±7.91 and 83.85±21.06mg/l. Dissolved oxygen (DO) ranged from 6.23±0.05 to 8.28±0.10 mg/l and Electrical conductivity (EC) ranged from 40.00±4.32 to 87.25±19.97□/s. The parameters were correlated within the stations. The results from the study showed that most of the physicochemical parameters were within the accepted values for consumption, biodiversity, productivity, domestic usage and are below pollution level.

Keywords: Bodna River, physiochemical parameters, significance, seasonal, domestic and correlation.

Introduction

Limnological studies include the physicochemical and biological parameters of fresh waters (Idowu *et al*., 2013). Water bodies are constantly used as receptacles for untreated waste water from industrial activities. (Efe, 2000).This may render the water bodies unsuitable for both primary and secondary usage. A major problem in developing countries including Nigeria is the shortage of adequate potable water, especially for rural communities that depend on streams, rivers and ponds as chief sources of drinking water. (Dan-kishiya *et al.*, 2013)

Rivers are vital and vulnerable freshwater systems that are critical for the sustenance of all life, providing main water resources for domestic, industrial and agricultural purposes (Farah *et al*. 2002). Unfortunately, river waters are being polluted by indiscriminate disposal of sewage, industrial waste and a plethora of human activities that affect their physicochemical parameters and microbiological quality (Oboh *et al*., 2017), (Efe, 2000). The streams, rivers, wells and boreholes which are mostly untreated, they are associated with various health risks (Agbarie *et al.*, 2009).

The physico-chemical parameters of the river tell much about its quality and suitability for both humans and survival of the living biota within it. (Bellingham, 2012). Humans may survive for several weeks without food, but barely few days without water because constant supply of water is needed to replenish the fluids lost through normal physiological activities, such as respiration, perspiration, urination, (Muhammed *et al*., 2009). At a global scale, rapid change in climate leads to increase in extinction risk across all types of life forms, (Bellard *et al.*, 2012). Aquatic eco systems are critical component of global environment. In addition of being essential contribution to biodiversity and ecological productivity also provides variety of service for human population such as water for drinking, irrigation, recreational opportunity and habitat for economically important fisheries. (Dankishiya *et al.*, 2013). The general desire to protect fresh water fisheries has led to an expansion of research into their water quality requirements, in terms of their physicochemical parameters such as P^H, temperature, dissolve oxygen, transparency, total alkalinity, total hardness, electrical conductivity, total dissolved matter, e.t.c. These factors serve as a basis for the richness or otherwise biological productivity of any aquatic environment, (Edokpayi and Osimen (2002), Unanam and Akpan, 2006). Several of these physicochemical parameters have been studied on large man-made lakes in Northern Nigeria on Makwaye Lake, Zaria, (Oniye *et al*., 2002)

This is because Changes in the physicochemical parameters may positively or negatively affect the biota of water bodies in a number of ways such as their survival and growth rate and these may eventually result in disappearance of some species of organisms or its reproduction (Edward, 2010).

MATERIALS AND METHODS

Study Area

In Kwali region of FCT Nigeria, the problem is getting portable water because of environmental pollution and degradation. Bodna River in kwali area council of FCT, is a tributary to lower Usman dam. The river has a tremendous economic importance to the indigenous settlers which ranges from domestic usage, irrigation for agricultural activities and fishing. These activities are source of employment opportunities to some of the community members. However, less attention has been given to the Bodna River despite its importance in the lives of the inhabitants of the area, who rely mainly on the river for drinking, domestic water supply, fishing, farming, bathing, laundry and sand mining. The river is being polluted by the human activities such as; bathing, washing, refuse dumping and defeacation around the river banks. These activities in one way or the other affects the physicochemical parameters of the water body and the fishes in it.

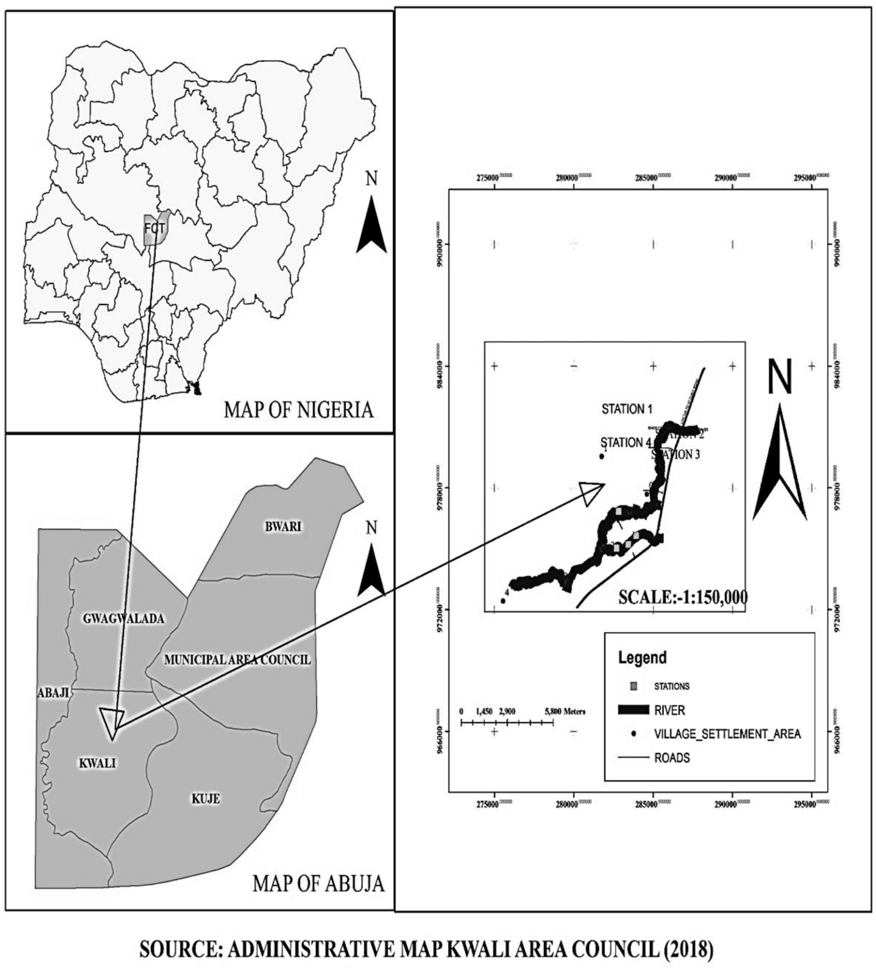

Figure 1: *Map of Abuja showing the study Area in Kwali.*

Physicochemical Parameters

The physicochemical parameters readings were taken from the four different stations on monthly basis. Some were determined insitu with an apparatus 'La motte' model (1766) and some were taken to the laboratory using different equipment to determine the reading. The physicochemical parameters like temperature, pH, total dissolved solid, electrical conductivity and salinity of the river were determined using the Lamotte digital Pocketester apparatus which was suspended in the water body vertically for 3 to 5 minutes to stabilize and the readings were taken. The mode of the apparatus was changed from time to time to get readings of the physico-chemical parameters mentioned above. This was conducted in all the four sampling stations.

Temperature Determination

The temperature of the atmosphere and the surface water were taken insitu using a thermometer calibrated in degree Celsius (^{0}C).The atmospheric temperature was taken before the thermometer was lowered into the water body and retained inside for about 3-5 minutes to take the temperature of the surface water.

Water pH

The pH of the water was determined using the La Motte Tracer (pocketester) by changing the mode. The apparatus was dipped into the water for about 3-5 minutes and the reading was recorded.

Water Transparency

This was carried out insitu using a calibrated secchi disc as described by Boyd (1985). The secchi disc was dipped into the water body vertically and suspended. The calibrated reading was taken at the point which the white line goes faint (disappears). Then, the secchi disc was raised and the reading at which the white lines appearance was also taken. The average value of the disappearance and the appearance reading showed the transparency of the water body. This was applied to all the sampling stations and readings were taken in centimetre (cm).

Salinity Determination

The salinity values of the water body were taken at the different sampling stations using the La Motte Tracer (pocketester) apparatus. The apparatus was suspended in the water body for about 3-5 minutes to get the readings. Salinity is measured in parts per million (ppm).

Total Dissolved Solids (TDS)

La Motte Tracer (pocketester) was used to take the value of the Total Dissolved Solids in the water body expressed in parts per million (ppm). The apparatus was dipped into the water and left for about 3-5 minutes to take the TDS reading.

Electrical Conductivity (EC) Determination

This was done using the digital pocketester suspended in the water vertically and the reading was taken. It is measured in micro siemen/centimetre (μS/cm).

Dissolved Oxygen (DO)

The water sample collected to determine the Dissolve Oxygen was fixed insitu with 2ml of Winkler's reagent immediately. This was determined in the laboratory using the Winkler's titration method. Materials used includes 200ml DO bottle with a functional stopper, a conical flask, pipette, droppers for reagents, measuring cylinder, reagents I, II and III ($MnSO_4$, KOH + KI and conc. H_2SO_4) and indicator ($Na_2S_2O_3$) Sodium thiosulphate. Dissolved Oxygen is measured in milligram per litres (mg/L).

Procedure

200ml of water sample was poured gently into the DO bottle to avoid air bubbles.

1ml of reagent I ($MnSO_4$) was added to the sample and corked with the stopper, the bottle was inverted a few number of times to mix properly.

1ml of reagent II (KOH + KI) was dropped into the sample and inverted severally to mix, a brownish cloudy precipitate (floc) was formed showing the presence of Oxygen which settled down at the bottom of the bottle.

1ml of reagent III (conc. H_2SO_4) was dropped in the water sample which immediately converted the precipitate to a golden yellow solution.

10ml of the solution was measured using a calibrated measuring cylinder and was transferred into a clean and dry conical flask. Using a calibrated pipette, pipette 10mls of the indicator (sodium thiosulphate) and then titrate the solution in the conical flask by adding in drops (one drop at a time) until the yellow colour dissipated. 1.0 of thiosulphate used is titrimetrically equivalent to1.0 mgO_2/ml. (USEPA, 1979).

The amount of sodium thiosulphate used determined the value of dissolved Oxygen of the water sample. This procedure was used in all the water samples.

Statistical Analysis

ANOVA (Analysis Of Variance) was used to determine the significance differences in physicochemical parameters of the sampling stations and monthly variations, while T-test was used to determine the seasonal variation of the physicochemical parameters using SPSS package version 24. Pearson correlation was used to show the relationship within the physicochemical parameters in the Bodna River.

Results

Physicochemical parameters of Bodna River. The mean monthly physicochemical parameters of Bodna River are shown in Table1. The air temperature varied throughout the months with the lowest mean value 32.10±0.73 (32.10 ºC) in the month of October 2018 and the highest mean value 36.15±0.17 (36.15 ºC) in the month of April 2019. Analysis of variance (ANOVA) shows that there was significant variation ($P<0.05$) in the monthly mean of air temperature. The water temperature ranges from 29.10 ºC in the month of March to 34.10 ºC in the month of October. The pH was within the ranged 7.14to7.23 in the month of May and 7.20 to7.22 in the month of December. The parameters with same superscript are not significantly different ($P>0.05$),see Table 1.

The stations mean air temperature value ranged between 33.97 ºC to 34.48 ºC across the stations with the lowest temperature observed in station I and highest value recorded in station IV. The mean water temperature ranged between 30.20 ºC in the month of Oct. 2018 to 34.20 ºC in March 2019. Analysis of variance (ANOVA) showed significance different ($P<0.05$) in the water temperature values with same super script within the month. The water temperature mean value in the sampling stations ranged between 29. 10 ºC in station I to 32.82 ºC observed in station IV. The analysis of variance (ANOVA) showed no significance variation (P>0.05) between the sampling stations of the Bodna rivers.

The lowest value of transparency was observed in the month of March at 5.95cm to 19.50cm in the month of August which is higher. The transparency of the study area is 15.8cm with a high turbidity, showing the clarity of the water body. It was noticed at the dry season that the turbidity rate increases, where the bottom of the water body can be viewed clearly.

The mean monthly value of the water salinity of Bodna River varied between 2.08mg /l to 3.75 mg/l. This shows significant variation (p<0.05) in the monthly values of salinity with the lowest value observed in January, February and March 2019 and the highest value recorded in July, August and September 2018 respectively. See Table 1. Salinity in the sampling station of the River ranged between 2.58 mg/l in station III and 2.82 mg/l in station I, as shown in Table 2. There was no significant difference with the sampling stations. The seasonal value of the water salinity was recorded lower in the dry season 2.29mg/l and high in the wet season 3.04mg/l. The T-value showed significant difference in the seasonal values. This could results to heavy rain flood which moves other sediments and industrial wastes from various places to the study area.

The Total Dissolve Solids (TDS) value was 89.25mg/l. The result showed increase in the value during the heavy rain in the months of July, August, September and October. It was also noticed that, increase in the salinity equally increases the Total Dissolve Solid and Electrical conductivity.

The Dissolved Oxygen (DO) content of the water was 8.28mg/l in average, not exceeding the range which is the most well established indicator of water quality. There are physical factors that can lessen the amount of oxygen dissolved in the River Bodna. High temperatures, which may result from high turbidity, from the return of domestic used water to the river decrease the amount of gases that can be dissolved in water. Dry periods also decrease flow which reduces the amount of oxygen into the water.

Conductivity of the groundwater for the entire study area stands at an average of 87.25µS cm-1. This gives a picture of very high solute dissolution generally in the groundwater.

The mean physicochemical parameters of the sampling stations of the Bodna River were presented in Table 2. The highest mean value temperature 34.48 ºC was at station IV while the least temperature value 29.10 ºC was observed at station I. The values with same superscript within the rows are not significantly different P>0.05 as observed in the stations.

The mean seasonal variations of the physicochemical parameters of Bodna River are shown in Table 3. The temperature value 33.93 ºC was observed to be higher in the dry season while the lowest temperature value 30.24 ºC recorded in the wet season. The student T' test showed that the 'T values with the asteric (*) are significantly different (P<0.05) while, the dissolved oxygen and electrical conductivity are not significantly different (P>0.05) as shown in Table 3.

Correlation of physicochemical parameters of Bodna River

Pearson Correlation showing the relationship between physicochemical parameters of Bodna River were presented in Table 4. The result showed no significance correlation (p>0.05) between the air temperature and water temperature of value (087) and has a negative value of (-057) with pH. It was also observed that air temperature has no significance correlation (p>0.05) with other parameters.

There was negative but highly significance correlation (-420**) between water temperature and P^H, (448**) between salinity, (513**) Total dissolved solids (TDS) and (376**) Electrical Conductivity (EC), but has no significance correlation (047) with transparency and negative relationship (-0.62) with dissolve oxygen (DO).

It was observed that there was no significance correlation between pH and Dissolved oxygen (DO) (021), negative correlation (-114) with transparency and (-107) Electrical Conductivity (EC), but negative significance correlation at (p<0.05) with salinity (-293*) and Total dissolved solids (TDS) (-291*).

There was no significance correlation (p>0.05) between the transparency (147) and salinity, negative values with Dissolved oxygen (DO) (-153) and Electrical Conductivity (EC) (-

0.16) but highly significance correlation (425**) was observed between transparency and Total dissolved solids (TDS).

The result on salinity showed highly significance correlation (612**) with Total dissolved solids (TDS) (518**) and with Electrical conductivity (EC) but showed no significance correlation (145) with Dissolved oxygen (DO).

There was negative and no significance correlation (-144) between Total dissolved solids (TDS) and Dissolved oxygen (DO) but highly significance correlation (-059) between Dissolved oxygen (DO) and Electrical conductivity (EC).

Table 1: Mean Month Physicochemical Parameters of Bodna River from May 2018 to April2019

Month	Parameters							
	Air temperature (ºc)	Water temperature (ºc)	pH	Transparency (cm)	Salinity (mg/l)	TDS (mg/l)	Dissolved oxygen (mg/l)	Electrical conductivity (μ/s)
May	35.68±0.54^{cd}	32.60±1.85^{ab}	7.19±0.04^{a}	12.78±2.46^{bc}	2.29±0.22^{a}	73.35±2.83^{bcd}	8.23±0.10^{a}	72.75±2.87^{a}
	(35.00-36.20)	(30.00-34.40)	(7.14-7.23)	(11.20-16.40)	(2.10-2.60)	(70.00-76.20)	(1.10-1.30)	(69.00-75.00)
June	34.40±0.68^{abcd}	31.75±2.17^{ab}	7.19±0.03^{a}	18.76±6.17^{c}	2.18±0.24^{a}	72.55±18.32^{bcd}	8.10±0.05^{a}	87.25±19.97^{ab}
	(33.40-34.90)	(29.80-34.10)	(7.15-7.21)	(15.30-28.00)	(2.00-2.50)	(56.60-97.00)	(1.20-1.30)	(70.00-103.00)
July	34.60±0.29^{bcd}	33.55±0.42^{b}	7.18±0.04^{a}	10.50±1.35^{ab}	3.75±0.50^{b}	80.63±15.83^{cd}	8.27±0.10^{a}	54.00±24.09^{b}
	(34.20-34.90)	(33.10-34.10)	(7.12-7.20)	(8.50-11.50)	(3.00-4.00)	(60.60-90.80)	(1.20-1.40)	(73.00-128.00)
August	34.55±0.73^{bcd}	33.60±0.64^{b}	7.16±0.04^{a}	11.23±2.67^{ab}	3.75±0.50^{b}	83.38±16.56^{cd}	8.27±0.15^{a}	53.50±19.97^{b}
	(33.90-35.60)	(33.10-34.50)	(7.10-7.19)	(9.50-15.20)	(3.00-4.00)	(59.60-95.10)	(1.20-1.50)	(75.00-120.00)
September	34.98±0.97^{cd}	33.63±0.75^{b}	7.17±0.05^{a}	11.30±3.94^{ab}	3.75±0.50^{b}	83.85±21.06^{cd}	8.27±0.10^{a}	57.75±11.73^{b}
	(33.80-36.00)	(32.60-34.40)	(7.10-7.20)	(9.20-17.20)	(3.00-4.00)	(52.30-96.00)	(1.20-1.40)	(94.00-118.00)
October	32.10±0.73^{ab}	34.30±0.22^{b}	7.16±0.05^{a}	10.75±2.06^{ab}	2.52±0.55^{a}	89.25±2.98^{d}	8.28±0.10^{a}	56.75±8.99^{b}
	(32.10-33.60)	(34.10-34.60)	(7.10-7.20)	(8.20-12.70)	(2.00-3.00)	(85.00-92.00)	(1.20-1.40)	(96.00-116.00)
November	32.48±0.43^{a}	33.40±0.49^{b}	7.21±0.01^{a}	9.25±1.05^{ab}	2.62±0.56^{a}	59.33±6.62^{abc}	8.23±0.05^{a}	46.10±11.23^{ab}
	(32.10-33.10)	(33.00-34.10)	(7.19-7.22)	(8.20-10.20)	(2.11-3.20)	(50.20-66.00)	(1.20-1.30)	(86.00-112.00)
December	33.95±1.44^{abc}	31.55±1.48^{ab}	7.21±0.01^{a}	8.43±0.72^{ab}	2.08±0.06^{a}	46.15±1.11^{ab}	7.30±0.14^{a}	46.00±2.31^{ab}
	(33.10-36.10)	(29.80-33.10)	(7.20-7.22)	(8.00-9.50)	(2.01-2.15)	(45.19-47.11)	(1.20-1.50)	(94.00-98.00)
January	34.23±0.22^{abcd}	31.88±0.46^{ab}	7.21±0.01^{a}	8.18±1.36^{ab}	2.28±0.26^{a}	50.11±5.78^{ab}	7.37±0.15^{a}	43.75±2.22^{ab}
	(34.00-34.50)	(31.20-32.20)	(7.20-7.22)	(6.70-10.00)	(2.00-2.51)	(44.30-58.12)	(1.20-1.50)	(91.00-96.00)
February	33.78±0.89^{abc}	32.03±0.49^{ab}	7.20±0.00^{a}	8.40±0.49^{ab}	2.08±0.10^{a}	46.70±1.71^{ab}	7.30±0.08^{a}	43.00±3.16^{ab}
	(33.20-35.10)	(31.40-32.60)	(7.20-7.20)	(8.00-9.00)	(2.00-2.21)	(44.20-48.10)	(1.20-1.40)	(79.00-86.00)
March	32.98±1.24^{ab}	30.20±0.94^{a}	7.19±0.01^{a}	5.95±0.61^{a}	2.08±0.16^{a}	33.50±7.91^{a}	6.23±0.05^{a}	41.75±2.87^{a}
	(32.30-34.30)	(29.10-31.40)	(7.18-7.21)	(5.50-6.80)	(1.93-2.30)	(21.70-38.00)	(1.20-1.30)	(70.00-76.00)
April	36.15±0.17^{d}	31.55±1.48^{ab}	7.21±0.01^{a}	8.18±1.36^{ab}	2.62±0.56^{a}	59.33±6.62^{abc}	6.33±0.13^{a}	40.00±4.32^{ab}
	(36.00-36.40)	(29.80-33.10)	(7.20-7.22)	(6.70-10.00)	(2.11-.3.20)	(50.20-66.00)	(01.20-1.50)	(84.00-94.00)

Note: *Values with the same superscript within the columns are not significantly different (P>0.05)*

Table 2: Station Variation in the Physicochemical Parameters of Bodna River 2018 to 2019

Parameters	Stations			
	I	II	III	IV
Air temperature(ºc)	33.97±1.43^{a} (31.30-36.10)	34.22±1.18^{a} (32.30-36.00)	34.13±1.22^{a} (32.40-36.40)	34.48±1.42^{a} (32.10-36.20)
Water temperature(ºc)	32.32±2.15^{a} (29.10-34.60)	32.30±1.39^{a} (30.00-34.30)	32.57±1.47^{a} (30.20-34.40)	32.82±1.03^{a} (30.10-34.20)
pH	7.18±0.05^{a} (7.10-7.23)	7.19±0.02^{a} (7.14-7.22)	7.19±0.03^{a} (7.14-7.22)	7.19±0.03^{a} (7.10-7.21)
Transparency(cm)	11.56±5.40^{a} (6.80-28.00)	9.55±2.66^{a} (5.50-16.40)	10.29±3.84^{a} (6.00-17.20)	9.83±3.19^{a} (5.50-16.40)
Salinity(mg/l)	2.82±0.71^{a} (1.93-4.00)	2.64±0.76^{a} (2.00-4.00)	2.58±0.75^{a} (2.00-4.00)	2.63±0.84^{a} (2.00-4.00)
TDS(mg/l)	57.05±15.53^{a} (21.70-85.00)	69.17±22.03^{a} (36.30-97.00)	67.52±20.85^{a} (38.00-96.00)	65.63±21.71^{a} (38.00-94.30)
Dissolved oxygen(mg/l)	3.7±0.10^{c} (1.20-1.50)	3.1±0.10^{bc} (1.20-1.50)	2.3±0.05^{ab} (1.20-1.30)	1.9±0.03^{a} (1.10-1.20)
Electrical conductivity(μ/s)	44.12±10.56^{a} (70.00-96.00)	58.92±17.06^{a} (69.00-118.00)	52.67±12.89^{a} (75.00-120.00)	56.17±19.77^{a} (70.00-128.00)

Note: *Values with the same superscript within the rows are not significantly different (P> 0.05)*

Table 3: *Seasonal Variation in Physicochemical Parameters of Bodna River 2018 to 2019*

Parameters	Seasons		
	Wet	Dry	t-value
Air temperature (ºc)	31.48±1.10	33.93±1.42	1.52
Water temperature (ºc)	30.24±1.40	31.77±1.30	3.78 *
pH	7.17±0.04	7.20±0.01	-3.69
Transparency (cm)	12.55±4.26	8.06±1.36	4.93 *
Salinity (mg/l)	3.04±0.83	2.29±0.39	3.98 *
TDS (mg/l)	80.49±14.45	49.19±10.29	8.65 *
Dissolved oxygen(mg/l)	6.26±0.09	9.29±0.11	-1.13
Electrical conductivity(µ/s)	42.00±19.51	48.43±10.08	1.91

Note: The t-values with **(*)** are significantly different (P<0.05)

Table 4: *Pearson Correlation showing the relationship between physicochemical parameters of Bodna River*

Parameters	Air temp	Water temp	PH	Transparency	Salinity	TDS	DO	EC
Air Temp	1							
Water Temp	.087	1						
PH	-.057	-.420**	1					
Transparency	.074	.047	-.114	1				
Salinity	.215	.448**	-.293*	.147	1			
TDS	.242	.513**	-.291*	.425**	.612**	1		
DO	.032	-.062	.021	-.153	.145	-.144	1	
EC	.035	.376**	-.107	-.016	.518**	.668**	-.059	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Discussion

Physicochemical Parameters

The physicochemical parameters of Bodna River showed some variations for months, stations and seasons. The water temperature of Bodna River was within the range of 10^0C to 50ºC meant for domestic purposes and for fish culture in the tropics (WHO, 2000). The water temperatures were relatively low in the wet season 30.24 ºC than the dry season in this study, this was similar to the findings of Mustapha (2008) and Anago *et al.* (2013), but differs from other studies where the water temperatures were observed to be low during the dry season Ibrahim, *et al*, (2009) and Andem *et al.*, 2012). The variation in water temperature for months and seasons could be attributed to meteorological conditions such as trade winds, sunshine durations and absorption of solar radiation by the river water.

The transparency was low in rainy season than dry season. The low transparency of the river in the rainy season may be attributed to the washing silt, sediments, debris, organic and inorganic suspended particles flushed into the river by flood and surface run-off during rainy season. High water transparency in the dry season could be due to absence of flood water and settling of the particles at the bottom of the river. This result corresponds with the findings of Ibrahim *et al*, (2009), Bala, (2011) and Anago *et al*, (2013). Lower transparency recorded during rainy season when there was turbulence and high turbidity, has a corresponding low primary productivity, because turbidity reduces the amount of light penetration, which in turn reduces photosynthesis and hence primary productivity (APHA, 1995).

The hydrogen ion concentration (P^H) was neutral throughout the study period, and it was within the range for inland waters (P^H 7.1 to 7.2). Boyd (1979) reported pH range of 6.09 – 8.45 as being ideal for supporting aquatic life including fish. Federal Environmental Protection Agency (FEPA) recommended P^H of 6.5-8.5 for drinking and 6.0-9.0 for aquatic life. Thus the pH range recommended in this study is within the acceptable level of 6.0-8.5 for culturing tropical fish species and for drinking water (WHO 2000). Aquatic organisms are affected by pH range for suitable aquatic life is pH 6.5-8.5 (Murdock et al., 2002). Fresh water ranges of pH 6.0-9.0 have been noted to be productive and thus recommended for fish culture. Offem *et al*. (2011). Andem *et al*. (2012) and Anago *et al.* (2013) reported similar findings in some of the Nigerian water bodies.

Similarly, values of the salinity of river 2 to 3 mg/l depends on the drainage area, the nature of its rock, precipitation and human activities. This result agrees with the work of Banyigyi, (2016) on Doma reservoir with salinity variation of 16 to17ppm. Variation in the values of salinity observed in this study may be due to the effects of rainfall, evaporation, precipitation and other weather related factors (McNeely *et al*, 1979). This was in disagreement with Anago *et al.* (2013), who reported a range of water salinity between 0.11-0.19ppm in Awba Reservoir, university of Ibadan, Nigeria.

The values of total dissolved substance (TDS) obtained in this study fell within tolerable limits for drinking water 89mg/l, as it did not exceed 500mg/L (EPA, 1976). The total dissolved substance which usually consist of inorganic materials dissolved in water (Wetzel, 1983) are essential in the life of Aquatic bio-community and water bodies normally containing 80 – 400mg/L of TDS are unlikely to support good fisheries Bala, (2011). Though the monthly values obtained from this study were higher than what was obtained by Banyigyi, (2016)- 40 mg/l but same with Mustapha (2008), Bala, (2011) and Anago *et al.* (2013), the result showed similar observation of no significant difference ($P>0.05$) in the mean values of TDS in relation to seasons.

Conductivity levels below 50µmhos/cm are regarded as low; those between 50-600µmhos/cm are medium while those above 600 µmhos/cm are highly conductive (Anago *et al*, 2013). Thus the range of 40.00 to 87.25 µs/cm electrical conductivity obtained in this study indicates same conductivity of the river when compared with findings of Mustapha (2008), Bala, (2011) and Anago *et al*. (2013) who recorded conductivity values above 50µS/cm indicating medium conductivity of the river. Boyd (1979) affirmed that natural water normally has conductivity ranges from 20-1500 µS/cm.

Conclusion

This research on Bodna river indicates that the physicochemical parameters which includes; temperature, pH, salinity, electrical conductivity, total dissolved solid and dissolved oxygen varies from stations to stations and from season to season. The water temperature of Bodna River, the ionic concentration, total dissolved solid, dissolved oxygen and electrical conductivity all fell within the tolerant limit that favours aquatic environment. Water level increased with rainy season leading to annual flooding which also favoured the breeding of organisms and also increase the primary production of the river. Similarly, values of the salinity of river 2 to 3 mg/l depends on the drainage area, the runoff water, precipitation and human activities.

Recommendations

In the study of physicochemical parameters of Bodna River, it revealed that the River was safe for domestic uses and for aquatic life. Presently, there is no environmental concern for the Bodna River. In view of the expected increase in industrialization and urbanization in Kwali Area Council, it is still important to formulate pollution control policies that take in to account the need to regulate discharge of contaminant into the River.

Environmental auditing which involves self-regulations should be encouraged within the community as part of an overall environmental management policy.

It is also recommended to monitor human activities and fishing intensity on the River to avoid destroying the fish diversity for management and sustainability of the fishery resources.

References

Agbaire P.O. and Obi C.G. (2009) Seasonal Variations of Some Physico-Chemical Properties of River Ethiope , Abraka, Nigeria. *Journal of Applied Science. Environ. Manage.*13 (1) 55 –57.

Anago, I.J., Esenowo I.K. and Ugwumba, A.A.A., (2013). The physico-chemical and plankton diversity of Awba Reservoir, University of Ibadan, *Nigerian Research Journal of Environmental and Earth Sciences,* 5 (11):638-644.

Andem, A.B., Udofia, Okorafor,K.A., Okete, J.A. and Ugwumba, A.A.A (2012). A study on some physical and chemical characteristics of Ona River, Apata, Ibadan, South-west, Oyo state, Nigeria. *European Journal of Zoological Research* 1 (2): 37-46.

APHA (1992). American Public Health Association. Standard methods for the examination of water and waste water 19tedition. Pp472

Bala, U.and Bolorunduro P.I., (2011). Limnological survey and nutrient load of Sabke Reservoir, Katsina State, Nigeria, *African Scientist*, 12,(3): 163-168

Banyigyi, H.A. (2016). Physicochemical parameters and Fish diversity of Doma reservoir in Nasarawa State. A P.hDthesis, Ahmadu Bello University, Zaria. Pp.105 -115.

Bellingham, K. (2012). Physicochemical Parameters of Natural Waters. Stevens Water Monitoring Systems, Inc. (http://www.stevenswater.com)

Boyd, P.W., Wong R. and Lee, H. (2000): A Meso scale phytoplankton bloom in the polar southern ocean stimulated by iron fertilization nature 407**:** 695- 702.

Dankishiya, A.S., Olatunji, A.A., Balogun J.K. (2013); Ichyofauna composition and diversity of a tropical water supply reservoir in Bwari, Abuja, Nigeria. *American Journal of Research Communication.*15:365-377.

Efe, S.T. (2000). An Appraisal of the Quality of Rain and Groundwater Resources in Nigerian Cities. The case of Warri Metropolis. A. Ph.D seminar paper presented to the Department of Geography and Regional Planning, Delta State University, Abraka, pp. 29.

Farah N, Zia MA, Rehman K, Sheikh M. (2002). Quality characteristics and treatment of drinking water of Faisalabad city. *International Journal of Agricultural Biology* 3: 347–349.

Hannifer, M. A., Nagaraja, M. and Gopalakarisnan, (2006). Length-Weight relationship of Channa punctata(Bloch, 1793) from Western Ghats Rivers of Tamil Nadu. *Journal of Applied Technology* 22(5): 463-463.

Ibrahim Baba Usman (2009). Fish composition and some aspect of the physic-chemical parameters of kontagora reservoir, Niger state, Nigeria. *Bayero Journal of pure and applied sciences*, 2 (1):64-69.

Idowu E.O., Ugwumba A.A.A., Edward J.B and Oso J.A. (2013). Study of the Seasonal Variation in the Physico-Chemical Parameters of a Tropical Reservoir. *Greener Journal of Physical Sciences*, 3 (4):142-148.

McNeely, R.N., Neimanis, V, P, and Dweyer, L. (1979). Water Quality Book: A guide to water quality parameters. Inland waters Directorate, water quality branch, Canada. PP:88s

Mustapha, M.K., (2008); Assessment of the water quality of Oyun Reservoir, Offa Nigeria using selected physic-chemical parameters. *Turkish journal of fisheries and aquatic science.8:309-319*

Oboh, I.P. and Agbala, C.S.; (2017): Water quality assessment of the Siluko River, southern Nigeria. *African Journal of Aquatic Science*, DOI: 10.2989/16085914.2017.1371579

Offem, B.O. Ayotunde, E.O., Ikpi G.U., Ochang, S.N. and Ada, F.B, (2011): Influence of seasons on water quality, abundance of fish and plankton species of Ikwori lake, South- Eastern Nigeria. *Fisheries and Aquaculture Journal*, 2011, 18pp.

Unanam, A.E. and Akpan, A.W.(2006). Analysis of physicochemical characteristics of some freshwater bodies in Essien Udim Local Government area of Akwa Ibom State, Nigeria. In: Proceeding of the 21St Annual Conference of the Fisheries Society of Nigeria (FIS0N) Calabar, 13th -17th November, 2006.