



ASSESSMENT OF SURFACE WATER PHYSICO-CHEMICAL PARAMETERS OF YARDANTSII RESERVOIR, GUSAU NIGERIA

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ABSTRACT

The Yardantsii Reservoir, Gusau Nigeria serves multitude of purposes for the Gusau populace. It is the main source of water for domestic purpose, irrigation, and fishing. The reservoir receives both organic and inorganic waste through runoffs and seepage from the catchment areas. The physico-chemical parameters of the surface water were investigated monthly from May, 2015 to April, 2017. Samples were collected from five sampling stations and analyzed using standard procedures for examination of water and waste water. The data obtained was subjected to multivariate analysis using Microsoft office excels and SPSS. The results showed the following mean seasonal variation of surface water temperature (26.62 ± 0.34 – $30.12 \pm 0.17^\circ\text{C}$), transparency (48.82 ± 1.08 – $22.07 \pm 0.87\text{cm}$), mean depth (2.12 ± 0.05 – $2.65 \pm 0.04\text{m}$), pH (7.61 ± 0.15 – 7.96 ± 0.13), electrical conductivity (186.32 ± 3.84 – $108.05 \pm 5.43\mu\text{S/cm}$), total dissolved solids (96.00 ± 1.95 – $63.70 \pm 3.68\text{mg/L}$), dissolved oxygen (7.80 ± 0.11 – $6.91 \pm 0.10\text{mg/L}$), biochemical oxygen demand (2.71 ± 0.09 – $2.48 \pm 0.05\text{mg/L}$), alkalinity (40.57 ± 0.69 – $27.87 \pm 0.51\text{mg/L}$), hardness (59.20 ± 1.01 – $32.18 \pm 0.94\text{mg/L}$), $\text{NO}_3\text{-N}$ (2.28 ± 0.08 – $4.44 \pm 0.07\text{mg/L}$), $\text{PO}_4\text{-P}$ (123.72 ± 1.44 – $173.48 \pm 2.78\text{mg/L}$), sulphate (31.62 ± 1.45 – $71.80 \pm 1.82\text{mg/L}$) and chloride (74.08 ± 1.67 – $37.64 \pm 0.96\text{mg/L}$) for dry and rainy seasons respectively. The results revealed that a highly significant seasonal variation ($p < 0.01$) was exhibited in all parameters with the exception of pH which shows no significant seasonal variation ($p > 0.05$) and biochemical oxygen demand, which shows a significant seasonal variation ($p < 0.05$). The results of this survey showed that the parameters observed indicated that most of them fall within the recommended range set by World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ).

Keywords: Dissolved oxygen, electrical conductivity, pH, reservoir, temperature

INTRODUCTION

Reservoirs or man-made lakes are impoundments created largely by humans by the damming of river valleys. Humans have created artificial lakes by damming for at least 4000 years. It is only recent that the damming activities have become highly significant for the purpose of flood control, irrigation, and provision of power and water supplies for urban, ever-growing populations (Ismael, 2009). Anthropogenic activities such as agriculture, industrial and domestic discharges have contributed to the deterioration of the environment (Ansari *et al.*, 2014; Van Dover, 2014). Pollutants from these activities are released either directly into the aquatic ecosystem in the form of wastewater discharges, oil spillages, agricultural run-offs (Hassan *et al.*, 2014), or indirectly through deposition from soil or air within the catchment of such water bodies (Bako *et al.*, 2014). In recent years there have been increasing concern about the rate at which inland waters are polluted through human activities, agriculture waste, manure, fertilizers and pesticides, which find their way through run-offs into streams and lakes there by enriching the water bodies, leading to eutrophication (Adakole *et al.*, 2003). The quality of any given water body is governed by its physical, chemical and biological

factors, all of which interact with one another and greatly influence its productivity (Ajana *et al.*, 2006). Muhar, *et al.*, (2000) reported that a study of physico-chemical characteristics provides great insight into why problems occur; help to discern the trends and asses potential remedies. Therefore monitoring the physico-chemical characteristics of reservoirs is important for both short term and long term trends, which will enable appropriate decisions and action to minimize deleterious effects. This research work is aimed at evaluating some aspect of limnology; physico-chemical parameters with a view of assessing the water quality of Yardantsii Reservoir Gusau.

MATERIALS AND METHODS

Study Area

The reservoir is located in Gusau Local Government Area of Zamfara State, (Figure 1), Northwestern Nigeria, located between latitude $12^\circ 10' 12.86''$ - $12^\circ 17' 02.40''$ N and longitude $6^\circ 39' 50.83''$ - $6^\circ 66' 41.20''$ E, and occupies an area of $3,364\text{km}^2$ ($1,298.8\text{sqmi}$). Gusau Local Government had a population of 383,162 people (NPC, 2006). The hottest months in the area are March and April that is just before the onset of the first rains.

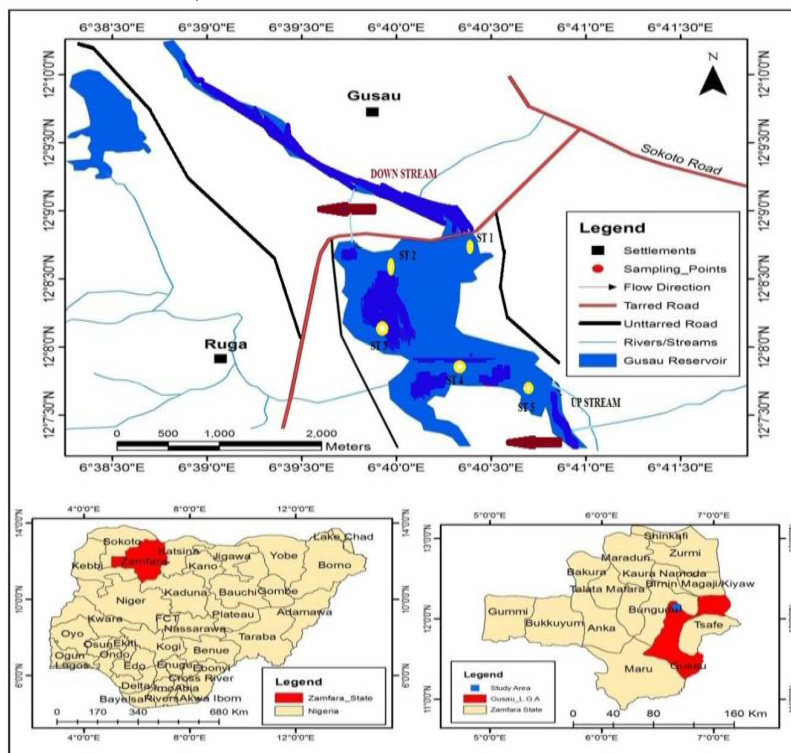


Figure 1: Map of the Study Area Showing Yardantsi Reservoir

The onset of the rains tends to bring a cooling effect with temperatures dropping below 36°C. The peak of the rainy season is from July to September except towards the end of October/November when the tropical continental air masses from the Sahara predominate which leads to lower temperatures of around 17°C–20°C. The mean annual rainfall in the area is 990mm (Mamman *et al.*, 2000).

Collection of Surface Water Samples

The reservoir was divided into five stations, with a distance of 500m between the stations. Surface water samples were collected in one litre capacity plastic bottles, from the sampling stations, for the period of twenty four months, to cover four seasons from May 2015 to April 2017. The samples were filtered in the field through a 0.45µm membrane filter and preserved at 4°C. Each sample collected was taken to the Hydrobiology laboratory of Biology Department Ahmadu Bello University, for determination of physico-chemical parameters. Five water samples were collected for each sampling month, representing one sample per station, for the duration of this research work.

Temperature, pH, electric conductivity and total dissolved solid were determined *in situ*, using portable HANNA Combo pH/EC/Temp metre model/HI 98129. The metre was calibrated and then the values were recorded as displayed on the meter.

Transparency was determined *in situ*, using Secchi-disc of 30cm diameter, by placing the disc vertically with measuring tape attached in the water; the measurement of the distance when the disk disappears from view was recorded as P₁; The disc was then pull out and the distance when the disk re-

appears was measured and recorded as P₂. The transparency was calculated by taking the average of these distances, using the following formula: Transparency = P₁ + P₂/2. Mean depth of each station was determined with string attached with heavy object and a measuring tape. In this method, the depth of each station was measured by dipping the string till it settle down; the measurement was then taken and recorded in metres.

Dissolved oxygen, biochemical oxygen demand, alkalinity, hardness, chloride were determined by titration methods, while phosphate-phosphorus, nitrate-nitrogen, sulphate were determined by colourimetry as described in APHA 2005.

Data Analysis

IBM SPSS Statistics software version 22 was used for the; Two-way analysis of variance (ANOVA) to analyze the physico-chemical parameters results for significant difference (p<0.05) between the means. Microsoft office excel, 2012 was used for the construction of graphs/charts.

RESULTS AND DISCUSSION

The results of this research showed a wide range of variation for all the physico-chemical parameters of Yardantsi Reservoir, Gusau. Fourteen (14) physico-chemical parameters viz; temperature, transparency, mean depth, pH, total dissolved solid, electrical conductivity, dissolved oxygen, biochemical oxygen demand, alkalinity, hardness, nitrate-nitrogen, phosphate-phosphorus, sulphate and chloride were monitored. The mean seasonal variation of the physico-chemical parameters for the period of these studies are presented in Table 1.

Variation of these parameters due to pollution (agricultural runoff viz; application of fertilizers, insecticide and herbicide), mixed farming, deforestation along with other climatic factors such as wind and rainfall and their effects on the reservoir were also considered (Tomasz, 2016). Pace *et al.*, (2012) and Lar (2013) reported that the activities in the catchment areas are the most prominent determinants of water quality in an aquatic system. The mean seasonal surface water temperatures were observed to be 26.62°C and 30.12°C for dry and rainy season respectively, the higher temperature rainy season may be due to an increasing photoperiod and longer day length (Mohan *et al.*, 2013), this agrees

with the findings of Hai *et al.*, (2013) in their studies on Lake Taihu, China. Analysis of variance (Table 2) shows that significant variation existed between seasons and months ($p < 0.05$). The seasonal variation revealed that dry season recorded the lowest; this could be in response to seasonal changes in air temperature resulting from the North-East trade winds (Harmattan) which is typical of the season. This agrees with the findings of Shanur *et al.*, (2015), Magami *et al.*, (2014), Zelalem (2013), Adakole (1995), Balarabe (1989) in their studies on river Dakatia, Bangladesh, Shagari Reservoir, Lake Adale, Ethiopia, River Kubbbani and Makwaye lake Zaria respectively.

Table 1: Mean (±SD) Annual and Seasonal Variation of different Surface Water Parameters of Yardantsi Reservoir, Gusau

Metals	Years		P-value	Seasons		P-value	NSDWQ	WHO
	Year 1	Year 2		Dry Season	Rainy Season			
Temperature (°C)	28.38±0.35	28.21±0.35	0.332	26.62±0.34	30.12±0.17	0.000		
Transparency (cm)	35.05±0.20	36.07±2.06	0.382	48.82±1.08	22.07±0.87	0.000		
Depth (m)	2.25±0.04	2.49±0.06	0.000	2.12±0.05	2.65±0.04	0.000		
PH	7.97±1.03	7.61±0.15	0.082	7.61±0.15	7.96±0.13	0.091	6.5-8.5	
TDS (mg/L)	69.14±3.91	90.54±2.80	0.000	96.00±1.95	63.70±3.68	0.000	500	
EC (µs/cm)	126.46±6.64	166.36±6.34	0.000	186.32±3.84	108.05±5.43	0.000	1000	
DO (mg/L)	7.29±0.12	7.45±0.11	0.150	7.80±0.11	6.91±0.10	0.000		
BOD (mg/L)	2.57±0.08	2.62±0.07	0.443	2.71±0.09	2.48±0.05	0.017		
Alkalinity (mg/L)	34.23±1.00	34.48±1.07	0.714	40.57±0.69	27.87±0.51	0.000		
Hardness (mg/L)	45.48±1.98	46.32±2.09	0.301	59.20±1.01	32.18±0.94	0.000	150	
NO ₃ -N	3.40±0.15	3.31±0.17	0.224	2.28±0.08	4.44±0.07	0.000	50	50
PO ₄ -P	148.66±3.69	148.72±4.26	0.974	123.72±1.44	173.48±2.78	0.000		
Sulphate	51.07±3.06	51.86±3.20	0.449	31.62±1.45	71.80±1.82	0.000	100	
Chloride	55.03±2.71	57.43±2.79	0.032	74.08±1.67	37.64±0.96	0.000	250	

The relatively circum neutral nature of the water pH between seasons and the slight fluctuation to alkaline conditions could be regarded as normal, since the mean seasonal values 7.61 and 7.96 for dry and rainy season respectively, obtained in this studies support aquatic life, including fishes and is desirable ranges for fish production as reported by (Mohan *et al.*, 2013 and Adakole, 1995). The values obtained were within the maximum permissible limits (MPL) set by Nigerian standard for drinking water quality (NSDWQ, 2007) and in relation to this the water is considered safe for human consumption and biota. Analysis of variance

(Table 2) shows no significant variation existed between years, seasons, months and stations ($p > 0.05$).

The observed variations in pH among seasons may be due to non-point source inflow of waste water from residential areas, markets, surface run off from agricultural area; geology of the stream bedrock; as well as the hydrobiology of the catchment (Hassan, 2014; Fan and Shibata, 2015; Gara and Staphanian, 2015).

Table 2: ANOVA for different Surface Water Parameters of Yardantsi Reservoir, Gusau

Parameters	Year	Season	Month	Station	Year by Month	Year by Station	Month by Station	Year by Month by Station
Temperature	NS	*	*	NS	NS	NS	NS	NS
Transparency	.	.	.	.	.	.	.	.
Mean Depth	NS	*	NS	NS	NS	NS	NS	NS
PH	NS	NS	NS	NS	NS	NS	NS	NS
TDS	*	**	*	NS	NS	NS	NS	NS
EC	**	*	*	NS	NS	NS	NS	NS
DO	NS	*	NS	NS	NS	NS	NS	NS
BOD	NS	NS	NS	NS	NS	NS	NS	NS
Alkalinity	.	.	.	.	.	.	.	.
Hardness	NS	NS	*	NS	NS	NS	NS	NS
NO ₃ -N	.	.	.	.	.	.	.	.
P-PO ₄	NS	*	*	NS	NS	NS	NS	NS
Sulphate	NS	**	*	NS	NS	NS	NS	NS
Chloride	NS	*	NS	NS	NS	NS	NS	NS

** = Highly significant (p<0.01); * = Significant (p< 0.05); NS = Not significant (p >0.05); TDS=Total Dissolved Solid; EC= Electrical Conductivity; DO= Dissolved Oxygen; BOD= Biological Oxygen Demand

Transparency was observed to be significantly higher in dry season than the rainy season with mean seasonal values 48.82cm and 22.07cm for dry and rainy season respectively, (Table 1). The lower transparency observed during rainy season could be attributed by soil erosion, surface runoff and siltation from the catchment as well as the timely discharge of the water to control the reservoir capacity during rainy season thereby mixing the surface water with bottom water and the sediment. Similar findings were reported by Magami *et al.*, (2014), Adakole (1991) and Balarabe (1989) in their studies on Shagari Reservoir, River Kubanni and Makwaye lake Zaria respectively. Analysis of variance (Table 2) shows no significant variation existed between years, seasons, months and stations (p>0.05).

Electrical conductivity and total dissolved solid were found to be significantly lower in the rainy season (Table 1); this may be due to dilution of the water as the volume increases and continues discharge of the water to maintain a certain capacity/volume of the reservoir in prevention of flood, as the reservoir is gated. This agrees with the findings of Magami *et al.*, (2014), Devangee *et al.*, (2013), Adakole (1995) and Balarabe (1989) in their studies on Shagari Reservoir, Kankariya, Vastrapur, Malav, and Chandola Lake India, River Kubanni and Makwaye lake Zaria respectively. The values obtained were within the MPL sets by NSDWQ (2007) and in relation to electrical conductivity and total dissolved solid the water is considered safe for human consumption.

Analysis of variance for total dissolved solid (Table 2) shows that significant variation existed between years and months (p<0.05), and a highly significant variation existed between seasons (p<0.01), but no significant variation existed between stations (p>0.05). While electrical conductivity (Table 2) shows that a highly significant variation existed between years (p<0.01), and a significant variation existed between seasons and months (p<0.05), but no significant variation existed between stations (p>0.05).

The dissolved oxygen concentrations were observed to have mean seasonal values of 7.80mg/L and

6.91mg/L for dry and rainy season respectively, it is significantly higher in dry season, this could be in response to seasonal changes in air temperature resulting from the harmattan and agree with the findings of Devangee *et al.*, (2013) in their studies on Kankariya, Vastrapur, Malav, and Chandola Lake India. Also APHA (2005) explained that dissolved oxygen concentration of above 5 mg/L is suitable for the support of diverse biota. The highest dissolved oxygen concentrations were recorded in January which coincided with minimum surface water temperature due to seasonal changes in air temperature resulting from the North-East trade winds (Harmattan) which is typical of the season. These findings are in agreement with the Magami *et al.*, (2014), Adakole (1995) and Balarabe (1989). Analysis of variance (Table 2) shows that no significant variation existed between years, months and stations (p>0.05) but a significant variation existed between seasons (p<0.05).

Biological oxygen demand concentration was observed to be higher in dry season (Table 1), which could be due to draw down in water level. The variations between seasons were not significant; this could be due to inflow of organic pollutants along with surface runoff. This agrees with the findings of Tanimu (2015) and Hassan *et al.*, (2014) in their studies on Tudun Wada-Makera Drain and River Kaduna and Hussainiya River, Holy Karbala-Iraq respectively.

Surface water hardness and alkalinity was observed to be higher in dry season (Table 1), this could be attributed to increase in concentration of salts due to draw down in water level and action of wind which enhances the resuspension of sediment calcium and magnesium ions. The rainy season hardness could be attributed to components of artificial fertilizer of alkaline earth metals origin in the form of (NPK, NH₃, (NO₃)₂ etc) and or pesticide and herbicides from the catchment area runoff. Analysis of variance (Table 2) shows that no significant variation existed between years, seasons and stations (p>0.05) but significant variation existed between months (p<0.05).

The surface water nitrate-nitrogen, phosphate-phosphorus and sulphate recorded the higher concentration in the rainy season (Table 1), which could be attributed to surface runoff from the catchment areas exposed to fertilizer applications as reported by Balarabe (1989) and Tanimu, (2015) in their studies on Makwaye lake and Tudun Wada-Makera Drain and River Kaduna respectively. Auro and Cochlan, (2012) reported that phosphorus can be introduced in to the environment in the form of phosphoric acid, phosphate fertilizers, phospholipids in dead tissues while nitrogen can be introduced in to the environment in the form of urea and nitrate fertilizers, urine and other forms. The values obtained were within the MPL sets by NSDWQ and in relation to this the water is considered safe for human consumption.

Analysis of variance for phosphate-phosphorus (Table 2) shows that no significant variation existed between years, and stations ($p > 0.05$), but significant variation existed between seasons and months ($p < 0.05$). The sulphate ANOVA (Table 2) shows that no significant variation existed between years, and stations ($p > 0.05$), but significant variation existed between seasons ($p < 0.05$), and highly significant variation existed between months ($p < 0.01$). The ANOVA for chloride (Table 2) shows that no significant variation existed between years, months and stations ($p > 0.05$), but significant variation existed between seasons ($p < 0.05$).

Chloride concentration in surface water was found to be higher in dry season than the rainy season (Table 1) for both years. This agrees with the findings of Gadzama *et al.*, (2011). The higher concentration of

chloride in rainy season is important for the metabolic activities in the biota. The values obtained were within the MPL sets by NSDWQ and in relation to this the water is considered safe for human consumption.

CONCLUSION

The results revealed that a highly significant seasonal variation ($p < 0.01$) was exhibited in all parameters with the exception of pH which shows no significant seasonal variation ($p > 0.05$) and Biological oxygen demand, which shows a significant seasonal variation ($p < 0.05$). Also it indicated that the parameters observed falls within the recommended range set by World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ), therefore the water is of good quality for human consumption and to support aquatic life such as fishes.

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CONTRIBUTION OF AUTHORS

This study provided baseline information on the physico-chemical parameters of the reservoir and it indicated that the water is good for human and animal consumption.

CONFLICT OF INTEREST

This study is in line with the previous studies conducted using inland aquatic ecosystems within and outside Nigeria.

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