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Effects of Anthropogenic Activities on the Seasonal Variation of Some Physico-Chemical Parameters in Ajiwa Reservoir, Katsina State, Nigeria

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ABSTRACT

Studies on the effects of anthropogenic activities on the seasonal variation of Some Physico-Chemical Parameters in Ajiwa Reservoir, Katsina State, Nigeria was carried out from September, 2014 to August, 2015. Nineteen (19) physicochemical parameters were analysed at five different sampling locations in the reservoir. The physicochemical parameter was determined using standard methods, procedures, and instruments. Mean value of some of the physicochemical parameters in the reservoir that are beyond permissible limit include; Turbidity (98.0 ± 2.28 NTU), Total Hardness (87.16 ± 2.37 mg/l), Calcium (40.34 ± 1.35 mg/l), Nitrate-Nitrogen (1.07 ± 0.08 mg/l), Chloride (52.26 ± 1.65 mg/l), Magnesium (2.21 ± 0.14 mg/l) and Iron (0.50 ± 0.02 mg/l). The fluctuation of the physicochemical parameters of the reservoir could be attributed to farming activities, cattle rearing and bathing within the vicinity of the reservoir. Monitoring of human activities within the immediate catchment area of the reservoir and education on wise use of the water is recommended.

Keywords: Physico-Chemical, Seasonal, Water Quality, Irrigation farming, Reservoir, Stations

INTRODUCTION

Limnology is the study of physical and chemical factors occurring in inland water bodies. Nigeria is blessed with about 15 million hectare of inland water mass capable of producing over 1.5 million metric tons of fish annually [1]. Water is a primary natural resource and its availability has played a vital role in the evolution of human settlements. Humans depend mainly on freshwater available in inland lakes and rivers, which constitute less than 50% of the total amount of the water in biosphere [2]. As a result, there has been a growing necessity for conservation of water as a result of growing populations and increase in pollution of surface waters. Inland water bodies depend on the amount of annual rainfall, size, seepage, climate and geographical location. Most water bodies in the savannah region of Nigeria are seasonal. The quality of a given water body is controlled by its physical, chemical and biological factors, all of which interact with one another to influence the quality of water [3].

Availability of safe and reliable water is an essential prerequisite for sustained development [4]. It is important to constantly protect and control the quality of water [5,6]. Over-growing population has resulted to the impoundment of many dams and reservoirs. It is therefore necessary to maintain our reservoirs by addressing the consequences of present and future threats of contamination and degradation of our water bodies. The freshwater ecosystem is categorized into lotic (river, stream/springs) which could be perennial or seasonal and lentic, that is standing waters (ponds, lakes and swamps) which could be perennial or temporary depending upon the geological basin [7]. As population continue to increase, industrialization and intensification of agriculture had led to increase pollution of surface waters. This induces ecological imbalances, deleterious for sustained development of fisheries resources which has necessitate the suspension of the beneficial uses of these water bodies in some placed.

The impoundment of river and subsequent creation of Ajiwa reservoir has assisted to provide water for drinking, irrigation and fish farming in Katsina State. However, human activities in these catchments may have cause pollution resulting from deforestation, farming activities, grazing and bush burning which enhances accelerated silting, addition of large quantities of nutrients chemicals, herbicides and organic matter in water bodies through surface run-offs [3]. Ezealor et al., noted that extensive human activities through agricultural practices, fertilizer application and overgrazing around the catchment areas of aquatic habitats results in marked fluctuations in the physicochemical parameters of lentic ecosystems [8].

MATERIALS AND METHODS

Study area

Ajiwa reservoir is located at Batagarawa L. G. A of Katsina state on latitude between 12°56'N and longitude 7°45'E (Figure 1). It is in the Sudan savannah zone of Nigeria with two distinct seasons (wet and dry). The rainy season period on the average last from May to October and dry season from November to April. The main purpose of the reservoir is irrigation and water supply to the people of Katsina, Batagarawa, Mashi, and Mani local government areas. The reservoir was impounded in 1973 and commissioned in 1975. Its major source is river Tagwai. It has original height of 12 m but after being rehabilitated in 1998 the height is now 14.7 m, original reservoir crest length was 880 m, but after being rehabilitated reservoir crest length is now 1491.8 m. It also has surface area of 607.0 ha. The storage capacity of the water is about 22,730,000 m^3 [9] The reservoir serves as source of livelihood to the nearby communities such as Ajiwa, Masabo, Tsagero, Kwatami, Maje and Gajeren giwa towns.

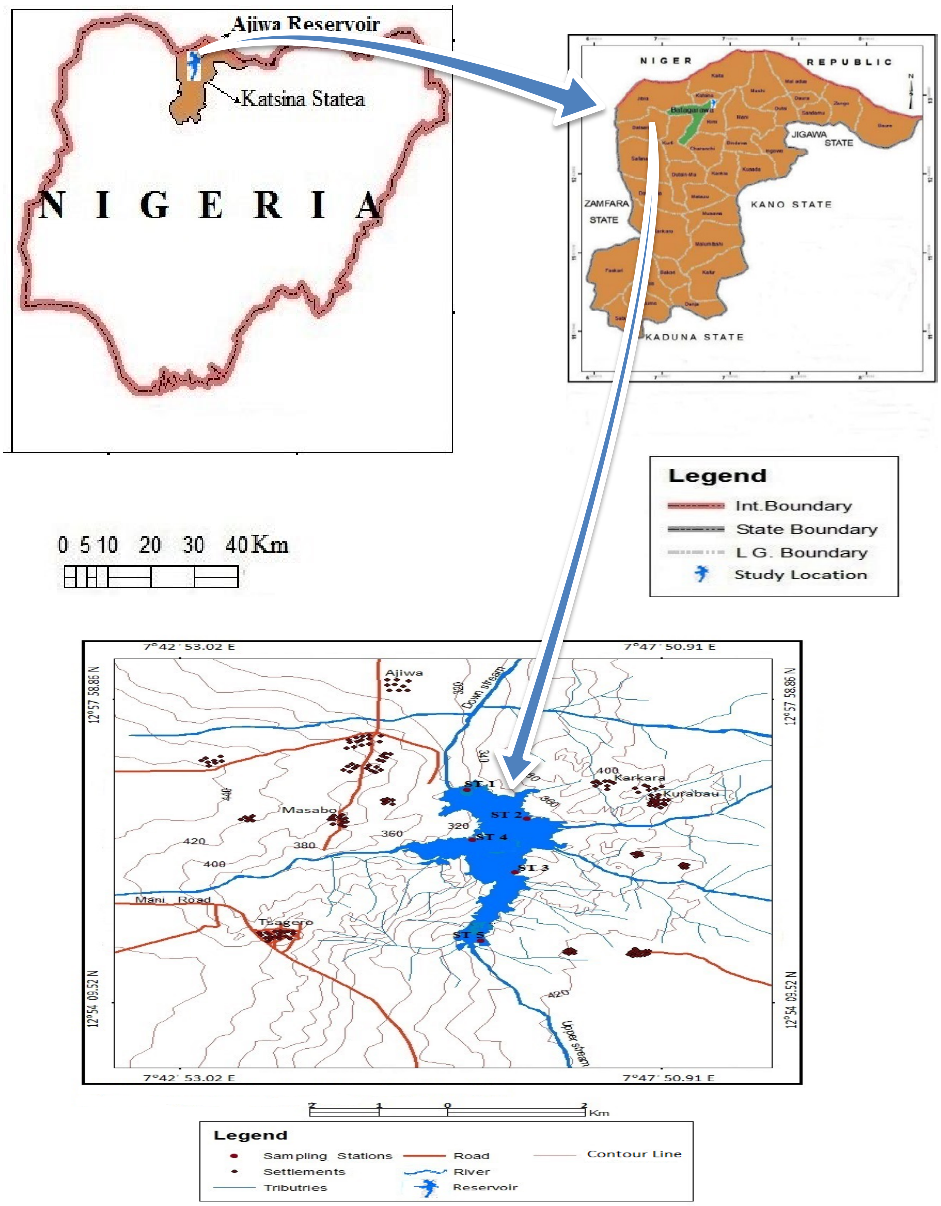

Figure 1: Map of Nigeria (top left), Katsina state (top right) indicating Batagarawa L.G.A, Ajiwa reservoir showing sampled stations (bottom)

Sampling procedures

Sampling of physicochemical was carried out monthly from each sampling stations, from September 2014 to August 2015 (12 months). Water was sample at the surface level by dipping 1 litre plastic sampling bottle sliding over the surface of the water with their mouth against the water current to permit undisturbed passage of the water into the bottle. The water samples were transported to the laboratory for physico-chemical parameters analysis.

RESULTS AND DISSCUSSION

Water temperature of Ajiwa reservoir fluctuated within months in all the five sampling station. The low water temperature recorded in the reservoir was in the dry season (Table 1), this could be attributed to seasonal changes in air temperatures associated with the cool dry North-East winds. This observation was supported by the findings of [10], which attributed variations in water temperature in the dry season to the effect of harmattan. High water temperature stress aquatic ecosystem by reducing the ability of water to hold essential dissolved gases like oxygen which cause fish and other invertebrate mortality [11]. Ajiwa reservoir showed high water temperature during the wet season.

Table 1: Mean monthly variation of physical parameters in Ajiwa reservoir katsina, Nigeria.Note: means along the same column with the same alphabet are not significantly different. **Highly significant at $p<0.01$

Months	Watertemperature (°C)	Waterdepth (m)	Transparency (cm)	Turbidity (NTU)	Totaldissolvedsolids (mg/l)	Totalsuspendedsolids (mg/l)	Totalsolids (mg/l)
September	24.00 ± 0.35^{de}	6.04 ± 0.48^{a}	45.80 ± 3.43^{a}	113.20 ± 2.50^{b}	46.12 ± 1.60^{g}	31.85 ± 1.74^{a}	77.97 ± 3.23^{fg}
October	23.58 ± 0.28^{de}	4.48 ± 0.71^{abc}	37.80 ± 2.44^{bc}	119.20 ± 4.78^{b}	51.95 ± 1.43^{g}	28.77 ± 0.99^{b}	79.06 ± 2.62^{efg}
November	23.70 ± 0.30^{de}	4.28 ± 0.70^{bcd}	33.20 ± 1.69^{cde}	101.80 ± 3.12^{c}	60.86 ± 1.93^{ef}	25.76 ± 1.21^{c}	77.96 ± 1.73^{efg}
December	20.00 ± 0.65^{f}	3.88 ± 0.65^{cd}	34.40 ± 1.63^{cd}	97.60 ± 2.94^{cd}	65.93 ± 1.67^{de}	29.20 ± 0.70^{cd}	85.14 ± 2.35^{def}
January	18.30 ± 0.25^{g}	3.54 ± 0.66^{cde}	31.80 ± 1.53^{cde}	90.80 ± 2.52^{de}	71.62 ± 2.11^{cd}	23.31 ± 0.56^{de}	86.93 ± 2.65^{def}
February	23.20 ± 0.12^{e}	3.10 ± 0.66^{cde}	28.60 ± 0.93^{de}	87.00 ± 2.05^{ef}	79.28 ± 3.63^{c}	20.62 ± 0.64^{ef}	94.90 ± 4.25^{cd}
March	24.30 ± 0.20^{de}	2.70 ± 0.63^{def}	27.00 ± 1.30^{ef}	83.60 ± 2.86^{efg}	97.33 ± 2.96^{b}	22.65 ± 0.48^{fg}	119.98 ± 3.07^{ab}
April	25.00 ± 0.27^{d}	1.96 ± 0.45^{ef}	22.40 ± 1.81^{fg}	79.40 ± 2.94^{fg}	106.55 ± 3.90	19.71 ± 0.53^{g}	125.26 ± 4.32^{a}
May	26.20 ± 0.25^{c}	1.34 ± 0.27^{f}	21.00 ± 1.52^{g}	74.40 ± 1.89^{g}	94.84 ± 5.39^{b}	17.03 ± 0.48^{g}	111.87 ± 5.85^{bc}
June	27.00 ± 0.35a	2.06 ± 0.37^{cd}	27.20 ± 1.39^{ef}	90.00 ± 2.70^{de}	76.78 ± 3.21^{c}	18.93 ± 0.84^{fg}	94.71 ± 3.88^{de}
July	27.50 ± 0.22^{a}	3.76 ± 0.30^{abc}	37.20 ± 1.59^{bc}	114.40 ± 4.25^{b}	52.78 ± 2.53^{fg}	23.93 ± 1.07^{c}	92.26 ± 3.13^{g}
August	26.80 ± 0.25^{ab}	4.90 ± 0.28^{ab}	41.60 ± 3.04^{ab}	128.20 ± 3.17^{a}	44.08 ± 1.45^{g}	25.35 ± 1.86^{b}	69.42 ± 3.27^{g}
Total	24.05 ± 0.38	3.84 ± 0.23	32.33 ± 1.07	98.30 ± 2.28	70.68 ± 2.71	17.01 ± 0.93	87.37 ± 2.07
P value	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}

The mean water depth of Ajiwa reservoir for the wet and dry seasons during study period was 4.43 ± 0.33 m and 0.98 b $\pm$ 0.27 m respectively. The decrease in water depth especially during the dry season was probably caused by high evapo-transpiration and cessation of rainfall. Ibrahim et al. made similar observation of water depth fluctuation with season in Kwantagora reservoir [12]. The depth of the reservoir decreases light intensity [13]. Light penetration depends on the available intensity of the incident light, which varies with geographical location of a reservoir [3]. The negative correlation between water depth and water temperature, dissolve oxygen, and biochemical oxygen demand indicates that low levels of dissolved oxygen was available for the biota. Adakole et al. reported aquatic animals being stress due to low oxygen levels [4]. The mean secchi disc transparency during the dry season was low and this could be attributed to the absence of floodwater and surface run-offs. Lower Secchi visibilities recorded between June and September could be attributed to increase flooding which washed earth materials in to the water body. This agreed with the findings of [6] who observed that onset of rain decreased the Secchi disc visibility in two mine lakes around Jos, Nigeria.

The high dry season electrical conductivity value may be due to the higher rate of evaporation that reduces the water level and increase in nutrients due to run off from inorganic fertilizer from irrigation farm lands. Decrease in conductivity values during the rainy season might be due to increase in rainwater which cause dilution of the dissolved solids in the reservoir. This was similar to the observation of Gadzama and Mondo [14]. Increases in total dissolved organic matter results in increase in electrical conductivity [3].

Turbidity of water is affected by the amount of the suspended solids in it, hence restricts the light penetration and indirectly affects the phytoplankton growth [4]. High turbidity observed in Ajiwa reservoir during the rainy season could be due to increase in surface run-off, which cause re-suspension of dissolved materials. Lowest turbidity observed during the dry season could be as a result of prevailing condition of less-surface run-off.

Ajiwa reservoir has higher value of TDS during the dry season than wet season; 86.26 ± 3.24 mg/l and 51.09 ± 3.61 mg/l respectively. This could be due to decaying of vegetation and higher rate of evaporation. Similar observation was made [14]. The total dissolved solids negative correlation with dissolved oxygen and biochemical oxygen demand may be due to inflow of substance during the rainy season and settling effect of the substance in dry season. This agrees with the findings of Araoye [15].

A pH range of 6.0 to 9.0 appears to provide protection for the life of fresh water fish and bottom dwelling invertebrates. pH of Ajiwa reservoir was within 6.22 ± 0.04 to 8.36 ± 0.20 (Table 2), throughout the study period making the water of the reservoir to be circum-neutral. This was similar with the results of Ibrahim et al. which reported that pH was nearly neutral throughout both seasons in Kontagora reservoir [12]. The (7.34 ± 0.12) of pH during the dry season may be due to decomposition of living organisms in the water coupled with the reduction in the water level during the dry season. The little decrease in (6.67 ± 0.08) pH during the rainy season was probably due to the stirring effect of the incoming flood from the rivers that converged towards the lake resulting in the mixing of the poorly alkaline or acidic bottom water with alkaline surface water to reduce pH in the reservoir.

Table 2: Mean monthly variation of chemical parameters in Ajiwa reservoir katsina, Nigeria.Note: means along the same column with the same alphabet are not significantly different. **Highly significant at $p<0.01$

Months	Watertemperature (°C)	Waterdepth (m)	Transparency (cm)	Turbidity (NTU)	Totaldissolvedsolids (mg/l)	Totalsuspendedsolids (mg/l)	Totalsolids (mg/l)
September	24.00 ± 0.35^{de}	6.04 ± 0.48^{a}	45.80 ± 3.43^{a}	113.20 ± 2.50^{b}	46.12 ± 1.60^{g}	31.85 ± 1.74^{a}	77.97 ± 3.23^{fg}
October	23.58 ± 0.28^{de}	4.48 ± 0.71^{abc}	37.80 ± 2.44^{bc}	119.20 ± 4.78^{b}	51.95 ± 1.43^{g}	28.77 ± 0.99^{b}	79.06 ± 2.62^{efg}
November	23.70 ± 0.30^{de}	4.28 ± 0.70^{bcd}	33.20 ± 1.69^{cde}	101.80 ± 3.12^{c}	60.86 ± 1.93^{ef}	25.76 ± 1.21^{c}	77.96 ± 1.73^{efg}
December	20.00 ± 0.65^{f}	3.88 ± 0.65^{cd}	34.40 ± 1.63^{cd}	97.60 ± 2.94^{cd}	65.93 ± 1.67^{de}	29.20 ± 0.70^{cd}	85.14 ± 2.35^{def}
January	18.30 ± 0.25^{g}	3.54 ± 0.66^{cde}	31.80 ± 1.53^{cde}	90.80 ± 2.52^{de}	71.62 ± 2.11^{cd}	23.31 ± 0.56^{de}	86.93 ± 2.65^{def}
February	23.20 ± 0.12^{e}	3.10 ± 0.66^{cde}	28.60 ± 0.93^{de}	87.00 ± 2.05^{ef}	79.28 ± 3.63^{c}	20.62 ± 0.64^{ef}	94.90 ± 4.25^{cd}
March	24.30 ± 0.20^{de}	2.70 ± 0.63^{def}	27.00 ± 1.30^{ef}	83.60 ± 2.86^{efg}	97.33 ± 2.96^{b}	22.65 ± 0.48^{fg}	119.98 ± 3.07^{ab}
April	25.00 ± 0.27^{d}	1.96 ± 0.45^{ef}	22.40 ± 1.81^{fg}	79.40 ± 2.94^{fg}	106.55 ± 3.90	19.71 ± 0.53^{g}	125.26 ± 4.32^{a}
May	26.20 ± 0.25^{c}	1.34 ± 0.27^{f}	21.00 ± 1.52^{g}	74.40 ± 1.89^{g}	94.84 ± 5.39^{b}	17.03 ± 0.48^{g}	111.87 ± 5.85^{bc}
June	$27.00 \pm 0.35a$	2.06 ± 0.37^{cd}	27.20 ± 1.39^{ef}	90.00 ± 2.70^{de}	76.78 ± 3.21^{c}	18.93 ± 0.84^{fg}	94.71 ± 3.88^{de}
July	27.50 ± 0.22^{a}	3.76 ± 0.30^{abc}	37.20 ± 1.59^{bc}	114.40 ± 4.25^{b}	52.78 ± 2.53^{fg}	23.93 ± 1.07^{c}	92.26 ± 3.13^{g}
August	26.80 ± 0.25^{ab}	4.90 ± 0.28^{ab}	41.60 ± 3.04^{ab}	128.20 ± 3.17^{a}	44.08 ± 1.45^{g}	25.35 ± 1.86^{b}	69.42 ± 3.27^{g}
Total	24.05 ± 0.38	3.84 ± 0.23	32.33 ± 1.07	98.30 ± 2.28	70.68 ± 2.71	17.01 ± 0.93	87.37 ± 2.07
P value	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}	0.000^{**}

Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement) and as a waste product of photosynthesis [11]. The values for dissolved oxygen concentration of Ajiwa reservoir in all the five sampling stations fall within the mean range of 2.88 ± 0.07 mg/l to 6.19 ± 0.08 mg/l (Table 2). There was significant difference between the seasons. Rainy season showed higher concentration than the dry season (6.19 ± 0.08 mg/l and 2.88 ± 0.07 mg/l) respectively. Lowest concentration during dry season could be attributed to the peak time of biochemical oxygen demand due to bacteria and other decomposers uptake. The higher the temperature the lower the dissolved oxygen and the lower the temperature the higher dissolved oxygen [16].

Biochemical Oxygen Demand (BOD) was higher in the dry season than the rainy season (2.28 ± 0.06 mg/1 and 0.85 ± 0.06) respectively (Table 2). This coincided with the period of oxygen consumption by decomposers on the biodegradable materials as revealed by negative correlation with oxygen [3]. The negative correlation with pH may be due to inflow of substance during the rainy season from the farm lands near the reservoir and evaporations in the dry season.

Ajiwa reservoir was moderately soft during the rainy season (75.82 ± 1.17 mg/l $CaCO_3$) and slightly hard (114.76 ± 4.70 mg/l $CaCO_3$) in the dry season. The moderately soft water during the rainy season could be attributed to the leaching of artificial fertilizer in to the reservoir. Similar observation was made by Balarabe [17]. The result also indicated that the reservoir was slightly hard during dry season (114.76 ± 4.70 mg/l $CaCO_3$) this could be due to increase in the concentration of metals from chemical fertilizer as a result of draw-down in water level and re-suspension of sediments like Ca++ and mg++ ions as a result of wind action.

Nitrate-nitrogen level in Ajiwa reservoir ranged 0.51 ± 0.02 mg/l to 2.31 ± 0.10 mg/l throughout the study period (Table 3). The mean value recorded in rainy season was higher than that in dry season; this may be due to excessive influx of nutrients from farmlands where fertilizer is used to boost crop production particularly around the reservoir.

Table 3: Mean monthly variation of chemical parameters in Ajiwa reservoir katsina, Nigeria. Note: means along the same column with the same alphabet are not significantly different. **Highly significant at p<0.01

Months	Calcium	Chloride(mg/l)	TotalAlkalinity(mgCaCO$_3$/l)	Magnesium(mg/l)	Iron(mg/l)
September	27.18 ± 1.97^{g}	38.78 ± 2.77^{gh}	40.74 ± 2.41^{de}	0.95 ± 0.06^{e}	0.30 ± 0.02^{e}
October	30.66 ± 2.05^{fg}	47.32 ± 3.28^{defg}	49.22 ± 2.97^{bcd}	1.46 ± 0.09^{de}	0.36 ± 0.02^{e}
November	34.34 ± 1.54^{ef}	50.74 ± 3.31^{def}	47.08 ± 3.57^{cd}	1.89 ± 0.13^{cd}	0.45 ± 0.03^{d}
December	37.94 ± 1.44^{de}	46.50 ± 2.03^{efg}	47.06 ± 2.59^{cd}	2.54 ± 0.24^{bc}	0.59 ± 0.02^{bc}
January	41.22 ± 2.14^{cd}	51.22 ± 3.12^{def}	51.02 ± 2.20^{abc}	2.39 ± 0.12^{c}	0.53 ± 0.02^{c}
February	45.10 ± 2.06^{bc}	55.50 ± 2.24^{cd}	56.42 ± 1.76^{ab}	3.15 ± 0.03^{ab}	0.64 ± 0.02^{b}
March	48.00 ± 2.01^{b}	60.58 ± 2.82^{bc}	50.64 ± 4.60^{abc}	3.17 ± 0.21^{ab}	0.72 ± 0.03^{a}
April	58.66 ± 3.35^{a}	78.36 ± 3.41^{a}	58.90 ± 3.19^{a}	3.24 ± 0.72^{ab}	0.78 ± 0.03^{a}
May	54.10 ± 3.00^{a}	66.10 ± 3.15^{b}	49.52 ± 2.53^{bcd}	3.69 ± 0.16^{a}	0.58 ± 0.03^{bc}
June	42.92 ± 2.22^{bcd}	53.04 ± 3.03^{cde}	44.66 ± 2.76^{cd}	1.90 ± 0.15^{cd}	0.38 ± 0.02^{e}
July	33.20 ± 1.42^{efg}	42.94 ± 1.40^{fgh}	40.74 ± 1.46^{de}	1.24 ± 0.17^{de}	0.33 ± 0.02^{e}
August	30.76 ± 1.30^{fg}	36.02 ± 2.03^{h}	33.76 ± 1.97^{e}	0.86 ± 0.11^{e}	0.30 ± 0.02^{e}
Total	40.34 ± 1.35	52.26 ± 1.65	47.48 ± 1.13	2.21 ± 0.14	0.50 ± 0.02
P value	0.000**	0.000**	0.000**	0.000**	0.000**

Similar observation was made by Chia et al. [18]. Nitrate-nitrogen higher values in rainy season also coincide with high plankton composition and abundance in the reservoir during the rainy season. This supports the observation of Chigor et al. who observed that the peak nitrate seem to be related to input from agricultural lands. Low nitrate-nitrogen values indicate period of extreme dry season or early onset of rains and the period preceding the first upsurge of phytoplankton growth [19]. Hassan et al. observed that concentration of nitrate could be reduced by plankton and macrophytes uptake or denitrification in the sediments [20].

Phosphate-phosphorus values obtained in Ajiwa reservoir ranged between 0.67 ± 0.05 mg/l to 0.40 ± 0.03 mg/l throughout the study period (Table 3). Phosphate-phosphorus level was higher during wet season than that of dry season; this might be due to agricultural run-off from nearby farmlands. Relatively high dry season mean values of 0.40 ± 0.03 mg/l (Table 4) observed could be attributed to concentration effect, because of reduction in water volume and intensive agricultural activities around the reservoir involving the use of fertilizers and pesticides.

Table 4: Mean seasonal variation of physico-chemical parameters in Ajiwa reservoir katsina, Nigeria

Physicochemical Parameters	Wet Season	Dry Season	WHO Standard (2011)	USEPA Standard (2002)
Water Temperature (°C)	25.85 ± 0.30	20.25 ± 0.52	-	-
Water Depth (m)	4.43 ± 0.33	0.24 ± 0.27	-	-
Transparency (cm)	35.10 ± 1.80	29.57 ± 0.94	06	15
Turbidity (NTU)	106.57 ± 3.65	80.03 ± 1.77	06	0-5
Total Dissolved Solids (mg/l)	51.09 ± 3.61	86.26 ± 3.24	500	500
Total Suspended Solids (mg/l)	29.81 ± 1.56	14.21 ± 0.75	-	-
Total Solids (mg/l)	85.72 ± 2.59	103.03 ± 2.75	500	500
Ph	7.34 ± 0.12	6.67 ± 0.08	6.5	6.5-8.5
Electrical Conductivity (µS/cm)	147.55 ± 4.80	169.55 ± 2.48	-	-
Total Hardness (mg/l)	81.21 ± 2.65	93.10 ± 3.67	-	-
Dissolve Oxygen (DO)	4.50 ± 0.20	2.69 ± 0.12	-	-
Biochemical Oxygen Demand (BOD)	1.01 ± 0.08	1.74 ± 0.07	-	-
Calcium	31.47 ± 1.89	49.21 ± 1.67	75	65
Nitrate-Nitrogen ((NO3-N) (mg/l)	1.41 ± 0.11	0.73 ± 0.05	50	10
Phosphate-Phosphorus (PO4-P) (mg/l)	0.67 ± 0.05	0.40 ± 0.03	-	0.7
Chloride (mg/l)	47.37 ± 2.12	68.15 ± 2.21	200	250
Total Alkalinity (mgCaCO$_3$/l)	33.11 ± 1.35	51.85 ± 1.43	-	-
Magnesium (mg/l)	1.68 ± 0.18	2.73 ± 0.15	50	50
Iron (mg/l)	0.28 ± 0.15	0.72 ± 0.02	0.1	0.3

CONCLUSION

Water quality of Ajiwa reservoir is influenced by anthropogenic activities such as farming, bush burning, cattle rearing and bathing. The reservoir water is not suitable for direct consumption but for irrigational and other domestic purposes in terms of most of the physico-chemical parameters analysed. However, considering that the reservoir is a source of drinking water, the potential impact of the anthropogenic inputs should be minimized.

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