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Spatio-Temporal Variation of Physico-Chemical Parameters in Wasai Reservoir, Kano State

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ABSTRACT

The present study assessed the physico-chemical parameters variation in Wasai reservoir with the aim of providing current information on the water quality for agricultural and domestic usage. Water samples were collected from four different sampling stations and the physico-chemical parameters were analyzed using standard procedures. The data obtained were analyzed using analysis of variance with Duncan's New Multiple Range Test used to separate significant means at 5% level. Data were compared with recent reports by World Health Organization and FEPA permissible limits for aquatic water quality. The result obtained revealed no significant difference in water surface temperature (27.20 ^{o}C) and pH (8.49) for the period of ten months. However, significant difference ($P \leq 0.05$) in the EC ((151.33-252.00 µS/cm), Total Dissolved Solids (TDS) (162.67-242.00 mg/L) and BOD (2.25-8.57 mg/l) were found among the sampling locations with variation in months. The EC, TDS, DO and BOD values in all the locations were above their permissible limits (pH= 6.5-8.5; EC= 1000 µS/cm; 1000 mg/L).

Keywords: Pollution, Surface water, Water quality, Wasai Reservoir

INTRODUCTION

Water is a natural resource and fundamental need of all organisms, plants, animals and humans; it is also the most necessary solvent for agriculture, industry, tourism and aquaculture (Aydin, 2018). Water pollution is one of the most common environmental problems worldwide, as it poses a serious threat to the economic and social development of mankind (Soceanu *et al*., 2021). The characteristics and quality of water bodies are defined by specific physical, chemical and biological properties, and how these properties impact the survival, reproduction, growth and management of aquatic life (Aduwo and Adeniyi, 2019). Reservoirs in many countries all over the world, has become an important part of the drinking water supply process for industrialized areas, for agriculture, and not least for household use (Shakerkhatibi *et al*., 2019). Constant assessment of physical and chemical parameters in freshwater ecosystems is largely recommended. This is even more important when water resources such as reservoirs in most countries, serve as a source of water for domestic and commercial purposes, and /or when freshwater ecosystems represent a refuge for most aquatic organisms (Andong *et al*., 2019).

Ironically, despite the relative importance of reservoirs to human endeavor, most records these days indicate that water quality is

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increasingly deteriorating, and this is cause of a global concern (Mahananda *et al*., 2005). A previous study (Salla and Ghosh, 2014) emphasized that about 75% of surface water may be contaminated by different kinds of pollutants. Pollutants from industrial discharges (Mahananda *et al.,* 2005) or agricultural activities played a great vital role in imparting pollution of the water bodies. The investigation of water quality levels which comprises of physical and chemical properties of Wasai reservoir by a comparison with a set of standards (Dirican, 2015) may be beneficial for the Government to enact policies (Patil *et al*., 2012). This study therefore aimed at assessing the spatio-temporal variations of physico-chemical parameters of Wasai reservoir, Kano state.

MATERIALS AND METHODS

Study Area

The Wasai- Reservoir is situated on the Jakara River at a point about 2 km South– East of Wasai village in Minjibir Local Government Area of Kano State (Amin, 1992). It is situated on latitude 12^{o}N and 13^{o}N and longitude 8^{o}E and 9^{o}E. The reservoir was constructed in 1976 for recycling purposes. The dam has a maximum height of 9.33 m, while reservoir has a surface area of 1,250 hectares and a total storage capacity of 65.38 m3, this places the reservoir among the medium size man-made lakes in Kano state (Figure 1).

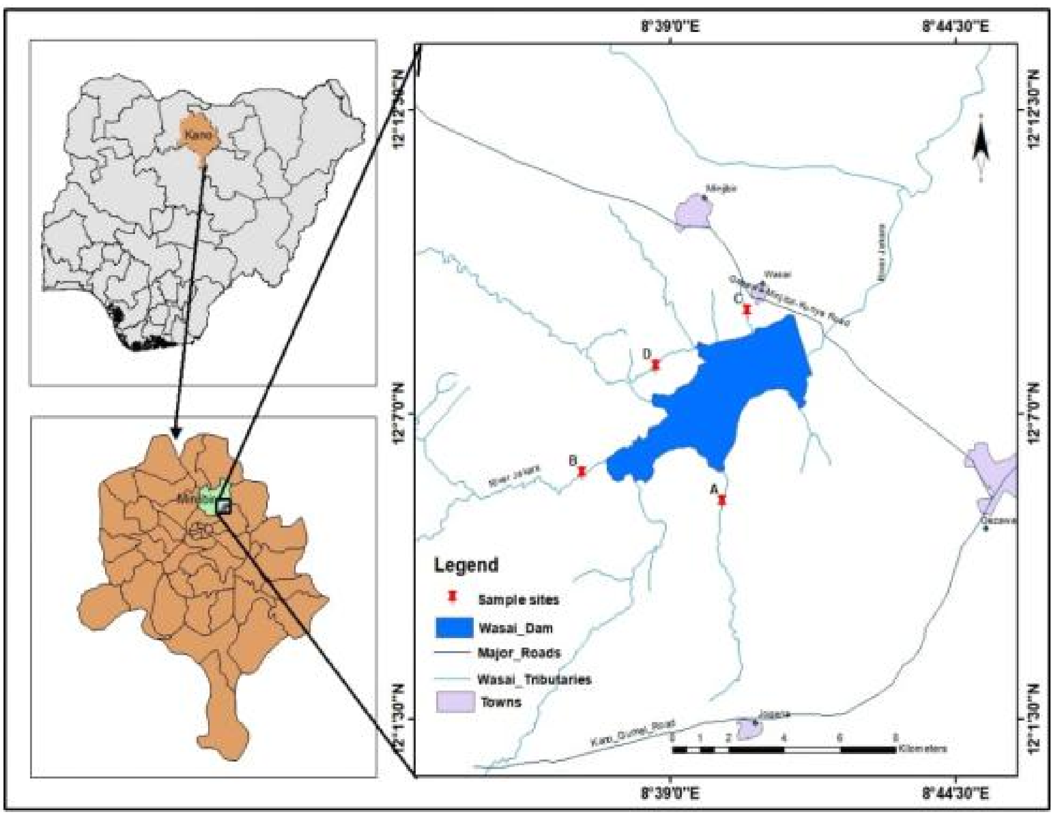

Figure 1: Map of study area showing the sampling Stations.

(Source: GIS Lab Department of Geography Using Arc GIS 10.3 Software)

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Sampling Station

Four sampling stations were identified and designated for the purpose of this study, namely 1, 2, 3, and 4 respectively. Transect sampling across the basin was carried out, starting from the two tributaries i.e. Jakara river, the confluence where the two rivers meet, the entry point where the water drains into the Wasai Reservoir, the spillway of the reservoir. Samplings were conducted from 06:00 am-07:00 am monthly. Water and sediment samples were collected from the reservoir during the period from September, 2018 to June, 2019.

Water Sampling

Samples were collected in 250 mL plastic bottle for chemicals parameters analysis. The samplings were carried out midstream by dipping the sample plastic bottle to approximately 20-30 cm below the water surface, projecting the mouth of the containers against the direction of flow direction. Some physico-chemical parameters of the water samples such as pH, temperature, Dissolved oxygen (DO), Biological Oxygen Demand (BOD), electrical conductivity (EC) were analyzed on the spot using HANNA instrument (Model: H193703) while Total Dissolved Solids (TDS) were analyzed in the Laboratory of the Department of Biological Science, Bayero University, Kano.

Data Analysis

Data obtained were analyzed using analysis of variance with Duncan's New Multiple range test used to separate significant means at 5% level.

RESULTS

The result for the analysis of mean temperature and pH variations for ten months across the sampling stations along Wasai reservoir, Kano state is presented in Table 1. The result indicated no significant difference ($P \geq 0.05$) in the water temperature across all the station in all the ten months. The result showed that, the highest mean temperature value (27.20 ^oC) was found in Station 1 in March, 2019 while the lowest mean temperature value (23.66 ^oC) was found in station 4 in January 2019. The trend in monthly variation in temperature showed that, the temperature values decrease from September 2018 to November 2018 across all the stations except in station 3 where the temperature increases in November. The temperature values continue to decrease from December 2018 up to March 2019; where the temperature values increased. The temperature then continued to decrease from March 2019 to June 2019 across all the stations.

The values of the water pH revealed that, the water is alkaline throughout the period of study. The highest mean pH value of 8.49 was found in March 2019 at station 1 with the lowest mean value recorded in March (7.19) in station 2. The trend in the monthly variation of pH showed that, the pH values increased from September to November in Station 1 and 4 but decreased n stations 2 and 3. The pH values in all the stations fluctuate with variations in monthly mean values.

The results for the mean values of Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) in four stations along Wasai reservoir for ten months are shown in Table 2. The results revealed significant difference ($P \leq 0.05$) in the values of DO and BOD in the four stations across the months. The result also indicated highest DO value of 4.60 mg/L at station 3 in February 2019. However, the least DO value of 2.10 mg/L was found in station in November 2018. A significant increase in DO values was observed from 2.57 mg/L in December 2018 to as high 4.60 mg/L in the month of February, 2019. The trend in the monthly variations in DO showed that, the values almost remain constant from September

2018 to April 2019 in station 1. However, the DO values increased from May to June 2019. Furthermore, in station 4, the values increased from September 2018 to March but decreased in April to June. However, station 2 and 3 showed variation in DO with months.

Table 1: Monthly Mean Variations of Temperature (ºC) and pH in Wasai Reservoir.

Parameter	Months	STATION 1 Mean ± S.D	STATION 2 Mean ± S.D	STATION 3 Mean ± S.D	STATION 4 Mean ± S.D
Temperature	SEPT	25.03 ± 0.95[a]	25.05 ± 1.95[a]	25.57 ± 1.43[a]	25.20 ± 0.91[a]
	OCT	24.70 ± 0.66[a]	23.90 ± 1.57[a]	24.46 ± 0.15[a]	24.97 ± 0.42[a]
	NOV	24.33 ± 0.15[a]	23.80 ± 1.08[a]	25.17 ± 0.85[a]	24.63 ± 0.66[a]
	DEC	25.33 ± 0.06[a]	23.86 ± 0.71[a]	24.67 ± 0.42[a]	25.03 ± 0.74[a]
	JAN	24.10 ± 0.45[a]	23.73 ± 0.65[a]	24.47 ± 0.47[a]	23.66 ± 046[c]
	FEB	24.60 ± 0.36[a]	24.20 ± 0.30[a]	24.80 ± 0.62[a]	24.53 ± 0.42[a]
	MAR	27.20 ± 2.21[a]	26.03 ± 1.50[a]	25.73 ± 1.42[a]	26.23 ± 2.01[a]
	APRIL	25.77 ± 1.36[a]	25.57 ± 1.45[a]	25.10 ± 0.85[a]	25.90 ± 1.93[a]
	MAY	25.27 ± 0.94[a]	25.97 ± 1.54[a]	25.63 ± 1.35[a]	25.03 ± 0.95[a]
	JUNE	25.07 ± 0.90[a]	24.57 ± 0.40[a]	25.10 ± 0.85[a]	25.53 ± 0.42[a]
pH	SEPT	7.35 ± 0.14[a]	7.24 ± 0.05[ab]	7.61 ± 0.03[b]	7.22 ± 0.05[a]
	OCT	7.62 ± 0.02[bc]	7.23 ± 0.01[ab]	7.23 ± 0.03[b]	8.14 ± 0.12[de]
	NOV	8.16 ± 0.14[d]	7.27 ± 0.02[b]	7.90 ± 0.01[c]	7.95 ± 0.02[d]
	DEC	7.75 ± 0.26[bc]	8.17 ± 0.05[e]	8.27 ± 0.23[d]	8.27 ± 0.04[ef]
	JAN	7.85 ± 0.04[c]	7.81 ± 0.06[d]	7.61 ± 0.02[b]	7.32 ± 0.02[ab]
	FEB	7.58 ± 0.07[b]	8.22 ± 0.02[e]	7.68 ± 0.16[b]	8.37 ± 0.32[f]
	MAR	8.49 ± 0.05[e]	7.19 ± 0.04[a]	7.25 ± 0.05[a]	7.68 ± 0.03[c]
	APRIL	7.84 ± 0.02[c]	7.23 ± 0.01[ab]	7.32 ± 0.07[a]	7.63 ± 0.03[c]
	MAY	7.66 ± 0.04[bc]	7.25 ± 0.05[ab]	7.22 ± 0.19[a]	7.49 ± 0.05[bc]
	JUNE	7.21 ± 0.22[a]	7.47 ± 0.02[c]	7.62 ± 0.07[b]	7.25 ± 0.05[a]

N.B: Value(s) with the same superscripts across a row are not significantly different at $P \leq 0.05$

Similarly, highest BOD value of 8.57 mg/l was found in station 1 in March, 2019 with the lowest BOD value of 2.25 mg/L June at the same station 1. The result also indicated monthly variation in BOD in all the stations.

The result for the mean values of electrical conductivity (EC) of the Wasai reservoir is shown in Table 3. The result revealed significant difference ($P \leq 0.05$) in the EC values in the four stations across the months. Highest value of EC (252.00 µS/cm) was found in station 1 in March, 2019 with the lowest EC value of 151.33 µS/cm at station 2 in September, 2018. The EC values increased from September 2018 to March 2019 and then decreased to June 2019. In station 2 the EC values decreased from September to November and increase from December to January. Similar pattern of EC values fluctuation was found in station 4.

Table 2: Variations in Dissolved Oxygen and Biological Oxygen Demand of Wasai Reservoir.

Parameter	Months	STATION 1 Mean ± S.D	STATION 2 Mean ± S.D	STATION 3 Mean ± S.D	STATION 4 Mean ± S.D
DO	SEPT	2.33 ± 0.05[a]	4.23 ± 0.06[d]	3.16 ± 0.05[b]	2.27 ± 0.12[a]
	OCT	2.26 ± 0.15[a]	4.20 ± 0.10[d]	3.17 ± 0.21[b]	2.37 ± 0.15[a]
	NOV	2.27 ± 0.12[a]	2.10 ± 0.10[a]	3.50 ± 0.10[c]	4.23 ± 0.06[d]
	DEC	2.20 ± 0.10[a]	2.33 ± 0.15[ab]	2.57 ± 0.15[a]	3.47 ± 0.25[c]
	JAN	2.30 ± 0.34[a]	3.53 ± 0.30[c]	3.67 ± 0.15[cd]	4.53 ± 0.21[d]
	FEB	2.26 ± 0.15[a]	2.53 ± 0.15[b]	4.60 ± 0.20[f]	4.30 ± 0.17[d]
	MAR	2.20 ± 0.26[a]	3.43 ± 0.21[c]	3.93 ± 0.06[d]	4.20 ± 0.26[d]
	APRIL	2.46 ± 0.15[a]	3.60 ± 0.20[c]	2.66 ± 0.05[a]	2.77 ± 0.15[b]

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	MAY	3.23 ± 0.05[b]	2.40 ± 0.10[b]	4.30 ± 0.26[e]	3.23 ± 0.06[c]
	JUNE	4.47 ± 0.21 [c]	3.33 ± 0.11[c]	4.40 ± 0.20[ef]	3.33 ± 0.25[c]
	F	47.178	67.255	58.588	61.088
BOD	SEPT	8.23 ± 0.21[ef]	3.48 ± 0.02[ab]	5.35 ± 0.33[b]	7.70 ± 0.26[e]
	OCT	7.13 ± 0.61[cd]	2.73 ± 0.46[a]	5.45 ± 1.77[b]	8.20 ± 0.26[e]
	NOV	7.33 ± 0.72[cde]	6.23 ± 0.40[d]	2.91 ± 1.05[a]	2.96 ± 0.45[ab]
	DEC	6.65 ± 1.06[c]	6.13 ± 0.51[cd]	7.30 ± 0.10[c]	3.87 ± 0.51[abc]
	JAN	6.35 ± 0.13[c]	4.00 ± 0.61[ab]	3.37 ± 0.14[a]	2.88 ± 0.57[ab]
	FEB	8.03 ± 0.21[e]	6.30 ± 0.61[d]	2.97 ± 0.50[a]	2.53 ± 0.51[a]
	MAR	8.57 ± 0.57[f]	5.23 ± 0.06[bcd]	2.53 ± 0.59[a]	3.17 ± 1.15[abc]
	APRIL	7.00 ± 0.20[c]	3.47 ± 0.05[ab]	6.17 ± 1.41[bc]	6.03 ± 0.49[d]
	MAY	3.63 ± 0.50[b]	4.43 ± 2.80[abc]	2.30 ± 0.10[a]	4.42 ± 1.58[c]
	JUNE	2.25 ± 0.12[a]	3.47 ± 0.03[ab]	3.10 ± 0.10[a]	4.19 ± 0.54[bc]
	F	44.669	5.767	13.199	22.346

N.B: Value(s) with the same superscripts across a row are not significantly different at P≤0.05

Table 3 also showed the values of Total Dissolved Solids (TDS) in four stations across the months along Wasai reservoir Kano state. The result revealed significant difference (P≤0.05) in the values of TDS in the four stations across the months. Highest TDS value of 242.00 mg/L at station 1 in September 2018 with the lowest TDS value of at station 4 in March. The trend of the TDS values decreased in all the stations from September to 162.67 mg/L February and increased n the month of March across all the stations.

Table 3: Variations of Electrical Conductivity (µŞ/cm) and Dissolved Solids in Wasai reservoir.

Parameter	Months	STATION 1 Mean ± S.D	STATION 2 Mean ± S.D	STATION 3 Mean ± S.D	STATION 4 Mean ± S.D
EC	SEPT	171.33±34.93[a]	151.33±34.35[a]	237.33±34.15[c]	244.00±6.55
	OCT	199.23±26.50[ab]	203.67±22.81[ab]	222.67±29.67[bc]	198.67±61.42
	NOV	228.00±5.19[bcd]	220.33±14.01[b]	175.67±34.79[a]	216.00±9.85
	DEC	238.00±3.46[cd]	178.67±29.36[ab]	218.00±15.72[bc]	190.00±7.00
	JAN	226.67 ±16.77[bcd]	189.00±10.00[ab]	250.00±17.00[c]	238.67±10.97
	FEB	245.33±27.59[d]	218.67±32.86[b]	173.00±15.72[a]	180.67±24.83
	MAR	252.00±5.29[d]	229.67±15.27[b]	248.00±9.16[c]	208.00±36.26
	APRIL	249.67±5.29[d]	233.00±11.13[b]	250.57±6.03[c]	220.67±39.26
	MAY	207.00±2.65[bc]	198.00±34.38[ab]	178.00±10.00[a]	207.00±25.12
	JUNE	232.00±3.61[bcd]	202.67±22.81[ab]	187.67±8.96[ab]	214.00±11.36
	F	5.966	2.186	13.199	1.403
TDS	SEPT	242.00±2.65[d]	204.67±7.23[bc]	235.00±11.14[b]	236.33±11.84[e]
	OCT	222.67±29.69[bcd]	186.67±7.51[abc]	226.33±23.45[b]	236.00±8.18[e]
	NOV	203.67±22.81[abcd]	214.00±22.11[cd]	197.67±20.23[ab]	220.00±24.24[cde]
	DEC	168.00±28.16[a]	206.00±19.00[bc]	216.33±8.96[ab]	224.67±16.16[de]
	JAN	175.67±34.79[ab]	172.00±17.35[a]	211.67±30.43[ab]	182.67±17.89[ab]
	FEB	203.33±23.69[abcd]	176.00±19.92[ab]	180.67±24.83[a]	192.00±12.29[abc]
	MAR	238.67±9.82[cd]	240.33±12.66[d]	208.00±36.75[ab]	162.67±11.55[a]
	APRIL	179.33±23.45[cd]	203.00±4.35[abc]	204.67±6.11[ab]	183.67±19.14[ab]
	MAY	190.34±13.65[abc]	200.67±4.62[abc]	212.35±3.61[ab]	232.00±3.61[e]
	JUNE	180.67±46.54[ab]	214.00±31.32[cd]	223.67±3.79[b]	199.33±29.16[bcd]
	F	3.015	4.220	1.708	7.141

N.B: Value(s) with the same superscripts across a row are not significantly different at P≤0.05

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DISCUSSION

Assessment of variations in physico-chemical parameters of water bodies have proved to be vital index in water quality monitoring the world over. In the present study, the range of surface water temperature in the four stations was below the limits of the Federal standard (35°C) and also within the values reported by some other researchers such as 26.5-33°C by Oluyemi *et al*. (2010), 24.2-26.2°C by Nwoko *et al*. (2015) and 25.6-27.8 °C by Andong *et al*. (2019). The slight variation in water surface temperature can be attributed to the changes in the atmospheric temperature which on the other hand influence other water quality indices (Dirican, 2015). The slight variation in pH values reported by the present study corroborates with the finding of Ahmad *et al*. (2018) who reported slight variation in pH between months at Kafinchiri reservoir Kano. The pH value recorded by this study falls within the acceptable limits of 5.9-9.3 for fresh water bodies according to FAO (2007) standards. This also agrees with the findings of Orobator *et al*. (2020). Keremah *et al*. (2014) reported that pH values of 6.5-9.0 are good for fish production.

High level of DO noticed is an indication of aquatic life sustenance as WHO stipulates 5 mg/L as adequate limit for aquatic organisms whereas concentration below this level could adversely affect aquatic life. Even, concentration below 2 mg/L may lead to death for most fishes as suggested Chapman (1997). Elevated levels of DO recorded could be attributed to precipitation of nutrients associated with organic matters brought in by domestic and fertilizer application as suggested by Yasmeen *et al*. (2010). High concentration in DO observed could be traced to heavy application of chemicals as dissolved oxygen is a measure of the degree of pollution by organic matters. WHO (1985) sets 9.20 mg/L as maximum limit for DO in wastewater indicating this site is less in dissolved oxygen with International standards limit.

The mean BOD reported by this study is below the limits of the WHO (2011) standard of 8.5 mg/L. The high levels of BOD observed during sampling periods could be attributed to the use of chemicals such as mechanic paints sprays, herbicides, pesticides and Nitrogen fertilizer which were organic or inorganic that are oxygen demand in nature as stressed by Akan *et al*. (2008) as BOD is known as a measure of the oxygen required by micro-organisms while breaking down organic matters. WHO (2018) recommends 50 mg/L as maximum allowable limit for BOD in wastewater before it could be discharged into the stream indicating wastewaters from these sampling sites are not polluted with BOD. Similarly Akubugwo *et al*. (2012) reported 2.48 – 20.74 mg/L and Yasmeen *et al*. (2010) reported 362 mg/L as BOD in wastewater which were higher than concentration obtained in this study.

The EC value of pond D could be a pointer to its pollution status probably caused by run-off during rains into the ponds and waste products from other insect's population within the pond (Solomon *et al*., 2013). Pond D is the only one amid all the investigated fishing ponds that is situated very close to the wall of the building where rain water from the roof top flows directly into it. In addition, it is located very close to the moat which is known to be highly polluted with domestic wastes and dense vegetation. This may also account for the high insect population within pond D. The Benin Moat called 'Iya' in the local language was built as a defensive fortification around Benin City in the great Kingdom. It is a deep, broad ditch, either dry or filled with water that is dug surrounding Benin City which historically was to provide her with a preliminary line of defense. Presently, it is a major dumping site for the inhabitants that live around it. The

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result of EC obtained for water in pond D may also be due to its low pH value. Kefas *et al*. (2015) stated that acidic waters have appreciated higher conductivity values. Similarly, the higher values of Chloride (112.20 Mg/l), nitrate (59.40 Mg/l) and phosphate (19.80 Mg/l) could account for higher EC content in pond D. Kefas *et al*. (2015) state that increase presence of chloride, phosphorus and nitrate in water could instigate a raise in the status of EC. The values of EC observed for this investigation was lower than that reported Agbaire *et al.* (2015) who reported the value 18.00 µs/cm as the highest EC value in their study.

The alkaline contents for this study were similar in values; this may be due to the inability of the culturists to change water in their ponds (with the exception of pond E) as a result of incessant power failure in the country and the high cost involved in using generators. Pond E (earthen pond) is readily serviced with water from rains, runoff and underground water from Ikpoba River. Alkalinity status in ponds is affected when there is no frequent change of water along with processes of respiration and nitrification by plankton and macrophytes (Mustapha, 2017). The alkalinity values obtained for all the investigated fish ponds were below WHO (2009) range (25-100 Mg/L). This implies that they cannot encourage high production in fish cultivation. The obtained values of TSS for all the fish ponds cannot affect the fish functioning and survival as they did not exceed the limit set of 80.00 Mg/l. Total Dissolved Solids (TDS) is an indication of the load of dissolved substances (Agbaire *et al*., 2015). Ogbeibu and Edutie (2006) noted that the use of artificial animal feeds to supplement pond nutrients result to increased TDS in aquatic water. However, the values obtained for this study were low and optimum which is good for fish productivity. The values are far lesser than the FEPA (1993) limit of 500 Mg/l.

The values obtained for turbidity are also within the WHO (2009) limit (5-25 NTU) which makes the studied ponds fit for fish farming. This infers that the status of turbidity for all the studied fish ponds is favorable for the fish health since it does not poses severe risk to their survival. The findings of this investigation negate the result of Dinesh *et al*. (2017) that recorded maximum turbidity value of 32.33 NTU and minimum value of 17.66 NTU. The COD values observed in pond B (white plastic pond) indicate that some amount of non-biodegradable oxygen demanding pollutants were present in it. This reflects the biodegradable nature of plastics. The COD values obtained in all the examined fish ponds were above WHO (2009) set standards (10 Mg/l). This could be harmful to the survival of aquatic life in these ponds.

The values of dissolved oxygen infer that the water in the ponds may not yield good fish productivity. It may also imply that the culturists of the selected fish ponds may be involved in either of the following; over application of fertilizers and organic manure to manage DO level, physical control aquatic plants and also management of phytoplankton biomass, recycling of water and use of aerators or artificially or manually beating of water (Bhatnagar and Devi, 2013). Low levels dissolve oxygen is a lethal concentration that can put undue stress on fish and are often linked to fish kill incidents (Danba *et al.,* 2015). However, DO contents obtained for fish ponds F (6.17 Mg/l) and A (7.32 Mg/l) were very close to FEPA (1993) set standards of 8-10 Mg/l. To make these fish ponds fit for fish farming, increasing the mixing of air and water by splashing the water with one's hands or with a broad stick or paddle should be carried out. Biological Oxygen Demand contents in ponds B, C, D and E may be due to the effects of fallen leaves and debris, and waste product of fishes and other insect population within each of the fish pond; also eutrophication resulting from unused feed present in water is another possible reason for a sudden rise in BOD (Solomon *et al*., 2013). The occurrence of high levels of Biological Oxygen Demand can threaten the survival of fish in these ponds. The highest BOD values of fish pond water recorded for this study was 86.38 Mg/l.

CONCLUSION

It was concluded that there is significant variation in the physic-chemical parameters of surface water of Wasai Reservoir in terms of surface water temperature with the highest value of 27.20 ^{o}C and pH (8.49). Similarly, the EC (151.33-252.00 µS/cm), Total Dissolved Solids (TDS) (162.67-242.00 mg/L) and BOD (2.25-8.57 mg/l) varies with the sampling locations with variation in months. The EC, TDS, DO and BOD values in all the locations were within the permissible limits (pH= 6.5-8.5; EC= 1000 µS/cm; 1000 mg/L).

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