



SEASONAL VARIATION OF PHYSICO-CHEMICAL FEATURES OF WATER SAMPLED FROM TIGA RESERVOIR, NIGERIA

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ABSTRACT

This study assessed the physico-chemical features and dissolved mineral elements of the water sampled from Tiga reservoir, Nigeria. The sampling period was between the months of May, 2014 to April, 2015, water samples were collected from a strategic point of effluent in cleaned bottles of average volume 250 ml. The physico-chemical and mineral elements were analysed in accordance to standard method using spectrophotometer. The results of the wet and dry seasons showed significant differences ($p < 0.05$), total dissolved solids (77.08 mg l^{-1} and 54.88 mg l^{-1}); turbidity (77.81 NTU and 34.01 NTU); chromium (0.02 mg l^{-1} and 0.01 mg l^{-1}) and potassium (0.17 mg l^{-1} and 0.15 mg l^{-1}). The mean values of biological oxygen demand (2.80 mg l^{-1}); alkalinity (41.79 mg l^{-1}); dissolved oxygen (7.05 mg l^{-1}); calcium (0.15 mg l^{-1}) and potassium (0.17 mg l^{-1}), were within the recommended limits of European union (EU) and world health organisation (WHO) for aquatic life. Similarly, total dissolved solids (77.08 mg l^{-1}); zinc (0.01 mg l^{-1}); iron (0.15 mg l^{-1}); chloride (6.67 mg l^{-1}); sulphate (4.11 mg l^{-1}) and nitrate (0.80 mg l^{-1}) values stood within the limits recommended for drinking water by WHO. However, lead and cadmium were not detected. There were seasonal fluctuation of the water quality parameters. Also, it was a good appraisal of the water content on the basis of EU and WHO water quality standards. However, there was proof of contamination of the water sampled, as the BOD was high which suggest further survey to be conducted on regular basis in order to ascertain the condition of the water content in the reservoir.

Keywords: Climate, lake, ecology, component, health

INTRODUCTION

As the incessant reportage on contamination of aquatic environment continues, this has raised concern among various stakeholders in Nigeria and other third world nations (Adelegan, 2008). Worthy of mention are works of Ayodele and Abubakar (2001) and Sani, (2011). Individual and group agitation is on the increase day in day out concerning quality of the environment, this menace cut across borders. The released of contaminants impact on the rate of production in agricultural sector, environmental and health hazards (Gadzała-Kopciuch, 2004).

Water is known to function as an enabling medium for the proliferation of most contaminants and serves as universal solvents to major substances allowing the connection such as from the air to the soil then to the plants and finally to animals (Nałecz-Jawecki and Sawicki, 1998). Most contaminant released into the environment were carried in water, air and biomes. Others exist naturally as biogeochemical features and found in the energy cycle (Gadzała-Kopciuch, 2004). There is lagging in terms of the time between the emission period and the subsequent observable evidence of pollution, results in delay of all action related to prevention of contaminants that likely show up in the nearest future (Alloway and Ayres, 1998).

Minerals represent inorganic elements found in most body parts of organism and their involvement in these tissues is

significant for the effective body function and maintenance. They are not known to have contributed to any energy source but identified at ensuring effective body functions (Eruvbetine, 2003). All living organism needs these minerals for effective life functioning (Ozean, 2003).

The Tiga Reservoir plays important roles such as but not limited to source for irrigation scheme, fishing, domestic, hydroelectricity, water control and aesthetic values. These laudable objectives could be distorted in event of improper management. Thus there is a need for timely assessment at ensuring effective collection of relevant information. The purpose of this study was to evaluate the physico-chemical parameters and mineral contents of sampled water in respect to seasonal variation.

MATERIALS AND METHODS

Study area and climate

The study area was at Tiga Reservoir on the main water source-Kano River which is averagely 70km from the Kano metropolis in Nigeria, with the longitudes $8^{\circ} 18'$ to $8^{\circ} 35'E$ and latitudes of $11^{\circ} 18'$ to $11^{\circ} 27'N$. Tiga Reservoir on average has a maximum length of 6 km (crest length), 48m in its height (the dam height) and a total volume capacity of $1,974.49 \times 10^6 \text{ m}^3$ (HASKONING Engineering Consultants Nigeria and HASKONING Nijmegen, 1978). In Kano rainfall usually begin as from 30th may, nevertheless, in some rare

cases it may be noticed even from 15th of May and ends in October in every other year (Akintola, 1986). The Tiga Reservoir climate is of Sudan savanna typically known for its transpiration and evaporation of just below 44% per annum with characteristic three months of raining season (June – September), with mean highest daily temperature as high as 33.5°C (Papadakis, 1965).

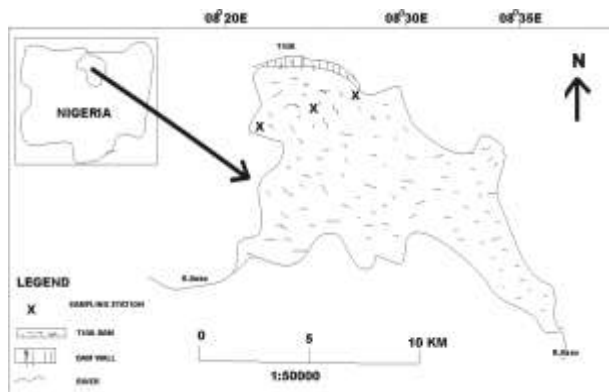


Figure 1: The location of Tiga Reservoir in Kano, Nigeria.

Sample collection and analyses

The collection of water samples were done at Rano settlement which was a major point for agricultural effluent. The sampled water were collected using cleaned bottles of volume (250 ml) on monthly basis in three replicates, strictly following the standard stipulated in United States Environmental Protection Agency (USEPA) (USEPA, 1994). The temperature (°C) was determined and recorded on site by inserting the probes of the ATC portable pH/Temp meter model pH-009 (III) into the water on the spot. The pH was determined and recorded on the spot by inserting the probes of the ATC pH/Temp meter into the water. The conductivity (µs) was determined and recorded on site by inserting the probes of the ELE conductivity meter model DA-1 into the water on the spot. The Total Dissolved Solid (TDS) (mg/l) was analyzed and recorded on the spot by dipping the probe of HANNA conductivity meter model H18733 into the water. The Winkler method was used for the determination of Biological Oxygen Demand (BOD) (mg/l). A 300 ml glass BOD bottle was used to collect the water sample to the brim and stoppered. Then 2 ml of manganese sulphate was added into the collection bottle by inserting a calibrated pipette just below the surface of the water. Also 2 ml of alkali-iodide-azide reagent was added into the collection bottle. In order to ensure a good mix, the sample was inverted severally and a brownish-orange cloud of precipitate was noticed. A 2 ml of concentrated tetraoxosulphate (VI) acid was added using a pipette held just above the surface of the sample and the bottle was stoppered and inverted severally to dissolve the floc. At this point the sample was fixed and stored in a cool dark place for up to 5 days. After which 201 ml of the sample was titrated with sodium thiosulphate to a pale straw colour. A 2 ml of starch solution was then added which resulted to a blue colour and the titration continued until the sample turns clear. At the endpoint the concentration of dissolved oxygen in the sample

is equal to the volume of titrant used. The BOD was calculated using equation 1

$$BOD(mg/l) = \frac{(DO-D5-BC) \times \text{Volume of Sample}}{\text{Volume of Sample Taken}} \quad (1)$$

Where. DO = Initial dissolved oxygen of the diluted sample, D5 = Dissolved oxygen at the end of 5 days, BC = Blank correction (CO – C5), CO = Initial dissolved oxygen of the blank and C5 = Dissolved oxygen at the end of 5 days for the blank. Similarly, the Winkler method was used to determine the Dissolved Oxygen (DO). The Dissolved Oxygen Saturated (DO SAT (% Sat)) was calculated using equation 2.

$$DO\ SAT\ (\% \text{ SAT}) = \frac{DO\ of\ the\ Water\ Sample \times 100}{DO\ of\ distilled\ Water\ at\ a\ given\ Temperature} \quad (2)$$

Where. DO SAT = Dissolved Oxygen Saturated and DO = Dissolved Oxygen. Nephelometric method was used to determine the turbidity of the water sample. The sample was mixed on centrifugal apparatus until solids were dispersed and allowed to settle at room temperature until air bubbles disappeared. The sample was poured into the turbidimeter tube and results were recorded from the instrument scale. For alkalinity, a 20 ml of water sample was pipetted into a conical flask, followed by 1-2 drops of Phenolphthalein indicator. The water sample in the flask was used to titrate with N/10 hydrochloric acid in a burette till the pink colour just disappears. The total volume of acid used represents the total alkalinity. Mohr's method (Argentometric) was adopted for the analysis of Chloride ion (Cl⁻) in the water sample. To a 50 ml of water sample in a conical flask, 3-4 drops of potassium chromate solution was added. This was followed by slowly dropping of the standard silver nitrate solution from the burette into the content of the flask and the solution was allowed to mix properly after some shaking. At the end point, light yellow colour turns red and the red colour persists. The quantity of silver nitrate solution used gives the quantity of chloride ion in the given water sample. Sulphate ion was determine when a 100 ml of the water sample was measured into a 250 ml Erlenmeyer flask and 5 ml of conditioning reagent was added. The solution was mixed in the stirring apparatus, followed by the addition of a spoon full of barium chloride crystals. As stirring period elapsed, some of the solution was dropped into the absorption cell of the photometer. The absorption was then measured at the 5th minute and the amount of MgSO₄ present in the sample was recorded from the calibration prepared by standard solutions. Also a 50 ml of the water sample was collected in a 125 ml Erlenmeyer flask and followed by the addition of 1 ml of tetraoxosulphate (IV) acid. The solution was allowed to boil gently on a pre-heated hot plate for 30-40 minutes, cooled, diluted to about 40 ml and then filtered. The filtrate was then poured into the absorption cell of the photometer and the reading taken after 5 minutes of absorbance at a wavelength of 650 nm with a spectrophotometer. The quantity of phosphorus present in the sample was determined from the standard curve. Again a 50 ml water sample was collected in a 250ml Erlenmeyer flask, followed by addition of 1 ml of diluted hydrochloric acid and 1 ml of sulfanilic acid reagent. The solution was allowed to mix properly by shaking the flask and a 1 ml of Zn/NaCl granular mixture was measured and

added into the flask. The solution was allowed to swirl for 7 minutes and then filtered with a vacuum flask followed by rinsing with purified water. The filtered water sample was poured back into the Erlenmeyer flask, a 1 ml N-1-naphthylethylenediamine dihydrochloride reagent was added to the filtered sample and mixed. A 1 ml of 2 M sodium acetate solution was added and allowed for 5 minute after mixing for colour development. The colour intensity was measured with a spectrophotometer at a wavelength of 550 nm and the concentration of nitrate ions in the sample was measured from the standard curve.

Statistical analyses

The statistical analyses were conducted using Statistics Package for Social Science (SPSS) version 20 for window and T-test for equality of means showed significant differences.

RESULTS AND DISCUSSION

The Outcomes of the physico-chemical parameters of the water sampled are presented in Table 1 (student T-test). Total Dissolved Solids (TDS) and Turbidity values were significantly ($p < 0.05$) higher (77.08 mg l^{-1} and 77.81 NTU) in the wet relative to the dry seasons. This report was in line with the study by Chowdbury and Khan (1994), that elevated records of turbidity can be noticed specifically in wet season as a result of effluents collected in large bulk by water from

its' catchment areas. The amount of TDS observed in this study in the wet season can be attributed to domestic and agricultural inputs that often results to the local, spatial and temporal changes in the effluents (Martins and Hanifa, 2003). While, the TDS value fell within the limits of WHO standards, the amount of turbidity was far higher than recommended value of less than 5 NTU by WHO and SON for drinking water (Chapman and Kimstach, 2006).

The alkalinity results for wet and dry seasons were (41.67 mg l^{-1} and 41.79 mg l^{-1}). These values fell within the tolerable limits of WHO for freshwater and aquatic life (Chapman and Kimstach, 2006). The natural source of alkalinity in surface water was as a result of presence of carbon (iv) oxide in large amount which could triggered off breaking down of particles leading to the higher level of alkalinity (Raymond and Cole, 2013). The BOD values (2.51 and 2.80) for dry and wet seasons fell outside the recommended threshold of WHO for freshwater and aquatic life (Chapman and Kimstach, 2006). It was an indication of high volume of organic degradation by microbial activities in the water (Nduka and Orisakwe, 2007). It was reported by Akpata *et al.* (1993), that in any given environment, the amount of organic matter broken down by microorganisms is a function of its' biological oxygen demand (BOD).

Table 1: The physico-chemical parameters of water sampled from Tiga reservoir, Nigeria

Para meters	Season	Mean	Std. Deviat.	T-value	T-test
Temp ($^{\circ}\text{C}$)	Wet	27.09	± 0.26	-1.56	$p > 0.05$
	Dry	27.29	± 0.41		
pH	Wet	7.07	± 0.10	-1.37	$p > 0.05$
	Dry	7.15	± 0.20		
BOD(mg/l)	Wet	2.51	± 0.64	-1.45	$p > 0.05$
	Dry	2.80	± 0.55		
TDS(mg/l)	Wet	77.08	± 23.35	3.45	$P < 0.05$
	Dry	54.88	± 15.15		
Conductivity($\mu\text{s/cm}$)	Wet	62.08	± 18.81	1.07	$p > 0.05$
	Dry	56.46	± 12.64		
Turbidity (NTU)	Wet	77.81	± 26.15	5.72	$P < 0.05$
	Dry	34.01	± 19.14		
Alkalinity(mg /l)	Wet	41.67	± 22.87	0.02	$p > 0.05$
	Dry	41.79	± 24.81		
DO(mg/l)	Wet	6.23	± 0.78	-2.63	$p > 0.05$
	Dry	7.05	± 0.93		
DO SAT(%sat)	Wet	74.92	± 7.39	-0.78	$p > 0.05$
	Dry	77.79	± 11.62		

$P < 0.05$ (Significant) & $p > 0.05$ (Not Significant), ND: (Not Detected). Temp: Temperature, BOD: Biological Oxygen Demand, TDS: Total Dissolved Solids, DO: Dissolved Oxygen, DO SAT: Dissolved Oxygen Saturated.

The value of dissolved oxygen (DO) for the dry season was higher (7.05 mg^l⁻¹), this could be due to less of organic materials released from surrounding farm-stead. Similar report was made by Gupta *et al.* (1996) that relative to summer values elevated DO levels in freshwater maybe noticed in monsoon. There was no disparity in temperature of the water between the wet and dry seasons, however, these values were in conformity with Tiga reservoir (Akindele *et al.*, 2013). Elevated temperature is inversely related to rate at which gases dissolved and directly related to rate of evaporation as well as chemical reaction (Akindele *et al.*, 2013). The conductivity is a measure of the amount of dissolved solids in water, in this study the conductivity values for wet and dry seasons were far below the WHO acceptable threshold (WHO, 2004). The pH values for both wet and dry seasons were neutral to a bit of alkaline, this was an indication that the surface water is suitable for aquatic life. Also, the pH values fell within limits of international standard (Oram, 2004) and similar record was reported for Tiga reservoir (Akindele *et al.*, 2013).

The mean mineral content of water sampled are presented in table 2 (Student T test). Chloride elements are found scattered in various forms as rocks and are distributed across water as

runoffs (Braide *et al.*, 2004), Both values of chloride (5.91 mg^l⁻¹ and 6.67 mg^l⁻¹) for wet and dry seasons, fell below the limits for water pollution. However, excessive concentration of chloride is detrimental to water quality and undesirable for human or livestock uses (Egereonu, 2004). Rainfall and industrial effluents are the two major sources of sulphate in surface water. The average values of sulphate for both seasons (3.82 mg^l⁻¹ and 4.11 mg^l⁻¹) were comfortably within the recommended limits for drinking water as well as freshwater and aquatic life (Chapman and Kimstach, 2006; Egereonu, 2004). The low values (0.80 mg^l⁻¹ and 0.70 mg^l⁻¹) of nitrate recorded for both seasons were within the WHO recommended range for freshwater and aquatic life. However, the phosphate values (0.59 mg^l⁻¹ and 0.54 mg^l⁻¹) for both seasons were slightly above the limits for growth of planktons which are natural source of food for fish but concentrations were not enough to have resulted to eutrophic lake. The calcium values (0.13 mg^l⁻¹ and 0.15 mg^l⁻¹) for both seasons met the WHO standards for good freshwater and thriving aquatic life. Likewise, zinc values (0.01 mg^l⁻¹ and 0.01 mg^l⁻¹) for both seasons were within the tolerant levels for the WHO, SON and EU standards for drinking and freshwater (Chapman and Kimstach, 2006).

Table 2: The mineral content of water sampled from Tiga reservoir, Nigeria

Parameter s (mg/l)	Season	Mean	Std. Error	T-value	T-test
Cl ⁻	Wet	5.91	±1.89	0.80	p>0.05
	Dry	6.67	±2.96		
SO ₄ ⁻	Wet	3.82	±0.43	1.46	p>0.05
	Dry	4.11	±0.61		
PO ₄ ⁻	Wet	0.59	±0.40	0.41	p>0.05
	Dry	0.54	±0.32		
NO ₃ ⁻	Wet	0.80	±0.38	0.73	p>0.05
	Dry	0.70	±0.37		
Ca ⁺	Wet	0.13	±0.04	-1.66	p>0.05
	Dry	0.15	±0.03		
Zn ⁺	Wet	0.01	±0.01	-1.18	p>0.05
	Dry	0.01	±0.01		
Fe ⁺	Wet	0.15	±0.02	0.99	p>0.05
	Dry	0.15	±0.02		
Cr ⁺	Wet	0.02	±0.01	3.07	P<0.05
	Dry	0.01	±0.01		
K ⁺	Wet	0.17	±0.01	2.63	P<0.05
	Dry	0.15	±0.02		
Mg ⁺	Wet	0.18	±0.01	0.14	p>0.05
	Dry	0.18	±0.02		
Cd ⁺	-	ND	-	-	-
	-	ND	-	-	-
	-	ND	-	-	-
Pb ⁺	-	ND	-	-	-

P<0.05 (Significant) & p>0.05 (Not Significant), ND: (Not Detected). Cl⁻: Chloride, SO₄⁻: Sulphate, PO₄⁻: Phosphate, NO₃⁻: Nitrate, Ca⁺: Calcium, Zn⁺: Zinc, Fe⁺: Iron, Cr⁺: Chromium, K⁺: Potassium, Mg⁺: Magnesium, Cd⁺: Cadmium, Pb⁺: lead.

Table 3: Comparison of physicochemical parameters of water sampled from Tiga reservoir with known standards Standard Organisation of Nigeria Chapman and Kimstach (2006)* ND (Not Detected)**

Parameters	Value of water sample	Drinking Water		Freshwater/Aquatic life	
		W.H.O standards*	SON**	E.U. standard*	W.H.O standard*
Ph	7.15	< 8.0	6.5 - 8.5	6.0 - 9.0	6.0 - 8.5
Biological Oxygen Demand (mg/l)	2.80	-	-	3.0 - 6.0	< 2.0 (unpolluted)
Total Dissolved Solids (mg/l)	77.08	< 1000	< 500	-	-
Turbidity (NTU)	77.81	< 5.0	< 5.0	-	-
Total Alkalinity (mgCaCO ₃ /l)	41.79	-	-	-	> 24.0
Dissolved Oxygen (mg/l)	7.05	-	-	5.0 - 9.0	5.0 - 10.0
Cl ⁻ (mg/l)	6.67	< 250.0	-	-	< 10.0
SO ₄ ²⁻ (mg/l)	4.11	< 250.0	< 100.0	-	2.0 - 80.0
NO ₃ ⁻ (mg/l)	0.80	< 50.0	< 50.0	-	< 1.0
Ca ²⁺ (mg/l)	0.15	-	-	-	< 15.0
Zn (mg/l)	0.0008	< 3.0	< 3.0	0.03 - 2.0	-
Fe (mg/l)	0.15	< 0.30	< 0.30	-	-
K ⁺ (mg/l)	0.17	-	-	-	< 10.0
Mn (mg/l)	ND				
Cu (mg/l)	ND				

CONCLUSION

This survey revealed variations of the physico-chemical parameters and mineral contents between the wet and dry seasons. The effects can be attributed to agricultural and domestic inputs from the tributaries within the catchment area. These effluents may be transformed after the local, spatial and temporal changes. Thus, depict seasonal variations of the water quality features. On the basis of the EU, WHO and SON standards, there was a good appraisal of the water content in the reservoir. However, the high value of BOD was a proof of contamination of the water sampled, which suggest further survey to be conducted on regular basis in order to ascertain the condition of the water content in the reservoir.

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