



## Hydro-chemical Characteristics of Surface Water and Its Suitability for Drinking at Kwanar-Are Dam, Rimi Area of Katsina State, Nigeria

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### ABSTRACT

The present study investigated hydro-chemical characteristics of Kwanar-Are dam water and its suitability for drinking purposes at Rimi Area of Katsina State, Nigeria. Water samples were collected using clean dry polythene sample bottles of (1 liter capacity) during the rainy season of 2018. Concentration of dissolved oxygen (DO), biological oxygen demand (BOD), total alkalinity (TA), chloride (Cl<sup>-</sup>), total hardness (TH), sulphate (SO<sub>4</sub>), nitrate (NO<sub>3</sub>), calcium ion (Ca<sup>2+</sup>) and magnesium ion (Mg<sup>2+</sup>) were analyzed and compared with standard limits recommended by Nigerian Standards for Drinking Water Quality and World Health Organization. The result obtained revealed that, all parameters were found within the desirable limit of drinking water standards. Water Quality Index (WQI) was employed to assess the suitability of the water for drinking and the result indicated that, the quality of the water was very poor and concluded that the water is unfit for human consumption sol also irrigation. It is recommended that, further treatment is required before use and surface water management plan is needed to improve the quality of the water.

**Keywords:** Hydro-chemical; Kwanar-Are dam; Suitability assessment; Surface water; WQI.

### INTRODUCTION

Water is an important natural resource for mankind and all living organisms for their survival and growth. Adequate fresh water supply is the most important prerequisite for sustaining human life, maintaining ecosystem and ecodiversities and achieving sustainable development (Godwin and Oborakpororo 2019). The need for humanity to sufficient fresh water for survival and various social and economic development in enormous, and will remain a major priority across the globe in the years to come (Malami *et al.*, 2014). Different kinds of impurities are contained in natural water, introduced through natural and anthropogenic activities such as rocks weathering, soil leaching, dissolution of aerosols particles from the atmosphere, mining as well as processing (Shaka *et al.*, 2018). The importance of water to human health and wellbeing is encapsulated in the Human Right to Water and Sanitation, which entitles everyone to "sufficient, safe, acceptable physically accessible and affordable water for personal and domestic uses" (Bain *et al.*, 2014). It is reported that climate change (floods and draughts) have directly affected water availability and surface water quality (UN, 2012). It is estimated that 1.8 billion people (28% of the world's population) use unsafe water in 2010 and that additional 1.2 billion (18% of the world's population) use water from water sources with significant sanitary risks (Friedlander *et al.*, 2015; Sila, 2019).

Chemicals are the basis of life, but excess anthropogenic influence of some organic chemicals pose inherent dangers. Agrochemicals, industrial chemicals, pharmaceuticals, and other synthetic chemicals can enter the environment and the food chain, causing unwanted effects and disease (Escher *et*

*al.*, 2020). Chemical pollutants in surface water can cause a number of intoxication. The effects of inorganic chemicals are better known than those of trace levels of organic chemicals detected in water (Huckins *et al.*, 2006). The list of water contaminants includes hydrocarbons, metals, cyanide, arsenic, various synthetic substances, including soluble forms of nitrogen, phosphorous, and organic matter (Pindi *et al.*, 2014). Chemicals can contribute to toxicity in a complex mixture even if they are present below their own effect threshold and/or analytical detection limit (Kortenkamp and Faust, 2018). Surface waters are contaminated with an increasing diversity of anthropogenic compounds, giving rise to the presence of complex contaminant mixtures that can cause serious harm to human health, ecosystems and diminish the quality of the aquatic resources (Bernhardt *et al.*, 2017; De Baat *et al.*, 2020). Impacts of chemical pollution on aquatic biota and wildlife triggering development and implementation of environmental laws (Posthuma *et al.*, 2019).

A number of studies since the early 2000s have demonstrated the complexity and near-ubiquitous presence of contaminants of emerging concern (CECs) mixtures in surface waters. Recently, dramatically expanded chemical assessments provide only partial coverage of the presumptive surface water contaminant space (Tang *et al.*, 2013; Blackwell *et al.*, 2019). A growing consensus among scientists and authorities that the methods currently used for chemical and ecological water quality assessment require a revision to obtain a more coherent and future-proof approach (Escher *et al.*, 2020). Traditionally, hydro chemical water quality is assessed by monitoring of

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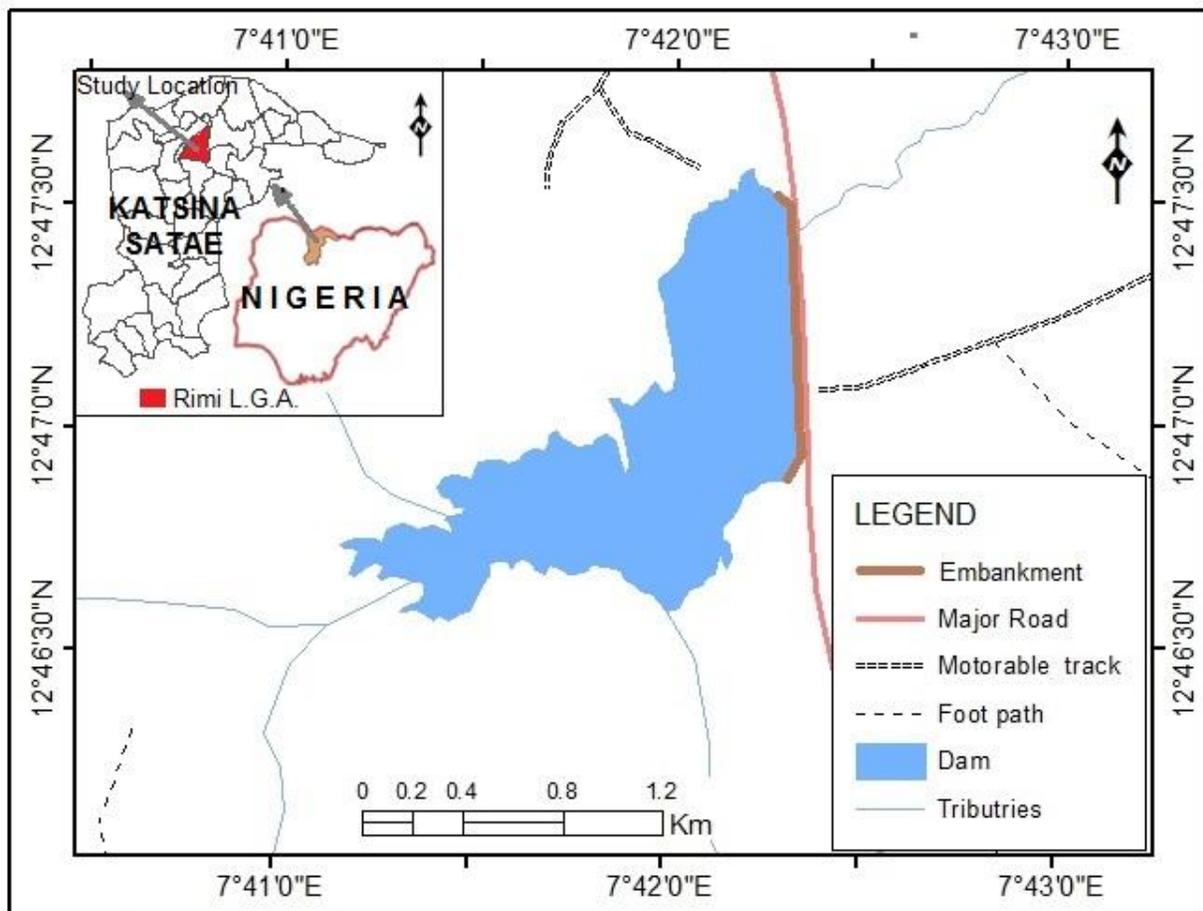
concentrations of a limited list of individual priority compounds. However, environmental concentrations of these compounds are decreasing, and consequently, currently identified risks to aquatic ecosystems are caused by complex mixtures of unknown, unregulated and unmonitored compounds (Neale *et al.*, 2017). Therefore, careful monitoring and management of surface water resources is needed, include control over of pollution.

Although multiple studies in Nigeria investigated physical, chemical and bacteriological quality of surface water (Suleiman and Audu, 2014; Onojake *et al.*, 2017; Ezekiel *et al.*, 2020), the present study is among a growing number of studies to apply water quality index (WQI). This is with a view to assess the hydro-chemical water quality of surface water and its suitability for drinking purposes in Kwanar-Are dam. Hence the study will provide baseline condition in terms of chemical quality of the water so as to help decision-makers and scientists with a sense of direction to take appropriate action.

## MATERIALS AND METHODS

### Study Area

The study area is in Kwanar-Are dam Rimi Local Government Katsina State, Nigeria, located between latitude  $12^{\circ}46'30''\text{N}$  to  $12^{\circ}47'30''\text{N}$  and longitude  $7^{\circ}41'00''\text{E}$  to  $7^{\circ}43'00''\text{E}$ . (Figure 1). It covers a total catchment area of 1,382,470 square meters. It is accessible through the Katsina-Kano road. The dam experiences a tropical wet and dry climatic zone and the average annual rainfall within the area varies considerably from 600mm to 700mm. The mean monthly temperature range from  $24^{\circ}\text{C}$  to  $31^{\circ}\text{C}$  and mean annual of  $27^{\circ}\text{C}$  (Maiwada and Hassan, 2019). The basin area is relatively flat with an average elevation of 300 m above mean sea level. The Kuraye River yields its water to Kwanar-Are dam which provides water for agricultural activities within the area. The area experienced high relative humidity during rainy season and falls down rapidly in dry season. Surface soils are mainly sandy loam and contain more clay. Underlying geology in the area consists mainly of fine grain gneisses, quartzite and magnetite with some coarse-grained granitic outcrops in few places (Hassan and Kabir, 2019).



**Figure 1:** Map of Kwanar-Are Dam

Source: National Aeronotic and Space Administration Spot Image 2020

### Water Sampling Collection

Water samples were collected on weekly basis from 8:00am to 10:00am during the rainy season of 2018. Standard procedures APHA, 2012 were adopted. All samples were collected in a cleaned, dry polythene sample bottles of 1-litre capacity and mixed with appropriate preservatives such as dilute nitric acid at point of collection prior to laboratory analysis, after labeling, the samples were taken to laboratory for analysis.

### Determination of Chemical Parameters

DO and BOD were measured using DO Meter (HANNA HI9146 Model) The DO values were taken for the first day, the samples were tightly closed and incubated at 20°C for 5 days, on the 5<sup>th</sup> day the D.O values were taken again, the difference between the two values gives the BOD value. Total alkalinity (TA) was analyzed using volumetric dosage O.INHIC solution. Total hardness (TH), sulphate (SO<sub>4</sub>), chloride (Cl<sup>-</sup>), nitrate (NO<sub>3</sub>), calcium ion (Ca<sup>2+</sup>) and magnesium ion (Mg<sup>2+</sup>) were determined using titrimetric method. Standard method described by American Public Health Association of 2012 was used in the determination of these parameters.

### Calculation of Water Quality Index (WQI)

Water Quality Index (WQI) was used using selected parameters for this study, these were dissolved oxygen (DO), biological oxygen demand (BOD<sub>5</sub>), total alkalinity (TA), sulphate (SO<sub>4</sub>), chloride (Cl<sup>-</sup>), nitrate (NO<sub>3</sub>), total hardness (TH), and calcium ion (Ca<sup>2+</sup>), magnesium ion (Mg<sup>2+</sup>). WQI is calculated using the following equation

$$WQI = \frac{\sum(W_i Q_i)}{\sum W_i} \quad (1)$$

Sub index (Q<sub>i</sub>) was calculated using the following equation:

$$Q_i = \frac{(V_i - V_o)}{(S_i - V_o)} \times 100 \quad (2)$$

Where,

V<sub>i</sub> is the estimated value of ith water quality parameter at a given sample location, V<sub>o</sub> is the ideal value for ith parameter in pure water. Note that, V<sub>o</sub> for DO = 14.6, and 0 for all other parameters, and S<sub>i</sub> is standard permissible value of ith water quality parameter.

$$W_i = \frac{K}{S_i} \quad (3)$$

Where K is a proportionality constant, which is calculated using the following equation

$$K = \frac{1}{\sum(\frac{1}{S_i})} \quad (4)$$

**Table 1:** Classification of water quality based on WQI method (Hassan *et al.*, 2020)

WQI	Status	Possible Usage
0-25	Excellent	Drinking, irrigation and industrial
26-50	Good	Domestic, irrigation and industrial
51-75	Poor	Irrigation
76-100	Very poor	Restricted use for irrigation
Above 100	Unfit for drinking	Proper treatment required before use

### Statistical Analysis

The data were subjected to statistical analysis using the statistical package, SPSS 20.0 and results were compared with the drinking water standards.

### RESULTS AND DISCUSSION

The result of chemical properties of water samples from Kwanar-Are dam were presented (Table 2) and statistical summary in Table 3.

**Table 2:** Result of chemical properties of water samples (mg/l).

Parameters	Samples					
	A	B	C	D	E	F
DO	1.24	1.23	1.18	1.15	1.25	1.17
BOD	.77	.95	.83	.76	.68	.75
TA	24.91	27.5	30.0	27.60	26.80	29.33
Cl <sup>-</sup>	143	136.60	106.51	100.82	127.37	79.52
TH	32.70	33.92	40.22	35.06	37.60	32.30
SO <sub>4</sub>	14.0	12.6	13.9	11.7	16.3	14.9
NO <sub>3</sub>	7.21	9.35	8.63	7.92	10.24	8.39
Ca <sup>2+</sup>	14.50	13.40	19.70	20.20	17.70	15.60
Mg <sup>2+</sup>	18.20	20.52	20.52	14.86	19.90	16.70

Dissolved oxygen is an important indicator of water quality, ecological status, productivity and health of a reservoir (Mustapha, 2008). Result of dissolved oxygen obtained ranged between 1.15mg/l and 1.25 mg/l with the average value of 1.20±0.04 mg/l. The mean dissolved

oxygen values recorded in this study is reported within the limits (> 5 mg/l) set by WHO (2017) and NSDWQ (2007). Level of dissolved oxygen found in this study might be due to discharge of organic wastes during wet season which led to biological respiration and decomposition processes,

which in turn reduced the concentration of DO in water bodies. Rabiou *et al.* (2018) also reported similar observation in Watari dam, Kano State where DO value was found to be within the permissible limit during the rainy season.

The BOD value ranged from 0.68 mg/l and 0.95 mg/l with a mean value of  $0.79 \pm 0.09$  mg/l. The mean value is within the acceptable value recommended by WHO, 2017. The low BOD value obtained could be as a result of some amount of waste flowing into the dam during wet season hence oxygen will be consumed faster by microbial population. This result corroborated with the finding of Keke *et al.* (2015) in their study on Physico-chemical parameters and heavy metal content of surface water in downstream of Kaduna river, they observed that increased organic matter from weeding decompose within lake water and domestic sewage increased the biological oxygen demand. Adamu and Wudil (2017) observed similar findings in Watari dam Kano.

Total alkalinity found in this study ranged from 24.91 mg/l to 30.0 mg/l with a mean value of  $27.69 \pm 1.82$  mg/l. This does not exceed the limit recommended by WHO, 2017. The low value of alkalinity could be due to dilution as a result of high water level during the rainy season. Muhammed *et al.* (2018) recorded similar result in their studies on water quality in Tagwai reservoir Nigeria. The study of Ibrahim *et al.* (2009) in Kontagora reservoir Niger State, Nigeria also corroborated with the present findings. Chloride is a ubiquitous aqueous anion in all natural waters, the concentrations varying very widely. Chloride obtained in this study ranged from 79.52 mg/l to 143 mg/l with the mean value of  $115.64 \pm 24.22$  mg/l. Observed chloride mean value is within the permissible limit recommended by WHO, 2017 and NSDWQ, 2007. This result agreed with the findings of Usman *et al.* (2017) who recorded similar values in Ajiwa reservoir Katsina State.

Total hardness in water comprises the determination of calcium and magnesium as the main constituents. Kwanar-Are dam water is soft going by the mean range of the total hardness from 32.3mg/l to 40.22 mg/l. A mean value of  $35.3 \pm 2.07$  mg/l was observed which is within the acceptable limit by WHO (2017) and NSDWQ (2007). This is also fell within the Hanna (2003) hardness scale classification for soft water. The low concentration of total hardness could be due to dilution effect of rainfall. The observed total hardness values in this study is fit for drinking and will support fish. This result is collaborated with the findings of Adamu and Wudil (2017) in Watari dam Kano state, Nigeria.

Sulphate occur naturally in surface water which arises from the leaching of sulphur compounds either as sulphate minerals such as gypsum or sulphite as pyrite or from sedimentary rocks (Usman, 2015). Sulphate in this study ranged from 11.70 mg/l to 16.30mg/l with the average value of 13.90 mg/l. This value is reported within the

acceptable limits by WHO 2017 and NSDWQ 2007. The low concentration of sulphate could be due to the fact that the sulphate discharged to the lakes was used up as a source of oxygen by bacteria and was converted entirely to H<sub>2</sub>S under anaerobic conditions (Kolo *et al.*, 2010). The study of Akachukwu *et al.* (2019) reported similar findings with the present study.

Nitrate value obtained in this study ranged from 7.21 mg/l to 10.24 mg/l with the mean concentration of 8.26 mg/l. The mean value obtained does not exceed the threshold limit by WHO (2017) and NSDWQ (2007). The low concentration of nitrate could be attributed to inflow of agricultural waste (including excess application of inorganic nitrogenous fertilizers and manures), wastewater disposal and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks during the rainy season. The low nitrates level might as well be attributed to high photosynthetic activities by aquatic plants since the vegetation of the study sites vegetation reflected that of savannah zone, dominated by grass but with scattered trees. This corroborated the study of Yakubu *et al.* (2014) on the assessment of the water quality parameters of Agaie/Lapai dam in Niger State, Nigeria. Suleiman and Ibrahim (2019) observed a similar findings in Zobe reservoir, Dutsinma Katsina State, Nigeria.

Calcium concentration for all the measured samples ranged from 13.4mg/l to 20.2 mg/l with the mean value of  $16.85 \pm 2.79$  mg/l. This is lower than that of NSDWQ 2007 and WHO 2017. Low concentration in the body could cause malfunction of neuromuscular excitability, and function of myocardial system, heart and muscle contractibility, including blood coagulation (Shuaibu *et al.*, 2020). According to Mustapha (2008), waters with calcium levels of <10 mg/L are usually oligotrophic, while those above 25 mg/l are eutrophic. Dilution from heavy rains coupled with the weathering from rock, and run-offs from surrounding watershed might have contributed to the availability of calcium and magnesium ions.

Magnesium values obtained in this study ranged from 14.86 mg/l to 20.52 mg/l with the mean value of  $18.45 \pm 2.31$  mg/l. The mean values obtained are within the stipulated limit set by WHO (2017). This result agreed with the similar findings of Olanrewaju *et al.* (2017). Shuaibu *et al.* (2020) reported that magnesium deficiency increases risk to humans of developing various pathological conditions such as vasoconstrictions, hypertension, atherosclerotic vascular disease, and acute myocardial infection.

The obtained result for water quality index (WQI) revealed that the Kwanar-Are water is not fit for drinking as well as irrigation since the value were found to be 85.27. Therefore, this value is within the critical value of 100. The status of the water is very poor and requires further treatment before drinking.

**Table 3:** Summary statistics of chemical parameters (mg/l)

Parameters	Min	Max	Mean	St. dev.	Standards		
					WHO 2017		NSDWQ 2007
					HDL	MPL	
DO	1.15	1.25	1.20	0.04	-	5.0	5.0
BOD	0.68	0.95	0.79	0.09	-	10	6
TA	24.91	30.0	27.69	1.82	-	200	500
Cl <sup>-</sup>	79.52	143	115.64	24.22	200	600	250
TH	32.3	40.22	35.30	3.07	100	500	150
SO <sub>4</sub>	11.70	16.30	13.90	1.63	200	400	100
NO <sub>3</sub>	7.21	10.24	8.62	1.07	45	-	50
Ca <sup>2+</sup>	13.4	20.2	16.85	2.79	75	200	75
Mg <sup>2+</sup>	14.86	20.52	18.45	2.31	30	150	0.20

HDL = Highest desirable limit, MPL = Maximum permissible limit

**Table 4:** Water Quality Index (WQI) for collected water samples

Parameters	Observed value (Vi)	Standard value (Si)	1/Si	Weight (Wi)	Sub-index (Qi)	WiQi
DO	1.20	5	0.2	0.580	139.58	80.96
BOD	0.79	10	0.1	0.290	7.9	2.29
TA	27.69	200	0.005	0.014	13.85	0.19
Cl <sup>-</sup>	115.64	600	0.0017	0.005	19.27	0.10
TH	35.30	500	0.002	0.006	7.06	0.04
SO <sub>4</sub>	13.90	400	0.0025	0.007	3.48	0.02
NO <sub>3</sub>	8.62	45	0.0222	0.064	19.16	1.23
Ca <sup>2+</sup>	16.85	200	0.005	0.014	8.43	0.12
Mg <sup>2+</sup>	18.45	150	0.007	0.019	12.3	0.23
			Σ = 0.345	Σ = 0.999	Σ = 85.18	

## CONCLUSION

The findings from present study revealed that, all the parameters were found to be within the permissible limit recommended by WHO (2017) and NSDWQ (2007). The WQI assessment indicated that the quality of water was very poor which is unsuitable for human consumption and domestic uses. Boiling of water and good hygiene practice is advised. It is recommended that governments should strengthen mechanisms to monitor and enforce regulations on the quality of surface water. Water management plan is highly needed in the area. Water should carefully treated before drinking. Further investigation on bacteriological parameters is also recommended.

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