Assessment of Physicochemical Quality Parameters of Thomas Dam Water for Irrigation Suitability in Kano State, Nigeria

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Abstract
Water scarcity is a major challenge faced by humanity and alternative means to complement demand are employed to solve these issues globally. The study focus on the assessment of the physicochemical quality parameter of Thomas Dam located in Danmarke village within Dambatta L.G.A., Kano State. Analyses were conducted on the water samples collected for parameters such as pH, EC, TDS, SAR and Na% amongst others. The result indicated that all parameters were within the limits allowed for irrigation water. Assessment of irrigation parameter showed that SAR average value was 5.30±3.06 and that of Na% was 76.64±14.65. Classification restriction degree for use in irrigation farming using SAR and EC values obtained showed the range slight to moderate. The study therefore concluded that individuals and governmental organizations consigned with the management of such water and surrounding environment should be on the lookout in order to prevent accumulation of toxic materials in irrigated crops and prevent great public health problems.

Keywords: *Irrigation water quality, Physicochemical, SAR, Thomas Dam.*

Introduction

Water scarcity is a major challenge to the existence of life in our universe (Huertas *et al.,* 2008; Meneses *et al.,* 2010). Several factors are behind water shortage globally such as increase in human population, low rainfall intensity, high evaporation, industrialization, and increased demand on fresh water amongst others. Constant increase in the demand for water has resulted in alternative means to complement supply (Levine and Asano, 2004; *Asano et al.,* 2008).
In an attempt to provide lasting solution to water problems alternative measures such as reclamation of wastewater, construction of dams, desalination, water harvesting amongst other methods are employed (Asano *et al.,* 2008). However, water quality parameters are defined based on its intended use i.e. water which might be suitable for drinking and other domestic activities might not be for irrigation and industrial uses. Therefore, irrigation water quality required careful planning and implementation of policies to safe guide public health (Al-khashman *et al.,* 2013; WHO, 2006).

Irrigation agriculture is dependent on an adequate water supply of usable quality (Huertas *et al.,* 2008). Emphasis is placed on the chemical and physical characteristics of water considered for irrigation purpose (IWMI, 2006; WHO, 2006). Thus in turn determine the type of crops

irrigated with such water and also considered in describing the effects of such water on soil quality profiling. Establishment of irrigation water quality criteria should consider parameters like salinity hazard, sodium hazard, pH, alkalinity, specific ions and microbial load of the water (Ayers and Westcot 1985; WHO, 1989; Pescod, 1992). The objective of this paper is the assessment of water quality parameter of Thomas dam water for irrigation purpose.

Methodology

Thomas dam constructed during Late AuduBako administration in 1973. The Dam was named "Thomas" which was derived from the name of the stream. The Dam is about 585 square meters, while the depth is about 30m. The dam is now sited near Danmarke village in Dambatta Local Government Area of Kano State, about 30 km away from the ancient Kano city (Fig. 1). Sandy-loam and clay–loam are the soil types of the area of which they are rich in nutrients and other minerals. The vegetation of the area is of Sudan Savannah type. Rainy season occurs during the warm summer months (May to September) with average rainfall estimated at 385 mm during months of July and August. Total annual water evaporation was calculated as 248 mm from the station, and monthly evaporation varies from 171m in December to 270 m in May (Mukhtar, 2000).

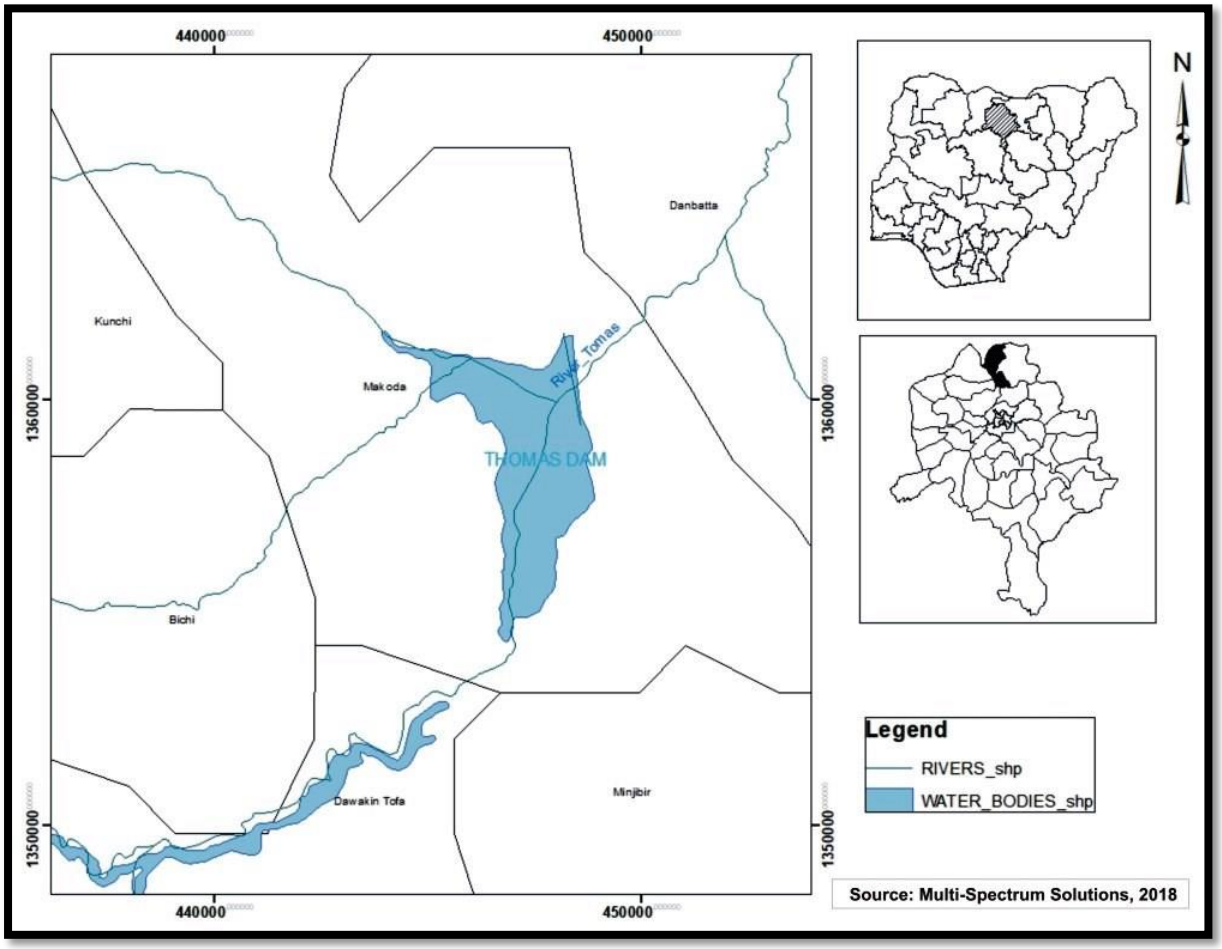

Figure 1: Map showing the description of Thomas Dam water

Water samples were collected from the sampling site in accordance to methods described by APHA, (1998) for a period of 8 weeks during the dry season in triplicates. After which analysis were conducted for the following parameters: turbidity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Total Dissolved Solute (TDS), Total Soluble Solute (TSS) and

alkalinity following methods described by APHA. Irrigation water quality indication such as pH, electric conductivity (EC), Sodium adsorption ratio (SAR), and Sodium percentage (Na %) was used to access suitability of the water for irrigation purpose.

Results and discussions

Twenty four water samples were collected from different locations in the dam for the study within the period of eight weeks from April to May 2018. Statistical summary from table 1 shows that the average pH of 7.54±0.52 was recorded for the water. The normal pH values of water used in irrigation agriculture ranges from 6.5-8.4and values outside such range may cause nutritional imbalance or contain toxic ions as reported by WHO, 2006; Tak, *et al.*, 2012.

An abnormal value indicates that the water needs further evaluation. Electrical conductivity of the water had 1.06±0.27dS/m which also reflects the salinity as TDS of water samples and it's suitability for use in irrigation farming. However, TDS mean values were within 676.06±173.86mg/L and considered a good measurement of salinity hazard to irrigated crops. The ionic abundance showed variations within the water samples, potassium had an average of 8.86±4.2mg/L, sodium (95.34±44.09mg/L), calcium (17.07±6.66mg/L), magnesium (7.88±3.46mg/L), bicarbonate (231.69±34.89mg/L) and carbonate (164.99±32.57mg/L).Turbidity of the water sample was low with an average value of 36.53±9.64cm.

Table 1: Physicochemical quality parameters of Thomas Dam water

Parameter	Unit	Min.	Max.	Mean	SD
pH	-	6.25	8.54	7.54	0.52
EC	dS/m	0.43	1.67	1.06	0.27
Turbidity	cm	19.66	49.00	36.53	9.64
TDS		277.55	1068.80	676.06	173.86
TSS		20.00	39.00	27.63	6.34
DO		2.05	5.64	4.35	1.04
BOD_5		19.00	89.00	55.21	19.05
Na^+	mg/L	27.56	149.09	95.34	44.09
Ca^{2+}		7.00	28.33	17.07	6.66
Mg^{2+}		3.67	17.67	7.88	3.46
K^+		1.30	17.65	8.86	4.20
HCO_3^-		181.68	258.39	231.69	34.89
CO_3^{2-}		103.92	208.98	164.99	32.57

The Sodium adsorption ratio (SAR) defines the sodicity in terms of the relative concentration of sodium (Na) compared to the sum of calcium (Ca) and magnesium (Mg) ions in the water sample and it addresses the potential for infiltration problems due to sodium imbalance in irrigation water (Tak, *et al.*, 2012). Water suitability for irrigation is analysis based on certain qualities, their adverse effects on soil and plant growth (Ayers and Westcot, 1985). Reduction in water infiltration can occur when irrigation water contains high sodium relative to that of calcium and magnesium. The SAR values are defined using the formula:

$$\text{SAR} = \frac{Na^+ meq/L}{\sqrt{\frac{\left(Ca^+\frac{meq}{L}\right)+\left(Mg^{++}\frac{meq}{L}\right)}{2}}}$$

Table 2: Sodium adsorption ratio and Sodium percentage value of Thomas Dam water.

Parameter	Min	Max	Mean	Sd
SAR	1.34	10.15	5.30	3.06
Na%	50	92	76.64	14.65

From table 2, the SAR values ranged from 1.34-10.15 with an average of 5.30±3.06. The SAR values obtained (Table 2) can be further explained based on the guidelines adopted from University of California Committee of Consultants 1974 (Table 3) which illustrates the potential of irrigation water causing infiltration problems using the SAR and EC values. It showed that the SAR and EC values obtained were within the range slight to moderate as classification degree of restriction for use in irrigation farming.

Table 3: Guidelines for assessment of sodium hazard of irrigation water based on SAR and EC.

	Degree of restriction on use		
	None	Slight to moderate	Severe
	EC_w (dS/m)		
When SAR=0-3 and EC_w	>0.7	0.2-0.7	<0.2
When SAR=3-6 and EC_w	>1.2	0.3-1.2	<0.3
When SAR=6-12 and EC_w	>1.9	0.5-1.9	<0.5
When SAR=12-20and EC_w	>2.9	1.3-2.9	<1.3
When SAR=20-40 and EC_w	>5.0	2.9-5.0	<2.9

***Source:** Ayer and Westcot (1989): Water quality for Agriculture, Irrigation and Drainage paper 29, rev. 1, Food and Agriculture Organization of the United Nations, Rome.

These implies that no soil or cropping problems are experienced with water values less than those shown in the 'no restriction or none' degree of classification. With restrictions in the slight to moderate range values, gradually increase care in selection of crop and management alternatives if required for full yield potential is to be achieved. On the other hand, if the water has equal or exceeding values shown for severe restrictions, the water user should experience soil and cropping problems or reduced yields. If water quality values are found which approach or exceed those given for the severe restriction category, it is recommended that before initiating the use of such water in a large project, a series of pilot farming studies should be conducted to determine the economics of the farming and cropping techniques that need to be implemented.

Another parameter used in the study for the assessment of irrigation water quality is sodium percentages. This is calculated using the formula:

$$\text{Na \%} = \frac{Na+K}{Ca+Mg+Na+K} * 100$$

The result obtained reveals minimum value of 50% and a maximum of 92% with an average of 76.64±14.65 sodium percentages in the samples collected (Table 2). Majority of the samples had sodium percentage values greater than 80 which are classified as unsuitable water for irrigation (Table 4). This might have resulted due to time variation in sample collection and other domestic activities engaged by locals within the dam site. Higher concentration of sodium in irrigation water tends to be absorbed by clay minerals displaying magnesium and calcium

which reduces permeability and eventually results in soil with weak internal drainage (Al-khashman *et al.,* 2013). Although plant growth is primarily limited by salinity (EC_w) level of the irrigation water, the application of water with a sodium imbalance can further reduce yield under certain soil texture conditions (Tak, *et al.,* 2012).

Table 4: Suitability of water for irrigation based on Sodium percentages

Sodium percentages	Water class	No. of samples	Sample %
<20	Excellent	-	-
20-40	Good	-	-
40-60	Permissible	7	29.17
60-80	Doubtful	3	12.50
>80	Unsuitable	14	58.33

Conclusion

Analysis on the water physicochemical quality parameters were conducted and assessed for suitability in irrigated agriculture. The study emphasize on the effects of irrigation water on the general productivity of crops, effects on soil profile and microbial content of the soil which can inversely result in serious public health issues if mismanaged. However, domestic activities of locals within irrigation water body's sites contribute greatly to water quality parameters. This study therefore concluded that individuals and governmental organizations consigned with the management of such water and surrounding environment should be on the lookout in order to prevent accumulation of toxic materials in irrigated crops and prevent great public health problems.

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