Direct RESEARCH JOURNALS

Direct Research Journal of Engineering and Information Technology
Vol. 7(2), pp. 27-34, June 2020
ISSN 2354-4155
DOI: https://doi.org/10.26765/DRJEIT10873984
Article Number: DRJEIT10873984
Copyright © 2020
Author(s) retain the copyright of this article
http://directresearchpublisher.org/drjeit/

Full Length Research Paper

Salinity Levels of Irrigation Water for Bakori, Jibia and Mairuwa Irrigation Schemes in Katsina State, Nigeria

Umar A. Masari, Isiya Aminu Dabai and Magaji Sani

Department of Civil Engineering Technology, Federal Polytechnic, Kaura Namoda, Zamfara State, Nigeria.
*Corresponding author E-mail: masariumar93@gmail.com

Received 3 April 2020; Accepted 21 May, 2020

ABSTRACT: Irrigation water quality has great significance especially in arid and semi-arid regions and it is based on salinity and permeability. In this research, water samples were collected in a dry season from Bakori, Jibia and Mairuwa irrigation schemes in Katsina State Nigeria. Electronic Conductivity (EC), Total Dissolved Solids (TDS) and Total Hardness (TH) test in accordance with APHA 2005, standard methods for examination of water and wastewater were conducted in order to determine the salinity level in irrigation water. The result shows that average values of EC are 6.18, 6.22 and 2.51dS/m for Bakori, Mairuwa and Jibia respectively while TDS values are found to be 297.3, 297.6 and 119mg/l for Bakori, Mairuwa and Jibia. The TH values for Bakori and Mairuwa are 97.3 and 98.2mg/l while that of Jibia was recorded as low as 61.3mg/l.

Keywords: Irrigation water; Irrigation scheme; Salinity; Water quality; EC; Katsina State

INTRODUCTION

In semi-arid regions, environmental deterioration and scarcity of water have increasingly becoming serious problem (Ajon et al., 2014), especially in extreme part of Northern Nigeria like Katsina State. In order to decelerate the degradation of the environment and to lessen the conflicts between water users sectors, there is need to controlled unprecedented waste release in to the environment (Danazumi and Bichi, 2010; Ekiye and Luo, 2010) as well as efficient quality and quality of water for domestic, industrial and agricultural purposes. Natural resources depletion was caused by increasing demand of water due to industrialization, agricultural practice and rapid population growth (Krishan et al., 2016; Kumar et al., 2016).

In such region, surface water, especially in the dams shoulder the responsibility for water supply and play detrimental role for satisfying industrial, drinking, domestic and agricultural demands (Zahedi, 2017; Sad at-Noor et al., 2013). Forecast on water need globally, predicts sharp future increase in demand in order to satisfy the aforementioned conflicting sectors of interest, because more than one billion people do not yet have access to good quality and quantity of water and sanitary (Fererer and Maria, 2007) and little attention was paid to meet the requirement of water for healthy ecosystem. General belief is that the worldwide single problem is scarce of water and there uncertainly about the intensity of the problem in future.

Irrigation sector is one of the main users of global diverted water with a proportion above 70-80% in semi-arid zones (Martina et al., 2016) and account for more than 40% of the total land and utilizes only 17% of the land for production of crops (Fererer et al., 2004) to cater for the present teaming and increase in population in the future. Therefore, management of irrigation water in the scarcity zones must be effectively carried out to save

water and maximizing productivity. Water conservation through increasing water use efficiency in irrigation and promoting dry land farming with effective use of rain fall during rainy season will play detrimen role in maintaining food production and security (Adamu, 2013; Deng et al., 2006).

Irrigated agriculture being combination of dams, canals, gates and irrigable land for growing crops, in essence, plant growth and its yield depend solemnly on the quality of irrigation water. This quality is a function of anthropogenic activities ranging from urbanization, industrialization to agricultural practices like application of organic and/or inorganic fertilizers and pesticides, as well as weathering, catchment erosion and other natural processes (Baath et al., 2017). Among the natural phenomenon, geology of the region, rate of weathering of some types of rocks, other inputs apart from rock-water interaction play vital roles in controlling the quality of surface water bodies and this may lead to reduction of irrigation water quality (Drechsel et al., 2015; Schacht et al., 2016; Wada et al., 2012), with increase in dissolved substances, salinity and subsequent restrain of growth and yield of plants (Anikwe et al., 2002; Munns, 1973)
Generally, all waters for irrigation contain certain level of salt and as evapotranspiration take place, salt concentrations increases in the soil profile and should be displaced away from plant root region before reaching the level that inhibit growth and yields of plants. Application of excess irrigation water above required for crop water relationship and evapotranspiration in order to leach the excess salt concentration in soil deep down to ground away from root zone (Nematian, 2016). In this, there is unavoidable water loses to checkmate the balances of salts and will only be possible and efficient in an area abundance water resources supply not the areas with water shortages like Katsina State.

Plant growth is usually reduced due to high salts and water absorption by roots of the plant as a result of excessive osmotic pressure of water, and high level of soluble salts in the roots. Globally, salt-affected potential arable covered about 33% (Assouline et al., 2015), with 950 million hectares in semi-arid and arid regions. About 20% of the land (450,000km^2) allocated for irrigation globally affected by salt and 2000 hectares of farm land is lost every day by degradation related to salts and the inflation adjusted cost of salt-induced land degradation in 2013 was estimated at $440 per hectares (Qadir et al., 2014), yielding $27 billion/year in excess to an estimate of global economic loses.

Due to alliance of economic, agronomic and environmental implications of irrigation with saline water coupled with global stress in freshwater supply, there is need to check the salinity of an irrigation in order to improve the growth of plant and yields of irrigated crops and also avoid unnecessary excessive water use for leaching. This research intended to access the salinity of irrigation water in Bakori, Jibia and Mairuwa dams in Katsina State in order to avoid the problems associated with high salinity in the irrigation systems by investigating the electrical conductivity (EC), total dissolved solids (TDS) and total hardness (TH) (Ismail et al., 2016; Martina et al., 2016; Bassuony et al., 2012; Jahin and Gabar, 2011) and comparing the values obtained with standard practiced all over the world due the lack of such documented research in the schemes under considerations.

MATERIALS AND METHODS

Study area

Bakori and Mairuwa irrigation Schemes are situated in the Northern part of Katsina State while Jibia irrigation scheme is located in the Southern part of the State. Katsina State covering an area of 24,192 km^2, located between 12° 15′ 0″ N, 7° 30′ 0″ E, with population estimate as of 2016 to be 10,102,813 (Mikhail, 2016), it forms part of the extensive plains known as the high plains of Hausaland in Northern part of Nigeria as it can be seen from (Figure 1). The state is composed of undulating plains which generally rise gently from 360m in the northeast around Daura to 600m around Funtua in the southwest. Generally, the state has two geological regions. The south and central parts of the state are underlain by crystalline rocks of the basement complex (from Funtua to Dutsin-ma) where Bakori and Mairuwa schemes is located, but in the northern parts cretaceous sediments overlap the crystalline rocks where Jibia scheme was established. The Katsina-Daura plains lie at a lower base level than other parts of the state. Southwards of the Katsina-Daura plains, is the flat to gently undulating surface which is the end result of years of erosion action on the surface rock. In areas around Funtua and Dutsen-ma, there are numerous quartzatic and granitic hills which rise 600m above the surrounding plains. These hills are probably the results of the intrusion of older granites into the basement complex which have undergone long periods of denudation (Buchanan and Pugh, 1955). The state can be classified into two zones climatically; tropical continental and semi arid continental. The south of the state (from Funtua to Dutsen-ma) belongs to the tropical continental with total annual rainfall values ranging from 1000mm around Funtua to over 800m around Dutsen-ma. The north of Katsina State (from Kankia to the extreme north east) has total rainfall values ranging from 600 to 700mm annually. Generally climate varies considerably according to months and seasons (Wakuti, 1973).

Major rivers which originate in or transverse the state include the Koza, Sabke, Tagwai and Gada systems in the northern half of the state (all flowing either north or north-westwards). Rivers in the south include, the Karaduwa, Bunsuru, Gagare, Turami, Sokoto, Tubo,

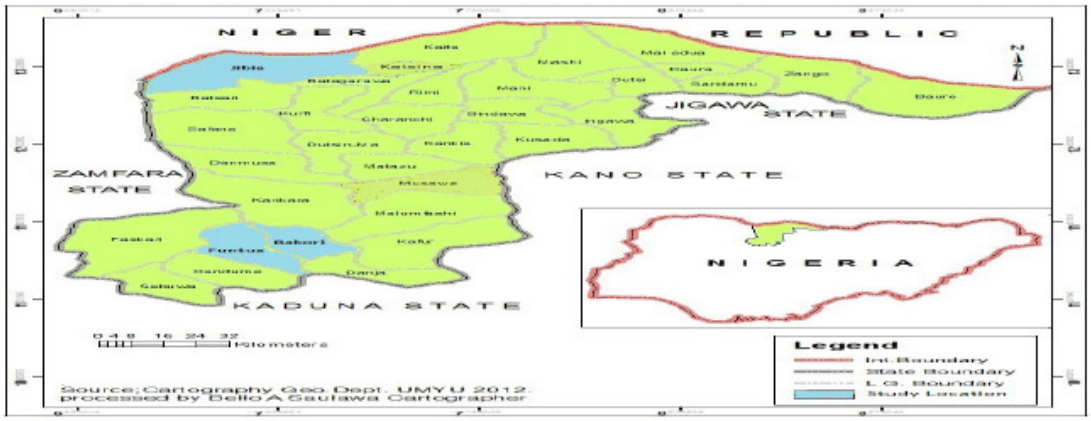


Figure 1: Map of Katsina State showing the study areas (Bello (2012).

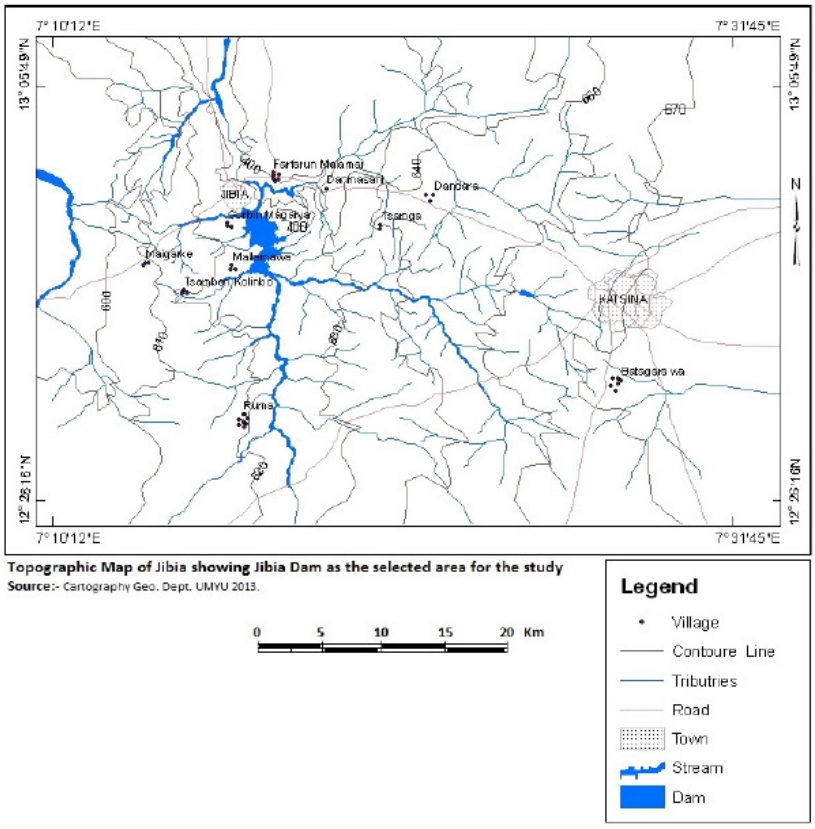
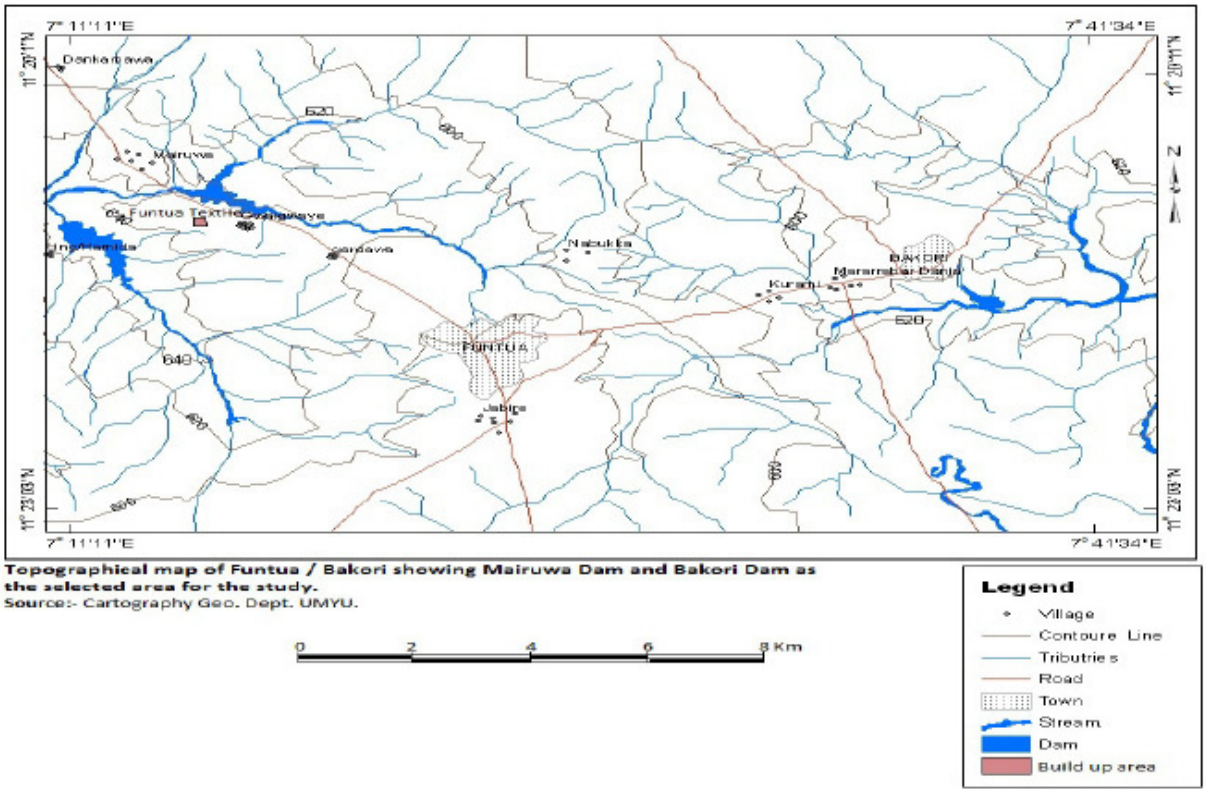


Figure 2: Topographical Map Showing Jibia Dam and its tributaries.
Source: (Bello, 2013).

Chalawa, Jare and Gilme rivers (flowing either northwest, southeast or east). However, all these river systems contain water in their channels only during the rainy season and have little or no water in the dry-season (Sokoto Rima River Basin Development Authority; SRRBDA, 2013). The major sources of water for Bakori, Jibia and Mairuwa dams is runoff from their respective watersheds in the catchment which travels through a long distance to the reservoirs as it can be seen from (Figures 1, 2 and 3). This causes a significant level of pollution by mixed up with all surface pollutants and soil or rock constituents which in turn dissolved in to the runoff and this may alter the physio-chemical and bacteriological properties of the runoff and find its way



Topographical map of Funtua / Bakori showing Mairuwa Dam and Bakori Dam as the selected area for the study.
Source:- Cartography Geo. Dept. UMYU.

Figure 3: Topographical Map Showing Bakori and Mairuwa Dam and their tributaries
Source: (Bello, 2013).

to streams, rivers and reservoirs.

A field research was conducted to assess the salinity level of water for irrigation purposes in Bakori, Jibia and Mairuwa Irrigation Schemes in Katsina State. Ten water samples each from the schemes (a total of thirty) were collected at different point in each dam in bottles on 19th March, 2017 and then taken to laboratory for testing. The collected water samples were preserved in separate containers according to the parameters needed to be measured and they were preserved in cold icebox until they reach the laboratory. The chemical analyses were conducted according to the Standard methods for the analysis of water and wastewater (APHA, 2005). The Electrical Conductivity (EC) and Total Dissolved Solids (TDS) was measured using an Orion (T^414) multi-parameter meter and Total Hardness (TH) using EDTA-titrimetric method.

RESULTS AND DISCUSSION

Electrical conductivity (EC) was used to measure hazards associated with salinity being most important water quality guideline on growth of plant and its subsequent yield (Jahin and Gabar, 2011). It can be seen from Table 1, that the EC values obtained from Bakori dam ranges between 6.15-6.28dS/m with an average of 6.22dS/m while EC obtained in Mairuwa which ranges between 6.17-6.26dS/m with an average of average of 6.22dS/m, this was close to that of Bakori as it can be observed from Figure 4 where plots overlap each other due to their closeness in location and the same source of water. The values obtained from Jibia dam was found to be lower than that from Bakori and Mairuwa which range between 2.44-2.63dS/m with an average of 2.51dS/m.

Elevated values of EC in irrigation water can damage plant growth media and rooting, resulting in nutrient imbalances and water uptake. Even though EC values are important for dissolution of salts, but it should not be more than 3dS/m (FAO, 1994; Christiansen et al., 1977) the EC values obtained from Jibia dam was within this limit while those obtained from Bakori and Mairuwa are above the permissible limit of less than 3dS/m.

Data of TDS as presented in Table 1, indicates that the values obtained from Bakori dam ranges between 292-302mg/l with an average of 297.3mg/l, while that of Mairuwa dam is between 296-299mg/l with an average of 297.6mg/l and the TDS values from Jibia dam ranges

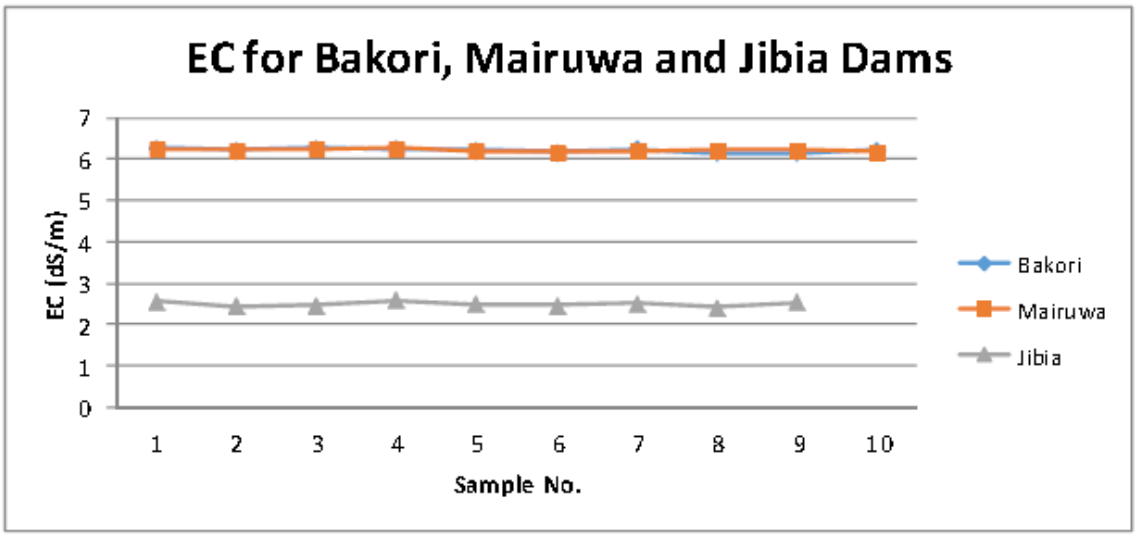


Figure 4: EC for Bakori, Mairuwa and Jibia Dams.

Table 1: EC, TDS and TH of water samples from Bakori, Mairuwa and Jibia Dams.

Sample No	Bakori Dam		
	Conductivity (dS/m)	TDS (mg/l)	Total Hardness TH (mg/l)
1	6.27	296	99
2	6.21	294	96
3	6.28	302	98
4	6.25	298	94
5	6.22	292	94
6	6.18	296	96
7	6.24	299	98
8	6.15	295	97
9	6.16	301	102
10	6.22	298	99
Sample No	**Mairuwa Dam**		
	Conductivity (dS/m)	**TDS (mg/l)**	**Total Hardness TH (mg/l)**
1	6.24	299	96
2	6.22	297	98
3	6.25	299	102
4	6.26	295	94
5	6.20	297	90
6	6.18	298	96
7	6.19	296	99
8	6.23	299	97
9	6.22	298	105
10	6.17	298	102
Sample No	**Jibia Dam**		
	Conductivity (dS/m)	**TDS (mg/l)**	**Total Hardness TH (mg/l)**
1	2.63	124	60
2	2.56	120	58
3	2.44	115	57
4	2.46	121	62
5	2.58	123	63
6	2.49	116	58
7	2.47	117	69
8	2.52	122	56
9	2.41	114	63
10	2.54	118	67

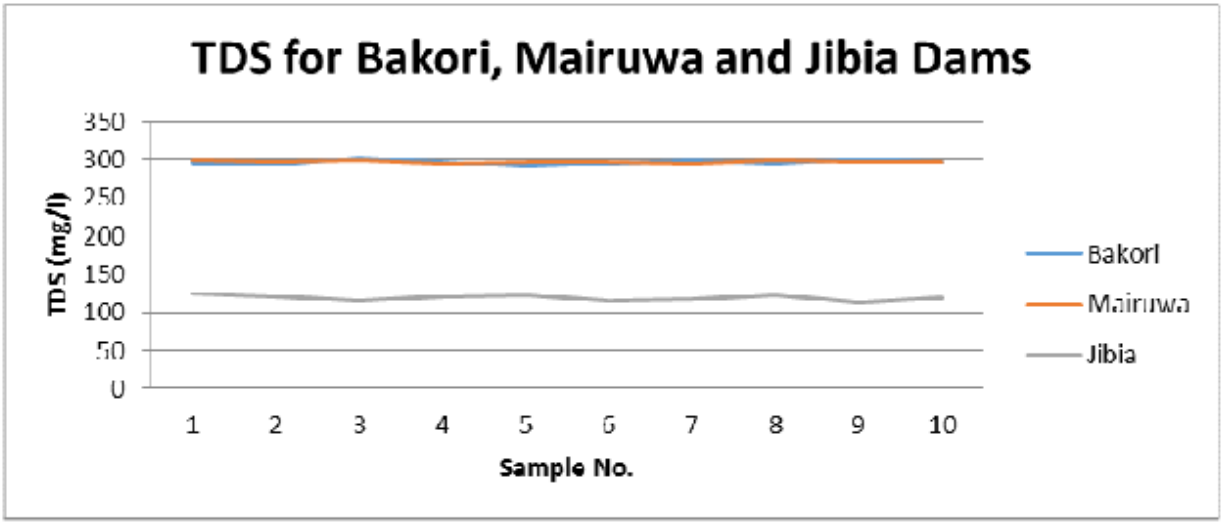


Figure 5: TDS values for Bakori, Mairuwa and Jibia Dams.

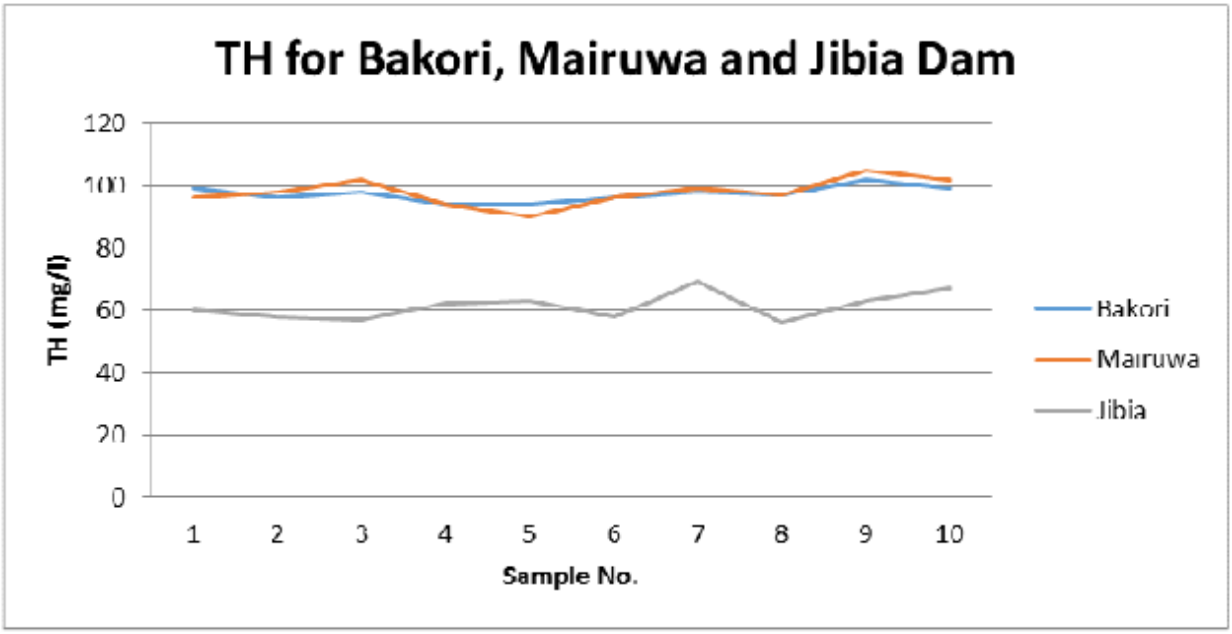


Figure 6: TH for Bakori, Mairuwa and Jibia Dams.

between 114-124mg/l with an average of 119mg/l as it can be observed from Figure 5, TDS values for Jibia far less than that of Bakori and Mairuwa. TDS levels should be below 640mg/l to avoid problems in plugs and below 960mg/l (Bryan, 2017) for other plants growing conditions, while levels above 2000mg/l are likely to cause plant growth problems (FAO, 1994).

As closely related to EC, high TDS waters will need advanced treatment or dilution to make it suitable for irrigation purposes. Dissolved salts in irrigation water present numerous challenges to plants especially to the growers. Salts reduce the osmotic potential of water, increasing the energy that plants use to extract moisture from soil (Adamu, 2013; USDA, 1954), and making them more susceptible to wilting. In addition to contributing to water stress, some constituents of salts are toxic if they accumulate in the leaves and stem. High sodium levels can also reduce the rate that water infiltrates into soil. All TDS values obtained from the three irrigation water were within the limit specified by FAO. Majority of the irrigated

crops grown in the schemes, which include maize, tomatoes, pepper, lettuce, wheat, and beans, are all moderately tolerant, for TDS and EC (George, 2004; Tanji, 1990).

Hardness being determined by the calcium and magnesium content of water, since calcium and magnesium are essential nutrients for plant growth and development. Moderate levels of hardness ranges between 100-150mg/l are considered ideal for plant growth (Bryan, 2017). Total hardness (HT) tests from the dams under consideration revealed that the values for Bakori dam was found to range between 94-102mg/l with an average of 97.3mg/l, while the hardness at Mairuwa ranges from 94-105mg/l with an average of 98.2mg/l. The hardness recorded at Jibia dam ranges between 56-69mg/l with an average of 61.3mg/l. Also from Figure 6, TH values for Bakori and Mairuwa are higher than that of Jibia.

According to FAO (1994) for efficient plant growth, the total hardness of irrigation water should not be less than 80mg/l. It could be observed that that the hardness requirement obtained from irrigation water from Bakori and Mairuwa while that of Jibia was less than the minimum amount required for efficient plant growth. Higher concentrations of hardness above 150mg/l (Bryan, 2017; George, 2004) will build up on contact surfaces, plug pipes and irrigation lines especially for sprinkler and drip methods of irrigation and also cause foliar deposits of scales on plants.

Conclusion

The EC, TDS and TH parameters of water samples from Bakori, Jibia and Mairuwa Irrigation Schemes was obtained and compared with water quality standards for irrigation purposes. The results shows that the average values of EC was found to be less than 3dS/m which was within the limit specified by FAO (1994), while those obtained from Bakori and Mairuwa are above the limit. TDS values are all within the acceptable range specified for proper plant growth. Lastly, the TH values obtained from Bakori and Mairuwa are within the limit for plant growth while that of Jibia found to be a little bit lower than minimum value required for proper growth of plants.

REFERENCES

Adamu GK (2013). 'Quality of Irrigation Water and Soil Characteristics of Watari Irrigation Project' American Journal of Engineering Research, Vol. 2(3):59-68.

Ajon AT, Utsev JT , Nnanji CC (2014). "Physiochemical Quality of Irrigation Water in River Katsina-ala Catchment Areas of Northern Nigeria, Current World Environment, Vol. 9(2): 301-311.

American Public Health Association (APHA) (2005). 'Standard methods for the examination of water and wastewater' (22thEd.), DC 200036, Washington, D.C.

Anikwe MAN, Ofeke PE, Mbah CN (2002). 'Relationship between Irrigation Water Quality and Salinity of selected Irrigation Soil in Abakaliki South Eastern Nigeria' Nigerian Journal of Soil Res, 47(3):220-223.

Assouline S, Russo D, Silber A (2015). "Balancing water scarcity and quality for sustainable irrigated agriculture" Water Resour. Res., 51, 3419–3436, doi:10.1002/ 2015WR017071.

Baath SG, Shukla KM, Bosland PW, Stainer RL , Walker SJ (2017). 'Irrigation salinity in at various growth stages of Capsium annuum' Agricultural Water Management, 179: 246-253 https://doi.org/10.1016/j.agwat.2016.05.028

Bassuony MA, Ali ME, Abdelhameed AH, Jahin HS (2012). "Evaluation of Irrigation Water Quality in Different Regions of North East Delta-Egypt" International Journal of Engineering and Applied Sciences, Vol. 5, No. 01 www.eaas-journal.org.

Bello AS (2012). "Map of Katsina State showing Study Areas" Cartography, Department of Geography, Umar Musa Yar'adua University, Katsina (UMYU).

Bello AS (2013). "Topographical Maps for Study Areas" Cartography, Department of Geography, Umar Musa Yar'adua University, Katsina (UMYU)

Bryan S (2017) "Interpreting Irrigation Water Test" College of Agricultural Sciences research and extension, Pennsylvania State University

Buchanan KM, Pugh JC. (1955). 'Land and People of Nigeria, University of London Press, London Retrieved www.worldwidelife.org/ecoregions/ati010/05/05/12

Christiansen JE, Olsen EC, Willard LS (1977). 'Irrigation Water' Journal of Irrigation and Drainage Div, ASCE 103: 155-169.

Danazumi S, Bichi MH (2010). 'Industrial pollution and heavy metals profile in Chalawa River in Kano, Nigeria' Journal of Applied Sciences in Environmental Sanitation, 5(1): 23-29.

Deng XP, Shun L, Zhang H, Neil CT (2006). 'Improving agricultural water use efficiency in arid and semi-arid areas of China' Agricultural water management, 80: 23-40.

Drechsel P, Danso G, Qqdir M (2015). 'Wastewater use in agriculture: challenges in assessing cost and benefits' Wastewater, Spinger, pp. 139-152.

Ekiye E and Luo Z (2010). 'Water Quality Monitoring in Nigeria; case Study of Nigeria's Industrial Cities' Journal of American Science Vol. 6(4).

Fererer E, Cannon DJ, Cabrera E, Cobacho R (2004). 'Sustainable water management in agriculture: Challenges in new water policies for the XXI century' Lisse, The Netherlands, A. A Bulkema pp. 157-170.

Fererer E, Maria AS (2007). 'Deficit irrigation for reducing agricultural water use' Journal of Experimental Botany 58(2):147-159 https://doi.org/10.1093/jxb/erl165

Food and Agriculture Organization (FAO) (1994). "Water Quality for Agriculture" Irrigation and Drainage Paper 29, Rev. 1, Rome.

George PR (2004). 'Agricultural Water Quality Criteria' Irrigation Aspect Res. Mgt. Tech. Report No. 30. Department of Agriculture, Western Australia.

Ismail T, Halil K, sadat K, Zeki G (2016). 'Effect of irrigation water quality (different salinity levels and boron concentrations on morphological characteristics of grafted and non-grafted Eggplant' Current Trend in Natural Sciences, 5(1): 179-186.

Jahin HS, Gaber SE (2011). "Study of ground water quality in El-kharga Oasis, Western Desert, Egypt" Asian Journal of Water, Environment and Pollution, Vol.8 No. 4, Pp.1-7.

Krishan G, Sigh S, Kumar CP, Gurjar S, Ghosh NC (2016). 'Assessment of water quality index (WQI) of groundwater in Rajkot district, Gujarat, India, Journal of Earth Sci. Clim Change, 7(134) (10.4172.2157-7617.1000341).

Kumar P, Tharkur PK, Bansod BKS, Debnath SK (2016). 'Assessment of the effectiveness of DRASTIC in predicting the vulnerability of groundwater to contaminants: a case study from Fatehgarh Sahib District in Punjab, India, 75 pp. 879.

Martina F, Julia F, Marcus M, Jeanetti V, Joseph A (2016). 'Implications of salinity pollution hotspots on agricultural production' EGU General Assembly, Vienna, Austria, id. EPSC 2016-15192.

Mikhail Z (2016). "Katsina State Population" Nigerian Data Portal, National Bureau of Statistics, Nigeria.

Munns R (1973). 'Comparative physiology of salt and water stress'

Plant Cell Environ., 25: 239-250.
Nematian J (2016). 'An extended two-stage stochastic programming for water resources management under uncertainty' Journal of Environ Informatics, 27(2): 72-84.
Qadir M, Quill_erou E, Nangia V, Murtaza G, Singh M, Thomas RJ, Drechsel P, Noble AD (2014). "Economics of salt-induced land degradation and restoration" Nat. Resour. Forum, 38:282–295.
Sadat-Noor SM, Ibrahim K, Liaghat AM (2013). 'Groundwater quality assessment using the water quality index and GIS in Saveh-Nabaran equifer, Iran' Environ Earth Sci 71(9): 3827-3843.
Schacht K, Chan Y, Tarchitzky J, Marshner B (2016). 'The use of treated water for irrigation as a component of integrated water resource management: reducing environmental implications on soil and groundwater by evaluating site-specific soil sensitivities' Irrigated Water Resources Management: concept, research and implementation, Spinger, pp. 459-470.
Tanji KK (Ed.) (1990). "Agricultural salinity assessment and management" American Society of Civil Engineers (ASCE) Manuals and reports on engineering Practice No.71, New York, USA.
USDA (1954). "Diagnosis and improvement of saline and alkali soils" U.S. Dep. Agric., Hand book, No.60, pp 160.
Wada Y, Beek L Bierkens MF (2012). 'Non-sustainable groundwater sustaining irrigation: a global assessment' Water Resource Res. 48.
Wakuti CE (1973). 'Water Resources Development Master Plan of the Area "A" in the Northern Part of Katsina Emirate North Central State Water Board, Federal Republic of Nigeria.
Zahedi S (2017). 'Modification of expected conflicts between drinking water quality and irrigation water quality index in water quality ranking of shared extraction wells in multi criteria decision making techniques' Ecological Indicators, 83: 368-379.