

ASSESSMENT OF TUBEWELL WATER QUALITY USED FOR IRRIGATION IN KEBBI STATE, NORTH-WESTERN, NIGERIA.

ABSTRACT

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand for more water of high quality for domestic, agricultural and other economic activities like transportation and recreation increases. A field experiment was conducted with the aim of assessing the tubewell water quality used for irrigation in four (4) selected local Government Area of Kebbi State, North-Western Nigeria. From each local government area, water samples in triplicates were collected from in clean 2liter plastic bottles. Each water sample was analyzed for pH, electrical conductivity (Ec), total dissolved solid (TDS), sodium adsorption ratio (SAR), residual sodium concentration (RSC), calcium (Ca), magnesium (Mg), potassium (K), Sodium (Na), chloride (Cl⁻) and (P) using standard procedures. Result obtained showed that overall mean of pH, SAR, Ca, Mg, K, Na, P and Cl were 6.3, 1.5mg/l, 165.17mg/l, 128.0mg/l, 1.20, 7.47, 0.16 and 3.75 mg/l, respectively. However, Ca (165.17mg/l), and Mg (128.00mg/l) were observed to high concentration in almost all the selected local government areas. Furthermore, result obtained also revealed that tubewell water were high for the parameters considered and therefore special attention must be given to Bunza tubewell to avoid becoming saline or sodic which could have detrimental effects on growing crops.

Keywords: Tubewell, water quality, irrigation, sodicity, Nigeria.

INTRODUCTION

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand for more water of high quality for domestic, agricultural and other economic activities like transportation and recreation (UNEP, 2001). Water sources other than rainfall, include streams, rivers, dams, ponds and tubewells. Despite its importance, water is the most poorly managed resource in the world. The quality of any body of surface or ground water is a function of either or both natural influences and human activities (Kolawole et al., 2008).

However, the way that water has been managed in agriculture has caused wide scale change in land cover with water courses, contributing to ecosystem degradation and undermining the process that supports ecosystem and the provision of a wide range of ecosystem services essential for human well-being. (Megersa and Abdulahi 2015, Malin *et. al.*, 2007, Adelana and Olusehinde, 2003).

Irrigation waters whether derived from springs, diverted from streams or pumped from well contain appreciable quantities of chemical substances in solution that may reduce crop yield and deteriorate soil fertility. Also it may carry substances derived from its natural environment or from the waste products of man's activities (domestic and industrial effluents). Understanding irrigation water quality is critical for sustainability of crop production (Dukes *et. al.*, 2005). Poor quality water may affect irrigated crops by causing accumulation of salts in the root zone, by causing loss of permeability of the soil due to excess sodium or calcium leaching, or by containing pathogens or contaminants which are directly toxic to plants or to those consuming them (Rhodes, 1974; Cooper, *et al.*, 1992). Water used for irrigation can vary greatly in quality depending upon types and quantity of dissolved salts, these salts are applied with the water and remained behind in the soil as water evaporates or is used by the crop (Tanji, 1990, Longenecker and Lyerly 1974). However water quality in irrigated agriculture include salinity hazard (Total Soluble Salt Content), Sodium hazard, (ratio of Sodium (Na⁺) to Calcium (Ca²⁺) and Magnesium (Mg²⁺) ions, water pH, Alkalinity (Carbonate and Bicarbonate) specific ions: Chloride (Cl⁻) Sulfate (So₄²⁻), Boron (Bo) and nitrate – nitrogen (NO₃N), Organic contaminant (Oil pollutant) and other factors such as heavy metals (Bauder *et. al.*, 2007). It is commonly accepted that the problems originating from irrigation water quality vary in type and severity as a function of numerous

factors including the type of soil and the crop, the climate of the area as well as the farmer who utilizes the water. So, evaluation of water used for irrigation is a prime need for sustainable crop production as well as food security (Chukwuma *et al.*, 2016).

This research is therefore aimed at evaluating irrigation water quality from tubewell in selected local government areas of Kebbi State and to ascertain its suitability for crop production..

MATERIAL AND METHOD

Study Area

The Study comprises of four local government areas of the state, namely, Augie (4.6 12⁰ 52' N, 4⁰ 36' 0"E), Argungu (12⁰ 44' 36.02N, 4⁰ 31' 36.73E), Birnin Kebbi (12⁰ 27' 7.79"N, 4⁰ 12' 0.60"E) and Bunza (12⁰ 5' 3.98"N, 4⁰ 1' 38.91"E) local government areas. Kebbi State is situated in the extreme north-west of Nigeria between latitudes 10⁰06'-13⁰10¹ North and longitudes 3⁰0¹-6⁰03¹ East (KARDA, 1998). It shares boarder with both Niger and Benin Republics in the west. On the East, it is bordered by Sokoto State and in the South by Niger State. The State enjoys a semi-arid climate where precipitation is usually less than the normal requirement of most agricultural crops. The rainy season consists of a short (May – October) period with rainfall poorly distributed throughout the growing period. Frequent and heaviest precipitation is experienced between August and September. The annual rainfall ranges from 400 to 850mm increasing both in quantity and intensity within the state from north to south (Kebbi Investment Company Limited, 2000).

Sample Collection

Water samples were collected in 1.5 liters sterilized bottles in triplicates. Water samples were collected from three (3) different boreholes per local government and blended together to form a representative sample in all the four (4) local government areas. Water sample was collected in March, 2021 during dry season. After sampling, the bottles were marked, sealed and taken to the laboratory for further analyses.

Sample Analysis

Water quality sampling was carried out according to American Public Health Association (APHA; 2005). EC and pH measurements were determined using EC and pH Meters which were calibrated prior to taking readings. The sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were calculated as follows:-

$$\text{SAR} = \frac{\text{Na}^{2+}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}} \dots\dots\dots (\text{Brady and Weil, 1999})$$

$$\text{RSC} = (\text{CO}_3^{2-} + \text{HCO}_3^-) - (\text{Ca}^{2+} + \text{Mg}^{2+}) \dots\dots\dots (\text{Doneen, 1964})$$

Statistical Analysis

The data obtained was subjected to analysis of variance (ANOVA) using SPSS (2000). Means found to be significantly different were separated using Duncan New Multiple Range Test (DNMRT). The treatment means were separated at 5% level of probability

RESULT AND DISCUSSION

Table 1. Mean values of pH, EC (ds/m), SAR (mg/l), TDS (mg/l) RSC (mg/l) and HCO₃⁻ for Tubewell Water of some selected Local Governments areas of Kebbi State

LGA	pH	EC	SAR	TDS	RSC
Augie	6.3	0.247	0.24	0.933	36.57
Argungu	6.4	0.802	0.69	0.533	23.33
B/Kebbi	6.0	0.124	0.08	0.533	10.27
Bunza	6.6	2.413	1.54	3.767	117.33
Overall Mean	6.3	0.896	0.64	1.442	35.21
SE±	0.808	0.362	0.269	0.458	575.07

Table 1 showed that the pH of the tubewell water in the study areas ranged from 6.0 – 6.6 (overall mean pH 6.3 indicating that the water samples were slightly acidic). However, when comparing the mean values within the selected local government areas, Bunza local

government area appeared to have highest pH value of 6.6 indicating that the water was neutral. While Argungu (6.4), Augie (6.3) and the lowest (6.0) was observed in Birnin Kebbi had a pH of 6.4, 6.3 and 6.0 respectively indicating a slightly acidic water samples. Although all the water samples from the study areas were observed to be within the recommended pH range of 6.5- 8.4 for irrigation water as given by FAO (2005) and WHO (2008). This result agrees with that obtained by Augie (2004) for tubewell water (5.4-7.7) in fadama soils of Sokoto state. Similarly pH (5.1-7.8) was reported by Singh (2000b) for tubewell water in Zamfara state. The mean pH values obtained shows that the tubewell water is safe for irrigation, although application of irrigation water with pH outside the threshold could cause nutritional disparity or lead to toxic ion build up in the soil (Adegbola *et al*, 2021; Ayers *et al.*, 1985).

Electrical conductivity (EC) is the ability of water to transmit the electric current. It is a good indicator of the overall amounts of mineral salts contained in water (Warrence *et al*. 2003). When the EC of water is high, it shows that there is high concentration of ions in the water and also affects the plant growth. EC from table 1 shows that the value ranged from 0.124-2.413ds/m with a mean value of 0.896ds/m indicating low EC when compared with irrigation quality standard of 0-3ds/m as recommended by regulatory agency (Bauder *et al.*, 2011). However, special attention must be given to tubewell water from Bunza with a mean value of 2.41ds/m because any increase in EC will lead soil clogging and permeability hence restricting the movement of nutrients from soil to crop through the roots (Bauder *et al.*, 2011; Sanda *et al.*, 2020). Result obtained in this study agrees with report of Singh (2000a) that 98% of the tubewell water in Kebbi state belonged low to medium salinity water category.

The overall mean value of the Sodium Adsorption Ratio (SAR) from table 1 ranged from 0.08-1.54mg/l with overall mean value of 0.64. SAR is the measure of the proportion of sodium to calcium and magnesium in the water. According to U S Salinity Laboratory Staff (Richards, 1954) who observed that, water with SAR value of <10 is considered excellent for irrigation. Therefore tubewell water from the study areas is considered as free from sodicity problems and could be suitable for irrigation without any restriction. This result agreed with Singh *et al.* (1996) and Singh and Tsoho (2001) who reported SAR values of 0.71 and 0.75 for Kandoli Shela Stream water.

Residual sodium carbonate (RSC) is used to determine the hazardous effects of carbonate and bicarbonate on irrigation water quality. RSC according to table 1 indicated Bunza had the highest value of 117.33mg/l while Augie had the lowest RSC value of 36.57. RSC value from all the study areas were below < 2.5mg/l and therefore safe for irrigation. The tube well water of the fadama of Kebbi State with RSC could be safely used for irrigation in terms of carbonates and bicarbonates hazards. Similarly, Singh (2000a) reported low RSC value for irrigation water samples in Kebbi and Zamfara States and were also below the maximum permissible limit according to WHO 2008 and Salifu *et al.*, 2017.

The TDS value of the tube well water of Kebbi state as presented in table 1 shows that the values ranged from 0.533 – 3.767 (overall mean 1.442 mg/l). The result showed that Bunza local government area had highest TDS value of 3.767mg/l. when compared with other local government areas. It was followed by Augie local government area with mean TDS value of 0.933mg/l⁻¹ while Argungu and BirninKebbi local government areas were statistically the same with mean values of 0.533mg/l⁻¹ each. This result contradicted the observation of Singh (2000) who reported TDS range of 10-3250 (mean 419) mg/l for tube well water in the fadama areas of Kebbi State. Similarly, mean value of 555mg/l⁻¹ was observed in Sokoto river water (Singh and Tsoho2001). As per the mean TDS value of 1.442mg/l and the criteria set by Todd 1980; WHO 2008; Salifu *et al.*, 2017 that water with TDS 0-2000mg/l, could be

rated as fresh and could be used for irrigation without any restriction, the tube well water of the study area could safely be used for irrigation.

Table 2. Mean values Ca (mg/l), Mg (mg/l), K (mg/l), Na (mg/l) and Clmg/l of some selected Local Governments Areas of Kebbi State

LGA	Ca	Mg	K	Na	Cl
Augie	51.33	52.00	0.33	1.77	1.33
Argungu	80.00	62.00	1.47	5.90	3.60
B/Kebbi	50.00	77.60	0.33	0.63	1.77
Bunza	479.33	320.40	2.67	21.57	8.30
Overall Mean	165.17	128.00	1.20	7.47	3.75
SE±	62.63	46.96	0.394	3.144	1.057

Means having different letter(s) along the same column differed significantly ($p < 0.05$)

The concentrations of exchangeable cations in the tubewell water of Kebbi state were presented in table 2. The table showed that the respective mean values in the tubewell water of Kebbi State for Ca, Mg, K, and Na were 165.17mg/l, 128.00mg/l, 1.20mg/l and 7.47mg/l, respectively.

The study revealed high concentration of Ca (165.17mg/l). However, when comparing within the selected local government areas, Bunza local government area had highest calcium value of 479.33mg/l while lowest value of Ca was observed in Birnin Kebbi local government area with mean value of 50mg/l. The values obtained falls within the Ca range of 29-467mg/l as reported by WHO 2008 and Salifu *et al.*, 2017 and also for Kebbi state as reported by Singh (2000a). High concentration of Ca in irrigation water is known to cause salinity problems. Unfortunately, the result revealed high concentration of Ca in Bunza irrigation water and therefore should be appropriately managed to avoid further accumulation of calcium salt on the irrigated soils.

The obtained exchangeable Mg value in the water of the study area was 128.00mg/l. Similarly, the result in table 2 showed that Bunza local government area had significantly higher magnesium content than other local government areas with mean values of 320.40mg/l which is higher than the permissible limit set by WHO 2008 and Salifu *et al.*, 2017 and therefore, urgent attention must be given to irrigation water samples in Bunza. Augie local government area recorded least mean value of 52mg/l for Mg. This result fell within the range of 18-898mg/l for tubewell water in Kebbi state (Singh, 2000a). Similar result was reported (18-360mg/l) in Zamfara state (Singh, 2000b). Substantially, high concentration of Mg and K in irrigation water suggests that it contains a lot of Mg and K salts. Continuous and particularly excessive irrigation with such water may lead to a build-up of salts and subsequent salinization.

Furthermore, table 2 showed that the overall mean K value of the tubewell water of the study area was 1.20mg/l. In comparing the local government areas, Bunza local government area had the highest potassium content than other local government areas with mean value of

2.67mg^l⁻¹ It was followed by Argungu local government area with mean value of 1.47mg^l⁻¹ while a lower value of 0.33mg^l⁻¹ were observed in Augie and BirninKebbi local government, respectively. The overall K mean value of 1.20mg/l fell within the range of 0.3-19.0mg^l⁻¹ for West African ground water (Roose and Lelong, 1981). Similar result of 1.01mg^l⁻¹ of potassium content was reported by Augie (2019).

The overall Na mean value of the water of the study areas was 7.47mg/l (table 2). It follows similar trend of Bunza having the highest Na content when compared with other local government areas with mean value of 21.57mg^l⁻¹. This result fell within the range of 1-160mg^l⁻¹ for tubewell water in Kebbi state (Singh, 2000a) and ≤ 200 according to WHO 2008 and Salifu *et al.*, 2017. Similarly, a sodium mean value of 0.2-49.0mg^l⁻¹ was recorded for West African ground water (Roose and Lelong, 1981).

Chloride (Cl⁻) is a toxic substance that requires special attention when water is used for irrigation. The observed mean concentration of the tubewell water of the study areas ranged from 1.33 to 8.30 mg/l (overall mean 3.75) mg/l. However, on the bases of comparison, it follows similar trend of Bunza having the highest Cl⁻ value with Augie recording the lowest value 1.33mg/l. Based on the classification of water for irrigation according to WHO 2008; Salifu *et al.*, 2017 in terms of chloride concentration, the result indicated that the water is safe to be used for irrigation. Chloride is very essential to plants but at very low concentration. This is so because Cl⁻ is not tied up by the soil, but it is moved with the soil-water, being absorbed by the crop, translocates in the transpiration stream, and eventually stored in the stems, roots and leaves of the growing plants.

CONCLUSION

The Tubewell water samples from all the selected local governments appeared to be safe for irrigation purpose because they were below the standard set by WHO 2006, 2008 and Salifu *et al.*, 2017. However, special attention must be given to Bunza tubewell because of its high concentration of all the parameters considered and therefore has a tendency for the soil to become prone to sodic.

Recommendations

Based on the results obtained, the following recommendations would be given: -

1. As a result of high concentration of Ca and Mg ions in the tube well water of the study area, farmers could be advised to ensure light but frequent irrigation with this water to avoid accumulation of these ions on the soil surface.
2. As a result of high concentration of other cations such as Na, Ka and Cl, farmers would be advised to apply proper water management practices to prevent the soil from being saline or sodic which could have detrimental effects on growing crops and soil physical characteristics.
3. Based on the salinity and sodicity parameters such as pH, Ec, TDS and ESP, the water could be used for irrigation without any restrictions.

DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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