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

ABSTRACT

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, three farms wererandonmly selected.Water samplesin triplicates were collected from each farm totaling twelvesamplesfrom the four selected local government areas. These samples were collected in clean 2 liter water bottles provided with caps to avoid any contamination. 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 was 6.3, SAR was 1.5mg/l,K, Na, P and Cl were 1.20, 7.47, 0.16 and 3.75 mg/l, respectively. However, there was high concentration of Ca (165.17mg/l), and Mg (128.00mg/l) in almost all the selected local government areas. Result shows that Tubewell water samples from all the selected local government areas appeared TDS free and were rated fresh water and therefore could be used safely for irrigation purposes without any restriction. All the water samples belonged to C_1 (low salinity water category) and therefore suitable for irrigation. The water also appeared to be free from sodicity problem at least for now. However, Based on the high concentration of K, Na, P, and Clthetubewell water in the study area could be considered to have potential threat to salinity and sodicity problem in the very near future. In view of that, proper water management practices should be applied to prevent the soil from being saline or sodic which could have detrimental effects on growing crops.

Keywords: Tubewell,water quality, irrigation, kebbi and sodicity.

INTRODUCTION

A tubewell is a type of well in which a long 100-200mm (5-8 inches) wide stainless steel tube or pipe bored into an underground aquifers. The lower is fitted with a strainer and a pump at the top that lifts water for irrigation. The required depth of the well depends on the water table. It is a known fact that tubewell water has been one of the major sources of water for irrigation in the fadama soils of KebbiState.

The use of low quality irrigation water coupled with semi-arid weather condition of the area could make the irrigated soils prone to salinity and sodicity hazards. Use of poor quality irrigation water can have adverse effects on both soil and the growing crops (Bello 2001).

The most ordinarily dissolved ions in water that are detrimental to both soil and growing crops when in high concentrations are sodium, magnesium, calcium (Ca^{2+}), sulphate ($SO4^{2-}$), nitrate (NO_3^-), chloride (Cl^-), boron (B), carbonate (CO_3^{2-}) and bicarbonates (HCO_3^-) (Adamu, 2013). The concentration and proportion of these dissolved ions among other things determine the suitability of water for irrigation (Ajayi, 1990; Adamu, 2013).

Therefore, there is need to ascertain the current quality status of tubewell waterbeing used for irrigation in the area. The information obtained could help in knowing the appropriate management practices to be employed in using this water for irrigation purpose.

MATERIAL AND METHOD

Kebbi State - Location and Agroclimate

Kebbi State is situated in the extreme north-west of Nigeria between latitudes 10^o06^1-13^o10^1 North and longitudes 3^o0^1-6^o03^1 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). The continental air mass from Sahara usually brings a season of very cold weather (the harmattan) with very low temperatures in the night during the months of November to early February. The harmattan winds during this period are very descanting and blow a lot of sand.

Fig 1: Study area

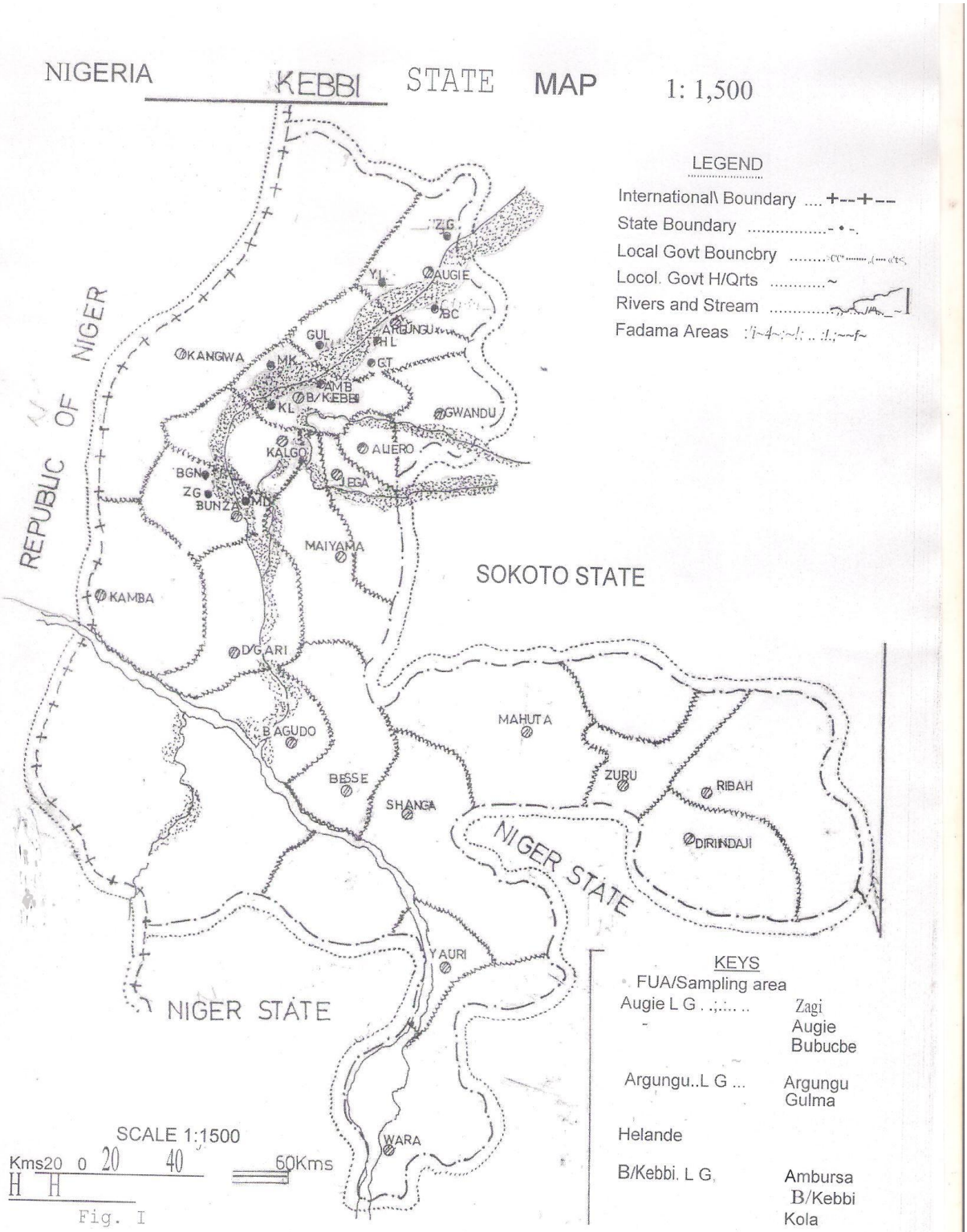

Fig. I

Map of Kebbi State showing the Fadama Users Associations (FUAs) / sampling areas

Sampling Techniques

Four local government areas were selected from the state, namely, Augie, Argungu, Birninkebbi and Bunza local government areas. From each local government area,one community/village was randomly selected and three farms were also selected within each selected community/village. A sample of water from a tubewell in each selected farm was collected. Two-liter plastic bottles were used in collecting water samples. Each bottle was thoroughly washed using distilled water in the laboratory before taken to the field. This was to avoid contamination of the collected samples. Each water bottle was provided with a cap to ensure that the collected sample was a true representation of the water from the aquifer.

Water Sample Analysis

The procedure described by Chopra and Kanwar (1991) was used for the analysis of water samples; pH and electrical conductivity (EC) meters were used to determine pH and electrical conductivity, respectively. Total dissolved solids (TDS) were determined by evaporation and drying method. Carbonate and bicarbonate ions were determined by Atomic Absorption Spectrophotometer. Potassium and sodium were read on flame photometer. The sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were calculated as follows:-

$$SAR = \frac{\text{Exchangeable sodium}}{\sqrt{\frac{Ca + Mg}{2}}}$$

$$RSC = (CO_3 + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

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).

RESULT AND DISCUSSION

Table 1. Mean values of pH, EC (dsm/l), SAR (mg/l), TDS (mg/l) RSC (mg/l) and HCO_3^- for Tubewell Water of some selected Local Governments areas of Kebbi State

LGA	pH	EC	SAR	TDS	RSC	HCO_3^-
Augie	6.3^{ab}	0.247^{b}	0.24^{a}	0.933^{b}	-36.57^{a}	66.67^{a}
Argungu	6.4^{a}	0.802^{ab}	0.69^{a}	0.533^{b}	23.33^{a}	165.33^{a}
B/Kebbi	6.0^{b}	0.124^{b}	0.08^{a}	0.533^{b}	-10.27^{a}	117.33^{a}
Bunza	6.6^{a}	2.413^{b}	1.54^{a}	3.767^{a}	-117.33^{a}	85.33^{a}
Overall Mean	**6.3**	**0.896**	**0.64**	**1.442**	**-35.21**	**108.67**
SE±	**0.808**	**0.362**	**0.269**	**0.458**	**575.07**	**19.77**

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

pH of Tubewell Water

Table1 Showed that the pH of the tubewell water in Kebbi state ranged from 6.0 – 6.6 (overall mean pH 6.3). 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 which was within the recommended pH range of 6.5- 8.4 for irrigation water as given by Ayers and Westcot(1976) and FAO(1985).It was then followed by Argungu local government area with pH value of 6.4.Argungu was then followed byAugie local government area with pH mean value of 6.3. Lowest pH value of 6.0 was observed in BirninKebbi local government area.These values fell within the range of 5.4-7.7 (mean 6.5) for tubewell water in fadama soils of Sokoto state as given by Augie(2004). Similarly pH range of 5.1-7.8(mean 6.7) was reported by Singh (2000b) for tubewell water in Zamfara state.Acording to Ayers and Westcot(1976) and FAO(1985), normal and safe pH range of irrigation water is 6.5- 8.4. Based on this, the tube well water of the study area with PH ean value of 6.3 could be safely used for irrigation.

Electrical Conductivity of the Tubewell Water

The values of electrical conductivity (EC) of the tubewell water of Kebbi state were presented in Table 1. The values ranged from 0.124 – 2.413dSm/l withoverall mean value of 0.896dSm/l Based on the U S Salinity Laboratory Staff (Richards, 1954) classification of irrigation water, the water could be classified as C1- low salinity water category and could therefore be used for irrigation without any restriction. This also agreed with report of Singh (2000a) that 98% of the tubewell water in Kebbi state belonged to C1-C2 (low to medium salinity water category).

Sodium Adsorption Ratio (SAR)

The overall mean value of the Sodium Adsorption Ration(SAR) in the water of the study area was 0.64mg/l.Bunza local government area had highest SAR value of 1.54mg/l. It was followed by Argungu local government area with mean EC value of 0.69mg/l while Augie and B/Kebbi local governments areas recorded 0.24mg/l and 0.08mg/l, respectively.According to U S Salinity Laboratory Staff (Richards, 1954) who observed that, water with SAR value of >10 is considered as low in sodium, and therefore the tubewell water of Kebbi state which contained SAR value of 0.64mg/l could be 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 for KandoliShela Stream water and SAR value of 0.75, respectively. They considered the water from the two sources as free from sodicity problem and thereforegood for irrigation.

Residual Sodium Carbonates(RSC)

The result in Table 1 indicated absence of carbonate CO_3^- in the tubewell water of Kebbi state while HCO_3^- ranged from 66.67 - 165.33 (overall mean 108.67mg/l). When making comparism between the local government areas, Argungu local government area has highest HCO_3^- value of 165.33mg/l, followed by B/Kebbi with mean value of 115.33mg/l while Bunza local government area recorded a mean RSC value of 85.33mg/l and the lowest mean value of 66.67mg/l was observed in Augie local government area of Kebbi state. RSC in the study area was observed to be negative (-35.21)..Based on the report by Wilwox (1954) that water with RSC > 1.25mg/l is safe for irrigation, the tube well water of the fadama of Kebbi

State withnegative RSC could be safely used for irrigation interms of carbonates and bicarbonates hazards. Du Preez(1961) reported no carbonates in the water of Nigerian basementcomplex. Similarly, Singh(2000a) reported that there was negative amount of carbonates andbicarbonates in the water of Kebbi and Zamfara States.

Total Dissolved Solids (TDS).

The TDS value of the tube well water of Kebbi state is presented in Table 1. 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 0.933mgl^{-1} while Argungu and BirninKebbi local government areas were statistically the same with mean values of 0.533mgl^{-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 555mgl^{-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) that water with TDS 0-1000mg/l, could be rated as fresh andcould be used for irrigation without any restriction, the tube well water of the study area could safely be used for irrigation.

Table 2.Mean valuesCa (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^{b}	52.00^{b}	0.33^{b}	1.77^{b}	1.33^{b}
Argungu	80.00^{b}	62.00^{ab}	1.47^{ab}	5.90^{b}	3.60^{ab}
B/Kebbi	50.00^{b}	77.60^{ab}	0.33^{b}	0.63^{b}	1.77^{b}
Bunza	479.33^{a}	320.40^{a}	2.67^{a}	21.57^{a}	8.30^{a}
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 ($p<0.05$)

Concentration of Basic Cations

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 Kebbistate forCa, Mg, K, and Na were 165.17mg/l, 128.00mg/l, 1.20mg/l and7.47mg/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,. It was followed by Argungu local government area with mean value of 80mg/l and Argungu was followed byAugie local government area with calcium content of 51.33mgl^{-1} while lowest value of Ca was observed in BirninKebbi local government area with mean value of 50mgl^{-1}. These results agreed and fell within theCa range of 29-467mgl^{-1}

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 the water of the study area and therefore it should be appropriately managed to avoid further accumulation of calcium salton the irrigated soils.

The obtained exchangeable Mg value in the water of the study area was128.00mg/l.The result in Table 2.showed that Bunza local government area had significantly (P>0.05) higher magnesium content than other local government areas with mean values of 320.40mgl^{-1}. It was followed by BirninKebbi local government area with mean values of 77.60mgl$^{-1.}$ Argungu local government area on the other hand had Mg meanvalue of 62mgl^{-1} while Augie local government area recorded least mean value of 52mgl^{-1} for Mg. This result fell within the range of 18-898mgl^{-1} for tubewell water in Kebbi state (Singh, 2000a). Similar result was reported (18-360mgl^{-1}) in Zamfara state (Singh, 2000b). Substantially, high concentration of Mg and K in irrigation water suggests tha 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.

The result in 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 significantly (P<0.05) highest potassium content than other local government areas with mean value of 2.67mgl^{-1} It was followed by Argungu local government area with mean value of 1.47mgl^{-1} while a lower value of 0.33mgl^{-1} were observed in Augie and BirninKebbi local government, respectively. The overall K mean value of 1.20mg/l fell within the range of 0.3-19.0mgl^{-1} for West African ground water (Roose and Lelong, 1981). Similar result of 1.01mg^{-1} of potassium content was reported by Augie (2019).

The overall Na mean value of the water of the study area was 7.47mg/l(Table 2). As for the individual local government areas studied,Bunza local government area was significantly (P<0.05) the highest in exchangeable sodium content when compared with other local government areas with mean value of 21.57mgl^{-1}. It was followed byArgungu local government area with mean value of 5.90mgl^{-1} while Augie and BirninKebbi local government recorded mean value of 1.77 and 0.63mgl^{-1}, respectively. This result fell within the range of 1-160mgl^{-1} for tubewell water in Kebbi state (Singh, 2000a). Similarly, a sodium mean value of 0.2-49.0mgl^{-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 meanCl^- ion concentration of the tubewell water of the stydy areas ranged from 1.33 to 8.30 mg/l (overall mean 3.75) mg/l. However, on the bases of comparison within the selected local government areas, Bunza local government area recorded significantly (P>0.05) highestCl^- value of 8.30 mg/l, It was followed by Argungu local government area with mean value of 3.60mg/l whileB/Kebbi local government area recorded Cl mean value of 1.77mg/l.Augie local government area on the other hand recordedCl mean value of 1.33 mg/l. Based on the classification of water for irrigation 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 TDS free and were rated fresh water, therefore could be used safely for irrigation purposes with no restrictions. All the water samples belong to C_1 (low salinity water category) and therefore suitable for irrigation.With regards to sodification, the water samples from all the selected local governments appeared to be free from sodicity problems with an overall SAR mean value of $1.5mgl^{-1}$. The overall mean pH 6.6 was within the normal range of (6.5 to 8.4) for irrigation water. However, high concentration of Ca and Mg in almost all the selected local governments particularly in Bunza local government was observed. The tubewell water, though appeared to be free from sodicity problem, however, the higher concentration of sodium especially in Bunza local government makes the soils more prone to sodification.

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 sodicityparameters such as pH, Ec, TDS and ESP, the water could be used for irrigation without any restrictions.

COMPETING INTERESTS 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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