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Irrigation Suitability of Ground Water at Lowland Areas of Selected Local Government Area in Kebbi State, North Western, Nigeria

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Abstract: **Introduction**-Ground water is an important water resource for agricultural production in other to meet global food demand as a result of increase in human population coupled with reduction in agricultural land. **Aim**-The aim of this research was to assess the ground water quality of lowland areas of Selected Local Government Area of Kebbi State. **Methodology**-Water samples were collected in triplicates and blended together to form a representative sample. The samples were taken from a 75 cl clean water bottle with a stopper. Parameters analysed includes pH, Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Total Dissolved Solid (TDS), Electrical Conductivity (EC), Residual sodium carbonate (RSC), Carbonate (Co_3^{-1}) and Bicarbonate (HCo_3^{-1}). Data obtained was subjected to descriptive statistics to compare the differences that existed within and between the sampling areas. **Result**-Result obtained shows that TDS was 24 Mg/l^{-1}, pH 6.3, EC 268dsm^{-1}, Ca (1.8mgl^{-1}), Mg (1.14mgl^{-1}), K (0.6mgl^{-1}) and Na (2.3mgl^{-1}). The water was categorized as fresh and therefore suitable for irrigation without any restriction. **Conclusion**-Based on the high concentration of Na ion (2.3mgl^{-1}) in the water under study compared with other soluble salts, EC value of 268dsm^{-1} and SAR value of 1.76mgl^{-1}, the water has the potential to become saline and sodic. In view of that, frequent but light water applications should be the best practice to prevent further accumulation of salts on the soil surface. Irrigation could also be done either in the morning or late in the evening so as to reduce the rate of evaporation.

Keywords: Electrical conductivity, ground water, Kebbi, saline and sodic.

INTRODUCTION

Increasing human population in the world means there is need for increase in food production. However, food production to this growing population is decreasing due to poor agricultural practices and reduction in agricultural lands. One of the ways to solve this problem is through the use of irrigation practices [Sanda, A. R. *et al*., 2014].

Water quality is an essential factor of consideration while deciding to use any water resource for irrigation, because use of poor quality irrigation water can adversely affect crop production as well as soil quality [Musa, A. A. *et al*., 2014]. The quality of water for irrigation is mostly affected by natural factors such as rocks, soil surfaces on which it flows and the anthropogenic factors like industrial, agricultural and mining activities (WHO, 1996). The most important characteristics that determine the quality of irrigation water include Total Concentration of Soluble Salts (TDS), Relative Proportions of Sodium (Na) to Calcium (Ca) and Magnesium (Mg), Sodium Adsorption Ratio (SAR), Concentration of Boron and other elements that are phytoxic (Sanda, et al., 2014). According to [Adamu, G. K. *et al*., 2013], the most ordinary dissolved ions in water are sodium (Na), magnesium, calcium sulphate, nirate, chloride, boron, carbonate ($C0_3^-$) and bicarbonate (HCo_3^-) ions. The presence of these ionic species in irrigation water often raises a source of concern, especially when they occur in higher concentrations. The amount of soluble salts that dissolved in water is expressed as total dissolved solids (TDS), their concentration in water is determined in terms of electrical conductivity (EC) measured at 25^0C. It constitutes a measure of salinity hazard for irrigation water. Sodium affected soils take water slowly and results in the formation of dry hard clods that melt when wetted and tend to seal the soil pores at the surface leaving a stink appearance and eventually causing soil sodification. Sodium could not only affect soil structure but may also have toxic effects on growing plants. Water having high concentration of carbonate ions in excess of Ca and Mg would leave behind residual sodium carbonate (RSC) upon evaporation [Augie, M. A. *et al*., 2019].

The consequences of all these are poor crop production and deterioration of agricultural land [Musa, A. A. *et al*., 2014]. Irrigation water could also be classified as acidic, neutral and alkaline. The degree of acidity or alkalinity could be described by pH value that ranges from 0-14. Any value below 7.0 is acidic, at 7.0 is neutral and above 7 is alkaline. The need to use good quality water for irrigation in the study area coupled with considerations of the possible consequences of using poor quality irrigation water made it necessary to investigate the quality of this water resource (ground water) and its inherent chemical characteristics so as to identify appropriate management strategies for sustainable long term agricultural productions in the study area.

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MATERIALS AND METHODS

The Study Area

Gindi lowland area is in the extreme north-western part of Nigeria originating from Zamfara State. It runs South West of Birnin Kebbi, Kebbi State. It is at latitudes 12°11'N, 4^0 16^1E to 13°10'N in the Sudan savannah agro-ecological zone [KARDA. 1998]. The climate of the area is semi-arid with an average annual rainfall of about 500-650mm per annum. The relative humidity ranges from 21-47% and 51-92% during the dry and rainy seasons respectively, whereas temperature ranges from 20-30^{0}C during the dry cold season, and 27-41^{0}C during the hot season. The main source of water for irrigation at the study area is the tube well and the crops commonly grown in the area include cereal crops, such as rice, maize, guinea corn and wheat. Vegetables like tomatoes, pepper, lettuce and spinach, tuber crops, such as potatoes and cassava; and tree crops like mangoes, cashew and guava are all grown in the area [KARDA. 1998]

Sampling Sites

Four local government areas were covered for the purpose of this study, namely Jega, Maiyama, Kalgo, and Bunza local government areas. From each local government area, two villages were randomly selected. The selected villages in Jega local government area were Jega and Gindi, those selected in Maiyama local government area were Mungadi and Gadi. In Kalgo local government the villages selected were Kalgo and Badariya while in Bunza local government area, Loko and T/ Lele were selected (Fig. 1).

Sampling Techniques

Three samples of water collected from each village were later thoroughly mixed to form one representative sample for each village. Clean water bottles washed with distilled water were used in the collection of water samples. Each bottle was sealed tightly with a cap, to avoid contamination of the collected samples and ensure that the samples were true representations of water from the aquifer. The sealed water samples were taken to the laboratory for analysis in the year 2020.

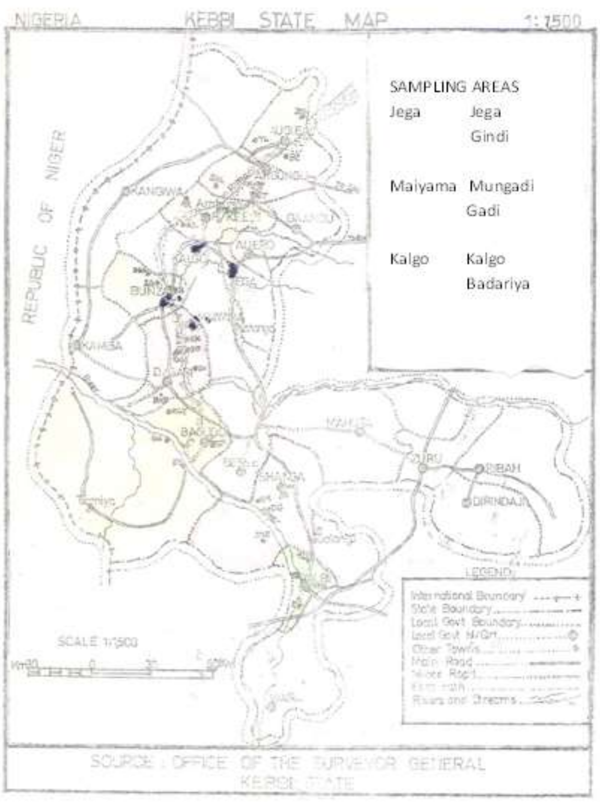

Fig. 1 Map of Kebbi State Showing the Sampled Areas

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Analytical Procedures

Each blended water sample was analyzed following the procedure described by [Roose, E. J. *et al*., 1981]. Electrical conductivity and pH were determined using conductivity meter and glass electrode pH meter, respectively. Total dissolved solids (TDS) were determined by evaporation and drying method. Carbonate and Bicarbonate ions were determined by volumetric titration while calcium was determined by use atomic absorption spectrophotometer. EDTA titration was used to determine Mg while K and Na were read on a flame photometer. Sodium Adsorption Ratio (SAR) and Residual sodium carbonate (RSC) were calculated using the formulae below:-

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

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

STATISTICAL ANALYSIS

The data generated from this research were subjected to descriptive statistics using simple statistical tools such as means, ranges and percentages to compare the differences that existed among the sampling areas.

RESULTS AND DISCUSSION

Table 1: Chemical Composition of Ground Water of the Study Areas

LGA	TDS	Ca	Mg	K	Na	SAR	EC	pH	$C0_3$	$HC0_3$	RSC
Jega	25	1.7	1.0	0.5	1.9	1.25	191.5	6.6	0	2.1	-0.6
Kalgo	25	1.9	1.25	0.8	1.2	0.94	373	6.6	0	2.0	-1.2
Maiyama	23	1.8	1.20	0.8	2.7	1.76	367	6.4	0	2.2	-0.8
Bunza	24	1.7	1.10	0.4	3.6	3.10	140	5.6	0	2.1	-0.7
Overall Means	24.3	1.8	1.4	0.6	2.3	1.8	268	6.3	0	-	-0.5
Ranges	23-25	1.7-1.9	1.0-1.25	0.4-0.8	1.2-3.6	0.94-3.1	140-373	5.6-6.6	0	2.0-2.2	-0.6-1.2

LGA: Local government area, TDS: Total dissolved solid, Ca; Calcium, Mg: Magnesium, K: Potassium, Na: Sodium, SAR: Sodium adsorption ratio, EC: Electrical conductivity, $C0_3$: Carbonates, $HC0_3$ Bicarbonates and RSC; Residual sodium carbonate

Concentration of Basic Cations

Table1 showed the values and overall means of Ca, Mg, K and Na in the water of the four local government areas under study. The ranges and overall means for Ca were 1.7- 1.9 (mean, 1.8) $mgl^{-1,}$ Mg 1.0- 1.3 (mean, 1.4) mg/l^{-1}, K 0.4-0.8 (mean, 0.6) mgl^{-1} and Na 1.2-3.6 (means, 2.34)mgl^{-1} . Based on the overall mean value of Ca (1.8mgl^{-1}), the water of the study area was low in Ca ion concentration and fell within the safe range for irrigation water. [Singh, B. R. *et al*., 2000] reported similar Ca values of 1.8- 12.0mgl^{-1} for the West African ground water while [Singh, B. R. *et al*., 1996] reported Ca value of 0.22-0.5mgl^{-1} for water from the rivers in Sokoto States. [FAO. 1985], reported the Ca value of 29-46mgl^{-1} (mean,17mgl^{-1}) for tube well water in fadama land of Kebbi State. The reported Mg value of 1.0-1.25(mean, 1.14mgl^{-1}) in the ground water of Gindi low land area was within the limit of 0-5mgl^{-1} for the safe use of irrigation as given by [HTSL. 1970]. The K value of 0.4-0.8 (mean, 0.6) $mg1^{1}$ (Table 1), was below the reported K value of 3-19 mgl^{-1} for the West African ground water [Singh, B. R. *et al*., 2000]. [FAO. 1985], reported greater value of 9 mgl^{-1} for the Kandoli Shela stream water in Sokoto state. Based on the control values of K for the safe use of water for irrigation as given by [HTSL. 1970], the water could be used for irrigation without any restriction.

The Na value observed in the ground water of the study area ranged from 1.2-3.6 mgl^{-1} with mean value of 2.3mgl^{-1}. The obtained value of 2.3mgl^{-1} was more than the reported Na value of 24 mgl^{-1} for the water along Dalloi mauri valley in Niger Republic [Singh, B. R. *et al*., 2000]. Based on the obtained value of 2.3mgl^{-1}, the water could be used for irrigation without any hazard. The value of exchangeable bases such as Ca (1.7) mgl^{-1}), Mg (1.14 mgl^{-1}), K (0.6mg11) and Na (2.34 mgl^{-1}) were within the required concentration of basic cations for irrigation water.

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Salinity and Sodicity Indicators

pH, EC and SAR are the major indicators of water quality for irrigation purposes. Table 1 showed that the pH value of water in the study area was 6.3. This was close to the pH of 6.7 for the tube well water in Zamfara State as given by [Dupreez, J. M. *et al*., 1961]. However the observed value of 6.3 was lower than 7.3 and reported by [Singh, B. R. *et al*., 2000] for rivers, streams and lake in Sokoto state. However, pH range of 6.5-8.8 was reported by [Dupreez, J. M. *et al*., 1961] for the underground water in the Nigerian basement complex. As for the pH value of 6.3, the water could be used for irrigation, but with slight restriction to avoid acidification of soil. This is because the safest pH range for irrigation water as given by [Todd, D. K. *et al*., 1980; HTSL. 1970] was 6.5-8.8.

The ground water of study area was observed to have EC range of 140-373 dsm^{-1} (mean, 267.6dsm^{-1}) Table 1. Richard (1954) classified irrigation water into three categories based on its electrical conductivity. Category one, low salinity water EC of (<250dsm-1), category 2, medium salinity water, EC (250-750) and category 3, High salinity water (> 2250dsm^{-1}). Based on this classification, the ground water of the study area with EC of 267.6 dsm^{-1} could be classified as medium salinity water.

The TDS of the ground water of study area was discovered to be within the range of 23-25.1 (mean, 24.27) mgl^{-1}. Based on the classification of water for irrigation given by [16] that water with TDS 0-1000 mgl^{-1} is fresh and that with TDS of 1000 to 10,000 is brackish while water with TDS of 10,000-100,000 is saline, the ground water of the studied area could be classified as fresh and therefore could safely be used for irrigation without any restriction.

The range of bicarbonate in the ground water of the study area was 2.0-2.2 mgl^{-1} (mean, 2.1mgl^{-1}) with 0 carbonate. This agreed with report of [Ayres, R. S. *et al*., 1976] that ground water of the Nigerian basement complex did not contain carbonate ions but possessed negligible bicarbonate ions. It could therefore be mentioned that the concentration $C0_3^{-1}$ (0) mgl^{-1} and bicarbonate (2.1mgl^{-1}) ions are highly negligible to cause any residual carbonate problem on both the soil and growing crops.

The obtained values of SAR ranged from 0.94-3.1 (mean, 1.76) mgl^{-1}. This value was higher than the reported values of 0.32 mgl^{-1}, 0.75 mgl^{-1} and 0.32 mgl^{-1} given by Singh 1996 *et al.* for Kandoli Shela stream, [Singh, B. R . *et al*., 2000] for river Niger and Goronyo Dam, respectively. Based on this moderate concentration, the water could be used for irrigation under the condition of light but frequent application of water to prevent further accumulation of sodium on the soil surfaces.

CONCLUSION

The result of the study indicates that the water was slightly acidic but could be tolerated by many crops grown in the area. The water could be classified as fresh and could therefore be used for irrigation without any restriction. Based on high concentration of Na (2.3 mgl^{-1}) and SAR (1.76) mgl^{-1}, the water could be used for irrigation through light but frequent application to avoid further concentration of Na on the soil surface. The water contained negative RSC which meant low carbonates and bicarbonates. Such water is free from problems associated with residual carbonates and bicarbonates, hence, can be used safely for irrigation.

RECOMMENDATION

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

1. As per the concentration Na (2.3 mgl^{-1}) and SAR (1.76) mgl^{-1}, farmers would be advised to use the ground water of the study area for irrigation but through light but frequent water application to avoid further accumulation of Na ion on the soil surface.
2. The water in Kalgo (Ec 373 dsm^{-1}) and Maiyama (367 dsm^{-1})local government areas could be classified as C2, medium salinity category and therefore could be used for irrigation but with restrictions to avoid further accumulation of salts.
3. Farmers should reduce excessive evaporation on the soil surface which would in turn decrease the concentration of excess salts on the upper most layer of the soils.
4. Farmers should provide adequate drainage that can permit sufficient leaching of excess salts to the desired depth below the rooting zone.

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