Salinity level assessment of Irrigation water sources in some selected Local Government Areas of Kebbi State Nigeria

Sanda, A.R.[1], SaniAbdulkadir[2], Ahmed Idris[1], Saddam Abubakar Kola[1]and Ramatu Idris[1].

1. Department of Soil Science, Faculty of Agriculture, Kebbi State University of Science and Technology Aliero, P.M.B. 1141, Birnin Kebbi, Kebbi State, Nigeria.
2. Soil Science Department, Kano University of Science and Technology, Wudil, Nigeria.

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Abstract – A field and laboratory study was conducted during the 2019 rainy season on the salinity assessment level in water used by farmers to irrigate their crops in some selected local government areas of Kebbi State namely; Bunza, Augie, Yauri and Birnin Kebbi. Water samples were collected from three different sources in clean plastic bottles as Borehole water, Stream water, and a combination of the two that is a blend of borehole and stream water. The collected samples were preserved in an ice crest for onward transporting to laboratory for analysis. The results show all the salinity indices tested were slightly moderate to severe due to continuous poor agricultural practices such as inappropriate fertilizer uses and poor drainage system, however it was observed that stream water has the highest salinity indices, while bore hole water is the next and a blend of the two water has the lowest salinity indices tested.

Keywords: salinity, borehole, stream, irrigation, moderately, severe.

Introduction

Water is an essential resource for living system, industrial process, agricultural production and domestic use. Ninety-seven percent of the world's water is found in ocean. Only 25% of the world's water is non-saline (Kwaghe et al., 2011, Shakoor et al. 2015). However, 75% of all fresh water is bound up in glaciers and ice cap. Only 1% of fresh water is found in lakes, rivers soils and 24% is present as ground water. The use of water increases with growing population, putting increasing strain of these water resources. There is a growing human population in the world which means there is need for an increase in food production (Sadik 2011). However, food production to feed this growing population is decreasing due to poor agricultural practices (Sanda etal. 2014). One means to ameliorate this problem is the use irrigation practices; however, irrigation is associated with a number of problems ranging from water mismanagement to use of poor quality irrigation water as a result of salinity, turbidity, heavy metal pollution and other chemicals constituents that make irrigation water of low quality for crop production (Sanda etal. 2014).
Suitability of water for irrigation is determined by its chemical composition as regards to concentrations and types of soluble salts present (Adegbite et al. 2018). The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plants available nutrients (Ayers and Westcott, 1985). Electrical conductivity (EC) is a good index of salinity hazard while sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) indicate the sodium hazard of irrigation water. Quality of ground water varies from place to place and from season to season. The basic criteria used for determining the suitability of ground water for irrigation includes chemical analysis requiring the determination of concentration of inorganic constituents such as chlorides, sulphate, nitrates, iron, manganese and dissolved gases. Other parameters include Electrical conductivity (EC), Total dissolved Solid (TDS), potassium (K), calcium (Ca), Magnesium (Mg), pH and evaluation of sodium adsorption ratio (SAR).The impairment of water quality due to introduction of pollutants is a problem faces by most industrial cities around the world. Agricultural activities as well as domestic and industrial activities that are carried out to boost production such as application of manures, fertilizers, pesticides and herbicides, use of effluents water and municipal waste bring in contaminant into the water and soil (Etim and Adie, 2012, Bationo et al.,2003).Quality of irrigation water is essential for the yield and quality of crops produced, maintenance of soil productivity and protection of the environment (Tahir et al.,2003, Eswaran et al., 2001). The analysis of irrigation water arises as a need to know the impact of irrigation water on the soil, yield of crops, the effect, and the necessary control measures to rectify the effect of this for optimum production and yield of crops. Quality of irrigation water is an important consideration in any appraisal of irrigation schemes and especially in the saline or alkaline conditions in irrigated areas (Kahlown and Khan, 2002, Kahlown et al.2006). Irrigation water quality could have a profound

impact on crop production; low quality water for irrigation can impose a major environmental constraint to crop productivity and soil damage over time. All irrigation water contains dissolved mineral salts, but the concentration and composition of the dissolved salts vary depending on the water source. Therefore, the objective of this study is to assess the water that is used by farmers in the study areas in relation to its suitability for irrigation purposes.

Materials and Methods

The study was conducted in four distinct locations namely Augie (12^0 54'2"N, 20 $36'2^0$"E), Birnin Kebbi (12^0 27'14"N, 4^0 11'51"E), Bunza (12^0 5'3"N, 4^0 1'15"E), and Yauri (10^0 46'55"N, 4^0 48'28"E). The climate of the study area is classified as semi-arid equatorial Tropical, consisting of a long dry (October - May) and a short wet (June – September) season. Mean annual rain fall ranges from 860mm at Yauri to 690mm and 591mm at Augie, Birnin Kebbi and Bunza respectively.The water samples were taking from the Bore holes, Streams, and Bore holes + Streams water from irrigation farms in Yauri, Bunza, Augie, and Birnin Kebbi local government area.The water from River Niger was collected at three different points of 200m intervals and the surface water sample was mixed to have a representative surface water sample. The sub-surface water bore-hole in irrigation farms was collected at three different point of 200m interval and the sub-surface water sample was mixed to have a representative sub-surface water sample.The water samples were taking from the Bore holes, Streams, and Bore holes + Streams water from irrigation farms in Yauri, Bunza, Augie, and Birnin Kebbi local government areas.The parameters that were measured as indices for irrigation water quality include (EC) total dissolved solids (TDS), pH, Calcium, (Ca^{2+}), Magnesium (Mg^{2+}), sodium (Na^{+}), Potassium (K^{+}), Boron, sodium adsorption ratio(SAR), nitrate (NO_3), and chloride (Cl^{-}). Standard laboratory techniques were used to evaluate the concentrations of the above mentioned parameters, thereafter guidelines for interpretation of water quality for irrigation (Ayers and Westcot, 1985; 1994) was used to discuss the results of this work.

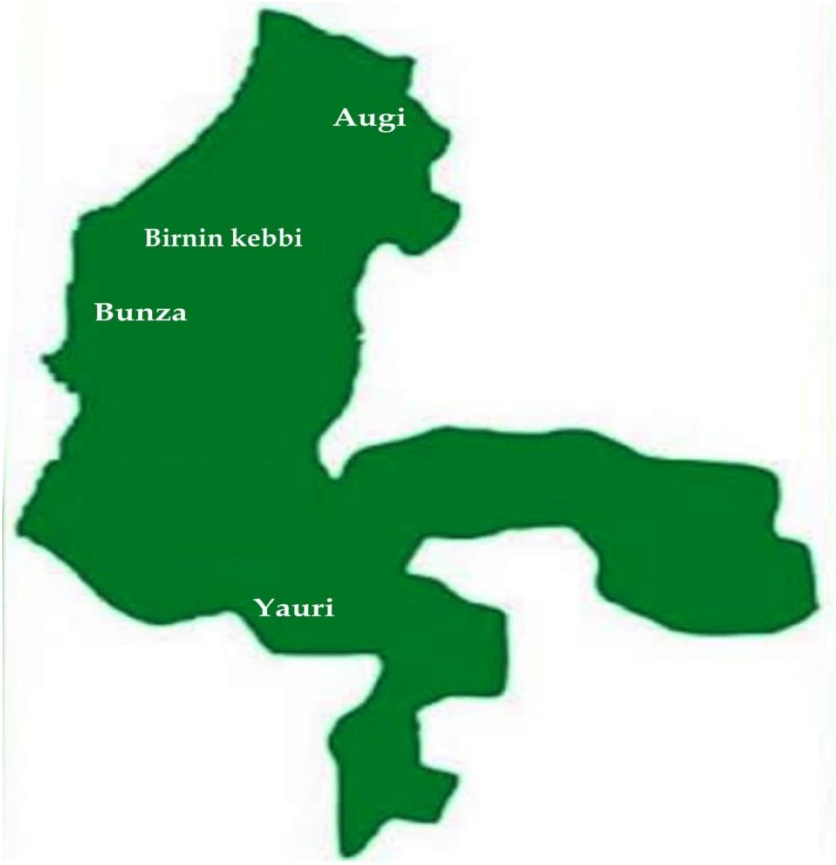

Figure 1: Map of Kebbi State showing the study area.

Results and Discussions

The results of this study that was conducted in some selected local government areas of Kebbi State namely; Bunza, Augie, Yauri and Birnin Kebbi were presented as follows, with Table 1 as a guideline for the interpretations of the finding and other relevant literature that could also be cited.

Table 1. Guidelines for interpretation of water quality for irrigation (Ayers and Westcot, 1985; 1994)

Potential Irrigation Problem		Degree of Restriction on Use		
		None	Slight Moderate	Severe
Salinity				
	EC_w (dS m^{-1})	<0.7	0.7 – 3.0	>3.0
	TDS (mg L^{-1})	<450	450 – 2000	>2000
Infiltration (Evaluate using EC_w and SAR together)				
SAR	= 0 – 3 **and EC_w**(dS m^{-1})	>0.7	0.7 – 0.2	<0.2
	= 3 – 6	>1.2	1.2 – 0.3	<0.3
	= 6 – 12	>1.9	1.9 – 0.5	<0.5
	= 12 – 20	>2.9	2.9 – 1.3	<1.3
	= 20 – 40	>5.0	5.0 – 2.9	<2.9
Specific Ion Toxicity (affects sensitive crops)				
	Sodium	< 3	> 3	
	Chloride	<4	4 – 10	>10
	Nitrogen	<5	5 – 30	> 30

Table 2.Mean Salinity indices concentration in irrigation water (mg/L) of Bunza at 3 different sources.

Water sources	EC	TDS	Ca	Mg	Na	K	SAR	NO_3	Cl	SO_4	Bore hole
	3.36	427.57	1.47	1.42	0.75	0.75	0.73	4.47	0.68	0.61	
Stream	2.36	536.97	1.67	1.56	0.77	0.77	0.72	5.70	0.69	0.92	
Bore hole + Stream	1.02	332.90	1.69	1.59	0.77	0.77	0.71	6.07	0.69	0.93	
Total Mean Value	**2.25**	**432.29**	**1.70**	**1.52**	**0.76**	**0.76**	**0.72**	**5.41**	**0.69**	**0.82**	

Table 3.Mean Salinity indices concentration in irrigation water (mg/L) of Augie at 3 different sources.

Water sources	EC	TDS	Ca	Mg	Na	K	SAR	NO_3	CL	SO_4	Bore hole
	3.31	338.83	1.58	1.59	0.85	0.85	0.85	4.78	0.79	0.73	
Stream	3.78	524.46	1.66	1.40	0.86	0.86	0.88	5.68	0.80	0.77	
Bore hole & Stream	2.45	427.45	1.65	1.69	0.86	0.87	0.88	6.85	0.84	0.85	

Total Mean Value	**3.18**	**430.091.63**	**1.56**	**0.860.86**	**0.87**	**5.77**	**0.81**	**0.78**

Table 4. Mean Salinity indices concentration in irrigation water (mg/L) of Yauri at 3 different sources.

Water sources	EC	TDS	Ca	Mg	Na	K	SAR	NO_3	$ClSO_4$
Borehole	3.32	417.08	1.45	1.39	0.74	0.75	0.78	4.54	0.85	0.93
Stream	2.65	514.091.67	1.59	0.76	0.77	0.77	6.48	0.86	0.94	
Bore hole & Stream	3.12	315.16	1.55	1.62	0.76	0.76	0.80	6.58	0.85	0.95
Total Mean Value	**3.03**	**415.44**	**1.561.53**	**0.750.75**	**0.78**	**5.87**	**0.85**	**0.94**		

Table 5. Mean Salinity indices concentration in irrigation water (mg/L) of Birnin Kebbi at 3 different sources.

Water sources	EC	TDS	Ca	Mg	Na	K	SAR	NO_3	Cl	SO_4
Bore hole	3.32	412.08	1.30	1.35	0.64	0.65	0.68	3.54	0.75	0.83
Stream	2.65	510.09	1.37	1.19	0.66	0.67	0.67	4.38	0.73	0.66
Bore hole & Stream	2.32	313.16	1.05	1.12	0.66	0.66	0.60	5.58	0.75	0.85
Total Mean Value	**2.76**	**411.77**	**4.67**	**4.60**	**2.26**	**2.28**	**2.35**	**17.60**	**2.56**	**2.82**

Salinity indices concentrations in irrigation water of Bunza at 3 different sources

The main salinity indices concentrations of irrigation water tested in Bunza such as EC, TDS, SAR, Cl, Na, Ca, and Mg as presented in Table 2 were found to be within the range of moderate to getting severe as suggested by Ayers and Westcot, 1985; 1994. Moving towards severity of these indices could be attributed to continuous usage of the same water source and using the same agricultural practices over the years that leads to accumulation within the soil profiles of these indices. However other activities that might likely brings those salinity indices into the water sources could be the drain of water from houses, municipal wastes that were sometimes been dumped along the streams and rivers.

Salinity indices concentrations in irrigation water of Augie at 3 different sources

The salinity indices measured in the 3 water sources from Bunza, though they were found to be within the range of slightly moderate to getting severe were lower than that found in Augie especially with respect to the concentration of EC, Na, K, SAR, NO_3, and Cl. The higher concentrations of these indices could be attributed to the level of awareness between the two farming communities, as farmers in Bunza are more enlighten and has more access to the extension services than those at Augie, therefore it is expected that in appropriate agricultural practices that could leads to soil salinity be more in Augie than Bunza.

Salinity indices concentrations in irrigation water of Yauri at 3 different sources

The concentrations EC, NO_3, Cl, and SO_4 in the irrigation water from Yauri as shown in Table 4, though regarded within the range of slightly moderate, but it is tilting towards severityAyers and Westcot, 1985; 1994, several reasons could be attributed to this which includes disposal of wastes from nearby mechanic workshops, excessive use of agricultural chemicals and fertilizers as well as the use of some chemicals by some fishermen in their art of fishing. However, the concentrations of these salinity indices were found to be higher in the stream water in Yauri than in either borehole

or a blend of borehole and stream water respectively, a provable reason to this could be attributed to the various capacities of these sources as the water source we considered as a stream water in Yauri was river Niger which has the highest water content and the longest distance of area it carries its water from.

Salinity indices concentrations in irrigation water of Birnin Kebbi at 3 different sources

The main salinity indices concentrations of irrigation water tested in Birnin Kebbi such as EC, TDS, SAR, Cl, Na, Ca, and Mg as presented in Table 5 were found to be within the range of moderate to getting severe as suggested by Ayers and Westcot, 1985; 1994. Moving towards severity of these indices could be attributed to continuous usage of the same water source and using the same agricultural practices over the years that leads to accumulation within the soil profiles of these indices. However other activities that might likely brings those salinity indices into the water sources could be the drain of water from houses, municipal wastes that were sometimes been dumped along the streams and rivers. However, considering the concentrations of these indices from Bunza, Augie and Yauri, that of Birnin Kebbi is considered to be the lowest and this could be attributed to the farmer's level of awareness with regards to the modern agricultural practices and accessibility to extension services by both farmers which is higher in Birnin Kebbi than the other places for its advantage of been a state capital.

Summary and Conclusion

In this study which was aimed at assessing the salinity level of irrigation water sources in some selected local government areas of Kebbi State, in which irrigation water was sampled from the main sources of water for irrigation in the selected areas thus as borehole water, stream water and a blend of borehole and stream water respectively. It was observed that generally the concentrations of those indices studied ranges from slightly moderate and tilting towards severity across all the 3 sources irrespective of the location sampled. Considering this scenario, we concluded that poor agricultural practices and lack of awareness on the possible causes of salinity could be the main reasons of this and we suggest that more enlightenment campaign by the government through extension workers and posting of more extension workers to the rural areas need to be intensify.

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