



Assessment of Salinity and Sodicity Levels of Bagudo Local Government Area, Kebbi State, Nigeria

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DOI: 10.5281/zenodo.20536716

Submission Date: 28 April 2026 | Published Date: 04 June 2026

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Abstract

This study was aimed at assessing the salinity and sodicity status of the Fadama soil of Bagudo local government area, of Kebbi state. Soil samples from ten villages were collected and investigated. Using standard procedure for parameters such as texture, exchangeable cation such as Mg, Na, Ca, K and N, P, pH, CO_3^{2-} , HCO_3 , EC, TDS, ESP and C.E.C. The results obtained were subjected to analysis of variance. The texture of the soils were observed to be Sandy loam which could be good for the production of Agricultural crops under good management practices. Based on the results obtained the soils were observed to be low in total nitrogen with mean value (0.055892g/kg), available phosphorus was valued at (0.39933g/kg) and other exchangeable bases such as Ca, Mg, K and Na valued at (1.24499cmol/kg, 0.279331cmol/kg, 0.141669cmol/kg and 0.301667cmol/kg, respectively), pH, EC, TDS and ESP were also rated low with mean values of 5.49%, 0.05%, 23.27 and 1.44, respectively, an indication that the soils were free from salinity and sodicity problems. However, the C.E.C. of the soils was observed to be high with a mean value of 44.898cmol/kg, Carbonates and bicarbonates were found to be moderate with mean values of 7.4772 and 4.5416, respectively. Application of inorganic fertilizers like compound fertilizer such as N. P. K. coupled with addition of organic matter could be recommended to ensure sustainable crop production in the study area.

Keywords: Assessment, Salinity, Sodicity, Fadama, and Sodification.

1.0 INTRODUCTION

Soil salinity and sodicity are among the most common problems associated with irrigated farming in many Fadama areas of low rainfall and high evapo-transpiration (Quesada, 2020). Overtime, salinization and sodification of lands put environmental sustainability and agricultural crop productivity at risk (Gangwar, 2019). Soil salinity and sodicity affect plant growth directly through the effects on water uptake by plants, nutrients availability for plants and by imposing plant toxicity. While indirectly, through the deterioration of soil physical conditions (Puthur *et al.*, 2021).

The movement of water from the soil into the roots, through the stem into the leaves and finally to the atmosphere is mainly driven by a decreasing water potential along this track (Quesada, 2020). When water transpired from a plant leaves to the atmosphere both plants water content and water potential decrease. This result to a movement of water through the plant tissues towards the leaves, when water potential in the root cells is lower than that of the soils rhizosphere zone, this water is replenished by water that the plant takes from the soil (Quesada, 2020). The presence of water soluble salts in the soil increases the osmotic potential and hence reduces the water potential of the soil, bringing it closer to the water potential in the plant roots which leads to stress (Gebremeskel, 2018).

Soil salinity is caused by either natural processes or by human activities or naturally by the accumulation of salts in the soil can be through physical or chemical weathering and transport from parent material, geological deposits or ground water. It can also occur due to parent rock constituents such as carbonate minerals and/or field spars or as a result of one time submergence of soils under sea water (Singh, 1999). Sea level rise also induces seepage into areas lying below sea

level. In Arid areas, saline soils are formed due to evapo-transpiration and lack of rainfall to flush the soils. So also, wind in the coastal areas can blow moderate amount of salts to the land (Desoky *et al.*, 2019).

This research work was carried out to assess the salinity and sodicity levels of some selected Fadama soils in Bagudo local government area of Kebbi State. The main areas covered for the purpose of this study were Bagudo, Gendane, Gwamba, Kaliel, lafagu gante, Gante Fadama, Gante tudu, Tungar Buda, Kwasara and Tuga.

The aim of this research work was to assess the salinity and sodicity level of some selected Fadama soils in Bagudo local government area of Kebbi State, Nigeria while the specific.

The fadama land has high agricultural potentials compared with adjacent upland when fully exploited, it could provide sustainable food security in the country and could allow the production of many crops such as, tree crops, cereal crops and vegetable crops.

2.0 Materials and Methods

The research was carried out on the Fadama soils of Bagudo Local Government Area of Kebbi State, Nigeria. Bagudo lies between latitude $11^{\circ}24'N$ to latitude $11^{\circ}26'N$, and longitude $4^{\circ}5'E$, to longitude $4^{\circ}15'E$, covering an area of about 7,782 kilometers square and is situated at the extreme Northern part of Kebbi State, Nigeria.

2.1 Sampling Techniques

The Fadama soils of Bagudo local Government area were found along the rivers with many villages found adjacent to the rivers. From each village 2 farms were selected randomly and each selected area 2 composite samples were collected at the depth of 0-30cm using soil auger giving the total of 20 samples. The size of composite samples were reduced by successive quartering to manageable and portable sizes.

Each composite sample was labeled and put in a clean plastic bag for easy conveyance and avoidance of contaminants. The samples were air dried, gently crushed using porcelain pestle and mortar and sieved through 2mm sieve before taken to the laboratory for analysis.

2.3 Procedures for Soil Analysis

The soil sample was analyzed for various physical and chemical properties following the procedure by (Sarkar *et al.*, 2005).

2.4 Statistical Analysis

The data were subjected to one-way Analysis of variance (ANOVA). Significant means were separated by using Least Significant difference (LSD) as recommended by Stewart *et al.*, (2021).

3.0 RESULT AND DISCUSSION

3.1 Soil texture

The texture of a soil greatly affects its physicochemical properties and handling quality. Figure 1 showed the particle size distribution of the soils of the ten fadama area of Bagudo Local Government area. The overall means of sand, silt and clay were 76.651%, 7.5328% and 15.8162% respectively.

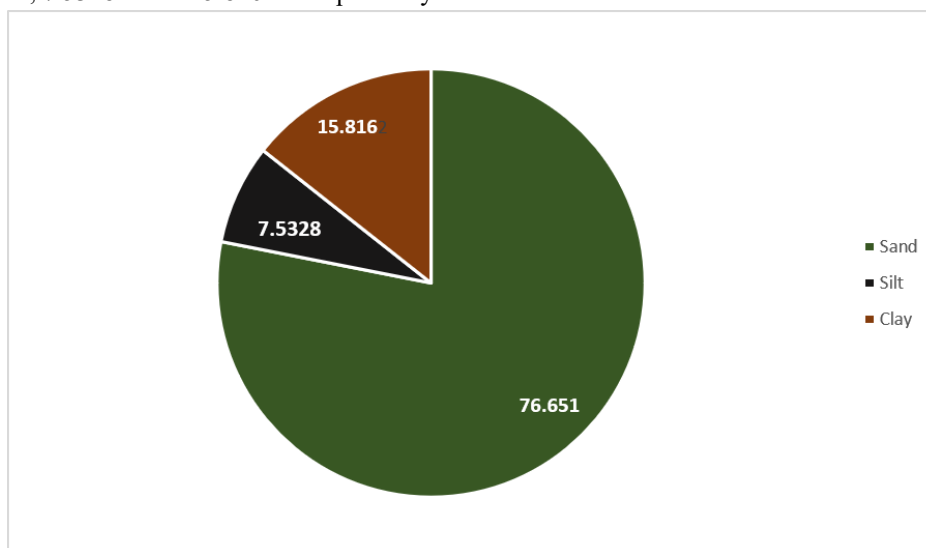


Figure 1: Showing soil textural distribution of the study area.

3.2 Concentration of Carbonate, bi-carbonate, Total Nitrogen, Available Phosphorous and TDS

3.2.1 Carbonate (g/kg^{-1})

Table 3.1 showed the values of carbonates which ranged from 2.890 to 11.757, with the mean value of (7.4772.). The highest value of Carbonates 11.757 was obtained in soil of Bagudo while the lowest value 2.890 was observed in the soil of Bahindi kaliel. Bicarbonates values ranged from 1.6167 to 6.9600, with the mean value of (4.5416) the highest value of bicarbonates (6.9600) was obtained in the soil of Bagudo while the lowest value of bicarbonates [1.6167] was observed in the soil of Bahindi kaliel. The TDS value ranged from 15.635 to 35.29, with the mean of (23.2706) the highest value of TDS (35.293) was obtained in the soil of Bagudo while the lowest value of TDS (15.635) was observed in the soil of Bahindi Kaliel. In view of the results obtained, when related to standard provided by (Wali *et al*, 2018) the soil could be classified as moderate in carbonate and bicarbonate.

3.2.2 Total Nitrogen (g/kg^{-1})

Table 3.1 revealed that overall percentage of total nitrogen ranged from 0.26200-0.02333 with mean value of (0.055892 g/kg^{-1}). The highest value (0.26200) was obtained in the soil of Gante fadama area while the lowest value of nitrogen was observed in the soil of Bagudo. These values were similar to 0.008 to 0.29 g/kg^{-1} for the well-drained top soil in savannah region of Nigeria (Kaur, 2016).

Samples Names	No. of Samples	N	P	CO_3^{2-}	HCO_3	TDS
Bagudo	2	0.02333b	0.2867b	11.757a	6.9600a	35.293a
Bakindi/kalie	2	0.03347b	0.5033b	2.890g	1.6167	15.635d
Gante tudu	2	0.02833b	0.4033b	8.677b	5.5700a	28.434b
Gante fadama	2	0.26200a	0.2933b	8.457e	5.3833a	16.271d
Gendine	2	0.03443b	0.3933b	5.927e	3.6533b	23.961c
Gwamb	2	0.04533b	0.3167b	9.837b	5.8867a	17.967c
Tuga	2	0.03367b	0.5333b	5.697f	3.7033b	23.030c
Tungar buda	2	0.03733b	0.5400a	11.270b	6.7567a	21.063c
Kwasara	2	0.03033b	0.2067c	6.320e	3.7167b	28.041b
Lafagu gante	2	0.03070b	0.5167b	3.940g	2.1700c	23.011c
Overall Mean	20	0.055892	0.39933	7.4772	4.54167	23.2706

Table 3.2 Concentration of CEC Exchangeable in ($\text{cmol}^{(+)} \text{kg}^{-1}$).

Samples Names	No. of Samples	CEC	Mg	K	Na	Ca
Bagudo	2	85.13a	0.22000de	0.09667b	0.20333d	0.2600d
Bahidi/K	2	45.48c	0.17667e	0.16000b	0.50333a	1.4433b
Gante/T	2	34.37c	0.18667e	0.06667b	0.17667d	2.7933a
Gante/F	2	40.84c	0.21333e	0.19667a	0.27333c	1.3467c
Gendine	2	33.18c	0.29333d	0.16667b	0.22667d	0.9733c
Gwamba	2	62.85b	0.31000b	0.08000b	0.24000d	0.9533c
Tuga	2	34.82c	0.38000b	0.17667b	0.35667b	0.5533d
Tunga/B	2	18.06d	0.40667a	0.19667a	0.36000b	3.2667a
Kwasara	2	50.31b	0.31000b	0.17000b	0.39000ba	0.2100d
Overall Mean		44.898	0.279334	0.122002	0.301667	1.24499

3.2.1 Concentration of CEC and Exchangeable Bases Cmol/kg^{-1}

3.3.2 Cations Exchange Capacity

Table 3.2 showed the overall C.E.C values ranged from 18.06 to 85.13 (means 44.898 cmol/kg). The highest values of C.E.C (85.13) obtained in the soils of Bagudo while the lowest value (18.06) was observed in the soil of Tungar Buda. Based on the rating scale provided by Ilori *et al.*, (2020) and Esu (1991) in Table 3.2 these soils could classified as soil with high cation Exchange Capacity (C.E.C.).

3.2.3 Exchangeable Na

Table 3.2 showed the overall concentration of sodium in Bagudo local government which ranged from 0.17667 to 0.50333 (means 0.301667cmol/kg). The highest value of Na (0.50333) was obtained in soil of Bahindi Kaliel, while the lowest value (0.17667) was observed in soil of Gante Tudu. Based on the result in table 3.2 the soil was rated moderate in sodium, if related to the rating standard provided by (Ilori et al, 2020) in Table 3.2. Bagudo Fadama soils were observed to have low sodium value of 0.17667-0.50333cmol/kg.

3.2.4 Exchangeable Potassium K

Table 3.2 showed the values of exchangeable K of fadama soils of Bagudo Local Government `Area of Kebbi State which ranged from 0.06667 to 0.19667 (mean 0.141669cmol/kg). The highest value of K (0.19667) was obtained in soils of Gante and Tungan Buda Fadama areas while the lowest value of K (0.06667) was observed in the soil of Gante Tudu. Mshelmbula (2015) reported 0.05-0.22 (mean 0.12cmol/kg) of K in soils from Kandoli, Sheli stream valley. The obtained value were higher than the available value of K 0.15 to 0.33 (mean 0.28cmol/kg) given for the fadama soils in Sokoto Rima River Basin by Singh (2010).

4.3.4 Exchangeable Ca and Mg

Table 3.2 showed that the overall value of Ca and Mg were 0.2100-3.2667 (mean 1.24499cmol/kg) and 0.17667-0.40667 (mean 0.279331cmol/kg-1) respectively. The highest value (3.2667) was obtained in the soil of Tungan Buda while the lowest value (0.2100) was observed in the soil of kwasara. Also, the highest Mg value (0.40667) was obtained in the soil of Tungan Buda while the lowest value (0.17667) was observed in the soils of Bahindi Kaliel. Based on the results in table 4 the soil could be rated as low in Ca⁺ and moderate in Mg⁺, if related to the rating standard provided by Ilori, (2020) in Table 4.1. The values of Ca are lower than the 1.92 to 2.73 (mean 2.36 cmol/kg) and those for Mg are highest than 0.32 to 0.99 (mean 0.80cmol/kg) are reported by Mshelmbula (2015) for the soils in Sokoto Rima River Basin.

4.4 Salinity/Sodicity Status

Table 3.3 indicated that the pH, EC (uscm⁻¹) and ESP values ranged from 4.5400 to 6.5300 with mean (5.49332), 0.02900-0.21690 with mean (0.055716) and 0.123-6.253 with mean (1.4416) respectively. The pH value agrees with 5.1-6.2 (mean 5.7) in Sokoto Rima River Basin (Wali, 2025) and 6.1 to 8.2 with mean (7.2) in Kandoli, Shela Stream valley (Raheem, *et al* 2025). Observed that 98% and 94% of the soils in Kebbi State had EC of 2000uscm⁻¹ and ESP of < 15 respectively.

Table 3.3: Concentration of Soil pH, EC, and ESP of the study area

Samples Names	No. of Samples	pH	EC	ESP
Bagudo	2	6.5300a	0.05940b	0.187b
Bahindi/k	2	5.8733b	0.02940b	1.180b
Gante tudu	2	6,2333b	0.04420b	0.183b
Gante fadama	2	5.4833b	0.02900b	0.390b
Gendine	2	5.1467d	0.03760b	0.483b
Gwamba	2	4.5400d	0.02900b	0.417b
Tuga	2	5.1433d	0.03903b	1.123b
Tunga buda	2	4.9833d	0.03670b	6.253a
Kwasara	2	5.6000b	0.21690a	0.680b
Lafagu gante	2	5.6400b	0.03593b	3.707b
Overall Mean		5.51732	0.049053	1.4603

3.3.1 pH of the soil of the study area

The overall pH value obtained in the soils of the study area was 5.51. It was slightly acidic to neutral in reaction. Bagudo tested significantly higher ($P < 0.05$) in pH with mean values of 6.53. It was then followed by Gante tudu with pH mean value of 6.23. Bahindi/ kaliel, Gante fadama, Gendine, Tuga, Kwasara, Lafagu gante were statistically similar with mean pH values of 5.87, 5.48, 5.14, 5.60 and 5.64, respectively (Table 3.3). At this pH levels, these soils would provide conducive environment for plants and soil micro-organisms though they appear to be potentially moderately acidic. The lowest pH value of 4.54 and 4.98 was obtained in Gwamba and Tungan buda. Soils of this area should be reclaimed by the way of liming to bring the pH to the optimum level for proper plant growth and microbial activities.

3.3.2 Electrical conductivity (EC)

Electrical conductivity (EC) measures the total quantity of soluble salts in the soil. The overall EC level of the soil of study area was 0.049dSm^{-1} . The significantly higher EC value of 0.216dSm^{-1} was obtained in Kwasara fadama soil. It was then followed by Bagudo and Gante Tudu soil with EC mean values of 0.05940 and 0.04420dSm^{-1} , respectively. Gendine, Tuga, Tungar buda, and Lafagu gante statistically were similar with mean EC value 0.037 , 0.039 , 0.035 respectively. Gante fadama and Gwamba was significantly lowest ($P>0.05$) with mean EC value of 0.029 and 0.029dSm^{-1} (Table 3.3).

3.3.3 Exchangeable sodium percentage (ESP)

The overall ESP value of the soils of the of the study area were 1.4603% (Table 3.3) Tungar buda and Lafagu gante fadama tested significantly higher in ESP with mean ESP value of 6.253% and 3.707% respectively. Bahindi/ kaliel and Tuga statistically were similar in ESP with mean value 1.180% and 1.123% while Gante fadama, Gendine, Gwamba, and Kwasara obtained the same value of ESP with mean value in ESP 0.39% , 0.48% , 0.41% , and 0.68% . The lowest value of ESP were obtained in Bagudo and Gante tudu fadama soils with mean value of ESP 0.187% and 0.183% (Table 3.3)

3.4 Salinity and sodicity status

Table 5 indicated that the pH, EC (dSm^{-1}) and ESP (%) valued 5.51 , 0.049dSm^{-1} and 1.4603% , respectively. According to the criteria in (Table 3.4) set by Richard (1954), that soils with $\text{EC} >4\text{dSm}^{-1}$, $\text{ESP} <15$ and $\text{pH} <8.5$ are saline, those with $\text{EC} >4\text{dSm}^{-1}$, $\text{ESP} >15$ and $\text{pH} <8.5$ are saline, while those with $\text{EC} <4\text{dSm}^{-1}$, $\text{ESP} >15$ and >8.5 are sodic. As per this criteria, the soils of the studied areas (EC 0.0490dSm^{-1} , ESP 1.460% and pH 5.51); could be said to be free from salinity and sodicity problems. However, with appreciable Mg^{2+} , K^{+} and Na^{+} contents, these soils could be said to have potential treat to salinity and sodicity problems except if measures are taken to arrest the salt build up. Also sampling units with appreciable EC values like Bagudo (0.05dSm^{-1}), Gante tudu (0.044dSm^{-1}) and Kwasara (0.21dSm^{-1}) have potential treat of salinity problems and therefore proper management practices should be adopted to avoid further accumulation of salts to the detrimental levels.

Table 3.4: Classification of the salt affected soils

Soil	EC (dSm^{-1})	ESP (%)	pH	Description
Saline	>4	<15	<8.5	Non-sodic soils containing sufficient soluble salts to interfere with growth of most crops.
Saline Sodic	>4	>15	<8.5	Soils with sufficient exchangeable sodium to interfere with growth of most plants, and containing appreciable quantities of soluble salts.
Sodic	<4	>15	>8.5	Soils with sufficient exchangeable sodium to interfere with growth of most plants, but without appreciable quantities of soluble salts.

Source Richard (1954)

CONCLUSION

From the results obtained in this study, it was concluded that the fadama soils in Bagudo local government area, Kebbi State, Nigeria were moderate in carbonate and bi carbonate, low in total nitrogen, available phosphorus and high in CEC. The soils were also observed to be low in exchangeable bases such as Ca, Mg, K and Na with low level of pH, EC and ESP. The fadama soils were considered to be free from salinity and sodicity problems.

Based on these, addition of organic matter and artificial fertilizers to ensure sustainability of agricultural production in the area should be made.

RECOMMENDATIONS

Based on the results obtained under this study, the following recommendation would be given;

As a result of low level of N, P, K and other exchangeable Cations, organic and inorganic fertilizers should be added to the soils to ensure sustainable crop production in the area.

The soils were moderately acidic and therefore liming materials should be added to bring the soil to the neutral level so as to provide more conducive environment for both crops and microorganisms growing on the soils.

Based on the low salinity and sodicity levels of the soils, care should be taken not to use saline or poor quality water for irrigation to avoid salt buildup of the soils.

The texture of the soils was observed to be sandy loam which is also good for production of agricultural crops and therefore good tillage practices should be adopted so as to maintain the current texture of the soils of the study area.

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CITATION

Isah, A., Augie, M. A., Bubuche, T. S., Ibrahim, M., Abdulsalam, A., Garba, A., & Shuai'bu, N. (2026). Assessment of Salinity and Sodicity Levels of Bagudo Local Government Area, Kebbi State, Nigeria. In *Global Journal of Research in Agriculture & Life Sciences* (Vol. 6, Number 3, pp. 35-40).

<https://doi.org/10.5281/zenodo.20536716>