

1 **ASSESSMENT OF SOIL QUALITY IRRIGATED WITH TUBE WELL WATER AT**
2 **UNIVERSITY FADAMA FARM JEGA, KEBBI STATE UNIVERSITY OF SCIENCE**
3 **AND TECHNOLOGY, ALIERO.**
4

5 **ABSTRACT**

6 A research was conducted on the soils of teaching and research fadama farm of Kebbi State
7 University of Science and Technology Aliero located at Jega, with the aim of assessing the soil
8 quality irrigated with tubewell water of the study area. The entire University Fadama land was
9 divided into three sections namely T1, T2 and T3 and from each section, three (3) composite soil
10 samples were collected. Each soil sample was collected 2meters away from a tubewell where
11 water sample was also collected. Three (3) samples of the tubewell water were collected from the
12 three demarcated areas T1, T2 and T3, making a total of nine (9) samples. These samples were
13 collected in a clean 75cl water bottle provided with a cap. Each water sample was analysed for
14 pH, total dissolved solid (TDS), electrical conductivity (EC), sodium adsorption ratio (SAR),
15 magnesium (Mg) and potassium (K). Soil sample was analyzed for pH, organic carbon, total
16 nitrogen, available phosphorus. Result obtained showed that pH was 7.2, TDS 2.55mg/l, EC
17 0.25 μ s/cm, SAR 1.35, Mg 90.25, K 1.43 and RSC -3.8. Soil analysis showed that organic carbon
18 content was 0.75g/kg, total nitrogen 0.06g/kg, Phosphorus 0.65g/kg and CEC ranged 6.96-
19 7.32cmol(+)/kg. The study showed that soil in the area were low in fertility, therefore fertilizer of
20 both organic and inorganic should be supplemented to make the soils more fertile. The soils were
21 found to be free from salinity/sodicity problems at least for now.

22 Keywords : Tubewell, fadama land, salinity, irrigation and aliero.

23 **INTRODUCTION**

24 Water is an essential resource for living systems, industrial processes, agricultural production and
25 domestic use. Ninety seven percent of the world's water is found in oceans. Only 2.5% of the

26 world's water is non-saline fresh water (Itodo and Itodo, 2010). However, 75% of all fresh water
27 is bound up in glaciers and ice caps. Only 1% of fresh water is found in lakes, rivers, soils and
28 24% is present as groundwater. The use of water increases with growing population, putting
29 increasing strain on these water resources.

30 There is a growing human population in the world which means there is need for an increase in
31 food production. However, food production to feed this growing population is decreasing due to
32 poor agricultural practices (Sanda *et al.*, 2014). One means to ameliorate this problem is the use
33 of irrigation practices; however, irrigation is associated with a number of problems ranging from
34 water mis-management to use of poor quality irrigation water as a result of salinity, turbidity,
35 heavy metal pollution and other chemical constituents that make irrigation water of low quality
36 for crop production (Sanda, *et al.*, 2014).

37 Suitability of water for irrigation is determined by its chemical composition as regards to
38 concentrations and types of soluble salts present. The chemical constituents of irrigation water
39 can affect plant growth directly through toxicity or deficiency, or indirectly by altering plants
40 available nutrients (Ayers and Wescot, 1985). Electrical conductivity (EC) is a good index of
41 salinity hazard while sodium adsorption ratio (SAR) and residual sodium carbonate (RSC)
42 indicate the sodium hazard of irrigation water. Quality of groundwater varies from place to place
43 and from season to season. The basis used for determining the suitability of groundwater for
44 irrigation includes chemical analysis requiring the determination of concentration of inorganic
45 constituents such as chlorides, sulphate, nitrates, iron, manganese and dissolved gases. Other
46 parameters include Electrical conductivity (EC), Total Dissolved Solid (TDS), potassium (K),
47 calcium (Ca), magnesium (Mg), pH and Sodium adsorption ratio (SAR).

48 A tubewell is a type of well in which a long 100-200mm (5-8inches) wide stainless steel tube or
49 pipe is bored into an underground aquifers. The lower fitted with a strainer and a pump at the top
50 lifts water for irrigation. The required depth of the well depends on the water table.

51 Tube well has been used to irrigate crops on soils of the university teaching and research fadama
52 farm area of Jega for several years now, however, little attempts has been made to ascertain the
53 quality of water as per its suitability for irrigation. It is therefore necessary to obtain some
54 information on the current quality status of the tube well water as well as its effect on soil
55 fertility, salinity and sodicity status.

56 MATERIALS AND METHODS

57 Study Area

58 The study was conducted at the Teaching and Research Farm of Kebbi State University of
59 Science and Technology located at Jega town (Lat.12° 11', Long. 4° 16' E) in the Sudan
60 Savanna zone covering twenty hectares of land. The climate of the area is Dry sub humid.
61 Temperature varies from about 15°C in November through January to about 40°C in March to
62 May and means annual rainfall is in the range of 580mm-700mm (Arnborg, 1988). Relative
63 humidity ranged between 21-47% in the dry season and 51-79% during rainy season.

64 Sample Site

65 The entire University fadama land was divided into three sites namely T1, T2 and T3. From each
66 area, three composite soil samples were collected at 2m away from a tube well where water
67 sample was collected.

68 Sampling Techniques

69 From each area selected, three (3) hectares was demarcated as sampling units. The distance
70 between one sampling unit and another was 50meters. From each sampling units a composite
71 sample of three (3) borings of 25 meters interval was collected with the help of soil auger at a
72 depth of 0-15cm, 2meters away from tube wells giving a total of nine (9) composite samples.
73 Each composite sample was labeled and put in a clean polythene bag for easy conveyance and
74 avoidance of contaminants. The samples were then air-dried, gently crushed using a porcelain
75 pestle and mortar and then sieved through a 2mm sieve for laboratory analysis.

76 Three samples of tube well water were also collected from each of the three demarcated areas
77 (T1, T2, and T3). The samples were taken in a clean 75cl water bottle provided with a cap. The
78 tube well water was pumped out for atleast 10minutes before sampling in order to ensure that the
79 collected sample is a true representative of the water from the aquifer.

80 **Water Sample Analysis**

81 Water samples were analysed as described by Chopra and Kanwar (1991). Water pH and
82 Electrical conductivity (EC) were determined using pH and conductivity meters. Total dissolved
83 solids (TDS) was determined using evaporation and drying method. Carbonates and
84 bicarbonates ions were determined using volumetric titration method. Sodium adsorption ratio
85 (SAR) AND Residual sodium carbonate (RSC) were calculated using:

$$86 \text{ SAR} = \frac{\text{Na}}{\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}} \quad (\text{USSL}, 1954)$$

$$90 \text{ RSC} = (\text{CO}_3^- + \text{HO}_3^-) - (\text{Ca}^{2+} + \text{Mg}^{2+})$$

91

92 **Soil Analysis**

93 Soil samples were analysed using methods described by Page *et al.*, (1982). Particle size
94 distribution was analyzed using the Hydrometer method. Soil texture was determined with
95 textural triangle. Organic C was determined using Walkley-Black (1934), total N by Micro-
96 Kjeldahl technique and available P using Bray 1 method (Bray and Kurtz, 1945). pH CaCl₂
97 (1:2.5) was determined with glass electrode pH meter (Jackson, 1962), CEC was determined by
98 saturating the soil with excess ammonium acetate solution and washing with excess alcohol. The
99 samples were later distilled and the distillate received over boric acid indicator and titrated
100 against standard HCl as outlined by Chapman (1964). Exchangeable bases were extracted with
101 neutral NH₄ Ac solution; Na and K were then read on flame photometer while Ca and Mg
102 determinations were determined by EDTA titration. Exchangeable sodium percentage (ESP) was
103 calculated using the formula

104
105
$$\text{ESP} = \frac{\text{Exchangeable Na} \times 100}{\text{CEC}}$$

106

107 Where Na and CEC were in cmol(+)kg of soil.

108
109 **Statistical Analysis**

110 Data obtained from soil analyses were analysed using descriptive statistics tools such as means,
111 ranges and percentages.

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113

114 **Table 1: pH, EC, SAR, and RSC of water from tube well within the study area**

S i t e s	p	H	EC (μ s / c m)	S	A	R	R	S	C
T 1	7		0 . 2 3	1	.	2 5	-	3	. 4
T 2	7	.	2	0	.	2 1	1	.	3 9 5
T 3	7	.	4	0	.	3 1	1	.	4 1
Overall Mean	7	.	2	0	.	2 5	1	.	3 5 - 3 . 8

115 **Tube well water quality**

116 Table 1 showed that pH of tube well water in the study area ranged from 7-7.4 with overall mean
 117 of 7.2. this pH agreed with the findings of Singh *et al.*, (1996) and Singh and Tsoho (2000)
 118 which indicated that tube well water from Kebbi State had neutral to slightly to alkaline reaction.
 119 This could also be compared with mean pH of 6.7 for the West African ground water given by
 120 Roose and Lelong (1981). Furthermore, the values obtained are somewhat similar to pH (6.7) for
 121 tube well water observed by Singh (2003) in Zamfara State and (7.2-7.3) for rivers and streams
 122 in Sokoto State as reported by Singh and Tsoho (2000b). pH ranges of 5.4-7.7 (mean 6.5) agreed
 123 with observation of Singh *et al.*, (1996), which indicated that water from the tube wells in the
 124 fadama areas of Kebobs State varied from neutral to slightly alkaline reaction. EC values
 125 observed for tube well water in the study area ranged from 0.2-0.31 μ s/cm respectively which
 126 were higher than EC of 0.211 μ s/cm observed on the tube well water in T2. The overall mean
 127 was 0.25 μ s/cm. based on the US Salinity Laboratory Staff (Richard, 1954) classification
 128 suitability of irrigation water showed that the rube well water within the study area could be
 129 placed in C₁-low salinity water category. Table 1 also showed that mean value of SAR obtained
 130 was 1.35mg/l. The observed SAR was in order T1, T2 and T1 according to US Salinity
 131 laboratory staff (Richard, 1954), the SAR based classes are S₁-low sodium water, SAR<10, S₂-
 132 medium sodium water, SAR 10-18, S₃-high sodium water, SAR>26 with maximum SAR of
 133 1.35mg/l, all the waters in the fadama. RSC is usually assessed when bicarbonate and carbonates

134 levels are >120 and 15mg/l, respectively. The ranges of CO_3^- and HCO_3^- were -0 to 0.0.2 (mean
 135 0.2) and 2.9-8.0 (mean 4.8). RSC in the study area was observed to be negative (-3.4 to -4.1).

136 **Table 2: TDS and basic cation concentration (mg/l) in water of tube wells in the study area**

S i t e s	TDS (Mg/l)	Ca (Mg/l)	Mg (Mg/l)	K (Mg/l)	Na (Mg/l)
T 1	3	0 . 6 8	0 . 1 8	1 . 4	1 . 1
T 2	1 . 6 7	0 . 6 1	0 . 1 7	1 . 4	1 . 1 6
T 3	3	0 . 7	0 . 1 3	1 . 5	1 . 2 3
Overall Mean	2 . 5 5	0 . 6 6	0 . 1 6	1 . 4 3	1 . 1 6

137 Table 2 showed the result of TDS and basic cation concentration. The TDS values for the tube
 138 well water investigated ranged from 1.667-3.00mg/l. water in the tube wells from fadama area
 139 T1 and T3 were observed to be higher (3.00mg/l) in comparism to TDS from tube well water in
 140 fadama area T2 (1.67mg/l). The overall TDS water in the tube wells was 2.55mg/l. the results on
 141 the range of TDS value reported in this study is slightly lower than the range of 4-9mg/l for the
 142 parameter on the tube well water in Zamfara State. This tube well water could be considered as
 143 having no restriction for irrigation use. The low TDS observed in this study could be attributed to
 144 low level of pollution of the ground water in the area which could be related to low population
 145 and low level of industrial activities.

146 Table 2 showed the basic cations concentrations for tubewell water at the study area were;
 147 0.66mg/l for Ca, 0.16mg/L for Mg, 1.16mg/L for Na and 1.43m. Ca salts are known to cause
 148 salinity problems, fortunately, its concentration in the tube wells within fadama land of Kebbi
 149 State University Farm Jega area is quiet low, greatly lower than the rest of the basic cations.
 150 Substantially, high Mg^{2+} and K^+ in the irrigation water suggests that it contains a lot of Mg^{2+} and
 151 K^+ salts. Continuous and particularly excessive irrigation with such water may lead to a build up
 152 of salts and subsequent salinization. Sodium on the other hand is low. The result obtained in this

153 study for basic cations is lower compared to that obtained by Sanda *et al.*, (2014) who reported
 154 1.1mg/l for Ca, 1.7mg/L for Mg, 29mg/L for Na and 21mg/L for K for tubewell soils of the study
 155 area.

156 **Table 3: Particle size distribution of the soil and texture in the study area**

S i t e s	S a n d (%)	S i l t (%)	C l a y (%)	Texture class
T 1	6 5 . 2	1 9 . 7	1 5 . 1	Sandy loam
T 2	7 4 . 4	1 5 . 7	9 . 9	Sandy loam
T 3	7 8 . 6	1 3 . 4	7 . 9	Loamy sand
Overall Mean	7 2 . 7 3	1 6 . 2 6	1 0 . 9 6	Sandy loam

157 Table 3 showed the textural class of the soils of the study area. At T1, particle size analyses
 158 showed that sand had 65.2%, silt 19.7% and clay 15.1% respectively belonging to sandy loam.
 159 At T2, sand, silt and clay had 74.4% 15.7 and 9.9% respectively also classified as sandy loam.
 160 T3 also showed that sand, silt and clay had 78.6%, 13.4% and 7.9% ranked as loamy sand. Over
 161 all mean from table 2 showed that sand, silt and clay had 72.73%, 16.26% and 10.96 respectively
 162 ranked as sandy loam.

163 **Table 4: pH, EC and ESP within fadama area of the study area**

S i t e s	P h	EC (μ s / c m)	ESP (g / k g)
T 1	6 . 0	5 3 . 6 7	1 1 . 2
T 2	6 . 0	3 9 6 . 6 7	1 0 . 7
T 3	6 . 2	2 5 3 . 6 7	2 9 . 6
Overall Mean	6 . . 1	2 3 4 . 6 7	1 7 . 1 6

164 Table 4 showed that pH in T1, T2 and T3 had pH range from 6.0-6.2 with overall mean of 6.0.
 165 This showed that the pH in the study area is slightly acidic. The pH observed in this work is
 166 within optimum range for growth of most crops. This result agrees with Jones and Wild (1975),

167 who reported that most of the arid and semi-arid soils have pH within the range of 6.0-6.8. The
 168 pH range for fadama soils in SokotoRima River Basin was 5.1-6.3 (mean 5.7) which also agrees
 169 with the values obtained by Yacouba, (1996). Table 4 also showed that EC and ESP ranges and
 170 mean 6-6.2 (overall mean 6.0), 198-653 (overall mean 396.67) and 11-29.6. (overall mean
 171 17.16), respectively. The values agrees with 5.1-6.2 (mean 5.7) in SokotoRima River Basin
 172 (Yacouba, 1996; Singh, 1999a) observed that 98% and 94% of soils in Kebbi State had
 173 $EC < 2000 \mu\text{s/cm}$ and $ESP < 15$ respectively. According to the criteria used for classifying salt
 174 affected soils, set by U.S Salinity Laboratory Staff (Richards, 1954), a soil with $EC > 400 \mu\text{s/cm}$,
 175 $ESP < 15$ and $pH < 8.5$ as saline, those with the $EC > 4000 \mu\text{s/cm}$, $ESP > 15$ and $pH > 8.5$ are saline
 176 sodic and that with $EC < 4000 \mu\text{s/cm}$, $ESP > 15$ and $pH > 8.5-10.0$ is sodic.

177 **Table 5: Organic carbon (c) Total nitrogen (N) and available phosphorous (P) contents of**
 178 **the study area**

S i t e s	Organic carbon (%)	T o t a l N (%)	Available P (mg/kg)
T 1	0 . 2 3	0 . 1 0 5	0 . 9 3
T 2	0 . 3 8	0 . 0 7 4	0 . 8 4
T 3	0 . 4 1	0 . 0 6 6	0 . 7 5
Overall Mean	0 . 3 4	0 . 0 8 1	0 . 8 4

179 The percentage Organic carbon in all locations was rated as low as shown in Table 5, this is a
 180 typical characteristics of the majority soils within the savannah region, but when carefully
 181 observed, the results from the table in both locations showed that percentage organic carbon is
 182 higher at 0-15cm soil depth, this is obvious because it is where the deposition of the dead plants
 183 and animals are.

184 Table 5 also showed that total N concentrations in all locations were regarded as low when
 185 compared with the standard given by (Esu, 1991). This result indicates the true characteristics of

186 the savannah soils of low N content which could be attributed to higher volatile nature of N and
 187 the amount of solar radiation that were intercepted within the region.

188 Furthermore, table 5 showed the proportion of the available P within the study area does not
 189 differ much with that obtained for organic carbon and total N, that is low concentration which as
 190 indicated before is a typical nature of the savannah soils. However, since P is not as mobile as N,
 191 the danger of P deficiency is no longer there.

192 **Table 6: K, Ca, Mg, Na and CEC**

S i t e s	K	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)
T 1	1 . 1 6	0 . 8 2	1 . 2 7	0 . 2 7	7 . 3 2
T 2	1 . 0 0	0 . 7 7	1 . 1 7	0 . 1 1	7 . 1 9
T 3	1 . 8 8	0 . 7 1	1 . 1 8	0 . 1 1	6 . 9 6
Overall Mean	1 . 0 1	0 . 7 6	1 . 2 0	0 . 1 6	7 . 1 5

193 Table 6 showed that K obtained from T1,T2 and T3 ranges from 1.00-1.16 (overall mean 1.01)
 194 cmol(+)/kg. Singh *et al*, (1996), reported 0.05-0.22 (mean 0.12)cmol(+)/kg of potassium in soils
 195 from Kandolishela stream valley. These obtained values were higher than the available
 196 potassium of 0.15-0.33 (mean 0.25)cmol(+)/kg given for fadama soils of SokotoRima River Bsin
 197 by Singh (1997b). Graham and Singh (1997) reported low available potassium of 0.2-0.3(mean
 198 0.5)cmol(+)/kg in the Wurno project area. This indicates that T2 and T3 have low exchangeable
 199 K compared to T1 which has high exchangeable K with overall mean of 1.01. Based on the
 200 rating scale, the soil have been classified as high in K. the high exchangeable K could be
 201 attributed to the use of NPK fertilizer by the farmers as well as K bearing minerals in parent
 202 materials of the study area. Na value obtained in table 6 from all sites (T1-T3) ranged from 0.71-
 203 0.82 (overall mean 0.76). This showed that the value of Na in the study area was high. Singh and
 204 Tsoho (2001), reported the values of Na for soils around river of SokotoKandolishela streams
 205 lakes and Goronyo Dam in Sokoto State as having 0.4-0.8, 0.3-0.9, 0.3-0.5 and 0.8-1.4
 206 respectively. The Na content for the fadama soils of Kalambaina, Illela and UsmanDanfodio

207 University in Sokoto State as reported by Sahabiet *al.*, (2002) were 0.39, 0.53 and 0.51
208 respectively.

209 From the result obtained on Ca and Mg (Table 6), the overall ranges respectively for Ca and Mg
210 were 1.17-1.27 (overall mean 1.20) and 0.11-0.27 (overall mean 0.16cmol(+)/kg for Ca and Mg
211 respectively. The values for Ca and Mg in the study area are low. This is similar to the values
212 obtained by Adegbite (2012) who reported 0.88cmol(+)/kg for Ca and 0.45cmol(+)/kg for Mg.

213 CEC from table 6 is rated as medium with values ranged from 6.96-7.32 (overall mean 7.15)
214 from T1, T2 and T3. Jones and Wild (1975) reported CEC of 3-8cmol(+)/kg for the Savannah
215 soils in general. FAO (1969) reported CEC values of 8-10cmol(+)/kg for West African Soils as
216 indicative of the minimum values in the top 30cm of soil for satisfactory crop rotation.

217 **Conclusion**

218 Most of the water samples (70%) appeared TDS free (fresh water) and therefore could be used
219 for irrigation purposes. Based on salinity hazard, 96% of the water sample belonged to C₁-low
220 salinity category and hence suitable for irrigation with minimum SAR. All the water in the study
221 area could be used for irrigation purpose and are free from sodicity problems. The soils of the
222 study area were observed to be free from salinity and sodicity hazards and could be
223 recommended that many crops could be grown on it with good management practices.
224 Furthermore, the soils were low in fertility and therefore should be supplemented with both
225 organic and inorganic fertilizer.

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