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

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ABSTRACT

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

INTRODUCTION

Water is an essential resource for living systems, industrial processes, agricultural production and domestic use. Ninety seven percent of the world's water is found in oceans. Only 2.5% of the world's water is non-saline fresh water (Itodo and Itodo, 2010). However, 75% of all fresh water is bound up in glaciers and ice caps. 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 on these water resources.

There is a growing human population in the world which means there is need for an increase in food production. However, food production to feed this growing population is decreasing due to poor agricultural practices (Sanda *et al*., 2014). One means to ameliorate this problem is the use of irrigation practices; however, irrigation is associated with a number of problems ranging from water mis-management 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, *et al.,* 2014).

Suitability of water for irrigation is determined by its chemical composition as regards to concentrations and types of soluble salts present. The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plants available nutrients (Ayers and Wescot, 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 basis 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 includes Electrical conductivity (EC), Total Dissolved Solid (TDS), potassium (K), calcium (Ca), magnesium (Mg), pH and Sodium adsorption ratio (SAR).

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

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

MATERIALS AND METHODS

Study Area

The study was conducted at the Teaching and Research Farm of Kebbi State University of Science and Technology located at Jega town (Lat.12^{o} 11', Long. 4^{o} 16' E) in the Sudan Savanna zone covering twenty hectares of land. The climate of the area is Dry sub humid.

Temperature varies from about 15^{o}C in November through January to about 40^{o}C in March to May and means annual rainfall is in the range of 580mm-700mm (Arnborg, 1988). Relative humidity ranged between 21-47% in the dry season and 51-79% during rainy season.

Sample Site

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

Sampling Techniques

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

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

Water Sample Analysis

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

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

$$RSC = (CO_3^{-} + HO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

Soil Analysis

Soil samples were analysed using methods described by Page *et al.,* (1982). Particle size distribution was analyzed using the Hydrometer method. Soil texture was determined with textural triangle. Organic C was determined using Walkley-Black (1934), total N by Micro-Kjeldahl technique and available P using Bray 1 method (Bray and Kurtz, 1945). pH $CaCl_2$ (1:2.5) was determined with glass electrode pH meter (Jackson, 1962), CEC was determined by saturating the soil with excess ammonium acetate solution and washing with excess alcohol. The samples were later distilled and the distillate received over boric acid indicator and titrated against standard HCl as outlined by Chapman (1964).Exchangeable bases were extracted with neutral NH_4 Ac solution; Na and K were then read on flame photometer while Ca and Mg determinations were determined by EDTA titration. Exchangeable sodium percentage (ESP) was calculated using the formular

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

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

Statistical Analysis

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

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

Sites	pH	EC (µs/cm)	SAR	RSC
T1	7	0.23	1.25	-3.4
T2	7.2	0.21	1.39	-3.95
T3	7.4	0.31	1.41	-4.1
Overall Mean	7.2	0.25	1.35	-3.8

Tube well water quality

Table 1 showed that pH of tube well water in the study area ranged from 7-7.4 with overall mean of 7.2. this pH agreed with the findings of Singh *et al*., (1996) and Singh and Tsoho (2000) which indicated that tube well water from Kebbi State had neutral to slightly to alkaline reaction. This could also be compared with mean pH of 6.7 for the West African ground water given by Roose and Lelong (1981). Furthermore, the values obtained are somewhat similar to pH (6.7) for tube well water observed by Singh (2003) in Zamfara State and (7.2-7.3) for rivers and streams in Sokoto State as reported by Singh and Tsoho (2000b). pH ranges of 5.4-7.7 (mean 6.5) agreed with observation of Singh *et al.,* (1996), which indicated that water from the tube wells in the fadama areas of Kebobs State varied from neutral to slightly alkaline reaction. EC values observed for tube well water in the study area ranged from 0.2-0.31µs/cm respectively which were higher than EC of 0.211µus/cm observed on the tube well water in T2. The overall mean was 0.25µs/cm. based on the US Salinity Laboratory Staff (Richard, 1954) classification suitability of irrigation water showed that the rube well water within the study area could be placed in C_1-low salinity water category. Table 1 also showed that mean value of SAR obtained was 1.35mg/l. The observed SAR was in order T1, T2 and T1 according to US Salinity laboratory staff (Richard, 1954), the SAR based classes are S_1-low sodium water, SAR<10, S_2-medium sodium water, SAR 10-18, S_3-high sodium water, SAR>26 with maximum SAR of 1.35mg/l, all the waters in the fadama. RSC is usually assessed when bicarbonate and carbonates levels are >120 and 15mg/l, respectively. The ranges of CO_3^- and HCO_3^- were -0 to 0.0.2 (mean 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).

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

Sites	TDS (Mg/l)	Ca (Mg/l)	Mg (Mg/l)	K (Mg/l)	Na (Mg/l)
T1	3	0.68	0.18	1.4	1.1
T2	1.67	0.61	0.17	1.4	1.16
T3	3	0.7	0.13	1.5	1.23
Overall Mean	2.55	0.66	0.16	1.43	1.16

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

low level of pollution of the ground water in the area which could be related to low population and low level of industrial activities.

Table 2 showed the basic cations concentrations for tubewell water at the study area were; 0.66mg/l for Ca, 0.16mg/L for Mg, 1.16mg/L for Na and 1.43m. Ca salts are known to cause salinity problems, fortunately, its concentration in the tube wells within fadama land of Kebbi State University Farm Jega area is quiet low, greatly lower than the rest of the basic cations. Substantially, high Mg^{2+} and K^{+} in the irrigation water suggests that it contains a lot of Mg^{2+} and K^{+} salts. Continuous and particularly excessive irrigation with such water may lead to a build up of salts and subsequent salinization. Sodium on the other hand is low. The result obtained in this study for basic cations is lower compared to that obtained by Sanda *et al.,* (2014) who reported 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 area.

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

Sites	Sand (%)	Silt (%)	Clay (%)	Texture class
T1	65.2	19.7	15.1	Sandy loam
T2	74.4	15.7	9.9	Sandy loam
T3	78.6	13.4	7.9	Loamy sand
Overall Mean	72.73	16.26	10.96	Sandy loam

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

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

Sites	pH	EC (µs/cm)	ESP (g/kg)
T1	6.0	53.67	11.2
T2	6.0	396.67	10.7
T3	6.2	253.67	29.6
Overall Mean	6.1	234.67	17.16

Table 4 showed that pH in T1, T2 and T3 had pH range from 6.0-6.2 with overall mean of 6.0. This showed that the pH in the study area is slightly acidic. The pH observed in this work is within optimum range for growth of most crops. This result agrees with Jones and Wild (1975), who reported that most of the arid and semi-arid soils have pH within the range of 6.0-6.8. The pH range for fadama soils in Sokoto Rima River Basin was 5.1-6.3 (mean 5.7) which also agrees with the values obtained by Yacouba, (1996). Table 4 also showed that EC and ESP ranges and mean 6-6.2 (overall mean 6.0), 198-653 (overall mean 396.67) and 11-29.6. (overall mean 17.16), respectively. The values agrees with 5.1-6.2 (mean 5.7) in Sokoto Rima River Basin (Yacouba, 1996; Singh, 1999a) observed that 98% and 94% of soils in Kebbi State had EC<2000

µs/cm and ESP<15 respectively. According to the criteria used for classifying salt affected soils, set by U.S Salinity Laboratory Staff (Richards, 1954), a soil with EC>400 µs/cm, ESP<15 and pH<8.5 as saline, those with the EC>4000 µs/cm, ESP>15 and pH 8.5 are saline sodic and that with EC<4000 µs/cm, ESP>15 and pH8.5-10.0 is sodic.

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

Sites	Organic carbon (%)	Total N (%)	Available P (mg/kg
T1	0.23	0.105	0.93
T2	0.38	0.074	0.84
T3	0.41	0.066	0.75
Overall Mean	0.34	0.081	0.84

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

Table 5 also showed that total N concentrations in all locations were regarded as low when compared with the standard given by (Esu, 1991). This result indicates the true characteristics of the savannah soils of low N content which could be attributed to higher volatile nature of N and the amount of solar radiation that were intercepted within the region.

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

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

Sites	K	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)
T1	1.16	0.82	1.27	0.27	7.32
T2	1.00	0.77	1.17	0.11	7.19
T3	1.88	0.71	1.18	0.11	6.96
Overall Mean	1.01	0.76	1.20	0.16	7.15

Table 6 showed that K obtained from T1,T2 and T3 ranges from 1.00-1.16 (overall mean 1.01) cmol(+)/kg. Singh *et al,* (1996), reported 0.05-0.22 (mean 0.12)cmol(+)/kg of potassium in soils from Kandolishela stream valley. These obtained values were higher than the available potassium of 0.15-0.33 (mean 0.25) cmol(+)/kg given for fadama soils of Sokoto Rima River

Bsin by Singh (1997b). Graham and Singh (1997) reported low available potassium of 0.2-0.3 (mean 0.5) cmol(+)/kg in the Wurno project area. This indicates that T2 and T3 have low exchangeable K compared to T1 which has high exchangeable K with overall mean of 1.01. Based on the rating scale, the soil have been classified as high in K. the high exchangeable K could be attributed to the use of NPK fertilizer by the farmers as well as K bearing minerals in parent materials of the study area. Na value obtained in table 6 from all sites (T1-T3) ranged from 0.71-0.82 (overall mean 0.76). This showed that the value of Na in the study area was high. Singh and Tsoho (2001), reported the values of Na for soils around river of Sokoto Kandolishela streams 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 respectively. The Na content for the fadama soils of Kalambaina, Illela and Usman Danfodio University in Sokoto State as reported by Sahabi *et al.,* (2002) were 0.39, 0.53 and 0.51 respectively.

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

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

Conclusion

Water samples were observed to have a mean pH (7.2), EC(0.25µs/cm) and SAR (1.35) and therefore could be used for irrigation purposes. Based on salinity hazard, 96% of water samples belonged to C_1-low salinity category and hence suitable for irrigation with minimum SAR. All the water in the study area could be used for irrigation purpose and are free from sodicity problems.

The soils of the study area were observed to be free from salinity and sodicity hazards with pH(6.1), EC(234.67µs/cm) SAR(17.6) and could be recommended that many crops could be grown on it with good management practices. Furthermore, the soils were low in fertility and therefore should be supplemented with both organic and inorganic fertilizer.

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