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MONITORING SALINIZATION ALONG LUGU MAIN CANAL OF WURNO IRRIGATION PROJECT

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ABSTRACT

A study was conducted to monitor salinity development along Lugu main canal of Wurno Irrigation Project. The objective of the study was to determine the current salinity levels at different soil depths. Four transects were randomly selected and soil samples were taken at two sampling points in each transect at 0 - 15, 15 - 30 and 30 - 45 cm depths. Soil pH, EC, CEC and exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) were determined while sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) were calculated from the results. The result shows that the surface soils (0 - 15 cm) were saline - sodic while the lower depths (15 - 30 and 30 - 45 cm) had no threat of salt accumulation. Continuous monitoring of the quality of the irrigation water and reclamation through substitution of Na^{+} from the exchange complex with Ca^{2+} using gypsum ($CaSO_4$. $2H_2O$) and subsequent leaching out of the salt with high quality irrigation water along with the provision of an efficient drainage system were recommended for the surface soils.

Keywords: Soil salinity; Sodicity; Wurno Irrigation Project

INTRODUCTION

Soil salinity is a common problem in soils of arid and semi arid regions, where irrigation farming is practiced. Presently, about 10% of the world arable lands are affected by salinity (Zimmar *et al.*, 2008). It is one of the major environmental factors limiting the productivity of agricultural lands (Sharma and Rao, 1998). About 20% of irrigated lands in the world are affected by different levels of salinity and sodicity, perhaps as a result of Irrigation farming which has increase by about 300% during the last 3 - 4 decades due to increased demand for food (Mostafazadeh-fard *et al.*, 2007). High ground water table coupled with increased frequency of irrigation expose soils to salinity/sodicity development (Mustapha and Nnalee, 2007). When water table is shallow, moisture is easily drawn to the surface by capillary action, and this brings dissolved salts to the soil surface as the moisture evaporates (Fitzpatrick, 1992). Alternatively, the water used for irrigation, whether taken

from a river or wells, may contain some impurities and dissolved salts (Rowell, 1988; Brady and Weil, 1999), which gets eventually deposited in the soils.

These soluble salts deposited in the soils affect growing plants greatly and in two ways; the ions they contain are harmful to the plants and the raising of osmotic pressure of the solution around the roots of the plants (Rowell, 1988). The former may be harmful in itself, but its harmful effects are more likely to be due to the consequence of high pH it brings about, which renders many nutrients such as P, Fe, Zn and Mn unavailable while the latter condition hinder uptake of water, P, Ca and K (Rowell, 1988).

Other primary physical processes associated with high sodium concentrations are soil dispersion which could result in reduced infiltration and hydraulic conductivity, surface crusting and increased bulk density. This hinder seed germination, root penetration, soil aeration and workability, thus adversely affecting plant growth and productivity (Graham and Singh, 1997). Therefore, monitoring soil salinity and sodicity has been a primary issue for irrigation systems management and rehabilitation policies (Zimmar *et al*., 2008).

It is worrisome that in spite of the high value attached to Wurno Irrigation Project by both the local farmers and the policy makers, which led to its rehabilitation, there is little or no documented information on the salinity/sodicity status of the soils of the project area. Farmers of the area have been expressing some concerns over the decline in crop yields due to possible accumulation of soluble salts in the soils. Previous reports identified Wurno as one of the areas affected by salt accumulation in Sokoto state (Webber and Monthirth, 1983; Graham and Singh, 1997 and Audu *et al.,* 2009). This study was therefore, undertaken to monitor the current salinity and sodicity status of the soils at different depths.

MATERIALS AND METHODS

The Study Area

Wurno Irrigation Project is located in the Northeastern part of Sokoto state, about 45 km from Sokoto town, within the Sudan savanna ecological zone. It is a small scale irrigation project of about 1200 ha with about 13 villages around it (Babura, 1993). The project comprises a storage reservoir with a capacity of 19, 501, 200 m^3 of water supplied from River Rima. The reservoir is linked to two main canals; Tutudawa and Lugu main canals which pass through Tutudawa and Lugu villages respectively. This study was limited to the Lugu main canal section of the Project.

Sokoto state is located between Latitudes $11^0\,30^1$ to $13^0\,50^1$ N and Longitude $4^0\,0^1$ to $6^0\,0^1$ E (SSGOD, 2003).The climate consists of a long dry season (October to May) and a short wet season (June to September) (Graham and Singh, 1997). The mean annual rainfall in the area is about 550 - 600 mm with the peak in August (Singh, 1995). The rainfall is scanty in quantity, erratic in behavior and poor in distribution (Singh, 1995; Graham and Singh, 1997). The temperature ranges from a minimum of 17^{o}C in December/January to 40^{o}C in April/May.

Soil Sampling, Preparation and Analyses

Four transects were randomly chosen and two sampling points were marked on each. Soil samples were then taken from each sampling point at 0 - 15, 15 - 30 and 30 - 45 cm

depths, giving a total of 24 samples. The soil samples were air dried, ground with a pestle and mortar, sieved through 2 mm sieve mesh for chemical analyses.

Soil chemical properties determined from the samples were as follows; Soil pH in 0.01 M $CaCl_2$, 1:1 soil: solution ratio using pH meter, CEC by ammonium saturation method (Black, 1965), the extract was retained and used for the determination of exchangeable bases; Na and K were determined by flame photometry (Rich, 1965) while Ca and Mg were determined by EDTA titration method (Devis and Freitas, 1970). Electrical conductivity (EC) was determined in 1:5 soils: water suspension ratio using conductivity meter.

The following parameters were calculated from the results of the chemical analyses using the following expressions:

1. Exchangeable sodium percentage (ESP): $ESP = \frac{Conc\ Na^{+}\ X\ 100}{CEC}$

Where the units of concentration are in $cmol_c\ kg^{-1}$

2. Sodium adsorption ratio: $SAR = \frac{[Na^{+}]}{\sqrt{1/2([Ca^{+}]+[Mg^{+}])}}$

Where [ ] = concentrations of Na, Ca and Mg (Van de Graff and Patterson, 2001).

RESULTS AND DISCUSSION

The result of the chemical analyses is shown in Tables 1-3. The soil pH ranged between 6.0 - 7.8, 5.8-7.8 and 5.5-7.6 for the 0-15, 15-30 and 30-45 cm soil depths respectively, indicating a neutral to slightly acid pH, gradually decreasing down the profile an indication of an increasing level of acidity down the profile.

Table 1: Some chemical properties of soils of Lugu main canal of Wurno Irrigation Project after rehabilitation (0 -15cm depth)

Transects	Sampling spots	pH	Ca	Mg	K	Na	CEC	EC	SAR	ESP
		<-------$cmol_c\ kg^{-1}$---------->						dSm^{-1}		
A	1	7.3	0.40	1.75	0.21	0.90	5.92	6.72	0.87	15
	2	7.4	0.44	2.15	0.26	0.52	3.85	4.99	0.46	14
B	1	7.8	0.70	1.45	0.24	1.27	4.72	1.72	1.22	27
	2	7.7	0.55	1.50	0.30	1.47	4.20	10.27	1.68	35
C	1	6.0	0.50	2.20	0.24	1.16	6.24	3.64	1.96	19
	2	6.7	0.85	1.00	0.16	1.15	4.45	2.43	1.19	26
D	1	7.0	0.70	0.55	0.14	0.52	3.32	1.47	0.66	22
	2	7.1	0.85	0.70	0.11	0.78	3.60	1.79	0.89	23
Mean		7.12	0.62	1.41	0.20	0.97	4.41	4.12	1.11	23
St. Dev.		0.58	0.18	0.62	0.07	0.34	1.25	3.09	0.51	6.86
St. Error		0.20	0.06	0.21	0.02	0.12	0.44	1.09	0.18	2.42

The mean CEC values of the soils were 4.41, 4.34 and 3.99 $cmol_c\ kg^{-1}$ for the 0-15, 15-30 and 30-45 cm depths respectively, which shows low CEC that decreased down the

profile. Low levels of Ca and K (means of 0.62 and 0.20 $cmol_c\ kg^{-1}$), moderate Mg (mean of 1.41 $cmol_c\ kg^{-1}$) and high Na (mean of 0.97 $cmol_c\ kg^{-1}$) at surface soil were obtained (Table 1). Similarly, very low Ca and K (means of 0.88 and 0.15 $cmol_c\ kg^{-1}$), moderate Mg and Na (means of 1.16 and 0.48 $cmol_c\ kg^{-1}$) at the 15-30 cm depth (Table 2). There was very low Ca and K (means of 0.82 and 0.09 $cmol_c\ kg^{-1}$), high Mg (mean of 1.30 $cmol_c\ kg^{-1}$) and moderate Na (mean of 0.47 $cmol_c\ kg^{-1}$) values at the 30-45 cm depth (Table 3), indicating higher sodium content at the surface soils.

Table 2: Some chemical properties of soils of Lugu main canal of Wurno Irrigation Project after rehabilitation (15 - 30 cm depth)

Transects	Sampling spots	pH	Ca	Mg	K	Na	CEC	EC	SAR	ESP
			<----------$cmol_c\ kg^{-1}$---------->					dSm^{-1}		
A	1	5.9	0.70	1.55	0.20	0.83	5.88	1.79	0.78	14
	2	7.8	0.55	1.90	0.12	0.59	3.65	3.45	0.53	16
B	1	6.2	1.45	1.45	0.21	0.31	4.82	1.15	0.28	6
	2	7.8	1.30	1.30	0.15	0.43	3.12	8.57	0.43	14
C	1	5.8	1.35	1.35	0.15	0.15	5.20	0.89	0.14	3
	2	6.8	0.95	0.95	0.15	0.50	5.31	1.34	0.43	9
D	1	7.3	0.15	0.15	0.12	0.31	3.21	1.40	0.38	10
	2	7.4	0.65	0.65	0.11	0.71	3.56	1.60	0.81	20
Mean		6.9	0.88	1.16	0.15	0.48	4.34	2.52	0.47	11
St. Dev.		0.82	0.45	0.55	0.03	0.22	1.08	2.56	0.23	5.55
St. Error		0.29	0.16	0.19	0.01	0.07	0.38	0.90	0.08	1.96

The electrical conductivity (EC) of the surface soils (0 - 15 cm) ranged between 1.47 - 10.27 with a mean of 4.12 d S m^{-1}, and 0.89 - 8.57 with a mean of 2.52 d S m^{-1} and 1.15 - 3.90 with a mean of 2.47 d S m-^{1} at the 15 - 30 and 30 - 45 cm depths respectively, an indication of high salt accumulation at the surface and gradually decreasing down the profile. The mean EC, pH, SAR and ESP of the surface soils are 4.12, 7.12, 1.11 and 23% (Table 1) which indicates domination of the exchange complex with Na, and when related with the USLS(United States Laboratory Staff) (1954) critical limits for EC (d S m^{-1}), ESP and pH as > 4, < 15 and < 8.5 for saline, > 4, > 15 and < 8.5 for saline sodic and < 4, > 15 and > 8.5 for sodic soils. The surface soils were saline - sodic, which corroborates the report of Audu *et al*. (2009). Similar criteria were adopted by FMAWRRD (1989) and FMANR (1990) in classifying soils of other areas. The result implies that the soils have sufficient exchangeable sodium that could interfere with the growth of most plants, and contain appreciable quantities of soluble salts (Adepetu, 2000). Under such conditions of high ions content in the soils could be toxic to the crops and could result in a rise of osmotic pressure of the soil solution in the rhizosphere of the plant roots and could also hinder uptake of P, Ca and K (Rowell, 1988).

On the other hand, the soils in the 15 - 30 and 30 - 45 cm depths had mean EC, ESP and pH as 2.52 d S m^{-1}, 11% and 6.9 ; 2.47 d S m^{-1}, 13% and 6.5 respectively (Tables 2 and 3), which were less than the critical values indicating that the soils at these depths were normal. This implies that salinity/sodicity problems were not expected down the profile and do not pose any hazard problem. The upper soil layers being saline - sodic, requires

reclamation through the use of judicious quantity of gypsum; calcium sulphate ($CaSO_4$. $2H_2O$) and subsequent leaching of the salts.

Table 3: Some chemical properties of soils of Lugu main canal of Wurno Irrigation Project after rehabilitation (30 - 45 cm depth)

Transects	Sampling spots	pH	Ca	Mg	K	Na	CEC	EC	SAR	ESP
		<----------$cmol_c\ kg^{-1}$---------->						dSm^{-1}		
A	1	5.5	0.65	1.65	0.16	0.71	5.24	1.85	0.66	14
	2	7.6	0.50	1.15	0.16	0.45	2.68	2.36	0.50	17
B	1	5.9	0.90	1.05	0.13	0.38	5.06	1.15	0.38	8
	2	7.6	1.10	0.90	0.04	0.24	2.56	2.27	0.24	9
C	1	5.9	0.80	1.35	0.12	1.12	6.36	3.90	1.08	18
	2	6.3	0.95	1.00	0.05	0.17	2.40	3.00	0.17	7
D	1	7.2	0.85	1.80	0.02	0.17	4.00	1.66	0.15	17
	2	6.6	0.80	1.45	0.07	0.48	3.68	3.58	0.45	13
Mean		6.57	0.82	1.30	0.09	0.47	3.99	2.47	0.45	13
St. Dev.		0.81	0.18	0.32	0.06	0.32	1.50	0.96	0.30	4.39
St. Error		0.28	0.06	0.11	0.02	0.11	0.51	0.34	0.11	1.55

CONCLUSION

The surface soils in the command area of the Lugu main canal of Wurno Irrigation Project were saline- sodic, as such crop growth would be hindered, while the lower depths (15-45 cm) were free of salinity problem for now. The CEC values of the soils were low at all depths, with very low levels of Ca and K, moderate to high levels of Mg and Na which were higher at the surface and decreased down the profile. Reclamation by substitution of the Na in the exchange complex with Ca using judicious quantity of gypsum ($CaSO_4$. $2H_2O$) and subsequent leaching with adequate quantity of high quality irrigation water, along with provision of adequate drainage is recommended to improve the soil productivity. The situation of Wurno Irrigation Project also requires continuous monitoring the soil.

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