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Assessing the Effect of Salinity on an Irrigated Land

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Abstract

A study of the effect of salinity on an irrigated land was carried out at Kofai, Ardo-Kola Local Government of Taraba State. The study area was divided into four (4) units designated as A, B, C and D, each unit was subdivided into five (5) parts, designated as A_1, A_2, A_3, A_4, A_5, B_1, B_2, B_3, B_4, B_5, C_1, C_2, C_3, C_4, C_5, D_1, D_2, D_3, D_4, and D_5, respectively, made up of twenty (20) soil samples that were collected within the irrigated land for the laboratory analysis of salinity. The parameters analyzed were pH, Electrical Conductivity (EC), Magnesium, Sodium, Potassium, Calcium, Hydrogen and Aluminum concentration. The results of the soil sample analysis shows that the mean value of pH is 5.99 which indicates that the soil is slightly acidic, the mean value of electrical conductivity (EC) is 0.76 ds/m, Calcium, Magnesium, Aluminum and Hydrogen concentration were obtained to be 11.29, 7.89, 7.98 and 16.88 mg/l respectively, while Sodium and Potassium concentration were obtained to be 0.90 and 0.67 mg/l respectively with Sodium Absorption Ratio (SAR) of 0.25 mEq/l. From the analysis it indicates that the soil is low in salinity. Similarly for water sample analysis the pH is 7.7 which indicate that the water is slightly alkaline, EC is 0.8 ds/m, calcium and magnesium concentration were 0.48 and 0.35 mg/l, while sodium and potassium were

0.57 and 0.71 mg/l respectively, with Sodium Absorption Ratio (SAR) of 0.89 meq/l, which shows that the water sample were found within the safe limit for irrigation. It can be recommended that application of good quality water, choice of salt tolerant crops and gypsum be adopted in the study area.

Keywords

Soil Sample; Water Sample; Salinity; Slightly alkaline; Slightly Acidic

Introduction

All irrigation water contains dissolved mineral salts, but the concentration and composition of the dissolved salts vary depending on the source of the irrigation water. Too much salt can reduce or even prohibit crop production while too little salt can reduce water infiltration, which indirectly affects the crop. An understanding of the quality of water used for irrigation and its potential negative impacts on crop growth is essential to avoid problems and to optimize production. Maas and Grattan [1], provide an extensive list of salinity coefficient for a number of horticultural and agronomic crops. These coefficients consist of a threshold and slope. The salinity threshold (a) is the maximum average soil salts EC_e that the crop can tolerate in the root zone without a decline in yield. The slope coefficient (b) is the percent loss in relation to yield the crop will experience for every unit increase in EC_e above the threshold. Using these coefficients, the yield potential (% Yield) can be estimated from the following expression:

$$\% \text{ Yield} = 100 - b\,(EC_e - a)$$

Irrigation salinity is the rise in saline of groundwater and the buildup of salt in the soil surface in irrigated area. Salinity is the presence of soluble salts in the soil or water; it is generally used to describe the presence of elevated levels of different salts such as sodium chloride, magnesium, calcium sulfate and Bicarbonate in the soil and water table rising to or close to the ground surface. Saline soils are soil having excessive soluble salts that make the soils solution sufficient concentrated to injure plants and hinder soil productivity. Soil salinity problems generally occur in arid and semiarid regions and reduce crop production at different levels. Salinity is also a major limiting factor for crop yield in poorly drained soils [2-5].

In some areas of the world where salinity is a major problem, it is rather difficult to monitor the required ground information in the areas affected by salinity [6]. Multitemporal

analysis might be effective in detecting salt dynamics in a certain region and assessing the degree of damage on both crops and yield. It was estimated that one third of irrigated land has been affected by salinity problem [7], in addition nearly 300,000 hectares in loss of their productivity because of missing irrigation every year in the world [8]. In Turkey, the areas affected are about 2 million hectares but it may increase if management systems are not considered.

In salinity soil, water uptake by plants root is limited because of high osmotic potential and toxicity of sodium and chlorine irrigated. These are the main reason for low plant production in salts affected areas [9, 10].

Material and Method

Study Area

The study area is located in the eastern part of Jalingo Town, in Ardo-Kola Local government area of Taraba state, with a population density of 87,488 [11]. Ardo-Kola Local government area is bounded in the east of Gassol local government in the south. The region characterized by different mountains with vegetation cover and streams, with river Benue along the northern border. The climate tolerates all kinds of crops and it is moderately warm with a temperature of 30 - 36°C during the rainy season, which is from April to November every year [12]. The major occupations of the people in the area are farming and a little cattle rearing. They practice both rainy and dry season farming, during the dry season farming, crops grown include vegetables, maize, water melon, okro, pepper, sugar cane, this takes place from the month of September to April.

Procedure for Soil Sample Collection

The study area covers about ten (10) hectares, the area was divided into four (4) units as A, B, C and D, each unit was sub-divided into five (5) parts, designated as, A_1, A_2, A_3, A_4, A_5, B_1, B_2, B_3, B_4, B_5, C_1, C_2, C_3, C_4, C_5, D_1, D_2, D_3, D_4, and D_5, made up of twenty (20) soil samples that were collected for the laboratory analysis, the samples were collected at the depth of 0 – 25 cm from the virgin soil.

Method Used for Chemical Analysis

The pH and electrical conductivity (EC) values were determined electrometrically using pH meter and electrical meter [13]. Potassium and Sodium were determined by flame emission spectrophotometer [14]. Calcium and Magnesium were analyzed directly by Atomic Absorption Spectrophotometer [15]. Exchangeable acidity, Aluminum and Hydrogen were determined using titration method [16].

Results and Discussion

The results obtained from the laboratory analysis are shown in Tables 1 - 3.

Table 1. Chemical Properties for Soil Sample of Kofai Irrigation Area

Sample Number	pH	EC ds/m	Exchangeable Acidity (mg/l)		Exchangeable Bases (mg/l)			
			$H^+ + Al^{2+}$	H^+ alone	Ca^{2+}	Mg^{2+}	Na^+	K^+
A_1	6.20	0.60	11.00	7.90	18.70	14.80	0.50	0.66
A_2	5.70	0.84	9.60	8.40	20.70	12.56	0.34	0.61
A_3	5.90	1.20	8.40	6.70	15.60	10.12	0.78	0.89
A_4	5.64	1.08	13.45	9.40	10.70	6.80	1.02	0.49
A_5	5.33	0.52	14.78	7.40	23.00	5.70	2.40	0.78
B_1	5.71	0.70	11.30	4.70	17.86	4.87	0.50	0.43
B_2	5.90	1.97	10.80	7.80	10.50	7.80	0.70	0.34
B_3	6.40	0.59	10.20	6.70	17.80	13.40	0.34	0.13
B_4	6.10	0.90	12.70	9.90	12.70	14.70	0.38	0.74
B_5	5.49	0.87	13.50	11.10	23.00	8.50	2.40	0.67
C_1	6.12	1.30	10.12	8.40	11.20	9.45	2.12	0.60
C_2	5.95	1.20	9.90	7.70	8.90	2.90	0.94	0.68
C_3	6.30	0.67	12.14	9.90	32.40	4.86	1.48	0.77
C_4	5.43	1.01	14.40	9.70	25.07	6.30	1.52	0.45
C_5	5.92	0.85	9.70	3.00	18.90	5.70	0.87	0.89
D_1	7.01	0.46	8.97	7.20	15.77	8.90	0.30	0.54
D_2	6.81	0.50	12.00	9.00	16.08	8.50	0.12	0.63
D_3	5.78	1.49	10.89	7.87	10.43	9.70	0.18	0.47
D_4	5.67	1.30	12.18	5.79	13.49	14.10	0.49	0.54
D_5	6.34	0.76	9.80	6.35	14.75	12.78	0.59	2.11
Ranges	5.33 - 7.01	0.46 - 1.97	8.40 - 14.78	3.00 - 11.10	8.90- 32.40	2.90-14.80	0.12-2.40	0.13-2.11
Average	5.99	0.96	11.29	7.98	16.88	9.16	0.90	0.67

The Sodium Absorption Ratio (SAR) for the soil sample was determined as 0.25 mEq/l.

The pH values of soil sample varied from 5.33 - 7.01 with mean value of 5.99 (Table 1), which indicate that the soil is slightly acidic, similarly that of water sample varied from

7.60 - 7.80 with the mean value of 7.70 (Table 3), indicating that the water is slightly alkaline in nature, the pH values are within the safe limit for irrigation, since the recommended pH limit for irrigation water ranges from 6.0 to 8.5 [17].

Table 2. Determined Chemical Properties for the Soil Sample of Kofai Irrigation Area

Sample Unit	TEB	CEC	ECEC	PBS	ESP
A_1	34.60	42.57	53.57	81.44	1.17
A_2	34.21	42.61	52.21	80.29	0.80
A_3	27.48	34.18	42.58	80.40	2.28
A_4	19.01	28.41	41.86	66.91	3.59
A_5	31.86	39.28	54.06	81.16	6.11
B_1	23.66	28.36	39.66	83.43	1.76
B_2	19.34	27.14	37.94	71.26	2.58
B_3	31.67	38.37	48.57	82.54	0.89
B_4	28.52	38.42	51.12	74.23	0.99
B_5	34.57	45.67	59.17	75.70	5.26
C_1	23.37	31.77	41.89	73.56	6.67
C_2	13.42	21.12	31.02	63.54	4.45
C_3	39.51	49.41	61.55	79.69	3.00
C_4	33.34	43.04	57.44	77.46	3.53
C_5	26.36	29.36	39.06	89.78	2.96
D_1	25.51	32.71	41.68	78.00	0.92
D_2	25.33	34.33	46.33	73.78	0.35
D_3	20.78	28.65	39.54	72.53	0.63
D_4	29.32	35.11	47.29	83.51	1.40
D_5	30.29	36.59	46.39	82.78	1.61
Ranges	13.42 - 39.51	21.12 - 49.41	31.02 - 61.55	63.54 - 89.78	0.35 - 6.67
Average	26.41	35.38	48.65	77.63	2.55

TEB = Total Exchangeable Bases; CEC = Cation Exchange Capacity;
ECEC = Effective Cation Exchange Capacity; PBS = Percentage Base Saturation;
ESP = Exchangeable Sodium Percentage

Table 3. Chemical Properties for the Water Sample of Kofai Irrigation Area

Parameter	Unit	Values
SAR	Meq/l	0.89
Sodium	Mg/l	0.57
Calcium	Mg/l	0.48
Magnesium	Mg/l	0.35
Potassium	Mg/l	0.71
Electrical Conductivity (EC)	ds/m	0.80
pH	-	7.70

Electrical conductivity (EC) of soil sample ranged from 0.46 to1.97 ds/m with a mean value of 0.96 ds/m (Table 1), indicating that there is no salinity risk to soil, since no value is up to 4 ds/m, which is the critical limit [18], similarly that of the water sample is 0.8 ds/m (Table 2), this also indicate that there is no salinity risk to water for irrigation, since the usual

range of Electrical Conductivity (EC) in irrigation water ranges from 0 to 3.0 ds/m. Calcium ranged from 8.90 to 32.40 mg/l with a mean value of 16.88 mg/l for soil, Magnesium ranged from 4.86 to 14.80 mg/l with the mean value of 9.16 mg/l, Potassium ranged from 0.13 to 2.11mg/l with a mean value of o.67 mg/l and Sodium ranged from 0.30 to 2.40 mg/l with the value of 0.90 mg/l (Table 1), these values shows that the soil has high cation exchangeable capacity (CEC) bases, similarly for the water sample, the Calcium is 0.48 mg/l, Magnesium is 0.35 mg/l, Potassium is 0.71 mg/l and Sodium is 0.57 mg/l (Table 3), the Ca, Mg, K and Na contents of water sample were found within the safe limit for irrigation, since the recommended limits for Ca, Mg, K and Na, for irrigation water were ranged between 0 – 20 mg/l, 0 - 5 mg/l, 0 – 2 mg/l and 0-40 mg/l respectively [17].

The exchangeable acidity of the soil sample ranged from 7.98 to 11.29 mg/l with mean value of 9.64 mg/l (Table 1), this value is due to less content of exchangeable acidic cation ($H^+ + Al^{2+}$) at the exchange site of the soil. The cat ion exchange capacity (CEC) value ranged from 21.12 to 49.41 mg/l of soil with the mean value of 35.56 mg/l (Table 2), the value is moderate for most crops to adopt [19].

The Sodium Absorption Ratio (SAR) of the soil sample is 0.25 meq/l (Table 1) which indicates that the overall alkalinity hazard of the soil is very low, thus the soil is safe for crop production and irrigation use. Similarly that of the water sample is 0.89 meq/l (Table 3), also indicate that the salinity is low, since the usual range of the Sodium Absorption Ratio (SAR) in irrigation water ranges from 0 to 15 meq/l [17].

Conclusions

The results of the soil sample analysis shows that the mean value of pH is 5.99 which indicates that the soil is slightly acidic, the mean value of electrical conductivity (EC) is 0.76 ds/m, Calcium, Magnesium, Aluminum and Hydrogen concentration obtained were 11.29, 7.89, 7.98 and 16.88 mg/l respectively, while Sodium and Potassium concentration were obtained to be 0.90 and 0.67 mg/l respectively with SAR of 0.25 meq/l. From the analysis it indicates that the soil is low in salinity. Similarly for water sample analysis the pH is 7.7 which indicate that the water is slightly alkaline, EC is 0.8 ds/m, calcium and magnesium concentration were 0.48 and 0.35 mg/l, while sodium and potassium were 0.57 and 0.71 mg/l respectively, with SAR of 0.89 meq/l, which shows that the water sample were found within

the safe limit for irrigation.

Generally the result of the analysis shows that, the pH values for both the soil and water samples were within the range quality standard for irrigation purposes and the Sodium Absorption Ratio (SAR) recorded shows that, there is no salinity risk within the irrigation land.

Recommendation

The following management practice should be adopted for both the water and soil

- Application of lime to the soil to keep the soil in good condition;
- Application of good quality water that contain relatively low amount of dissolved salts;
- Choice of salt tolerant crops;
- Application of acid fertilizer should be avoided e.g. urea and ammonium sulphate.

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