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Reclamation of saline sodic lands with chemical amendments

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INTRODUCTION

In the arid and semi arid regions of the world the soils are deficient in moisture. They have established equilibrium with their environments and show the characteristics of salinity and sodicity. The canal irrigated areas of Pakistan are also a part of these regions and consequently the lands are inherently saline and sodic in nature.

The introduction of canal irrigation system in the country has caused the ground water level to rise which has aggrevated the situation further with respect to salinity and sodicity (1985). In the Punjab alone at present 2.66 million acres of the cultivated land (11.11%) is in the grip of salinity and sodicity. This is on the basis of the visual soil salinity survey. The magnitude of salinity and waterlogging problems in Pakistan has also been assessed by Planning Division WAPDA (1979) in the country wide survey in the irrigated areas of 34.5 million acres. According to these data 25% of the irrigated land is affected by salinity in varyingdegreeson the surface. The profile salinity has been estimated at 38% in the culturable commanded area.

To achieve the desired level of production of agricultural crops, the reclamation of these lands is a pre-requisite. This would ensure the prosperity of the masses in the country..

Reclamation of saline sodic lands involves the elimination of two components: Salinity and Sodicity, Salts in saline sodic lands are mainly sodium chloride and sodium sulphate which are highly soluble in water. At room temperature the solubility of sodium chloride is 37%, whereas that of sodium sulphate is 14%. They are easily removed by leaching when an adequate amount of irrigation water is applied for this purpose but sodicity persits. It takes 4 to 6 years to get rid of it by simple leaching which is generally practised in the country at present. It needs the replacement of exchangeable sodium from the soil with an equivalent amount of some divalent cations.

With the application of suitable soil amendments which may provide divalent cations directly or indirectly the process of reclamation of a saline sodic land can be achieved within a short period of time.

The commonly available amendments for the reclamation of saline sodic/sodic lands are gypsum and sulphuric acid. Recently the Ittehad Chemicals Ltd Kalashah Kaku have started the manufacture of castic soda from sodium chloride. During its manufacturing process about 50 tons hydrochloric acid is obtained as a by product daily. Its disposal has been a problem for the castic soda manufacturers. It has utility for the reclamation of saline sodic/sodic soils.

The effectiveness of gypsum, sulphuric acid and hydrochloric acid has been examined experimentally both at the Laboratory and Field levels and the results achieved therefrom are discussed in this paper:

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REVIEW OF LITERATURE

1. Kelley (1951) applied gypsum to an alkali soil at the rate of 10 – 12 and 15 tons per acre. The plots were flooded continuously for three weeks. He found that the exchangeable sodium was effectively removed to a depth of four feet and practically a barren land was converted into a high productive land.

2. Haider (1959) reported that leaching with water alone was in-effective while gypsum in comibination with leaching effectively reclaimed a "Bara" soil.

3. R.C. Renord and C.A. Bower (1960) used sea water for reclaiming a sodic soil. The sea water contained 11.6 meq/1 of Ca + Mg. They pointed out that with the use of only 4 feet of Sea water combined with 6 feet of Clorado River water, reduced the initial exchangeable sodium percentage of the soil from 39 to 5 and reduced the time of reclamation from 120 days to 12 days.

4. Bower (1962) recommended that for soils having a gypsum requirement upto 5 meq/1 100 gms of soil growing of rice and green manure crops could be depended upon for reclamation of a saline sodic soil in a reasonable period of time.

5. Zaidi and Qayyum (1968) reported that the rate of reclamation increased considerably with the use of gypsum and farm yard manure and the income obtained with the use of amendments for reclamation is more than that with leaching without amendments.

6. Hussain Mohammad (1968) reported had it takes 6 – 8 years for reclaiming a saline sodic soil by rice culture and that application of gypsum accelerates the replacement of exchangeable sodium.

7. B.K. Khosla and I.P. Abra (1972) studied the effect of gypsum of varying fines on the composition of saturation extract of a saline sodic soil. They reported that much of the gypsum is utilized in precipitating the soluble carbonates to form relatively insoluble calcium carbonate. Gypsum of slightly finer than 0.59 mesh would be more effective than that of the coarse grades. The amount of gypsum needed to neutralize the soluble carbonates is shown to be indicative to the minimum amount of amendments required to start the reclamation of a saline sodic soil high in carbonates.

8. G.R. Dutt: Terkeltoul and Roa Shkoll R.S. (1972) pointed out that the amounts of water and gypsum required for reclaiming the soil were highly dependent upon the quality of water used for leaching.

9. Mohammad and Khaliq (1975) reported that gypsum sulpher combination with manure were quite efficient in reclaiming a saline sodic soil.

10. Hussain and Asghar (1985) found out that with the application of Gypsum even though it is applied to the extent of 1/2 or 1/4 of the total requirement of the soil the reclamation of saline sodic soil is accelerated and can be achieved within a limited period of time. The increase in infiltration rate of the soil is almost equal with 1/2 and 1/4 of the gypsum requirement applications. They further concluded that the rice is a highly sodic resistant crop.

MATERIAL AND METHODS

In the laboratory the experiment was carried out in glazed pots, 28 Cm in dia-meter and 26 Cm deep. There was a hole close to the bottom on one side of the pot to pass the leachate. Saline sodic soil was used for the study. It was prepared and sieved through 0.2 mm mesh. It was analysed

for its mechanical ingredients: sand, silt and clay. It was also analysed to find out its salinity and sodicity status, calcium carbonate, base exchange capacity and exchangeable sodium percentage. The analysis results are given in Table-I.

A one centimetre deep layer of sand was placed at the bottom of each pot. On it 18 k. grams of soil was packed uniformly.

The amendments; hydrochloric acid, sulphurc acid and gypsum were applied on the basis of the gypsum requirements of the soil. The following alterative treatments were studied:-

1. Application of hydrochloric acid to meet the full gypsum requirements of the soil.
2. Application of hydrochloric acid to meet 1/2 gypsum requirements of the soil.
3. Application of hydrochloric acid to meet 1/4 gypsum requirements of the soil.
4. Application of sulphuric acid to meet the full gypsum requirements of the soil.
5. Application of sulphuric acid to meet the 1/2 gypsum requirements of the soil.
6. Application of sulphuric acid to meet the 1/4 gypsum requirements of the soil.
7. Application of gypsum to meet the full gypsum requirements of the soil.
8. Application of gypsum to meet the 1/2 gypsum requirements of the soil.
9. Application of gypsum to meet the 1/4 gypsum requirements of the soil.
10. Control. (No amendments now applied)

There were four replications of each treatment. In both the cases of the laboratory and the field studies/Gypsum was applied and mixed with upper 7.5 cm soil depth before starting the leaching process, whereas sulphuric acid and hydrochloric acid were applied with the first irrigation given for leaching.

In the laboratory during the leaching process the pots were kept covered with polyetheylene sheet to intercept the rainfall to avoid overflow of water in case of a heavy rainfall.

The first irrigation was of 4 litre water to bring the soil moisture to the field capacity level. After this the soil was allowed to settle for 7 days. After this leaching with canal water was started. Water was applied when the water given previously had just disappeared. The leaching process was completed within 15 days. pH and EC of the leachate were found out after applying the last irrigation for leaching. Air dry decomposed Farm Yard Manure and Ammonium sulphate were applied at the rate of 70 gms and 2 gms respectively. Rice plants of variety 370 were planted. They were put in at 4 spots in each pot at equal distances from each other. 2 plants were put in at each point. Irrigation were applied to the crop in a way that the water was put in a pot when the water given to it previously had just disappeared. 33.02 Cm rainfall was received during the growth period of the Rice crop.

The crop matured and the paddy was removed to find out its yield. The infilteration rate of the soil was found out after removing the crop. The berseem crop followed the Rice crop.

In the field 40.64 Cm water was applied for leaching. 3.8 Cms rainfall was received during the leaching period. The leaching process was completed within 20 days. The first crop grown was Berseem.

RESULTS AND DISCUSSION

The analysis results (Table-I) indicate that the soil was loam in texture. It was highly saline and sodic in nature and was suitable to carry out the study to observe the effectiveness of different amendments to convert a dead soil into a living and productive material.

The results show (Table-2) that 29.21 Cm water could be applied for leaching in case of control and the same was 38.86 Cm in case of one quarter hydrochloric acid applications whereas in all other treatments it was 45.72.

The PH values of the leachate indicate that the abnormal condition of sodicity existed at the end, in cases of control, one half and one quarter hydrochloric acid applications, when the leaching process had been completed, whereas in others it had been lowered to the permissible limits of a normal soil. The EC of the lachate show that it remained high (8-6 mmhos/cm) in case of control. The sodium absorption ratio values show the characteristics of a sodic soil in case of control and one quarter hydrochloric acid treatments.

The irrigation delta applied to rice crop was 70.5 Cms in case of control; 76.5 Cms in one quarter hydrochloric acid applications, 81 Cms in case of one half hydrochloric acid treatments and 38 Cms in one quarter sulphuric acid applications. In all other treatments it was more than 90 Cms.

All these figures are related to the infilteration rate of the soil which seems to have a relationship with the molecular size of the salt that passed through the soil during the reclamation process of the soil. The malecules that passed through the soil with leaching/infiltering water were of sodium chloride and sodium sulphate which were produced by the replacement of the exchangeable sodium by calcium from calcium sulphate or calcium chloride added into the soil. The yield results of both the Rice and Berseem crops (Table-3) indicate that the rice crop is quite resistant to sodicity, whereas the berseem crop does not give good response to it.

The similar results were obtained in the field trials.

CONCLUSIONS

1. The reclamation process of a saline sodic/sodic soil is highly accelerated with the use of amendments to provide divalent conditions.
2. Gypsum and sulphuric acid are equally effective to increase the infilteration rate of a degraded saline sodic land.
3. Hydrochloric acid produces calcium chloride in a saline sodic calcareous soil. Calcium chloride provides the calcium to eliminate the sodicity present in the soil.
4. The developed infilteration rate of the soil is co-related to the molecular size of the compound passing through the soil in solution.

Table-I Showing the Analysis results of the soil

					Clay	Percentage of Silt			Sand	
					14.2	28.8			56	
			Texture					Loam		
Saturation %	pH	ECx10^6	Ca+Mg	Na	Co_3	HCO_3	Cl	SO_4	SAR	
				Milliequivalent/Liter						
35	9.8	25	1.5	26.5	4.6	9.50	190.5	61.9	308.1	

Gypsum requirement tons per acre foot of the soil	=	9.62
C.E.C.	=	6.0
Exchangeable sodium meq/100 grams	=	5.7
Exchange sodium %	=	95
Calcium Carbonate %	=	18

Table – 2 Mean Values of:

	Full HCL	½ HCL	¼ HCL	Full H_2SO_4	H_2SO_4 ½	H_2SO_4 ¼	Full Gyp.	½ Gyp.	¼ Gyp.	Control
Irrigation delta applied for leaching cms Mean Values of (Cms)	45.72	45.72	38.90	45.72	45.72	45.72	45.72	45.72	45.72	29.21
pH of the leachate	8.3	8.6	8.7	8.3	8.5	8.5	8.3	8.4	8.5	9.4
EC x 10^3 of the leachate.	1.4	2.1	4.8	2.8	2.7	2.5	3.8	3.2	3.3	8.6
SAR of the leachate	0.9	11.3	19.2	1.9	2.8	2.2	1.0	1.3	3.5	24.98
Infilteration rate of the soil after the 1st. rice crop.	.67	.44	.27	1.03	.88	.55	1.07	.92	.86	.22
Irrigation delta applied for growing rice crop (cms)	95.5	81.8	76.5	98.5	96	88	95.5	94.5	91	70.5