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Effect of Amendments on Problem Soils with Poor Quality Irrigation Water under Sugarcane Crop

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Abstract: In many arid and semi-arid regions of the world, due to the inadequate availability of good quality water, the farmers have to use saline and sodic groundwater and wastewater / treated industrial effluent for irrigation. Excess of cations such as sodium and anions like carbonate, bicarbonate and chloride present in irrigation water, increase soil pH, Electrical Conductivity (EC) and Exchangeable Sodium Percentage (ESP) may affect the growth and yield of the crops. To realize this problems field experiments were conducted to screen the saline tolerant sugarcane varieties for poor quality irrigation water under different amendments. The field experiment: I-was conducted on sandy loam soil at Pandipalayam, Karur District with treated paper mill effluent as irrigation source and experiment-II-was conducted on sandy clay loam soil at Vatamalaipalayam, Thudialur, Coimbatore District with saline groundwater as irrigation source, during October 2006-January 2008 in a split plot design, with three replications. The experiment consists of seven main plot treatments i.e. Basal application of 500 kg ha^{-1} gypsum (control), 50 % Gypsum Requirement (GR), 50 % GR + FYM @12.5 t ha^{-1}, 50 % GR + composted coir pith @ 12.5 t ha^{-1}, 50 % GR + vermicompost @ 5 t ha^{-1}, 50 % GR + pressmud @ 6 t ha^{-1}, 50 % GR + pressmud @15 t ha^{-1} along with 100 % NPK (275:60:60 kg ha^{-1}) through inorganic fertilizers. The sub plot treatment consist of four saline tolerant varieties *viz.,* COC(SC)23, COSi(SC)6, COG(SC)5 and CO86032. *In situ* incorporation of green manures (Daincha-*Sesbania aculeata*) on 45 days after planting (DAP) and micronutrient spray (1 % $FeSO_4$ + 0.5 % $ZnSO_4$ + 0.5 kg urea) was applied on 45 and 75 DAP. Application of organic amendments along with 50 % GR (Gypsum Requirement) had better influence on soil quality parameters under poor quality irrigation water. Among the different amendments, pressmud @ 15 t ha^{-1} along with 50 % GR significantly reduced the soil pH under poor quality irrigation water and it also registered low EC. The soil exchangeable cations like Ca, Mg and K were comparatively increased and the exchangeable Na was significantly decreased by application of pressmud @ 15 t ha^{-1} + 50 % GR under poor quality water irrigation when compared to initial soil levels. This amendment combination also increased the soil CEC. Application of amendments reduced the ESP of the soil under poor quality irrigation water.

Key words: Organic amendments · pH · Electrical conductivity · Exchangeable sodium percentage

INTRODUCTION

Increasing the productivity of water and making safe use of poor quality waters in agricultural will play a vital role in easing competition for scarce water resources, prevention of food security. Driven by the pressure to produce more, even the saline and alkali waters are being increasingly diverted to irrigated agriculture. Development of salinity, sodicity and toxicity problems in soils not only reduces the crop productivity and quality but also limit the chose of the crops. There are two major approaches to improving and sustaining the productivity in the saline environment: modifying the environment to suit the plant and modifying the plant to suit the environment but the former has been tried more extensively [1]. In addition to structural improvements, incorporation of organic or green manures has added advantages in soil irrigated with saline water in several ways. Organic manure/ amendments has a beneficial acidifying effect on the sodicity of the soil both through the action of organic acids formed during its breakdown and the calcium and magnesium contained in organic manures replaces the

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sodium from the exchange complex. Therefore, addition of organic materials would help the reclamation process by reducing pH and exchangeable sodium in soils [2-4]. The maintenance of adequate soil physical and chemical properties in sodic or saline environment may be achieved by using good quality water, proper choice and/or combination of soil ameliorants, good drainage and appropriate cultural practices [5]. In this respect, the development of most suitable reclamation technology or a combination of technologies may be critical to optimize farm management practices and better crop yields in saline sodic and sodic soils.

MATERIALS AND METHODS

Two field experiments were conducted in farmer's field at Pandipalayam, Karur District and at Vatamalaipalayam, Thudiyalur, Coimbatore during 2006-2008. Mainly based on the levels of EC, chloride and bicarbonate content, the irrigation waters are termed as poor quality water. The details about the irrigation water analysis and amendments were given in Table 1 and 2.

Details of Field Experiments

Field experiment	I	II
Design	Spilt plot design	Spilt plot design
Replication	Three	Three
Spacing	80 x 80 cm	80 x 80 cm
Individual Plot size	40 sq.m	20 sq.m
Irrigation source	Treated TNPL effluent	Saline ground water
Date of planting	01.10.2006	25.01.2007
Date of harvest	05.10.2007	30.01.2008

Treatment Details

Main plots: Amendments

M_1-500 kg of Gypsum ha^{-1} (control)
M_2-50% GR ha^{-1}
M_3-50% GR + FYM @ 12.5 t ha^{-1}
M_4-50% GR + Composted coir pith @ 12.5 t ha^{-1}
M_5-50% GR + Vermicompost @ 5 t ha^{-1}
M_6-50% GR + PM @ 6 t ha^{-1}
M_7-50% GR + PM @ 15 t ha^{-1}

Table 1: Characteristics of irrigation water

		Values	
Parameters	Unit	Treated paper mill effluent	Saline groundwater
Colour	-	Light brown colour	Colourless
TSS	mg L^{-1}	167	-
TDS	mg L^{-1}	1760	2450
pH	mg L^{-1}	7.61	7.47
EC	dS m^{-1}	2.95	4.14
Organic carbon	per cent	0.61	BDL
BOD	mg L^{-1}	30.0	15.0
COD	mg L^{-1}	240.0	285.0
NH_4-N	mg L^{-1}	29.2	BDL
P	mg L^{-1}	1.45	BDL
CO_3	mg L^{-1}	BDL	BDL
HCO_3	mg L^{-1}	256.2	273.3
Total alkalinity	mg L^{-1}	256.2	273.3
Ca	mg L^{-1}	229.3	214.0
Mg	mg L^{-1}	38.00	108.3
Na	mg L^{-1}	295.0	495.9
K	mg L^{-1}	33.15	19.10
Chloride	mg L^{-1}	766.8	1221
Sulphate	mg L^{-1}	59.24	88.51
Potential salinity (PS)	-	22.53	35.81
Sodium Adsorption Ratio (SAR)	-	4.70	6.9
Per cent Sodium	-	43.68	51.01
Residual sodium carbonate (RSC)	-	-10.43	-15.22
Category	-	Poor quality irrigation water	

* BDL - Below deletable level

Table 2: Characteristics of organic amendments

		Amendments			
Parameters	Unit	FYM	Vermicompost	Composted coir pith	Pressmud
pH	-	7.40	7.40	6.80	7.46
EC	dS m^{-1}	1.42	1.28	1.34	1.56
Total N	per cent	0.88	1.54	0.98	1.89
Total P	per cent	0.75	1.62	0.40	1.50
Total K	per cent	0.60	0.95	1.17	0.50
Organic Carbon	per cent	22.14	28.66	24.90	32.50
Calcium	per cent	0.55	0.68	0.50	2.00
Magnesium	per cent	0.20	1.40	0.38	1.40
C: N ratio	-	25.1:1	18.9:1	19.8:1	17.2:1

Table 3: Characteristics of field experiment soil samples

		Field sites	
Parameters	Unit	I-Pandipalayam	II-Thudiyalur
Mechanical analysis			
Clay	per cent	16.4	25.4
Silt	per cent	6.0	10.0
Sand	per cent	77.6	64.0
Textural class	-	Sandy loam	Sandy clay loam
Physical analysis			
Bulk density	Mg m^{-1}	1.18	1.25
Particle Density	Mg m^{-1}	2.35	2.22
Physico-chemical analysis			
pH	-	8.25	8.77
EC	dS m^{-1}	1.90	0.11
Available N	kg ha^{-1}	168.00	201.00
Available P	kg ha^{-1}	10.20	9.80
Available K	kg ha^{-1}	332.00	288.00
Organic Carbon	(%)	0.55	0.48
Exchangeable Ca	cmol (p^{+}) kg^{-1}	6.20	4.50
Exchangeable Mg	cmol (p^{+}) kg^{-1}	2.20	1.50
Exchangeable Na	cmol (p^{+}) kg^{-1}	5.20	4.20
Exchangeable K	cmol (p^{+}) kg^{-1}	1.35	0.88
CEC	cmol (p^{+}) kg^{-1}	14.95	11.08
ESP	-	34.78	37.91
Chloride	cmol (p^{+}) kg^{-1}	2.25	1.00
Gypsum Requirement	t ha^{-1}	7.75	9.50
Biological analysis			
Bacteria	(x 10^6 CFU g^{-1} of soil)	18.30	17.50
Fungi	(x 10^4 CFU g^{-1} of soil)	10.50	11.00
Actinomycetes	(x 10^3 CFU g^{-1} of soil)	5.00	5.00
Dehydrogenase	μg of TPF g^{-1} of soil	7.25	7.00
Urease	μg of ammonia release g^{-1} of soil h^{-1}	15.10	13.75
Phosphates	μg of PNPP g^{-1} of soil	11.52	11.25
Category	-	Saline sodic soil	Sodic soil

Sub plots: Sugarcane varieties

S_1-COC(SC)23
S_2-COSi(SC)6
S_3-COG(SC)5
S_4-CO86032

GR-Gypsum requirement, FYM-Farmyard Manure, PM-Pressmud.

Common application

- NPK: 275:60:60 kg ha^{-1}
- Micronutrient foliar spray
  1 % $FeSO_4$ + 0.5 % $ZnSO_4$ + 0.5 Kg Urea on 45^{th} and 75^{th} days after planting the sugarcane setts.
- Intercrop with green manure, daincha seed @ 10 kg ha^{-1} and subsequent *in situ* incorporation of green manure at 45^{th} Days after sowing (DAS).

Soil Sample Collection and Analysis: Pre-planting composite soil samples were taken from the experimental field from a depth of 0-15 cm. The analysis details are given Table 3. Similarly, plot wise post harvest soil samples (0-15 cm) were collected. The collected samples were shade dried, powdered with wooden mallet, passed through 2 mm sieve, packed in polythene bags, stored and used for analysis. The physical, chemical and biological characteristics of the soil samples were analyzed as per the standard methods.

RESULTS AND DISCUSSION

In general, application of amendments significantly influenced the soil properties, however the sugarcane varieties did not influence the soil properties under poor quality irrigation water. Among the amendments, addition of organic amendments along with 50% GR (Gypsum Requirement) had significantly influenced the soil properties than application of 50 % GR and 500 kg ha^{-1}of gypsum alone. The organic amendments could able to supply considerable quantities of primary and secondary nutrients along with appreciable quantities of organic matter to the soil and thus it improves the soil quality parameters.

Soil pH: Data in Table 4 indicated that application of organic amendments along with 50 per cent of gypsum requirement (50 % GR) significantly reduced the pH of post harvest soil under poor quality irrigation water (treated paper mill effluent and saline groundwater irrigation). This could be ascribed to the acidifying effect due to organic acids produced during the course of decomposition of organic amendments and green manure (Daincha-*Sesbania aculeata*). Acid forming amendments will also increase the availability of Ca in irrigation water by neutralizing HCO_3 and CO_3 that otherwise tie up some of the Ca to form lime precipitates. Since, these amendments form acids during the soil reaction, they can reduce soil pH if applied in sufficient quantity. Similar findings were reported by Guidi and Hall [6] who also observed that the application of various organic materials decreased the pH values due to organic and inorganic acids formed when organic matter decomposition takes place. The maximum reduction of soil pH was observed in pressmud application @ 15 t ha^{-1} along with 50 % GR. The observed decline in soil pH suggests that desodification of the saline sodic soil and sodic soil is a result of beneficial effects of pressmud and gypsum. The possible mechanism involved is that when pressmud applied in the soil, the ongoing microbial activity causes reduction of pH owing to the production of organic acids or increased CO_2 partial pressure leading to the development of reducing conditions.

The pH reductions in 500 kg ha^{-1} gypsum application and 50 % GR treatments were comparatively low. This phenomenon might have attributed to the pH increase due to poor quality irrigation water (treated paper mill effluent and saline groundwater irrigation). Previous studies suggested that as the salt concentration in soil solution increases, Ca^{2+} precipitates as $CaCO_3$ and, to a lesser extent as $CaSO_4$, leaving preponderance of Na^+ in soil solution that subsequently induces Na^+ adsorption on the cation exchange sites [7] and increases soil pH. Phukan

Table 4: Influence of amendments and sugarcane varieties on soil pH and EC (dSm^{-1}) under poor quality irrigation water

	Soil pH										Soil EC (dSm^{-1})									
	Treated paper mill effluent					Saline ground water irrigation					Treated paper mill effluent					Saline ground water irrigation				
Treatments	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	8.17	8.24	8.18	8.23	8.21	8.73	8.79	8.73	8.78	8.76	1.81	1.84	1.86	1.84	1.84	0.37	0.42	0.41	0.37	0.39
M_2	8.23	8.17	8.22	8.17	8.20	8.77	8.71	8.76	8.71	8.74	1.80	1.82	1.82	1.82	1.82	0.38	0.33	0.37	0.33	0.35
M_3	8.19	8.14	8.20	8.14	8.17	8.71	8.66	8.72	8.66	8.69	1.74	1.76	1.76	1.76	1.76	0.33	0.30	0.34	0.29	0.32
M_4	8.16	8.22	8.16	8.21	8.19	8.67	8.73	8.67	8.72	8.70	1.74	1.72	1.74	1.74	1.74	0.32	0.36	0.31	0.37	0.34
M_5	8.14	8.19	8.20	8.15	8.17	8.65	8.70	8.71	8.64	8.68	1.77	1.75	1.77	1.77	1.76	0.30	0.35	0.34	0.30	0.32
M_6	8.21	8.16	8.22	8.16	8.19	8.72	8.67	8.73	8.66	8.70	1.76	1.76	1.74	1.76	1.76	0.36	0.31	0.35	0.31	0.33
M_7	8.12	8.16	8.17	8.11	8.14	8.63	8.68	8.69	8.63	8.66	1.69	1.71	1.74	1.69	1.71	0.26	0.28	0.26	0.30	0.28
Mean	8.17	8.18	8.20	8.17	8.18	8.70	8.71	8.72	8.69	8.70	1.76	1.77	1.78	1.77	1.77	0.33	0.33	0.34	0.32	0.33
	SED				CD(0.05)	SEd				CD(0.05)	SEd				CD(0.05)	SEd				CD(0.05)
M	0.02				0.04	0.02				0.03	0.03				0.07	0.01				0.02

S, M X S and S X M Non-Significant

and Bhattacharya [8] also supported that the paper mill effluent irrigation turned the soil pH towards alkalinity. The soil pH shifted towards alkaline in soils irrigated with undiluted paper factory effluent [9-11] and simultaneous reduction to some extend by the organic acids that are produced at the rhizosphere and decomposition of green manure. Choudhary *et al.* [12] also reported that the excess cations such as bicarbonate and chloride present in irrigation water increased the soil pH.

Soil Electrical Conductivity: Data in Table 4 also showed that the soil EC of experimental field was significantly influenced by application of amendments and poor quality irrigation water. In the present study, continuous availability of moisture in the rhizosphere region of organic manures (FYM, composted coir pith, vermicompost and pressmud) applied treatments might have prevented the capillary rise of the salts from the sub surface layer but not in the case of inorganic amended plots.

The soil EC of field trial irrigated with treated paper mill effluent was decreased from initial to harvesting stage of the crop. While the soil EC of field trial irrigated with saline groundwater was increased from initial to harvest stage of the crop. The decrease in EC of field experiment I might be due to the addition of organic amendments, which produced organic and inorganic acids during decomposition, which was responsible for leaching of salts. During this decomposition of organic materials acidification will occur and encourage base cation uptake (by plants and microbes), which again leading to leaching of bases with carbonic, organic or nitric acids and humus formation [13]. The field experiment I was conducted under saline sodic, sandy loam soil and the physical properties of this soil was in good condition (light textured, porous soil), which may be facilitate the leaching of salts through irrigation water and organic acids produced during the decomposition of organic matter.

The highest EC reduction was observed due to application of pressmud @ 15 t ha^{-1} along with 50% GR and this might be due to addition of higher levels of organic matter through pressmud, which increased the production of organic acids by enhancing the microbial activity, on the other hand gypsum improves the soil physical structure, both could facilitate the leaching of salts from soil. These results are in line with the findings of Seth *et al.* [14], who reported that the application of sulphitation pressmud (SPM) and its compost reduced the pH and EC of the soil which was supported by Niazi *et al.,* [15] 2001.These results suggested that combined application of organic and inorganic ameliorants were superior in reducing the EC_e. The decrease in EC_e may probably be due to leaching of soluble salts into the drainage systems or into the deeper layers of the profile. The lowest reduction of EC observed in 50 % GR ha^{-1} and 500 kg ha^{-1} of gypsum application reveals that addition of inorganic amendment alone was not enough to improve the soil physical structure and microbial activities.

The soil EC was slightly increased under irrigation with saline groundwater. Due to high ESP of soil and poor physical properties (sodic, sandy clay loam), the Na content of the soils lead to dispersion of fine clay particles resulting into low permeability, crusting and hardening of the surface soil upon drying as a result soil water impended. So, the salts are not enough to leach. This was corroborated with Isabelo and Jack [16], who reported that in semi-arid zones there was intense evaporation, which tends to accumulate salts in the upper soil profile, especially when it is associated with an insufficient leaching or where soluble salts move upward in the soil profile from the water table instead of downward.

Soil Exchangeable Cations: The exchangeable cations like Ca, Mg and K were increased in both the field experiment soils due to the application of both inorganic and organic ameliorants along with green manure under poor quality irrigation water (Table 5,6).

In general, gypsum has 23 per cent of Ca and 20 per cent of sulphur, which is moderately soluble in water. The less soluble properties of the gypsum may release the Ca slowly during entire period of crop growth. This might be the principle reason for increasing levels of exchangeable calcium to the soil. Apart from the gypsum, all organic amendments had appreciable quantities of the Ca, Mg and K. During the mineralization process, the amendments may release the cations to the soil. Among the amendments, pressmud @ 15 t ha^{-1} + 50 % GR applied soils had higher exchangeable Ca, Mg and K. The pressmud contains higher proportions of cations, which were responsible for the build up of exchangeable cations in soil than the other organic amendments and it supplied approximately 300 kg ha^{-1} of calcium, 210 kg ha^{-1} of magnesium and 301 kg ha^{-1} of potassium. The increase exchangeable cations by the application of pressmud were supported by Soundarrajan *et al.* [17], who reported that the composted pressmud (bio earth) and FYM were significantly increased the exchangeable cations of post harvest soil.

Table 5: Influence of amendments and sugarcane varieties on soil exchangeable calcium and magnesium (cmol (p^+) kg^{-1}) under poor quality irrigation water

	Exchangeable calcium (cmol (p^+) kg^{-1})										Exchangeable magnesium (cmol (p^+) kg^{-1})									
	Treated paper mill effluent					Saline ground water irrigation					Treated paper mill effluent					Saline ground water irrigation				
Treatments	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	6.81	7.17	6.91	7.17	7.02	4.27	4.56	4.27	4.53	4.41	2.26	2.45	2.31	2.43	2.36	1.55	1.73	1.60	1.72	1.65
M_2	7.57	7.38	7.51	7.26	7.43	5.17	4.74	5.09	4.82	4.95	2.52	2.33	2.54	2.35	2.44	1.74	1.56	1.76	1.58	1.66
M_3	7.61	7.42	7.65	7.36	7.51	5.15	4.82	5.20	5.14	5.08	2.65	2.48	2.67	2.46	2.57	1.86	1.69	1.87	1.67	1.77
M_4	7.27	7.55	7.42	7.55	7.45	4.82	5.13	4.81	5.12	4.97	2.47	2.64	2.44	2.69	2.56	1.69	1.86	1.67	1.91	1.78
M_5	7.38	7.52	7.55	7.32	7.44	4.82	5.12	5.13	4.81	4.97	2.42	2.63	2.59	2.40	2.51	1.64	1.85	1.81	1.62	1.73
M_6	7.55	7.40	7.41	7.59	7.49	5.15	4.85	5.17	4.84	5.00	2.78	2.64	2.73	2.50	2.66	1.99	1.85	1.94	1.72	1.88
M_7	7.60	7.64	7.51	7.50	7.56	5.00	5.34	5.36	5.02	5.18	2.73	3.03	2.99	2.78	2.88	1.94	2.22	2.18	1.98	2.08
Mean	7.40	7.44	7.42	7.39	7.41	4.91	4.94	5.00	4.90	4.94	2.55	2.60	2.61	2.51	2.57	1.77	1.82	1.83	1.74	1.79
	SEd			CD(0.05)		SEd			CD(0.05)		SEd			CD(0.05)		SEd			CD(0.05)	
M	0.06				0.14	0.10				0.23	0.06				0.13	0.06				0.13

S, M X S and S X M Non-Significant

Table 6: Influence of amendments and sugarcane varieties on soil exchangeable potassium and sodium (cmol (p^+) kg^{-1}) under poor quality irrigation water

	Exchangeable potassium (cmol (p^+) kg^{-1})										Exchangeable sodium (cmol (p^+) kg^{-1})									
	Treated paper mill effluent					Saline ground water irrigation					Treated paper mill effluent					Saline ground water irrigation				
Treatments	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	1.87	1.90	1.80	1.83	1.85	0.94	0.98	0.88	0.96	0.94	5.07	5.45	5.18	5.36	5.26	4.09	4.52	4.50	4.43	4.38
M_2	1.80	1.80	1.80	1.73	1.78	1.00	0.96	0.94	0.90	0.95	4.99	4.89	4.94	4.89	4.93	4.28	4.12	4.20	4.15	4.19
M_3	2.27	2.17	2.27	2.20	2.23	1.44	1.33	1.47	1.36	1.40	4.88	4.65	4.96	4.57	4.77	4.16	3.92	4.24	3.84	4.04
M_4	2.43	2.60	2.47	2.63	2.53	1.62	1.79	1.63	1.80	1.71	4.70	5.02	4.62	4.94	4.82	3.95	4.27	3.87	4.19	4.07
M_5	1.80	1.80	1.90	1.80	1.83	0.93	0.98	1.03	0.98	0.98	4.71	4.95	5.03	4.63	4.83	3.96	4.20	4.28	3.88	4.08
M_6	2.27	2.17	2.30	2.20	2.23	1.44	1.33	1.47	1.36	1.40	4.90	4.66	4.98	4.59	4.78	4.15	3.91	4.23	3.83	4.03
M_7	2.53	2.70	2.70	2.50	2.61	1.72	1.88	1.89	1.71	1.80	4.50	4.81	4.89	4.58	4.69	3.78	4.10	4.18	3.86	3.98
Mean	2.14	2.16	2.18	2.13	2.15	1.30	1.32	1.33	1.30	1.31	4.82	4.92	4.94	4.79	4.87	4.05	4.15	4.22	4.02	4.11
	SEd			CD(0.05)		SEd			CD(0.05)		SEd			CD(0.05)		SEd			CD(0.05)	
M	0.04			0.09		0.04			0.09		0.08			0.16		0.08			0.17	

S, M X S and S X M Non-Significant

Generally, decreasing trend of exchangeable sodium was observed during the advancement of crop growth because of increasing concentration of soil exchangeable cations like Ca, Mg and K of soil. Among the treatments, application of pressmud @ 15 t ha^{-1} + 50 % GR had the lowest exchangeable Na. This might be due to the addition of gypsum with pressmud, which favoured leaching of Na in soil complex. The exchangeable sodium from the soil exchangeable sites was mainly replaced by calcium and it was leached by irrigation water, rainfall and organic acids and the lowest pH increases the solubility of gypsum, thus, removing some of the Na^+ ions [18]. This is in conformity with the findings of Shaik and Furtado [19]. This was also supported by Kaushik and Subashini [20] who had the same opinion on the reduction of sodium from 24.56 to 15.36 meq / 100 g of soil treated with gypsum. Application of pressmud for soil amelioration has been documented by Zahid and Niazi [21] who suggest that the pressmud an important by product of the sugar industry had considerable quantities of Ca, S, Organic carbon and N, P and K and also a cheaper source of organic matter rather than gypsum, which can successfully be used for the reclamation of saline-sodic soils. Pressmud contains sulphur (3.2 %) [22], this sulfur may be oxidized by soil bacteria and react with water to form sulfuric acid. Sulfuric acid reacts immediately with the soil calcium carbonate to release soluble calcium for exchange with sodium.

Table 7: Influence of amendments and sugarcane varieties on soil cation exchange capacity (CEC) (cmol (p^+) kg^{-1}) exchangeable sodium percentage (ESP) under poor quality irrigation water

	CEC										ESP									
	Treated paper mill effluent					Saline ground water irrigation					Treated paper mill effluent					Saline ground water irrigation				
Treatments	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	15.99	16.96	16.20	16.83	16.50	10.84	11.79	11.25	11.63	11.38	31.69	32.12	31.97	31.85	31.91	37.99	38.31	38.63	38.07	38.25
M_2	16.92	16.40	16.77	16.25	16.58	12.19	11.37	11.99	11.45	11.75	29.46	29.83	29.45	30.08	29.71	34.98	36.45	35.05	36.27	35.69
M_3	17.41	16.71	17.57	16.56	17.06	12.61	11.76	12.78	12.00	12.29	28.05	27.83	28.24	27.60	27.93	33.02	33.35	33.19	31.97	32.88
M_4	16.88	17.82	16.94	17.80	17.36	12.07	13.06	11.97	13.02	12.53	27.85	28.16	27.29	27.74	27.76	32.71	32.75	32.31	32.19	32.49
M_5	16.29	16.93	17.04	16.17	16.61	11.35	12.15	12.26	11.29	11.76	28.92	29.24	29.50	28.64	29.08	34.87	34.59	34.97	34.35	34.69
M_6	17.49	16.86	17.41	16.87	17.16	12.73	11.94	12.82	11.75	12.31	28.00	27.66	28.58	27.18	27.86	32.61	32.74	33.02	32.58	32.74
M_7	17.36	18.15	18.07	17.37	17.74	12.44	13.54	13.61	12.57	13.04	25.93	26.49	27.03	26.36	26.45	30.40	30.29	30.71	30.72	30.53
Mean	16.91	17.12	17.14	16.84	17.00	12.03	12.23	12.38	11.96	12.15	28.56	28.76	28.87	28.49	28.67	33.79	34.07	33.98	33.74	33.90
	SEd			CD(0.05)		SEd			CD(0.05)		SEd			CD(0.05)		SEd			CD(0.05)	
M	0.22			0.48		0.27			0.59		0.17			0.38		0.27				0.59

S, M X S and S X M Non-Significant

This is also being the reason for reduced exchangeable sodium observed in pressmud amended soil.

Soil CEC: Application of organic amendments with gypsum increased the CEC of the both field trials irrigated with poor quality irrigation water (Table 7). This is in line with those obtained by Suguna Devakumari [23] and Vijayakumar [24]. Among the amendments, application of pressmud @ 15 t ha^{-1} + 50 % GR recorded higher value of CEC than other amendments. During mineralization of organic amendments Ca, Mg and K were released in to soil. This may be the reason for higher CEC of the experimental soils.

Soil ESP: Data in Table 7 also indicated that application of amendments reduced the ESP of the soil gradually from the initial level. Similar findings were supported by Choudhary *et al.* [12], who reported that application of amendments (gypsum and FYM) decreased the pH and ESP of the soil. Application of pressmud @ 15 t ha^{-1} along with 50 % GR significantly reduced the ESP of the soil under poor quality irrigation water, which contributes some amount of the sodium to the soil. But the gypsum and organic amendments reduce the build up of sodium by continuous irrigation with the poor quality water. Juwarkar and Subramanyan [25] reported that high toxicity due to Na can be reduced by decreasing the SAR and ESP, which could be augmented by increasing the proportion of Ca^{2+} and Mg^{2+} to Na^+ in soil exchange complex by the addition of Ca and Mg salts. So the increasing content of soil exchangeable Ca, Mg and K and decreasing concentration of soil exchangeable Na, reduces the soil ESP. Makoi and Nadkidemi [26] also ascribed that FYM decreased the ESP by 30.4, gypsum by 30.3 per cent when the two amendments were combined.

CONCLUSION

In this study concludes that, organic amendments along with 50 % GR (Gypsum Requirement) application had better influence on soil quality parameters under poor quality irrigation water. The application of pressmud @ 15 t ha^{-1} along with 50 % GR significantly reduced the soil pH, where 1.33 per cent reduction was observed under treated paper mill effluent irrigation and 1.25 per cent was recorded under saline ground water irrigation and the soil exchangeable cations like Ca, Mg and K were increased and exchangeable Na was decreased by the application of pressmud @ 15 t ha^{-1}. Besides this the application of amendments reduced the soil ESP and pressmud @ 15 t ha^{-1} + 50 % GR reduced soil ESP of 26.45 per cent under treated paper mill effluent and 19.47 per cent under saline ground water irrigation.

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REFERENCE

1. Sharma and Minhas, 2005. Strategies for managing saline/ alkali waters for sustainable agricultural production in south Asia. Agric. Water Manag., 78: 136-151.
2. Carpenter-Boggs, L., A.C. Kennedy and S.P. Reganold, 2000. Organic and biodynamic management: Effects on soil biology. Soil Sci. Soc. Am. J., 54: 1651-1659.
3. Ferreras, L., J.L. Costa, F.O. Garcia and C. Pewrari, 2000. Effect of no. tillage on some soil physical properties of a structural degraded petrocalcic pateudoll of the Southern Pampa of Argentina. Soil Till. Res., 54: 31-39.
4. Bandyopadhyay, B.K., H.S. Sen, B. Maji and J.S.P. Yadav, 2001. Saline and alkali soils and their management. ISCAR Monograph 1. ISCAR, CSSARI, WB, pp: 72.
5. Grattan, S.R.. and J.D. Oster, 2003. Use and reuse of saline-sodic water for irrigation of crops. In: Crop production in saline environment: Global and integrative perspectives. (Eds.), S.S. Goyal, S.K. Sharma and D.W. Rains, Haworth press. New York, pp: 131-162.
6. Guidi, G. and J.E. Hall, 1984. Effect of sewage sludge on the physical and chemical properties of soils. J. Indian. Soc. Soil Sci., 29: 129-131.
7. Suarez, D.L., 1981. Relation between pH_c and sodium adsorption ratio (SAR) and an alternative method of estimating SAR of soil (or) drainage water. Soil Sci. Soc. Am. J., 45: 469-475.
8. Phukan, S. and K.G. Bhattacharyya, 2003. Modification of soil quality near a pulp and paper mill. Water, Air Soil Pollution, 146: 319-333.
9. Udayasoorian, C., K. Mini and P.P. Ramaswami, 1999. Bagasse pith compost-an effective ameliorant in paper mill polluted soil environments. In: Nat. Symp. on bioremediation of polluted habitats, Tamil Nadu Agric. Univ., Coimbatore, pp: 72-73.
10. Srinivaschari, M., M. Dhakshinamoorthy and G. Arunachalam, 2000. Accumulation and availability of Zn, Cu, Mn and Fe in soils polluted with paper mill wastewater. Madras Agric. J., 87: 237-240.
11. Prasanthrajan, M., C. Udayasoorian and P. Singaram, 2005. Impact of paper board mill solid sludge biocompost and treated effluent irrigation on growth and yield attributes of vegetable cowpea. Madras Agric. J., 91: 483-488.
12. Choudhary, O.P., A.S. Sosan, M.S. Bajwa and M.L. Kapur, 2004. Effect of sustained sodic and saline-sodic irrigation and application of gypsum and farmyard manure on yield and quality of sugarcane under semi-arid conditions. Field Crops Research, 87: 103-116.
13. Ulrich, B., 1980. Production and consumption of hydrogen ions in the ecosphere. In: Effects of acid precipitation on terrestrial ecosystems. (Eds.) T.C. Hutchinson and M. Havas Plenum, New York, pp: 255-282.
14. Seth, R., R. Chandra, N. Kumar and A.K. Tyagi, 2005. Utilization of composted sugar industry waste (pressmud) to improve properties of sodic soil for rice cultivation. J. Environ. Sci. Eng., 47: 212-217.
15. Niazi, B.H., M. Ahmed, N. Hussain and M. Salim, 2001. Comparison of sand, gypsum and sulphuric acid to reclaim a dense saline sodic soil. Int. J. Agric. Biol., 3: 316-318.
16. Isabelo, S.A. and E.R. Jack, 1993. Phosphogypsum in agriculture. Adv. Agron., 49: 55-118.
17. Soundarrajan, M., B. Anandakrishnan, M.S. Dawood, S. Jebaraj and R. Pushpavalli, 2007. Integrated nutrient management with organic and inorganic fertilizers on productivity of sugarcane and its impact on soil properties of *Typic haplustalf.* Sugar Technol., 9: 142-146.
18. Wahid, A., S. Akhtar, I. Ali and E. Rasul, 1998. Amelioration of saline-sodic soils with organic matter and their use for wheat growth. Commun. Soil Sci. Plant Anal., 29: 2307-2318.
19. Shaik, M.R. and I. Furtado, 1995. Use of cyanobacteria for bioameliration of saline soils of Goa. In: Nat. Symp. of " Frontiers in Applied Environmental Microbiology", SES, CUSAT, Cochin, pp: 207-208.
20. Kaushik, B.D. and D. Subhashini, 1990. Amelioration of salt affected soils with blue green algal improvement in soil properties. In: Proc. Indian Nat. Sci. Acad., 51: 386-389.
21. Zahid, L. and F.K. Niazi, 2006. Role of ristech material in the reclamation of saline sodic soils. Pakistan J. Water Res., 10: 43-49.
22. Jain, S.P., 2002. Bioenergy from sugar factory pressmud. A quarterly newsletter of the national bioenergy board, Ministry of non-conventional energy sources, Government of India, 6(3): 13-15.

23. Suguna Devakumari, S., 2005. Integrated management of treated papermill effluent and solid wastes on soil, ground water and productivity of fodder grass (CO_3) and sugarcane (CO86032) and biobleaching of kraft pulps by elite fungal species. Ph.D thesis, Tamil Nadu Agric. Univ., Coimbatore.
24. Vijayakumar, P.S., 2006. Phytoremediation efficiency of silvipasture system in paper board mill effluent polluted habitat and their possible nano mechanism. Ph.D. Thesis, Tamil Nadu Agric. Univ., Coimbatore.
25. Juwarkar, A.S. and P.V.R. Subrahmanyam, 1987. Impact of pulp and paper mill waste water on crop and soil. Wat. Sci. Technol., 19: 693-700.
26. Makoi, J.H.H.R. and P.A. Nadkidemi, 2007. Reclamation of sodic soils in Northern Tanzania, using locally available organic and inorganic resources. African J. Biotechnol., 6(16): 1926-1931.