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# Influence of Ameliorants on Physicochemical Properties and Salinity of a Coastal Soil of West Bengal

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Saline soils defined as soils having a conductivity of the saturation extract greater than 4 dS $m^{-1}$ and an exchangeable sodium percentage less than 15 with pH less than 8.5 (Biswas and Mukherjee, 1994). The presence of salts leads to alteration of the osmotic potential of the soil solution. Consequently, water intake by plants restricted and thereby nutrients uptake by plants is also reduced. In this soil due to high salt levels, microbial activity is reduced. Specific ion effects on plants are also seen due to the toxicity of ions like chloride, sulphate, etc. (Adams, 1984).

The reclamation of saline soils involves basically the removal of salts from the saline soil through the processes of leaching and drainage. Sub-surface drainage is an effective tool for lowering the water table, removal of excess salts and prevention of secondary salinization of ions like chloride, sulphate, etc. Provision of lateral and main drainage channels of 60 cm deep and 45 cm wide and leaching of salts could reclaim the soils (El-Dardiary, 2007). The addition of an extra dose of nitrogen to the tune of 20-25% of recommended level will compensate for the low availability of N for crops which are having high threshold salinity (Cotton, sugarbeet, etc.) in these soils. The addition of organic manures like, FYM, compost, etc., helps in reducing the ill effect of salinity due to the release of organic acids produced during decomposition. Green manuring with Sunhemp (*Crotalaria juncea*), Daincha (*Sesbania aculeata*), Kolingi (*Nigella sativa*) and or green leaf manuring also counteracts the effects of salinity (Hake and Kerby, 2008).

The fertility status of the coastal soils of West Bengal is low. Soil nitrogen content is low, phosphorus content is low to medium, potassium content is medium to high (Maji and Mandal, 2014). The soil salinity of the region becomes high particularly in the winter and summer seasons. It has been proposed that the water and nutrient holding capacity of these soils could be increased by the addition of organic amendments, thereby enhancing soil fertility (Pattanayak *et al*., 2012). Soil amendment with organic materials and manures has been found to improve the physical and chemical properties of soil. Beneficial effects of organic soil amendments include decreased soil bulk density, and increased water holding capacity, aggregate stability, saturated hydraulic conductivity, water infiltration rate and biochemical activity (Martens and Frankenberger, 1992; Turner *et al*., 1994).

Keeping all these facts in background, an experiment was conducted in an Inceptisol of Central Soil Salinity Research Institute, Canning Town research farm to study the influence of different ameliorants on soil physico-chemical properties. The soil of the experimental site was clayey (16% sand, 30% silt and 54% clay) in nature. Four ameliorants namely, farmyard manure (FYM), green leaf manure (*Acacia auriculiformis*), tank silt and poultry manure were used. The design of the experiment was split-plot with three replications where the ameliorants were allocated to the main plots and doses in the subplots. The doses were 2, 4, 6, 8, 10 and 12 t $ha^{-1}$ ($D_1$, $D_2$, $D_3$, $D_4$, $D_5$ and $D_6$, respectively) on the basis of moist weight. The ameliorants were added in the plots and well mixed at 0-15 cm soil layer before the onset of monsoon (February-March, 2020). The field was left undisturbed for nearly one year so that the ameliorants were well decomposed. Besides a control plot was also maintained in the adjacent area to which no ameliorant was added. Composite soil samples were collected from 0-15 cm depth from each replicate during December 2020 and were processed and analysed for physico-chemical properties following standard methods (Black, 1965). For measuring bulk density undisturbed amples were collected with core samplers in three replicates without disturbing in situ soil conditions. The saturated hydraulic conductivity was determined from disturbed soils packed in cores maintaining a uniform bulk density (1.2 Mg $m^{-3}$) using constant head method. The different particle sizes were determined using a Buoycous hydrometer. Diameters of soil particles at 10% cumulative weight ($d_{10}$) for different plots receiving various doses of amendments were calculated. Hydraulic conductivity of soil under different doses was also determined from Kozeny-Carman equation (Chapuis and Aubertin, 2003) and Shepherd's (1989) equation as given below:

$$K = \rho.g.c_k.f_k\ (n)\ d^2_{10}/(\mu)\text{(Kozeny-Carman)} \quad (1)$$

where ρ is density, g is the acceleration due to gravity, μ is dynamic viscosity, $C_k$ is $8.3 \times 10^{-3}$, $f_k$ (n)= $n^3/(1-n)^2$; n is porosity, $d_{10}$ is 10% cumulative passing (geotechnical grain size distribution).

$$K = ad^b \text{ (Shepherd)} \quad (2)$$

where K is saturated hydraulic conductivity (cm $s^{-1}$), d is grain diameter (mm), 'a' values range from 4.79 × $10^{-2}$ to 9.86 cm $s^{-1}$, 'b' (dimensionless) is 1.11 to 2.05.

The content of soil organic carbon was estimated by Walkley-Black method (Black, 1965). Soil EC and soil pH (1:2 soil: water suspension) were also determined.

Soil bulk density (Mg $m^{-3}$) after one year of experimentation was higher for the control plot soil (1.45 Mg $m^{-3}$) than for all other amendment treatments that were applied, with averages of 1.36 (Table 1). Some differences in soil bulk density among amendment treatments were measured, for example, soil bulk density was lower for the tank silt treatment (1.37 Mg $m^{-3}$) than F.Y.M. treatment (1.38 Mg $m^{-3}$). As a result of treatments, there was a decrease in soil bulk density with the increase in doses, 1.30 Mg $m^{-3}$ for 12 t $ha^{-1}$ amendments. Whereas, the value was 1.43 Mg $m^{-3}$ for 2 t $ha^{-1}$ amendment used. Changes in saturated hydraulic conductivity were also dependent on the treatment and doses (Table 1).

The hydraulic conductivity values were relatively lower for green leaf manure and tank silt treatments (3.8-4.9 cm $h^{-1}$) than to poultry manure and FYM treatments (5.1-4.9 cm$h^{-1}$) for the soil. The saturated hydraulic conductivity was increased from 1.2 to 5.5 cm $h^{-1}$ when the amount of doses increased from 2 to 12 t $ha^{-1}$. The use of different ameliorants did not bring about significant change in soil parameters like bulk density (BD) (avg. 1.36 Mg $m^{-3}$) and saturated hydraulic conductivity (HC) (4.7 cm $h^{-1}$) (Table 1). However, saturated HC for different plots treated with different doses of ameliorants differ significantly (C.D. $t_{0.05}$ = 1.28 for the treated soil) (Table 1). The interaction effects of ameliorants and doses were also significant in bringing significant change in saturated hydraulic conductivity of soil.

***Table 1.*** *Effect of different ameliorants and their doses on soil bulk density and hydraulic conductivity*

| Treatments | Bulk density (Mg $m^{-3}$) | Saturated hydraulic conductivity (cm $h^{-1}$) |
|---|---|---|
| Ameliorants | | |
| Farmyard manure (FYM) | 1.38 | 4.9 |
| Green leaf manure (Acaicia leaf) | 1.42 | 3.8 |
| Tank silt | 1.37 | 4.9 |
| Poultry manure | 1.28 | 5.1 |
| C.D. (p=0.05) | NS | NS |
| Dose | | |
| $T_1$ (2 t $ha^{-1}$) | 1.43 | 1.2 |
| $T_2$ (4 t $ha^{-1}$) | 1.40 | 2.0 |
| $T_3$ (6 t $ha^{-1}$) | 1.38 | 3.5 |
| $T_4$ (8 t $ha^{-1}$) | 1.34 | 4.6 |
| $T_5$ (10 t $ha^{-1}$) | 1.30 | 5.2 |
| T6 (12 t $ha^{-1}$) | 1.30 | 5.5 |
| C.D. (p=0.05) | 0.15 | 1.28 |
| Interaction ameliorant X dose | NS | S |

NS = Non significant; S = Significant

The relationship between measured and calculated hydraulic conductivities using Kozeny-Carman equation was significant ($r^2$ = 0.97, p<0.01) (Fig. 1).

But the calculated values were slightly higher than measured values. Hydraulic conductivity values determined from Shepherd's equation were relatively higher than those that were measured in the laboratory

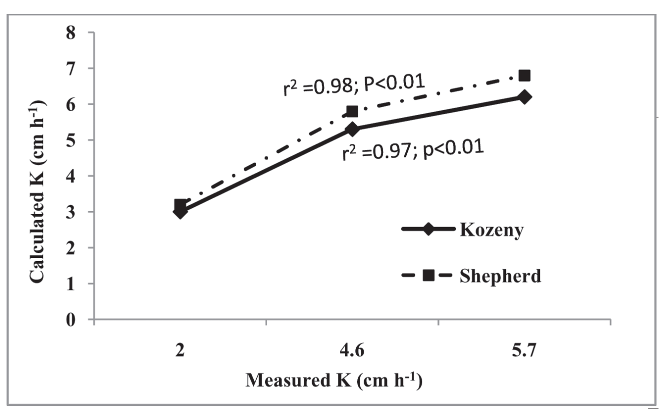


***Fig. 1.*** *Relation between calculated and measured hydraulic conductivities*

***Table 2.*** *Effect of ameliorants and their doses on soil salinity and pH*

| Doses | $EC_2$ (dS $m^{-1}$)/ESP | | | |
|---|---|---|---|---|
| | Ameliorants | | | |
| | FYM | Green leaf manure | Tank silt | Poultry manure |
| $T_1$ (2 t $ha^{-1}$) | 4.0/8.5 | 3.0/8.7 | 3.4/8.7 | 2.9/8.6 |
| $T_2$ (4 t $ha^{-1}$) | 3.1/8.3 | 2.9/8.5 | 3.1/8.4 | 2.9/8.4 |
| $T_3$ (6 t $ha^{-1}$) | 3.4/8.3 | 2.9/8.2 | 3.0/8.4 | 2.7/8.4 |
| $T_4$ (8 t $ha^{-1}$) | 3.0/8.4 | 1.9/8.2 | 2.2/7.9 | 2.5/8.4 |
| $T_5$ (10 t $ha^{-1}$) | 2.9/8.2 | 1.8/7.8 | 1.9/7.8 | 2.2/8.0 |
| $T_6$ (12 t $ha^{-1}$) | 2.3/7.1 | 1.8/7.5 | 1.9/7.9 | 2.0/7.5 |

C.D. (p=0.05) - Non significant; Interaction between ameliorants X doses - Non significant

using Kozeny-Carman equation. This is because for the wide range of soil type the best overall estimation of permeability is reached based on Kozeny-Carman's equation (Odong, 2007). The relationship between the calculated (Shepherd's equation) and measured hydraulic conductivities was also significant ($r^2$ = 0.98 for soil) (Fig. 1).

The EC (1:2 soil: water suspension) values of the soil varies from 4.0 to 2.3 dS $m^{-1}$ in the 2 t $ha^{-1}$ and 12 t $ha^{-1}$ FYM treated plots, respectively where as the values varied from 3.0 to 1.8 dS $m^{-1}$ in the 2 t $ha^{-1}$ and 12 t $ha^{-1}$ green leaf manure treated plots. The values were 2.9 dS $m^{-1}$ to 2.0 dS $m^{-1}$ for poultry manure treatments. The exchangeable sodium percentage (ESP) values were 8.5 to 7.1% for FYM and 8.7 to 7.9% for poultry manure treated plots. In general, with increase in the ameliorant doses there was a decrease in EC and ESP values of soils but the differences were non-significant (Table 2). These findings are in agreement with those of Morrissey *et al*. (2014).

From the study, it can be concluded that the effect of different ameliorants on changing bulk density and saturated hydraulic conductivity was not significant in this soil but their doses were effective in bringing significant differences in the soil parameters like saturated-hydrau;ic conductivity. The optimum dose with respect to different physico-chemical properties and cost is 6-8 t $ha^{-1}$ for different ameliorants. The relation between measured and calculated hydraulic conductivity using Kozeny-Carman equation was significant ($r^2$ =0.97; p<0.01 for the soil) and the calculated values were found slightly higher than measured values.

## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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