# IMPACT OF DIFFERENT AMENDMENTS AND MICRONUTRIENT MIXTURE ON BIOLOGICAL PROPERTIES OF SODIC SOIL

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## Abstract

Sodic soils have low organic carbon content, microbial load and their activities which were the biological indicators of soil health. Soil organic carbon is the kay factor which derives the soil functions. A field experiment was conducted to study the effect of different amendments and micronutrient mixture on soil biological properties. Gypsum+GM, DSW (distillery spent wash) and GLM (Glyricidia) were used as amendments. Application of amendments reduced the pH and ESP of the soil and thereby improved the physico-chemical properties of sodic soil. The microbial population, organic carbon status and enzyme activites were also improved on reclamation of sodic soil over control (without any amendment) and DSW treatment found superior to other treatments. Grain and straw yield was increased on application of amendments and micronutrient mixture. Significant response was also observed for micronutrient application in sodic soils. However, the degree of response varied with kinds of amendments.

**Keywords:** Sodic soil; amendments; organic carbon; microbial population; enzyme activities.

## Introduction

Soils are under many stresses including humans and agriculture which might affect the soil health. Salt stress is considered as one of the major stress depleting the soil health. Soil health is normally assessed by soil physical, chemical and biological properties. As like physical, chemical and fertility status of the soil, criteria of biological status for a healthy soil not well defined because of its dynamic nature and these properties have a great impact on soil physical and chemical properties. In India, nearly 6.73-million-hectare area is salt affected and out of that 3.77 million hectares of land is affected by sodic soil which requires an efficient, inexpensive and eco-friendly amelioration. Sodic soils are normally poor in biological properties with low organic carbon content and lower microorganisms (Gupta *et al.*, 1974). Rietz and Haynes (2003) found that an increase in soil sodicity inhibited several soil enzymatic activities and microbial respiration. Microbial activity has direct impact on the plant nutrient cycling and organic matter stabilization in soils. Kremner and Li (2003) reported that sustainability of soil health is based, in part, on the efficient management of soil microorganisms to improve soil quality. Thus, sodic soil reclamation not only improves the physical and chemical properties but also the biological properties and is based on the type of amendment used. Therefore, the present study was undertaken with the view of studying the effect of different amendments on soil biological properties under field condition.

## Materials And Methods

A field experiment was conducted in split plot design with amendments as main-plot treatments and levels of MN mixture as sub-plot treatments using rice (var. CO 41) as a test crop. Gypsum @50% GR+GM (Daincha) @ 6.25 t $ha^{-1}$, DSW (distillery spent wash) @5 lakh L $ha^{-1}$ and GLM (Glyricidia) @ 12.5 t $ha^{-1}$ were used as amendments for the reclamation of sodic soil. Different levels of TNAU MN (micronutrient) mixture for wetland rice available at TNAU, Coimbatore, *viz.*, 75, 100, 125 and 150 percent of recommended dose of MN mixture (25 kg $ha^{-1}$) were imposed as sub-plot treatments. DSW was uniformly applied and water was impounded to a depth of 10-15 cm after 7 days and the impounded water was drained after 24 hours. Repeated impounding of water and drainage were given 2-3 times and allowed 45 days for natural oxidation. Simultaneously, in the gypsum applied fields also water was impounded and excess Na present were leached out. After that these plots were left for natural oxidation for few days and *Sesbania aculeata,* a green manure, raised upto flowering stage and then incorporated in the same field. The weight of green manure from the plots was made before incorporation so as to maintain the treatment schedule (6.25 t $ha^{-1}$). A GLM, *Glyricidia sepium* was collected, weighed and incorporated to the fields as per the treatment schedule and irrigation was made to induce the activity of microbes for the degradation of GLM. The GLM treatment applied fields were left for decomposition before planting.

Fresh samples were drawn from the reclaimed fields and analysed for soil microbial population and enzyme activities. Processed samples were used for the soil organic carbon (OC) estimation. The microbial population was estimated by serial dilution plating technique using Nutrient agar media, KenKnights Agar media and Rose bengal agar media for bacteria, actinomycetes and fungi respectively. The estimation soil enzyme activities like urease, phosphatase and dehydrogenase were done in the methods given by Tabatabai and Bremner

(1972), Halstead (1964) and Casida *et al.* (1964) respectively. The soil organic carbon status was estimated by Wet chromic acid digestion method given by Walkley and Black (1934).

**Results And Discussion**

**Physico-Chemical Properties**

Application of amendments decreased the pH of the post harvest soil. The pH declined from the initial level of 9.86 to 8.50, 8.32 and 8.96 due to application of Gypsum+GM, DSW and GLM respectively. Maximum reduction in soil pH was recorded in DSW applied plots. This reduction in pH on application of DSW was acidic nature (pH 4.3) of DSW which directly contributes to the pH reduction. Because of the acidic nature of DSW, the free lime may be solubilized in soil and releasing Ca ions which replaces Na ions and forms soluble sodium salts which get leached out during leaching. The reduction in pH might also be due to Ca supplied directly by the DSW. The reduction in soil pH on application of Gypsum+GM was attributed to the displacement of exchangeable Na by the calcium ions of gypsum and subsequent formation of sodium sulphate which get leached out due to drainage provided. Application of GLM and GM had ameliorative effect and reduced the soil pH due to liberation of $CO_2$ and organic acids during decomposition process and produce hydrogen ions which solubilize the $CaCO_3$ and neutralize the sodicity. The soluble salt concentration was found to be slightly increased in the DSW applied plots, but the extent of increase was within the permissible limit ($<4$ dS $m^{-1}$).

Soil ESP was significantly reduced on reclamation to the level of 17.5, 14.5 and 21.4 per cent on account of application of Gypsum+GM, DSW and GLM from the initial level of 26.9 per cent. The application of spent wash might have solubilized sufficient free lime in sodic soils due to acidic nature, thus releasing adequate free calcium ions that replaced exchangeable Na and reduced the ESP. Presence considerable amount of Ca (3215 ppm), Mg (2315 ppm) and K (12000 ppm) in DSW also contribute for the reduction in ESP.The reduction in ESP was attributed to replacement of exchangeable Naby Ca of the gypsum in case of gypsum. The application of GLM also reduced the soil ESP from initial level which may be due increase in exchangeable Ca and Mg ions due to solubilization during decomposition of organic matter and also due to supply of cations like K, Ca and Mg from the GLM.

Table 1. Effect of amendments on soil pH, EC and ESP.

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Control | Gypsum+GM | DSW | GLM | SEd | CD (0.05) |
| pH | 9.86 | 8.50 | 8.32 | 8.96 | 0.03 | 0.08 |
| EC (dS $m^{-1)}$ | 0.70 | 0.72 | 1.02 | 0.71 | 0.01 | 0.02 |
| ESP | 26.9 | 17.5 | 14.5 | 21.4 | 0.36 | 0.89 |

* Effect of micronutrient mixture was not significant.

**Soil OC status**

Soil organic carbon content is generally considered as the index of soil fertility and sustainability of agricultural systems which in turn reflects on soil microbes, enzyme activities and nutrient release. Many strategies have been developed to increase the organic carbon content in soil. The application of amendments significantly increased the OC content of the post harvest soil. Highest OC content was recorded in the DSW applied plots (0.82%), followed by GLM (0.65%) and Gypsum+GM (0.62%) applied plots and control recorded lowest (0.53%). Application of DSW increased OC to the tune of 0.29 percent over the control.

The increase in organic carbon content might be due to decomposition and humification of organic matter in soil supplied through DSW. Further, addition of organic matter through DSW, better crop growth with concomitant higher root biomass generation could be the probable reasons for improvement in organic carbon content. The Gypsum+GM applied plots also showed higher OC content over the control. The increase in OC content due to addition of GM and GLM was due to addition of organic matter.

**Microbial Population**

Microbial activity had a direct impact on the plant nutrient availability as well as other properties related to soil productivity. Microbial activity is dependent on adequate energy supply from organic C, inorganic ion availability and numerous environmental conditions. The population of bacteria, fungi and actinomycetes were increased on reclamation over control. This may be due reduction in the adverse nature of sodic soil. Among the above, the population of bacteria found to be highest than fungi and actinomycetes. An increase of 2.0, 20.9 and 4.7 × $10^5$ bacterial CFU $g^{-1}$ were recorded due to Gypsum+GM, DSW and GLM treatments respectively over the control. An increase of 0.98, 7.8 and 2.02 × $10^2$ fungal CFU $g^{-1}$ were recorded due to Gypsum+GM, DSW and GLM treatments respectively over the control. An increase in population of 1.04, 3.06 and 2.14× $10^3$ actinomycetes CFU $g^{-1}$ were recorded due to application of Gypsum+GM, DSW and GLM application respectively over the control. Being rich in nutrients and organic material, particularly easily oxidizable and soluble organic carbon, the DSW might have favoured the proliferation of microbial population throughout the crop growth by the steady supply of nutrients and build up of organic matter in soils. The increased microbial population in GLM applied plots over Gypsum+GM plots may be due increased OM addition.

Table 2. Effect of amendments on soil microbial population and organic carbon

| Treatments | Bacteria (× $10^5$ CFU $g^{-1}$ of soil) | Fungi (× $10^2$ CFU $g^{-1}$ of soil) | Actinomycetes (× $10^3$ CFU $g^{-1}$ of soil) | OC (%) |
|---|---|---|---|---|
| Control | 16.9 | 3.60 | 1.70 | 0.53 |
| Gypsum+GM | 18.9 | 4.52 | 2.74 | 0.62 |
| DSW | 37.8 | 11.4 | 4.76 | 0.82 |
| GLM | 21.6 | 5.62 | 3.84 | 0.65 |
| SEd | 0.35 | 0.08 | 0.04 | 0.01 |
| CD (0.05) | 0.85 | 0.19 | 0.10 | 0.03 |

* Effect of micronutrient mixture was non-significant.

**Soil Enzymes**

Enzyme activity in soil is an indirect indication of the microbial activity, which is directly correlated with soil microbial population. Dehydrogenases are considered to play an essential role in initial stages of the oxidation of soil organic matter by transferring hydrogen and electrons from substrates to acceptors. The phosphatases hydrolyze organic P to inorganic P, catalyze the rate limiting steps of P nutrient cycling and therefore, phosphatase activity plays a significant role in P availability to plants from native organic P compounds. The enzyme urease was associated with N mineralization. These three enzymes play a significant role in the bio-transformation of nutrients in soil, and thus influence the nutrients availability in soil and uptake by crops. There is always a positive correlation exists between N mineralization and Urease as well as P mineralization and phosphatase activity. In the present investigation, greater activities of dehydrogenase, phosphatase and urease were observed with the DSW application followed by GLM and Gypsum+GM. The DSW being liquid organic manure increased the organic matter and nutrients content of the soil and subsequently enhanced the microbial biomass. It implies that organic and inorganic amendments provided a nutrient rich environment, which is essential for the development of microbes and synthesis of enzymes (Kamalakumari and Singaram, 1995).Ramana *et al.*

(2002) also reported that the enzyme activities were increased due to the application of distillery effluent. Generally, organic manure addition was found to enhance the microbial activities which in turn favoured the synthesis of various enzymes in soil.

Table 3. Effect of amendments and micronutrient mixture on dehydrogenase (µg TPF $g^{-1}$ $hr^{-1}$) activity of post harvest soil.

| **Treatments** | **Levels of MN mixture (S)** | | | | | |
|---|---|---|---|---|---|---|
| | Control | 75% RD | 100% RD | 125% RD | 150% RD | Mean |
| **Amendments (M)** | | | | | | |
| Control | 1.22 | 1.26 | 1.28 | 1.27 | 1.30 | 1.27 |
| Gypsum+GM | 1.51 | 1.54 | 1.56 | 1.59 | 1.62 | 1.56 |
| DSW | 1.85 | 1.88 | 1.90 | 1.92 | 1.92 | 1.89 |
| GLM | 1.60 | 1.63 | 1.66 | 1.68 | 1.69 | 1.65 |
| Mean | 1.55 | 1.58 | 1.60 | 1.62 | 1.63 | 1.59 |
| | **M** | **S** | **M at S** | **S at M** | | |
| **SE d** | 0.02 | 0.03 | 0.06 | 0.07 | | |
| **CD (0.05)** | 0.06 | NS | NS | NS | | |

Table 4. Effect of amendments and micronutrient mixture on urease activity (µg $NH_4$-N $g^{-1}$ $hr^{-1}$) of post harvest soil.

| **Treatments** | **Levels of MN mixture (S)** | | | | | |
|---|---|---|---|---|---|---|
| | Control | 75% RD | 100% RD | 125% RD | 150% RD | Mean |
| **Amendments (M)** | | | | | | |
| Control | 1.78 | 1.80 | 1.81 | 1.83 | 1.84 | 1.81 |
| Gypsum+GM | 2.00 | 2.20 | 2.30 | 2.50 | 2.52 | 2.30 |
| DSW | 4.10 | 4.15 | 4.20 | 4.22 | 4.23 | 4.18 |
| GLM | 2.54 | 2.56 | 2.57 | 2.60 | 2.61 | 2.58 |
| Mean | 2.61 | 2.68 | 2.72 | 2.79 | 2.80 | 2.72 |
| | **M** | **S** | **M at S** | **S at M** | | |
| **SE d** | 0.04 | 0.06 | 0.11 | 0.11 | | |
| **CD (0.05)** | 0.10 | 0.11 | 0.22 | 0.23 | | |

Table 5. Effect of amendments and micronutrient mixture on phosphatase activity (µg nitrophenol $g^{-1}$ $hr^{-1}$) of post harvest soil.

| **Treatments** | **Levels of MN mixture (S)** | | | | | |
|---|---|---|---|---|---|---|
| | Control | 75% RD | 100% RD | 125% RD | 150% RD | Mean |
| **Amendments (M)** | | | | | | |
| Control | 5.90 | 6.10 | 5.82 | 6.00 | 6.10 | 5.98 |
| Gypsum+GM | 6.41 | 6.42 | 6.45 | 6.47 | 6.70 | 6.49 |
| DSW | 9.06 | 9.18 | 9.20 | 9.26 | 9.29 | 9.20 |
| GLM | 8.10 | 8.26 | 8.34 | 8.36 | 8.40 | 8.29 |
| Mean | 7.37 | 7.49 | 7.45 | 7.52 | 7.62 | 7.49 |
| | **M** | **S** | **M at S** | **S at M** | | |
| **SE d** | 0.11 | 0.15 | 0.29 | 0.30 | | |
| **CD (0.05)** | 0.27 | 0.31 | 0.61 | 0.62 | | |

**Grain and straw yield**

The grain and straw yield was significantly increased by amendments as well as micronutrient application (Table 6). On application of amendments, highest yield was recorded in DSW applied treatment followed by Gypsum+GM and GLM treatments and lowest was recorded in the control. On application of DSW favourable soil properties was obtained. Higher nutrient availability, facilitating higher amount of nutrient absorption and translocation which ultimately resulted in higher grain production. The reduction in pH and creation of favorable micro climate, increased availability of essential nutrients which in turn increased the yield in Gypsum+GM and GLM applied plots.

**Table 6. Effect of amendments and micronutrient mixture on grain yield (kg $ha^{-1}$) of rice**

| **Treatments** | **Levels of MN mixture (S)** | | | | | |
|---|---|---|---|---|---|---|
| | Control | 75% RD | 100% RD | 125% RD | 150% RD | Mean |
| **Amendments (M)** | | | | | | |
| Control | 1075 | 1420 | 1690 | 1948 | 2205 | 1668 |
| Gypsum+GM | 3520 | 3860 | 4150 | 4415 | 4512 | 4091 |
| DSW | 4215 | 4610 | 4705 | 4780 | 4810 | 4624 |
| GLM | 2900 | 3260 | 3520 | 3781 | 4015 | 3495 |
| Mean | 2928 | 3288 | 3516 | 3731 | 3885 | 3470 |
| | **M** | **S** | **M at S** | **S at M** | | |
| **SE d** | 54.4 | 60.2 | 121 | 120 | | |
| **CD (0.05)** | 133 | 123 | 256 | 245 | | |

The graded levels of micronutrient treatments significantly increased the grain and straw yield of rice. Among the micronutrient levels, 150% RD of micronutrient (MN) mixture applied treatment registered the highest grain yield and the control recorded the lowest grain yield. On application of amendments along with micronutrient mixture, highest (4810 kg $ha^{-1}$) and lowest (1075 kg $ha^{-1}$) grain yield was noted in the DSW+150% RD and absolute control respectively. In control and GLM incorporated treatments, grain yield was significantly increased up to 150% RD of micronutrient mixture. In the DSW and Gypsum+GM amended treatments, significant yield response was upto 75 and 125 % RD of micronutrient respectively.

**Table 7. Effect of amendments and micronutrient mixture on straw yield (kg $ha^{-1}$) of rice.**

| **Treatments** | **Levels of MN mixture (S)** | | | | | |
|---|---|---|---|---|---|---|
| | Control | 75% RD | 100% RD | 125% RD | 150% RD | Mean |
| **Amendments(M)** | | | | | | |
| Control | 1247 | 1647 | 1943 | 2259 | 2535 | 1926 |
| Gypsum+GM | 4224 | 4632 | 4980 | 5298 | 5413 | 4909 |
| DSW | 5184 | 5670 | 5787 | 5879 | 5916 | 5687 |
| GLM | 3509 | 3944 | 4259 | 4575 | 4858 | 4229 |
| Mean | 3541 | 3973 | 4242 | 4503 | 4680 | 4188 |
| | **M** | **S** | **M at S** | **S at M** | | |
| **SE d** | 54.9 | 76.0 | 147 | 152 | | |
| **CD (0.05)** | 134 | 155 | 306 | 309 | | |

## Conclusion

The present investigation concludes that application of amendments reduces the effect of severity of sodicity by reducing the high pH and ESP. This in turn improves the biological properties of the soil and enhances the soil fertility. The application of amendments enhanced the microbial population, soil enzyme activity and organic carbon status of sodic soil. The application of amendments and micronutrient mixture increased the grain and straw yield of rice.

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