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## The application of calcium containing tannery sludge for amelioration of alkali soils

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### Abstract

Tannery industry is one of the major industries in India. Solid waste from these industries contains high amount of calcium (17.2%) alongside considerable amount of essential nutrients and organic matter. The effects of sludge along with organic manures were assessed in comparison with gypsum on biometric observations and physicochemical properties of soil by conducting incubation and pot culture experiments had been assessed. A pot culture experiment was conducted during between 2015 and 2016 at Anbil Dharmalingam Agricultural College and Research Institute, Trichy in Tamil Nadu with marigold as test crop. our results indicated that the applications of tannery sludge along with organic amendments significantly improved the soil chemical properties by reducing the pH and ESP (Exchangeable Sodium Percentage) of soil and increasing the exchangeable calcium (Ca) content, coupled with decreasing exchangeable sodium (Na) levels. Such reclamation effect was much pronounced when tannery sludge was combined with press mud and vermicompost. Thus the treatment, T<sub>6</sub> (TS @ 100% GR+Pressmud @ 10 t ha<sup>-1</sup>) recorded the highest exchangeable Ca and lowest exchangeable Na content of soil with considerable decrease in pH.

**Keywords:** Alkali soil, amelioration, calcium, gypsum, tannery sludge

### Introduction

In India, tannery is one of the greatest contributors towards the economy of the nation and it is one of the oldest and most practiced manufacturing industries. Thousands of tannery units are spread mostly across Tamil Nadu, West Bengal, Uttar Pradesh, Andhra Pradesh, Karnataka, Maharashtra, Rajasthan and Punjab. Tanning in India has a long history as it has been the traditional occupation for subdued groups of people which employs more than 80000 people mainly in the three states, viz. Tamil Nadu, West Bengal and Uttar Pradesh. In Tamil Nadu alone, the Effluent Treatment Plants (ETP) generate about 100 tonnes of sludge per day (dry basis). As the sludge contains chromium, it is classified as hazardous material. In view of non-availability of secured landfill sites, solid waste and sludge are dumped in low-lying areas in an inappropriate and uncontrolled manner, or sometimes they end up being piled within the tannery/ CETP (Common Effluent Treatment Plant) premises.

As tannery sludge contains appreciable amount of Calcium (Ca), along with Sulphur (S) and Iron (Fe), it is being utilized in agriculture as an ameliorant and also as nutrient source. At the same time, as these sludges are rich in toxic constituents like Chromium (Cr) and its transformation must be understood in order to overcome their potential health hazards. While such wastes are applied to alkali soils, they replace sodium (Na) from the soil clay complex by exchange process, thereby restoring the soil's agricultural productivity potential. Further to this, the sludge contains appreciable amount of Ca, they also form highly insoluble calcium chromate compounds especially under alkaline condition, thereby reflecting limited bioavailability and mobility of Cr to plants is limited to the extent possible.

### Materials and Methods

The Samples of tannery sludge were collected from Common Effluent Treatment Plant (CETP) Erode and Trichy district, respectively. The test samples were analyzed for physical and chemical components prior to the experiment.

The present investigation was carried out in the tannery sludge applied the pot culture experiment at Anbil Dharmalingam Agricultural College and Research Institute (TNAU), Trichy, Tamil Nadu. The treatments imposed were graded levels of tannery sludge viz., 0, 50 and 100 Percent along with organic manures like vermicompost, pressmud with three replications in CRD was applied during between 2015 and 2016 to study its residual effect on soil physico-chemical properties. Surface soil samples (0-30 cm) of the investigation experimental field were collected from four places, mixed thoroughly and reduced to get a representative sample by quartering. Collected soil samples were air dried and ground to pass through a 2 mm mesh sieve. The soil samples were analyzed and averaged for different physico-chemical and biological properties. The soil physical properties viz., bulk density, porosity analyzed using standard methods suggested by Piper (1966) [8]. The chemical properties viz., pH and EC (Jackson (1973) [2], organic carbon (Walkley and Black (1934) [15], available N (Subbiah and Asija 1956) [9], P (Olsen *et al.*, 1954) [7], K (Stanford and English 1949) [10], DTPA (Diethylenetriaminepentaacetic acid) extractable micronutrients and heavy metals (Lindsay and Norvel 1978) [4] were also assessed. The biological properties viz., microbial populations (bacteria, fungi, actinomycetes) was carried out by methods suggested by Waksman and Fred (1922) [14], for the sampled soil.

## Results and Discussion

### Physico-chemical properties of tannery sludge

The sample of tannery sludge collected from ETP, Erode and was dark brown in colour with an unpleasant odour. The

unpleasant odour of TS (Tannery sludge) was attributed to the presence of calcium and other compounds. The pH was slightly alkaline in nature (8.30) being loaded with organic and inorganic salts as reflected by its high EC (2.19 dS m<sup>-1</sup>). These findings corroborated with the observation of Kadar and Morvai (2007 and 2008) [3].

The tannery sludge (TS) contained considerable amount of plant nutrients and organic matter. Among the plant nutrients, Ca and SO<sub>4</sub> were found in higher amounts (17.2 and 25.2%), followed by Nitrogen (0.45%), Potassium (0.73%) and Phosphorous (0.21%). Apart from macro nutrients, it also contains low amounts of micronutrients in the order of Fe > Cu > Zn > Mn.

### Characteristics of experimental soils (Table 1)

The physicochemical properties of initial soil sample taken for the incubation and pot culture studies are presented in Table 1. The experimental field was clay loam in texture; taxonomically belong to the family of *Typicustropept*. The pH of the initial soil was 9.26 (alkaline) and the EC of the soil was 0.72 dS m<sup>-1</sup>. The organic carbon content of the soil was 0.53 percent. Also the alkaline KMnO<sub>4</sub>-N content was found to be below (152 kg ha<sup>-1</sup>) while the available P (15 kg ha<sup>-1</sup>) and K (154 kg ha<sup>-1</sup>) contents were found to be medium. The DTPA extractable Mn (9.60 mg kg<sup>-1</sup>) and Fe (2.80 mg kg<sup>-1</sup>) were found to be in sufficient level in the soil. On other hand, the DTPA- Zn (0.43 mg kg<sup>-1</sup>) and DTPA- Cu (1.02 mg kg<sup>-1</sup>) were found to be deficient while the content of both Cr (VI) and Cr (III) in the soil-water extract was below detectable limit. (Table 1)

**Table 1:** Characteristics of experimental soil

S No	Parameter	Values
1.	Texture	Clay loam
2.	EC (dS m <sup>-1</sup> )	0.72
3.	pH	9.26
4.	Organic Carbon (%)	0.53
5.	Available Nitrogen (kg ha <sup>-1</sup> )	152
6.	Available Phosphorus (kg ha <sup>-1</sup> )	15
7.	Available Potassium (kg ha <sup>-1</sup> )	154
8.	DTPA-Zn (mg kg <sup>-1</sup> )	0.43
9.	DTPA-Fe (mg kg <sup>-1</sup> )	2.80
10.	DTPA-Cu (mg kg <sup>-1</sup> )	1.02
11.	DTPA-Mn (mg kg <sup>-1</sup> )	9.6
12.	Exchangeable Calcium (cmol (p <sup>+</sup> ) kg <sup>-1</sup> )	8.20
13.	Exchangeable Magnesium (cmol (p <sup>+</sup> ) kg <sup>-1</sup> )	6.10
14.	Exchangeable Sodium (cmol (p <sup>+</sup> ) kg <sup>-1</sup> )	5.30
15.	Exchangeable Potassium (cmol (p <sup>+</sup> ) kg <sup>-1</sup> )	0.14
16.	CEC (cmol (p <sup>+</sup> ) kg <sup>-1</sup> )	19.74
17.	ESP (Exchangeable Sodium Percentage)	26.1

### Effect of tannery sludge, organic manure and their combinations on physico-chemical properties of soil at different stages of marigold

#### pH

The pH of soil ranged from 9.01 (T<sub>1</sub>) to 8.32 (T<sub>6</sub>) (Table 2). There was a slight reduction in the soil pH due to the addition of tannery sludge and their combinations with press mud and vermicompost when compared to (T<sub>1</sub>) control (without adding amendments), the reduction in soil pH on application of organic amendments could be due to the acidifying effect of organic and inorganic acids produced during the process of decomposition of organic amendments. Soil pH increased with advancement of crop growth in the effluent irrigated treatments while under river water the

change was not at a considerable level. Similar viewpoints were expressed by Malathi (2001) [5].

#### EC

The EC of the soil ranged from 0.71 (T<sub>1</sub>) to 0.78 (T<sub>6</sub>) dS m<sup>-1</sup> (Table 2). There was significant decrease in the soil EC due to the addition of tannery sludge; press mud and vermicompost when compared to (T<sub>1</sub>) control (no amendment addition). Similarly under Pot experiments, a slight but not significant increase in the soluble salt level was observed. This may be due to the fact that the sludge itself has very low EC indicating the low soluble salt contents. The rate of application of sludge was very low, hence the nutrients added to the soil might be just enough as plant requirement. Increase

in EC could be attributed to the higher amount of salts contributed by the inorganic NPK fertilizers as well as micronutrients which were uniformly applied the soil. Similarly, the addition of organic amendments also influenced the electrical conductivity of soil. As a result it was observed that the application of press mud was more effective than vermicompost in reducing soil pH and contributing more salts resulting in an increase in EC at all stages of crop growth. Because of this reason, a slight increase in EC at higher doses would have been possible. These findings were in line with that of Hameed and Udayasoorian (1999) [1].

**Table 2:** Effect of tannery sludge and organic manures on soil pH, EC at flowering and post -harvests stages of Marigold - Pot Culture experiment

Treatments	pH			EC (dSm-1)		
	FS	PHS	Mean	FS	PHS	Mean
T1 - Control	9.11	8.90	9.01	0.69	0.70	0.70
T2 - 50% GR	8.78	8.12	8.45	0.71	0.70	0.71
T3 - TS @ 50%GR	8.92	8.57	8.75	0.73	0.69	0.72
T4 - TS @ 100%GR	8.90	8.42	8.66	0.79	0.78	0.79
T5 - TS @ 50% GR + PM 10 t ha <sup>-1</sup>	8.53	8.35	8.44	0.71	0.70	0.71
T6 - TS @ 100%GR + PM 10 t ha <sup>-1</sup>	8.42	8.22	8.32	0.78	0.77	0.78
T7 - TS @ 50% GR + VC 2.5 t ha <sup>-1</sup>	8.72	8.45	8.59	0.72	0.68	0.70
T8 - TS @ 100% GR + VC 2.5 t ha <sup>-1</sup>	8.65	8.39	8.52	0.78	0.76	0.77
MEAN	8.75	8.42	8.59	0.74	0.72	0.73
T (Treatment)	SEd	CD (0.05)	SEd	CD (0.05)		
S (Replication)	0.11	0.24	0.009	0.01		
T X S	0.05	NS	0.004	NS		
	0.16	NS	0.013	NS		

#### FS-Flowering stage,PHS-Post Harvest Stage, GR-Gypsum requirement, PM-Press mud, VC-Vermicompost Cation exchange capacity

The cation exchange capacity of the soil ranged from 19.08 (T<sub>1</sub>) to 19.67(T<sub>4</sub>) c mol (p<sup>+</sup>) kg<sup>-1</sup> (Table 3). Application of tannery sludge at 100% GR (T<sub>4</sub>) recorded the highest cation exchange capacity of 19.67 c mol (p<sup>+</sup>) kg<sup>-1</sup>. The effect of different growth stages of marigold and its interaction with amendments were non-significant. The application of tannery sludge with vermicompost and press mud amendments either solely or in combination or as gypsum -incubated organics exhibited an increase in the cation exchange capacity of soil. However, there was increase in exchangeable calcium, magnesium coupled with a decreased sodium levels. Similar findings were reported by (Tisdall, 1996) [13].

**Table 3:** Effect of tannery sludge and organic manures on CEC(c mol (p<sup>+</sup>) kg<sup>-1</sup>) and ESP (%) at different growth stages of marigold - Pot Culture experiment

Treatments	CEC (c mol (p <sup>+</sup> ) kg <sup>-1</sup> )			ESP (%)		
	FS	PHS	Mean	FS	PHS	Mean
T1 - Control	19.28	18.88	19.08	27.49	27.86	27.68
T2 - 50% GR	19.32	18.74	19.03	18.32	17.29	17.81
T3 - TS @ 50%GR	19.73	19.08	19.40	19.72	18.66	19.19
T4 - TS @ 100%GR	19.95	19.39	19.67	18.60	19.29	18.95
T5 - TS @ 50% GR + PM 10 t ha <sup>-1</sup>	19.60	18.82	19.21	17.24	17.43	17.34
T6 - TS @ 100%GR + PM 10 t ha <sup>-1</sup>	19.83	19.08	19.46	16.59	16.82	16.71
T7 - TS @ 50% GR + VC 2.5 t ha <sup>-1</sup>	19.72	18.30	19.01	17.61	17.85	17.73
T8 - TS @ 100% GR + VC 2.5 t ha <sup>-1</sup>	19.77	18.93	19.35	17.06	16.84	16.95
MEAN	19.65	18.97	19.31	19.08	19.01	19.04
	SEd	CD (0.05)	SEd	CD (0.05)		
T	0.26	NS	0.29	0.59		
S	0.13	NS	0.14	0.29		
T X S	0.37	NS	0.41	0.84		

#### Exchangeable sodium percentage

The mean exchangeable sodium percentage of the soil ranged

from 16.71(T<sub>6</sub>) to 27.68 (T<sub>1</sub>) percent. The treatment receiving TSat 100% GR+ press mud 10tons /ha (T<sub>6</sub>) significantly decreased the percentage but it was at par with T<sub>8</sub> (TS@100% GR +VC2.5 tons/ha) (16.95 percent).The effect of different growth stages of marigold and its interaction with amendments were significant in decreasing the proportion of exchangeable sodium percentage. Control recorded significantly higher ESP at both stages. UnlikeCa and Mg, there was a decrease in the content of exchangeable Na with increased addition of sludge and amendments. The mean exchangeable sodium content ranged from 3.25 to 5.28 c mol (p<sup>+</sup>) kg<sup>-1</sup>. Application of tannery sludge @100% GR+ press mud 10tons /ha (T<sub>6</sub>) has recorded the lowest exchangeable sodium content of 3.25 c mol (p<sup>+</sup>) kg<sup>-1</sup> but its effect was at par with treatmentT<sub>8</sub> (3.28 c mol (p<sup>+</sup>) kg<sup>-1</sup>) and T<sub>5</sub> (3.33 c mol (p<sup>+</sup>) kg<sup>-1</sup>). The effect of different growth stages of marigold and its interaction with amendments were significant in decreasing content of sodium. The results indicated that application of tannery sludge and organic amendments significantly reduced the ESP in all the treatments compared to the control soil. The incorporation of tannery sludge @100% GR+ press mud 10 tons /ha were more effective in reducing the soil ESP as compared with organic and inorganic amendments applied alone or in combination. It can be noted that the best reduction in ESP was observed when tannery sludge @100% GR+ press mud10 tons /ha was applied recording a value of 16.71 per cent. This value was much lower than the initial value (29 percent). The results are in accordance with the findings of Mark Rekasi *et al.* (2011) [6] who reported that the addition of organic matter with gypsum decreased the ESP of the alkali soils. The decrease in soil ESP with addition of amendments (organic alone, or in combination) may be attributed to increased Ca in soil solution. Resulting from the addition of tannery sludge and organic sources which promoted Na displacement and its subsequent removal during irrigation to lower soil layers

#### Conclusion

From the results obtained, and observations recorded, it can be concluded that the application of tannery sludge (TS) @ 100%GR+ Pressmud10 t ha<sup>-1</sup>(T<sub>6</sub>) would serve as a good source of amendment for alkali soil reclamation, and to obtain higher marigold yield than the application of gypsum alone. However, Hyphenate as long -term studies will be required to assess the potential of chromium to be bio magnified across the food chain if this treatment option is utilized.

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