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Evaluation of textile and dye industry liquid and solid waste and amendments on exchangeable magnesium content of soil under sunflower crop

M.Parameswari

Department of Environmental Sciences, Tamilnadu Agriculture University, Coimbatore, Tamilnadu, India.

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ESP-Exchangeablesodium percentage.

ABSTRACT

The effluent and sludge generated from various industries are being dumped into the environment, causing various hazards on a long run. At the same time, these wastes contain essential nutrients. So utilization of such wastes for crop production can enhance the availability of nutrients and enrich soil organic matters that ultimately increase the growth of crops. Gypsum, pressmud, Farm yard manure, ETP sludge were tried to ameliorate the textile and dye effluent polluted soil habitat, using sunflower (CO4) as a test crop. The sludge along with effluent irrigation added considerable quantities of cations (calcium, magnesium and sodium) to the soil system. Addition of amendments had a strong influence in enhancing the soil quality parameters like exchangeable calcium. Application of pressmud @ 5 t ha^{-1} along with 100 per cent GR + NPK reduced the soil ESP by 44.96 per cent. The heavy metal content were also reduced due to addition of pressmud. Application of 100 per cent GR + pressmud @ 5 t ha^{-1} + NPK under effluent irrigation increased the crop growth, yield attributes (head diameter, head weight, seed test weight) and yield of sunflower in effluent polluted soil habitat. The yield under pressmud amended plots was 36 per cent higher over control. Reclamation and restoration of textile dye effluent polluted soil habitat is possible by leaching the soil with 100 per cent GR followed by application of pressmud @ 5 t ha^{-1} and recommended NPK.

Introduction

The improper and indiscriminate disposal of industrial solids is posing a great challenge to India and other developing nations. They cause odor problem and are potential source of surface and ground water pollution. The sludge resulting from different industrial operations and wastewater treatment plants are managed through destructive methods: land filling and incineration (Ndegwa and Thompson, 2001). Land application of sludge provides an effective and environmentally acceptable option of waste disposal, which also recycles valuable nutrients into the soil-plant ecosystem (Chatterjee and Bhargava, 1982).The limited landfill space, more stringent national waste disposal regulations and public consciousness have made land filling increasingly expensive and impractical (Ndegwa and Thompson, 2001). The textile and dye industrial sludge is reported to promote crop growth if added to the soil in quantities below the toxicity limits. Moreover, the land application of industrial sludge provides an effective and environmentally acceptable option of waste disposal to recycle valuable nutrients into the soil plant system. Applying dye industrial sludge to agricultural land as a soil amendment or as a source of calcium and sulphate has been suggested as more desirable alternative to land fill (Thavamani, 2000).

Materials and Methods

A field experiment was conducted to assess the effect of dye effluent and sludge on soil fertility and productivity of sunflower. The treatment details are given below.

I_1 – Well water

I_2 – Treated textile and dye effluent

Treatments

T_1 - Control, T_2 - 50 per cent GR+ NPK, T_3 - 100 per cent GR + NPK, T_4 - 50 per cent GR+ Pressmud @ 5 t ha^{-1}+NPK, T_5 -100 per cent GR+ Pressmud @ 5 t ha^{-1}+ NPK, T_6 - 50 per cent GR+ETP Sludge @ 5 t ha^{-1}+ NPK , T_7 -100 per cent GR+ ETP Sludge @ 5 t ha^{-1} + NPK, T_8 - 50 per cent GR+ Farmyard manure @ 12.5 t ha^{-1}+ NPK, $\mathbf{T_9}$ - 50 per cent GR+ Farmyard manure @ 12.5 t ha^{-1} +NPK

Fertilizer dose : 40 kg N, 20 kg P and 20 kg K ha^{-1}

Design : FRBD

Replications : Three

The experimental data were statistically scrutinized to find out the influence of various treatments on the soil properties and crop growth as suggested by Panes and Sukhatme (1955). The critical difference was worked out at five per cent (0.05) probability.

The field experiment was initiated at ETP-Senepiratti, Karur, Tamil Nadu. Calculated amount of the amendments as per the treatments including the textile and dye sludge were uniformly spread in the plots and ridges and furrows were formed. Sunflower seeds (CO4) were sown adopting a spacing of 60 x 45 cm. Top dressing of NPK was carried out and irrigated once in a week. Soil samples were drawn at different intervals of field experiment and analysed for various biochemical properties as per the methods described in **Table 1**.

Characterization of effluent and solid waste from textile and dye effluent

Preparation of samples for analysis the sludge samples were shade dried, sieved through 2mm nylon sieve and stored in polythene bags. The samples thus prepared were analysed for their chemical properties.

Tele:
E-mail addresses: pariwari@yahoo.com

Table 1: Analysis method of textile and dye industry solid waste and soil sample

Parameters	Methods followed
pH and EC	Dye sludge and distilled water @ 1:10 and measured in pH meter and conductivity meter Falcon *et al.* (1987)
Preparation of triacid extract	Nitric acid: sulphuric acid: perchloric acid @ 9:2:1 ratio Biswas *et al*. (1977)
Preparation of diacid extract	Sulphuric acid and perchloric acid @ 5:2 ratio Biswas *et al.* (1977)
Total nitrogen	Diacid extract - semiautomatic Kjeldahl apparatus Bremner (1965)
Total phosphorus	Triacid extract - vanadomolybdate yellow colour method Jackson (1973)
Total potassium	Triacid extract - flame photometer Jackson (1973)
pH	Soil: Water suspension of 1: 2.5 Jackson (1973)
Available N	Alkaline permanganate method Subbiah and Asija (1956)
Available P	Photoelectric colourimeter at 660 nm Olsen *et al*. (1954)
Available K	Neutral Normal Ammonium acetate extract (Flame photometer) Stanford and English (1948)

Results and Discussion

Field experiment was conducted at Senapirattai, Karur, Tamilnadu, India using sunflower as test crop to assess its phytoremediation efficiency in textile and dye effluent polluted soil habitat. The results obtained from the field study are discussed here under. The pH of the experimental soil was 8.10 with EC of 3.30 dS m^{-1}. The soil available N, P, K contents were 136, 12.9 and 262 kg ha^{-1}, respectively. The organic carbon content was 0.60 per cent. It also had an appreciable amount of exchangeable Ca, Mg, Na and K with the values of 13.3, 9.50, 28.6 and 0.90 cmol (p^+) kg^{-1} respectively.

Characteristics of textile and dye effluent and well water used for irrigating the sunflower crop

The effluent used for the study had a pH of 6.23 with dull blue colour and EC of 3.28 dS m^{-1}. It also had an appreciable amount of nitrogen (32.0 mg L^{-1}), phosphorus (28.00 mg L^{-1}) and potassium (1.61 mg L^{-1}). The Ca, Mg and sulphate contents of the effluent were 178, 54.7 and 234 mg L^{-1}, respectively. The characteristics of the well water used for irrigation recorded a pH of 7.55, EC of 1.56 dS m^{-1}. The Ca and Mg contents were 80 and 28.6 mg L^{-1}, respectively.

Initial characteristics of sludge and amendments used for the field experiment

The textile and dye sludge used for the study had a pH of 8.60 and EC of 4.58 dS m^{-1}. The total nitrogen, phosphorus and potassium contents were 0.18, 0.12, 1.57 percentages respectively. The Ca, Mg, sulphate and carbonate content of the sludge were 17.35, 1.85, 18.6 and 16.34 percentages, respectively. The pH of the press mud, farmyard manure and gypsum were 7.12, 7.38 and 9.78, respectively, whereas the EC values were 1.65, 0.74 and 1.85 dS m^{-1}, respectively. Among the amendments, pressmud had the highest N, P, K of 0.98, 1.87, 0.72 per cent, respectively whereas gypsum recorded 0.18 per cent of phosphorus and the highest Ca and Mg contents of 16.58 per cent and 3.38 per cent, respectively. The lowest Ca and Mg of 1.05 per cent and 0.32 per cent were recorded in farmyard manure.

Soil characteristics as influenced by effluent and amendments

The soil pH values at vegetative stage ranged from 7.53 to 8.25. During flowering stage it ranged from 7.92 to 8.52 and at harvest stage it varied from 8.07 to 8.67. The soil reaction increased progressively till at the end of harvest stage. It might be due to continuous effluent irrigation, which was alkaline in nature. Similar increase in soil pH due to effluent irrigation was reported by Vasconcelos and Cabrel (1993). The increase in soil pH due to amendment addition, in the present study corroborates with the findings of Olaniya *et al*. (1991). 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 also expressed by Malathi (2001). The mean EC of soils ranged from 3.37 to 4.23, 3.08 to 4.17 and 2.92 to 4.09 dS m^{-1} at vegetative, flowering and at harvest stages, respectively. The treatment combination I_2T_1 recorded the highest EC value and the lowest value was observed in I_1T_3 at harvest stage. The higher EC in effluent receiving treatments might be due to salt accumulation because of continuous effluent irrigation. The increase in EC might be due to higher Ca and Mg content of sludge. These findings were in line with that of Hameed and Udayasoorian (1999).

Soil exchangeable Magnesium

Soil exchangeable Mg content ranged from 4.12 to 6.23 cmol (p^+) kg^{-1} in the sunflower grown soil (Table 1). In general, the exchangeable Mg content increased up to flowering stage and decreased at harvest stage. Continuous effluent irrigation increased the exchangeable Mg content over well water irrigation at all stages of crop growth. It was corroborate with the findings of the textile and dye CETP sludge had higher concentrations of secondary nutrients like calcium and magnesium and micronutrients such as Fe, Cu, Mn, Zn (Thavamani, 2000). In general, application of amendments recorded higher exchangeable Mg than farmers practice (T_1). Among the treatments, T_7 (5.98 cmol (p^+) kg^{-1}) recorded the highest mean value and the lowest mean was observed in T_1 (4.29 cmol (p^+) kg^{-1}) at vegetative stage. Similar trend was observed at flowering and harvest stages. The high magnesium, calcium and sulphur content of dye sludge makes these materials ideally suited to ameliorate both acid and alkali soils. Bhoyar *et al.* (1992) reported that waste amendments should be applied at low level to maintain a good soil physical condition Effect of effluent irrigation and amendments on exchangeable magnesium content of soil under Sunflower crop (cmol (p^+) kg^{-1}

Table 1. Effect of effluent irrigation and amendments on exchangeable calcium content of soil under Sunflower crop (cmol (p^+) kg^{-1}

Treatments	Exchangeable Magnesium					
	Vegetative stage		Vegetative stage		Vegetative stage	
T_1	4.29		4.29		4.29	
T_2	4.94		4.94		4.94	
T_3	5.01		5.01		5.01	
T_4	5.21		5.21		5.21	
T_5	5.63		5.63		5.63	
T_6	5.88		5.88		5.88	
T_7	5.98		5.98		5.98	
T_8	5.19		5.19		5.19	
T_9	5.57		5.57		5.57	
Mean	5.30		5.30		5.30	
Interaction	SEd	SEd	SEd	SEd	SEd	SEd
I	0.12	0.12	0.12	0.12	0.12	0.12
T	0.03	0.03	0.03	0.03	0.03	0.03
I x T	0.04	0.04	0.04	0.04	0.04	0.04

I_1 - Well water, I_2 - Treated textile dye effluent

T_1 – Control (NPK alone), T_2 – 50 %GR+NPK, T_3 – 100 %GR+NPK, T_4 –50%GR+PM+NPK,

T_5 – 100%GR+PM+NPK, T_6 –50%GR+ETP sludge +NPK, T_7 100% GR+ETP sludge + NPK,

T_8- 50%GR+FYM+NPK, T_9 -100 % GR+FYM+ NPK PM - Pressmud @ 5 t ha^{-1},
ETP sludge - Effluent Treatment Plant sludge @ 5 t ha^{-1}, FYM - Farmyard manure @ 12.5 t ha^{-1}

The exchangeable magnesium decreased towards the harvesting stage of crop growth. Similar observations in soil exchangeable cations due to manure application had been noticed by Anandavalli (1997). Textile and dye industrial CETP sludge was identified as an effective nutrients source for groundnut crop (Thavamani, 2000).

Conclusion

The combined use of manure and inorganic fertilizer increased the soil fertility that have resulted from the balanced availability of plant nutrients and humic substances, and the positive impact of each nutrient could have attributed to the higher vegetative growth as well as on yield and yield attributes. Also the addition of organic manures could have increased the efficiency of chemical fertilizers and improved the soil conditions resulting in the higher yield of crops.

Based on the results obtained from the field experiment, it could be concluded that the diluted treated textile and dye effluent can be safely used for irrigation along with appropriate amendments.

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