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Evaluating the nitrogen, phosphorus and potassium phytoremediation efficiency of sunflower in textile and dye effluent polluted soil habitat

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ABSTRACT

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. 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. Higher microbial population was also observed under effluent irrigation than well water. 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

Textile and dye industries consume large volume of water and chemicals for wet processing of textiles. On an average 200-300 litres of fresh water is used for each kg of hosiery and nearly 75 to 95 per cent of which is discharged as effluent. 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. The potential utilization of such wastes can be assessed to some extent based on its composition.

Most of the sludge have disadvantages like toxic constituents in the form of heavy metals, carcinogen, fluoride, cyanide etc. Proper recycling of this sludge in an integrated ecofriendly way has become the need of the day.

These sludge materials have been regarded as wastes that require disposal, but now there is a realization that as they are rich in calcium, sulphate, carbonate and potassium, it is worth recycling them for agriculture and other allied fields. Moreover, in order to avoid and reduce the pollution problems encountered by the textile and dye industries, these liquid and solid wastes can be scientifically utilized for agriculture. Hence, the present study was proposed to find scientific ways and means of utilizing the liquid and solid waste of the textile and dye industry for agriculture.

Considering the economic importance of the sludge of the textile and dye industry and problems connected with liquid and solid wastes disposal, this study was under taken for assessing various management options for the integrated ecofriendly utilization of the liquid and solid wastes of the textile and dye industry. In the present investigation an attempt has been made to assess the impact of textile and dye industrial effluent on soil and crops.

Experimental

Materials

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

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

Plant biometric observations were recorded at vegetative stage, flowering stage and at harvest stage. Five plants at random were selected from each plot and tagged. The observations plant height, plant girth and number of leaves were recorded the mean values were calculated. The plant height was measured from the ground level to the tip of the growing point and expressed in cm. Quality characteristics of yield attributes like single head weight (g), Head diameter (cm), 1000 grains weight: 1000 grains of each representative samples were

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recorded for each treatment and expressed in g. 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.

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.

Analysis method of textile and dye industry solidwaste and soil sample

S. No.	Parameters	Methods followed
Analysis of textile and dye solid waste		
1.	pH and EC	Dye sludge and distilled water @ 1:10 and measured in pH meter and conductivity meter Falcon *et al.* (1987)
2.	Preparation of triacid extract	Nitric acid: sulphuric acid: perchloric acid @ 9:2:1 ratio Biswas *et al*. (1977)
3.	Preparation of diacid extract	Sulphuric acid and perchloric acid @ 5:2 ratio Biswas *et al.* (1977)
4.	Total nitrogen	Diacid extract - semiautomatic Kjeldahl apparatus Bremner (1965)
5.	Total phosphorus	Triacid extract - vanadomolybdate yellow colour method Jackson (1973)
6.	Total potassium	Triacid extract - flame photometer Jackson (1973)
Analysis of soil sample		
1.	pH	Soil: Water suspension of 1: 2.5 Jackson (1973)
2.	Available N	Alkaline permanganate method Subbiah and Asija (1956)
3.	Available P	Photoelectric colourimeter at 660 nm Olsen *et al*. (1954)
4.	Available K	Neutral Normal Ammonium acetate extract (Flame photometer) Stanford and English (1948)

Results & 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. The soil had maximum bacterial population than fungi and actinomycetes.

Characteristics of textile and dye effluent and well water used for irrigating the experimental 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).

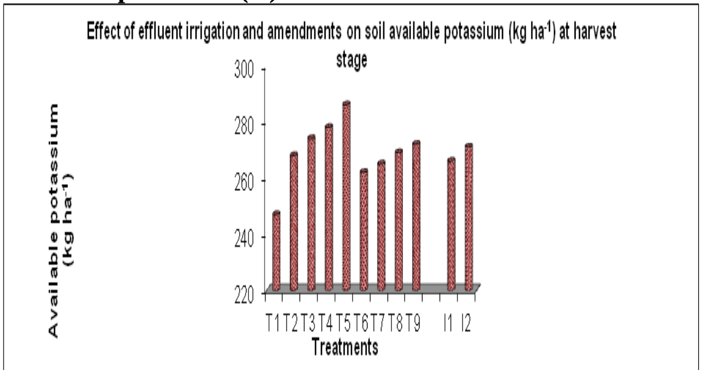
Available nitrogen (N)

Effluent irrigation significantly increased the soil available N compared to well water irrigation. Application of pressmud increased the soil available nitrogen over FYM and sludge. The highest mean available N content of 206 kg ha^{-1} was recorded in T_5 followed by T_4 (205 kg ha^{-1}), which was on par with each other while the lowest value of 142 kg ha^{-1} was observed in T_1 at vegetative stage The interaction effect was significant and the combination I_2T_5 recorded the highest value at all stages of crop growth.

Available phosphorus (P)

The available P content of the soil was also significantly influenced due to dye effluent irrigation. Results indicated that the available P status decreased with the advancement of crop growth. Throughout the crop growth, the available phosphorus was higher in effluent irrigation than well water irrigation. The highest available P content of soil increased due addition of 100 per cent GR + pressmud @ 5 t ha^{-1} + NPK (T_5). The rise in pH consequent to the addition of Ca and Mg may be responsible to the solubilization and release of available P by the replacement of absorbed phosphate ions (Ramasubramaniam and Chandrasekaran, 2001). Kale (1981) reported that pressmud treatment @ 5 t ha^{-1} increased the available P in the soil. A gradual reduction in available P in effluent irrigated experimental field soil indicated the crop removal. This was in accordance with findings of Hameed (1997) who reported that there was a gradual reduction in available P under effluent irrigation along with solid waste addition.

Available potassium (K)



Irrigation with effluent increased the available K content. Among the treatments, T_5 recorded the maximum mean value (317 kg ha^{-1}) and minimum value of 263 kg ha^{-1} was observed in T_1 (farmers practice) at vegetative stage. The higher amount of potassium in the treated effluent irrigated plots might be due to addition of K present in the effluent. This is also in harmony with the findings of Prabu (2003) who observed an increase in available K status due to mineralization of organic matter. Favourable effect on available K content of soil due to ETP sludge addition was reported by Dhevagi (1996). The available nutrient status decreased at reproductive stage indicating the absorption and conversion of nutrients into plant biomass.

Conclusions

The polluted soil was reclaimed with gypsum and organic amendments irrigated with effluent and well water. The continuous effluent irrigation had increased soil pH, EC and organic carbon content along with amendments when compared with well water irrigation. The available nitrogen, available phosporus and available potassium were influenced in effluent irrigated soils along with amendments, and the best performance was recorded in 100 per cent GR + pressmud @ 5 t ha^{-1} + NPK.

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