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MICRONUTRIENTS ZINC, MANGANESE, IRON AND COPPER STATUS OF SUNFLOWER CULTIVATED SOIL UNDER TEXTILE AND DYE EFFLUENT AND SLUDGE APPLICATION WITH AMENDMENTS

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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 was 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.

KEYWORDS: N- Nitrogen, P- Phosphorus, K- Potassium, GR Gypsum Recommendation, ESP Exchangeable Sodium Percentage

INTRODUCTION

Industrialized and developing countries spend a handsome amount of their Gross National Product (GNP) on pollution control measures, but the problem is worsening day by day. Pollution is an indicator of an inefficient process, which must be tackled by proper techniques. 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. 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 (Parameswari and Udayasoorian, 2003).

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 (Parameswari 2013). 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. The wastewater from dye industry could successfully be used for irrigation it is possible to prevent river water pollution and also to augment already scarce irrigation water resources (Oblisami and Palaniswami, 1991). Recycling of waste for irrigational purposes not only solve the disposal problem but also serve as an additional source of liquid fertilizer needed for the growing crops (Noorjahan *et al*., 2003).The effluents contain inorganic and in less concentration it is enhancing the growth and yield of crops. There are several reports of their beneficial influence on crop plants. But the effluents affect the soil and cause heavy damage to crops (Sundaramoorthy and Kunjithapatham, 2000).

MATERIALS AND METHODS

A sunflower crop 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 sunflower crop 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. 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 Sludge from Textile and Dye Industry

Preparation of samples for analysis **t**he 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 Table 1.

Table 1: Analysis Method of Textile and Dye Industry Solid Waste and Soil Sample

S. No.	Parameters	Methods Followed
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)
7	pH	Soil: Water suspension of 1: 2.5 Jackson (1973)
8	Available N	Alkaline permanganate method Subbiah and Asija (1956)
9	Total micronutrients Zinc(Zn) and Manganese (Mn)	Atomic Absorption Spectrophotometer (AAS)

RESULTS AND DISCUSSIONS

Sunflower crop 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. Addition of solid wastes and continuous effluent irrigation were reported to be advantageous to maize crop ecosystem (Parameswari and Udayasoorian, 2003).

Characteristics of Textile and Dye Effluent and Well Water Used for Irrigating the Experimental Crop

The textile and dye 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. EC increased with the application of effluent as irrigation water having high concentration of salts, particularly Na+ and Cl- has significantly increased the salinity as compared to the uncontaminated soil (Ishaya et al., 2011).

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. This increase in pH might be due to high nitrogen and soluble salts in manure and also due to free carbonates and bicarbonates in irrigation water. But a slight increase in pH was observed between vegetative and harvest stages. This might be due to the buffering capacity of amendments. Similar observation on the changes in pH due to manure application has also been reported by Sathish Kumar, P. 2002. 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). Effluent irrigation plus 20 t ha^{-1} gypsum recorded maximum germination percentage, shoot length, dry weight of sugar cane settling, and increase in content and uptake of N, P, K, Mn and Zn and also the Fe and Cu (Oblisami and Palanisami, 1991).

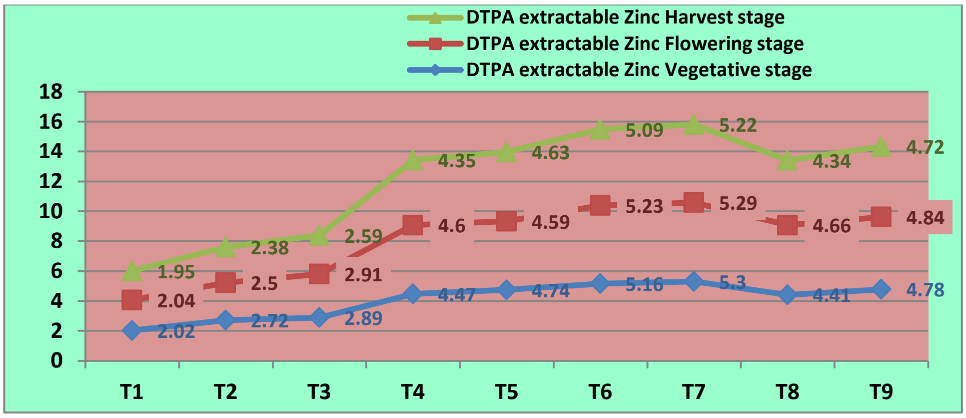
DTPA Extractable Micronutriments

DTPA Extractable Zinc

Table 2: Effect of Effluent Irrigation and Amendments on Zinc Content of Soil under Sunflower (mg kg^{-1})

Treatments	DTPA Extractable Zinc					
	Vegetative Stage		Flowering Stage		Harvest Stage	
T_1	2.02		2.04		1.95	
T_2	2.72		2.50		2.38	
T_3	2.89		2.91		2.59	
T_4	4.47		4.60		4.35	
T_5	4.74		4.59		4.63	
T_6	5.16		5.23		5.09	
T_7	5.30		5.29		5.22	
T_8	4.41		4.66		4.34	
T_9	4.78		4.84		4.72	
Mean	**4.05**		**4.07**		**3.92**	
Interaction	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**
I	0.012	0.024	0.012	0.023	0.011	0.023
T	0.025	0.050	0.0244	0.050	0.024	0.049
I x T	0.035	0.071	0.035	0.070	0.034	0.069

Amendment application significantly increased the DTPA extractable Zn and Mn contents of the soil at all stages as compared to control. The DTPA extractable Zn and Mn were not influenced due to effluent irrigation. The mean DTPA extractable Zn of effluent irrigated soil decreased from 5.77 mg kg^{-1} at vegetative stage to 5.54 mg kg^{-1} at harvest stage and the DTPA Mn from 10.37 mg kg^{-1} at vegetative stage to 10.31 mg kg^{-1} at harvest stage in effluent irrigated plots. The treatment T_7 registered the highest Zn content followed by T_6 and T_9 at all stages of crop growth. Madhumita *et al.* (1991) revealed that reduction in nutrient availability towards the maturity of crop might be due to higher uptake by plant.



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}

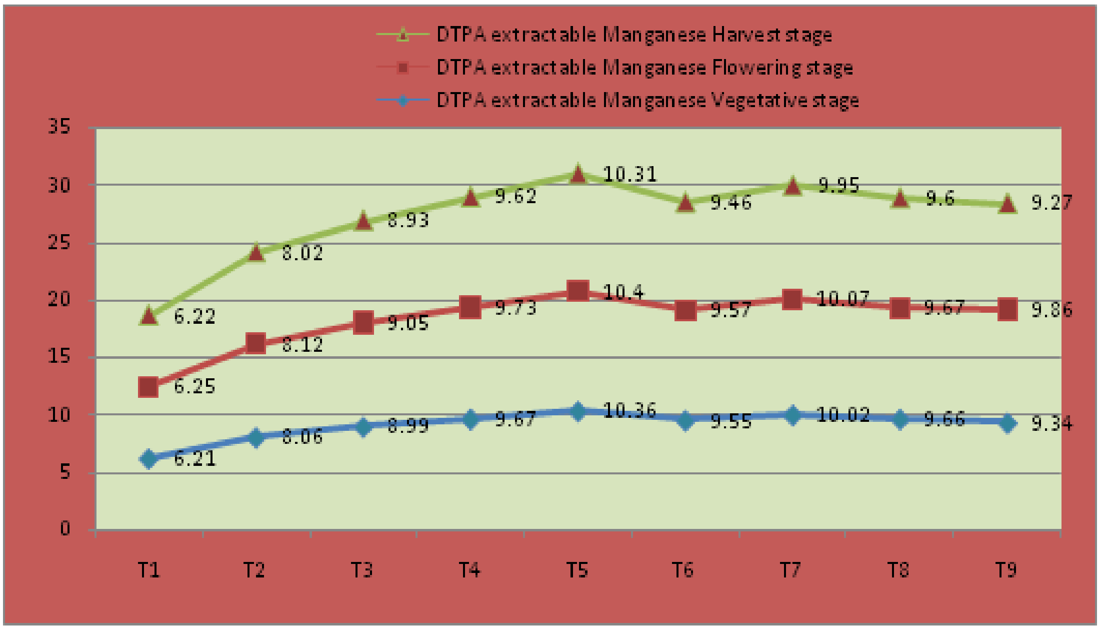
Figure 1: Effect of Effluent Irrigation and Amendments on Zinc Content of Soil under Sunflower (mg kg^{-1})

DTPA Extractable Manganèse

The mean DTPA extractable Mn soil ranged from 6.21 mg kg^{-1} at vegetative stage to 10.31 mg kg^{-1} at harvest stage. The treatment T_5 registered the highest Zn content followed by T_7 and T_4 at all stages of crop growth. The increased micronutrients status of the manure applied soil might be due to the availability of micronutrients in manures and the decreasing trend of micronutrients with the advancement of crop growth could be attributed to continuous uptake by plants

Table 3: Effect of Effluent Irrigation and Amendments on Manganese Content of Soil under Sunflower (mg kg^{-1})

Treatments	DTPA Extractable Manganese					
	Vegetative Stage		Flowering Stage		Harvest Stage	
T_1	6.21		6.25		6.22	
T_2	8.06		8.12		8.02	
T_3	8.99		9.05		8.93	
T_4	9.67		9.73		9.62	
T_5	10.36		10.40		10.31	
T_6	9.55		9.57		9.46	
T_7	10.02		10.07		9.95	
T_8	9.66		9.67		9.60	
T_9	9.34		9.86		9.27	
Mean	**9.09**		**9.19**		**9.04**	
Interaction	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**
I	0.022	0.045	0.022	0.045	0.022	0.044
T	0.047	0.097	0.047	0.095	0.046	0.094
I x T	0.066	0.135	0.066	0.135	0.065	0.133



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}

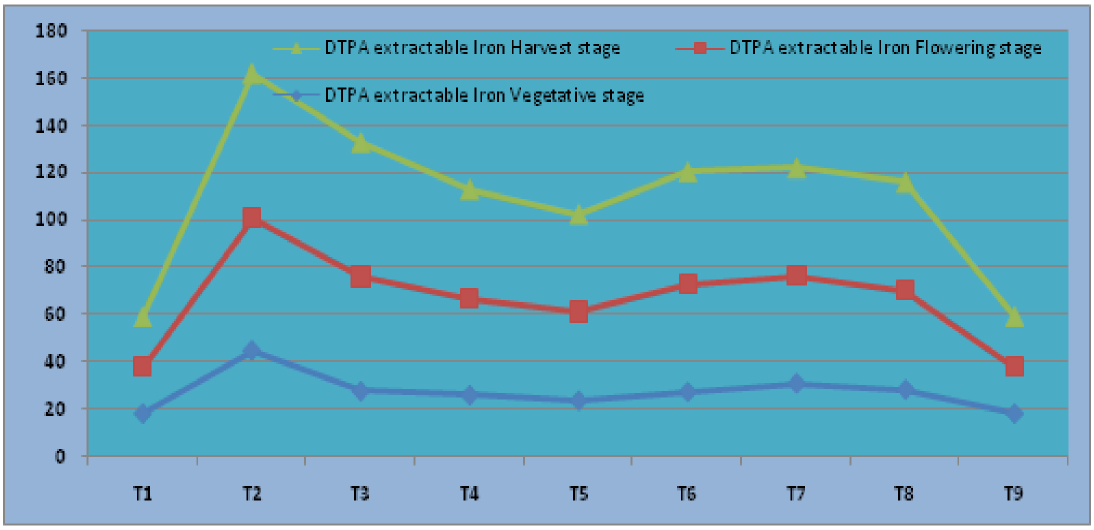
Figure 2: Effect of Effluent Irrigation and Amendments on Manganese Content of Soil under Sunflower (mg kg^{-1})

DTPA Iron (Fe)

The DTPA extractable Fe and Cu were higher in the treatments, which received effluent than those with river water irrigation. Application of amendments increased the DTPA extractable micronutrients invariably in all the treatments. The DTPA extractable Fe ranged from 9.86 to 59.25 mg kg^{-1} at vegetative stage. Among the treatments, T_2 registered the highest mean DTPA extractable Fe of 61.37 mg kg^{-1}, which was on par with T_3 (56.92 mg kg^{-1}) at harvest stage. Effluent irrigation plus 20 t ha^{-1} gypsum recorded maximum germination percentage, shoot length, dry weight of sugar cane settling, and increase in content and uptake of N, P, K, Mn and Zn and also the Fe and Cu (Oblisami and Palanisami, 1991).

Table 4: Effect of Effluent Irrigation and Amendments on Iron Content of Soil under Sunflower (mg kg^{-1})

Treatments	DTPA Extractable Iron					
	Vegetative Stage		Flowering Stage		Harvest Stage	
T_1	18.69		19.46		21.20	
T_2	45.25		55.50		61.37	
T_3	28.16		47.92		56.92	
T_4	26.44		40.33		46.33	
T_5	24.18		37.04		41.44	
T_6	27.86		44.87		47.81	
T_7	31.43		45.20		45.53	
T_8	28.85		41.47		45.80	
T_9	18.69		19.46		21.20	
Mean	**45.25**		**55.50**		**61.37**	
Interaction	**SEd**	**CD (0.05)**	***SEd***	**CD (0.05)**	**SEd**	**CD (0.05)**
I	3.77	7.63	4.28	8.65	4.91	9.93
T	5.77	11.7	6.54	13.2	7.51	15.2
I x T	9.99	NS	11.3	NS	13.0	NS



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}

Figure 3: Effect of Effluent Irrigation and Amendments on Iron Content of Soil under Sunflower (mg kg^{-1})

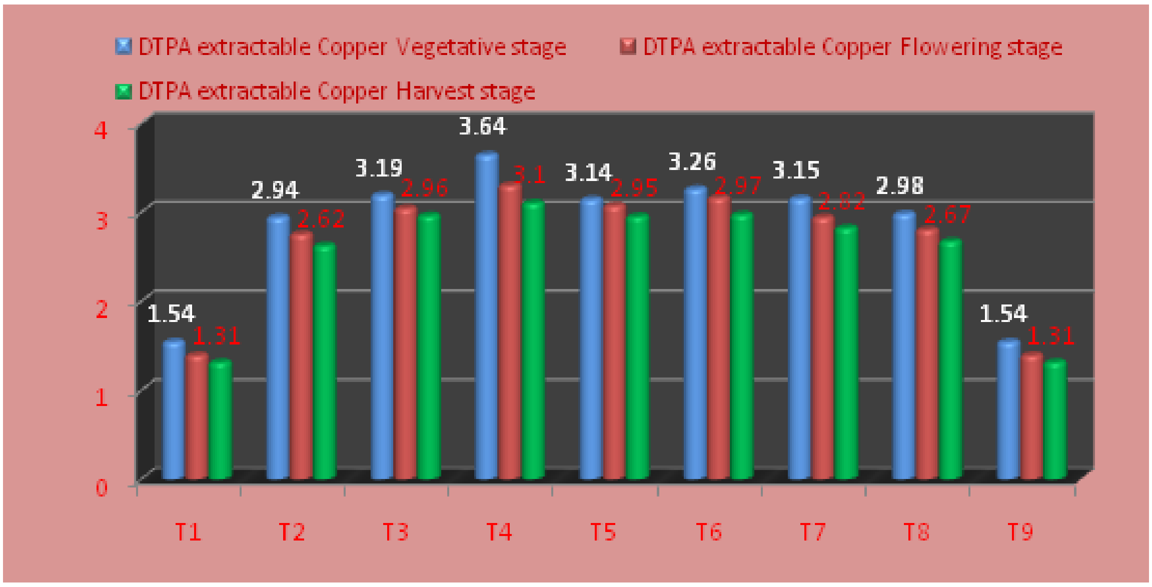
DTPA Copper (Cu)

The DTPA extractable copper content ranged from 0.85 to 4.12 mg kg^{-1} at vegetative stage. The highest mean copper content was recorded at vegetative stage, in T_4 (3.64 mg kg^{-1}) followed by T_6 (3.26 mg kg^{-1}), T_3 (3.19 mg kg^{-1}) and T_7 (3.15 mg kg^{-1}). The trend was similar at all the crop growth stages. The interaction between irrigation and amendment was non significant. Continuous use of paper and pulp industrial sludge over a period of 15 years to a sandy soil increased the soil EC, exchangeable Na, Ca, Mg and K, available P, K, Fe, Mn, Zn and Cu contents (Palaniswami and Sree Ramulu, 1994). Hameed Sulaiman and Udayasoorian (1998).

This findings corroborate with gypsum application was found to increase the availability of micronutrients in the soil (Palanisami, 1989). The exchangeable copper and iron decreased towards the harvesting stage of crop growth. Textile and dye industrial CETP sludge was identified as an effective nutrients source for groundnut crop (Thavamani, 2000).

Table 5: Effect of Effluent Irrigation and Amendments on Copper Content of Soil under Sunflower (mg kg^{-1})

Treatments	DTPA Extractable Copper					
	Vegetative Stage		Flowering Stage		Harvest Stage	
T_1	1.54		1.39		1.31	
T_2	2.94		2.75		2.62	
T_3	3.19		3.04		2.96	
T_4	3.64		3.30		3.10	
T_5	3.14		3.07		2.95	
T_6	3.26		3.16		2.97	
T_7	3.15		2.94		2.82	
T_8	2.98		2.80		2.67	
T_9	1.54		1.39		1.31	
Mean	**2.94**		**2.75**		**2.62**	
Interaction	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**
I	0.10	0.21	0.09	0.20	0.09	0.19
T	0.16	0.32	0.15	0.30	0.14	0.29
I x T	0.27	NS	0.26	NS	0.25	0.50



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}

Figure 4: Effect of Effluent Irrigation and Amendments on Copper Content of Soil under Sunflower (mg kg^{-1})

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. (Parameswari and Udayasoorian, 2013) who reported that there was a gradual reduction in available nutrients under effluent irrigation along with solid waste addition. The highest rate of sludge application to soil produced maximum dry matter in maize (Rajarajan, 1978).

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