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Effect of tannery effluent on soil physico-chemical properties and growth of finger millet

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Abstract : Investigatons were carried out to study the effect of tannery effluent on soil properties and growth of finger millet in pot culture. Amendments like gypsum, pressmud, FYM, rice husk ash, cement dust and composted coirpith were tested in combination with raw and diluted effluent. The effluent irrigation increased the bulk density, pH, EC and organic carbon content of soil. Raw effluent reduced the N,P and K uptake but the diluted effluent increased it. Among the amendments, gypsum, pressmud and composted coirpith recorded higher uptake of N, P and K respectively. The grain and straw yields were very much reduced due to effluent irrigation. The diluted effluent irrigation along with composted coirpith recorded higher yield. (*Key Words : Tannery effluent, Cement kiln dust, Composted coirpith, Nutrient uptake,Grain yield).*

With the rapid growth of industries in India, pollution has increased tremendously. Economic growth by industrialization aims at more jobs, more food and more consumer goods. Such economic growth should contribute to an improved quality of living. But, there may be some other adverse effects which may pollute the environment.

Leather industry is one of the important industries in India, which earns considerable forcign exchange through leather export. The effluent from these industries pollute the environment when they are discharged into the river streams. The tannery effluent contains considerable quantity of chloride, nitorgen, phosphate, sulphide and organic matter with excess water soluble salts rendering it saline (Anjum Farooqui, 1994). It contains high BOD and COD and characterized by high pH. The tannery effluent also contains considerable quantities of heavy metals especially chromium which will adversely affect the growth of plants. Therefore, this study is carried out with the objective of assessing the suitability of amendments and proportion of dilution of the effluent for irrigation purposes.

Materials and Methods

The tannery effluent collected from a common effluent treatment plant, Dindigul, Tamilnadu was analysed for physical, chemical and biological properties following the standard procdures.

A pot culture experiment was conducted at Agricultural College and Research Institute, Killikulam adopting 15 treatments *viz.*, T_1 : Irrigation water (control) (IW); T_2 : Raw tannery effluent (RE): Gypsum (RE+G); T_4 : RE + Pressmud (RE+PM): T_5 : RE + Farmyard Manure (RE+FYM): T_6 : RE + Rice husk ash (RE+RHA); T_7 : RE + Cement kiln dust (RE+CD): T_8 : RE + Composted coirpith (RE+CCP); T_9 : Raw effluent + Irrigation water - 1:2 dilution (1:2 DE); T_{10} : 1:2 (RE+IW) + Gypsum (DE+G); T_{11} : 1:2 (RE+IW) + Pressmud (DE+PM); T_{12} : 1:2 (RE+IW+FYM (DE+FYM); T_{13} : 1:2 (RE+IW) + Rice hush ash (De+RHA); T_{14} : 1:2 (RE+IW) + Cement kiln dust (DE+CD); T_{15} : 1:2 (RE+IW) + Composted coirpith (DE+CCP). Fertilizer schedule for all treatments is 60:30:30 kg NPK ha^{-1}.

The soil sample used for the pot culture experiment was analyzed at the post harvest stage for physico-chemical and chemical properties following the standard procedures. The experiment was conducted with finger millet Var.CO-13 as test crop in completely randomized block design and replicated twice.

Results and Discussion

The analytical results of the raw effluent collected from the common tannery effluent treatment plant is furnished in Table 1 and that of pot culture soil in Table 2.

The effluent was alkaline with high BOD, COD and suspended solids. This must be attributed to the fact that tannery effluent contain proteins, non-biodegradable materials, salts of elements like Na, Cr, etc., and suspended matter. Similar results have been reported by Sujatha and Asha Gupta (1996).

The soil used for the pot culture experiment was sandy clay lom, almost neutral in reaction, low in soluble salts, medium in organic carbon and available N and K and high in available P (Table 2).

The effect of effluent with amendments on the physical properties of soil is given in Table 3. There was an increase in bulk density from 1.11 mg m^{-3} in irrigation water treated plots(control) to 1.262 mg m^{-3} with 1:2 diluted effluent and 1.225

mg m^{-3} for raw effluent. This may be attributed to the twin effects of direct accumulation of large quantities of inorganic plus organic materials in the pore space and also interaction of sodium with exchange complex, thereby causing deflocculation effects. The water holding capacity was higher under effluent treatment combinations and might be due to the moisture retaining capacity of the various amendments used.

A general increase in pH due to effluent irrigation was observed, but it decreased for the various amendments used except for cement kiln dust (Table 4). The increase in soil EC due to effluent irrigation might be attributed to the addition of considerable quantities of dissolved salts through the effluent (Thamburaj *et al.* 1964). The increase in EC due to gypsum application might be due to dissolution and desiccation of Ca^{2+} and SO_4^{2-} from gypsum. An increase in organic carbon content of the soil due to the use of raw and diluted effluent might be due to the accumulation of organic matter added to the soil through the effluent which contained about 5395 mg l^{-1} of suspended solids.

The available N status of the soil was increased by 24 per cent and 18 per cent respectively for raw and diluted effluent. This increase might be due to the presence of substances like proteins, hide fat *etc.* in the tannery effluent (Stomberg *et al.*, 1984). The available P and K contents were also increased by the effluent irrigation. The increased contents of Na, Ca, Mg in the effluent correspondingly increased their exchangeable nutrient and the amendments which underwent decomposition and released significant quantities of N, Ca, K and P into soil.

The N uptake of finger millet grain under raw effluent with amendments increased N uptake over control. Among the amendments, gypsum, pressmud and CCP had increased the N uptake higher than other amendments (Table 5). Though the available P and K were high, their uptake values were lower for the raw effluent treatment. This might be due to some physiological inhibition by some toxic elements like Cr and Na that may be present in the effluent. Chromate being an anion might have competed with phosphate for uptake. Similarly Na and K might have competed with each other for uptake. Such inhibitory toxicity could be overcome by dilution of the effluent and application of certain amendments, such as gypsum, pressmud, CCP and their ameliorating effect could be ascribed to their Ca content. Raw effluent increased the uptake of Na and Ca. Gypsum reduced the uptake of Na but increased Ca uptake.

Irrigation with increased concentration of effluent decreased the grain yield. The increased concentration of effluent resulted in increased soil salinity. Murty and Rao (1965) reported that the increased salinity cause spikelet sterility and decreased grain yield (Table 6). Among the amendments, CCP increased the yield followed by gypsum, pressmud, FYM, RHA and cement dust. The CCP improved the drainage besides keeping the soil moist and preventing the capillary rise and accumulation of salts around the root zone. Devaraj (1991) had also advaocated the use of coirpith for increasing the yield of sugarcane in tannery polluted areas.

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Table 1. Physico - Chemical and biological characteristics of tannery effluent

S.No.	Characteristics	Value (mg l^{-1})
1.	Colour	Light brown
2.	Odour	Unpleasant (Foul)
3.	pH	8.81
4.	EC (dS m^{-1})	15.61
5.	Carbonate	400.0
6.	Bicarbonate	1880.0
7.	Chloride	3550.0
8.	Calcium	287.0
9.	Magnesium	141.0
10.	Sodium	2785.0
11.	Potassium	102.0
12.	Sulphate	519.4
13.	Total solids	15500.0
14.	T.D.S.	10075.0
15.	Organic carbon (%)	0.026
16.	Total N	201.72
17.	Ammoniacal N	92.4
18.	Total P	0.5
19.	C.O.D.	3250.0
20.	B.O.D.	1600.0
21.	Mn	0.11
22.	Zn	0.6
23.	Cu	0.12
24.	Fe	1.83
25.	Cr	23.5
Biological properties		
26.	Bacteria	29 x 10^5/ml
27.	Actinomycetes	Nil
28.	Fungi	8.1 x 10^3/ml

Table 2. Physico - chemical properties of experimental soil

Characteristics	Unit	Values
Clay	(%)	32.15
Silt	(%)	4.25
Coarse sand	(%)	9.51
Find sand	(%)	50.44
Textural class	(%)	Sandy clay loam
Apparent specific gravity	($\mu g\ m^{-3}$)	1.38
Absolute specific gravity	($\mu g\ m^{-3}$)	2.14
Maximum water holding capacity	(%)	26.25
Total pore space	(%)	42.07
Volume expansion	(%)	14.26
Loss on ignition	(%)	3.89
Sesquioxides	(%)	12.36
Total N	(%)	0.15
Total P	(%)	0.57
Total K	(%)	0.17
Total Ca	(%)	0.36
Total Mg	(%)	0.80
pH (1:2.5 soil water suspension)		6.81
EC	($dS\ m^{-1}$)	0.25
Organic carbon	(%)	0.68
Available N (Alk, $KMNO_4$)	($kg\ ha^{-1}$)	319.2
Available P (Bray No.1)	($kg\ ha^{-1}$)	34.50
Available K (Neutral N. NH_4OAc)	($kg\ ha^{-1}$)	278.0
CEC	(me 100 g^{-1})	23.00
Exchangeable Ca	(me 100 g^{-1})	12.40
Exchangeable Mg	(me 100 g^{-1})	8.59
Exchangeable Na	(me 100 g^{-1})	0.54
Exchangeable K	(me 100 g^{-1})	0.35
Available Cu	(ppm)	0.21
Available Zn	(ppm)	3.95
Available Fe	(ppm)	0.34
Available Mn	(ppm)	0.193
DTPA extractable Cr	(ppm)	Nil
Total Cr	(ppm)	1.15

Table 3. Effect of effluent irrigation and soil amendments on soil physical properties

Treatments	Bulk density ($\mu g\ m^{-3}$)	Particle density ($\mu g\ m^{-3}$)	% pore space	W.H.C. (%)	Volume expansion (%)
IW	1.110	2.140	50.88	26.85	8.74
RE	1.225	1.950	43.27	28.17	10.36
RE+G	1.194	1.846	40.12	29.48	10.18
RE+PM	1.233	2.064	45.01	28.00	8.18
RE+FYM	1.311	2.131	43.05	25.56	7.07
RE+RHA	1.252	2.010	42.07	26.01	6.34
RE+CD	1.262	2.138	45.99	28.73	8.95
RE+CCP	1.115	2.171	43.27	30.91	8.15
1:2 DE	1.262	2.063	44.03	27.12	8.66
DE+G	1.370	2.255	44.03	25.53	8.25
DE+PM Pressmud	1.252	2.237	47.95	28.89	6.87
DE+FYM	1.351	2.414	48.92	27.37	7.56
DE+RHA	1.272	2.096	43.05	27.37	7.14
DE+CD	1.301	2.246	45.99	27.72	6.86
CE+CCP	1.252	2.138	45.99	28.49	8.03
CD (P=0.05)	0.03	0.06	1.13	0.70	0.21

Table 4. Effect of effluent irrigation and soil amendments on soil properties

Treatments	pH	EC (dS m^{-1})	Organic carbon (%)	Available N (ppm)	Available P (ppm)	Available K (ppm)
IW	7.04	0.47	0.63	136.08	22.500	141.20
RE	7.51	1.77	0.66	168.23	24.505	143.50
RE+G	7.40	2.72	0.70	157.64	22.500	147.80
RE+PM	7.45	1.22	0.64	145.60	28.005	155.50
RE+FYM	7.38	0.92	0.64	150.78	26.500	148.40
RE+RHA	7.35	1.04	0.64	149.94	25.000	147.00
RE+CD	8.66	0.68	0.63	124.60	19.745	141.50
RE+CCP	7.38	0.92	0.64	149.74	20.755	148.50
1:2 DE	7.21	0.76	0.63	160.99	24.000	142.50
DE+G	7.41	2.33	0.63	151.90	24.000	143.50
DE+PM	7.43	0.72	0.64	136.03	26.125	150.60
DE+FYM	7.31	1.27	0.64	143.50	24.750	146.50
DE+RHA	7.12	0.86	0.63	138.32	24.505	146.00
DE+CD	8.38	0.69	0.63	101.36	13.750	140.40
CE+CCP	7.42	0.86	0.64	130.76	20.755	146.50
CD (P=0.05)	0.19	0.03	0.016	3.50	0.69	3.66

Table 5. Effect of effluent irrigation and soil amendments on nutrient uptake of grain (in mg pot^{-1} except for Na)

Treatments	N	P	K	Ca	Mg	Na (ppm pot^{-1})
IW	159.00	40.28	74.64	43.50	37.05	1063.26
RE	77.60	19.52	28.68	14.22	13.01	626.60
RE+G	119.39	30.58	47.54	28.58	2.11	854.92
RE+PM	117.65	32.05	46.85	18.67	17.96	859.49
RE+FYM	117.65	32.05	46.85	18.45	17.28	826.21
RE+RHA	110.07	27.22	43.81	17.94	16.80	840.00
RE+CD	108.84	26.90	40.56	18.86	17.31	824.72
RE+CCP	126.61	33.58	50.03	21.23	20.46	957.28
1:2 DE	157.77	40.67	71.99	36.26	33.63	1198.14
DE+G	190.44	47.91	84.30	47.91	41.86	1116.21
DE+PM	182.12	49.30	81.78	36.12	35.38	1264.40
DE+FYM	172.67	47.14	79.63	36.;12	34.53	1192.80
DE+RHA	170.25	46.31	79.22	36.09	34.28	1282.55
DE+CD	160.88	43.48	75.22	35.64	33.48	1141.35
CE+CCP	196.15	53.20	89.10	41.67	40.38	1410.20
CD (P=0.05)	3.70	0.98	1.63	0.79	0.73	26.23

Table 6. Effect of effluent irrigation and soil amendments on grain and straw yield of ragi (g pot^{-1})

Treatments	Grain yield	Straw yield
IW	10.740	23.78
RE	4.820	16.15
RE+G	7.370	24.37
RE+PM	7.045	23.70
RE+FYM	6.885	23.19
RE+RHA	6.720	23.21
RE+CD	6.760	23.24
RE+CCP	7.720	25.04
1:2 DE	10.510	24.02
DE+G	12.130	28.53
DE+PM	11.600	27.76
DE+FYM	11.360	27.16
DE+RHA	11.350	27.22
DE+CD	10.870	27.19
CE+CCP	12.820	30.14
CD (P=0.05)0.234	0.63	

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