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Characterization and impact of dyeing factory effluent on germination and growth of Maize [CO 1] and Cowpea [CO 4]

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Abstract: Recycling of solid and liquid wastes is gaining importance in recent years to reduce environmental pollution and at the same time to cope up with the shortage of resources. A study was carried out to elucidate an appropriate dilution of dyeing factory effluent for irrigating agricultural crops. A pot culture experiment was conducted as a preliminary study to determine the effect of dyeing factory effluent on cowpea (CO 4) and maize (CO 1) seedlings, which revealed that at lower concentrations (25 and 50 per cent) the effluent favoured the seed germination and growth of seedlings and increased the microbial activity in soil.

Key words : Dyeing factory, Effluent, Irrigation, Characterization.

Introduction

Industries, one of the wings of modern technology, provide the basic needs of the people in terms of cloth, food and shelter. But the wide spread of industrial activities and mis-management of resources have resulted in the dumping of solid and liquid wastes and thereby leading to pollution of the ecosystems. Textile and dyeing industry is the one which contribute much to soil and water pollution. There are about 900 dyeing and bleaching units located in and around Tiruppur and Coimbatore cities in Tamil Nadu state - on an average, 200-300 litres of fresh water is used for each kg of hosiery and nearly 75-95 % of which is discharged as effluent containing organic and inorganic pollutants and colouring materials (Banat *et al.* 1996). Barring a few, most of the industries do not have adequate provision for treating the effluent and hence it flows into the river as raw effluent and renders the river water useless and also pollutes the underground water and soil. Therefore an attempt was made to study the impact of dyeing factory effluent on growth and germination of maize and cowpea crops.

Materials and Methods

The effluent samples were collected from dyeing units located at Telungupalayam, Coimbatore district, Tamil Nadu. Samples for microbial examination were collected in sterilized 250 ml bottles. Immediately after collection, the samples were analysed for the physico-chemical properties like pH, EC, organic carbon, suspended solids, dissolved oxygen, biological oxygen demand, chemical oxygen demand, nitrate nitrogen, ammoniacal nitrogen, total phosphorus, sodium, potassium, chloride, sulphate, calcium, magnesium, carbonate and bicarbonate. The microbial population of the effluent sample was assessed by using the standard serial dilution plate technique (Jenson, 1968). A pot culture experiment was conducted to ascertain the impact of dyeing factory effluent at different dilutions on germination and growth of cowpea (CO 4) and maize (CO 1). Five kg of red soil was taken in the pots and five seeds were sown. The following treatments were taken for the study: T_1- control, T_2- 100% effluent, T_3- 75% effluent, T_4- 50% effluent, T_5- 25% effluent, Each of five treatments were replicated five times in completely randomized design (CRD). Observations for the germination, root length, shoot length and vigour index were made 15 days after sowing. Vigour Index(VI) was calculated using the following formula.

$$VI = (\text{root length} + \text{shoot length}) \times \text{germination \%}$$

(Abdul baki and Anderson, 1973)

The alteration in soil microbial population was assessed by employing the standard plate count method (Jenson, 1968). The plant biomass was calculated by the differences between the fresh weight and dry weight.

Table 1. Physico-chemical and biological properties of dye factory effluent

S.No.	Characters		Sample-1	Sample-2	Mean
A.	*Physico-chemical characters*				
1.	Colour		dark brown	dark green	-
2.	pH		9.59	9.87	9.73
3.	EC	dSm^{-1}	3.3	2.9	3.1
4.	TSS	$mg\ l^{-1}$	3500	3600	3550
5.	TDS	$mg\ l^{-1}$	2162	1870	2016
6.	DO	$mg\ l^{-1}$	1.9	2.1	2.0
7.	BOD	$mg\ l^{-1}$	260	290	275
8.	COD	$mg\ l^{-1}$	1100	1010	1055
9.	OC	(%)	0.72	0.68	0.70
10.	Calcium	$mg\ l^{-1}$	240	149	194.5
11.	Magnesium	$mg\ l^{-1}$	73	62	67.5
12.	Sodium	$mg\ l^{-1}$	1100	800	950
13.	Potassium	$mg\ l^{-1}$	13	7	10
14.	Chlorides	$mg\ l^{-1}$	1200	1050	1125
15.	Sulphates	$mg\ l^{-1}$	170	150	160
16.	Carbonates	$mg\ l^{-1}$	20	35	27.5
17.	Bicarbonates	$mg\ l^{-1}$	760	635	697.5
18.	Total N	$mg\ l^{-1}$	49	41	45
19.	Total P	$mg\ l^{-1}$	11	17	19.5
B.	*Biological characters*				
	Bacteria	$(x10^6\ ml^{-1})$	49	63	56
	Fungi	$(x10^3\ ml^{-1})$	13	16	14.5
	Actinomycetes	$(x10^4\ ml^{-1})$	2	3	2.5

Results and Discussion

The effluent samples were analysed for the physico-chemical and biological properties. The colour of the dye effluent varied from dark brown to dark green. The pH and EC were 9.73 and 3.10 dSm^{-1} respectively. The total suspended solids and total dissolved solids of the effluent were 3550 and 2016 $mg\ l^{-1}$. The organic carbon content was 0.7%. The total calcium, magnesium, chloride, sulphate, carbonate, bicarbonate and sodium were present to a level of 194.5, 67.5, 1125, 160, 27.5, 697.5 and 950 $mg\ l^{-1}$ respectively. In addition, the effluent contained 19.5 and 10 $mg\ l^{-1}$ of phosphorus and potassium respectively. The bacterial population was 56x $10^6\ ml^{-1}$ and that of actinomycetes 2.5x $10^4\ ml^{-1}$ (Table.1)

The mean germination per cent, root length, shoot length and vigour index were significantly influenced by different treatments. The increase in proportion of dye effluent in the irrigation water significantly decreased the germination percent of maize (CO 1). The highest germination per cent (85%) was recorded in T_5 (25 per cent effluent) and the lowest (45%) was recorded in T_2 (100 per cent effluent). Similar trend was observed in the case of root length, shoot length, vigour index and biomass production. Among the treatments T_2 recorded the lowest shoot length (16 cm), root length (12.01 cm), vigour index (1260) and biomass production (1.7 g) where as T_5 recorded the highest shoot length (25.2 cm), root length (14.4 cm), vigour index (3391) and biomass production (2.21 g). Regarding the root length, the treatments T_2 (100 per cent effluent) and T_3 (75 per cent effluent) were on par with each other while T_1, T_4 and T_5 were on par with each other, whereas in biomass production, the treatments T_3 and T_4 (50 per cent effluent) were on par with each other. With reference to microbial dynamics in soil, the diluted effluent favoured the proliferation of microbial activity. The maximum load of bacteria was observed in T_5 (23×10^6) and the minimum load was recorded in T_2 (11×10^6). Similar results were observed for the population of fungi and actinomycetes also (Table.2). Similar trend of results were observed for cowpea crop.

The colour of the effluent varied from dark brown to dark green and is dependent on the type of the dye employed (Banat *et al.* 1996). The pH of the effluent might be due to the presence of higher amounts of inorganic sodium compounds as well as dissolved inorganic salts (Ramachandran,1994). Presence of organic materials in large quantity resulted in higher biological oxygen demand and chemical oxygen demand content and reduced the level of dissolved oxygen in the waste water. Presence of high amount of sodium (950 mg^{-1}) and major inorganic nutrients in the effluent might be due to the usage of caustic soda and phosphorus and potassium containing chemicals in the dyeing process.

In the present study cowpea (CO 4) and maize (CO 1) grown at lower effluent concentration (25 and 50 per cent concentration) showed better germination and seedling growth. The increase in germination and growth parameters might be due to the reduced level of toxic compounds as a result of dilution, which in turn favoured better utilization of nutrients in the effluent by the seedlings(Swaminathan and Vaidheeswaran,1991). The textile mill effluent inhibited the germination of crops at 25 per cent concentration and this is due to exosmosis by higher concentration of salts in waste water. Similar results were reported by Dhevagi (1996) in diluted paper mill effluent, the growth reduction in plant system might be due to the toxic effects of excessive salts and heavy metals on soil permeability and nutrient availability

Soil micro organisms play an important role in better establishment and growth of plants. Plant growth and nutrient uptake through the seed in initial stages of growth were influenced

Table 2. Effluent irrigation on maize (CO 1) and Cowpea (CO 4)

Treatments	Germination (per cent)	Shoot length (cm/plant)	Root Length (cm/plant)	Vigour index	Biomass (g/plant)	Bacteria ($\times 10^6$ g/l)	Fungi ($\times 10^3$ g/l)	Actinomycetes ($\times 10^4$ g/l)
Maize								
T_1	97	28.0	14.9	4136	2.4	21	7	2.0
T_2	45	16.0	12.0	1260	1.7	11	5	1.2
T_3	65	19.6	12.6	2093	1.9	15	9	1.3
T_4	75	22.3	13.9	2715	2.0	19	11	3.0
T_5	85	25.2	14.4	3391	2.2	23	14	3.0
SEd	1.6	0.76	0.51	39.42	6.5	0.99	0.63	0.44
CD	3.3	1.59	1.06	82.19	0.13	2.08	1.31	0.93
Cowpea								
T_1	98.8	27.6	14.9	4250	3.96	26	9	2
T_2	51	19.0	10.1	1484	1.82	13	7	1.5
T_3	72	21.8	12.8	2491	2.16	19	11	1.5
T_4	84	26.8	13.1	3351	3.02	24	17	3
T_5	98.4	27	14.2	4120	3.42	27	19	4
SEd	1.31	0.61	0.44	40.51	0.13	0.99	0.52	0.46
CD	3.73	1.27	0.92	84.41	0.27	2.08	1.10	0.96

by microbially mediated changes in seed morphology, seed physiology, nutrient phase of equlibrium and soil chemistry etc (Killham,1994). In this study, the microbial population in soils grown with cowpea and maize seedlings recorded a decreasing trend with corresponding increase in dye effluent concentration. Higher population of microflora was found at lower effluent concentration of 25 and 50 per cent. Reduction in microbial population at higher effluent concentration might be due to reverse osmosis which reduced the moisture level of soil, an important factor that favours the microbial growth.

Conclusions

Results suggested that the dye effluent was dark brown to dark green in colour with alkaline pH and an EC of > 3 dSm^{-1}. It has considerable amounts of total dissolved solids (2016 mg l^{-1}) and total suspended solids (3550 mg l^{-1}) and low dissolved oxygen level (2.0 mg l^{-1}). An appreciable amount of chlorides, sulphates, carbonates and bicarbonates of calcium, magnesium and sodium with a little amount of inorganic nutrients were also present in the effluent. Considerable number of microbial poplulation was found in the effluent.

Better seed germination, root length, shoot length, biomass production and vigour index of seedlings were observed at lower effluent concentrations (25 and 50%). But the above parameters decreased with an increase in the effluent concentration (75 and 100%). The effluent can be safely used for irrigation with appropriate dilution.

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