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Bioremediation Potentialof*Brassicajuncea* Against Textile Disposal

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ABSTRACT

Heavy metal contamination caused by natural process or by human activity is one of the serious ecotoxicological problems. Phytoremediation is an emerging plant based technology for the removal of toxic contaminants in oil and water. It is relatively invasive and provides a low-cost remedial option suited too many sites. The present study is focused with an objective to remediate the textile effluent contamination using the plant *Brassica juncea***.** The textile dyeing effluent was collected at regular intervals and the physicochemical characteristics of the selected textile effluent were analyzed. The textile effluent was found to have high pH indicating alkalinity of the sample and large amount of total suspended solids, total dissolved solids, carbonate, bicarbonate, minerals and metals like sodium, potassium, chromium, nickel and zinc. *Brassica juncea*was grown as a control plant using water and also using textile effluent as such and with two different dilutions of the effluent (50% and 25% dilutions). The biometric and biochemical parameters were recorded at 30 daysinterval up to 90 days after sowing. Undiluted effluent did not favour the growth of plants and the few germinated plants died soon. The plants treated with diluted effluents had lower pigments, protein, DNA and RNA in the leaf over control. The 25% dilution was found to be better for plants than 50% dilution.

Keywords: Phytoremediation,*Brassicajuncea*, Bioremediation, textile effluent

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INTRODUCTION

Textile effluents are of concern because they colour the drains and ultimately the water bodies when let into the surrounding without treatment and therebyaffect the quality of water [15]. Textile industry is one of the country's largest industries earning large amounts of foreign exchange and attracts public attention from the view point of pollution. Untreated effluent from dyestuff production and dyeing mills are highly coloured and hence objectionable if discharged into open waters [7].

Dyes in the textile industry are designed to resist fading upon exposure to sweat, light, water, oxidizing agents and microbial attack [24]. The textile industries produce effluents that contain several types of chemicals such as dispersants, leveling agents, acids, alkalies, carriers and various dyes [15]. Processes based on physical and chemical treatment for decolourisation of textile wastewater have a number of operational problems, secondary pollution problems and high cost [11].

Currently bioremediation is becoming important because ofcost effective, environmental friendlytechnology and produces less sludge as compared to the chemical and physical decomposition processes [22].Phytoremediation is a new and a novel strategy to remove toxic heavy metals from soil through hyper accumulating plant species. This is a low cost and eco-friendly means of reclaiming heavy metal contaminated soils, resulting from developmental activities such as discharge of industrial effluents and city wastes into the drinking water [16,23]. The *Brassicaceae*family has the ability to accumulate the heavy metals in an extremely high degree [4]. An attempt has been made to use *Brassica juncea*for phytoremediation of textile effluent.

MATERIALS AND METHODS

Textile effluent

The effluent was collected from the selected textile dyeing industry at Coimbatore at regular intervals and stored at 4 $^{\circ}$C for analysis. The collected textile effluent was analyzed for physicochemical properties like colour, odour, turbidity, pH, total suspended solids, total dissolved solids,chemical oxygen demand,biochemical oxygen demand [1], carbonate and bicarbonate, sodium and potassium [14], chromium, copper, cadmium, nickel and zinc [1].

Soil

Red Soil of about three kilograms was filled in each pot before sowing seeds of the plant sample. Both the control soil and effluent treated soil were analysed for certain parameters like pH, sodium and potassium [14], chromium, copper, cadmium, nickel and zinc [1].

Selection and treatment of the plant

The seeds of the plant *Brassica juncea* selected for the study were collected from Tamil Nadu Agricultural University, Coimbatore. *Brassica juncea* was grown in control soil and effluent treated soil in three different concentrations (25% and 50% dilutions and undiluted 100%) for a period of 90 days. On 30^{th}, 60^{th} and 90^{th} days after sowing, the leaves were analyzed for different parameters such as, height of the plant, fresh and dry weight of the plant, biochemical parameters such as chlorophyll [25], carotenoid [26], protein [10], vitamin A [3], Chromium, Copper, Cadmium, Nickel and Zinc [1].

Statistical analysis

Two-way ANOVA was carried out between the treatments and days for all the biometric and biochemical parameters studied.

RESULTS AND DISCUSSION

Characterisation of textile effluent

TABLE 1: Physicochemical Characteristics of the textile effluent

Parameters	Sample#	Units	Bis limits*
Colour	Blue	-	Absent
Odour	Offensive	-	Absent
Turbidity	Turbid	-	-
pH	10.2	-	6.0-9.0
Total suspended solids	2100	mg/L	100
Total dissolved solids	11700	mg/L	2100
Chemical oxygen demand	213	mg/L	250
Biochemical oxygen demand	19	mg/L	30
Carbonate	7050	mg/L	NM
Bicarbonate	10,193	mg/L	NM
Sodium	45	mg/L	NM
Potassium	197	mg/L	NM

* - Tolerance limits for textile effluent discharged into inland water source as per Bureau of Indian Standards (BIS) (1986).

\# - Mean value of duplicate samples NM - Not mentioned

The collected textile dyeing industrial effluent was assessed for its physicochemical properties and its toxic metal levels were also determined. Table 1 shows the physicochemical characteristics of the selected textile effluent.The normal pH range of water should be between 6.0 and 9.0 [5]. The effluent sample analyzed had a pH value of 10.2 which is high when compared to standard value. Higher value of pH could be attributed to the presence of carbonates and bicarbonates [18].

The total suspended solids (2100mg/L)and total dissolved solids (11,700mg/L) in the sample was found to be high when compared with BIS standards. The presence of high level of total suspended solids and total dissolved solids might be due to the insoluble organic and inorganic matter present in the effluent [13]. COD and BOD in the selected textile effluent sample were found to be 213mg/L and 19 mg/L respectively. The high COD and BOD of the effluent may be due to the presence of oxidisable organic matter in it [21].

In the textile effluent sample analyzed, the presence of carbonate and bicarbonate were found to be high (7050mg/L and 10,193mg/L respectively) and from the study by High carbonate and bicarbonate contents contribute to the total alkalinity of the sample. The levels of sodium and potassium in the textile effluent were found to be 45 mg/L and 197 mg/L respectively [2].The level of exchangeable cations (sodium and potassium) in the soil irrigated with textile wastewater varied differently from control sites. In general, the exchangeable sodium and potassium were relatively high in treated textile wastewater [20].

TABLE 2: Metal levels in the textile effluent

Parameters	Sample# (mg/L)	Bis limits* (mg/L)
Chromium	176	2.0
Copper	173.2	NM
Zinc	164	NM
Nickel	81	NM
Cadmium	6.194	NM

* - Tolerance limits for textile effluent discharged into inland water source as per Bureau of Indian Standards (BIS).

- Mean value of duplicate samples. NM - Not mentioned.

The textile effluent chosen for the present study was analyzed for the presence of metals like chromium, copper, zinc, nickel and cadmium using Atomic Absorption Spectrophotometric method. Chromium is a widely used metal in textile industries and was found to be 176mg/L. Other heavy metals like copper, zinc, nickel and cadmium were present in the levels of 173.2mg/L, 164mg/L, 81mg/L and 6.194mg/L respectively (Table 2).

Characteristics of contaminated soil

Both the control and effluent contaminated soil samples were analyzed for essential parameters and the results are presented in Table 3.It is evident that the effluent contaminated soil had a great variation in the mineral and metal content than the control soil. The sodium content of the effluent contaminated soil (39.83 mg/kg) was low as compared to the control soil (118.07 mg/kg). This might be due to leaching of sodium ions from soil since most of the sodium salts are readily soluble in water. The average levels of potassium, chromium, zinc, cadmium, nickel and copper were found to be more in the effluent contaminated soil collected from textile industrial sites. The level of exchangeable cations (sodium and potassium) in the soil irrigated with tannery waste water was found to be higher than that in control sites [9]. The high chromium level in polluted soil can seriously affect the plant growth and metabolic functions[17].

TABLE 3: Analysis of textile effluent contaminated soil

Parameters	Control soil	Effluent contaminated soil
pH	8.14	8.57
Sodium(mg/kg)	118.07	39.83
Potassium(mg/kg)	492.06	595.75
Chromium(mg/kg)	21.41	87
Zinc(mg/kg)	47.83	91.7
Cadmium(mg/kg)	2.97	4.81
Nickel(mg/kg)	43.06	78.45
Copper(mg/kg)	20.55	63.75

Biometric observations

TABLE 4: Biometric observations of control and textile effluent treated *Brassica juncea*

Treatment	Plant height (cm)			Fresh weight (mg/g)			Dry weight (mg/g)		
	30th day	60th day	90th day	30th day	60th day	90th day	30th day	60th day	90th day
Control	22	34	41	7.25	20.01	29.38	0.99	8.62	16.03
50% concentration	14	21	26	3.52	16.18	22	0.40	4.24	10.12
25% concentration	17	25	30	5.32	18.64	28.08	0.60	6.40	13.75
SEd	**3.11**			**1.77**			**0.30**		
Cd (p<0.05)	**6.55**			**3.72**			**0.64**		

Values are mean of triplicates
SEd: Standard Error of Difference, Cd: Critical difference
p: Probability level

The biometric observations like height of the plant, fresh and dry weight of control plant and effluent treated plants were recorded on 30th, 60thand 90thdays after sowing (Table 4). In the plants treated with undiluted effluent there was very poor germination and the few germinated plants died within a few days since they could not tolerate the high concentrations of heavy metals. At the end of the experimental period (90 days) the height of the plants in 25% concentration of the effluent was 73% of the control plants while that of 50% concentration of effluent was 63.4% of control plants. A similar trend was observed in fresh and dry weights of the plants also.

Biochemical observations

The chlorophyll and carotenoid content in the leaves of the plant sample was decreased when grown in diluted effluent, which was increased with increase in dilution (Table 5). The decrease in pigment content was relatively less on 30th day and it increased on 90th day. A similar decrease in chlorophyll content in *Vallisneriaspiralis* plants grown in presence of heavy metals. The effluent treated plants showed a decrease in total chlorophyll, carotenoids and protein content in the leaves and roots of *Vallisneria* when compared to control plants. The decrease in pigments contents will seriously affect the photosynthesis and consequently the productivity of the plants [19].

TABLE 5: Effect of textile effluent on chlorophyll and carotenoid content in the leaves of *Brassica juncea*

Treatment	Chlorophyll (mg/g)			Carotenoid (mg/g)		
	30th day	60th day	90th day	30th day	60th day	90th day
Control	2.87	3.23	4.25	8.20	8.32	8.63
50% concentration	1.11	0.78	0.52	2.75	2.20	2.08
25% concentration	1.97	1.24	1.01	6.19	4.97	3.02
SEd	**0.0009**			**0.0008**		
Cd (p<0.05)	**0.002**			**0.001**		

TABLE 6: Effect of textile effluent on protein and vitamin A content in the leaves of *Brassica juncea*

Treatment	Protein (mg/g)			Vitamin A (mg/g)		
	30th day	60th day	90th day	30th day	60th day	90th day
Control	0.87	0.98	1.01	0.012	0.024	0.038
50% dilution	0.48	0.64	0.84	0.005	0.008	1.071
25% dilutioN	0.56	0.73	0.92	0.007	0.011	0.018
SEd	**0.0008**			**0.0002**		
Cd (p<0.05)	**0.001**			**0.0006**		

TABLE 7: Effect of textile effluent on zinc, cadium and nickel levels in the leaves of *Brassica juncea*

Treatment	Zinc(µg/g)			Cadmium(µg/g)			Nickel(µg/g)		
	30th day	60th day	90th day	30th day	60th day	90th day	30th day	60th day	90th day
Control	40.12	84.89	112.01	21.05	23.04	26.10	30.11	36.19	42.20
50% dilution	41.36	77.08	99.97	39.12	58.85	70.30	41.24	61.98	81.95
25% dilution	52.91	87.90	109.76	54.65	67.13	79.15	59.74	74.51	96.16
SEd	**0.008**			**0.008**			**0.008**		
Cd (p<0.05)	**0.018**			**0.017**			**0.017**		

The protein content of the 25% concentrated effluent treated plants showed a significantly higher amount of protein than that of 50% concentrated effluent. Similar results were noted for the vitamin A content of the plantsalso as in Table 6. Zinc and Cadmium content in the leaves of the plant increased when grown in diluted effluent. There is a significant increase in nickel content in the leaves of the plant on 90^{th} day of the plant growth (Table 7). This might be due to the presence of higherconcentrations of zinc and nickel in the textile effluent used for the study.

Spinach was most effective in the removal of the nickel, such removal increased linearly with the increase of metal concentration in the soil [16]. Nickel could reduce the photosynthetic activity of the plants probably by inhibiting some enzymes [12].*Brassica* *juncea*(L.) possessed the capacity to absorb and accumulate significant quantities of heavy metals such as Cd, Cu, Ni, Zn, Pd and Se and has a very high potential for phytoremediation [8].

TABLE 8: Effect of textile effluent on chromium and copper levels in the leaves of *Brassica juncea*

Treatment	Chromium(µg/g)			Copper(µg/g)		
	30th day	60th day	90th day	30th day	60th day	90th day
Control	0.002	0.02	0.03	1.12	2.71	3.91
50% dilution	42.06	61.21	80.79	6.48	10.45	14.51
25% dilution	61.42	64.12	69.19	11.09	27.90	39.14
SEd	**0.007**			**0.004**		
Cd ($p<0.05$)	**0.015**			**0.008**		

There was significant increase in the chromium and copper level in the leaves of the plant grown with diluted effluent showing their accumulation in the plants.Plants like *Scirpuis validates* and*Cyperusesculentus* accumulated 0.55kg and 0.73kg of chromium respectively. The accumulation of chromium was greater in roots than in shoots. They also reported that chromium(VI) has caused stunting and browning of roots produced from chromium treated excised leaves of *Limnanthemumcristatum* [6].

CONCLUSION

The present study was focussed with an objective to remediate the textile effluent contamination using *Brassica juncea.* From the analysis, the textile effluent was found to have high pH indicating alkalinity of the sample and large amounts of total suspended (TSS) and total dissolved solids (TDS), minerals and metals like sodium, potassium, chromium, zinc, copper etc. The results of Biometric observations showed that the plants grown under 25% concentrated effluent were taller than the plants grown using 50% concentrated effluent. The seeds did not germinate when the undiluted effluent was used as such for irrigating the plants.

Chlorophyll, carotenoids, protein and vitamin A were analyzed in the leaves of control plants and effluent treated plants. The biochemical constituents mentioned above were found to be high in the leaves of the plants treated with 25% diluted effluent when compared with the leaves of plants treated with 50% diluted effluent.

Potassium, copper, chromium, cadmium, nickel and zinc were found to be more accumulated in the leaves of the plants treated with 25% dilution effluent. This indicates the accumulation potential of leaves when they are grown using effluent with high dilution.

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