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Phytotoxicity Studies of Textile Wastewater on *Vigna radiata*

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ABSTRACT

The reuse of industrial wastewater for agricultural irrigation is often viewed as a positive means of recycling water due to the advantage of being a constant, reliable water source and availability in large volumes. In the present study, a laccase enzyme from the fungus *Cladosporium oxysporum* was used for treatment of textile industry wastewater. The fungal biomass was subjected to autoclaving (pretreatment) and, three different modes, agitated, aerated and rotating biological contactor were employed. In all three modes, autoclaved biomass of *C.oxysporum* was found to be most effective in removal of dyes from aqueous solutions. Among the three modes of batch studies, agitated mode was found to be more efficient and easy to operate. The resultant treated effluent from agitated mode as well as raw effluent was subjected to seed germination bioassays on *Vigna radiata* seeds. Root length, shoot length, root biomass and shoot biomass were increased in treated effluent when compared to untreated effluent. Seedlings irrigated with diluted (20%) untreated effluent yielded a total biomass of 538 mg, whereas treated effluent with 20% dilution yielded a total biomass of 626 mg. The untreated and treated effluents showed a phytotoxicity of 78.33 and 61.67% respectively and diluted effluents respectively had 26.67 and 20%. These results revealed that treatment of dye industry effluent with autoclaved biomass at optimum conditions reduced the toxicity of the effluent and the effluent after proper dilution can be used for irrigation.

Keywords: Textile Effluent, Laccase, *Cladosporium Oxysporum,* Phytotoxicity, *Vigna Radiata*

I. INTRODUCTION

There is an increasing trend to require more efficient use of water resources, both in urban and rural environments. In arid parts of the world, reliable low cost, low technology methods are needed for acquiring new supplies of water and protecting existing water sources from pollution.

Textile wastewater consists of high concentration of carcinogenic dye stuff, high biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TDS) and much more complex materials [1] [2]. One possible mechanism is the detoxification of textile wastewaters so it can be used in the place of other fresh water sources for irrigation. Reused water, particularly from sources such as treated industrial effluent, is a constant source of water and are produced in large volumes, which if not used would be merely discharged into the environment. The sensitivity of plants to different compounds can be used in toxicity tests to identify the presence of toxicants in the treated effluent, monitoring its suitability for agricultural use. [3][4].

The present study aims at developing a treatment strategy for dye industry effluent based on a fungal system. Laccase enzyme, produced by *Cladosporium oxysporum*, was used for dye industry effluent .Batch mode treatment process was employed as agitated mode, aerated mode and rotating biological contactor. The toxicity of the treated and untreated effluents was tested on *Vigna radiata* plant system. Seed germination, speed of germination, vigour index, seedling development, phytotoxicity and effluent tolerant index were used as pollution indices.

II. METHODS AND MATERIAL

Effluent treatment

The effluent sample was collected directly from Common Effluent Treatment Plant (CETP), Kuppandampalayam, Tirupur. The live and autoclaved biomass of the selected fungus was used as adsorbent. Adsorption of Reactive Blue HER, Reactive Yellow HE4R (BDSA) and Reactive Red HE3B by the fungal mycelium was studied in batch mode. It included agitated mode (stirred tank type), aerated mode (bubble reactor type) and rotating biological contactor (RBC). The effluent was treated with optimum dosage of autoclaved biomass for optimum contact time in agitated mode.

Effluent analysis

After the treatment, the biomass and the effluent were separated and the effluent was analyzed for its toxic parameter. The physico-chemical parameters of the effluent before and after treatment were estimated by APHA methods [5].

Phytotoxicity studies

The phytotoxicity of the untreated and treated effluent was analysed against *Vigna radiata* var. Co7 plant system. The *V. radiata* seeds were procured from Tamilnadu Agricultural University, Coimbatore. One hundred and eighty seeds were screened for their germination capacity by standard methods [6] .The speed of germination index was calculated by the method of Carley and Watson [7]. Vigour levels were calculated by multiplying per cent normal germination by length (mm) of embryonic axis [8]. Seedling development was recorded on 10th day in sand cultures by sowing seeds in a set of aluminium trays flooded with different concentrations (20-100%) of treated and untreated dye factory effluent. Biomass of root and shoot system were established by gravimetric method after drying the plant material at 60oC to a constant weight. Per cent phytotoxicity and effluent tolerant index were calculated by the method suggested by Turner and Marshal [9].The pollution parameters were analysed by Duncan's multiple range test (DMRT) [10].

III. RESULTS AND DISCUSSION

Efficiency of the fungus *Cladosporium oxysporum* to remove Reactive Blue HER, Reactive Yellow HE4R (BDSA) and Reactive Red HE3B from aqueous solutions was studied three different modes, agitated, aerated and rotating biological contactor. Among the three modes of batch studies, agitated mode was found to be more efficient and easy to operate (Table 1). This higher decolourization in agitated mode may be credited to the vigorous mixing of the dye solutions with the biomass, which helps in better contact of adsorbates with the adsorbent [11]. As in agitated mode, autoclaved biomass showed better adsorption in both aerated mode and RBC for all the three dyes. It has been reported that biosorption efficiency of biomass can be significantly enhanced by pre-treatment methods such as autoclaving, dyeing and exposure to chemicals such as formaldehyde and acid [12]. The results revealed that increase in adsorbent dosage increased the percent removal which may be due to greater availability of surface area and exchangeable adsorption sites [13] [14].

Table 1: Dye adsorption by fungal biomass : (pH: 7.0; Temperature: 30^{o}C; Adsorbent dosage: 1.0g/50mL)

Process	Pretreatment	Q_o, mg/g			b, L/mg		
		Reactive Blue HER	Reactive Yellow HE4R (BDSA)	Reactive Red HE3B	Reactive Blue HER	Reactive Yellow HE4R (BDSA)	Reactive Red HE3B
Agitated mode	Live	47.17	48.54	34.60	3.93	1.12	0.06
	Autoclaved	48.31	50.00	39.37	12.94	4.39	0.12
Aerated mode	Live	46.51	46.51	34.84	0.77	0.36	0.06
	Autoclaved	46.73	47.39	43.86	1.33	0.50	0.05
Rotating biological contactor	Live	38.46	41.15	27.62	0.32	0.24	0.04
	Autoclaved	46.95	41.19	30.40	0.90	0.57	0.08

***P*(%)**	1.0	1.0	1.0	-
SED	2.76	4.10	840.73	-
LSD (1%)	0.986	0.943	0.647	-

The physicochemical properties of the effluent before and after treatment were analysed. As shown in Table 2, the dissolved solids content were well reduced below the BIS standards. Similarly total alkalinity and hardness were reduced. The treatment was very much effective in removal of inorganic salts, oils and grease which are hard to remove even by reverse osmosis and electrodialysis. A considerable reduction in COD (72.03%) and BOD (63.64%) were obtained in the present treatment process [15].

Effluent toxicity studies (Table 3) showed that percent germination was not much affected by effluent irrigation. In untreated effluent irrigation the percent germination was 69%; but reduced the vigour index by 93.94%. The treated effluent diluted to 20-40% inhibited seed germination only by 1.8-23.64% and vigour index by 17.64-29.36%, which is negligible [16].

In seedling treatment (Table 4), control plants yielded 635 mg biomass, untreated effluent yielded 118 mg (81.42%) and the treated effluent yielded 352 mg (44.56%). Similar results were observed in the growth of various crop plants like *Arachis hypogea* [17] and sunflower [18]. The untreated and treated effluents showed a phytotoxicity of 78.33 and 61.67% respectively and diluted effluents respectively had 26.67 and 20% [19] [20].

Table 2: Physio-chemical parameters of treated and untreated textile dye effluent

Parameters	**Untreated effluent**	**Treated effluent**	**Removal (%)**	**BIS Standards**
pH at 30°C	8.5	7.4	12.94	5.5-9.0
EC(dSm^{-1})	3.1	1.3	58.06	-
Color	Bluish green	Colorless	100	Colorless
Temperature(°C)	39	30	23.08	Below 40
Turbidity	136	103	24.26	25
Odour	Oily smell	Odourless	100	Odourless
TSS(mg/L)	1831	524	71.38	200
TDS(mg/L)	3569	1257	64.78	2100
Total Hardness(mg/L)	620	316	49.03	600
Total alkalinity(mg/L)	600	468	22.00	-
Calcium(mg/L)	250	142	43.20	200
Magnesium(mg/L)	168	98	41.67	150
Chlorides(mg/L)	1125	465	58.67	600
Sulphates(mg/L)	321	128	60.12	1000
Iron(mg/L)	0.2	Nil	100	1
Silica(mg/L)	52	Nil	100	-
Fluoride(mg/L)	0.21	Nil	100	600
Chromium(mg/L)	12.5	0.1	99.20	0.1
Zinc(mg/L)	21.5	5.0	76.74	15.0
Copper(mg/L)	12.9	0.2	98.45	3.0
Oil and grease(mg/L)	18	06	66.67	10
Chemical oxygen demand(mg/L)	1055	295	72.03	250
Biological oxygen demand(mg/L)	275	100	63.64	30

Table 3: Effect of untreated and treated dye industry effluent on germination of *Vigna radiata* seeds

Treatment	**Per cent germination**	**Embroyonic axis length (cm)**	**Vigour index**	**DMRT ranking**
Control	100	35.32	3532	a
Untreated				
20	90.21	21.20	1912	ab
40	85.73	18.70	1603	ab
60	79.64	11.80	939	b
80	71.32	8.50	606	b
100	68.97	3.10	214	c
Treated				
20	98.20	29.70	2916	a
40	94.36	26.45	2495	a
60	96.56	19.37	1676	ab
80	80.43	14.44	1161	b
100	76.34	9.69	739	c
CV	8.95	8.24	23.99	-

Table 4 : Effect of untreated and treated dye industry effluent on seedling development of *Vigna radiate*

Treatment	**Shoot length (cm)**	**Root length (cm)**	**Shoot biomass (mg)**	**Root biomass (mg)**	**Total biomass (mg)**	**Phytotoxicity**	**Effluent tolerant index**	**DMRT Ranking**
Control	23.70	6.0	410	225	635	0.0	1.0	a
Untreated								
20	18.30	4.40	350	188	538	26.67	0.733	a
40	16.80	3.80	310	135	445	37.00	0.630	ab
60	12.20	2.90	200	91	291	52.67	0.483	bc

80	7.50	2.40	104	52	156	60.00	0.400	c
100	4.02	1.30	82	36	118	78.33	0.217	d
Treated								
20	22.08	4.80	406	220	626	20.00	0.800	a
40	20.6	4.1	395	192	587	31.67	0.68	ab
60	16.43	3.7	368	154	522	38.33	0.62	ab
80	12.56	3.1	310	107	417	48.33	0.52	b
100	7.93	2.3	254	98	352	61.67	0.38	d
CV	7.95	30.11	28.60	14.24	15.58	50.64	50.83	-
***P*(%)**	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-
SED	3.30	5.65	126.26	67.35	125.33	92.87	6.37	-
LSD (1%)	0.976	0.983	0.990	0.969	0.989	0.992	0.989	-

These results revealed that treatment of dye industry effluent with autoclaved biomass at optimum conditions could reduce the toxicity of the effluent and the effluent after proper dilution could be used for irrigation.

IV. CONCLUSION

Enzymatic treatment of the discharged effluents from textile industries can significantly reduce or completely remove its harmful impact on receiving environments. In addition, the reuse of treated effluents for purposes such as agricultural irrigation can reduce the pressures on other existing water sources or provide a water source where a suitable one does not already exist. Conventional treatment methods are not economical in the Indian context and so there is a need to develop low cost technologies for removal of toxic dyes in industrial effluent. In the present study, adsorption using fungal biomass emerged as an option for developing economic and eco-friendly wastewater treatment process. Maximum dye removal was attained with autoclaved biomass in agitated mode. Effluent toxicity studies on *Vigna radiata* showed that percent germination was not much affected by effluent irrigation. Results from the seedling development studies indicated that root length, shoot length, root biomass and shoot biomass were increased in treated effluent when compared to untreated effluent. Hence, biosorption of dyes from textile effluent by *C .oxysporum* produced laccase enzyme, rendered the effluent acceptable for irrigation with suitable dilution when tested on *Vigna radiata* plants.

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