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EVALUATION OF *CROTALARIA PALLIDA* AND *PHYLLANTHUS EMBLICA* SEED POWDER FOR DECOLOURISATION OF TEXTILE DYE EFFLUENT

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ABSTRACT: Textile industries apply different varieties of dyes which are of synthetic origin. They are an important class of water pollutants that are recalcitrant in nature and difficult to degrade. Effluent loaded with dye and other salts are detrimental to aquatic flora and fauna and unfit for domestic, agricultural or industrial purpose. As sources of water are shrinking, there is an urgent need to save water bodies from contamination and also to recycle existing water. Dye containing wastewater is frequentlytreated by physical, chemical and biological methods or combination thereof. All these methods have some disadvantages such as incomplete removal of dye, high cost, need for further treatment and higher production of sludge. Adsorption is a potential and efficient treatment methodto remove dye from wastewater due to its simple design and operational convenience. Seed powder of plants is widely used for the treatment of waste water. In our current study, we used the seed powder of *Crotalaria pallida* for primary treatment followed by secondary treatment with a Biofilter column, containing sand, egg shell and activated carbon of *Phyllanthus emblica* to evaluate their potential for decolourisation of textile dye effluent. It was found that the combination of treatments was capable of removing dye and other parameters in comparison to sodium hypochlorite.

KEYWORDS: Dye effluent, *Crotalaria pallida*, *Phyllanthus emblica*, seed powder, Biofilter column, adsorption.

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1.INTRODUCTION

Textile Dye as Pollutant

Dyes have a synthetic origin and are an important class of pollutants [1]. They are utilized for several commercial industrial purposes of which textile dyeing is the major application [2]. Different types of dyes used in textileindustry are complex, recalcitrant in nature and are difficult to degrade [3]. At the end of the dyeing process, the effluent is released in to water bodies which are detrimental to aquatic flora and fauna [4] and may decompose to form carcinogenic compounds [20]. They are also loaded with more than permissible levels of pH, BOD, COD, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), color and odour[2]. This alters the water quality to a great extent and renders the water unusable for domestic purpose.Thus, there arrives the need for proper treatment of effluent before their discharge in to the environment. Also, due to shortage of water supply, recycling and reuse of waste water becomes a necessity of time [5].

Remedies for Dye Effluent Treatment

Several processes exist for the treatment of dye containing effluents that broadly includesphysical, chemical and biological methods. Dye containing wastewater is frequentlytreated by physical or/and chemical methods such as oxidation or ozonation [6], biodegradation [7], adsorption to activated carbon [8], photochemical degradation [9], coagulation and flocculation [10], membrane separation [11], reverse osmosis [12] and ion-exchange [13]. Various biological process of dye removal from textile effluent was reviewed by [14, 15]. All these methods have their advantages and disadvantages. Some of the disadvantages include incomplete removal of dye from effluent, high capital and operational cost, need for further treatment by other methods and production of elevated sludge level. Moreover, most of thesereports are direct evidence from bench scale experiments and not tested in field applications. Thus, further studies are warranted to assess the application of novel process in terms of financial and environmental impact.

Biological Treatment – Plant Seed Powder as Adsorbent

Routinely used methods of biologicalwastewater treatment are not efficient in treating effluent containing dyes [16]. Adsorption is a potential and efficient treatment methodto remove dye from wastewater due to its simple design, operational convenience, and capability to withstand toxic chemical substances [17]. Seeds of plants are widely used for the treatment of waste water. Among them, *Moringa oliefera* is the most widely employed seed for the successful removal of dye and other parameters of environmental concern.[18,19,20 &21]. Papaya seeds were used as a non-conventional low-cost adsorbent for removal of methylene blue from aqueous solutions[22]. [23] employed the seeds of *Zizyphus maruritiana* for the removal of anionicdye Congo red from aqueous medium. *Strychnos potatorum* seeds were used for surface absorption of methylene blue and 1 gm of the seed could absorb 78.84 mg of the dye [17]. [24] used the seeds of *Annona squmosa* as a source of activated carbon and studied its application toremove malachite green. Recently, [25] used low-cost carbon prepared from seeds of *Phyllanthus emblica*, *Syzygium cumini*, *Tamarind indicus*, and *Acacia sinuate* and found that the seeds have good adsorption capacity, of which Amla seed carbon was better than others.

Seeds of *Crotalaria pallida* [26]

Crotalaria pallida, a native plant of Africa, belongs to the family *Fabaceae* and is considered significant both in medical and economicalaspect. It is also common in India, SriLanka and throughout Southeast Asia. It is an annual/perennial shrub/herb of 1.5 m or more. The corpulent stem is hairy and has longitudinalgrooves. Leaves are trifoliate with a long petiole and flowers appear yellow with reddish-brownvein. Fruits have 30-40heart or kidney-shaped shiny, mottled ochre and darkbrown seeds.

Seeds of *Phyllanthus emblica* [27]

P. emblica, also called as Amla/Indian gooseberry, belongs to the family *Euphorbiaceae*. It is native to India and other tropical and subtropical countriesof Asia and Southeast Asia. [28] have used the wood of *P.emblica*for the treatment of distillery effluent and found to be efficient removing the colour, pH neutralization along with reduction of parameters such as COD, BOD and totalhardness. Thus, we made an attempt to employ the seed powder of *C. pallida* followed by an in-house developed biofilter column containing sand, egg shell and activated carbon from *P. emblica* seed to explore their adsorption potential, in succession, to treat the dye containing textile effluent in comparison to treatment with sodium hypochlorite. The percentage removal of the dye was evaluatedusing diverseoperating parameters such ascolor, pH, turbidity, dissolved and suspended solids, hardness, alkalinity and COD.

2. MATERIALS AND METHODS

Sample Collection

The effluent samples were collected from the Common Effluent Treatment Plant (CETP) at Angeripalayam, Tirupur district, Tamil Nadu. Effluentsfrom 58 dyeing units arebeing treated at this CETP.

Preparation of *Crotalaria pallida* Seed Powder

The *C. pallida*seeds werecollected from recently harvested, sundried plant. The dried seeds were separated manually from the plant and kept in a closed, airtight container. The shells of the seeds were removed and the seed was ground to powder using a domestic blender. The powder was then sieved through 600μmstainless steel sieve.The prepared seed powder wasstored in an airtight container for further use. No other additives were added prior to adsorption experiments.

Determination of coagulant activity (Standard Jar test method)

*C. pallida*seed powder was used in the following doses (1 g/L, 2 g/L, 3 g/L, 4 g/L and 5g/L) for treating 1 litre of dye effluent samples. It is important to determine the optimum dosage of the testing material for the efficient removal of dye where both higher and lower dosage would result in poor performance [21]. The required amount of *C. pallida*seed powder was added to the dye effluent and left for mixing, flocculation and settling using a Jar Test apparatus. This was achieved by mixing at high speed (120 rpm) initially for 1 min followed by 15 minutes of slow speed (30 rpm) stirring for flocculation. The mixture was finally allowed to settle for 60 minutes.

Preparation of Biofilter Column

The filter column was prepared by using sand, activated carbon and dry egg shells. Initially all the ingredients of the filter column were washed using 1N hydrochloric acid in order to remove any dust particles attached to it. The sand was then washed with distilled water and 50 mL of the sand was packed into the filter column. Activated charcoal was prepared by using dry Amla seed powder. The seed was crushed using a blender and burnt at 250ºC for few minutes using a Muffle furnace. The charcoal thus obtained was then washed with 1N hydrochloric acid until the pH was neutralized. It was further washed by using distilled water and dried in an oven. It was then packed into the filter column for about 50 mL and then with 75 mL of egg shells which was pre-treated with 1N hydrochloric acid and heated in an oven for about 24 hours. The effluent, after primary treatment with *C. pallida* seed powder, was passed through this column at a rate of approximately 2 mL/min (resident time of the effluent is approximately 1 min).

3. RESULTS AND DISCUSSION

Physicochemical Parameters

Textile effluent collected from CETP at Angeripalayam, Tirupurshowed water quality parameters above permissible limits of Central Pollution Control Board (CPCB) standards. The decolorizing effect of primary and secondary treatment with *C. pallida* and biofilter column with *P. emblica* seed powder, respectively,on dye effluent treatment was studied.Use of seeds is an added advantage because they are easily available in larger quantity, economically cheap and provide an alternative method of waste management. [26]. Various parameters such as pH, TDS, TSS, chloride, alkalinity, turbidity, colour, total hardness, calcium hardness, magnesium hardness, free residual chloride and COD were characterized for the raw dye effluent and are shown in Table I.

Table I: Characteristics of raw dye effluent

S.No	Parameters	Amount
1	Colour (visual)	Dark purple
2	Color (pt co)	5400
3	pH	9.80
4	Turbidity	62
5	Total dissolved solids (mg/L)	7040
6	Total suspended solids (mg/L)	228
7	Total hardness (mg/L)	480
8	Calcium Hardness (mg/L)	290
9	Magnesium Hardness (mg/L)	190

The results for various said parameters, after treatment with sodium hypochlorite, different concentrations of *C. pallida*seed powder and biofilter column were given in Table II.

Table II: Effect of *Crotalaria pallida* Seed Powder, Sodium Hypochlorite and Biofilter column on Decolourization of Dye Effluent

S. No	Parameters	Raw Effluent	Sodium Hypo chlorite	Concentration of *Crotalaria pallida* Seed powder (g/L)					Biofilter Column
				1	2	3	4	5	
1	Color (pt co)	5400	1240	5890	5710	4840	4110	3070	580
2	pH	9.80	9.98	7.76	7.8	7.87	7.67	7.89	7.42
3	Turbidity	62	53.4	174.2	148.3	128.4	90.5	73.6	10.5
4	Total dissolved solids (mg/L)	7040	7140	7210	7388	7548	7584	7600	7586
5	Total suspended solids (mg/L)	228	105	230	248	206	193	164	29
6	Total hardness (mg/L)	480	480	500	500	530	530	540	550
7	Calcium Hardness (mg/L)	290	290	260	230	230	250	250	280
8	Magnesium Hardness (mg/L)	190	190	240	270	300	280	290	260
9	Free Residual chloride (mg/L)	Nil	42.4	Nil	Nil	Nil	Nil	Nil	Nil
10	Chloride (mg/L)	3388	3564	3700	3718	3743	3828	3876	3872
11	Total alkalinity (mg/L)	1540	1180	1240	1220	1170	1100	860	610
12	COD (mg/L)	1036	1316	2340	2412	2108	2054	1884	812

The percentage removal of various constituents in the dye effluent was calculated using the following formula and represented as graphical figure (Fig. I).

$$\text{Percentage removal} = 100 \times (C_i - C_e)/C_i$$

Table III: Percentage of reduction of various parameters in dye effluent after treatment with*Crotalaria pallida* Seed Powder, Sodium Hypochlorite and Biofilter column

Parameters	Raw Effluent	Percentage of reduction		
		Sodium hypochlorite	***Crotalaria pallida* Seed powder**	**Biofilter column**
Color	100	77.04	43.15	89.26
pH	100	-1.83	19.49	24.29
Turbidity	100	13.88	-18.7	83.07
Total dissolved solids (mg/L)	100	-1.42	-7.95	-7.75
Total suspended solids (mg/L)	100	53.95	28.08	87.29
Total hardness (mg/L)	100	0	-12.5	-14.58
Calcium Hardness (mg/L)	100	0	13.8	3.45
Magnesium Hardness (mg/L)	100	0	-52.63	-36.84
Free Residual chloride (mg/L)	0	-42.4	0	0
Chloride (mg/L)	100	-5.19	-14.4	-14.28
Total alkalinity (mg/L)	100	23.38	44.16	60.39
COD (mg/L)	100	-27.02	-81.85	21.63

The colour of the dye effluent changed to light yellow colour after 13 hours. The colour of the raw dye effluent was found to be 5400 pt co whereas the effluent treated with the 5 g/L of *C. pallida*seed powder was 3070 pt co (% of reduction = 43.15) and found to be optimum among various other concentrations used. The percentage reduction of colour from the raw effluent was doubled after passing through Biofilter column (% of reduction = 89.26) which was higher than sodium hypochlorite (% of reduction = 77.04). In the case of reduction in pH, it was reduced from 9.8 in raw effluent to 7.67 at a dose of 4 g/L of *C. pallida*seed powder and after flow through biofilter column it was slightly better with a pH of 7.42. The turbidity was highly reduced after treatment with biofilter column(% of reduction = 83.07) and to an extent using sodium hypochlorite. Treatment with *C. pallida*seed powder and Biofilter column also decreased the COD content of the effluent, whereas it increased in the case of treatment with sodium hypochlorite. (Fig.I)

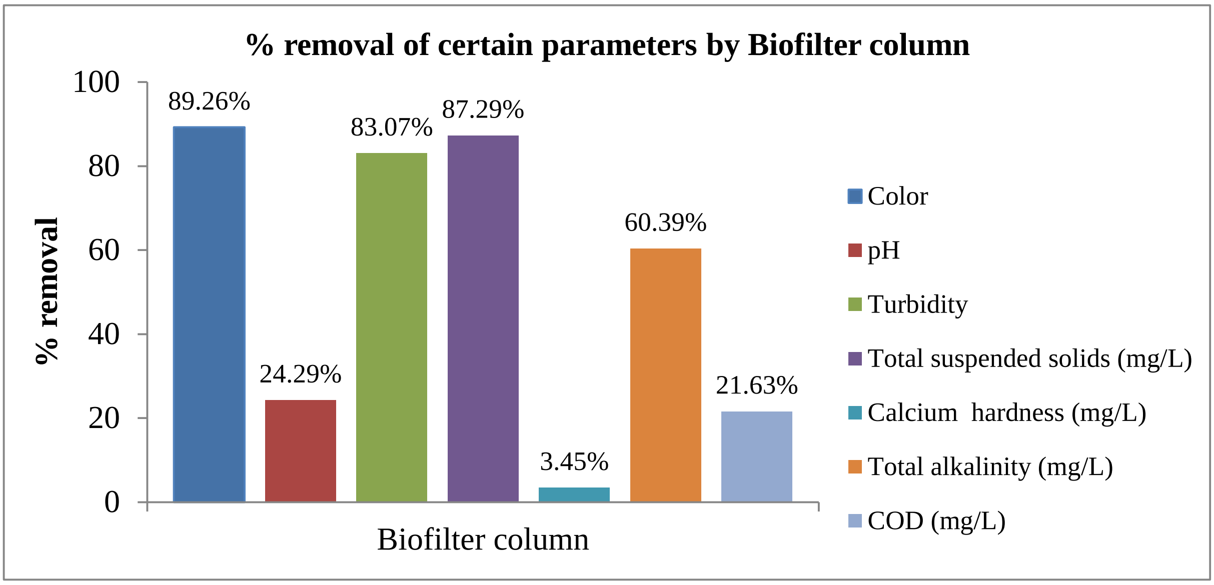

Figure I: Percentage removal of some parameters after treatment with *C. pallida* seed powder and Biofilter column in comparison with raw effluent

Of all the treatment methods, *C. pallida*seed powder at a concentration of 2 and 3 g/L was found to be effective to some extent in removal of calcium hardness (Table II). Free residual chlorine increased on treatment with sodium hypochlorite and no residual chlorine was found in effluent treated with *C. pallida*seed powder and biofilter column. Total alkalinity was reduced overall (% reduction; sodium hypochlorite = 23.38, *C. pallida*seed powder (5 g/L) = 44.16 and biofilter column = 60.39). Total suspended solids were also brought down by *C. pallida*seed powder (5 g/L) and biofilter column in combination than sodium hypochlorite (Table II). In the past, several authors have used combination of methods to effectively treat dyes/effluents from textile industries. [29] successfully used Amla (*Phyllanthus emblica*) seed carbon as a low-cost carbon for the removal of chromotrope dye from aqueous solution. Adsorption has been found to be an efficient and economicalprocess for the removal of pollutants such as dyes and color fromwastewater. Several authors have used studied low-cost natural materials and/or charcoal made from various parts of the plant such as root, leaf, seed, and bark for the removal of dyes and colorfrom wastewater [30]. Adsorption plays an important role in removal of dye from effluent where some are effective, and some may not be. Hence new adsorbents are required that are easily available, cheap, efficient, flexible in designing and degradable [31].

4. CONCLUSION

In our present study it was shown that successive treatment with *C. pallida* seed powder and Biofilter column packed with sand, activated charcoal of*P. emblica* seed and egg shell was found to be more effective in removal of colour, pH, Turbidity, Total suspended solids, Total alkalinity and COD. This is highly effective when compared with their chemical counterparts. Further, there is scope for testing the dosage of effluent, time required for dye removal and pH among various other parameters.

CONFLICT OF INTEREST

Authors have no conflict of interest.

REFERENCES

1. Gupta VK, Suhas. Application of low-cost adsorbents for dye removal – A review. J. Environ. Manage. 2009; 90:2313-2342.
2. Kabra AN, Khandare RV, Waghmode TR, Govindwar SP. Phytoremediation of textile effluent and mixture of structurally different dyes by Glandulariapulchella (Sweet) Tronc. Chemosphere. 2012; 87:265–272.
3. Ding S, Li Z, Wangrui. Overview of dyeing wastewater treatment technology. Water Res. Prot. 2010; 26:73-78
4. Hu MR, Chao YP, Zhang GQ, Xue ZH, Qian S. Laccase mediator system in the decolorization of different types of recalcitrant dyes. J. Ind. Microbiol. Biotechnol. 2009; 36:45-51.
5. Holkar CR, Jadhav AJ, Pinjari DV, Mahamuni NM, Pandit, AB. A critical review on textile wastewater treatments: Possible approaches. J. Environ. Manage. 2016; 182:351-366.
6. Malik PK, Saha SK. Oxidation of direct dyes with hydrogen peroxide using ferrous ion as catalyst. Sep. Purif. Technol. 2003; 31:241-250.
7. Daneshvar N, Khataee AR, Rasoulifard MH, Pourhassan M. Biodegradation of dye solution containing Malachite Green: optimization of effective parameters using Taguchi method. J. Hazard. Mater. 2007; 143:214-219.
8. Tan IAW, Ahmad AL, Hameed BH. Adsorption of basic dye on high-surface area activated carbon prepared from coconut husk: equilibrium, kinetic and thermodynamic studies. J. Hazard. Mater. 2008; 154:337-346.
9. Sohrabi MR, Ghavami M. Photocatalytic degradation of Direct Red 23 dye using UV/TiO2: effect of operational parameters. J. Hazard. Mater. 2008; 153:1235-1239.
10. Zonoozi MH, Moghaddam MRA, Arami M. Coagulation/flocculation of dye containing solutions using polyaluminium chloride and alum. Water Sci. Technol. 2009; 59:1343-1351.
11. Sachdeva S, Kumar A. Preparation of nonporous composite carbon membrane for separation of Rhodamine B dye. J. Membr. Sci. 2009; 329:2-10.
12. Kumar MR, Saravanan K. Application of reverse osmosis membrane system for treatment of effluent in textile knitted fabric dyeing. Afr. J. Biotechnol. 2015; 10(70):15756-15762.
13. Khan MI, Akhtar S, Zafar S, Shaheen A, Khan MA, Luque R, Rehman A. Removal of congo red from aqueous solution by anion exchange membrane (EBTAC): Adsorption kinetics and themodynamics. Materials. 2015; 8:4147-4161.
14. Banat IM, Nigam P, Singh D, Marchant R. Microbial decolorization of textile-dyecontaining effluents: A review. Bioresource Technol. 1996; 58(3):217-227.

15. Rai HS, Bhattacharyya MS, Singh J, Bansal TK, Vats P, Banerjee UC. Removal of dyes from the effluent of textile and dyestuff manufacturing industry: A review of emerging techniques with reference to biological treatment. Crit. Rev. Environ. Sci. Technol. 2005; 35:219-238.
16. Mondal S. Methods of dye removal from dye house effluent - An Overview. Environ. Eng. Sci. 2008; 25(3):383-396.
17. Senthamarai C, Kumar SP, Priyadharshini M, Vijayalakshmi P, Kumar VV, Baskaralingam P, Thiruvengadaravi KV, Sivanesana S. Adsorption behavior of methylene blue dye onto surface modified Strychnospotatorum seeds. Environ. Prog. Sustain. Energy. 2012; 32(3):624-632.
18. Bhatia S, Othman Z, Ahmad AL. Palm oil mill effluent pre-treatment using Moringa oleifera seeds as an environmentally friendly coagulant: laboratory and pilot plant studies. J. Chem. Technol. Biotechnol. 2006; 81:1852-8.
19. Beltran-Heredia J, Martin JS. Azo dye removal by Moringa oleifera seed extracts coagulation. Color. Technol. 2008; 124:310-317.
20. Vieira AMS, Vieira MF, Silva GF, Araujo AA, Fagundes-Klen MR, Veit MT, Bergamasco R. Use of Moringa oleifera seed as a natural adsorbent for wastewater treatment. Water Air Soil Pollut. 2010; 206(1-4):273-281.
21. Patel H, Vashi RT. Chapter 4 - Batch adsorption treatment of textile wastewater, Ed: Patel, H and Vashi, R.T. Characterization and treatment of textile wastewater, Elsevier. 2015; 111-125.
22. Hameed BH. Evaluation of papaya seed as a novel non-conventional low-cost adsorbent for removal of methylene blue, J. Hazard. Mater. 2009; 162:939-994.
23. Reddy MCS, Sivaramakrishna L, Reddy AV. The use of an agricultural waste material, Jujuba seeds for the removal of anionic dye (Congo red) from aqueous medium. J. Hazard. Mater. 2012; 203– 204:118-127.
24. Santhi T, Manonmani S, Vasantha, VS, Chang YT. A new alternative adsorbent for the removal of cationic dyes from aqueous solution. Arab. J. Chem. 2016; 9:466-S474.
25. Hameed KS, Muthirulan P, Sundaram MM. Adsorption of chromotrope dye onto activated carbons obtained from the seeds of various plants: Equilibrium and kinetics studies. Arab. J. Chem. 2017; 10:2225-2233.
26. Baruah1 P, Deka1 S, Baruah PP. Phytoremediation of crude oil-contaminated soil employing Crotalaria pallida Aiton. Environ Sci Pollut Res Int. 2016; 23(11):10595-10603.
27. Gaire B, Subedi L. Phytochemistry, pharmacology and medicinal properties of Phyllanthus emblica Linn. Chin. J. Integr. Med. 2015. DOI: 10.1007/s11655-014-1984-2.
28. Padmapriya R, Meena P, Thirunalasundari T. Phyllanthus Emblica - A remedy for distilleries effluent treatment. Int. J. Curr. Res. 2014; 6(9):8664-8668.

29. Patel H, Vashi RT. Chapter 6 - Use of naturally prepared coagulants for the treatment of wastewater from dyeing mills, Ed: Patel, H and Vashi, R.T. Characterization and treatment of textile wastewater, Elsevier. 2015; 147-158.
30. Sundaram MM, Hameed KS. Removal of chromotrope dye from aqueous solution using amla seed carbon: A new non-conventional low cost adsorbent. Indian J. Environ. Prot. 2012; 32:241-248.
31. Rahman, B.A., and Akter, M. Removal of dyes from textile wastewater by adsorption using shrimp shell. Int. J. Water Resources.2016; 6(3):244.
32. Chen, K.C., Wu, J.Y., Huang, C.C., Liang, Y.M., and Hwang, S.C.J.2003. Decolorization of azo dye using PVA-immobilized microorganisms. Journal of Biotechnology, 101:241-252.