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BIOREMEDIATION OF *MORINGA OLEIFERA* SEED USING BIOFILTER FOR DECOLOURISATION OF TEXTILE DYE EFFLUENT

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ABSTRACT: During the lengthy textile manufacturing process starch, waxes, Carboxymethyl Cellulose (CMC), Polyvinyl Alcohol (PVA), wetting agents and pectin's are required for sizing and designing processes which results in high Biochemical Oxygen demand (BOD) and Chemical Oxygen Demand (COD). Sodium hypochlorite, chlorine, alkali, peroxide, acids, surfactants, sodium phosphate are used in the bleaching process which increase the alkalinity and solid substances in the waste water. Various types of reducing agents, oxidizing agents, acetic acid, detergents, urea, starches, gums, oils, binders, thickeners, cross linkers and different types of dyes are used in the dyeing and printing stages. The printing and dyeing process generate highly colored waste water with heavy metals and increase BOD. In the present study, the seed powder of *Moringa oleifera* used as a natural coagulant for primary treatment followed by secondary treatment with a biofilter column, containing sand, egg shell and activated charcoal of *Phyllanthus emblica seed coat* to evaluate their potential for decolourization of textile dye effluent. It was found that the combinations of treatments was effectively removing colour and reduce other physicochemical parameters like colour, total alkalinity, turbidity and BOD when compared with sodium hypochlorite. **Keywords:** Dye effluent, *Moringa oleifera* seed powder, *Phyllanthus emblica* seed coat Activated Charcoal and Biofilter.

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1. INTRODUCTION

Synthetic dyes are an important source of water pollutants that are recalcitrant in nature and difficult to degrade. Water pollution causes serious impacts on socio-economic prominence of the people living around the Orathapalayam dam. The local communities through the Karur Noyyal Canal Agriculturists Association filed a PIL (Public Interest Litigation) against the polluters in the Supreme Court to direct Tamil Nadu Pollution Control Board to regulate against the polluting dyeing and bleaching units in Tirupur area. The Supreme Court based their ruling on the Precautionary Principle and the Polluters Pay Principle to extend its statement to the dyeing units to compensate the victims of the pollution along the Noyyal River and also to bear the cost of restoring the environmental degradation [1-3]. Bioremediation is the process of using organisms to neutralize or remove contamination from waste. It is very important to understand that this form of waste remediation uses no toxic chemicals, although it may use an organism that can be harmful under certain circumstances. At sites filled with waste organic material, bacteria, fungi, protists, and other microorganisms keep on breaking down organic matter to decompose the waste. These processes can be carried out *in situ* at the contaminated site and are cost-effective. Among the new technologies, utilizing plant residue as adsorbents for the removal of dyes and metal ion from wastewater is prominent. This technique, known as phytoremediation, proves to be quite an efficient method in comparison to other existing methods. Natural coagulants (plant products) are low-cost plant products, characterized by their environment friendly behavior and presumed to be safe for human health. There has been considerable interest in the development and usage of plant-based natural coagulants [5, 6, 7 and 8]. Use of plant-based materials as water treatment agents has a long history, particularly, wood charcoal is considered as an excellent adsorbent. Natural polyelectrolyte of plant materials has been used for many centuries for purification of turbid water in developing nations [9 and 10].

2. MATERIALS AND METHODS

Sample Collection

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

Collection of plant seeds

The plant seeds were collected from local markets and shade dried. After removing the shells manually, kernels were reduced to powder using a domestic grinder. The seed kernels were ground to fine powder (63-600μm) using an ordinary food processor. The seed powder was then used in each experiment.

Determination of coagulant activity (Standard Jar test method)

The coagulation studies were performed using Jar test apparatus which allowed for six 1 liter beakers to be agitated simultaneously and rotational speed could be varied between 0 and 100 rotations per minute (RPM). The beakers were filled with 1000ml dye effluent sample. During rapid mixing at 100 RPM for 2 min coagulant dosage was added into each beaker and was followed by slow mixing at 40 RPM for 30min. The duration of sedimentation was kept constant at 30 min. The supernatant after sedimentation was filtered using whatman filter paper [11].

Optimization process for coagulation studies

In this preliminary study among the 14 plant seeds, 1 plant seed was selected for studying the potential coagulant effect on dye effluents

Various dosages of coagulants were prepared as follows:

1. *Moringa oleifera* dosage: The 1000 ml volume of dye effluent water samples was used at a different concentration of *Moringa oleifera* seed powder dosage of 1g/l, 2g/l. 3g/l, 4g/l, 5g/l and 6g/l.

Statistical analysis

The data obtained from various experiments from various experiments were
Analyzed and expressed as mean ±standard deviation.
The percentage change was calculated between the controls and experimental
for the various experiments using the following formula:

$$\% \text{ Change} = \frac{\text{Control - Experimental}}{\text{Control}} \times 100$$

For statistical analysis, MS Excel was used in the present study.

Two-way ANOVA

The two-way analysis of variance is an extension of the one-way analysis of variance. There are two independent variables, hence named two-way ANOVA

Biofilter media prepared as follows

Egg shell

Chicken egg shells were collected from local restaurants in Sathyamangalam, Erode. The membranes were estranged from the egg shells and thoroughly washed by water. The egg shells were then washed with distilled water, air-dried, ground into powder with particle sizes of 100 µm and finish dried at 105 ^{o} C in an oven for 2 h. Once completely dried we pulverized and shred the egg shells to fine particles using mortar and grinder followed by a mixer, later we sieved the pulverized absorbent to obtain a homogenous size [12].

Activated carbon *(Phyllanthus emblica* seed coat)

In the present study *Phyllanthus emblica* seed coat is broken into 0.2 mm to 0.3 mm, and again washed in 2% HCl. Activated carbon was prepared by following procedure 40g of *Phyllanthus emblica* seed cover with 100 ml of (60 % H_3PO_4) at room temperature for 12hrs and again keep on muffle furnaces at 440^0C for 2 mins, next cool this for 1 hour at room temperature and thoroughly washed with distilled water to neutral pH. This was then dried overnight at 105^o C in [13].

Sand and Gravel

River sand was collected from sathyamangalam (latitude and longitude; 8.508815 and 76.970292) and was sieved through 0.6 micro is sieve. Crushed gravel of size 4.75 mm is used. Then the optimal dosage for each coagulant determined earlier was added to each jar test was performed. The optimum condition of coagulant process is determined by evaluating the minimum dosage of coagulant and the pH value needed that can yield the desired flocculent activity resulting in cleaner water. In this study, the same process was followed for chemical coagulant.

3. RESULTS AND DISCUSSION

Physiochemical Parameters

Textile effluent collected from CETP at Angeripalayam, Tirupur showed water quality parameters above permissible limits of Central Pollution Control Board (CPCB) standards. The decolorizing effect of primary and secondary treatment with *Moringa olifera* and biofilter column with activated carbon of *Phyllanthus emblica* coat 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 [14]. Various parameters such as pH, TDS, TSS, chloride, alkalinity, turbidity, and colour, total hardness, calcium hardness, magnesium hardness, free residual chloride and COD were analyzed for the raw dye effluent it was slightly exceed the standards of TNPCB. The results for various said parameters, after treatment with sodium hypochlorite, different concentrations of *Moringa olifera* seed powder and biofilter column are given in Table-1. The dye effluent treated with *M. oleifera* seed powder was observed and color, TSS, turbidity, Total hardness of the effluent was significantly reduced, in all the tested T3 concentrations. The colour was observed as follows: T1-1,583.33 Pt-Co; T2-1,241.67 Pt-Co; T3-925.00 Pt-Co; T4-983.33 Pt-Co; T5-990.00 Pt-Co; and T6-1043.33 Pt-Co. The color reduction in T3-925.00 Pt-Co was significant. The *M.oleifera* seed powder was used in 6 different concentrations to treat turbidity. It was estimated (T1-34.10 NTU to T6-22.15 NTU) as given in Table-14. The *M.oleifera* seed powder significantly decreased the turbidity with in concentration .The values of all the tested concentrations are as follow *M.oleifera* seed powder at T3 concentration gave maximum reduction of turbidity (21.03 NTU) The percentage removal of various constituents in the dye effluent was calculated using the following formula.

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

Table 1: Bioremediation of *Moringa oleifera* seed powder, biofilter and sodium hypochlorite column on dye effluent

S. No	Parameters	Raw Effluent	Sodium Hypo chlorite	Concentration of *Moringa oleifera* Seed powder (g/L)						Biofilter Column
				1	2	3	4	5	6	
1	Color (pt co)	**3994.00**	**901.67**	**1583.33**	**1241.67**	**1043.33**	**983.33**	**990.00**	**925.00**	**288.17**
2	pH	**9.41**	**9.89**	**9.56**	**9.54**	**9.57**	**9.50**	**9.43**	**9.48**	**8.86**
3	Turbidity	**68.20**	**35.52**	**34.10**	**31.9**	**22.15**	**21.07**	**21.48**	**21.03**	**6.65**
4	Total dissolved solids (mg/L)	**7598.00**	**7601.17**	**7610.00**	**7609.67**	**7580.33**	**7599.17**	**7588.33**	**7594.67**	**7584.00**
5	Total suspended solids (mg/L)	**182.80**	**52.50**	**92.17**	**61.33**	**27.50**	**25.83**	**26.00**	**26.82**	**12.35**
6	Total hardness (mg/L)	**398.00**	**380.00**	**385.00**	**376.67**	**378.33**	**361.67**	**378.33**	**361.67**	**388.33**
7	Calcium hardness (mg/L)	**206.00**	**213.63**	**218.33**	**215**	**210.00**	**213.33**	**211.67**	**213.33**	**216.67**
8	Magnesium hardness (mg/L)	**192.00**	**166.67**	**166.67**	**161.67**	**168.33**	**148.33**	**166.67**	**148.33**	**171.67**
9	Free Residual chloride (mg/L)	**-**	**41.67**	-	-	-	-	-	-	-
10	Chloride (mg/L)	**3450.60**	**3673.33**	**3521.00**	**3547.33**	**3509.00**	**3381.33**	**3511.67**	**3514.67**	**3499.33**
11	Total alkalinity (mg/L)	**484.00**	**386.67**	**315.00**	**298.33**	**291.67**	**248.33**	**273.33**	**231.67**	**231.67**
12	COD (mg/L)	**1195.60**	**1301.00**	**1837.67**	**1251**	**740.00**	**726.67**	**710.67**	**705.67**	**521.67**
13	BOD(mg/l)	**358.68**	**494.38**	**771.82**	**437.85**	**281.20**	**210.73**	**234.52**	**218.76**	**130.42**

In the present study, 3gm/l of seed powder from *M.oleifera* plant shows high potential in industrial dye effluent treatments. When using this much of concentration, considerable amount of color-76.84%, turbidity-69.16%, TSS-85.33%, COD-40.98%, total hardness-4.94%, megnesium-22.74%, BOD-13.72% and total alkalinity-52.13% other parameters were reduced, but the same time total dissolved solid was not reduced. After the bio filtration the parameter such as color-92.78%, turbidity-90.25%, TSS-93.24%, COD-56.37%, BOD-63.64%and total alkalinity-52.13% were reduced (fig-1). Previously reported that the extracts of three herbs namely *M. oleifera*, *Cicer arietinum* and *Dolichos lablab* were chosen for this study. The extracts of *M. oleifera* used as a natural coagulant for the clarification of water turbidity and it showed 90% (NTU) efficiency [27]. [28] Powder of peanut seeds was used for 20 mg/l synthetic water and turbidity removal of 92% was found. To treat laundry waste surfactant salt extract of orange pith gave good performance of 89.5, 81.5, and 56.4% removal of turbidity, TSS, and COD, respectively [29]. Number of reports suggested that *M. oleifera* seeds could serve as a coagulant because it contains low molecular weight of water soluble protein. Protein will be positively charged when dissolved in water and this protein will act as positively charged synthetic materials and can be used as synthetic polymer coagulant. Therefore, *M. oleifera* could be used as a best coagulating agent (When compared to previous works, a maximum percentage color reduction of 62.8% was reported by [1] using *M. oleifera* seed coagulant.When the coagulant was added to the sample and was followed by rapid stirring, the resulting cationic protein from *M. oleifera* was distributed to all parts of the liquid and then interacted with the negatively charged particles that caused dispersed turbidity. Such interactions disturb the fore that stabilizes the particles, so that it can bind to small particulates to form precipitate.

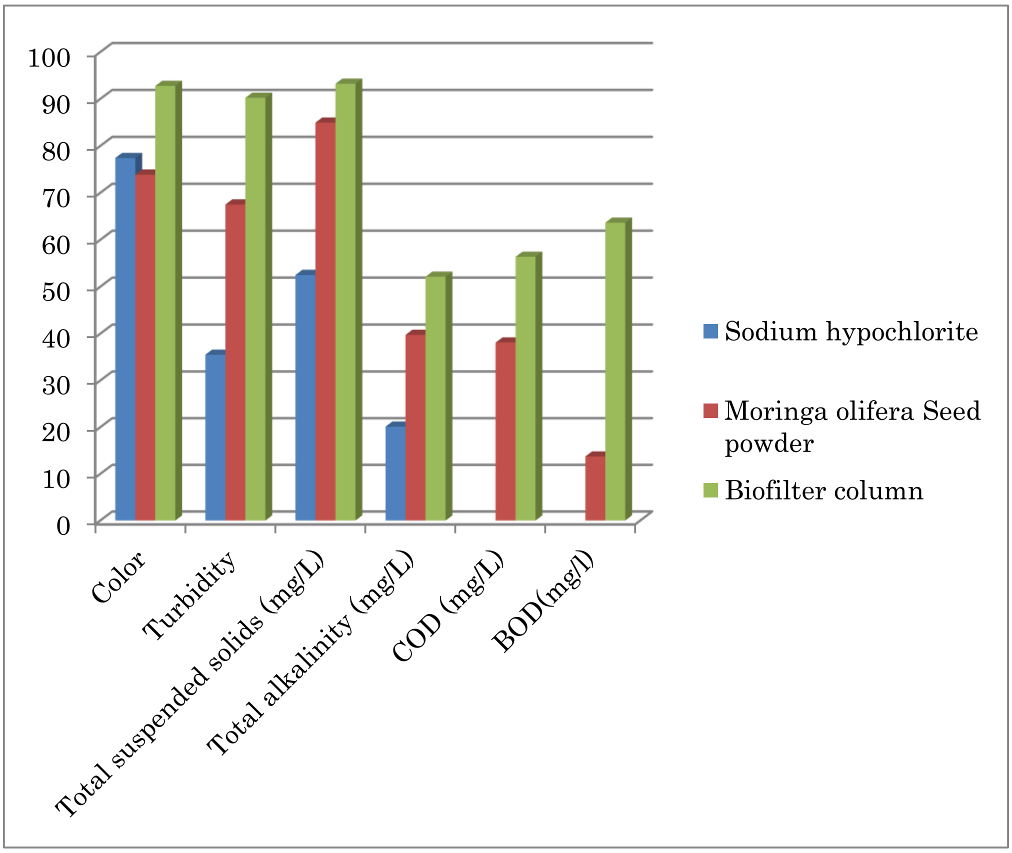

Figure 1: Comparation of effective removal % Color, Turbidity, TSS, total alkalinity, COD and BOD of biofiltration of *Moringa oleifera* seed powder treated effluent and sodium hypochlorite on dye effluent

This process is called coagulation. An additional advantage in this case is that all the sludge that comes from grain coagulation of *M. oleifera* is biodegradable and it an organic material [15]. Similarly, [16] reported maximum removal of color as well as COD from bleaching effluent (paper and pulp industry) with a current density of 20 mA /cm [22] stated a high potential adsorbent (egg shell) for the removal of Congo red from an aqueous solution. Previous studies on a variety of plant materials which can be used as source of natural coagulants have been reported. For example, natural coagulants from *M. oleifera* [17], Tamarind seed [18,19 and 20] and Strychnos potatorum [21] have been investigated. Color removal from textile wastewater using low cost and natural materials has been widely studied, but the use of water-soluble natural polymers has been scarcely reported. experiment showed that 70 mg/l of *M. oleifera* at optimum temperature, pH, and mixing speed could remove 62.05% of TSS. Also, alum 40 mg/l of removed 85.26% from the refinery wastewater. Moreover, when *M. oleifera* and alum were used together with a 2:1 dosage ratio (alum at 80 mg/l and *M. oleifera* at 70 mg/l), they removed TSS by 81.52%. These results were similar with the results obtained by [25 and 26] and the conclusions of Fo. High BOD noticed in various combinations of *Cassava* and *Moringa* may be because *Cassava* and *Moringa* are organic compounds with tendencies of increasing the organic content of the wastewater hence causing BOD to rise [27,28,29 and 30].

4. CONCLUSION

Perusal of the result in the present study *M.oleifera* seeds treatment followed by *P.emblica* bio-filter was effective on Color, BOD, COD, Turbidity, pH, TSS, Magnesium, Total hardness and alkalinity of the dye effluent which was more effective than the chemical sodium hypochlorite. In the present study natural coagulant treatment is more effective when treated effluent was filtered through biofilter. The best treated concentration for *M.oleifera* was 3gm/l. Total dissolved solid and chloride was increased with increasing concentration because adding seed powder. Calcium was not reduced effectively it maybe because of seed powder and eggshell in the biofilter. Future study could be made by using seed extracts of these plants and activated carbon for effective biofilter for treating the waste water from dye, printing and paper industry.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The authors confirm that the data supporting the findings of this research are available within the article.

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CONFLICT OF INTEREST

Authors have no conflict of interest.

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