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Research Article

PLANT SEED FLOCCULANTS: A NOVEL PHYSICO-CHEMICAL APPROACH FOR THE REMOVAL OF COLOUR, ODOUR AND TURBIDITY FROM TANNERY EFFLUENT

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A B S T R A C T

Tannery industry is one of the large scale industries which generate a lot of wastewater per day. Tannery effluents contain a lot of hazardous substances which can affect the aquatic and terrestrial environment when it is directly discharged in water bodies. Coagulation-flocculation is a suitable process for the treatment of tannery effluents whereas the chemical coagulants used for treatment causes more harmful effects to human beings. Hence, a novel approach of using plant seed materials, as natural coagulant for the treatment of tannery effluent because of the cost-effective and eco-friendly nature. In the present study three plant seed materials, namely, *Moringa olifera, Strychnos potatorum Sappindus emarginatus* and *Strychnos potatorum* was used, as natural coagulant, at different concentrations namely 0.05, 0.10, 0.15 and 0.20 g/ml concentrations were tested for the efficient removal on colour, odour and turbidity from tannery effluent. Interestingly, there was a maximum removal of colour, odour and turbidity observed by using *Strychnos potatorum* plant seed materials at 0.1 g/ml concentration compare to other plant seed materials. However, the effect was more pronounce at a pH level of 7 compare to other pH level. It is concluded that the plant seed materials *Strychnos potatorum* can be used as a natural coagulant at a dosage of 0.1 g/ml and pH level of 7 for the efficient removal of colour, odour and turbidity from the tannery effluent.

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INTRODUCTION

Tamilnadu is one of the state having much share in the industrial economy of India. The tannery industry is a major sharecropper of the foreign exchange earner when compared to other industry but, tanneries are typically characterized as pollution intensive industrial complexes which generate high strength of wastewater containing heavy metals, toxic chemicals, chloride, lime with high dissolved and suspended solids and other pollutants. Tanneries generate wastewater in the range of 30-35 L/Kg of skin/hide processed with variable pH and high concentrations of suspended solids, BOD, COD, tannins and chromium (Durai and Rajasimman 2011). The tannery wastewater is always characterized by strong colour, foul smell, high BOD and high dissolved solids, (Kumar and Mani, 2007). The effluent released from tannery industry was brown in colour and offensive odour. The colour of the effluent might be due to the presence of bio-degradable and non-biodegradable, high molecular weight organic compounds and high amount of chemicals used during the processing.

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The odour may be due to the processing of skin and hides by soaking and liming (Ravibabu *et al*., 2007; Zahid *et al*., 2006). Toxic odour causes pollution to the environment and causes problem to occupational safety of the workers in tannery. H2S, NH3, VOC and putrefying hides during the leather processing cause's bad odour. (Pandi *et al.*, 2007). For advanced purification of tannery effluents, different physico-chemical methods, such as, active carbon adsorption, ion exchange and reverse osmosis are used. But these processes are extremely expensive (Vieira and volesky, 2000). Various physico-chemical techniques have been studied for their applicability to the treatment of tannery wastewater. Among these techniques, coagulation and flocculation is widely followed in tannery wastewater treatment for the removal of pollutants. Coagulation and flocculation are two distinct processes usually carried out as combination of physical and chemical procedures, during the primary treatment of tannery effluent for colour, odour and turbidity removal (Shegani, 2014). Coagulants neutralize the repulsive electric charges (negative) surrounding particles allowing them to "stick together" creating flocs. Flocculants facilitate the sticking of the coagulated particles to form larger floccules and their by faster gravitational settling. Coagulation is the destabilization of colloids by neutralizing

the forces that keep them apart. Cationic coagulants provide positive electric charges to reduce the negative charge of the colloids. As a result, the particles colloid to form larger particles (flocs). Rapid mixing is required to disperse the coagulants thorough the liquid. The flocculation process, following coagulation, allows smaller particles formed during the rapid coagulation stage to stick into larger particles to form settleable and/or filterable floc particles. Numerous substances have been used as coagulant and flocculation aids, including, alum, ferric chloride, ferrous sulfate and calcium carbonate.

Vijayaraghavan *et al*., (2011) reported that the chemical substances used for coagulation- flocculation process caused harmful effects on soil, microbes and human beings. They also added that aluminium based coagulant will develop the diseases like Alziemers in human beings. They suggested the replacement of chemical coagulants with plant based coagulants to counteract the abovementioned drawbacks and also they are cost-effective and eco-friendly [1]. Raveendra babu and Malay chaudhari (2005), Phanimadhavi, and Rajkumar (2013) reported the use of M*oringa oleifera* seed materials for the treatment of different industrial wastewaters. Geethapriya and Sharpudhin (2016) reported the positive use of *Moringa olifera, Cicer Areitinums* and *Tamarind* seed materials, as natural coagulants, for the removal of colour and turbidity from industrial wastewaters. The positive role of other plant seed materials, as natural coagulants, for the removal of colour, odour and turbidity in tannery effluents have not been exploited, so far.

The present investigation has been undertaken with an aim to exploit the positive role of natural coagulants, such as, *Moringa olifera, Sappindus emarginatus and Strychnos potatorum* for the removal of colour, odour and turbidity from tannery wastewater in comparison with chemical coagulant, alum.

MATERIALS AND METHODS

Determination of colour of the tannery effluent

The colour of the tannery effluent was determined by visually.

Determination of odour of the tannery effluent

It was categorized as objectionable (or) non-objectionable by direct smelling of the sample.

Table 1 Physico-Chemical characteristics of the Tannery wastewater

S.No	Parameter	Initial values
1.	pH	9.5
2.	TDS mg/L	12,200
3.	Electrical Conductivity ms/cm^2	19,000
4.	Odour	Objectionable
5.	Colour	Brownish
6.	Turbidity NTU	420
7.	Total Hardness mg/L	1530
8.	DO mg/L	18
9.	BOD mg/L	1260
10.	Chromium mg/L	140

Preparation of natural coagulants

The seed parts of *Moringa olifera* (Drumstick), *Sappindus emarginatus* (Notched Leaf Soapnut) and *Strychnos potatorum* (Clearing Nut) are collected and dried naturally in direct sunlight after drying, remove the seeds from the hulls manually. The dried seeds were ground to fine powder by domestic blunder. This powder was sieved through 600 µm sieves and various concentrations namely 0.05, 0.10, 015, 0.20 g/ml was prepared in sterile water for optimization of pH experiment, the pH of the tannery effluent sample was adjust to different pH namely, 5, 6, 7, 8 by adding 1N NaOH (or) 1N Hcl.

The alum $(Al_2SO_4)_3$ $18H_2O$ was prepared at different doses namely 0.25, 0.50, 0.75, and 1.00 g/ml in sterile water, regarding the pH experiment. pH of the effluent sample was adjusted at different pH level namely 5, 6, 7, 8 by adding 1N NaOH or 1N Hcl to the effluent sample.

Coagulation-flocculation process

A conventional jar test was used in the experiment to coagulate the sample of turbid tannery effluent using chemical and natural coagulant and carried out as a batch test. The jar test was carried out according to Geethapriya and Sharpudhin, (2016) and the percentage of turbidity removal was measured by using turbidity meter.

RESULTS AND DISCUSSION

Colour and odour removal by chemical and natural coagulants

It was observed that there was a maximum reduction of colour (Brown to light brown) and odour (offensive to odourless) observed during the treatment of tannery effluents by chemical and natural coagulants. Alum at a dosage of 0.5 g/ml and plant seed materials at 0.1 g/ml at under optimum pH level of 7 recorded highest colour and odour removal of tannery wastewater. (Tasneem banu Kazi and Arjun Virupakshi 2013) reported the efficiency of natural and chemical coagulants on colour and odour removal from tannery wastewater.

In the present study also the plant seed materials as a natural coagulant, efficiently remove the colour, odour and turbidity from the tannery effluent.

Turbidity removal of tannery effluent by using alum, as chemical coagulant

The role of aluminium sulphate Al_2 $(SO_4)_3$ $18H_2O$ as a chemical coagulant, in the removal of turbidity in industrial wastewater has been reported by many workers (Shegani, 2014; Aboulhassan *et al*., 2008).

The positive role of pH, as an important factor of coagulation process and to maximize the removal of pollutants in tannery effluent has been reported by Aboulhassan *et al*., 2008 and Sabur *et al*., 2013.

In the present study also alum at a concentration of 0.5 g/ml and pH level of 7 exhibited a higher removal of turbidity in raw tannery effluent when compare to other concentrations and pH levels.

The turbidity removal of tannery effluent at different dosage of alum was studied and the results presented in Table no. 2. It was observed that there was an increase in the percentage of turbidity removal upto the dosage level 0.50 g/ml and thereafter a reduction in the turbidity removal of the tannery effluent, recorded. Regarding the optimization of pH level there was a maximum percentage of turbidity removal recorded at pH 7 when compared to other pH levels.

Alum [$Al_2 (SO_4)_3$ 18H_2O]

From the table 2, the volume of the effluent sample 500ml is taken and different alum dosage 0.25, 0.50, 0.75, 1.00, 1 g/ml, the percentage of turbidity removal was found to be increase while increasing the dosage level, the maximum amount of removal percentage obtained was 89 % at 0.50 gm/ml

Table 2 Effect of different concentrations of Alum, as chemical coagulant, on the efficient removal of turbidity from raw tannery effluent

S. NO.	Volume of sample (ml)	Dosa-ge (g/ml)	Turbidity Reading NTU		Removal of Turbidity (%)
			Initial	Final	
1.	500	0.25	420	64	84.7
2.	500	0.50	420	46	89.0
3.	500	0.75	420	48	88.6
4.	500	1.00	420	74	82.4

Determination of optimum pH

The optimum pH was determined at a pH of 7 and the turbidity removal was 91.0 % as shown in table 3. It was found that the percentage of turbidity removal was gradually increased from pH 5 to 8.

Table 3 Determination of optimum pH for the efficient removal of turbidity from raw tannery effluent at optimum concentration of Alum

S.No.	Dosage (g/ml)	pH	Turbidity reading (NTU)		Removal of Turbidity (%)
			Initial	Final	
1.	0.5	5	420	62	85.2
2.	0.5	6	420	44	89.5
3.	0.5	7	420	38	91.0
4.	0.5	8	420	53	87.4

Role of natural coagulants in turbidity removal

Moringa olifera

From the table 4, the volume of sample 500 ml taken at different dosage 0.05, 0.10, 0.15, 0.20 mg/l using *Moringa olifera*, the percentage of turbidity removal was found to be increase while increasing the dosage level the maximum amount of removal percentage obtained was 78.4% at 0.1 g/ml.

Table 4 Effect of different concentrations of *Moringa Olifera* seed materials as natural coagulant, on the efficient removal of turbidity from raw tannery effluent

S.No.	Volume of sample (ml)	Dosag-e (g/ml)	Turbidity reading (NTU)		Removal of Turbidity (%)
			Initial	Final	
1.	500	0.05	420	108	74.2
2.	500	0.10	420	91	78.4
3.	500	0.15	420	98	76.6
4.	500	0.20	420	122	71.0

Determination of optimum pH

The optimum pH was determined at a pH of 7 and the turbidity removal was 80.0% as shown in table 5. It was found that the percentage of turbidity removal was gradually increased from pH 5 to 8.

Sappindus emarginatus

From the table 6, the volume of sample 500ml taken at different dosage 0.05, 0.1, 0.15, 0.2, g/ml using *Sappindus emaginatus* as natural coagulant in jar test apparatus, the maximum amount of removal percentage obtained was 72.2% at 0.1 g/ml.

Table 5 Determination of optimum pH for the efficient removal of turbidity from raw tannery effluent at optimum concentration of *Moring Oleifera* seed material

S.No.	Dosage (g/ml)	pH	Turbidity reading (NTU)		Removal of Turbidity (%)
			Initial	Final	
1.	0.1	5	420	116	72.4
2.	0.1	6	420	99	76.4
3.	0.1	7	420	84	80.0
4.	0.1	8	420	108	74.2

Table 6 Effect of different concentrations of *Sappindus emarginatus* seed materials, as natural coagulant, on the efficient removal of turbidity from raw tannery effluent

S.No.	Volume of sample (ml)	Dosa-ge (g/ml)	Turbidity reading (NTU)		Remova-l of Turbidity (%)
			Initial	Final	
1.	500	0.05	420	133	68.4
2.	500	0.10	420	117	72.2
3.	500	0.15	420	124	70.4
4.	500	0.20	420	144	65.8

Determination of optimum pH

The optimum pH was determined at a pH of 7 and the turbidity removal was 74.4 % as shown in table 7. It was found that the percentage of turbidity removal was gradually increased from pH 5 to 8.

Table 7 Determination of optimum pH for the efficient removal of turbidity from raw tannery effluent at optimum concentration of *Sappindus emarginatus* seed materials

S.No.	Dosage (g/ml)	pH	Turbidity reading (NTU)		Removal of Turbidity (%)
			Initial	Final	
1.	0.1	5	420	139	66.9
2.	0.1	6	420	122	70.8
3.	0.1	7	420	108	74.4
4.	0.1	8	420	127	69.8

Strychnos Potatorum

From the table 8, the volume of the effluent sample 500 ml taken and different dosage 0.05, 0.1, 0.15, 0.2 g/ml using *Strychnos Potatorum* as natural coagulant, the maximum amount of removal percentage obtained was 84.2 % at 0.1 g/ml.

Table 8 Effect of different concentrations of *Strychnos potatorum* seed material, as natural coagulant, on the efficient removal of turbidity from raw tannery effluent

S.No.	Volume of sample (ml)	Dosage (g/ml)	Turbidity reading (NTU)		Removal of Turbidity (%)
			Initial	Final	
1.	500	0.05	420	98	76.6
2.	500	0.10	420	66	84.2
3.	500	0.15	420	81	80.8
4.	500	0.20	420	117	72.2

Determination of optimum pH

The optimum pH was determined at a pH of 7 and the turbidity removal was 88.0% as shown in table 9. It was found that the percentage of turbidity removal was gradually increased from pH 5 to 8.

Table 9 Determination of optimum pH for the efficient removal of turbidity in raw tannery effluent at optimum concentration of *Strychnos Potatorum* seed materials

S.No.	Dosage (g/ml)	pH	Turbidity reading (NTU)		Removal of Turbidity (%)
			Initial	Final	
1.	0.1	5	420	107	74.6
2.	0.1	6	420	86	79.6
3.	0.1	7	420	51	88.0
4.	0.1	8	420	97	76.8

The removal of turbidity of tannery effluent by using different plant seed materials, namely, *Moringa olifera, Sappindus emarginatus* and *Strychnos potatorum* at different concentrations namely 0.05, 0.10, 0.15 and 0.20 was tested by jar test and the results are presented in Table no. 4, 6, and 8. It was observe that there was a maximum reduction in the percentage of turbidity recorded at 0.10 g/ml concentration of plant seed material when compare to other concentrations. There was a maximum percentage of turbidity removal recorded by *Strychnos potatorum* seed materials followed by *Moring olifera* and *Sappindus emarginatus* regarding the optimization of pH there was a maximum removal of turbidity at pH 7 level when compare to other level of pH of the effluent during the usage of all the three plant seed materials. (Sri suhartini *et al*., 2013) reported that a protein extracted from *Moringa olifera* seed is responsible for the effectiveness in wastewater system. (Katayon *et al*., 2007) reported the efficiency of *Moringa olifera* seed materials in removing the 99% of suspended solids without changing the pH in the wastewater system (Mangales *et al*., 2012) concluded that *Moringa olifera* seed access a natural coagulant, flocculant and absorbent for the treatment of drinking water and also reduces the total hardness and turbidity of the water samples. The seed material of *Strychnos potatorum* has long been used as a natural coagulant for drinking water purifications in Tamil nadu and other southern states. The seed material of *Sappindus emarginatus* has long been used for the removal of dirt and impurities in golden ornaments.

In the present study also all the three plant seed materials were effectively remove the turbidity level of tannery effluent at 0.10 concentration and pH level of 7. The plant seed material of *Strychnos potatorum* was found in a superior turbidity remover of tannery effluent when compare to other plant seed materials.

CONCLUSION

The results of the present study clearly revealed the efficiency of *Strychnos potatorum* plant seed materials as a natural coagulant in tannery effluent treatment for the efficient removal of colour, foul smell and turbidity. Moreover, the seed materials are available abundantly all over India. When compare to other coagulants. The turbidity of tannery effluent was removed by 88% at pH 7 level whereas the colour and odour removal of tanning industry wastewater. So, this can be applied for large scale treatment process in tannery effluent treatment units for odour and colour removal.

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