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Effectiveness of Turbidity Removal from Synthetic and Tannery Wastewater by Using Seeds of a Natural Coagulant *Citrullus lanatus*

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ABSTRACT

The cost of water treatment is increasing due to suspended and colloidal particle load caused by land development and high storm runoff. Water from all sources must have some form of purification and treatment before consumption. The coagulation process can be used as a primary step for water and wastewater treatment processes. Among plant materials that have been tested, the seeds of water melon (*Citrullus lanatus*) have been shown to be one of the most effective primary coagulants in water and wastewater treatment. *Citrullus lanatus* is the best natural coagulant that removes the BOD, COD, TSS and turbidity level to the greater extent. It was aimed at identifying watermelon seed as a possible replacement for alum and other synthetic polyelectrolytes in treating water. Results obtained showed that the optimum dosage of 2 g/L of seed at a temperature of 35°C removes the turbidity from 1500 NTU to 35 NTU. The seeds of *C. lanatus* reported that the turbidity of tannery effluent reduced by 86.7%, COD reduced by 50% and BOD reduced by 55% at a coagulant concentration of 2 g/L. The concentration of watermelon seeds in wastewater changes the turbidity from 692 NTU to 92 NTU. The study proved that *C. lanatus* gives better removal efficiency than alum for synthetic and tannery wastewater treatment and can be used as an alternative coagulant against the use of inorganic coagulants.

INTRODUCTION

Water is a basic need required for living creatures and human beings. Water is the most essential component of life and is vital for nourishment. More than one-third of all countries will face risks of water shortage by mid-century as a result of global warming. It was estimated that 1.2 billion people in this world do not have access to safe drinking water (Botanic Garden Conservation News 2002). Industrial effluents are one of the major sources of water pollution. Each year billion tons of industrial waste is being pumped into the water resources. Ways and means are most urgently needed to effectively treat the effluents and reuse the treated water without seepage and contamination. Presently, the main objective of the environmental engineers is to lower down the cost of treatment and to improve the characteristics of the treated water for safe utilization. Coagulation is a process where the coagulant is added to water or wastewater to "destabilize" the colloidal suspensions. Coagulation is a chemical process that involves neutralization of charge, whereas flocculation is a physical process (Jagadish 2015). The coagulation-flocculation process can be used as a primary step for water and wastewater treatment process. Alum is the most commonly used coagulant and is easy to handle and produces less sludge than lime.

Coagulation is affected by the type of coagulant used, dosage of coagulant and the quantity of coagulant used, pH and initial turbidity of the sample and the properties of pollutants (Binti Saharudin et al. 2014). Coagulation itself results in the formation of floc, but flocculation is required to help the floc further aggregate and settle. The coagulation-flocculation process removes only about 60% of natural organic matter (NOM) and further process is required for complete water and wastewater treatment. A certain quantity of physico-chemical sludge is also formed, which is normally processed externally. Number of studies produced natural coagulants (Muthuraman et al. 2013) as a substitute for metal salts, some of them are *Moringa oleifera* (Othman et al. 2008, Daniyan et al. 2011), maize seeds, roselle seed, *Strychnos potatorum* and *Phaseolus vulgaris* (Talnikar 2017). This study was focused to compare the coagulant capacity of the *Citrullus lanatus* seeds. The seeds of watermelon are considered as agrowaste and are spitted out in spite of its high nutritional value. Watermelon seeds are known to be highly nutritional; they are rich sources of protein, vitamin B, minerals and fat among others as well as phytochemicals. The seeds of watermelon are effective water purifiers because of their adsorbent properties like most of the indigenous seeds. Roasted watermelon seeds are served as a snack to garnish salads. Watermelon seed oil is extracted from these seeds which is beneficial for hair and skin. This study was carried out to investigate the efficiency of the natural coagulant water melon (*Citrullus lanatus*) seeds for the treatment of water and wastewater.

MATERIALS AND METHODS

Coagulant: Fresh seeds of watermelon were obtained from the local market. The seeds were washed with water, sun-dried for a week, sorted to remove bad ones, shelled and ground with a high speed laboratory electric blender and packed in an air tight container (Yusuf et al. 2015). 150 g of the crushed seeds were placed in an extraction apparatus. 500 mL of n-hexane was used to extract oil from the crushed seeds in the column (Ndabigengesere et al. 1995). The apparatus was left running for about 6 hours and stopped when the extraction was complete. The cake was then washed with distilled water to remove residual n-hexane, dried at 80°C till constant weight and then sieved. The finer particles were then used as the coagulant.

Coagulation studies: When the primary seed treatment was over, various tests for optimization were employed to check the coagulation power of *Citrullus lanatus* seeds. The factors affecting the treatment are coagulant dosage, agitation, temperature, presence of aid and mixing speed. These are the parameters under which the optimization experiments were conducted.

Effect of coagulant dosage: The synthetic turbid water solution of 250 to 4000 NTU was kept in separate beakers and 2 g of coagulant was added to each sample. This experiment was carried out in a magnetic stirrer with agitation for one hour under constant speed and also without agitation. Various dosages of seed were added to each beaker and agitated by turbulent mixing for about 30 min. All the suspensions were then left for 30 min for sedimentation. The turbidity of each clarified sample was then measured using turbidity meter (Deshpande 2010).

RESULTS AND DISCUSSION

In case of no agitation, there is a lesser removal of turbidity compared to agitation. This happens due to the stationary phase of the suspended solids and other suspensions even after the addition of the coagulant. The protein content of the seed varies from 13% to 20% (Muthuraman et al. 2014). Since the coagulant agent contains protein, when the salt concentration increased, the solubility of the coagulation efficiency can occur, thus leading to a higher percentage of turbidity removal. Above 1500 NTU, the percentage of turbidity removal started to decrease, as the concentration increased (Table 1). This is attributed to the salting out effect whereby the solubility of the proteins decreases with concentration (Mirjana et al. 2010). When the amount of coagulant added was increased, the turbidity removal increased from 63.2 to 97.66%. Further increase in dosage leads to the decrease in the removal efficiency. Since the amount of coagulant added is to be proportional to cation exchange capacity in order to destabilize the suspended particles, additional dosage leads to the increase in turbidity of the solution, thereby the efficiency decreases (Table 2). Increase in the wastewater or water temperature shows no appreciable effect in the reduction of turbidity (Table 3). The results did not give conclusive evidence of any correlation between temperature of the water sample, and the turbidity level.

For tannery waste, the effluent was collected from a

Table 1: Effect of agitation on turbidity removal.

Turbidity of sample (NTU)	Amount of coagulant (g)	Turbidity after coagulation (without agitation) in NTU	% Decrease of turbidity	Turbidity after coagulation (with agitation at constant speed) in NTU	% Decrease of turbidity
250	2	101.08	59.28	92.00	63.20
500	2	110.20	77.94	82.00	83.6
1000	2	69.00	93.10	93.00	90.70
1500	2	80.40	94.64	35.00	97.66
2000	2	192.60	90.37	186.00	90.70
3000	2	500.00	87.50	352.00	88.26

Table 2: Optimization of coagulant dosage for turbidity removal.

Initial turbidity, NTU	Amount of coagulant (g)	Decrease in NTU	% Decrease in NTU
1500	1	50	96.67
1500	2	35.00	97.66
1500	5	30.40	97.97
1500	10	114.00	92.40

Table 3: Optimization of temperature for turbidity removal.

NTU of sample	Temperature (°C)	Decrease in turbidity	% Decrease in turbidity
1500	30	48.40	96.77
1500	40	55.30	96.30
1500	50	54.00	96.40
1500	60	70.20	95.32

Table 4: Effluent characteristics before and after treatment.

Parameter	Before treatment	After treatment
COD	4520 mg/L	2251 mg/L
BOD_3 at 27°C	2620 mg/L	1180 mg/L
TSS	1688 mg/L	526 mg/L
TDS	10556 mg/L	20050 mg/L
Turbidity	692 NTU	92 NTU

tanning industry located in Chennai. Along with 500 mL of effluent, 2 g of seed, 1 g of coagulant aid (alum) was added (Moramudaii et al. 2001). The solution was mixed at 100 rpm at 30°C for a time period of 30 min. The slurry of black colour of wastewater has changed to a grape wine colour after the process. Also, the suspensions are removed to a large extent. It was observed that the BOD at 27°C for 3 days of the sample reduced from 2620 mg/L to 1180 mg/L and the COD of the effluent reduced from 4520 mg/L to 2251 mg/L. Turbidity of the tannery effluent was reduced by 86.7% and the total suspended solids removal efficiency was 68.8% (Table 4).

CONCLUSION

Watermelon (*Citrullus lanatus*) is one of the fruits whose seeds are not eaten with the pulp. These seeds are discarded either as cheap animal feed or simply thrown away. Therefore, there is a need to explore the potential of the seeds by evaluating the coagulant properties. The *Citrullus lanatus* seeds were analysed for the coagulant property in the treatment of water and wastewater. The efficiency of turbidity removal was 98% for synthetic wastewater and 86.7% for the tannery effluent. The other physicochemical parameters of tannery wastewater such as BOD, COD and TSS of the wastewater were also reduced to a greater extent. The BOD of the wastewater reduced by 54.96% and COD removal efficiency was 50.19%. The watermelon seeds when employed as a coagulant significantly decrease BOD, COD, TSS and turbidity of the synthetic wastewater and also the tannery effluent.

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