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Distillery Wastewater Management using Natural Coagulant for Sustainable Environment

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Abstract: In India distilleries have become a major source of pollution as 88% of its raw materials are converted into waste and discharged into the water bodies, causing water pollution. The present study determine physical and chemical parameters in the treatment process of distillery wastewater using natural coagulants and assessing by comparing the performance with chemical coagulant alum. The plant-based method was best for distillery wastewater treatment. The crude extracts obtained from natural coagulant *Hibiscus rosa-sinensis* followed by *Moringa oleifera* have manifested improved coagulation performance compared to commercial alum. It exhibited a good reduction in turbidity, sulphate, biological oxygen demand, and chemical oxygen demand.

Keywords: *Hibiscus rosa-sinensis, Moringa oleifera,* Distillery effluent, Natural coagulant

The waste created by ago-processing industries is one of the major environmental issues faced by the world today. One among them is ethanol-producing distilleries which is considered a major source of water and soil pollution. Distilleries are among the 17 most polluting industries listed by the Central Pollution Control Board of India (CPCB 2003). Currently, in India, 397 distilleries pproduce approximately 3.25×10^{10} liters of ethanol and generate approximately 40.90×10^{15} liters of spent wash per annum (Kumar and Chandra 2018). For every one litter of alcohol production 15 litters of spent wash is generated (Beltran et al., 2001). Spent wash discharged into land or water bodies without proper treatment leads to pollution. In aquatic forms, it reduces the penetration power of sunlight thus reducing the photosynthetic activity and dissolved oxygen content. The discharge into land bodies without adequate treatment inhibits seed germination and leads to the depletion of vegetation by reducing soil alkalinity and manganese availability (Chowdhary et al., 2017 b). Due to high pollution status of spent wash, Ministry of Environment, Forest, and Climate Change, Govt. of India, enumerated ethanol industries at the top among the “Red category” industries (Tewari et al., 2007).

Coagulation and flocculation are the most common techniques adapted for treating various types of wastewater, including industrial, municipal, and stream water. During the coagulation process, synthetic materials like ferrous sulfate ($Fe(SO_4)$), aluminum sulfate or alum ($Al_2(SO_4)_3$), and poly aluminum chloride (PAC) ($Al_2(OH)_3C_{l3})_{10}$ are added to form precipitates by neutralizing the charged particles. Synthetic materials are non-efficient, and make water treatment more expensive which is not affordable by developing countries (Yuliastri 2016).

Physio-chemical treatment is used to overcome the problem, but it can't overcome several issues like decolorization, BOD, COD, the outlet of hazardous by-products, etc. This leads to the demand for more cost-effective and more environmentally friendly methods to be opted for detoxifying the hazardous waste. By sustainable development and waste minimization issues, phytoremediation is a new technology of using plants as a natural and eco-friendly process for the treatment of industrial effluent. Natural coagulants are biodegradable and do not introduce harmful chemicals into the environment, making them more sustainable and less pollution compared to chemical coagulants. The *Moringa oleifera* used to treat acidic wastewater, it showed a good rreduction in turbidity, colour, and COD by 98, 90.76 and 65.8 % , respectively (Desta and Bote 2021). Wagh et al. (2022) report that *M. oleifera* when used to treat synthetic dairy wastewater reduce turbidity by 95 % and colour by 94 %. The main objective of the current work was to analyse the role of the natural coagulants on physico-chemical parameters of distillery effluent.

MATERIAL AND METHODS

The effluent was collected form one of the distilleries in Karnataka and was stored in plastic cans at 4°c till further use to assess various physico-chemical characteristics. The temperature and pH of the effluent were recorded at the time of sample collection, by using thermometer and pocket digital pH meter, respectively. Sulphate, turbidity, biological oxygen

demand, and chemical oxygen demand were estimated in the laboratory by standard methods (APHA 2005).

Preparation of material: The leaves of *Hibiscus rosa sinensis*, *Moringa oleifera, Pisum sativum,* and *Azadiracta indica* were freshly collected, cleaned, and dried in the shade, fine powder was prepared and stored in an air-tight container for further study.

Preparation of plant crude extract: The various plant extracts concentrations were prepared using 100 ml of 1M NaCl solution and the suspension was stirred using a magnetic stirrer for 15 min and filtered through Whatman paper No.3 to extract the coagulation active compound. Aluminium sulphate (alum) which was used as a control was prepared in different concentrations by dissolving in water.

Physio-chemical analysis of samples: The distillery effluent collected from the industries, was subjected to study of physio- chemical characteristics such as pH, turbidity, sulphate, BOD, and COD in the laboratory. Environmental agencies and analytical protocols, such as those by APHA (American Public Health Association) recommend storing wastewater samples at 4^0C to maintain integrity before analysis was followed. The samples were analyzed within 48 hrs after collection to ensure the accuracy and reliability of the results. The average value for every coagulant dosage was recorded based on three replications.

RESULTS AND DISCUSSION

Effectiveness of natural and chemical coagulants: The use of natural coagulants was more effective in treating distillery effluent compared to the chemical coagulant alum. Physio-chemical parameters before treatment is given in Table 1.

Table 1. Characteristics of distillery effluent before treatment

Parameters	Value
pH	7.71
Turbidity	1700 NTU
Sulphate	200 mg/l
BOD	14,500 mg/l
COD	37,060 mg/l

Turbidity reduction: Natural coagulant extracts of *Moringa oleifera, Azadirata indica and Hibiscus* resulted in the reduction in pH similar to that of alum. The initial turbidity of raw wastewater was 700 NTU. *Hibiscus sp.* and *Moringa oleifera* showed a similar turbidity reduction of 58% at an optimum dosage of 3g, outperforming alum, which achieved 56% reduction at the same dosage. *Azadiracta indica* reduced turbidity by 29%, while *Pisum sativum* was the least effective (Table 2). The reduction in turbidity increases with increased dosage up to optimal dosage and after that turbidity reduction decreases. When the coagulant concentration surpasses the optimum dosage no more colloids are free as they have been already neutralized into participates so excess coagulant will increase turbidity in water as no more opposite charged colloidal particles are available.

Biological oxygen demand: The high BOD levels in distillery effluent indicate limited oxygen availability for aquatic life. In distillery effluent, the amount of BOD was too high. *Hibiscus* and *Azadiracta indica* was best with 18% reduction in BOD reduction, which was similar to that of chemical coagulant alum. *Moringa oleifera* and *Pisum* reduced BOD by 7 and 4% respectively (Table 2).

Sulphate; The conventional alum showed just a 65% of reduction in sulphate (Table 3). It curbs sulphate in itself hence the reduction of sulphate is less when compared to *Hibiscus* and *Moringa oleifera* which showed 84% of sulphate reduction from the effluent followed by *Azadiracta indica* with 40% of reduction and *Pisum sativum* being the least.

Chemical oxygen demand (COD): COD is usually higher than BOD because more organic compounds can be chemically oxidized than biological oxidation, hence the distillery effluent had 37,060 mg/l of COD. *Hibiscus* exhibited 21% of COD reduction, which was better than Alum, which showed a 18% reduction followed by *M.oleifera* and *A.indica* with a 14% reduction, and *P.sativum* being the least with a 6% reduction (Table 3).

Table 2. Turbidity and BOD of distillery effluent treated with chemical and natural coagulant extracts

Coagulant	Various concentrations of plant extracts					
	1 g		2 g		3 g	
	Turbidity	BOD	Turbidity	BOD	Turbidity	BOD
Alum	1006.67±11.55	13466.67±57.73	900±0	11966.67±57.73	743±11.55	11566.67±57.73
Moringa oleifera	1000±0	12966.66±57.73	900±0	11966.67±50	711.67±10.40	11533.33±57.73
Hibiscus sp.	1166.66±57.73	13500±0	896.67±5.77	11933.33±57.73	711.67±10.40	11533.33±57.73
Azadiracta indica	1366.67±28.87	13516.66 ±28.86	1250±50	12966±57.73	1200±50	11850±50
Pisum sativum	1700±0	14266.66±57.7	1693.33±5.77	13916.66±76.37	1600±0	13633.33±57.73

Table 3. Reduction in sulphates and COD of distillery effluent treated with chemical and natural coagulant

Coagulant	Various concentrations of plant extracts					
	1 g		2 g		3 g	
	Sulphates	COD	Sulphates	COD	Sulphates	COD
Alum	79.67±0.57	31880±26.45	85±0.00	30360±10.00	86.67±2.89	29470±1.000
Moringa oleifera	46±1.73	31998.33±2.88	40.67±1.15	31967±15.39	33.33±2.89	30368.33±7.63
Hibiscus sp.	45±0	30450±50	40.67±1.15	29429.33±21.00	33.66±1.154	28470±26.45
Azadiracta indica	128.33±2.89	32033.33±57.73	119±1.15	31962±10.81	115±5	30433.33±28.26
Pisum sativum	200±0	35426.66±68.06	196.33±1.52	34790±10	191.67±2.88	33566.66±15.27

CONCLUSIONS

The study highlighted the effectiveness of *Hibiscus rosa-sinensis* extract as a natural coagulant, achieving significant reductions in BOD, COD, sulphate, and pH levels, followed by *Moringa oleifera*. The highest removal observed at a dosage of 3 grams per 100 ml of wastewater. The findings suggest that using plant-based extracts is more cost-effective and efficient alternative to chemical treatments for distillery effluents, allowing for significant reductions in treatment expenses.

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