RESEARCH PAPER

Wastewater treatment of sugar mill effluent using alumium chloride

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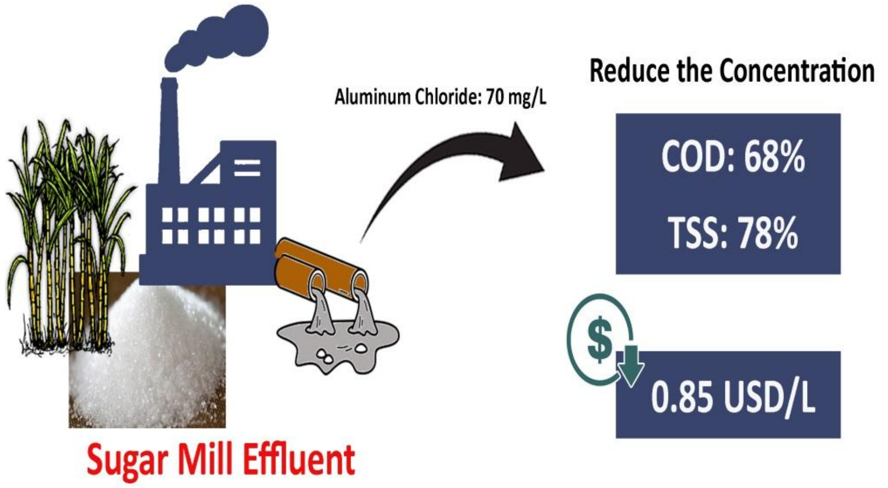
Highlights

- The disposal of industrial wastewater as untreated may create a great threat to the environment.
- The effluent of the sugar mill that is highly alkaline can adversely affect on the environment.
- The treatability performance of aluminum chloride has been applied and investigated.
- The optimum dosage of aluminum chloride (i.e., 70 mg/L), can significantly reduce the concentration of COD and TSS by 68 and 78%, respectively, at cost of 0.85 USD/L.

Graphical Abstract



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Abstract

The disposal of untreated industrial wastewater is posing a great threat to the environment, especially in developing countries. The effluent of the sugar mill is highly alkaline and polluted, thus adversely affecting the environment. Various attempts were done by previous researches, but were ultimately found to be uneconomical when applied on a larger scale. Therefore, this study was designed to investigate the treatability performance of aluminum chloride, as it is abundantly in the local market at a cheaper rate. The results of this study conclude that the optimum dosage of aluminum chloride, i.e., 70 mg/L, can effectively reduce the concentration of COD and TSS by 68 and 78%, respectively, at cost of 0.85USD/L.

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1. Introduction

The decline in surface water availability is a major problem in Pakistan. Unfortunately, the available water is also being polluted at an alarming rate, due to the disposal of untreated domestic and industrial effluent (Liu et al., 2020; Emmanuel et al., 2018). Since, industrial wastewater pollution is one of the major reasons for deteriorating the water resources water quality (Obropta et al., 2008). Therefore this study was designed to investigate the wastewater characteristics of the local sugar mill effluent, and to suggest a possible wastewater treatment option, in line with the available guideline, i.e. National Environmental Quality Standards (NEQS) of Pak-EPA (Cao and Zhang, 2006). This study was design with a main goal of developing low-cost economical wastewater system for the safe disposal of sugar mill effluent. The main objective of this study was to determine the most economical optimum coagulant dosage, i.e. of aluminum chloride, for the subject effluent treatment.

2. Materials and Methods

Wastewater samples were collected from the local sugar mill at regular intervals of time, to analyze its characteristics. pH, temperature, turbidity and TDS (Total Dissolved Solids), were determined at the site, whereas, for BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), and TSS (Total Suspended Solids) the sample was taken to the laboratory. All analytical procedures were conducted, using standard procedures, i.e. of the American Water Works Association (AWWA). The optimum dosage of aluminum chloride was extracted from the "Jar Test". The optimum dosage was later confirmed by using the principle of flocculent settling in a lab-scale sedimentation tank of 12cft (cubic feet) capacity (Sahu et al., 2018; Kadriu et al., 2016).

3. Results and Discussion

The wastewater quality analysis data obtained is given in Table 1. The results illustrate that the effluent of the sugar mill is highly alkaline in nature and rich in TSS concentration. Though, the pH is within the permissible limits of NEQS. But still it can affect the aquatic environment; it might decline the population of flora and fauna. The values of its BOD and COD are quite high, i.e., 940 mg/L and 1320 mg/L, respectively. The results obtained from Jar Test are illustrated in Fig. 1. Aluminum chloride ranging from 10-80 mg/L was used in this study (Murugan and Prabaharan, 2012; Xu et al., 2021a; Sharma and Simsek, 2020) (Fig. 1).

Table 1. Wastewater Characteristics of Sugar mill.

Ser#	Parameter	Unit	Result	NEQS	Remarks
1	pH	-	9.50	6-10	Permissible
2	Temperature	°C	27	<40	Permissible
3	Turbidity	NTU	580	--	Extremely high
4	BOD	mg/L	940	80	Beyond the limits
5	COD	mg/L	1320	150	Beyond the limits
6	TDS	mg/L	1194	3500	Within the limits
7	TSS	mg/L	920	150	Beyond the limits

The results show that more than 68% of Turbidity can be removed even with a small dosage, i.e., 10 mg/L. But, the corresponding COD removal at this particular dosage was observed to be hardly 56%. It was noticed that with the increase in the aluminum chloride dosage beyond 60 mg/L, there was an abrupt decrease in the removal efficiency of Turbidity. However, the COD removal efficiency was found to be gradually increasing with the increase in the concentration of the dosage. Since, the optimum dosage is extracted based on maximum Turbidity removal, therefore, in this study it was observed to be 50 mg/L. Corresponding to optimum dosage, i.e. 50mg/L, the removal efficiency in terms of COD, TDS, TSS and Turbidity removal was observed to be 68, 42, 78, and 82% respectively (Sangpal et al., 2011; Xu et al., 2021b; Yang et al., 2021; Mustapha and Omotoso, 2005).

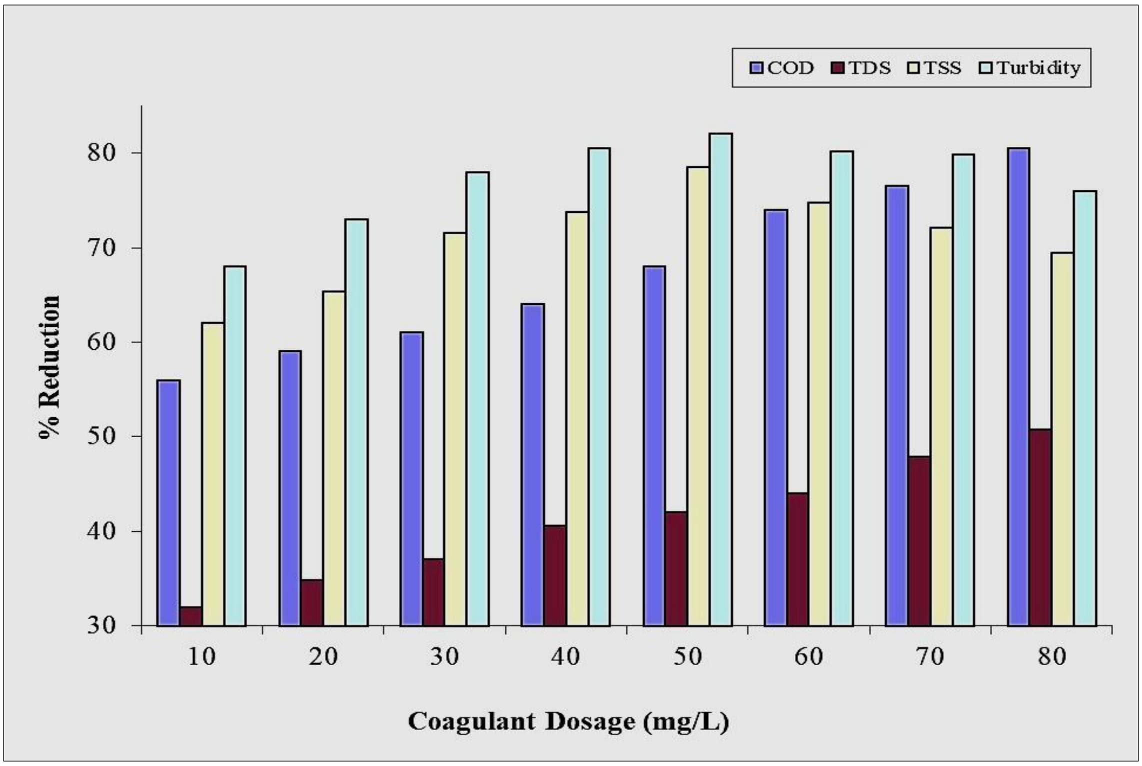

Fig. 1. Determination of optimum aluminum chloride dosage.

The optimum aluminum chloride dosage of 50 mg/L was confirmed by using a process of sedimentation in a tank of 12cft capacity. The results obtained are shown in Table 2. For economical sedimentation tank design, the hydraulic retention time was limited to 70 min. Reduction in the concentration of COD, BOD, TDS, and TSS at the effluent point of the sedimentation tank, was monitored at various retention times, ranging from 40-70 min. The amount of aluminum chloride was added at the influent point at the concentration of 50 mg/L.

Table 2. Flocculent Settling (Percentage Reduction).

Parameters	Values (mg/L)	Hydraulic Retention Time (min)			
		60	70	80	90
COD	1320	23	39	58	72
BOD	940	19	41	53	66
TDS	1194	11	14	17	20
TSS	920	44	66	79	83

The results indicate that there is a linear relationship between the hydraulic retention time and percentage reduction in pollutants. However, keeping in view the cost-benefit analysis the hydraulic retention time of 80 min was considered. Corresponding to this much hydraulic retention time, the percentage reduction in COD, BOD, TDS, and TSS was observed to be 585, 53, 17, and 79% respectively. The estimated cost calculated was 10.20 USD per day, for the wastewater flowing at the rate of 100 L/min (Sun et al., 2022; Wang et al., 2021).

4. Conclusion

Based on this study, the following results were obtained:

1) The sugar mill effluent is a major treat to the environment, based on its highly polluted wastewater.
2) Some of the main wastewater quality parameters, like BOD, COD, and TSS are beyond the limits of Pak-EPA i.e., NEQS.

3) The wastewater of the sugar mill effluent is highly alkaline, and the weighted average values of its BOD, COD, TDS, and TSS is found to be 940 mg/L, 1320 mg/L, 1194 mg/L and 920 mg/L, respectively.
4) With the help of 50 mg/L aluminum chloride, more than 68% COD and 78% TSS can be removed during flocculent settling at a hydraulic retention time of 70 min.
   The total operating cost of using aluminum chloride was estimated to be 0.85 USD/L.

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