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Treatment of Sugarcane Industry Waste Water by Combination of Chemical Coagulation and Activated Carbon

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Abstract. The study was designed to treat the effluent from sugarcane sector. The use of fresh water in sugarcane industry and result huge amount of waste water is not a secret to anyone. The use of chemicals in large quantities has caused a great risk and damage to the groundwater, soil, and aquaculture and ultimately leads to the destruction of our environment. Treatment of industrial sugarcane wastewater is not an easy task it has becomes a challenging task for environmental scientist. The purpose of our study is treatment, time saving and reuse for irrigation purpose. Coagulation with alum, ferric chloride, ferrous sulphate with combination of activated charcoal technique was used. The results of the study disclosed that COD and BOD were in huge amount and were successfully treated. Results of COD and BOD removal efficiencies were 51 and 28 mg/L, 76 and 42 mg/L, 90 and 52 mg/L by using alum, ferric chloride and ferrous sulphate respectively with combination of activated charcoal. After treatment, the effluent was very clear and met the requirements of National Environmental Quality Standards. Subsequently, using coagulation with combination of adsorption technique proved very effective, time saving, harmless technique for industrial sugarcane wastewater treatment.

Keywords: activated carbon, alum, BOD, coagulation, COD

Introduction

Water is a most vital and valuable source for all living organisms and also important role in environment. Because of rapid urbanization as well as industrialization, faced serious issues and challenges for its proper management of waste. Lack of resources, Interest less policies/planning are major reasons of pollution including discharging, industrial effluent freshwater. In developing countries (Kumar and Srikantaswamy, 2015). Untreated wastewater creates a lot of environmental problems such as water, soil and air pollution (Tanksali, 2013). Industrial and microbial activities are responsible of around 700 contaminants (Yang, 2011). It is reported in literature that by different coagulants *i.e.* alum, ferric chloride and ferrous sulphate can get better results on 6-8 pH, and best results were achieved for chemical oxygen demand and color by using the alum, ferric chloride and ferrous sulphate coagulants (Shammas *et al*., 2010). Adsorption by using activated carbon is the effective treatment technique and used successfully for sugarcane industry (Panhwar *et al*., 2020). (Hampannavar and Shivayogimath, 2010) reported that excess biological oxygen demand in sugarcane industrial effluent may cause dearth of the dissolve oxygen in freshwater reservoirs, which is harmful for human and aquatic life. Coagulation is an essential and effective step for different industries to maintain the environmental regulations (Sahu and Chaudhari, 2013). Adsorption technique is very useful for removal of the trace metals as well as organic pollutants (Devi and Dahiya, 2010; Parande *et al*., 2009). Often BOD, COD, SS, dyes and different toxic compounds contains in industrial effluents which affect our environment (Akyol, 2012). By alum can be removed a substantial amount of organic pollutants (Sahu and Chaudhary, 2013). Sugarcane industry's effluent is mostly disposed of on agricultural lands or in freshwater canals, while moving on land, part of pollutants in the effluent may be migrated and deposited between the gaps of soil stratum and adsorbed on the soil particles surface, resulting in pollution of soil. Furthermore, the migrated effluent flows through the gaps in the soil. Stratum and reaches the groundwater table, which may cause impact to the aquifer and thereby pose a potential risk to human health as well as the

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surrounding environment (Sivakumar, 2011). The effects of the pollution can be eliminated by waste assessment because waste assessment covers fibre and non-fibre waste (Hua *et al*., 2020).

Material and Methods

Chemical reagents and glasswares. The chemicals were obtained from Merck (Germany). Ultrapure water obtained from Milli purifier system (Millipore crop Bedford, MA, USA) was used throughout the study. Concentrated nitric acid and hydrogen peroxide were used for the digestion of samples. Standard solutions were prepared from stock standard solution and stored at 4 °C until analysis. Plastic and glasswares were cleaned by soaking in 2M of HNO_3 solution for over-night. Different sizes of beakers and flasks (volumetric and conical) pipettes, burettes, cylinders etc.

Sampling and its preparation. The effluent samples were collected in cleaned plastic bottles from the point of their discharge using standard procedures of sampling, and subjected to physico-chemical parameters by using standard procedures. As per moral obligation with the managements of the mills, the names and addresses of the mills are not mentioned in the paper. (Panhwar *et al*., 2019). Thirty samples were collected from ten different sugar industries units in triplicate and mixed as a composite sample for the evaluation of pollution strength. The composite samples were stored in clean plastic bottles at the 4 °C for maintain the chemical characteristics.

Experimental method. Measured wastewater 1000 mL was taken in a capacity of 2 L beaker. Alum, ferric chloride and ferrous sulphate were added as 100, 200 and 400 mg, to the samples. Stirring was done by using magnetic stirrer followed by sedimentation and filtered after settling, using Whatman 42 filter paper (Panhwar *et al*., 2020).

Measurement of physico-chemical parameters. The physico-chemical parameters *i.e*., BOD, COD were analyzed as per APHA (Table 1).

Statistical analysis. All experimental data were examined in triplicate and calculations (mean+std) were done by MS Excel.

Experimental section. *Coagulation process*. Based on the type of the industrial effluent it is very important to decide for which type of coagulant should be used before adsorption process. Understanding the nature of industrial effluent is an important for design of a suitable effluent treatment process, so it is necessary to ensure the safety, efficacy, quality of the treated wastewater.

Chemical coagulation. Treatment study was carried out to test the effectiveness of the various coagulants and dosing the samples with a range of various coagulants in different doses of 100, 200 and 400 mg/L. The coagulation was performed by mixing one liter of wastewater samples. After the addition of chemicals (alum, ferric chloride and ferrous sulphate) the waste-water was rapidly stirred at 200 rpm for five minute, 150 rpm for twenty five minutes and then slowly stirred at 80 rpm for more 30 min. The Wastewater was then allowed to settle for 60 min and then filtered by watsman 42 paper. After filtration, the samples were analyzed. The best results were achieved by using dose of 200 mg/L (Panhwar *et al*., 2020).

Column experiment. After chemical coagulation, the column/adsorption study was done. Column tests were performed to provide a real-life treatment process on laboratory scale using 5 g dose of activated carbon. Experiments were carried out in glass column having 75 cm length and 2.75 diameters (Panhwar *et al*., 2020). Adsorbent was filled in the column and at the top and bottom glass beds were filled for the supporting purpose, at flow rate 1000 mL/60 min (Patel and Painter, 2017).

Coagulation with aluminum salt. The most common and economical salt of aluminum is alum (Al_2 (SO_4) H_2O) and widely used as a coagulant in the water and wastewater treatment (Sahu and Chaudhari, 2013). The initial step is the chemical is added to wastewater; followed by the second step, where the solution is mixed

Table 1. Methodology of the study using standard procedures

Parameters	Unit	Instruments
Weight	g/Kg	Electronic balance EP214D OHAUS
pH	1-14	pH Meter (Mettler Toledo Seven Multi, Switzerland)
Chemical oxygen demand	mg/L	UV spectrophotometer (Thermo scientific, Model No. evolution 300)
Biological oxygen demand	mg/L	BOD5 track method Cooled incubator (Muve, Model) for BOD,

rapidly in order to make certain that the chemicals are evenly and homogeneously distributed throughout the wastewater. In the third step, the solution is mixed again, but this time in a slow fashion, to encourage the formation of insoluble solid precipitates, the process known as "coagulation." The final step is the removal of the coagulated particles by way of filtration or decantation (Yilmaz *et al*., 2007).

Results and Discussion

The coagulation technique with using alum, $FeCl_3$ and $FeSO_4$ is very effective for reduction of pollution from sugarcane industrial wastewater. The combination of activated charcoal with these three coagulants can enhance its efficiency. By using this combination achieved promising results. Activated charcoal effectively performs and removes organic pollutants. By coagulation with alum dose of 200 mg/L achieved impressive reduction (Table 2) and further treated by activated charcoal for COD and BOD respectively all results are showing in (Table 5), while results of ferric chloride were lower than alum, with same dose and the best results are in (Table 3), the samples were further treated by using of 5 g dose of activated charcoal for COD and BOD and got remarkable reduction in pollution load (Table 6), while the dose of 400 mg/L of ferric chloride could not produce better results as compared to dose of 200 mg/L, the minimal difference was recorded in (Table 3). The least reduction was observed by using ferrous sulphate for COD and BOD (Table 4). After addition of activated charcoal in combination of ferrous sulphate the removal efficiency improved (Table 7). The combination of alum and activated charcoal, proved more effective than combination of ferric chloride and

Table 2. Treatment of sugar mill effluent with different doses of alum

Parameter	NEQS	Before treatment	Alum (100 mg)	Alum (200 mg)	Alum (400 mg)
COD	150	1641 ± 33.4	459 ± 7.6	246 ± 2.72	240 ± 3.2
BOD	80	836 ± 11.5	242 ± 6.5	89 ± 2.8	89 ± 2.8

Different doses of alum 100, 200 and 400 mg/L were used and best results were achieved by using 200 mg/L dose, for COD and BOD respectively (Table 2).

Table 3. Treatment of sugar mill effluent with different doses ferric chloride

Parameter	NEQS	Before treatment	$FeCl_3$ (100 mg)	$FeCl_3$ (200 mg)	$FeCl_3$ (400 mg)
COD	150	1641 ±80	501 ± 20.2	261 ± 10.6	259 ± 17.7
BOD	80	836 ± 12.5	260 ± 16.8	120 ± 6.5	126 ± 6.9

Various doses 100, 200 and 400 mg/L of ferric chloride were used for obtaining good results. The best results were achieved on 200 mg/L dose for COD and BOD respectively (Table 3).

Table 4. Treatment of sugar mill effluent with different doses ferrous sulphate

Parameter	NEQS	Before treatment	$FeSO_4$ (100 mg)	$FeSO_4$ (200 mg)	$FeSO_4$ (400 mg)
COD	150	1641 ± 33.7	622 ± 38.2	156 ± 5.9	152 ± 5.6
BOD	80	836 ± 13.7	311 ± 18.4	189 ± 8.3	186 ± 8.2

100, 200 and 400 mg/L doses of ferrous sulphate were used for effective results and achieved best results by using dose of 200 mg/L for COD and BOD respectively (Table 4).

Table 5. Treatment of sugar wastewater with alum and adsorption

Parameters	NEQS	Before treatment	Alum (200 mg)	Activated charcoal (5 g)
COD	150	1641 ± 33.1	246 ± 8.4	51 ± 2.8
BOD	80	836 ± 12.7	100 ± 4.3	28 ± 1.2

The best results achieved by using alum, the samples were further treated by using activated charcoal 5 g dose (Table 5).

Table 6. Treatment of sugar wastewater with $FeCl_3$ and adsorption

Parameters	NEQS	Before treatment	Ferric chloride (200 mg)	Activated charcoal (5 g)
COD	150	1641 ± 33.4	261 ± 11.5	76 ± 3.3
BOD	80	836 ± 12.1	120 ± 6.8	42 ± 2.1

The results of 200 mg/L by ferric chloride were further treated with activated charcoal 5 g dose for best results (Table 6).

Table 7. Treatment of sugar wastewater with $FeSO_4$ and adsorption

Parameters	NEQS	Before treatment	Ferrous sulphate (200 mg)	Activated charcoal (5g)
COD	150	1641 ± 33.2	172 ± 7.5	90 ± 3.9
BOD	80	836 ± 12.9	189 ± 8.5	52 ± 2.2

The best results of ferrous sulphate by using 200 mg/L, further treated with activated charcoal 5 g dose for effective results for COD and BOD respectively (Table 7).

activated charcoal; whereas the least reduction was observed in combination of ferrous sulphate and activated charcoal for COD, BOD respectively. Using the coagulation and activated charcoal combination, very effective results can be achieved (Mayerly *et al*, 2018; Amerah and Mahdi, 2017; Khan *et al*., 2003).

Conclusion

Industrial effluent has becomes a great threat to our precious resource water as well as environment. It is a prime responsibility of environmental engineers to take efforts and make reusable the industrial wastewater for agriculture purpose. The ultimate goal of this study was to treat the sugarcane industry wastewater and protection of the environment. For this purpose the effluent from sugarcane industry was treated by different techniques such as coagulation with combination of activated carbon. Alum coagulant proved more effective which is easily available everywhere and cheapest coagulant than others. Using this technique achieved remarkable results upto 51 and 28 mg/L by using alum with combination of activated charcoal for COD and BOD respectively, while 76 and 42 mg/L results by using ferric chloride and activated charcoal, as well as 90 and 52 mg/L by using ferrous sulphate for COD and BOD and met the requirements of National Environmental Quality Standards and WHO/EPA standards for treated industrial wastewater reuse in agriculture. The treated water can be used in agriculture. From the above study, it can be said that by using this technique coagulation followed by adsorption with activated charcoal, the industrial wastewater can be treated very effectively using less space with time saving technique.

Conflict of Interest. There is no conflicts of interest among all authors.

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