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Treatment of industry wastewater using thermo-chemical combined processes with copper salt up to recyclable limit

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Abstract

Sugarcane is valuable crop of India and has a major role in foreign exchange. The aim of research work is to investigate the reduction of chemical oxygen demand and color from sugarcane industry effluent by thermolysis and coagulation method. The complete study was done in batch mode to determine the effect of operating parameters. The result shows maximum 73% of chemical oxygen demand and 76% color removal with copper oxide catalyst at 5 kg/m^3 massloading, 85 °C reacting temperature, 9 h treatment time and pH 8. Combined study showed 97.6% chemical oxygen demand and 99.9% color removal at pH 6.5 and mass loading 8 mM with copper sulfate salt. The settling and filtration was found to be good at 65 °C and 75 °C with copper oxide treated sugar industry wastewater.

Keywords: Catalyst; Destabilization; Inorganic pollutants; Sludge; Wastewater

1. Introduction

Worldwide water pollution is one of the serious problems. Rapid urbanization, industrialization and population growth have led to the severe contamination of most of the fresh water resources with untreated industrial and municipal wastes (Mane et al., 2015). According to built environment treatment and reuse of wastewaters has become an absolute necessity to avoid pollution of fresh water bodies (Shivayogimath and Jahagirdar, 2013). The design and operation of built environments have enormous implications for human health and social life. The aim is to develop affordable, appropriate, creative and innovative solutions for environmental quality standard, which minimize their negative impact on the environment, while maximizing positive economic and social impact. Such environment solution should prevent environmental degradation, and continue functioning into the future without depleting or overloading critical resources.

India is one of the largest producers and consumers of sugar per annum in the world (ISMA, 2014). During the processing nearly 1000 L of wastewater is produced for every ton of cane crushed. High oxygen demand sugar industry waste water lead to the depletion of dissolved oxygen content in the water bodies if discharged untreated, resulting in rendering the water bodies unfit for both aquatic and human uses (Qureshi et al., 2015). If untreated wastewater is discharged on land, decaying organic solids present in the wastewater clog the soil pores (Reddy

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et al., 2015). Hence purification of sugar industry wastewater is a challenging task due to the stringent discharge standards for the protection of environment. In literature different authors have reported the physico-chemical characteristic features of sugar industrial effluents, treatment and their adverse effects (Kumar and Srikantaswamy, 2015). Generally sugar industry effluent is treated by adopting various physico-chemical and biological methods (Santhanakrishnan and Emelda, 2013).

Chemical treatment is to provide a desired quality effluent at the required plant capacity with the most economical overall operation. The purpose of coagulation is to clump nonsettable particles together to form floc (Han et al., 2016). In the process, chemicals are added which will initially cause the colloidal particles to become destabilized and clump together. The particles gather to form larger particles in the flocculation process. When pieces of floc clump together, they may form larger, heavier flocs which settle out and are removed as sludge (Birjandi et al., 2014). Thermolysis is the thermodynamic process in which dissolved organic and inorganic substances of the waste water are decomposed by the heat and produced soluble, insoluble matters and gaseous products (Chaudhari et al., 2010). The reaction is usually endothermic (absence of air) as heat is required to break chemical bond of the compound undergoing decomposition at ambient temperature (Prajapati et al., 2015). Thermo-chemical precipitation of dissolved organics and some inorganics present in the wastewater remove the chemical and biological oxygen demand of the wastewater. Inorganic salts hasten the process of metal complexation and precipitation, just as coagulants/flocculants work at room temperature (Kondru et al., 2009).

The main aim of this work is to treat the sugar industry wastewater with copper catalyst and salt by combined thermolysis and coagulation process. The work focuses on the effect of pH, effect of mass loading, effect of temperature on pollution removal, settling characteristics, filtrations, FTIR and scanning electron microscopic study of generated sludge.

2. Material and methods

2.1. Material

The waste water was arranged from Bhoramdev Sugar Industry Ltd. Kavardha (C.G.) India. It was kept at kept at 4 °C in the freezer to prevent its quality from any change and the parameters are shown in Table 1. The laboratory grade chemical Merk India Limited Mumbai was used for experiment.

2.2. Experimental methods

A glass reactor was used for the thermolysis experiments at atmospheric pressure. This glass reactor (AGR) is a spherical vessel (capacity 0.5 dm^3) equipped with a PID temperature indicator cum controller, a long vertical condenser for condensing the vapor, and a magnetic stirrer with variable speed for stirring the reactor contents. The temperature of the reaction mixture during thermal pretreatment operations was maintained between 55 and 95 °C. The amount of wastewater ($COD_0 = 3682$ mg/l) taken in each run was 300 ml. The catalytic agents in desired concentration were used during the operation. Five milliliters of the sample was withdrawn at a definite interval of time and analyzed for its COD and color. The sugar industry wastewater was preheated in the AGR from the ambient temperature (T_0) to the treatment temperature (T_R). The preheating period (θ) varied with the T_R. Therefore, the time of start of treatment was considered as the "zero time" when the T_R was attained after the preheating of the wastewater from T_0. The oven-dried residue was analyzed for its C, H, N, S and ash content.

Table 1
Physicochemical characteristics of sugar industry wastewater.

S. No	Characteristics	Before treatment
1	Color	Dark yellow
2	pH	5.5
3	COD	3682
5	Phosphate	5.9
6	Protein	43
7	Total solid	1987
8	Suspended solid	540
9	Dissolved solid	1447
10	Chloride	50 mg/l
11	Hardness	900 mg/l

Except color and pH all values are in mg/dm^3.

Coagulation method is carried out in Jar test apparatus 0.20 dm^3 of SIWW was taken in a 0.50 dm^3 glass beaker. The pH of the effluent was noted and the initial pH (pH_0) was adjusted by adding aqueous NaOH (1 M) or H_2SO_4 (1 M) solution. A known amount of the coagulant was added to the effluent and flash-mixed for 5 min by a magnetic stirrer and, thereafter, slowly mixed for 30 min. The effluent sample was then taken in a glass cylinder and kept quiescent for 6 h. The supernatant liquor was centrifuged and analyzed for its COD value. These steps were repeated at different dosages of the coagulant. The filtration characteristics of the solid residue formed in the treated effluent was studied using an ordinary zero haze grade. The combined steps followed to treat the sugar industry waste water are shown in Fig. 1.

2.3. Analytical procedure

The COD of the samples was determined by the standard dichromate reflux method (Holt et al., 1999). The chloride concentration was determined by the standard titrimetric Volhard method (Vogel, 1958). Sulfates and the phosphates were determined using standard methods (Holt et al., 1999). The concentrations of the metal ions in the filtrate and the residue were determined using an

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