International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.07 pp 318-323, 2016

Treatment of Activated Sludge Lagoon Inlet Wastewater in Pulp and Paper Industry

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Abstract : Pulp and paper industry releases a huge volume of wastewater and it pollutes the environment. The pollution problems related to this type of industrial wastewater are mainly due to color, toxicity and odor. The removal of chemical oxygen demand (COD), biochemical oxygen demand (BOD), color and total suspended solids (TSS) of the wastewater is studied using coagulants like Ferrous sulfate, Alum, medium and high basicity of Polyaluminium chloride (PAC). At the optimized pH attained from these coagulants using to treat the wastewater, the flocs formation / settling and the pollutant removal efficiency is encouraging. The resulting color of the wastewater during Ferrous sulfate treatment is very effective for this wastewater is very effective compared with others. The reduction efficiency of color, TSS, COD and BOD_5 of the wastewater is 91%, 81%, 76% and 65% respectively.
Keywords : BOD_5, COD, coagulation, pulp and paper mill, wastge water.

Introduction

Pulp and paper industry consumes large quantities of water for its pulping processes and paper production. This type of industries has been associated with a variety of potential environmental problems, due to the high chemical diversity of the organic pollutants in the wastewater. The outlet of the pulp and paper mill effluent contains a considerable amount of toxic compounds to the environment. The chemicals and energy can be recovered through recovery boilers from the black liquor, which comes from cooking stage in an integrated pulp and paper industry. But during the bleaching process, it releases numerous numbers of organic compounds like organic acids, resin acids, chlorinated lignins, unsaturated fatty acids, phenolic compounds and terpenes in its wastewater. This wastewater can cause significant damage to the receiving bodies if discharged untreated. Unlike fresh water, pulp and paper mills wastewater contains fiber and can cause unique solid/liquid separation challenges. Most solid/liquid separation systems have difficulty operating when the requirements are to produce high quality water, to remove fine particles, to operate continuously and remove high quantities of fiber. Chemical coagulation is a probed technique for the treatment of high suspended solids wastewater, especially those formed by colloidal matters. Research and practical applications have shown that coagulation will lower the pollution load and could generate an adequate water recovery[1-5]. Much research has concluded that coagulation is an efficient and cost effective method for water and wastewater treatment[6-9]. Also this method gives the best, result in short reaction time when compared with biological treatment. During organics containing wastewater treatment through biological method, color commonly increases throughout the treatment systems, which may be due to the organic material being converted into smaller chromophoric units rather than being mineralized[10].

The use of Inorganic metal salts for coagulation process has been well documented. Pradeep Kumar et al[11]. has investigated PAC is found to be a better coagulant in comparison to Aluminium chloride and copper sulfate. The maximum COD and color removal of at pH 4 is 84% and 92% respectively were obtained using PAC as compared to 72 % and 84 % with Aluminium chloride at pH 5 and 74 % and 76 % with copper sulfate at pH of 6.

Robert J. Stephenson et al[12]. observed that color and COD removal of combined bleached chemi thermo mechanical/ thermo mechanical effluent is 90% and 98% respectively, when the use of both chloride and sulfate salts of iron and aluminum. Meena Solanki etal.[13] had investigated PAC is found to be a good coagulant for high organic textile wastewater. They observed that the sludge volume generated by PAC is less than that generated by alum and the removal efficiency of BOD, COD and TDS is 83.34%, 64.04% and 62.97% respectively when pH adjusted 6.2 to 6.9.

W. Chen and N. J. Horan[14] investigated that remove 70% of the COD and 90% of color using alum from the effluent of an activated sludge plant treating paper mill wastewater. Most of the researchers found COD and color removal using methods like electro coagulation, fungal treatment, chemical oxidation, and ozonation. Deepak Sharma[15] studied that the treatment of pulp and paper effluent by electro coagulation. He found that the reduction of color, COD and BOD is to be 92%, 89% and 85% respectively under optimal operating condition such as 25mA/cm^2 current density, pH of 7, 1 g/L NaCl, 100 rpm, 28°C temperature and 1.5 cm electrode distance.

Coagulation/ flocculation is not only the economic but also the effective method for removal of COD and color from pulp and paper mill wastewater. The treatment using this method is now fashion because of the processes is a promising way of removal of pollutants in short reaction time. In this present work, the wastewater treated with various coagulants and found the optimum dosage of suitable coagulant for this wastewater to improve the effluent treatment plant (ETP) performance.

Experimental

The pulp mill and paper machine mixed wastewater sample collected from an integrated pulp and paper mill, Tamilnadu, India. The wastewater sample was collected from combined outlet streams before going to Activated Sludge Lagoon (ASL) unit (Fig 1) without addition of any specialty chemicals. The sample was characterized and the physico-chemical analysis was performed by using prescribed Indian Standard IS 3025 standard methods are given in Table 1.

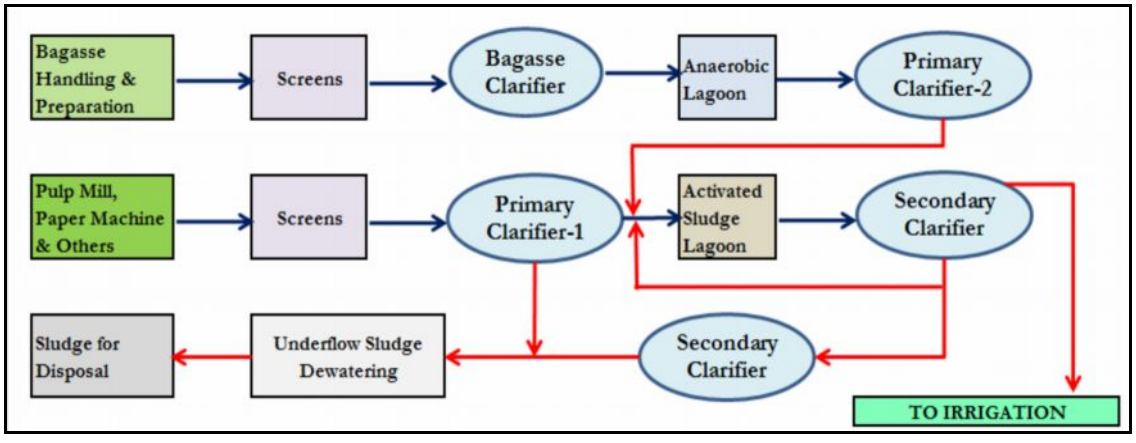

Figure 1 Effluent treatment plant layout

Jar test procedures carried out using 1000 ml of the pulp and paper mill wastewater samples with the various dosages of selected coagulants like Ferrous sulfate, Alum, medium and high basicity PAC (PAC_{MB} and PAC_{HB}) with. The basicity of PAC_{MB} and PAC_{HB} were 40.5% and 73.3%. The selected coagulants were added to 1000 ml of wastewater and it was stirred for a period of 5 minutes at 100 rpm and it was followed by further slow mixing of 2 minutes at 50 rpm. The flocs formed and settled within 45 minutes for the iron salts treatment and approximately 5 hours for PAC treatment. After settling, the pH, Color, COD, BOD and TSS were

analyzed. The analysis was repeated for 10 days for getting average values using Indian Standards IS 3025 standard methods.

Results and Discussion

The coagulant was chosen by depends on the nature of pollutants presents in effluent. Normally pulp and paper mill has strong anionic nature due to the major source of lignin/ chromophore derivatives contained pulp mill bleach effluent. The wastewater treated with optimum dosages of coagulants in milli grams per one litre of the wastewater sample have been shown below in Table 1.

Table 1 Physico- chemical characteristics of the untreated and treated wastewater sample

Particulars	Untreated wastewater	Treated wastewater with optimum dosage of coagulants			
		$FeSO_4$	Alum	PAC_{MB}	PAC_{HB}
pH	8.1	7.3	6.6	5.5	5.6
Color, PtCo	1020	95	150	200	180
TS, mg/L	3949	2422	2740	2684	2576
TDS, mg/L	2266	2103	2200	2200	2144
TSS, mg/L	1683	319	540	484	432
COD, mg/L	598	141	178	169	161
BOD_5, mg/L	119	42	59	50	50

For treating this wastewater of one litre, the optimum dosage of the $FeSO_4$, alum, PAC_{MB} and PAC_{HB} is 300 mg, 220 mg, 180 mg and 190 mg respectively. Treating the wastewater using Ferrous sulfate, the reduction efficiency of color, TSS, COD and BOD_5 is 91%, 81%, 76% and 65% respectively at the optimum pH of 7.3. When treating with alum, at pH 6.6, the color, TSS, COD and BOD_5 is 81%, 68%, 70% and 50% respectively. Not much difference reduction efficiency between medium and high basicity PAC, during the treatment of this wastewater. The maximum reduction efficiency of color is 82%, 74%, 73% and 58% respectively.

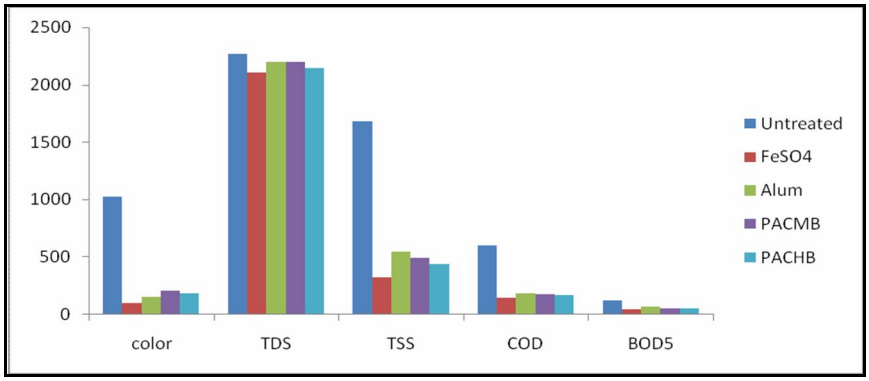

Figure 2 Reduction efficiency of the selected coagulants

Effect of coagulants:

The selection of coagulation is one the most important decision for the wastewater treatment. In this study, the Frrous sulfate coagulant is very effective when compared with Aluminium salts. The pH of the wastewater plays an important role when Aluminium and Iron salts are used for coagulation process. Ferrous sulfate is particularly applicable for decolorization and COD removal, and for ferrite co-precipitation in wastewater. Hydrolysis of $FeSO_4$ during coagulation results in the formation of corresponding gel like hydroxides and some positively charged mononuclear and poly-nuclear species. The precipitation of an amorphous hydroxide, which can play a very important role in coagulation and flocculation processes. Positively charged precipitate particles may deposit on contaminant particles (heterocoagulation), again giving the possibility of charge neutralization. In this case, these positively charged compounds combine with

negatively charged colloidal particles present in the pulp and paper mill wastewater by charge neutralization mechanism. At the time of settling under gravity these hydroxides and complexed hydroxides sweep away remaining uncharged/ charged colloidal particles of the wastewater with them and precipitate out.

When the use of Aluminium species in coagulation processes, the aqueous chemistry of aluminium is complex and upon the addition of an aluminium coagulant in water treatment, multiple reaction pathways are possible. The mechanisms by which aluminium functions depend on aluminium species react to remove dissolved or colloidal contaminants. For aluminium salts, the mechanism of coagulation is controlled by the hydrolysis. The coagulation process with alum as the sole coagulant is capable of achieving significant color and COD removal. The pH of the water during coagulation has profound influences on the effectiveness of coagulation for color, TSS, COD and BOD_5 removal.

From this result, the treatment with Ferrous sulfate giving a good results when compared with Aluminium compounds. Because the iron species may attract with negatively charged molecules present in the wastewater. Moreover sulfate radicals (SO_4^{2-}) are more reactive anion radical, and can therefore take part in the removal of pollutants like chloro organics. One more important thing, during the treatment of this wastewater, the TDS levels are maintained in the same trend and not much enhanced due to the raw material selection for this wastewater treatment and found the optimum dosage.

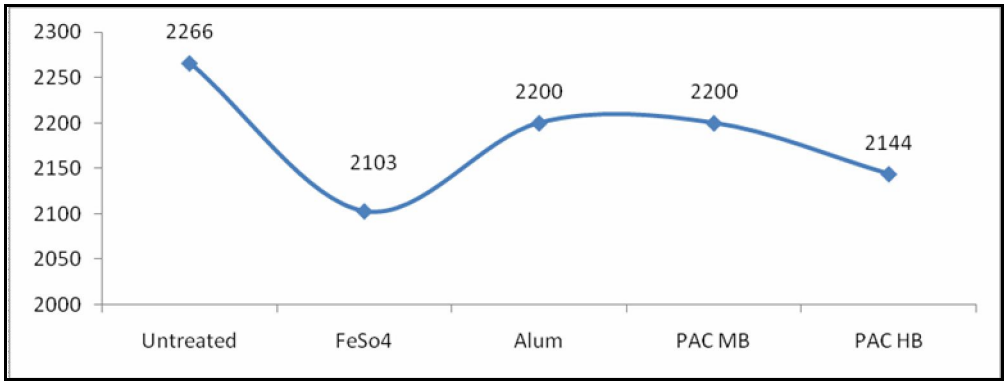

Figure 3 TDS (mg/L) level during the treatment of wastewater

Conclusion:

The purpose of this work to overcome the problem of disposal of colored high strength wastewater released from integrated pulp and paper industries. This particular work achieved by reducing the TSS, color, COD, BOD_5, from the wastewater can be highly appreciable and valuable along with it is applicable for pulp and paper industries. Moreover the same work highly useful to come out from the problem of TDS of the wastewater during treatment. During the treatment of this wastewater, the results show that the highest reduction efficiency achieved in Ferrous sulfate when compared with Alum and PAC compounds. Because the maximum reduction efficiency was achieved in Aluminium salts like Alum, PAC_{MB} and PAC_{HB} is slightly acidic. It may corrosive nature at the optimum dosage. Optimum dosage at nearby neutral pH of the iron salt is found most suitable coagulant for this wastewater stream. Moreover the cost of iron compounds may often be less than that of Aluminium salts. So adding the Ferrous sulfate to the inlet of ASL, to reduce the pollution load and improve the ETP performance of pulp and paper industry.

Acknowledgement:

The authors are thankful to Mr. Maruthaiya, Senior Manager (R&D and Environment) for providing the raw materials facility for this work.

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