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"Effect of thermal Energy on Artificial Coagulation for the Treatment of Wastewater"

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Abstract—*Coagulation is regarded as one of the predominant wastewater treatment processes which improve the cost effectiveness of wastewater. The sole purpose of this experiment on thermal coagulation by alum was to increase the efficiency and the rate of reaction. The process used thermal energy as a medium, which improve and minimize time in industrial wastewater treatment. The coagulation was done with the mix of bottom/fly-ash and aluminium sulphate. The aluminum sulphate act as a coagulant agglomerate the colloidal particles and Fly ash acts as an adsorbent and settled down most of the minor and macro particles by means of adsorption which not only helped to reduce the environmental burden of fly ash but also enhance economic benefit. The hostel wastewater was used for the entire study. The initial turbidity of the wastewater was 248 NTU, initial pH 9.01 and initial temperature was 27^0 C-30^0 C. The temperature variation of the entire process was 50^0 C- 70^0 C. The concentration of alum in wastewater was varied from 60mg/L-240mg/L. The turbidity was 13.3 NTU, pH was 7.73, and total time duration is 10 minutes for an alum dosage of 240 mg/l. The results indicated that the presence of thermal energy affect the coagulation treatment process. The performance of the coagulant under thermal conditions for the removal of turbidity was studied by means of jar test apparatus using wastewater as model raw water.*

Keywords: *Thermal coagulation, Turbidity Adsorbent, Fly Ash and Bottom Ash.*

1. INTRODUCTION

Coagulation in combination with flocculation and sedimentation is a process that is commonly used in water treatment to remove undesirable contaminants, such as natural organic matter. One of the most common used coagulants is alum, $Al_2(SO_4)_3{\cdot}14H_2O$.The optimal alum dose would result in better contaminant removal and less alum residues, producing a clean effluent water with minimal costs associated with coagulant addition and sludge handling.

Wastewater Treatment Consideration-Up to 70% of influent chemical oxygen demand (COD) in municipal wastewater is attributable to particulate matter larger than 0.45 m [1]. Thus,it is of interest to explore the development of a treatment strategy for the enhanced removal of suspended and colloidal solids from wastewater.

Wastewater treatment is a. extensive matter of particle separation. This has led to the strategy of removing particulate and colloidal matter in the primary stage and thereafter dealing with soluble compounds that need to be transformed to colloidal matter and particulate matter (e.g. bacteria) before they are finally separated [2]. Hence we considered the variation of different parameters on the basis of thermal energy provided to the wastewater vessel and the effect of energy on breaking down of organic and biological matters present in the wastewater sample.

On heating solutions of industrial wastewater, as the temperature rises, an irreversible change of state occurs so called "heated coagulation". Similarly, in the case of most proteins endowed with active physiological properties(e.g. - ferments, toxins, lysine, complements etc.) at or about a particular temperature these properties are destroyed [3].

The bottom/fly-ash used as an adsorbent will remove most of the bigger size particles by the means of adsorption and then removal of these waste particles by the process of filtration. Most of the particles like biological or organic impurities will degrade at a suitable temperature and then it will break down.

This research is undertaken to investigate the use of thermal; energy as an effective medium for treating industrial wastewater to obtain treated water free of suspended solids, turbidity and colloids which is suitable after filtration.

2. EXPERIMENTAL METHODOLOGY

2.1 Preparation of Coagulant stock solution.

2.1.1 Alum stock solution

Aluminium Sulphate (Alum) $Al_2(SO_4)_3$ used in this study was supplied by SDFCL(S Define chem. Ltd) Mumbai, India. A 2% solution of alum in distilled water was made (2 g of alum in 100mL of distilled water). The alum was entirely soluble at this concentration. The chemical leaves no residual color, offers very good turbidity removal.

2.2 Experimental Procedure

2.2.1 Chemical Coagulation experiments

Chemical coagulation was evaluated using an adaptation of the standard jar testing technique [4], with AR grade (99.8% pure) aluminum sulphate as the chemical coagulant [5]. Initial speed is such maintained that the paddles rotate at an angular velocity of 100 rpm for a time of 1-2 minute and further at angular velocity of 40 rpm for 8 minutes. The beakers are allowed to settle down for 10 minutes.

The wastewater samples were collected from the treatment plant in Pandit Deendayal Petroleum University, Gandhinagar, Gujarat, India. The characteristics of the wastewater are defined as follows:

Parameter	Indicative Value
pH	9.01
Turbidity	248NTU
COD	457 mg/L

1 L Beakers were used in standard jar and test apparatus. The initial stage of treatment involved the mixing of 3g of carbon-bottom ash into 1 L of waste water and then stirring it up for a proper mixing around 20 rpm.Then the sample was heated to around 50 to 80 degree Celsius. The sample is then poured over the sand filled square filter for removal of large particles or impurities by filtration. Addition of coagulantwas done in the proportion to heating.Then the particles we allowed to mix and settle down in the tank for some by the formation of flocks in it.The bottom sludge was taken out and the remaining water was piped to the fly ash pore filter chamber where the water will be filtered drop by drop through numerous pores of diameters in microns (specially designed). The treated water is again checked for turbidity.If less than 10NTU it can be used for agricultural irrigation, domestic purposes and other non-potable uses. If not, go for heated sand filtration.Then again we go for filtration through dripping, by porous flyash chamber. This is indicated in the line diagram and the figure below.

3. RESULTS AND DISCUSSIONS

In this study aluminium hexahydrate ($Al_2(SO4)_3.16H_2O$) was used as a coagulant to study the time relationship with the coagulation treatment process. The purpose of coagulation and flocculation is to transform small colloidal or suspended impurities into bigger aggregates under the thermal condition such that there was a reduction in total treatment time and to make the removal of aggregate easier.[6,7] It has been reported in the literature that the optimum coagulation pH for aluminium sulphate is between 5 and 6.[7]

Three types of aluminium dosage were used as a basis for comparing the effective use of alum as coagulant and the effect of heating the wastewater.

3.1 As per the coagulation through ALUM we have the following variations.

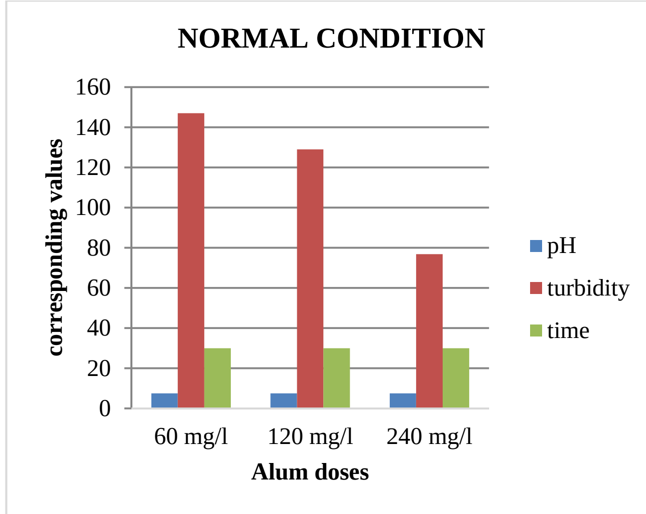

Fig. 1: Comparison of different Alum dosage at 27C-30C

Fig 1 gives the variation of alum dosage added in the wastewater. It shows that with the increase of alum dosage there was a decrease in turbidity and PH. The percentage decrease in the pH is 0.4 and the final ph obtained was 7.49 after the coagulant dose of 240 mg/L which is considerably high. The turbidity decreased by approx. 50 percent. This happens because most of the colloidal impurities are negatively charged and thus stable due to electrical repulsion. Destabilization can be achieved by the addition of chemicals that the water generate cations but can neutralize the charge of the particles. Aluminium based coagulants are widely used because they produce highly charged cations in water. [7, 8]

Table 1: comparison of different dosage of alum at 27C-30C.

Concentration	pH	Turbidity(NTU)	Time(Min)
60 mg/L	7.52	147	30
120 mg/L	7.50	129	30
240 mg/L	7.49	76.8	30

3.2 Thermal effect on coagulation treatment of wastewater.

Fig 2 shows the variation in turbidity, pH and time due to the application of thermal energy. Application of thermal energy shows that the time required for stabilization and settling of colloidal particles decrease by 3 times to 10 minutes as compared to the standard treatment process at the temperature of 27^0C and 30^0C which took 30 minutes. The increased temperature was 50^0C-60^0C. Thermal energy is used to break down the Natural Organic Matter (NOM) present in the wastewater. This increases the efficiency of the coagulants in settling down the charged and colloidal particles

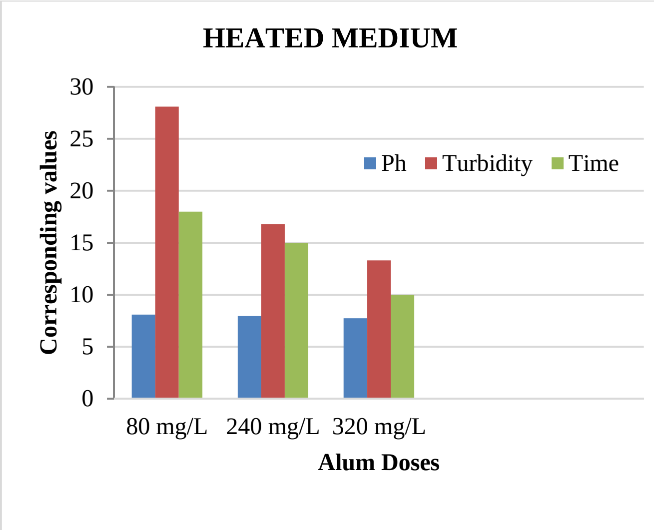

Fig. 2: Effect of heating on turbidity, p H and time at the same alum dosage

Table 2: comparison of different dosage of alum under thermal condition.

Concentration	pH	Turbidity(NTU)	Time(Min)
60 mg/L	8.29	24.1	18
120 mg/L	8.01	22.8	15
240 mg/L	7.75	11	10

4. CONCLUSIONS

In the wastewater treatment sequence investigated viz. Adsorption, sedimentation, coagulation under thermal conditions,the maximum overall removal of 50% COD is obtained with the coagulant combination of 240mg/L of alum. The majority of the turbidity is decomposed by the effect of the thermal energy. Furthermore, removal is evident during the adsorption and filtration process. Future work is planned to further more explore this area by undertaking laboratory study of direct and dual filtration of wastewater as an effective primary treatment step before colloidal stabilization

This process will help in the faster or rapid treatment of the industrial wastewater which contain certain amount of thermal energy within itself, hence increase the efficiency and productivity of the wastewater treatment plant.

This experiment showed a variation in the wastewater treatment process where the time interval was reduced by three than the actual time required for the coagulation treatment process. Also there was a considerable decrease in the turbidity as under standard condition the turbidity obtained on optimum doses of 240 mg/L was higher than what we obtained under thermal conditions.

The results obtained showed an incredible amount of decrease in the pH, Turbidity and removal or other foreign materials present in the water sample.

5. ACKNOWLEDGEMENTS

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