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Coagulation and Flocculation of Industrial Wastewater by Chitosan

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Abstract— **While Textile Effluent is discarding in to the nearby water bodies becomes a significant threat to Environment mostly to the aquatic life. The objectionable properties like turbidity, strong color, strong odor, toxicity and alkalinity etc. Coagulation and flocculation is simple and rapid technique. This is most often used pretreatment technique to treat the effluent. Aluminum sulfate (alum), ferrous sulfate, ferric chloride and ferric chloro-sulfate were commonly used as coagulants. However, a possible link of Alzheimer's disease with conventional aluminum based coagulants has become an issue in wastewater treatment. Hence, special attention has shift towards using biodegradable polymer, chitosan in treatment, which are more environmental friendly. Moreover, chitosan is natural organic polyelectrolyte of high molecular weight and high charge density which obtained from deacetylation of chitin. The experiment was carried out on textile industry wastewater by varying the operating parameters, which are chitosan dosage, pH and mixing time in order to study their effect in flocculation process by using chitosan.**

Index Terms— **Coagulation, Flocculation, Effluent, Suspended Solids.**

I. INTRODUCTION

Textile effluents are becoming a major threat to the environment mostly to the aquatic life, when it is discarded into nearby water bodies. Textile effluent have so many offensive properties like strong odor, strong color, Turbidity, alkalinity, Toxicity etc. The increase in the content of these objectionable properties results into adversative effects which influences the aquatic life of water bodies. Decrease in the dissolved oxygen content, excess growth of algae etc. are the adverse effects. So treating the textile effluent becomes necessary in order to reuse the water, either to domestic purposes or for industrial jobs. Dye is the important constituent used in the textile industries. The dyes possess so many potential health hazards like carcinogenic and mutagenic in nature. The dye removal becomes a critical part of effluent treatment. Among the available treatment techniques, Coagulation and flocculation is simple and rapid technique and the most often used pretreatment techniques for treating the textile effluent.

Coagulation and flocculation technique is well known for its operation and its maintenance. The choice of coagulant aids based on suitability of particular waste, availability and the cost of coagulant. Normally, the coagulants used were alum, polyelectrolyte and lime. The main flocculation not only used for the dye removal but also heavy metal removal. In the current study coagulation and flocculation was performed as a treatment technique to remove the turbidity, its odor and its color from the taken textile effluent.

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II. MATERIALS AND METHODS

2.1 Preparation of Chitosan Powder

Chitosan mainly available in shrimp shells of prawn, crab shells. Some of mushrooms also contain chitosan. Due to more availability of prawns, we use prawn shells for the preparation of chitosan powder. Different industries use different methods for production of chitosan powder. Among all the methods we find a simplest method for production of chitosan powder depending on lab scale requirement. In this method there is no need of complex equipment for the preparation of chitosan. According to this method, the preparation of chitosan involves 4 steps.

1. Preconditioning

The required amount of shrimp shells (including head and outer skeleton), which is obtained from prawns. Then these shrimp shells were allowed to soak in 0.05M acetic acid solution for 24 hours at ambient temperature (approximately 30^{o} C). Then shells were washed thoroughly with water and dried to remove excess water. Finally, weigh the amount dried shells obtained.

2. Demineralization

The dried shells obtained after preconditioning stage, were demineralized using 0.68M HCL (hydrochloric acid) (1:10 w/v) at ambient temperature (approximately 30^{o}C) for 6 hours. Then the residue was separated and it was washed with distilled water until pH in the range of 6.5 - 7.5 was obtained. Finally, the residue was dried and weighs the amount residue obtained.

3. De-protenization

The dried material obtained from demineralization step were deprotenized using 0.62M NaOH solution (1:10 w/v) at ambient temperature (approximately 30^{o} C) for about 16 hours. Then the residue was separated and it was washed with distilled water until pH in the range of 6.5 - 7.5 was obtained. The useful product obtained in this process is known as "chitin" The chitin was dried and ground and screened with 150μm sieve. Finally, weigh the amount of chitin obtained.

4. De-acetylation

The chitin obtain from the de-protenization step was de-acetylated in 25M NaOH (1:10 w/v) for about 20 hours at 65^{o} C. Then the residue was separated and it was washed with distilled water until pH in the range of 6.5 - 7.5 was obtained. The useful product obtained in this process is known as "chitosan" The chitosan was dried and weigh the amount of chitosan obtained.

III. EXPERIMENTAL PROCEDURE

3.1 Sample collection and materials

Sample of textile waste water was collected from a textile company nearer to Guntur, Andhra Pradesh, India. The sample had been stored in the refrigerator in order to minimize the changes in the characteristics of wastewater sample since it may vary from day to day. Chitosan obtained from shrimp shells of prawn in powdered form is used as coagulant. Prepare the Chemical Oxygen Demand (COD) reagent for the determination of COD of sample waste water and treated water after the process of coagulation and flocculation at every parameter study experiment.

3.2 Coagulant preparation

Stock solution of chitosan should be prepared before starting the experiment. 3g of chitosan which is obtained from de-acetylation of chitin in the form of white fine powder was used. Then 96 gm of distilled water and 1g of acetic acid were added in order to dilute the chitosan powder. The purpose of addition of acetic acid, because chitosan dissolved in acetic acid, was used in the coagulation and flocculation processes. Chitosan is soluble in acidic solution, which makes it more available for application. Therefore, acetic acid needs to be added in order to dilute the chitosan powder. After the addition of distilled water to chitosan powder, there is no solubility of chitosan powder in water was observed. So, for dissolving and dilution purpose we use acetic acid solution.

IV. Results & Discussion

4.1 Effect of Mixing Time

Comparing with the effect of chitosan dosage and pH, mixing time play an important role on flocs formation and growth in flocculation process. Polymeric flocculent disperses throughout the medium and adsorbs on the colloidal particle surfaces for inter particle bridging or charge neutralization during the mixing period. Besides, longer mixing time will lead to an increase in flocs breakage. Hence, it decreases the flocculation rate. On the other hand, if the mixing time is too short, the collisions between the flocculants and colloids are not efficient to precipitate suspended solids in wastewater. Thus, the flocculation rate is not optimum under this condition. Therefore, a study was conducted on the effect of mixing time in flocculation. The effect of mixing time was analyzed at chitosan dosage 30 mg/l and maintain constant pH of 4 with 175 rpm of mixing rate (rapid mixing) for 10 minutes and 30 minutes of settling time.

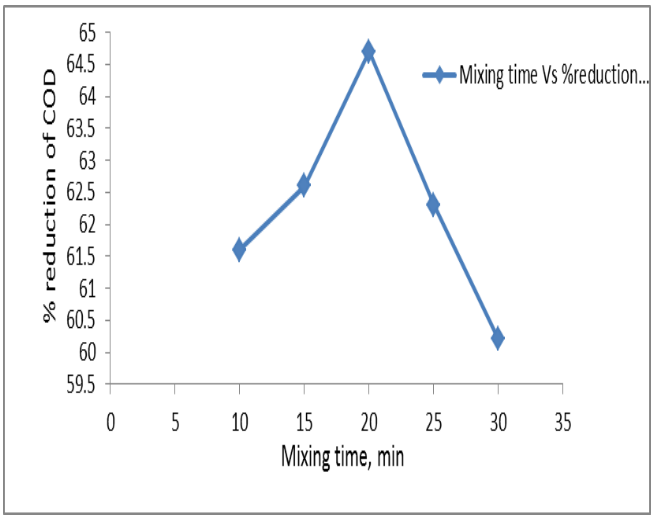

Figure 1: % reduction of COD with mixing time

From the above figure 1 the mixing time between 10 – 20 minutes the % reduction of COD increases. After that i.e. 20 – 30 minutes the % of COD reduction decreases due to moderate performance of chitosan for binding and bridging of colloidal particles i.e. restabilization of colloidal particles takes place. The optimum mixing time for effective coagulation and flocculation process is 20 minutes.

4.2 Effect of chitosan dosage

Dosage was one of the most important parameters that been considered to determine the optimum condition for the performance of chitosan in coagulation and flocculation. Basically, insufficient dosage or overdosing would result in the poor performance in flocculation. Therefore, it was crucial to determine the optimum dosage in order to minimize the dosing cost and obtain the optimum performance in treatment. The effect of dosage was analyzed at pH 4, 175 rpm of mixing rate for 10 minutes and 30 rpm of mixing rate for 20 minutes (optimum mixing time) and 30 minutes of settling time for a range of chitosan dosage which varied from 12 mg/l to 66 mg/l. Besides, the sample of wastewater was adjusted from the initial pH of 8.9 to pH 4 due to chitosan was soluble in acidic aqueous phases. After the completion of jar test, COD of every sample in beakers of different chitosan dosage were determined.The variation of COD with chitosan dosage and pecentage reduction of COD with chtosan dosage are shown in figure 2.

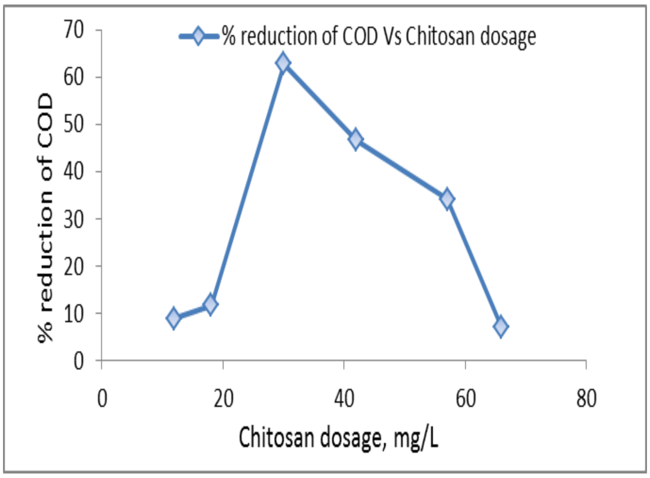

Figure 2: % reduction of COD with Chitosan dosage

From the above figure 2 chitosan dosage between 12 mg/l– 30 mg/l, % reduction of COD increases. From 30 – 66 mg/l, the % reduction of COD decreases due to electrostatic repulsion of colloidal particles based on charge density effect. The optimum chitosan dosage for effective coagulation and flocculation process is 30 mg/L.

4.3 Effect of pH

The pH will not only affects the surface charge of coagulants, but also affects the stabilization of the suspension. Besides, the solubility of chitosan in aqueous solution is influenced by pH value. Therefore, the study of pH was essential to determine the optimum pH condition of the treatment system. The effect of pH was analyzed at optimum dosage 30 mg/l, with 20 minutes of mixing time, 175 rpm of mixing rate for 10 mins & 30 rpm of mixing rate for 20 - 30 mins of settling time for a range of pH which varied from pH 2 to pH 10.

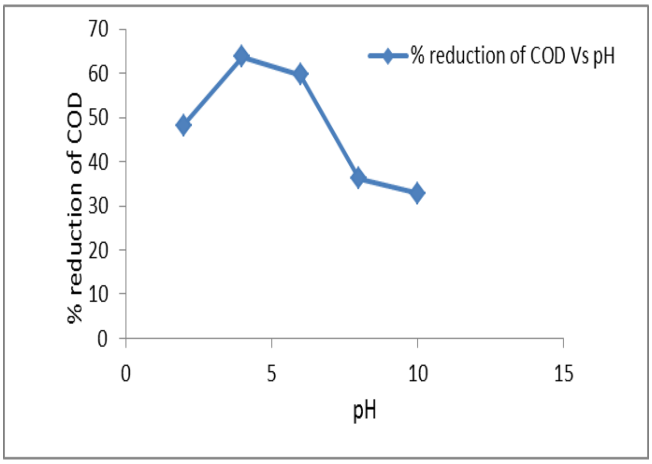

Figure 3: % reduction of COD with pH

From the figure 3, pH between 2– 4, the % reduction of COD increases. pH from 4 – 10 the % reduction of COD decreases due to chitosan more effective in acidic medium when compared to basic medium and 90% of the functional group of NH_2 on chitosan has been protonated at pH 4.

V. Conclusions

✓ From the experimental study the % reduction of COD of textile waste water about 63 -64 % by using chitosan as coagulant.

✓ Chitosan is exact replacement for aluminum based coagulants. Because aluminum based coagulants causes disease like Alzheimer's disease while chitosan was more ecofriendly characteristic and bio degradable polymer.

✓ Chitosan not only reduces the COD but also reduces the maximum percentage of turbidity of sample i.e. chitosan removes maximum color of sample and that solution becomes clear to see and there is no cloudiness is observed.

✓ The effect of mixing time at low mixing time (i.e. 10 minutes) there is no formation of flocs because the collisions between chitosan and suspended particles are low and lead to lower flocculation rate. On the other hand, at long mixing time (30 minutes) observed that there is a breaking of flocculate chains /bridges and this lead to limiting the size of flocs formed.

✓ Due to high charge density less amount of coagulant is sufficient for destabilization suspended and colloidal particles. It was observed that at dosage level of 12 - 30 mg/l formation bridges between flocs increases due to more sites are available on particle surfaces for the formation of interparticle bridges whereas dosage between 30 -66 mg/l, formation of between flocs decreases due to no sites available on particle surfaces for the formation of interparticle bridges due to excess polymer (coagulant) is adsorbed on the colloidal particles and producing restabilized colloids.

✓ In the study the effect of pH, chitosan is more soluble in acidic medium when compared to in basic medium and it also more efficient in acidic medium. Chitosan is a cationic polymer, as pH increases the positive charge on chitosan decreases. So, charge neutralization by chitosan on colloidal particles decreases. From the experiment at pH 4, the floc produced by chitosan appears rapidly and form a large size, which can be easily settled. From the experiment the chitosan soluble up to pH 6 and it is insoluble in pH more than 6 and it also exists as solid particles. It was concluded that chitosan has more efficiency in acidic medium when compared to in basic medium.

✓ The optimum conditions for maximum reduction of COD of sample of textile waste water. At these optimum conditions the percentage reduction of COD about 63-64 %.

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