Coagulation Studies in Industrial Wastewater Treatment

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Abstract: **Among the varied sized particles present in wastewater, the particles that are retained in a Gouche crucible and cannot be filtered are called colloidal particles (0.01 to 1.0 μm). Their removal is necessary before treating water chemically and biologically. The current work focuses on the use of coagulation as an efficient industrial wastewater pre-treatment method for removal of these colloidal particles from wastewater. During experimentation runs, Standard Jar Test apparatus was chosen for carrying out coagulation in selected industrial wastewater. The procedures included rapid mixing, followed by slow mixing and settling. Ferric chloride ($FeCl_3.6H_2O$) was used as a coagulant for experiment purpose. Using ferric chloride, different experimental runs were conducted to determine the optimum operating conditions and parameters. The operating conditions and parameters chosen were coagulant dosage, agitator rpm, and time of agitation. The optimum conditions obtained were 40 rpm, 30 minutes of agitation. Treated water samples were checked for turbidity (NTU) by using Nephelometer, Chemical Oxygen Demand (COD) removal and color reduction. Thus, a comparative analysis emerged out showing the effect of various conditions on the selection of dosage of coagulant used for the type of wastewater under consideration.**

Keywords: Coagulation, Jar Test, ferric chloride, turbidity, Nephelometer , Chemical Oxygen Demand.

I. INTRODUCTION

In the unfortunate scenario of relentlessly depleting water resources and the increase in toxicity and decrease in amenability of industrial waste water, it has become an utmost priority to ensure that effluents from industries are treated with the most systematic and the most efficient procedures. In almost all of the industrial waste water treatment plants, coagulation and flocculation are the primary processes. After these processes, significant improvement in the properties of waste water can be observed. Properties like turbidity, COD and color are substantially reduced.

Chemical coagulation is a unit process for the removal of colloidal solids from solution. The process consists of the addition of chemicals as slurries, solutions or in the dry form; a rapid mix to quickly disperse the chemicals throughout the solution; flocculation or a slow agitation period to permit floc growth and agglomeration of particles; and separation of solids and liquid phases. The chemicals normally added are coagulants, they are usually the salts of trivalent metal such as iron and aluminum, also control chemicals for pH and alkanity are added, usually lime.

The type, amount, order and point in the process at which the chemical additions should be made are important and are best determined by field measurements. The aim of chemical treatment is to provide a desired quality effluent at the required plant capacity with the most economical overall operation. Too little chemical addition will not provide the desired quality. Overfeed of chemicals is a waste it may result in interference with filtration and may result in undesirable chemical residuals in the plant effluent. If the sludges are to be separately digested, the effect of certain chemical additions must be carefully evaluated. Optimum dosage and process conditions must be integrated in order to obtain accurate and desirable results.

A. Materials and Methods

As stated above, it is very important to determine the quantity of coagulant to be added in the sample of waste water to engender effective and economical removal of colloidal particles. The current work was initiated by preparing bulk solutions of coagulants by adding the powdered form of coagulants in one liter of distilled water. The quantity of coagulant added was calculated by multiplying its density with the volume of distilled water. A bulk sample of waste water was collected from a general collection tank of a local textile industry.

B. Experimental set-up

The jar test was used to determine dosage requirements for chemicals added to remove small particulates from wastewater. At the same time, four beakers were assembled in the Jar Test apparatus; each containing 500 ml of waste water. Different dosages of coagulants were added in each beaker. Similarly for different experimental runs, other parameters such as time of agitation and RPM of blades were varied. The goal of performing these experiments was to determine the most optimum dosage and the most efficient operating conditions for effective and economical coagulation.

Fig1. Jar Test Apparatus

As soon as the flocs were settled in the beakers, the treated water was taken from each beaker and measured for its turbidity. The turbidity of the initial waste water sample was measured and was taken as a reference to determine the change brought about in turbidity by different dosages at different operating conditions. Nephelometer (commonly known as turbidity meter) was used for measuring the turbidity. The COD reduction and the decolorization was measured too by using standard COD reactor and UV spectrophotometer respectively. All the results at different dosages and different operating conditions were recorded.

C. *Chemicals*

Coagulant used in experimental runs was Ferric chloride ($FeCl_3.6H_2O$) and its solution was prepared as per its density.

D. *Results & Discussion*

The turbidity of the original waste water sample was found to be 177 NTU, the COD was 576 mg/l, the color was blackish and the pH was 9.8. Color inducing dyes like malachite green (630 nm), indigo dye (430 nm), Genacryl brilliant red (450 nm), Nitrobenzoxadidole (470 nm) etc. were present in the wastewater sample taken for study. The change in turbidity was measured for each sample of treated water and for each experiment, a plot of turbidity of treated water against the varying parameter was developed. Also the % COD reduction and % decolorization were computed and graphs were plotted for the same.

The first runs of experiments were performed for varying coagulant dosages (10 ml, 20 ml, 30 ml, 40 ml, 50 ml, 60 ml, 70 ml, 80 ml) at constant RPM (40) and constant time of agitation (30 min). The corresponding results are shown in table 1:

TABLE I
TURBIDITY AT VARIOUS COAGULANT DOSE

Dosage (ml)	Turbidity (NTU)
10	80
20	75.6
30	71.1
40	44.1
50	11.27
60	9.84
70	6.15
80	4.21

TABLE II
pH VARIATION WITH COAGULANT DOSE

Dosage (ml)	pH
10	9.3
20	8.27
30	8.2
40	7.2
50	6.51
60	5.95
70	4.48
80	3.94

TABLE III
COD VARIATION AT VARIOUS COAGULANT DOSE

Dosage (ml)	COD (mg/L)
10	544
20	528
30	512
40	480
50	448
60	384
70	352
80	320

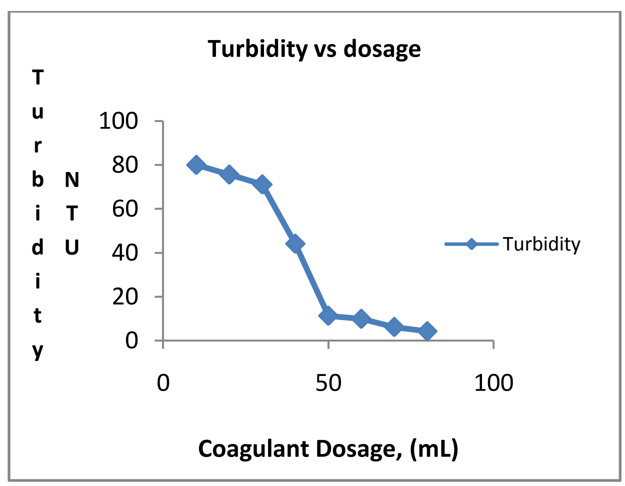

Fig2. Turbidity vs. Coagulant dosage

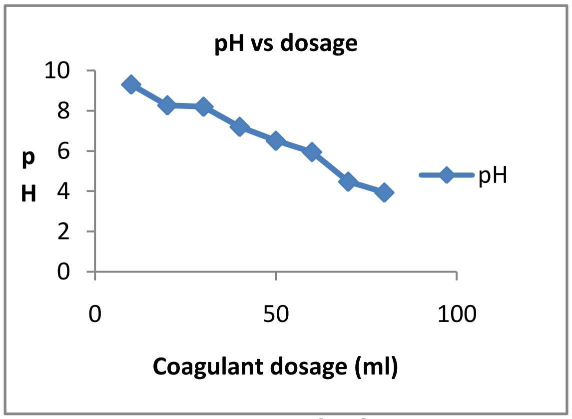

Fig3. pH vs. coagulant dosage

TABLE IV
AMOUNT OF COD REMOVAL

Dosage (ml)	COD
10	32
20	48
30	64
40	96
50	128
60	192
70	224
80	256

COD removal = $COD_{initial} - COD_{x}$
Where x = {10, 20,……, 80}

TABLE V
% COD Reduction

Dosage (ml)	COD % removal
10	5.55
20	8.33
30	11.11
40	16.67
50	22.22
60	33.33
70	38.8
80	44.44

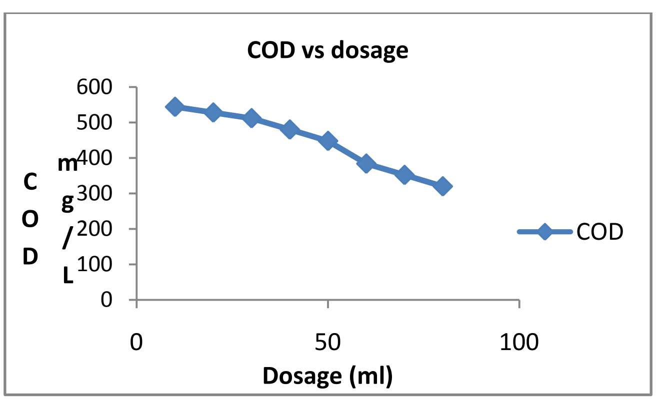

Fig4. COD vs coagulant dosage

Fig5. Samples of treated wastewater for COD and UV test

A visual color change was observed after the coagulation process and so it was further decided to check the decolorization by UV spectrophotometer test.

1) *Decolorization of malachite green:*

Initial absorbance: 0.276
Table VI shows variation of absorbance and % color removal at various dosages for malachite green and figures 6 and 7 show these variations graphically.

TABLE VI
ABSORBANCE AND % COLOR REMOVAL
(Malachite green)

Dosage (ml)	Absorbance	% color removal
10	0.198	28.26
20	0.156	43.47
30	0.136	50.72
40	0.116	57.97
50	0.061	77.84
60	0.046	83.33
70	0.017	93.84
80	0.017	93.84

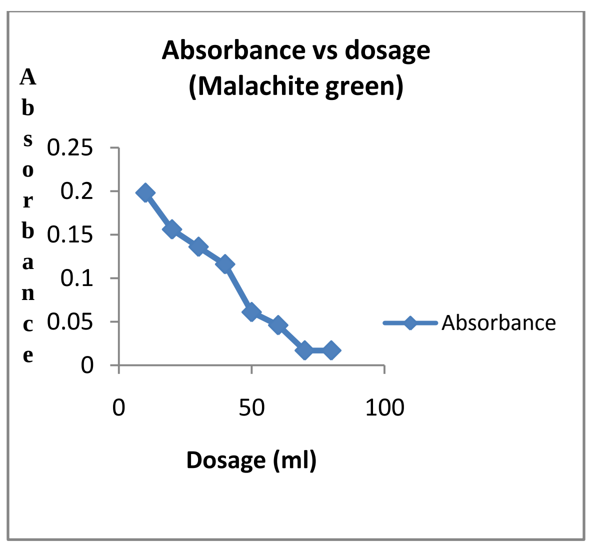

Fig 6. Absorbance vs dosage(Malachite green)

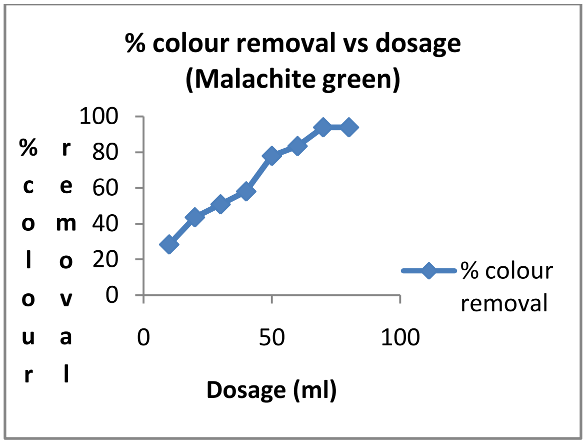

Fig 7. % Color removal vs dosage(Malachite green)

2) *Decolorization of Genacryl brilliant red:*

Initial absorbance: 0.383

Table VII shows variation of absorbance and % color removal at various dosages for Genacryl brilliant red and figures 8 and 9 show these variations graphically.

TABLE VII
ABSORBANCE AND % COLOR REMOVAL
(Genacryl brilliant red)

Dosage (ml)	Absorbance	% colour removal
10	0.379	2.39
20	0.312	18.53
30	0.256	33.15
40	0.200	47.78
50	0.139	63.7
60	0.113	70.49
70	0.075	80.41
80	0.071	81.46

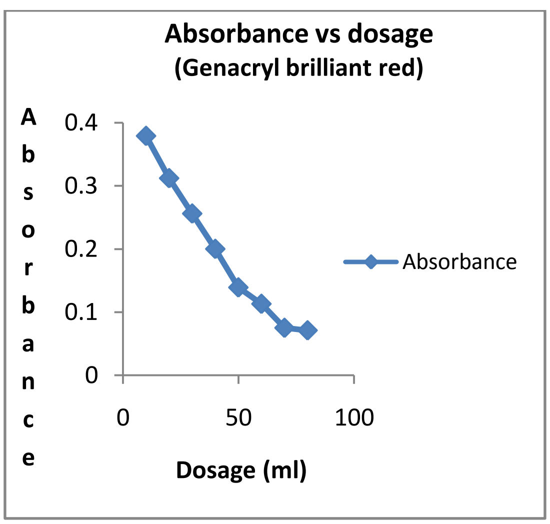

Fig 8. Absorbance vs dosage(Genacryl brilliant red)

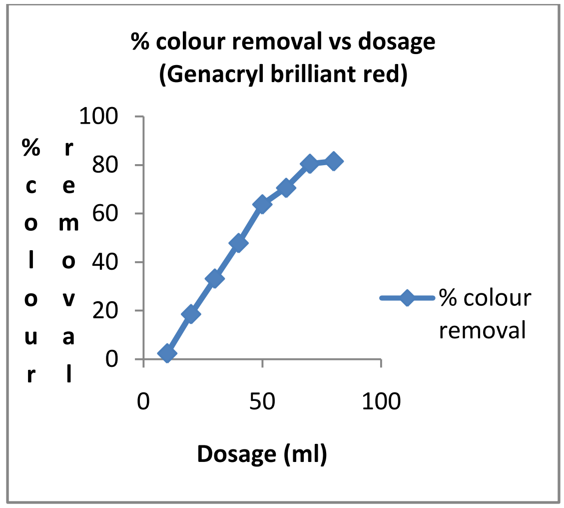

Fig 9. % Color removal vs dosage(Genacryl brilliant red)

3) *Decolorization of Nitrobenzaoxididole:*

Initial absorbance: 0.357

Table VIII shows variation of absorbance and % color removal at various dosages for Nitrobenzaoxididole and figures 10 and 11 show these variations graphically.

TABLE VIII
ABSORBANCE AND % COLOR REMOVAL
(Nitrobenzaoxididole)

Dosage (ml)	Absorbance	% colour removal
10	0.351	1.68
20	0.292	18.20
30	0.242	32.21
40	0.191	46.49
50	0.136	61.9
60	0.114	68.06
70	0.069	80.62
80	0.064	82.07

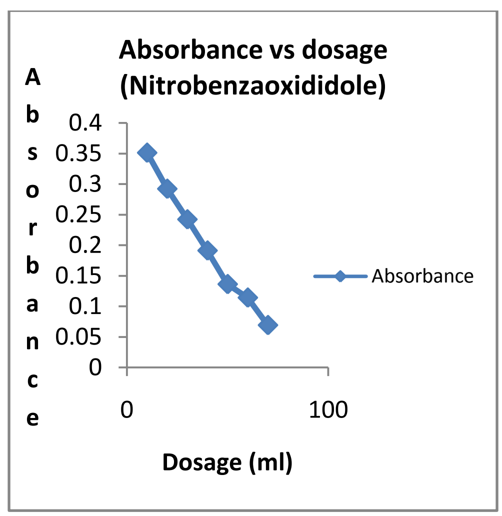

Fig 10.Absorbance vs dosage (Nitrobenzaoxididole)

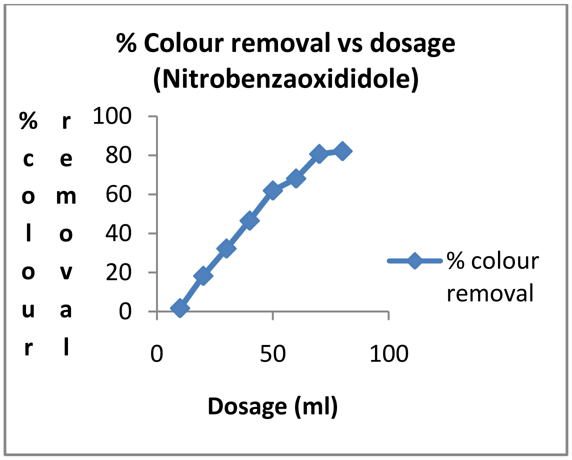

Fig 11. %Color removal vs dosage(Nitrobenzaoxididole)

4) *Decolorization of Indigo dye:*

Initial absorbance: 0.419

Table IX shows variation of absorbance and % color removal at various dosages for Indigo dye and figures 12 and 13 show these variations graphically.

TABLE IX
ABSORBANCE AND % COLOR REMOVAL
(Indigo Dye)

Dosage	Absorbance	% colour removal
10	0.413	1.43
20	0.356	15.03
30	0.287	31.5
40	0.224	46.53
50	0.151	63.96
60	0.120	71.36
70	0.084	79.99
80	0.083	80.19

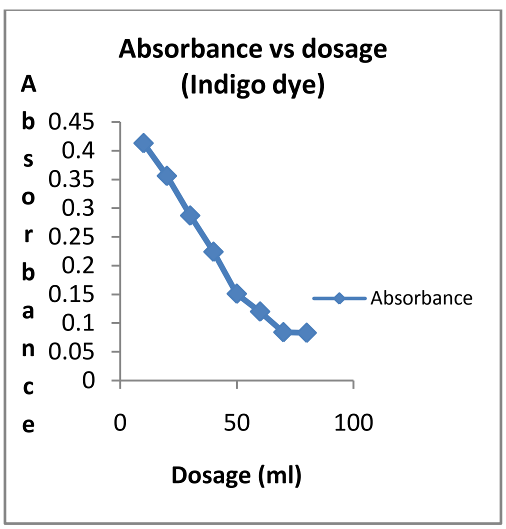

Fig 12. Absorbance vs dosage (Indigo Dye)

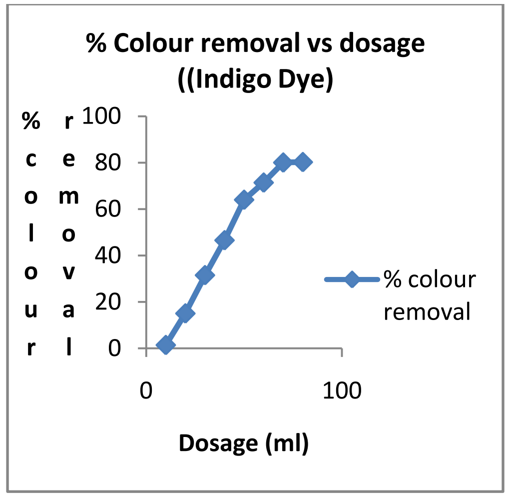

Fig 13. % Color removal vs dosage(Indigo Dye)

II. CONCLUSION

Effective turbidity, COD and color removal are found using coagulation as a pretreatment step for selected wastewater sample. However, the wastewater still needs to be processed further in order to reduce the COD level and adjust the pH as per the specified norms. Advanced polymer based coagulants may offer better prospects not only for turbidity reduction but also for more effective COD and color reduction.

ACKNOWLEDGEMENT

We are immensely thankful to our department of Chemical Engineering for providing all necessary infrastructure and support for the presented research work.

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