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TREATMENT OF TEXTILE DYEING INDUSTRY EFFLUENT USING COAGULATION TECHNIQUE

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ABSTRACT

Dyes are colouring compounds being extensively used in textile industries and the indiscriminate disposal of dye wastewater poses one of the major problems on the environment. This effluent contains a variety of contaminants viz. nature of acidic, caustic, dissolved solids and toxic compounds. The micro toxins are developed due to colouring agents by forming chelating under suitable chemical environment. The objective of the present work is to investigate the effectiveness of chemical treatment on removal of colour of simulated acid dye solutions. Three dye stuffs belonging to acid group were employed and batch tests were conducted with three coagulants (Calcium hydroxide, Ferric sulphate and Aluminium chloride) to access feasibility and also to study the optimum values for coagulant dosage, RPM, pH and time. The study clearly indicates that effluent-1 responds effectively to ferric sulphate, effluent-2 responds effectively to aluminium chloride and effluent-3 is moderately responded to calcium hydroxide.

KEYWORDS: **Coagulation, Dye effluent, Dosage, RPM, pH, Time**

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1. INTRODUCTION

Dyes usually have complex aromatic molecular structures which make them more stable and difficult to biodegradable. Furthermore, many dyes are toxic to some micro organisms and may cause direct destruction or inhibition of their catalytic capabilities [1]. Textile industries use dyes and pigments to color their products they are more than one lakh commercially available dyes with over 735 tons of dyes stuff are produced annually. Many types of dyes represent acute problems to ecological system as they considered toxic and have carcinogenic properties, which make the water inhibitory to aquatic life. The main sources of water generated by the textile industry originate from the washing and bleaching of natural fibers and from the dyeing and finishing steps. Given the great variety of fibers dyes and process aids, these processes generate waste water of great mechanical complexity and diversity, which are not adequately treated in conventional waste water treatment plant [2]. Recognition of color as a priority pollutants and promulgation of environmental regulations limiting effluent color levels have prompted several investigators to orient their research efforts towards color removal studies. Unfortunately, there are many variables to be considered for effective color removal and recognition of this fact is of primary importance for development of effective treatment technology [3]. Literature review suggests that the chemical treatment has a great potential for dye color removal mechanism. A systematic approach to the problem is necessary, to this end, an attempt was made in the present study to investigate the response of number of acid dyes belonging to various applications, classes and chemical families, through treatment with alum, ferric sulphate, calcium hydroxide, barium chloride, aluminum oxide and aluminum chloride with due reference to their chemical characteristics, nature and probe into the mechanistic aspect of color removal [4].

2. MATERIALS AND METHODS

2.1 Chemical Treatment

In order to improve the removal of settleable solids and to remove some of the colloidal components, coagulation can be employed. Dose rates can range up to several hundred mg/l of alum or iron salts. Since these salts consume alkalinity, coagulant dosage needs to be considered for pH control. Alum coagulated best near to or just below neutrality. If the dye waste is strongly alkaline it is usually more economic and effective to use sulphuric acid to adjust the pH then to add excess alum. Iron salts can coagulate effectively at high pH values and over a wider range so that pH control, with their use, may be easier. The optimum values for coagulant dosage, pH, RPM and time commonly determined by a series of tests on a representative sample of the waste [5].

2.2 Coagulation

In dye effluent treatment suspended particles to be removed is colloids and in suspended form. These colloids are destabilized by coagulation techniques. The degree of stability of colloidal particle is the result of interaction of electrostatic and Vander walls forces [6]. Coagulation means agglomeration of suspended particles by adding a chemical substance. It involves the reduction of surface charges and formation of complex hydrous oxide. Colloids that don't agglomerate naturally are called stable. The stability depends on large surface to volume ratio resulting from their small size. Surface phenomena predominate over mass phenomena. The most important surface phenomena are accumulation of electrically charged particle surface [7,8,9,10].

2.3 Experimental Procedure

Experiments were conducted to treat effluent-1 (green colored dye), effluent-2 (blue colored dye) and effluent-3 (red colored dye) using alum, ferrous sulphate, calcium hydroxide and aluminium chloride as coagulants. Test dye solution of 100 mg/l was prepared from effluent solution and is taken in the reagent bottles, varying doses of designated coagulants were added to study feasibility of color removal by chemical treatment and pH of the test mixture was adjusted when required. A number of such reagent bottles containing the test mixture depending upon the requirement were employed. Then the reagent bottles containing test mixture was placed in an orbital shaker operating at required RPM to facilitate effective mixing and precipitate formation. Then the reagent bottles containing the mixture were kept under undisturbed for 1 hr for settlement of precipitation formed. The settled precipitate is separated from the mixture by filtration with the help of filter paper. The filtrate is analyzed for percentage colour removal using the calibration curve prepared. The effect of parameters like time, speed, dosage and pH were studied for different effluents.

3.RESULTS AND DISCUSSION

3.1 Choice of Coagulant

Response of selected effluents to chemical treatment with different coagulants was assessed using batch test procedure. The percentage transmissivity with different coagulants is given in Table 1. It is observed that effluent-1 is amenable to chemical treatment with ferrous sulphate, effluent-2 is amenable to aluminium chloride and effluent-3 is amenable to calcium hydroxide.

Table 1
Choice of Coagulant

Coagulant	% Transmissivity		
	Effluent-1	Effluent-2	Effluent-3
Alum	24	77	16
Ferrous sulphate	**25**	88	72
Aluminium oxide	10	66	10
Barium chloride	19	67	78
Aluminium chloride	14	**91**	40
Calcium hydroxide	15	56	**80**

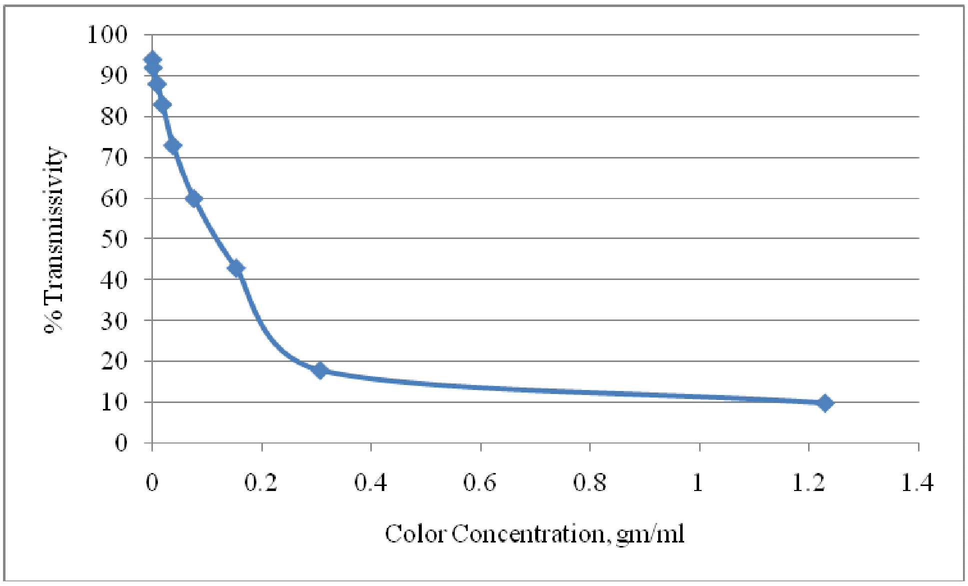
3.2 Treatment of Effluent-1

3.2.1 Calibration for Effluent-1

Table 2
Calibration data for effluent-1

Color Concentration (gm/ml)	% Transmissivity
0.001215	94
0.00241	92
0.009609	88
0.0192	83
0.0384	73
0.0768	60
0.15375	43
0.3075	18
1.23	10

Graph 1
Concentration vs. % Transmissivity

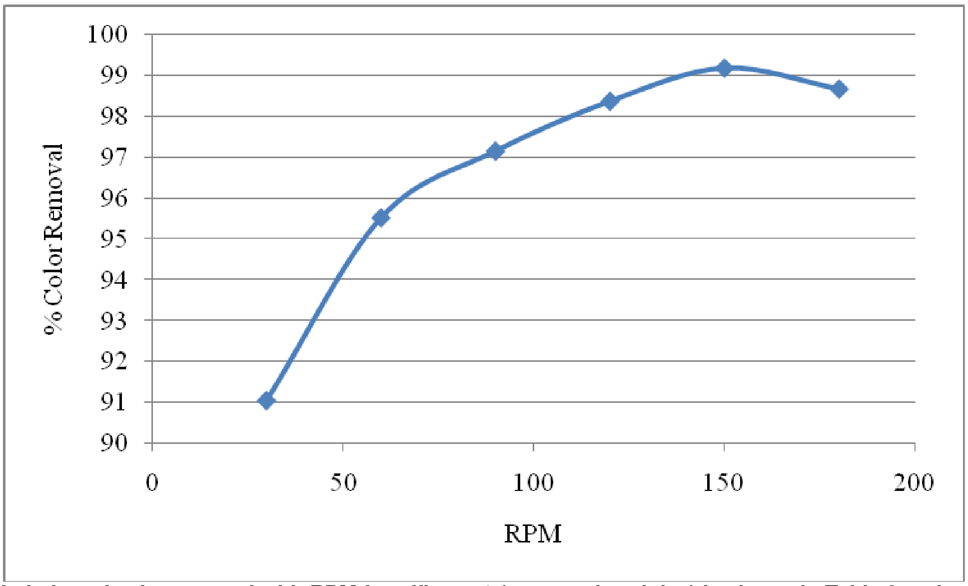


3.2.2 Effect of RPM on % Color Removal
Coagulant: Ferrous sulphate

Table 3
RPM vs. % Color Removal

RPM	% Transmissivity	% Color Removal
30	52	91.05
60	64	95.52
90	74	97.15
120	83	98.37
150	91	99.18
180	87	98.67

Graph 2
RPM vs. % Color Removal



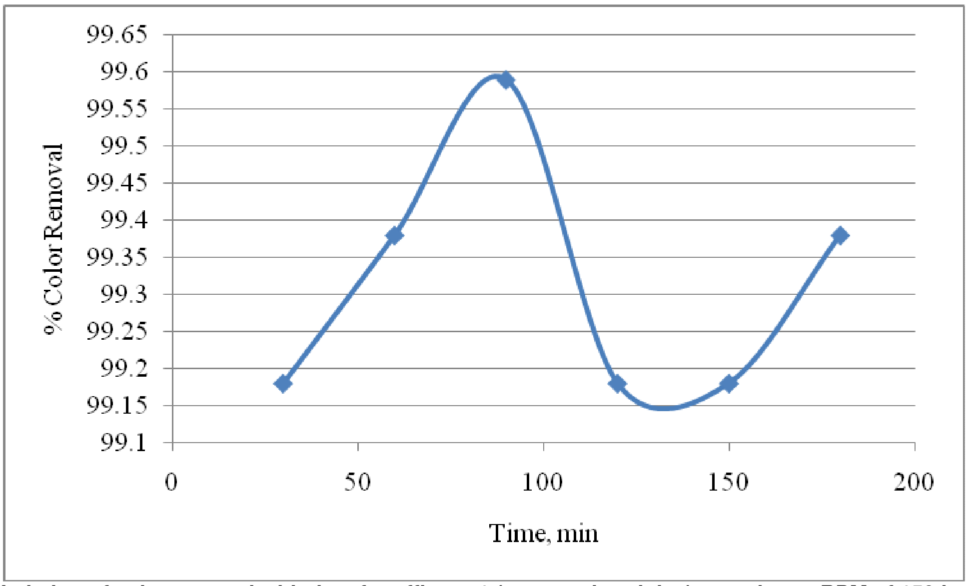
Variation of color removal with RPM for effluent-1 (green colored dye) is shown in Table 3 and Graph 2. Maximum color removal of 99.18 % occurs at optimum RPM of 150.

3.2.3 Effect of Time on % Color Removal

Table 4
Time vs. % Color Removal

Time (min.)	% Transmissivity	% Color Removal
30	91	99.18
60	93	99.38
90	94	99.59
120	91	99.18
150	91	99.18
180	93	99.38

Graph 3
Time vs. % Color Removal



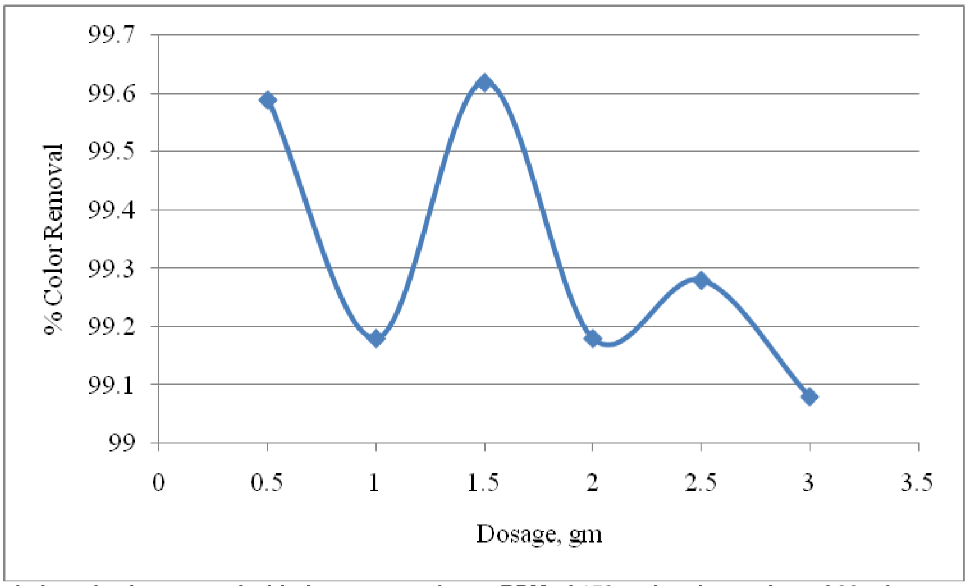
Variation of color removal with time for effluent-1 (green colored dye) at optimum RPM of 150 is shown in Table 4 and Graph 3. Maximum color removal of 99.59 % occurs at optimum time of 90 minutes.

3.2.4 Effect of Dosage on % Color Removal

Table 5
Dosage vs. % Color Removal

Dosage (gm)	% Transmissivity	% Color Removal
0.5	94	99.59
1.0	89	99.18
1.5	95	99.62
2.0	89	99.18
2.5	92	99.28
3.0	90	99.08

Graph 4
Dosage vs. % Color Removal



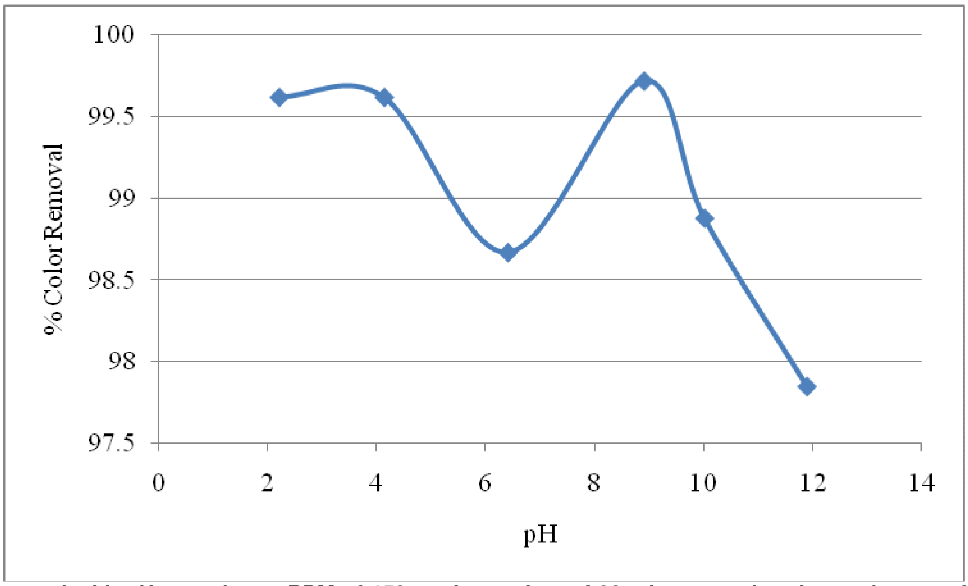
Variation of color removal with dosage at optimum RPM of 150 and optimum time of 90 minutes for effluent-1 (green colored dye) is given in Table 5 and Graph 4. Maximum color removal of 99.62 % occurs at optimum dosage of 1.5 gm.

3.2.5 Effect of pH on % Color Removal

Table 6
pH vs. % Color Removal

pH	% Transmissivity	% Color Removal
2.2	95	99.62
4.13	95	99.62
6.4	84	98.67
8.9	96	99.72
10.01	89	98.88
11.89	78	97.85

Graph 5
pH vs. % Color Removal



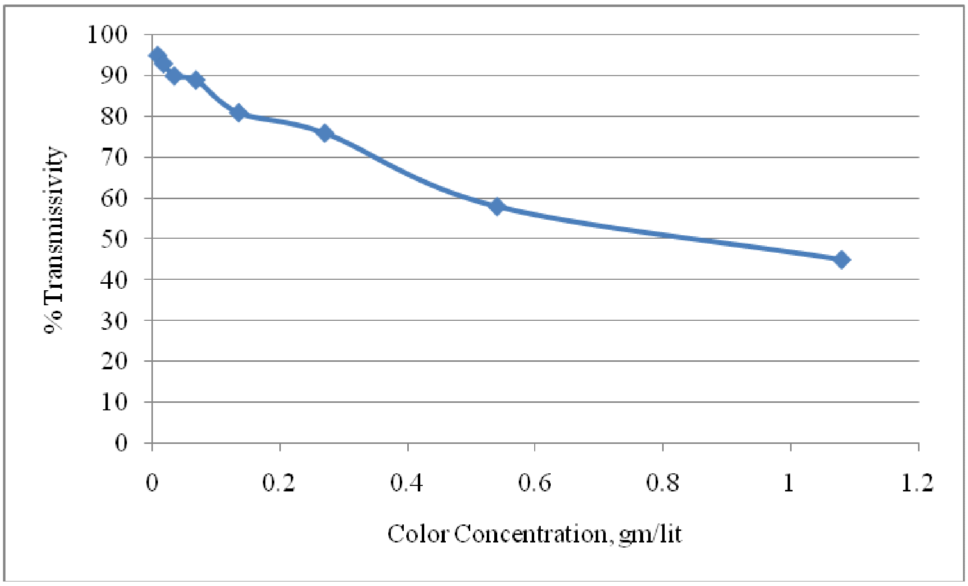
Variation of color removal with pH at optimum RPM of 150, optimum time of 90 minutes and optimum dosage of 1.5 gm for effluent-1 (green colored dye) is given in Table 6 and Graph 5. Maximum color removal of 99.72 % occurs at optimum pH of 8.9.

3.3 Treatment of Effluent-2
3.3.1 Calibration for Effluent-2
Coagulant: Aluminium Chloride

Table 7
Calibration data for effluent-2

Color Concentration (gm/lit)	% Transmissivity
0.008	95
0.017	93
0.034	90
0.068	89
0.135	81
0.27	76
0.54	58
1.08	45

Graph 6
Calibration curve for effluent-2

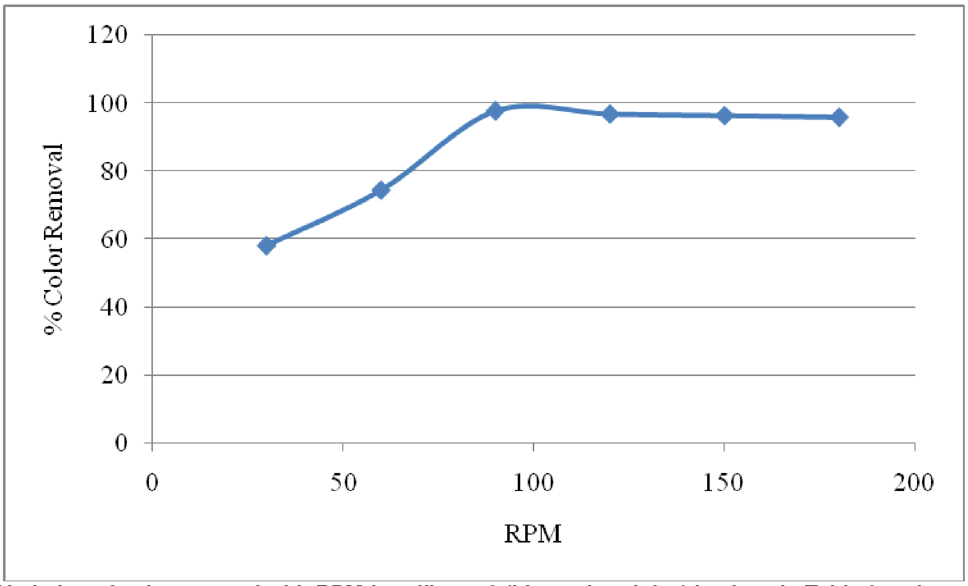


3.3.2 Effect of RPM on % Color Removal

Table 8
RPM vs. % Color Removal

RPM	% Transmissivity	% Color Removal
30	64	58.33
60	75	74.53
90	94	97.68
120	90	96.75
150	89	96.29
180	87	95.83

Graph 7
RPM vs. % Color Removal



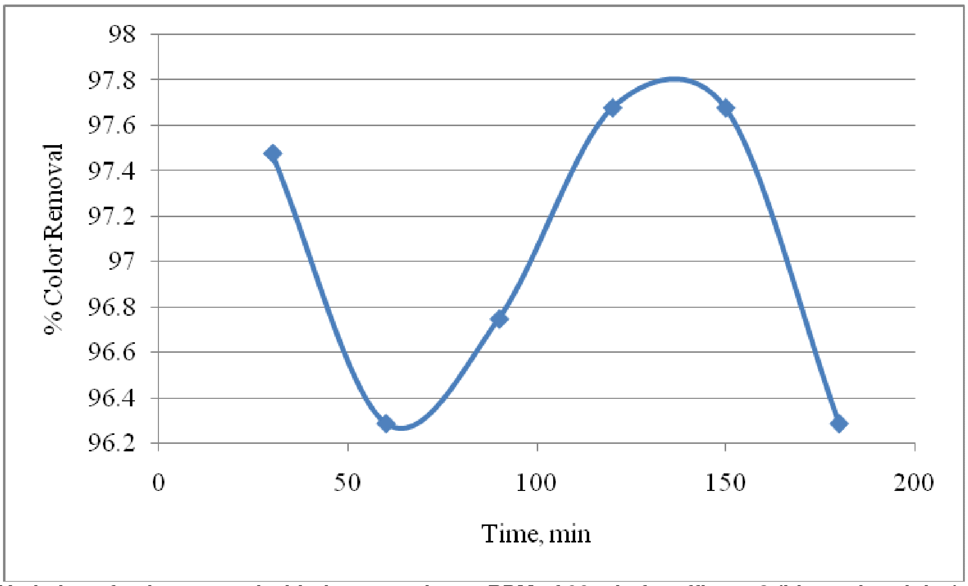
Variation of color removal with RPM for effluent-2 (blue colored dye) is given in Table 8 and Graph 7. Maximum color removal of 97.68% occurs at optimum RPM of 90.

3.3.3 Effect of Time on % Color Removal

Table 9
Time vs. % Color Removal

Time (min.)	% Transmissivity	% Color Removal
30	94	97.48
60	92	96.29
90	93	96.75
120	95	97.68
150	95	97.68
180	92	96.29

Graph 8
Time vs. % Color Removal



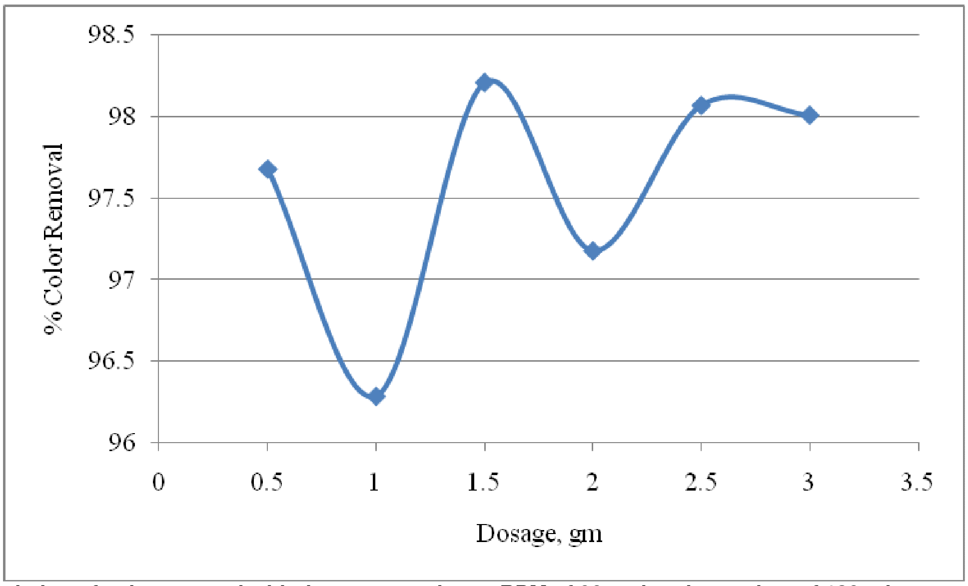
Variation of color removal with time at optimum RPM of 90 min for effluent-2 (blue colored dye) is given in Table 9 and Graph 8. Maximum color removal of 97.68% occurs at optimum time of 120 min.

3.3.4 Effect of dosage on % Color Removal

Table 10
Dosage vs. % Color Removal

Dosage (gm)	% Transmissivity	% Color Removal
0.5	95	97.68
1.0	89	96.29
1.5	96	98.21
2.0	94	97.18
2.5	96	98.07
3.0	96	98.01

Graph 9
Dosage vs. % Color Removal



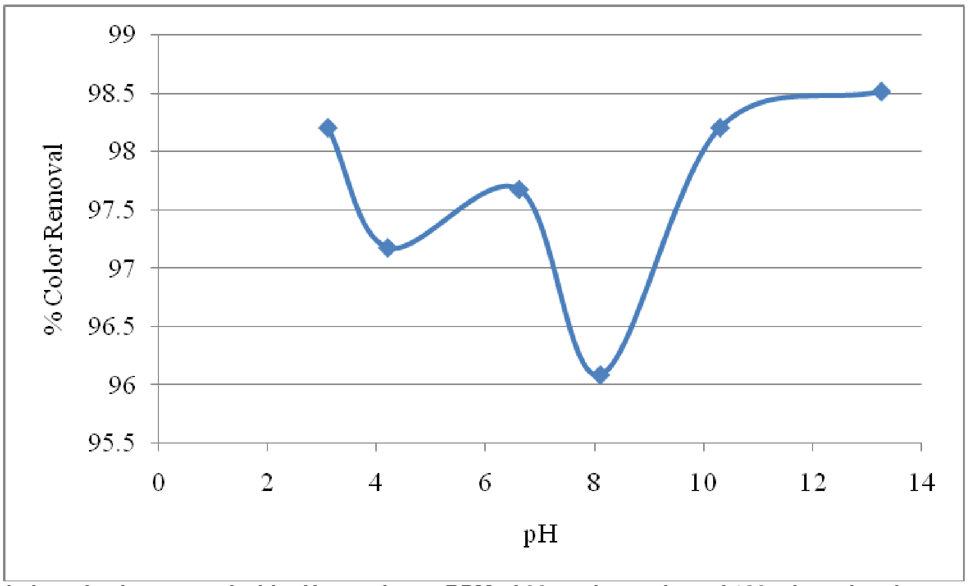
Variation of color removal with dosage at optimum RPM of 90 and optimum time of 120 minutes for effluent-2 (blue colored dye) is given in Table 10 and Graph 9. Maximum color removal of 98.21% occurs at optimum dosage of 1.5 gm.

3.3.5 Effect of pH on % Color Removal

Table 11
pH vs. % Color Removal

pH	% Transmissivity	% Color Removal
3.1	96	98.21
4.2	94	97.18
6.61	95	97.68
8.1	88	96.09
10.3	96	98.21
13.26	97	98.52

Graph 10
pH vs. % Color Removal



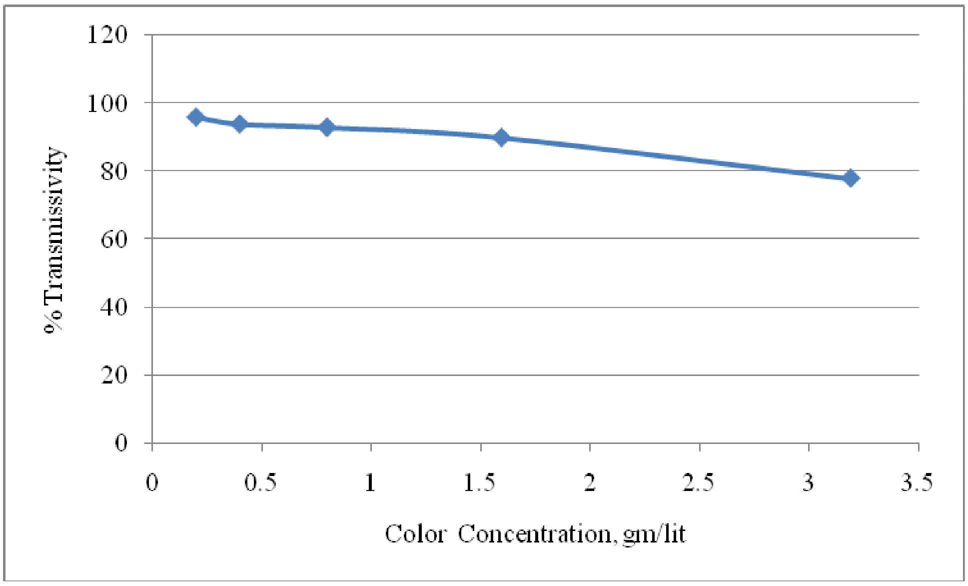
Variation of color removal with pH at optimum RPM of 90, optimum time of 120 min and optimum dosage of 1.5 gm for effluent-2 (blue colored dye) is given in Table 11 and Graph 10. Maximum color removal of 98.52% occurs at optimum pH of 13.26.

3.4 Treatment of Effluent-3
3.4.1 Calibration for Effluent-3
Coagulant: Calcium hydroxide

Table 12
Calibration data for effluent-3

Color Concentration (gm/lit)	% Transmissivity
0.19973	96
0.39875	94
0.7975	93
1.595	90
3.190	78

Graph 11
Calibration curve for effluent-3

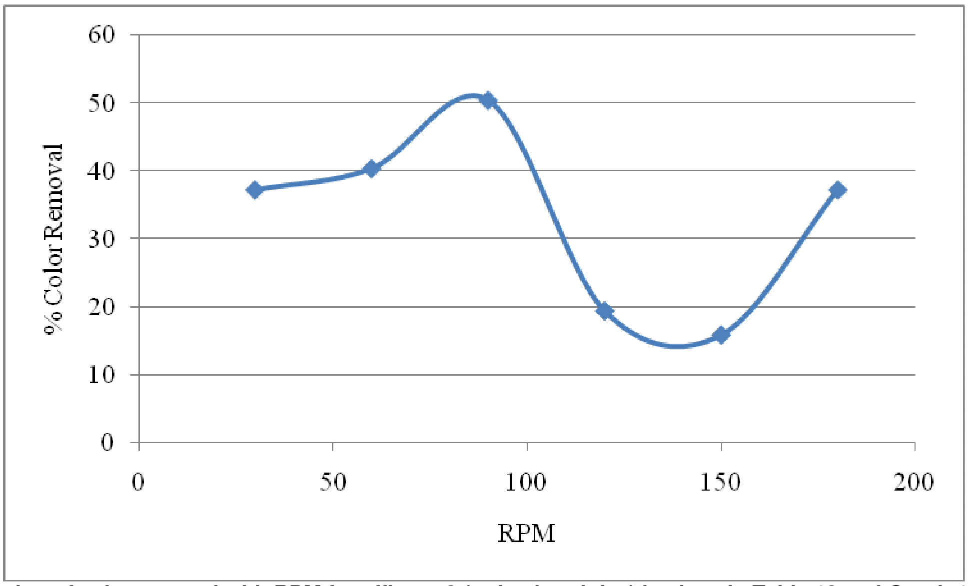


3.4.2 Effect of RPM on % Color Removal

Table 13
RPM vs. % Color Removal

RPM	% Transmissivity	% Color Removal
30	82	37.30
60	83	40.43
90	86	50.47
120	78	19.49
150	75	15.95
180	82	37.30

Graph 12
RPM vs. % Color Removal



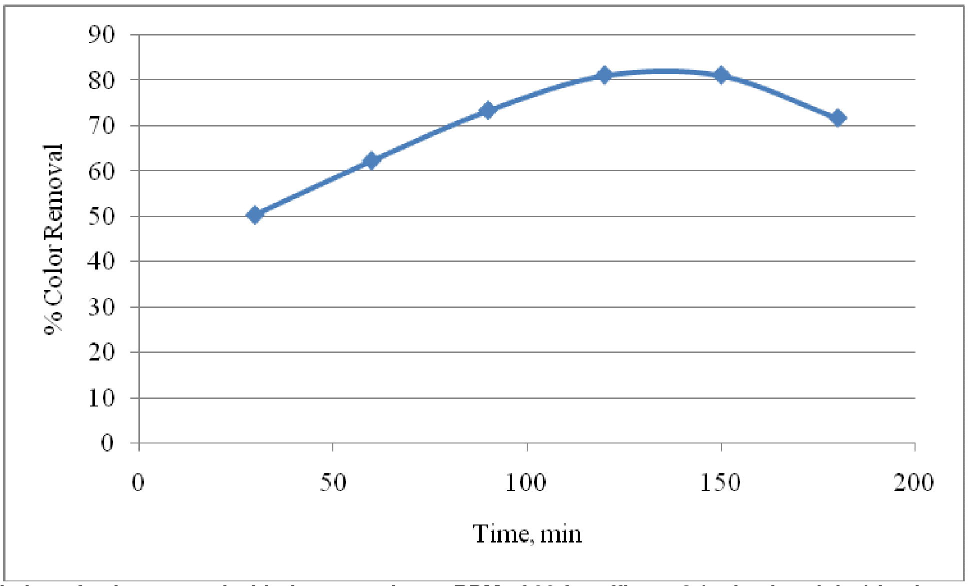
Variation of color removal with RPM for effluent-3 (red colored dye) is given in Table 13 and Graph 12. Maximum color removal of 50.47 % occurs at optimum RPM of 90.

3.4.3 Effect of Time on % Color Removal

Table 14
Time vs. % Color Removal

Time (min.)	% Transmissivity	% Color Removal
30	86	50.47
60	89	62.38
90	81	73.45
120	94	81.19
150	94	81.19
180	92	71.78

Graph 13
Time vs. % Color Removal



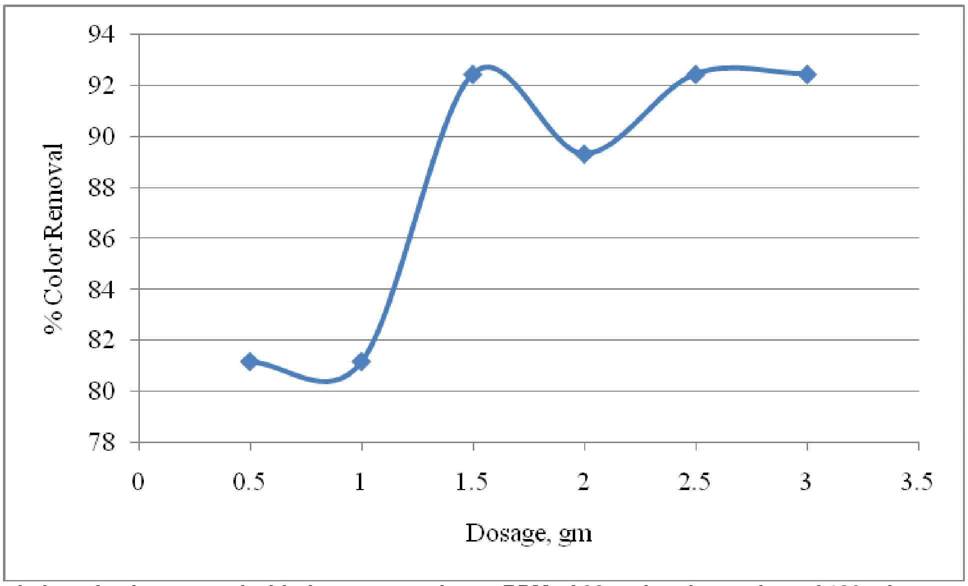
Variation of color removal with time at optimum RPM of 90 for effluent-3 (red colored dye) is given in Table 14 and Graph 13. Maximum color removal of 81.19 % occurs at optimum time of 120 min.

3.4.4 Effect of Dosage on % Color Removal

Table 15
Dosage vs. % Color Removal

Dosage (gm)	% Transmissivity	% Color Removal
0.5	94	81.19
1.0	94	81.19
1.5	96	92.47
2.0	95	89.34
2.5	96	92.47
3.0	96	92.47

Graph 14
Dosage vs. % Color Removal



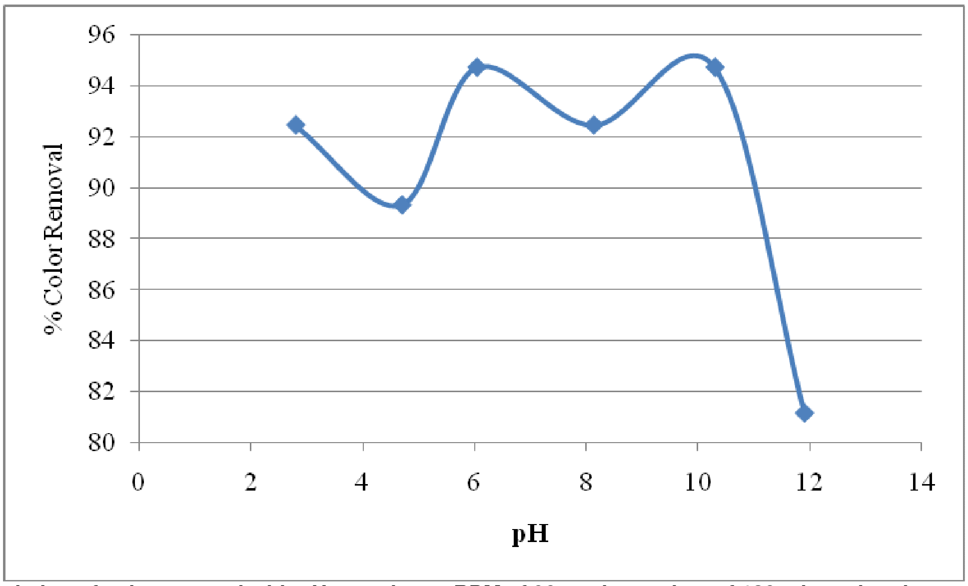
Variation of color removal with dosage at optimum RPM of 90 and optimum time of 120 minutes for effluent-3 (red colored dye) is given in Table 15 and Graph 14. Maximum color removal of 92.47 % occurs at optimum dosage of 1.5 gm.

3.4.5 Effect of pH on % Color Removal

Table 16
pH vs. % Color Removal

pH	% Transmissivity	% Color Removal
2.8	96	92.47
4.7	95	89.34
6.04	**97**	**94.73**
8.13	96	92.47
10.3	97	94.73
11.9	94	81.19

Graph 15
pH vs. % Color Removal



Variation of color removal with pH at optimum RPM of 90, optimum time of 120 min and optimum dosage of 1.5 gm for effluent-3 (red colored dye) is given in Table 16 and Graph 15. Maximum color removal of 94.73 % occurs at optimum pH of 6.04.

4. CONCLUSION

Maximum percentage of color removal from each of the textile dyeing industry effluent and optimum values for variables is given in the following table.

Effluent	Optimum Values of Variables				Maximum % Color Removal
	RPM	Time (min.)	Dosage (gm)	pH	
1	150	90	1.5	8.9	99.72
2	90	120	1.5	13.26	98.52
3	90	120	1.5	8.13	92.47

The removal is probably due to physicochemical mechanism of coagulation and flocculation and/or chelating complexation type reactions and colour removal at lower pH ranges may be either due to physicochemical coagulation or chelating complex formation reactions.

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