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Effect of Mixing Speed and Time on Dyes Removal through Coagulation and Flocculation from Dyebath Effluent

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ABSTRACT: It is difficult to treat textile wastewater to a satisfactory degree because of high chemical oxygen demand COD, Biochemical oxygen Demand BOD, Suspended solids (SS), conductivity and highly intense colours. Colour removal from textile waste water has gained considerable attention these days. Coagulation-Flocculation is a frequently used physiochemical treatment method to decolorize textile effluents and reduce the total loads of suspensions. Jar Test apparatus is used to conduct the research work. The study focuses on determining the effect of coagulation and flocculation, optimum dosage and PH of coagulant and flocculant on the removal of reactive textile dyes from the dye bath effluent of a textile industry. In dye bath effluent two reactive dyes are present named Sumifix Supra Red E-XF gran. and Sumifix Supra Yellow E-XF gran. in ratio 0.55:0.45.Dye bath effluent has initial pH of 11.Alum is used as a primary Coagulant and two flocculants named Polymer A110 (anionic) and Polymer 202 As (cationic) are used as flocculant aids. Effect of mixing speed and mixing time is almost same for both flocculants. Maximum dyes removal is at 200 rpm for Polymer A110 which is 86% and for Polymer 202As is 72.4% which is at 180rpm. At maximum dyes removal is achieved when the mixing time is 18 min it is 85.6% and 72.5% for Polymer A110 and Polymer 202As respectively.

KEYWORDS: Dye bath effluent, Coagulation, flocculation, mixing speed, mixing time, color removal.

INTRODUCTION

Textile industry is the greatest source of liquid effluent pollution because large quantity of water is consumed in dyeing processes. 10,000 different types of dyes and pigments are being produced these days. Annual production of these dyes is estimated to be 7×10^5 tons. Annual worldwide discharge of textile dyes is estimated to be more than 280,000 ton [1, 2]. Dyes are classified according to their dissociation in aqueous solution as follows [3]. Cationic include basic dyes**,** anionic include acid, reactive and direct dyes while nonionic include disperse dyes. Increased demand of cellulosic fiber, requirement of better dyeing conditions and bright colours have increased the consumption of reactive dyes in recent years.

Synthesis of azo dyes is easy and economical; these are highly stable also a wide range of colours (3000 varieties) is available in azo dyes as compared to natural dyestuff so these are produced in large amounts [4]. 70% of the worldwide dyestuff constitutes azo dyes [5], so these are largest group of synthetic dyes released into environment. Reactive dyes are hydrolyzed in water in presence of alkali and this is the reason of large amounts of these dyes in dyebath waste streams. Because of hydrolysis, their fixation to fiber is less than expected. Only 50-80% of these dyes are fixed and rest is present in waste stream [6]**.** Release of dyes especially azo dyes in aqueous streams e.g. Rivers, lakes, cause aesthetic problems and reduces penetration of sunlight into water which results in photosynthesis reduction. Consequently there is reduction in dissolved oxygen concentration, aquatics life and hence fish life is disturbed. Dye waste is also characterized by high BOD and COD. Further, dye waste is carcinogenic as well as mutagenic, and can cause dysfunctioning of some human organs e.g. Kidney [7, 8].

Except few simple structured dyes all azo dyes resist biodegradation using aerobic sewage plants [9]. Each treatment process has its associated advantage and disadvantages, e.g. adsorption is associated with problems like regeneration, and filtration and membrane separations have fouling problems. Although coagulation flocculation has high sludge production [10] but this process can be used before adsorption or other techniques to obtain 100% colour removal as no treatment alone can give 100% colour removal efficiencies.

Coagulation is to destabilize the charge of particles and this purpose is achieved by addition of oppositely charged colloids into solution containing impurities. After charge neutralization, colloids can stick together. This process leads to formation of slightly large particles called microflocs which cannot be seen by naked eye. If a large amount of coagulant is introduced into the system then charge reversal reduces the sedimentation and hence reduces the efficiency of the process [11]. It is also said that alum is precipitated in water in very complex form as $[Al_8(OH)_{20}\ 28H_2O]^{+4}$.When this large precipitate is settled down in water, it helps many colloids to be removed by enmeshment [12]. PH of solution to be treated is a major factor which plays a vital role in the removal of colloids. Usual flocculation contact time range from 15 -20 minutes to an hour [13].

Alum is used as primary coagulant with two flocculants, one is cationic with commercial name Polymer 202As and other is anionic with commercial name Polymer A110. Jar test Apparatus is employed to study coagulation flocculation on reactive dye solution. Dye bath waste from a local industry is collected which contains two reactive dyes Sumifix Supra Red E-XF gran. and Sumifix Supra Yellow E-XF gran. in the ratio Red E-XF/ Yellow E-XF = 55:45. Chemical structures of both dyes are not disclosed. The composition of dye Bath before dyeing was:

Sumifix Supra Red E-XF gran	=	2.34%
Sumifix Supra Yellow E-XF gran	=	1.88%
Salt	=	80 grams/litre
Soda ash	=	20 gm/litre
SARABID LDR (Leveling agent)	=	0.5g/litre
pH of waste	=	11

SARABID LDR is added in dye bath to improve the solubility of reactive dyes and in order to disperse them thoroughly.

LITERATURE REVIEW

Effect of coagulation alone on decolonization of some dyes was studied earlier. Effect of decolorization on some dispersed and reactive dyes was studied using Ferric Chloride coagulant. Jar test method was used to find dye removal, zeta potential distribution, suspended solids concentration, changes of the SCOD/TCOD. For dispersed blue 106 maximum removal efficiency was 97.7% at coagulant concentrations 0.93 mM ferric chloride at pH6. For dispersed yellow 54 maximum removal efficiency was 99.6% at coagulant concentrations 0.74 mM ferric chloride at pH5. For reactive blue 49 and reactive yellow 84 maximum removal efficiencies were 60.9% and 71.3% at coagulant concentrations of 2.78 mM and 1.85 mM ferric chloride at pH 7 and pH6 respectively. Conclusion was made that dispersed dye solutions are more easily decolorized as compared to reactive dye solutions using Chemical coagulation [14].

Further studies were done in order to consider the effect of coagulant along with adsorption on removal of reactive dyes. Work was done on removal of C.I. reactive red 45 and C.I. reactive green 8 using coagulation by aluminum chloride followed by adsorption by activated carbon method. It is shown that not only almost complete removal of both dyes from wastewater is obtained by combined coagulation and adsorption method but also 95.7% COD and 99.7 % TOC removal is obtained [15]. Later on experiments has been performed on waste mixtures of commercial dispersed and reactive dyes in different ratios using coagulation- flocculation method using Alum, $MgCl_2$, polyaluminium chloride and an anionic aid. Colour removal and chemical oxygen demand (COD) reduction is measured by changing initial pH of solution and coagulant type and their doses. It is evident that when percentage of reactive dyes in solution increases, demand for coagulant dose increases to obtain optimum colour removal and COD reduction. It is shown that polyaluminium chloride is more efficient in removing colour and COD, 99% and 96.3% respectively, as compared to both alum and magnesium chloride [16].

Effect of pH on polyaluminium chloride dose for reactive dyes is also studied later on. Experiments are performed on four reactive dyes namely turquoise DG, red DB-8, orange OGR and black DN. It is seen that dye removal depends strongly on pH. Maximum colour removal for turquoise DG is 99% at pH 3.5, for orange OGR 80% at pH 5, for black DN 81% between pH 4 and 5 and for red DB-8 64% at pH 5 [17]. Synthetic polymers prepared in laboratory are employed as flocculants. A synthetic polymer from formaldehyde and cyanoguanidine prepared under acidic conditions is used for some reactive dyes and real waste water containing those dyes. It was proved that using coagulant i.e. alum and ferric salt only 20 to 40 % removal of colour was obtained while with the aid of synthetic polymer almost 99% colour removal was achieved [18]. Dye removal studies have also been performed with Polyamine flocculants. Synthesis of polyamine flocculants was done by polycondensation of dimethylamine and epichlorohydrin, organic amines e.g. 1,2-diaminoethane as modifying agent. Color removal from reactive yellow, reactive red and reactive blue is obtained as 96%, 96% and 97% respectively.COD removal is also studied and COD reduction of 90% is achieved from actual waste water [19].

Later on coagulation flocculation method has been applied to highly concentrated C.I. Acid Black 210 dye using alum and five different commercially available flocculants which include low, medium and high molecular weights Polyacrylamide Cationic and anionic Polymers as flocculants aid. Dye removal increment is taken as difference between percentage dye removal due to coagulant and flocculants and due to coagulant alone on acid black 210 dye solution. Poly-diallyl-dimethyl ammonium chloride ACCEPTA 2058 gives best dye removal increment 36.6% [20]. Coagulation /flocculation method was applied to remove colour from residual dyebath effluents of cotton/polyamide blends dyeing using reactive and acid dyes. It is found that aluminium sulfate combined with cationic organic flocculant provides almost complete decolorization. Also it reduced TOC, COD and BOD [21].

Flocculation process was used to remove Suspended solids (SS), total dissolved solids (TDS) and dyes from textile waste water using food grade polysaccharides (mucilage), which is obtained from Hibiscus and Trigonella foenum graceum commonly known as Okra and Fenugreek, as flocculant. Parameters to be studied are change in dose of flocculant, contact time, and PH for removal of pollutants from textile wastewater. Polysacchrides used in this study provided 94 % SS, 44% TDS and 35% dye with very low dose of flocculant [22]. A composite coagulant was prepared by mixing of polyferric chloride and polydimethyl diallyl ammonium chloride (PDMDAAC) and used it for decolorization of actual textile wastewater as well as for simulated dye solution. It is found that composite coagulant is far better than PFC and PDMDAAC alone and treatment with PFC followed by PDMDAAC. Composite coagulant gave 98% colour removal for dispersed blue dye and 86% colour removal using reactive blue dye [23].

EXPERIMENTAL SETUP

Jar test method was employed in this research for the removal of reactive dyes from dye bath effluent of a Textile Mill using Alum as primary coagulant and two commercially available flocculants, Polymer A110 (anionic Polyacrylamide) and Polymer 202 As (Cationic). Studying the effect of mixing speed and time on coagulant and flocculants performance of dyes removal. This research paper discusses the effect of mixing speed and time on dyes removal from dye bath effluent.

Fig 1: Jar Test Apparatus

EXPERIMENTAL METHODOLOGY

- Collection of dye bath waste water
- Alum Solution Preparation
- Flocculant Solution Preparation
- Preparation of 2M HCl Solution

- Preparation of 2M NaOH Solution
- PH Adjustment of waste solution
- Addition of Coagulant during Rapid Mix for fixed time in Jar Test Apparatus
- Addition of Flocculant during slow mixing for fixed time Jar Test Apparatus
- Settling of sample for 60 minutes
- Analysis of Sample by UV Vis- Spectrophotometer

Sample Collection:

Waste water sample of textile Dyebath effluent was collected from a local industry. Dyebath waste contains two reactive dyes Sumifix Supra Red E-XF gran. and Sumifix Supra Yellow E-XF gran. in the ratio Red E-XF/ Yellow E-XF: 55%/45%.

Chemicals:

Alum was used as coagulant. Flocculants used were polymer A110 (anionic Polyacrylamide) and Polymer 202 As (Cationic), these flocculants were given in crystalline form by Khan Associates (TownShip). Other chemical are HCl and NaOH to adjust pH of the solution.

Instruments

- **UV Visible Spectrophotometer:** HITACHI 150-20 spectrophotometer with data processor.
- **pH Meter:** Portable pH meter-8414 with pH sensor
- Weighing Balance ARAK.

Solution Preparation:

Alum Solution Preparation:

Alum solution was prepared by adding 50 gm of reagent grade crystal of alum $Al_2(SO_4)_3$. $16H_2O$ into distilled water and making the volume upto 1000 ml.

Flocculant solution Preparation:

As recommended by supplier, 1% solution of both flocculants was prepared by addition of 1 gram of each flocculant into 1000 ml of distilled water. Each day fresh solution of flocculants was prepared because solution of polymers expires after 24 hrs.

Acid and base solution Preparation:

Solution of 2M HCl and NaOH was prepared.

Laboratory Glassware:

Beakers, Pipettes, Measuring cylinders, Conical Flask etc.

Determination of λ_{max} of dyebath waste water:

Determination of λ_{max} of dye water is necessary in order to analyze samples after treatment at this wavelength. For determination of λ_{max} of dyebath effluent, dyebath water was added in distilled water and very dilute solution of dye waste was prepared. Reference solution used in UV visible Spectrophotometer was distilled water. Dilute solution of dyes was placed in UV visible Spectrophotometer and scanned manually in the range of the wavelengths 400-800 nm with intervals of 10 nm starting from 400nm. After this, increment of 1 nm was made between the two values of wavelengths which gave maximum absorbance. In this manner the value of λ_{max} at which maximum absorbance of colours achieved was obtained.

Graph was also plotted between wavelength and absorbance to see λ_{max} graphically. Λ_{max} for dye sample was found to be 536 nm.

Figure 2: UV Visible Spectrophotometer

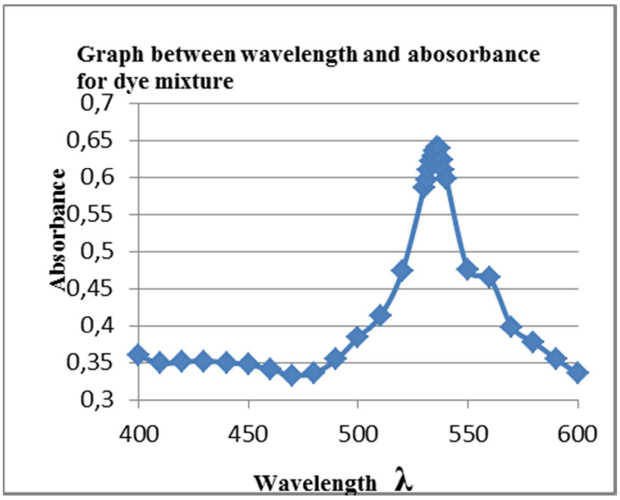


Fig 3. Graph of wavelength of dyebath waste solution vs. absorbance to find λ_{max}

Determination of Optimum pH.

1. A four beaker jar test apparatus was used for this study.
2. Beaker was filled upto 250 ml of dyebath waste water.
3. Adjust the pH of each beaker by adding HCL 2 M solution. Range of pH studied was from 4 to 11.
4. Fixed amount of coagulant (2g/L Alum) was added into each beaker and allowed for rapid mixing for 3 minutes at speed of 120 rpm.
5. During last seconds of mixing, 4 ml of flocculant (16ppm) was added into the beaker and speed reduced to 20 rpm. Slow mixing was allows for a period of 30 minutes for formation of flocs.
6. After treatment mixture was allowed to settle for 60 minutes.
7. Then 20 ml of sample was taken below 1 ml of upper layer of solution.
8. This sample was filtered and its absorbance was measured under UV Visible Spectrophotometer.
9. These experiments were separately performed with both flocculants.

Procedure with the addition of Coagulant combined with Flocculant:

1. Beaker was filled upto 250 ml of dyebath waste water.
2. Adjust the pH of each beaker by adding HCL 2 M solution.
3. Fixed amount of coagulant was added into each beaker and allowed for rapid mixing for 3 minutes at speed of 120 rpm. Optimum Concentration of coagulant was added.
4. During last seconds of mixing, flocculant was added into the beaker and speed reduced to 20 rpm. Slow mixing was allows for a period of 30 minutes for formation of flocs.
5. After treatment mixture was allowed to settle for 60 minutes.
6. Then 20 ml of sample was taken below 1 ml of upper layer of solution.
7. This sample was filtered and its absorbance was measured under UV Visible Spectrophotometer.

Effect of Mixing Speed on Percentage Colour Removal:

Experiments were performed in the same sequence with optimum pH and using optimum combination of coagulant and flocculant dosage while in each experiment, speed was varied from 100 to 200 rpm with increment of 20 rpm while mixing time of 3 minutes was used.

Effect of Mixing Time on Percentage Colour Removal:

Again experiments were performed with optimum pH of each flocculant and optimum dosages of Alum and flocculants. Mixing time varied from 3 to 18 minutes with increment of 3 minutes and mixing speed was fixed to 120 rpm.

RESULTS AND DISCUSSIONS

1. Determination of Optimum pH for Coagulation & Flocculation:

Determination of Optimum pH for Coagulation & Flocculation of mixture of Reactive Dyes using Alum as Coagulant and anionic Polymer A110 as a Flocculant.

Most important factor which affects colour removal of dyes is the pH of waste solution. In order to find the optimum pH for coagulation and flocculation jar test method was used. Fixed dosage of coagulant and flocculant was used by varying initial pH of waste solution in range of 4 to 11. Two sets of experiments were performed on Jar Test Apparatus with arrangement of four jars each set. Alum concentration was chosen to be 2 g/L and anionic flocculant (Polymer A110 1% solution) concentration 4 ml of flocculant per 250 ml of waste solution. Rapid mixing time of 3 minutes was allowed at 120 rpm with alum followed by addition of flocculant Polymer A110 with slow mixing for 30 minutes at 20 rpm. After treatment 20 ml of sample was taken and analyzed under spectrophotometer to measure its absorbance.

Table 1: Effect of pH on Coagulation Flocculation of Dyebath waste water using anionic Polymer A110

pH of Dyebath Solution	% Colour Removal (%)
4	57.0
5	65.4
6	64.6
7	70.4
8	67.0
9	60.4
10	61.6
11	63.4

Conditions:

Flocculant = Polymer A110
Cost of Flocculant= Rs. 350/kg
Volume of waste= 250 ml
Coagulant dose= 2g/L Alum
Flocculant dose= 4ml/250 ml of waste
Mixing Time = 3minutes
Mixing Speed = 120 rpm
C_i = 863.8 ppm

Fig 4 shows that maximum colour removal of 70.4% is achieved at initial pH 7 of dyebath waste water. Optimum initial pH of dye bath waste water for coagulation Flocculation using anionic Polymer A110 combined with alum = 7

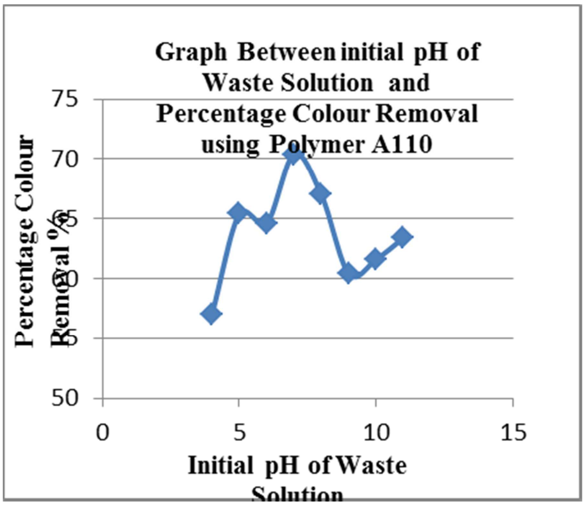


Fig 4: Effect of pH on percentage colour removal using Alum 2g/L and Anionic Polymer A110 (1% solution) 4ml/250 ml of dye bath waste water.

Determination of Optimum pH for Coagulation and Flocculation of mixture of Reactive Dyes using Alum as Coagulant and cationic Polymer 202 As as a Flocculant.

In order to find the optimum pH for coagulation and flocculation jar test method was used. Fixed dosage of coagulant and flocculant was used by varying initial pH of waste solution in range of 4 to 11. 2M HCl and 2 M NaOH solution was used for pH adjustment. Two sets of experiments were performed on Jar Test Apparatus with arrangement of four jars in each set. Alum concentration was chosen to be 2 g/L and cationic flocculant (Polymer 202 As 1% solution) concentration 4 ml of flocculant per 250 ml of waste solution. Rapid mixing time of 3 minutes was allowed at 120 rpm with alum followed by addition of flocculant (Polymer 202 As) with slow mixing for 30 minutes at 20 rpm. After treatment 20 ml of sample was taken and analyzed under spectrophotometer to measure its absorbance.

Table 2: Effect of pH on Coagulation Flocculation of Dyebath waste water using cationic Polymer A202

pH of Dyebath Solution	% Colour Removal (%)
4	57
5	65.4
6	68.2
7	67
8	64.6
9	60.4
10	61.6
11	63.4

Conditions:

Flocculant	=	Polymer 202 As
Cost of Flocculant	=	Rs 525/kg
Volume of waste	=	250 ml
Coagulant dose	=	2g/L Alum
Flocculant dose	=	4 ml/250 ml of waste
Mixing Time	=	3 minutes
Mixing Speed	=	120 rpm
C_i	=	863.8 ppm

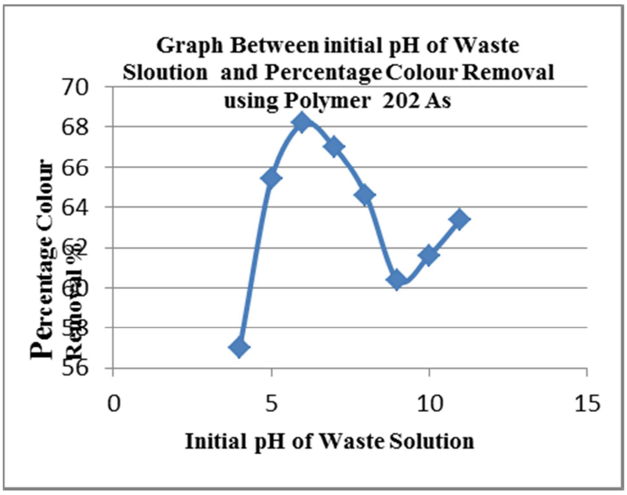


Figure 5: Effect of pH on percentage colour removal using Alum 2g/L and Anionic Polymer 202 As (1% solution) 4ml/250 ml of dye bath waste water.

Fig 5 shows that maximum colour removal of 68.2% is achieved at initial pH 6 of dyebath waste water. Optimum initial pH of dye bath waste water for coagulation Flocculation using cationic Polymer 202 As combined with alum = 6

Effect of Rapid Mixing Speed on Percentage Colour Removal using anionic Polymer A110.

Effect of Rapid mixing speed on coagulation

flocculation for removal of mixture of reactive dyes in dye bath waste is studied at the optimum pH and dosages of Alum and Polymer which have been determined before. Mixing speed range was taken from 100 rpm to 200 rpm with increments of 20 rpm, while mixing time was fixed to 3 minutes. It can be seen that with increasing mixing speed, Percentage colour removal also increases.

Table 3: Effect of Rapid Mixing Speed on Percentage Colour Removal using anionic Polymer A110:

Mixing Speed (rpm)	Percentage Colour Removal (%)
100	83.6
120	84.0
140	84.3
160	85.0
180	85.9
200	86

Conditions:

Dose of Alum used = 2g/L
Dose of Polymer A110 used = 8ml/250 ml of waste
Initial p`H = 7
Rapid Mixing time = 3 minutes

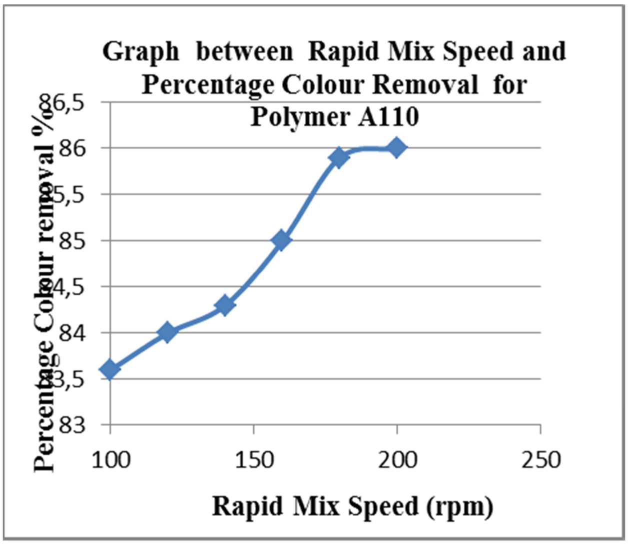


Fig 6: Effect on Percentage Colour Removal with increase in rapid mixing speed using Alum 2g/L and 8 ml of 1% solution of anionic Polymer A110.

Graph in Fig 6 shows that increase in mixing speed increases the color removal. This shows that high mixing speed enhances the performance of Polymer A110 for dyes removal from dye bath effluent. And the color removal is 86% at the speed of 200 rpm.

Effect of Rapid Mixing Speed on coagulation Flocculation of dyebath waste water using cationic Polymer 202 As:

Again effect of Rapid mixing speed on

coagulation flocculation for removal of mixture of reactive dyes in dye bath waste is studied with cationic polymer at the optimum pH and optimum dosages. Mixing speed range was taken from 100 rpm to 200 rpm with increments of 20 rpm, while mixing time was fixed to 3 minutes. It can be seen that with increasing mixing speed, Percentage colour removal increases discontinuously and maximum colour removal of 72.4% is achieved at 180 rpm.

Table 4: Effect of Rapid Mixing Speed on Percentage Colour Removal using cationic Polymer 202 As:

Mixing Speed (rpm)	Percentage Colour Removal (%)
100	70.3
120	71.5
140	70.3
160	71.6
180	72.4
200	71.9

Conditions:

Dose of Alum used = 2g/L
Dose of Polymer 202 As used = 10ml/250 ml of waste
Initial pH = 6
Rapid Mixing time = 3 minutes

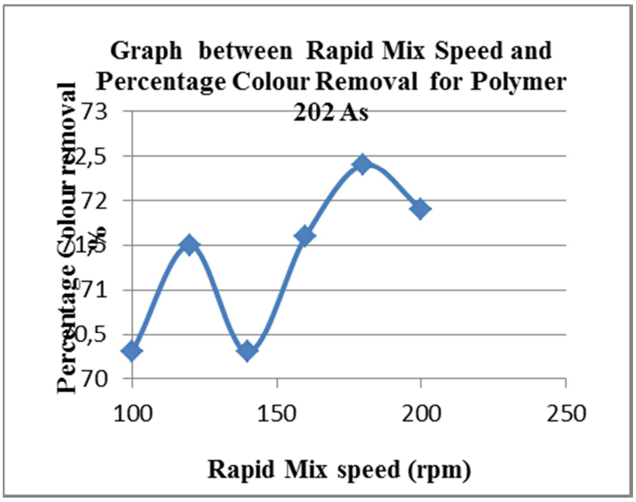


Fig 7: Effect on Percentage Colour Removal with increase in rapid mixing speed using Alum 2g/L and 10 ml of 1% solution of cationic Polymer 202 As.

Graph in Fig 7 shows that increase in mixing speed increases the color removal. This shows that high mixing speed enhances the performance of Polymer202 for dyes removal from dye bath effluent. And the maximum color removal is 72.4% at the speed of 180 rpm.

Effect of Rapid Mixing Time on coagulation Flocculation of dyebath waste water:

Effect of Rapid Mixing Time on Coagulation flocculation of dyebath waste water using anionic Polymer A110:

To investigate the effect of mixing time on dye removal by coagulation and flocculation experimentation was done with optimum dosages and pH as done before. Mixing time was varied from 3 to 18 minutes with increments of 3 minutes. Mixing speed of 120 rpm was chosen for experiments. In case of anionic polymer A110, percentage colour removal gradually increases as mixing time increases.

Table 5: Effect of Rapid Mixing Time on Percentage Colour Removal using anionic Polymer A110:

Rapid Mix Time min.	Percentage Colour Removal (%)
3	84.0
6	84.3
9	84.7
12	85.0
15	85.5
18	85.6

Conditions:

Dose of Alum used	=	2g/L
Dose of Polymer A110 used	=	8ml/250 ml of waste
Initial pH	=	7
Rapid Mixing Speed	=	120 rpm

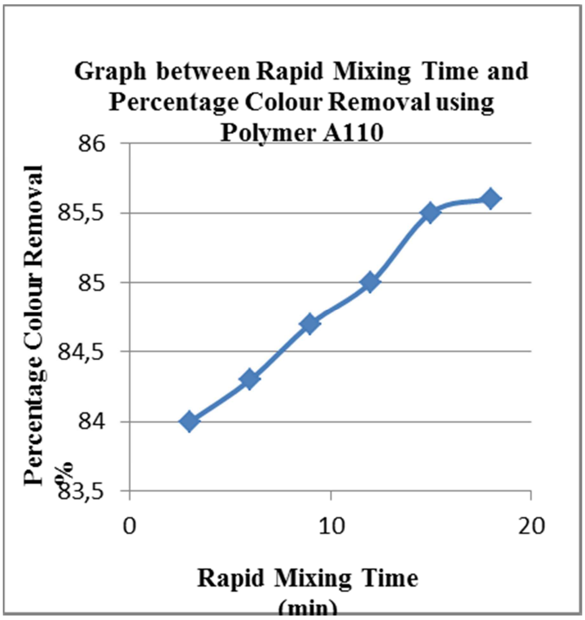


Fig 8: Effect on Percentage Colour Remova with increase in rapid mixing time using Alum 2g/L and 8 ml of 1% solution of anionic Polymer A110:

Graph in Fig 8 shows that increase in mixing time increases the color removal. This shows that high mixing time enhances the performance of Polymer A110 for dyes removal from dye bath effluent. And the maximum color removal is 85.7% when the mixing time is 18min.

Effect of Rapid Mixing time on Coagulation flocculation of dyebath waste water using cationic Polymer 202 As:

To investigate the effect of mixing time on dye removal by coagulation and flocculation experimentation was done with optimum dosages and pH as done before. Mixing time was varied from 3 to 18 minutes with increments of 3 minutes. Mixing speed of 120 rpm was chosen for experiments. In case of anionic polymer 202 As, percentage colour removal also gradually increases as mixing time increases.

Table 6: Effect of Rapid Mixing Time on Percentage Colour Removal using cationic Polymer 202 As:

Rapid Mix Time min.	Percentage Colour Removal (%)
3	71.5
6	71.8
9	71.9
12	72.2
15	72.3
18	72.5

Conditions:

Dose of Alum used = 2g/L
Dose of Polymer 202 As used = 10ml/250 ml of waste
Initial pH = 6
Rapid Mixing Speed = 120 rpm

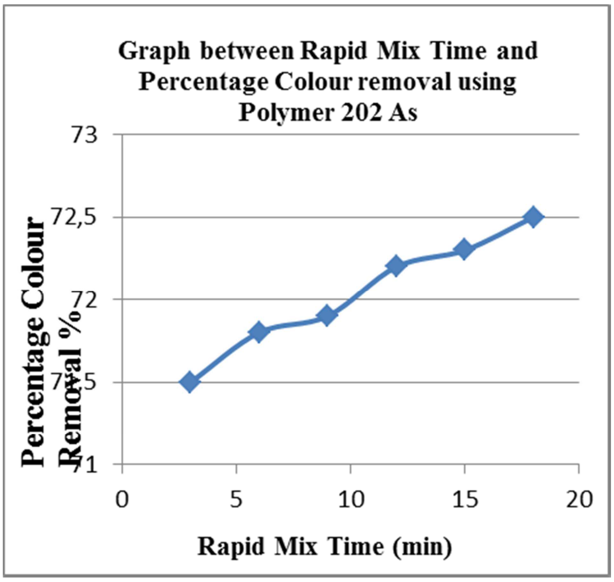


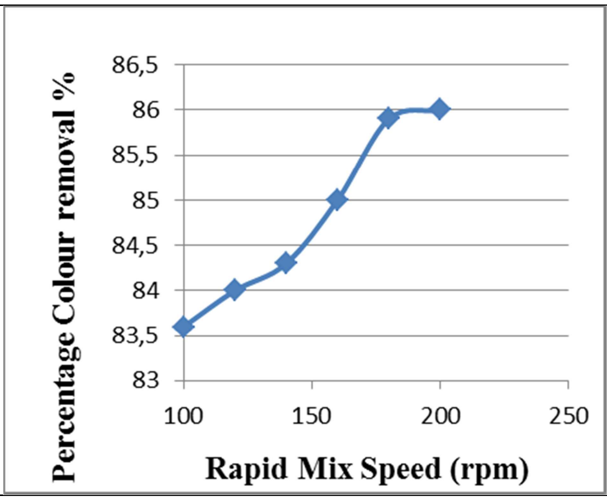
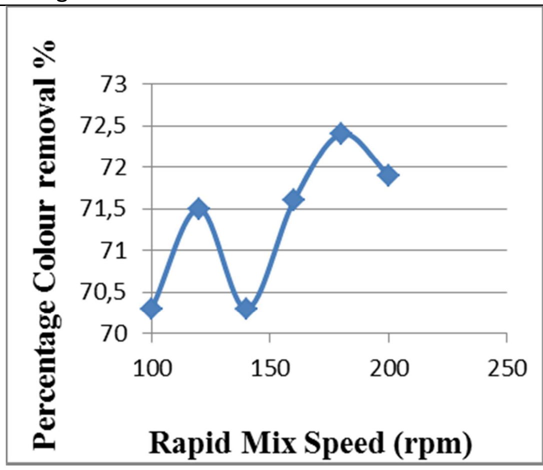
Fig 9: Effect on Percentage Colour Removal with increase in rapid mixing time using Alum 2g/L and 10 ml of 1% solution of cationic Polymer 202 As:

Graph in Fig 9 shows that increase in mixing time increases the color removal. This shows that high mixing time enhances the performance of Polymer202 for dyes removal from dye bath effluent. And the maximum color removal is 72.5% when the mixing time is 18min.

Comparison of Flocculants:

Results of previous study are summarized as:

Table 4.9: Comparison between Flocculant Polymer A110 & Polymer 202 A

<table>
<tr><th>Anionic Flocculant Polymer A110</th><th>Cationic Flocculant Polymer 202 As</th></tr>
<tr><td>Rs. 350/kg</td><td>Rs. 525/kg</td></tr>
<tr><td>Optimum dosage is 8 ml in combination with 2 g/L of alum and it gives 84 % dye removal.</td><td>Optimum dosage is 10 ml in combination with 2 g/L of alum and it gives only 71.5% dye removal.</td></tr>
<tr><td>Mixing speed has a pronounced effect on Percentage Colour Removal</td><td>Mixing speed do not have a pronounced effect on Percentage Colour Removal</td></tr>
<tr><td>
</td><td>
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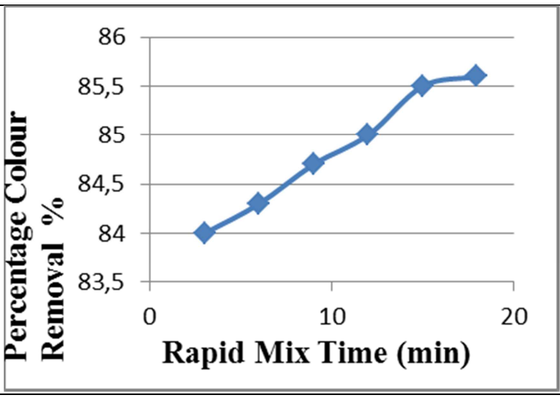
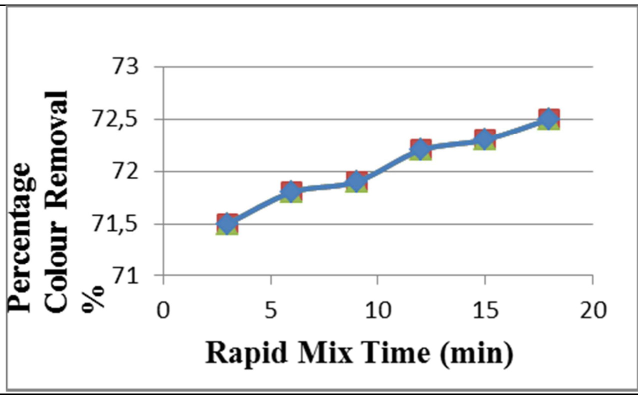
<tr><td>Percentage Colour removal for same mixing time is greater i.e. increment is of 1.6%.</td><td>Percentage Colour removal for same mixing time is not as greater as anionic polymer i.e. increment is of only 1% is achieved.</td></tr>
<tr><td>
</td><td>
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CONCLUSIONS

- Optimum pH for coagulation flocculation of dyebath waste water having mixture of reactive dyes using Alum (2g/L) as coagulant and anionic Polymer A110 (4ml of 1% solution in 250 ml of waste) as flocculant, is 7 with colour removal of 70.4 %.
- Using Alum (2g/L) as coagulant and cationic Polymer 202 As (4ml of 1% solution in 250 ml of waste) as flocculant, Optimum pH for coagulation flocculation of dyebath waste water having mixture of reactive dyes is 6 with color removal of 68.2 %.
- Effect of Rapid mixing speed on coagulation flocculation using optimum pH and optimum dosages of coagulant and flocculants is almost same. i.e. percentage colour removal increases with increasing Rapid Mixing Speed.
- Maximum color removal is 86% in case of Polymer A110 at 200rpm and at 180rpm color removal is 72.4%when Polymer 202As is used.

- Effect of Rapid mixing time on coagulation flocculation using optimum pH and optimum dosages of coagulant and flocculants is almost same. i.e. percentage colour removal increases with increasing Rapid Mixing time.
- Maximum color removal is when the mixing time is 18 min and for Polymer A110 it is 85.6% and for Polymer 202As is 72.5%.

FUTURE RECOMMENDATIONS

1. Coagulation and flocculation falls in the category of primary treatment in any waste treatment plant. To further purify a waste steam filtration or adsorption is usually used. In the present study colour removal of 84% is achieved. In order to achieve 100% colour removal it is recommended strongly to use adsorption followed by coagulation flocculation.
2. In this study only two flocculants have been considered, in future many flocculants can be studied.
3. Report is based only on Percentage colour removal. This research can be extended to study BOD and COD removal.
4. This study is performed batch wise, a continuous process studies can also be performed with this project.

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