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Removal of Colour from Textile Wastewater Using Two- Step Coagulation Process

Ria Nanda[*1], Ritu Vyas[2]

[*1] Research Scholar, Faculty of Engineering, Pacific University, Udaipur, Rajasthan, India
[2] Assistant Professor, Faculty of Engineering, Pacific University, Udaipur, Rajasthan, India
rianandachem@gmail.com

Abstract

The waste water from the textile dyeing industry produces large amount of coloured water and this needs to be treated before discarding in the ecosystem. There are various treatment technologies to remove colour from this wastewater which includes the most primitive yet effective method of coagulation-flocculation.

In this research, inorganic coagulants like Alum (trivalent) and ferrous sulphate (bivalent) were applied on commercial dyes Congo Red and Direct green 41 at different pH values of 8,9,10. Various parameters such as colour removal percentage, pH changes, TDS (Total Dissolved Solids), settled sludge volume has been evaluated.

It has been estimated that though FeSO4 is the better coagulant for colour removal but somehow it produced an anesthetic colour to the residual water in comparison to Alum. Moreover Congo red being less complex in structure is removed more effectively than Direct green 41.

Keywords: Coagulation, Azo dyes, Alum, Ferrous sulphate, Decolourisation

Introduction

Dyes are considered to be particularly dangerous organic compounds for the environment. Residual dyes after the treatment of fabric are characterized as wastewater. Wastewater treatment is the major environmental issue of the textile industries. Textile & dyeing industries use many kinds of artificial composite dyes & discharge large amounts of highly coloured wastewater [1].

Nearly 40,000 dyes and pigments are listed which consists of over 7000 different chemical structures and about 10-15% of these dyes are released as effluents. Dyeing and printing operations [2] produce large quantities of waste water that contains organic dyestuff, dye fixers and other contaminants that can be characterized as high level of total organic contents & colour [3],[4]. The colouring agents like dyes, inorganic pigments, lignin [5] usually imparts colour. Synthetic dyes are widely used in the textile industries and it is estimated that up to 15% of the dye [6] is lost in the effluent [7]. These coloured compounds are not only aesthetically displeasing, but they also impede light penetration, retard photosynthetic activity & inhibit the growth of biota [8]. Dyes are very much difficult to be decolourized due to their complex structure. Colour is mainly due to the presence of phenolic origin, organic groups which are called as chromophores like azo group (-N=N), nitroso group (-N=O), nitro group (-NO2) [9], [10].

Coagulation [11] is a highly employed method involving different inter-related parameters which makes the work a bit calculative in defining the coagulant dosages and the mixing time [12]. Coagulation-flocculation is a frequently used physicochemical treatment employed in textile wastewater treatment plants to decolourize textile effluent [13], [14] and reduce the total load of suspensions and organic pollutants [15], [16]. The main advantage of the coagulation-flocculation method is that the decolourization of the textile wastewater can be achieved through removal of dye molecules from the dyebath effluents [17], and not by partial decomposition of dyes, which could produce potentially harmful and toxic aromatic compounds such as benzene moieties, phenolic compounds, di-ketones, and amine compounds. The efficiency of the coagulation -flocculation method depends on the raw wastewater characteristics such as dye dosage (less amount of dye in waste water could be removed very easily and effectively) [18], class of dyes (basic azo dyes can be removed easily due to less loss to effluent), pH (pH near to neutral removes dye in very short span of time due to charge neutralization principle), dosage coagulants (minimum amount of coagulant should be used so that sludge production could be handled properly) [19], and the intensity and duration of mixing (rotation speed is the main reason for flocc formation) [20], [21].

The present paper involves the decolourization study of azo dyes using alum and ferrous sulphate as coagulants and the dyes on which coagulants are worked upon are Congo Red and Direct Green 26 (Figure 1).

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These dyes are cheaper, water soluble, commonly used in the textile industry and posses good colour fastness.

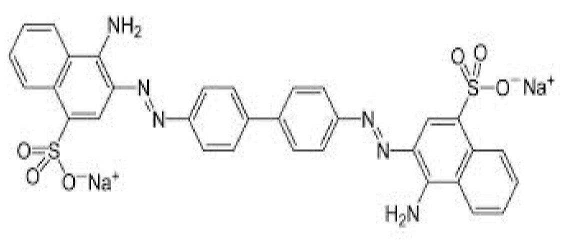
Materials and Methods

Coagulants

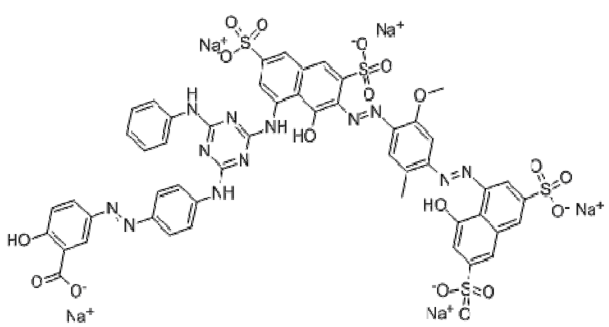
The analytical grades of Alum [$Al_2(SO_4)_3.16H_2O$], Ferrous sulphate [$FeSO_4$], sodium hydroxide (NaOH), sulphuric acid (98% H_2SO_4)were obtained from CDH (Chemical Drug House). A stock solution of Alum was prepared by dissolving 10g in 1 litre of distilled water; each 1ml of this stock solution was equal to 10ppm. But ferrous sulphate was weighted freshly because it easily gets oxidised if stock solution is prepared. 1.0 N NaOH and 1.0 N H_2SO_4 were prepared and diluted in requisite amount to maintain the various pH values of 8, 9 and 10 of the stocked dye solutions.

Dyes

The various commercially used textile dyes Congo Red (CR) and Direct green 26 (DG26) were obtained from M.H. Textiles pvt. ltd. (Mathura road, Faridabad) and stock dye solution of 100mg/l each was prepared and from this solution 500ml was used for the decolourisation process and the pH of the synthetic dye waste water was adjusted using NaOH and H_2SO_4.



Congo Red **[DYE 1]**



Direct green 26 **[DYE 2]**

Details of the four textile azo dyes:

Name of the dye	Classification	M.W (g)	λ(max) nm
Congo Red	Anionic Disazo	696.665	497
Direct green 26	AnionicTrisazo	1333.08	520

Experimental Design

The synthetic dye waste water measured 1000ml was taken in a 2 liter capacity beaker and pH was adjusted accordingly using pH meter (Hanna Instruments, Italy). Alum or ferrous sulphate was added as 0.2mg, 0.4mg, 0.6mg, 0.8mg to the sample dye water and stirring was done using magnetic stirrer (U-Tech Ltd). A rapid mixing of the dye waste water with the coagulants was done for 1 minute at maximum stirring rate followed by a slow mixing for 30 minutes at minimum stirring rate. Then the solution was allowed to settle for 24 hours and after settling process it was filtered using Watmann filter paper No. 42.

Again the sample treated water was decanted and 500ml from this was dosed again with same amount of coagulants and jar test was done as mentioned above.The residual water was then analyzed for various parameters. The maximum absorbance (λ_{max}) of the various dyes with the background of the deionised water was 497nm (CR), 520nm (DG26).

Physicochemical Analysis

The various parameters were measured using the standard methods and various instruments. TDS (ppm), pH (accuracy ±0.1) were measured with the digital instruments provided by HANNA Instruments. Suspended solids were measured using standards methods by APHA 2003. Absorbance was measured using digital spectrophotometer provided by ELICO PVT LTD. Percentage of dye removal was calculated by Eq. (1):

$$\text{Dye removal (\%)} = \frac{Cr - Ct}{Cr} \times 100$$

Where, Cr and Ct are the dye concentration in raw water and treated water respectively.

Statistical Analysis

All data were recorded as mean± SD and the mean values were calculated based on the data taken from three independent experiments estimated in triplicates.

Results and Discussion

Effect of coagulant dosage on removal efficiency

pH plays very important role in coagulation/flocculation process using inorganic coagulants. The pH factor affects the surface charge of the coagulants and also the stabilization of the suspension. Dye concentration was kept constant at 100ppm and pH of the samples was varied using NaOH and H_2SO_4.

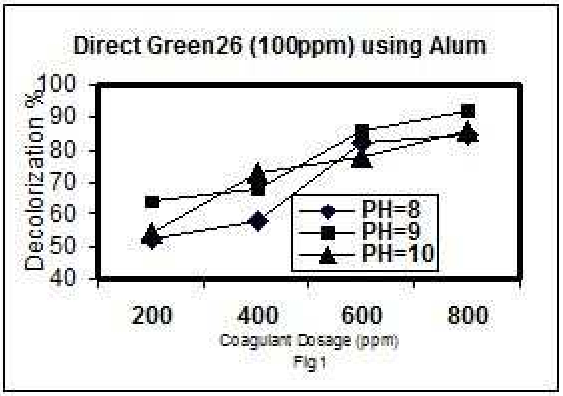


Fig: 1

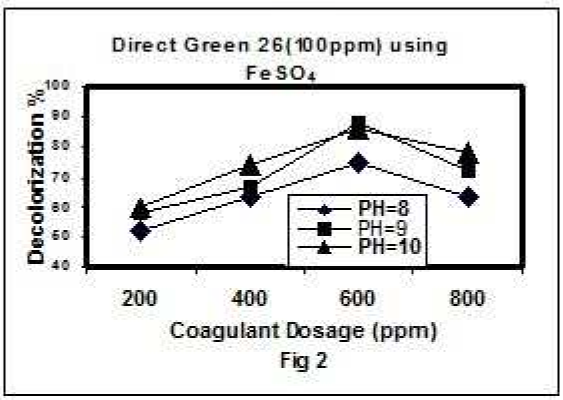


Fig: 2

For Direct Green 26, Fig 1&2 shows that decolourization depends upon coagulant dosage at various pH value. Using Alum as coagulant the maximum % removal is found to be at 800ppm as 85% (pH 8), 92%(pH 9),and 86% (pH 10) whereas if $FeSO_4$ is used maximum colour removal % is at 600ppm with the removal efficiency of 75% (pH 8), 88% (pH 9), 86% (pH 10).

Fig 3 & 4 shows that Congo Red (100ppm) is decolorized using coagulants at different dosages at various pH. Using Alum as coagulant the maximum % removal is found to be at 400ppm as 91% (pH 8), 86%(pH 9),and 82% (pH 10) whereas if $FeSO_4$ is used maximum colour removal % is at 600ppm with the removal efficiency of 78% (pH 8), 82% (pH 9), 84% (pH 10).

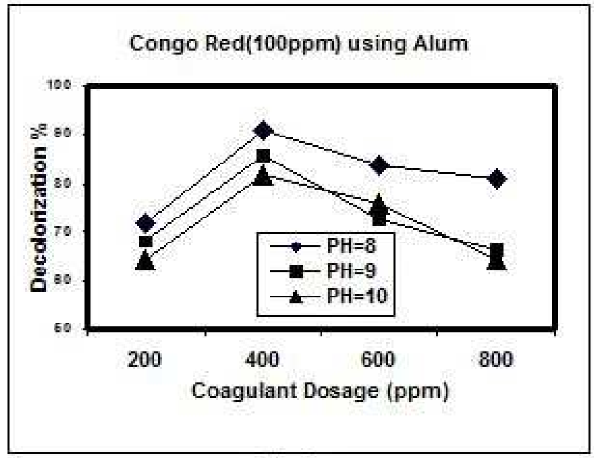


Fig: 3

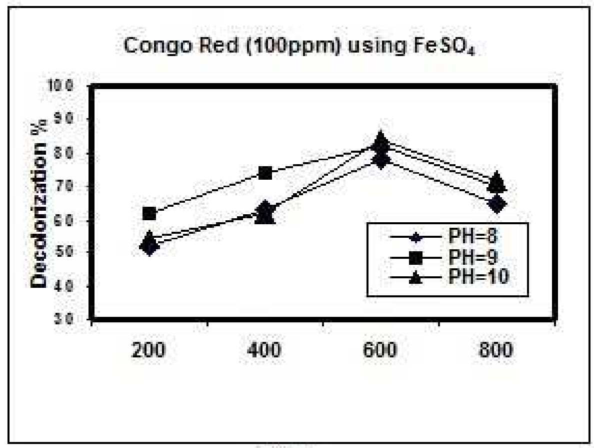
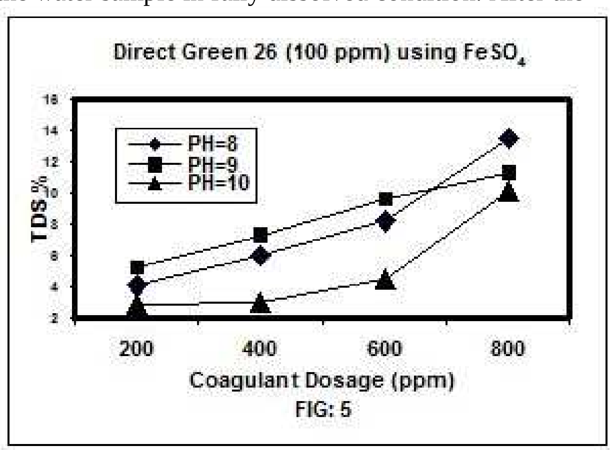


Fig: 4

Effect of Dosage on Total Dissolved Solids

Total dissolved solids are the solids present in the water sample in fully dissolved condition. After the



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coagulation and filtration process of the treated water, there still remains some amount of TDS in the residual water whose amount should be known as it is undesirable for potable water.

In the Fig 5, Direct green 26 is decolourized using $FeSO_4$ as coagulant and generally it was found that TDS increases with increase in coagulant dosage. But graphically it was showed that value of TDS does not increase much if pH is 10, maximum % was 6.4 for 800ppm. Worst performance is shown at pH 8 where TDS reached 9.5%.

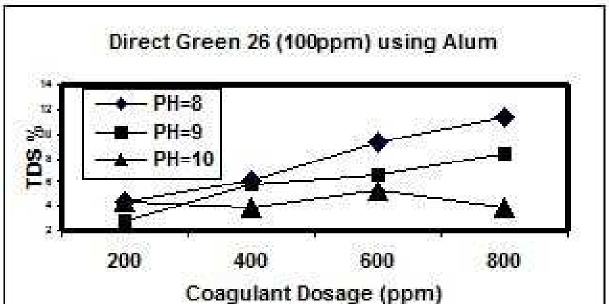

Fig. 6

Similarly in Alum (fig 6) is used for decolourisation again pH 10 was found to be the best pH value where 600ppm dosage has the least TDS % of 5.3%.

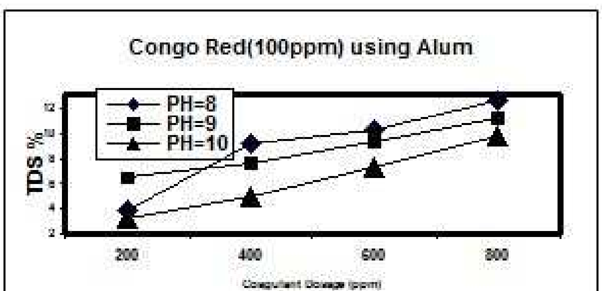

Fig. 7

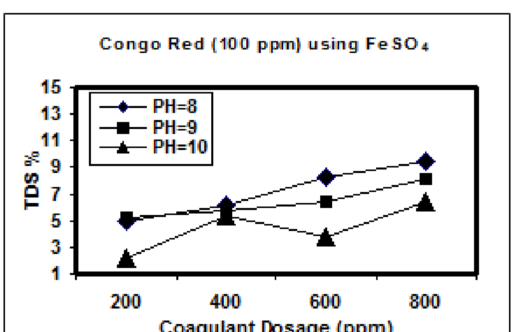

Fig. 8

Fig 7 shows the effect of alum dosage on TDS % in wastewater containing Congo red as dye. General observation concludes the increase of TDS value. Using 800ppm at pH10, TDS was found to be only 9.8% and for pH 8 and 9, TDS was found to be the maximum 12.5% and 11.2% respectively.

Similarly (fig 8) if $FeSO_4$ is used for decolourisation, pH 10 was found perfect with again the dosage of 800ppm with TDS only 6.4%. For pH 8 and 9, TDS values increases with the dosage of maximum of 9.5% and 8.1% respectively.

Effect of Dosage on Suspended Solids (S.S)%

Coagulation/ flocculation possess a single demerit of sludge production. After the mixing and settling of the coagulant, solid residues are produced which can not be thrown into the ecosystem. So choice of the coagulant dosage is also based on the minimum amount of sludge production. This sludge generally contains suspended, colloidal and dye residues.

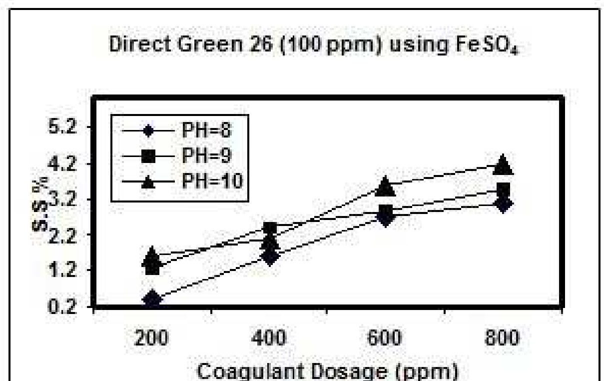

Fig 9

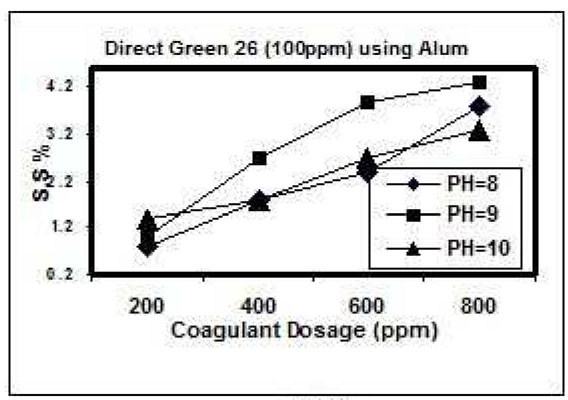

Fig 10

From the above study, it is concluded that as the amount of coagulant is increased, there is increase in the production of the sludge. So the optimum dosage of the coagulant needs to be calculated so that minimum amount of sludge is produced.Fig 9 and 10 shows the same observations, with the increase in coagulant dosage from 200ppm to 800ppm,the sludge production is increased to 3.8% (pH8), to 4.3% (pH9) and to 3.3% (pH10) using Alum. This explained that as the coagulant dosage is increased the amount of flocc formation is increased.

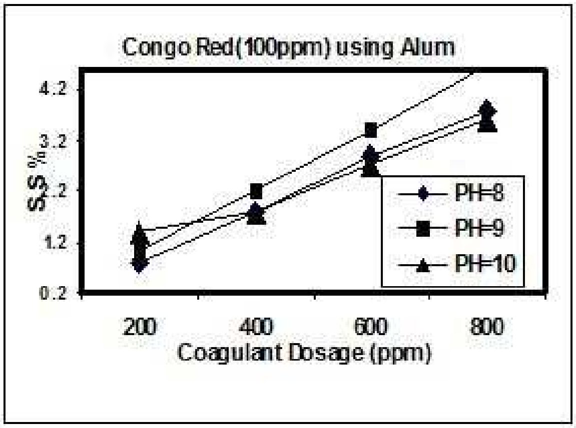

Fig 11

From the above study, it was found that sludge production increases with increase in dosage of coagulant. Fig 11 shows that using alum, the value increases to 3.8% at pH 8, 1% to 4.7% at pH 9 and 3.6% at pH10.

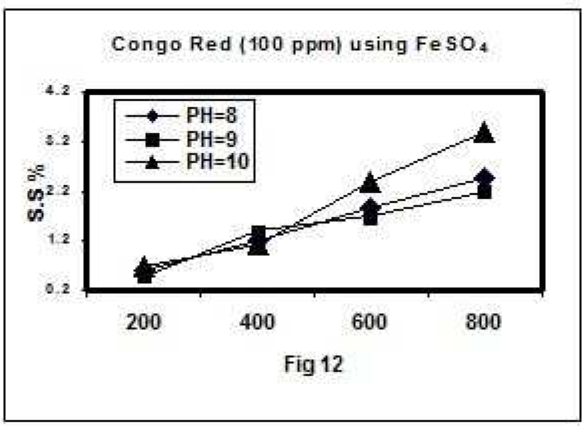

Fig 12

Fig 12 concluded that for pH 8 using ferrous sulphate value was found to be 2.5% for 800ppm (pH8), for pH9 is was 2.2% and for pH10 is was 3.4% as maximum values.

Conclusion

Present study first time analysed the effect of Alum and Ferrous sulphate as coagulants on two commercial textile dyes using different coagulants dosages at different pH values. The various parameters like TDS, colour removal efficiency and sludge production were investigated using statistical analysis.

It was also concluded that ALUM is although more effective than $FeSO_4$ but gets destabilized after a particular dosage value. But $FeSO_4$ also makes residual water a bit coloured due to oxidation of Fe^{+2} to Fe^{+3}. It was also concluded that Direct Green 26 is less decolourised from the waste water due to its complex aromatic structure as compare to other textile azo dyes taken for the experimental work.

Optimum dosage for DIRECT GREEN 26 was found to be 800ppm at pH=9 using ALUM with the TDS 8.4% and Sludge production of 4.3%.

Using $FeSO_4$ for DIRECT GREEN 26, the optimum dosage was found to be 600ppm at pH=9 with TDS 11.3% and sludge production of 3.5%.

Optimum dosage for CONGO RED was found to be 400ppm at pH=8 using ALUM with the TDS 12.5% and Sludge production of 3.8%.

Using $FeSO_4$ for CONGO RED, the optimum dosages found to be 600 at pH=10 with TDS 6.4% and sludge production of 3.4%.

References

[1] *Thorat P.R. & Pathade G.R; 2005; Treatment of textile industry waste water by coagulation process; Nature Env. Poll.Tech;* ***4(2);*** *233-236.*

[2] *B.H. Tan, T.T. Teng, A.K.M. Omar, Removal of dyes and industrial dye wastes by magnesium chloride, Water Res.* ***34*** *(2000) 597–601.*

[3] *Azbar, N. and Tonar, T., (2004). Comparison of various advanced oxidation processes and chemical treatment methods for COD and color removal from a polyester and acetate fiber dyeing effluent. J. Chemosphere,* ***55****, 35-43.*

[4] *Aslam, M., M. Baig, I. Hassan, I. Qazi, M. Malik and H. Saeed, 2004. Textile wastewater Characterization and Reduction of its COD and BOD by Oxidation, EJEAF Che.,* ***3(6):*** *804-811.*

[5] *Stanislow, L., S. Monika and Z. Renata, 2001. Biodegradation, Decolorization and Detoxification of Textile Wastewater Enhanced by Advanced Oxidation Processes. Journal of Biotechnology,* ***89****: 175-184.*

[6] *Chu, W., 2001. Dye Removal from Textile Dye Wastewater Using Recycled Alum Sludge. Water Research,* ***35(13):*** *3147-3152.*

[7] *D. Georgiou, A. Aivazidis, J. Hatiras, K. Gimouhopoulos, Treatment of cotton textile wastewater using lime and ferrous sulfate, Water Res.* ***37*** *(2003) 2248–2250.*

[8] *Sarvanan V & Sreekrishanan TR (2005) Bio-physico-chemical treatment for removal of*

ISSN: 2277-9655
Impact Factor: 1.852

*colour from pulp and paper mill effluents. J. Sci. Ind. Res. **64**: 61–64.*

[9] *Kim, T.K., Park, C., Shin, E., Kim, S., 2004. Decolorization of disperse and reactive dye solutions using ferric chloride. Desalination, **161**:49-58.*

[10] *Sureyya, M., Kaptan, D. and Tugba, O.; (2004). Color and COD removal from wastewater containing Reactive Black 5 using fenton's oxidation process; J.Chemosphere, **106**, 435-441.*

[11] *Islam M.A; Mozumdar M.S.I; (2010); Development of treatment technology for dye containing industrial waste water; Journal of Scientific Research; **2(3)** 567-576.*

[12] *Guendy H.R.; (2010); Removal of azo, reactive, direct dyes from waste water using different coagulants at different pH; Journal of Applied Sciences Research, **6(8)** 956-963.*

[13] *Y. C. Chung, C. Y. Chan, (2008); Degradation of azo dye reactive violet 5 by titanium oxide. Environ. Chem. Letter, Vol.7(4), 347-352.*

[14] *F. El-Goharyand ,A. Tawfik (2009); Decolorization and COD reduction of disperse and reactive dyes wastewater using chemical-coagulation followed by sequential batch reactor (SBR) process. Desalination, Vol. 249, Issue. **3**, 1159-1164.*

[15] *Beltrán-Heredia (2009); Removal of Alizarin Violet 3R (anthraquinonic dye) from aqueous solutions by natural coagulants. Journal of Hazardous material,Vol.170, **Issue 1**, 43-50.*

[16] *Xu G.R. (2008); Degradation of azo dye active brilliant red X-3B by composite ferrate solution. Journal of Hazardous material, Vol.161, Issue **2-3**, 1299-1305.*

[17] *Baoyou Sh. (2007); Removal of direct dyes by coagulation: The performance of preformed polymeric aluminum species. Journal of Hazardous material, Vol.143, Issue **1-2**, 567-574.*

[18] *Gao B.Y., Yue Q.Y., Wang Y., Zhou W.Z., (2007), Color removal from dye containing wastewater by magnesium chloride. Journal of Environmental Management, **82**, 167–172*

[19] *Yuan Yu li et al; (2006); Treatment of waste water from dye manufacturing industry by coagulation; Journal of Zhejiang university; 7 (supp II); 340-344.*

[20] *Golob V ,Vinder A ,Simonic M;(2005) Efficiency of the coagulation/flocculation method for the treatment of dye bath effluents, Dyes and Pigments, **67**, 93-97.*

[21] *APHA: 2003, 'Standard Methods for the Examination of Water and Wastewater', 21st ed., American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC.*