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# Evaluation of Industrial Dyeing Wastewater Treatment with Coagulants

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**ABSTRACT:** Textile industry is the major source of water consumption and wastewater pollution. There are various treatment techniques to remove textile wastewater pollution. Coagulation-flocculation is a widely used process to remove pollution due to suspended particles. In this research, different coagulants like Alum, Lime, $FeCl_3$, $FeSO_4$ and $MgCl_2$ were applied to select the suitable ones with optimum removal efficiency of sulfuric dyes. Settling characteristics of flocs formed in the coagulation process were studied in a laboratory scale settling column unit. Parameters such as color, COD, TSS, turbidity and settled sludge volume have been evaluated. The optimum coagulant dose and pH value were determined by comparing the effectiveness of these coagulants.Results showed other coagulants except lime could eliminate color and COD. In this case, $FeSO_4$ was chosen as an optimum coagulant for color removal because of the lowest required coagulant dose, minimum settled sludge volume and maximum de-colorization.

**Key words :** Dye removal , Coagulation , Textile wastewater , De-colorization

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## INTRODUCTION

Wastewater is the major environmental issue of the textile industries besides other minor issues like solid waste, resource wastage and occupational, health and safety. Textile and dyeing mills use many kinds of artificial composite dyes and discharge large amounts of highly colored wastewater. Pretreatment, coloration and after treatment of fibers, usually require large amounts of water and variety of chemicals. Variations in the fabric quality and treatment process results into large fluctuation in daily flow rates and pollutants concentrations. Textile wastewater pollutants are generally caustic soda, detergents, starch, wax, urea, ammonia, pigments and dyes that increase its BOD, COD, solids contents and toxicity. These wastes must be treated prior to discharge in order to comply with the environmental protection laws for the receiving waters. Biological treatment processes are frequently used to treat textile effluents. These processes are generally efficient for biochemical oxygen demand (BOD) and suspended solids (SS) removal, but they are largely ineffective for removing color from the wastewater (McKay, 1979; Taebi Harandi, 1986) because dyes have slow biodegradation rate (Bennett and Reeser, 1988). Now, the treatment technologies recommended meeting color removal requirements are physicochemical treatment operations, including adsorption (Ahmad & Ram, 1992; McKay, 1979), ozonation (Lin's, 1993), oxidation (Boon, *et al.*, 2000), chemical precipitation (Dziubek & Kowal, 1983), etc. Each has its merits and limitations in applied de-colorization treatment operations. But Coagulation-flocculation is the most common chemical treatment method for de-colorization (Carliell, *et al.*, 1994; Bennett & Reeser, 1988). All test results in Iran and other countries show chemical treatment is effective enough to treat textile wastewater and decrease considerable COD and dye. Hengame Goya factory is located in *Eshtehard* industrial town. In this factory, sulfuric colorants and 522 black color made in Shanghai China commercially named *sulfur black* 522 BR 200% are usually used for dyeing process.

## MATERIALS & METHODS

Both suspended and colloidal particles don't settle under gravity so they can't be removed by physical processes. Reason of this event is that some suspended solid have trifle weight and the charges present on colloid surfaces result into repulsion and do not allow them to agglomerate and form flocs. Coagulation process neutralizes the charge present on the particles surfaces with the help of coagulants whereas flocculation makes them to come close to each other to make flocs by slow agitation. Settling follows coagulation and flocculation to remove resultant flocs from the wastewater (Beulker & Jekel, 1993). Designing of coagulation, flocculation and settling tank requires study regarding optimum dose of coagulants at suitable pH to give maximum removal and settling characteristics of resultant flocs (Cooper, 1993; Jorgenson, 1974).

Factory wastewater samples were averagely taken weekly and then conveyed to the laboratory of Environment Faculty in Tehran University per month. Parameters such as pH, COD, dye concentration and TSS were determined. Then, COD and dye removal efficiencies were calculated. Experimental conditions of all tests are:

1.All tests have been performed in (25°C±2). Because temperature is one of the effective parameters on density, viscosity and thus retained volume of coagulant.

2.The volume of studied wastewater was 500 cc. Method No.522 in Standard Method was used to determine COD (chemical oxygen demand). COD concentration of the samples was measured by potassium dichromate method using HACH spectrophotometer. Color was determined by comparative methods using HACH spectrophotometer DR/2000. The color measurement unit is Pt/Co. TSS was determined in conformity with Standard Method using HACH Spectrophotometer RD/2000. PH was measured using digital SCHOTT pH meter model CG824 (accuracy pH $\pm$ 0.1) .Turbidity was determined using ANNA turbidity meter and the measurement unit is NTU (Rinker & Starent, 1974). All experiments were conducted using the jar testing method to determine the optimum pH value and coagulant dose. Six beakers positioned on magnetic stirrers were dosed with 0.5-L dye solution and a specified dosage of coagulant. The samples were stirred rapidly for 90 seconds, followed by 20 minute slow stirring for flocculation. The generation of flocs can be watched during this period. Flocs were allowed to settle for one hour before withdrawing samples for analysis. These procedures are performed for several times so that the optimum pH and dose of coagulant can be calculated (Hosseinian, 1991; Metcalf & Eddy, 1979; Torkian, 1996).

## RESULTS & DISCUSSIONS

In this study, coagulation-flocculation processes are used to de-colorize and bio-degraded textile finishing industry effluents. The optimum coagulant dose and pH value are determined by comparing the effectiveness of alum, $FeSO_4$, $FeCl_3$, lime, $MgCl_2$ for obtaining maximum color, TSS and COD removals. For each case, the optimum pH is primarily determined for 400 mg/L coagulant concentration based on more color and COD removal and also less settled sludge. Then the optimum effective dose of coagulant is calculated at the optimum pH. Finally at constant optimum pH and coagulant dose has been evaluated. According to figure 1 and 2 the optimum pH for 400 mg/L alum is 8.2 due to higher color and COD removal and lower volume of settled sludge. Figure 3 and 4 shows that the optimum dose of alum for color and COD removal is 200 mg/L.

To evaluate lime effect on color and COD removal of dyeing wastewater, first its effect at a constant pH for different doses of lime has been evaluated**.** Fig. 5. shows that 250 mg/L lime eliminates only 29 % COD and just 2.5 % color. After 3 hours no settled sludge has been found. Thus lime is not recommended for color removal of dyeing wastewater.

According to Figs. 1 and 2 the optimum pH for 400 mg/L $FeSO_4$ is 9.4 due to higher color and COD removal and lower volume of settled sludge. Figure 3 and 4 shows that the optimum dose of $FeSO_4$ for color and COD removal is 200 mg/L. According to figure 2 and 6 the optimum pH for 400 mg/L $FeCl_3$ is 8.3 due to higher color and COD removal and lower volume of settled sludge. Figure 4 and 7 shows that the optimum dose of $FeCl_3$ for color and COD removal is 200mg/L.

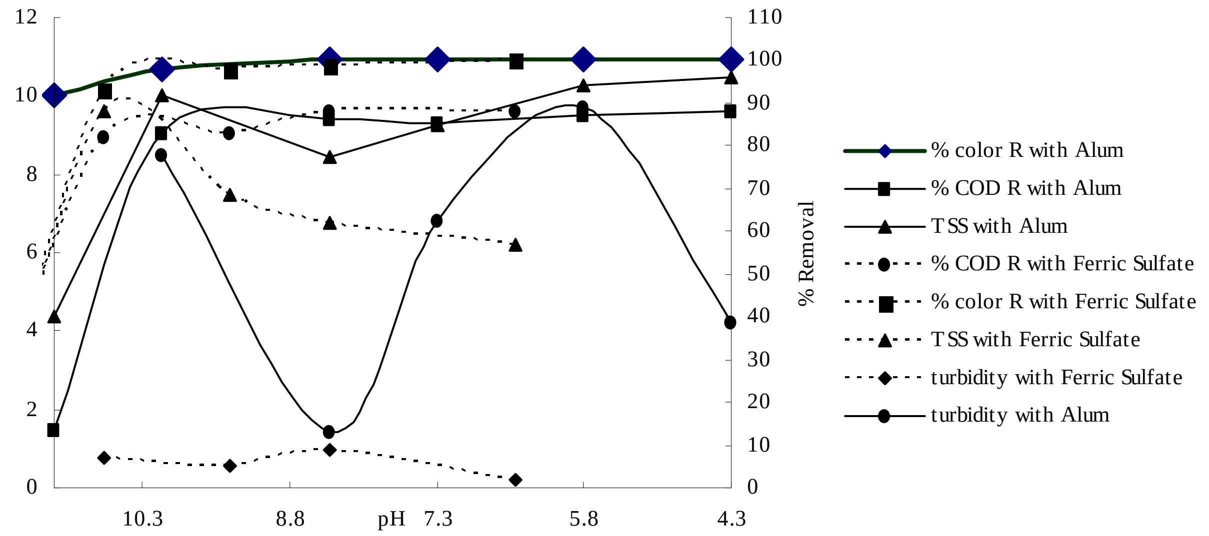


**Fig.1. % Removal of Color, COD & TSS and turbidity for different pH. (For 400 mg/L Alum or 400 mg/L of $FeSO_4$)**

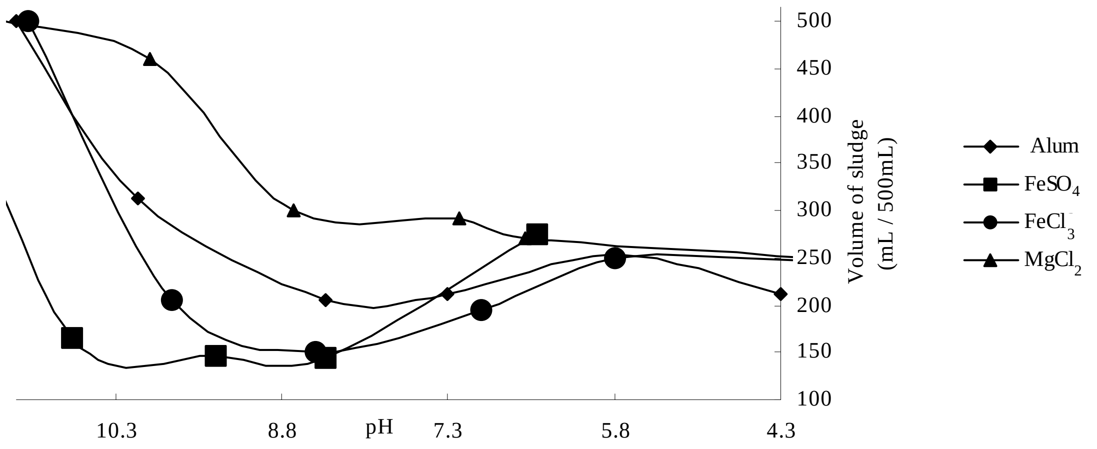


**Fig. 2. Settled sludge volume for 400 mg/L of coagulants**

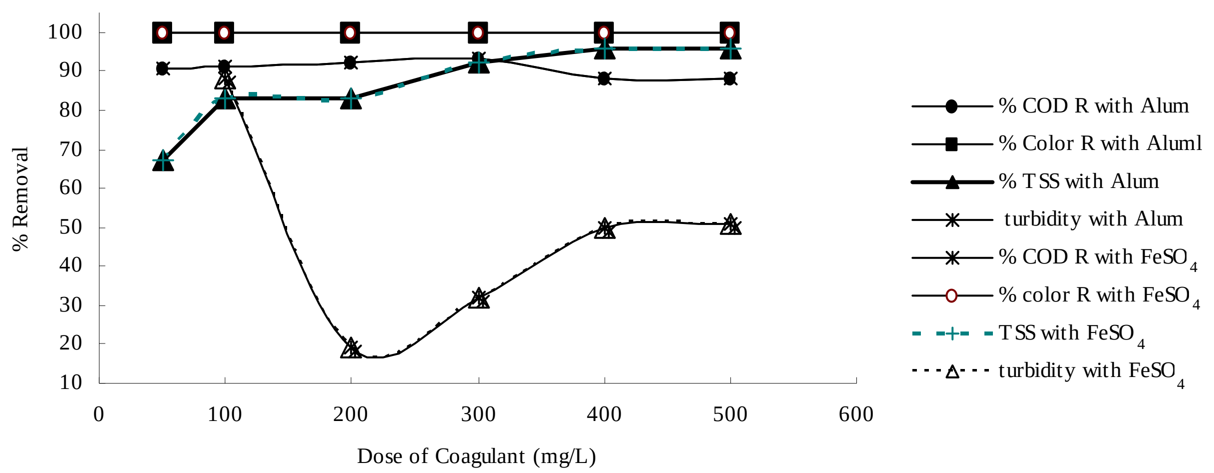


**Fig. 3. % Removal of Color, COD & TSS and turbidity for different doses of coagulant (At optimum pH=8.2 for Alum Or at pH=9.4 for $FeSO_4$)**

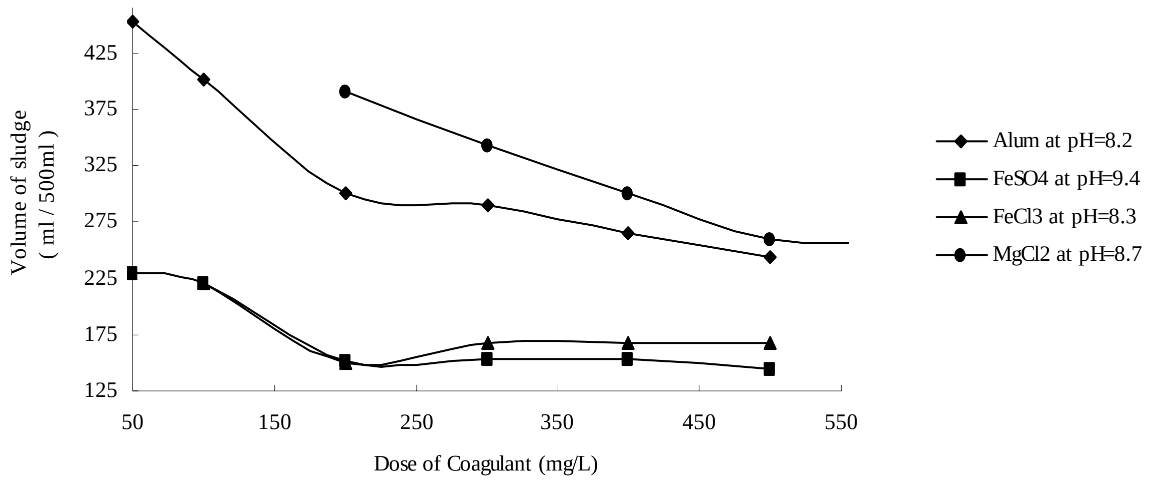


**Fig. 4. Settled sludge volume for different coagulants at their optimum pH**

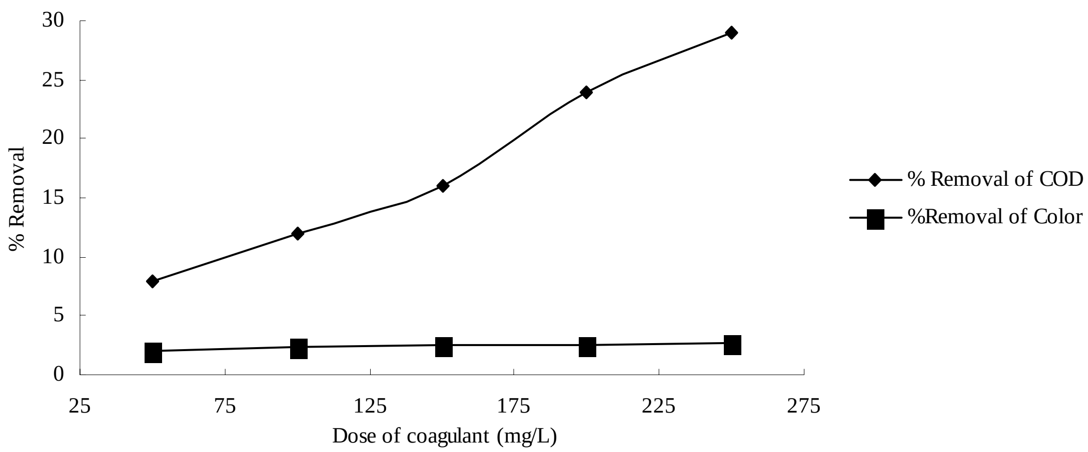


**Fig. 5. % Removal of Color & COD for different doses of lime (At pH= 10.3)**

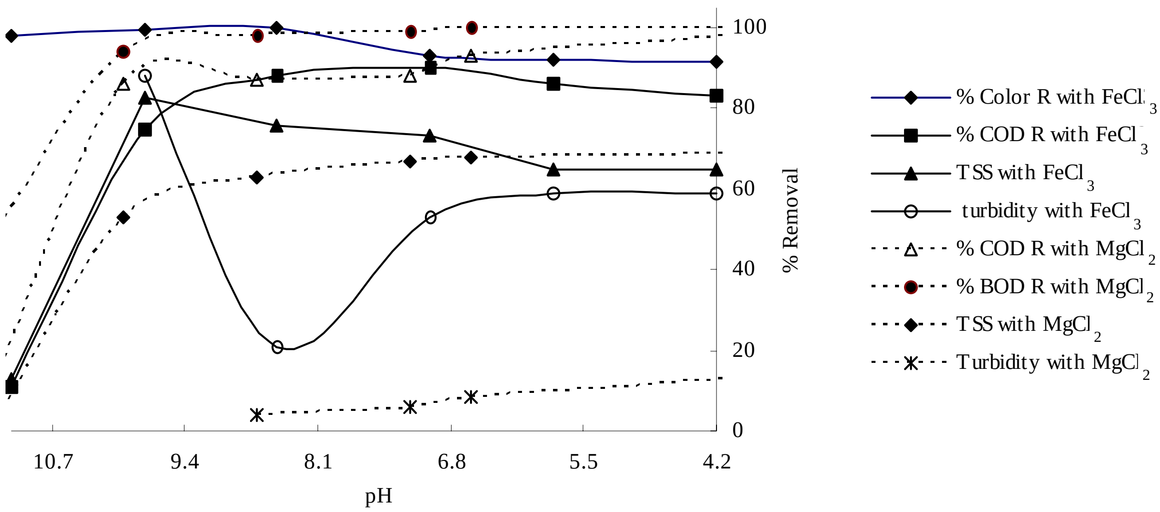


**Fig. 6. % Removal of color, COD & TSS and turbidity for different pH. (For 400 mg/L $FeCl_3$ or 400 mg/L of $MgCl_2$)**

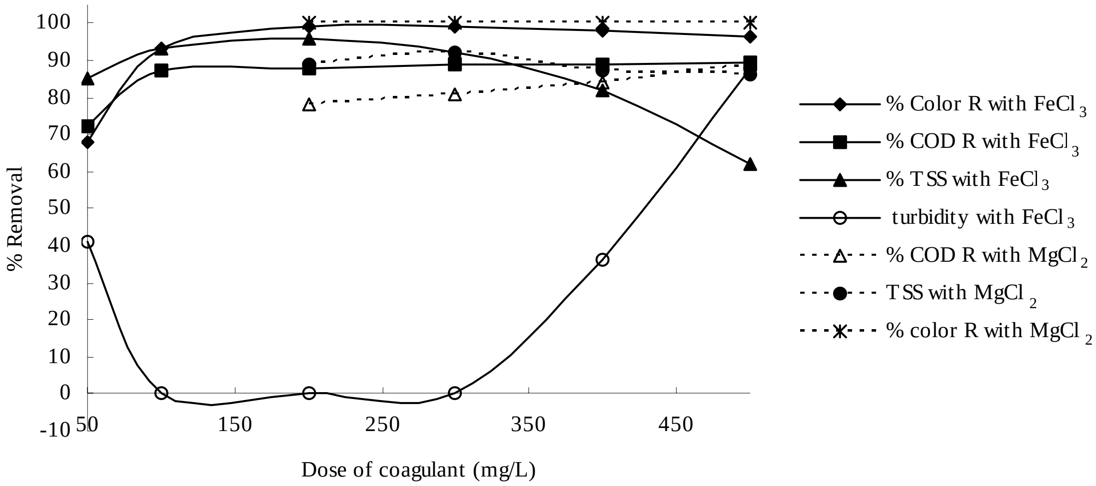


**Fig.7. % Removal of Color & COD or TSS and turbidity for different doses of Coagulant (At Optimum pH=8.3 for $FeCl_3$ or pH=8.7 for $MgCl_2$)**

According to figure 2 and 6 the optimum pH for 400 mg/l $MgCl_2$ is 8.7 due to higher color and COD removal and lower volume of settled sludge. Figure 4 and 7 shows that the optimum dose of $MgCl_2$ for color and COD removal is 500 mg/L.

## CONCLUSION

The results of the tests showing all coagulants except lime removed color. Both ferro sulfate and alum removed color at low concentration with roughly high efficiency whereas low concentration ferric chloride removed less dye. It was observed that magnesium chloride started to remove color in concentration higher than 200 mg/L. Lime didn't effect on COD removal. Magnesium chloride started to remove COD with concentration higher than 200 mg/L. Ferric chloride, alum and ferro sulfate had same COD removal with concentration higher than 100 mg/L.

Magnesium chloride and alum generated large amount of sludge it can cause sludge disposal problem and involve extra costs. To select the best coagulant, in addition to above parameters, it should be considered parameters such as required coagulant dose, coagulant cost and optimum pH after reaction for discharging into environment. Therefore alum because of large amount of generated sludge, ferric chloride and ferro sulfate because of their high cost are not appropriate for dye removal. In this study, ferric sulfate ($FeSO_4$) is recommended as the best coagulant to remove sulfuric dyes. Before industrial wastewater treatment, it would be better considering other aspects to decrease wastewater volume and mitigate its contamination. Following considerations are recommended increasing industrial wastewater treatment efficiency and also mitigating wastewater contamination of this industry:

- Proper process control to save water consumption in industrial units;
- Recovery and recycle;
- Substitution of soaps with lower BOD detergents or dye oxidation steam with acetic acid bath;
- Separation of dyeing wastewater from other units due to its different components;
- Investigation on used coagulant fluctuation on effluent wastewater;
- Investigation on rate and time effect in rapid and slow mixing on effluent wastewater
- The ability of various dyeing process wastewater reuse for using in other processes;
- The ability of dye bath reuse and finally
- Use pretreatment systems especially for dye removal.

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