Journal of Agriculture and Environmental Sciences
June 2015, Vol. 4, No. 1, pp. 108-117
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jaes.v4n1a14
URL: http://dx.doi.org/10.15640/jaes.v4n1a14

Investigation of Hose Dyeing Industry Waste Water Treatment Using Jar-Test

Esra Billur Balcioğlu[1] & Sevgi Güneş Durak[2]

Abstract

Jar-test based on coagulation is one of the conventional and constantly applicable methods for treatment of wastewaters. Aim of this study is to determine the treatment efficiency of hose dying industry wastewaters using coagulation and flocculation. Ipek Textile wastewaters were used as samples. Samples were obtained from two different points. First sample was from neutralisation output (before aeration tank), second sample was from industry output. In the study $Al_3(SO_4)_3$, $FeCl_3$, Natural Coagulant and polymer were used as coagulant and coagulant auxiliary product, respectively. The efficiency of coagulation- flocculation process was investigated at these samples. At the end of the study, $Al_2(SO_4)_3$ can be preferred as coagulant due to its high removal efficiency in hose dying industry wastewaters. However because of sulphate problem in textile industries, $FeCl_3$ should be used which is similar to $Al_2(SO_4)_3$ with polymer addition. Besides, use of this coagulant will reduce load of biological treatment removal significantly.

Keywords: Coagulation – flocculation, jar test, hose dyeing industry, organic coagulant

Introduction

The textile industry is one of those industries that consume considerable amounts of water in the manufacturing process. The water is primarily employed in the dyeing and processed to finished products. In a typical dyeing and finishing mill, about 100 L of water are consumed on the average for every ton of cloths processes eventually ends up as wastewater which needs to be treated before final discharge. Physical–chemical treatment of wastewaters is widely used in the field of the waste industrial effluents. Its application in textile industries can be performed in combination with a biological treatment or as unique treatment if the final effluent is discharged into a sewer. By means of a physical–chemical treatment, removal efficiencies of both suspended solids and COD can reach values up to 95 and 70%, respectively (Bes-Piá et al.2002), and colour can also be removed depending on the chemical used (Georgia et al., 2003). Other authors report about processes combining physical–chemical treatment with hydrolysis/acidification and Fenton oxidation (Wang et al., 2008), treatment of textile wastewater by homogeneous and heterogeneous Fenton oxidation processes (Karthikeyan et al., 2011), biological treatment plus membrane processes (Sahinkaya et al., 2008), synthesis of polyamine flocculants and its use in treating dye wastewater (Yue et al., 2008). Jar-tests are a valuable tool in wastewater treatment to evaluate the efficiency of a physical–chemical treatment (Clark and Stephenson, 1999). Chemicals selection and optimum operating conditions (pH and chemicals concentrations) are determined by means of these experiments (Aragones-Beltran et al., 2009). The optimum operation conditions (pH, chemical concentrations) are determined by means of these experiments. According to the double layer theory, electrical repulsion forces prevent from colloids aggression.

[1] Istanbul University Fisheries Faculty Marine Biology Department Laleli- Istanbul.
Phone: +90212 455 57 00/ 16454, Fax: +90212 514 03 79, Email: ebillur@istanbul.edu.tr
[2] Yildiz Technical University Civil Engineering Faculty Environmental Engineering Department Davutpaşa- Istanbul.
Phone: +90212 383 53 66, Fax: +90212 383 53 58, Email: ssevigunes@gmail.com.

In order to achieve an effective agglomeration, the compression of the thickness of the electrical double layer or a charge reduction of the particles has to be carried out. This implies the zeta potential reduction. In this way, the colloids can be settled (Bes-Piá et al., 2003).The coagulation= flocculation step is a major process in drinking water treatment plants and is used in most water treatment plants (about 95%) (Bouyer et al., 2005). Reliability of plant operation and the final water quality together with the problems of cost control are the most important issues for water treatment professionals. The prediction of the optimum coagulant dose is the crucial question for two basic reasons: firstly, coagulant overdosing leads to high operating costs and risks leading to problems with public health concerns. Secondly, under-dosing the coagulant leads to low treatment efficiency and insufficient removal of solid particles in the operation of water treatment plants (Bouyer et al., 2001). In this study removal efficiencies of hose dying industry wastewaters from industry output and neutralisation output were compared using coagulation and flocculation method. Experiments were performed at three stages. At first stage, characterization of wastewater were determined, at second stage, jar-test was applied to wastewater obtained from neutralisation output (before aeration tank) using $Al_3(SO_4)_3$, $FeCl_3$, Natural Coagulant and polymer, at third stage jar-test experiments were done to the wastewater of before treatment industry output using $Al_3(SO_4)_3$, $FeCl_3$, Natural Coagulant and polymer. In the study, SS, colour, turbidity and COD parameters were observed at before and after the treatment (jar-test) and results were evaluated using comparison of results.

Material - Method

Definition of Hose Dyeing Industry

The production unit having profession on hose dying, apply many textile process such as dying, ablution, bleaching, antibacterial (AEGIS-AEM, Purista, Sanitized, Ultra Fresh etc.) ablution, softening on cotton, nylon, pure wool, acrylic, artificial silk and products consisting of these articles. Reactive dyes and special chemicals are used in order to obtain desired purity. Ablution, staining, dry rubbing and yellowing tests are performed in the laboratory. Acetic acid, formic acid, sodium sulphate, sodium chloride and mineral water are used for dying. Water is filtered from sand filter and softened using ion exchange to accommodate it for the process. Production process of the industry is given in Figure 1.

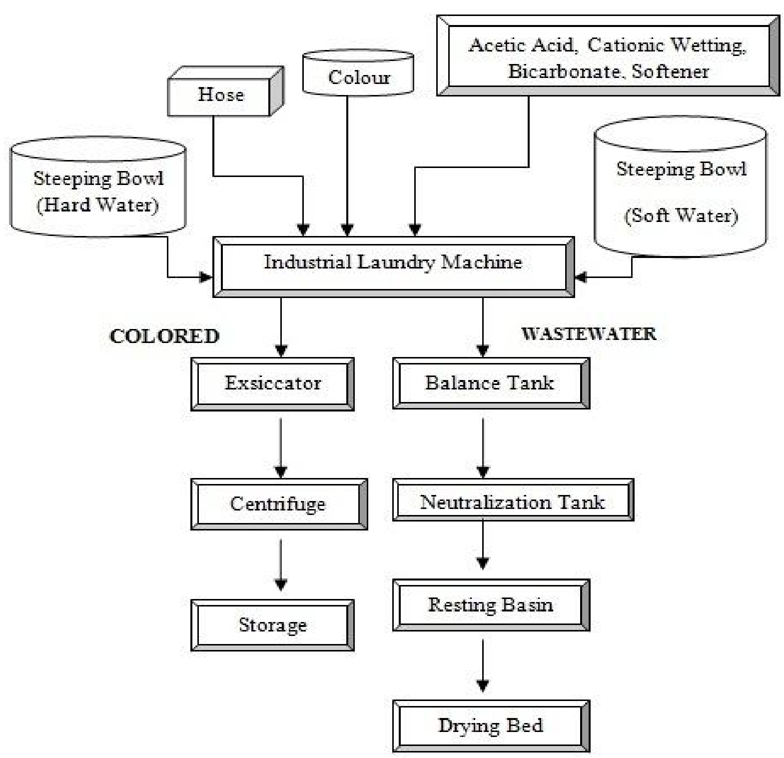

Figure 1: Flow Chart of Industry

Some parameters of wastewater are given in Table 1.

Table 1: Characterization of Hose Dyeing Industry Wastewater Samples

	SS (g/L)	Colour			Turbidity (NTU)	COD	pH
		436nm	525nm	620nm			
Neutralization effluent	0.38	113	92	71.2	232	2131.2	6.65
Plant effluent	0.48	109.5	89.8	71	197	1670.4	8.54

Definition of Treatment Plant

Wastewaters coming from production unit are sent to stabilization tank having volume of 60 m^3. Aim of stabilization tank is to immobilize the flow rate of input and to increase the removal efficiency. Wastewater going out from stabilization tank comes to neutralization tank. In the neutralization tank pH of wastewater is adjusted to 6.5-7 using acid. The volume of neutralization tank is 90 litres. After this unit wastewater is sent to biological treatment unit. Thus, contiguous batch reactor is used.

Experimental Set-up

Used beakers in the jar test are 1 litre capacity. Physical–chemical experiments were carried out in a multiple stirrer jar-test apparatus from SELECTA with 6 pedals. The procedure consisted in introducing 1 L of the sample in the jars, then the coagulant was added and rapidly mixed (100 rpm) during 3min. After that, the paddles velocity was decreased down to 20 rpm and for flocculation beakers were stirred 20 minutes. At last, the paddles were withdrawn so that the particles could settle during 30 min (ASTM, 1995). Experimental setup is given in Figure 2.

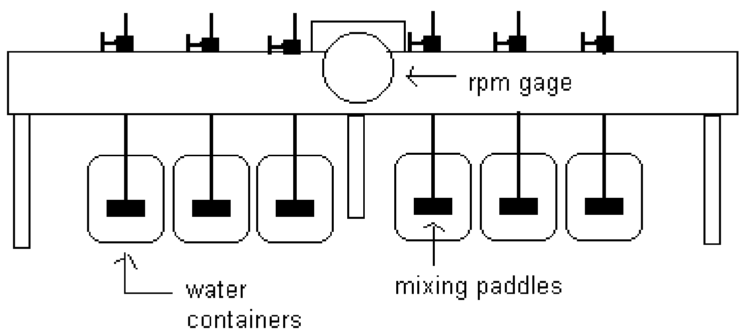

Figure 2: Diagram of Jar Testing Device [14]

Suspended solid matter, colour, turbidity and COD analyses were done according to standard methods (APHA, 1998).

Coagulants and Auxiliary Products

The removal of color by coagulation is a widely employed treatment process. In this study $FeCl_3$, Al_2SO_4, natural coagulant and polymer were used. Al and Fe coagulants are two principal inorganic coagulants used in wastewater treatment. These hydrolysable cations are readily available as sulfate or chloride salts in both liquid and solid from. However, aluminum is suspected harmful to human and living organisms. Thus, ferric ions are often the coagulant of choice to destabilize colloidal and suspend solids (Gao et al., 2006). The used natural coagulant in this study has 35-40% active material, high molecular weight, 19 Cps viscosity and pH 5. Besides removal efficiencies were compared before and after of polymer addition. The polymer in the experiment has 1.13 g/cm^3 density, 3.5 pH, 4.13 cst viscosity.

Results

Experiments on Neutralization Effluents

For removal efficiencies of COD, SS, colour and turbidity taking them source from neutralization; $Al_3(SO_4)_3$, $FeCl_3$ and Natural Coagulant are used without polymer of neutralization effluents. Then colour removal efficiency is compared of these three coagulants.

1.1.1.Addition of $Al_2(SO_4)_3$

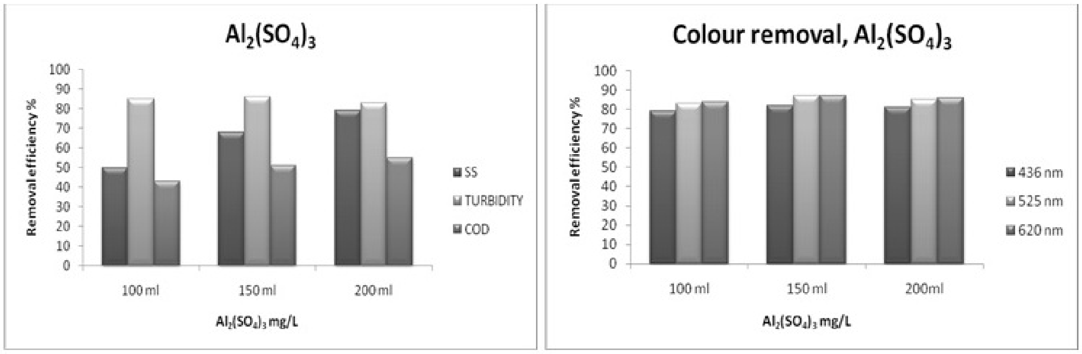

Figure 3: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $Al_2(SO_4)_3$ without Polymer of Neutralization Effluents

When $Al_2(SO_4)_3$ used alone, COD and SS removal efficiencies increased directly proportional with the amount of coagulant similarly as colour removal efficiencies measured at 436, 525, 620 nm wavelengths efficiency of turbidity removal ranged between 80-90% whether did not show significant differences.

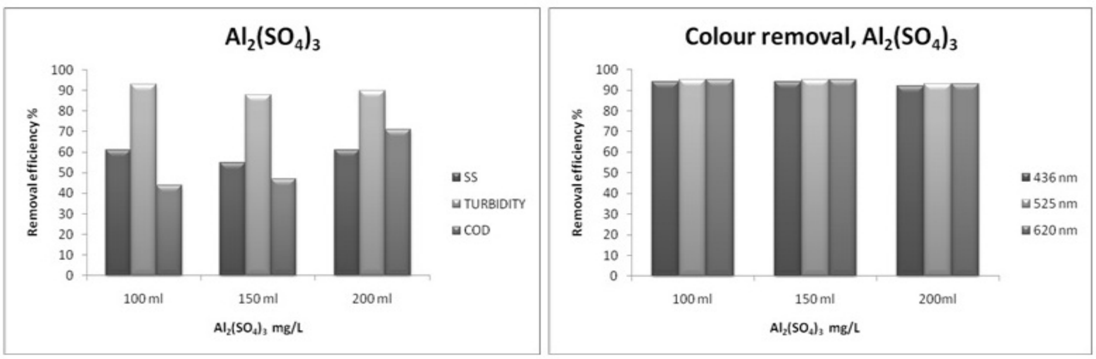

Figure 4: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $Al_2(SO_4)_3$ with Polymer of Neutralization Effluents

However addition of polymer enhanced the removal efficiency, there is not a significant change in the removal. Whereas removal efficiency of turbidity reached up 80%, SS and COD removal efficiencies ranged at 40-70%. The graphs showed that addition of polymer raised the colour removal efficiency considerably. In experiments using 200 mg/L coagulant there was an increase in efficiency more than experiments without polymer and there was a decrease in efficiency in comparison with 100 mg/L and 150 mg/L coagulants with polymer. At the same time no difference was observed in experiments using coagulant at 100 and 150 mg/L doses.

1.1.2. Addition of $FeCl_3$

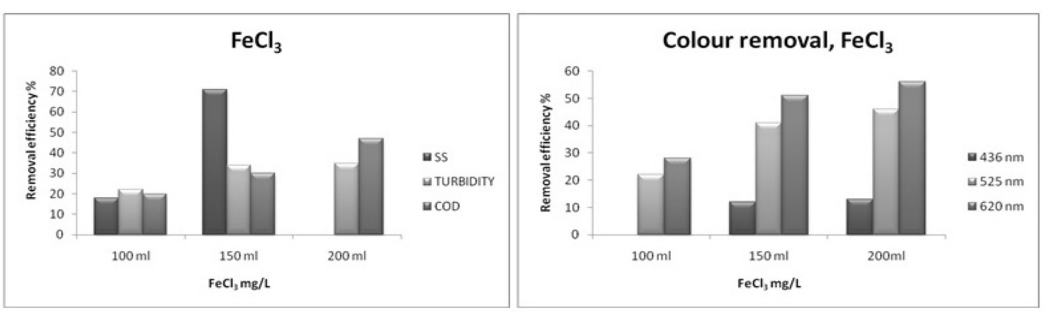

Figure 5: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $FeCl_3$ without Polymer of Neutralization Effluents

According to graphs use of $FeCl_3$ showed lower efficiencies in comparison with experiment with use of other coagulants. Although turbidity and COD removal efficiencies were not very high, increase with the amount of coagulant. As a result of use of $FeCl_3$ alone removal efficiencies of SS showed various values with the amount of coagulants independently. SS removal efficiency of $FeCl_3$ is in direct proportion to dosage of coagulant, yet it is observed that 436 nm wavelength increased lower than other wavelengths.

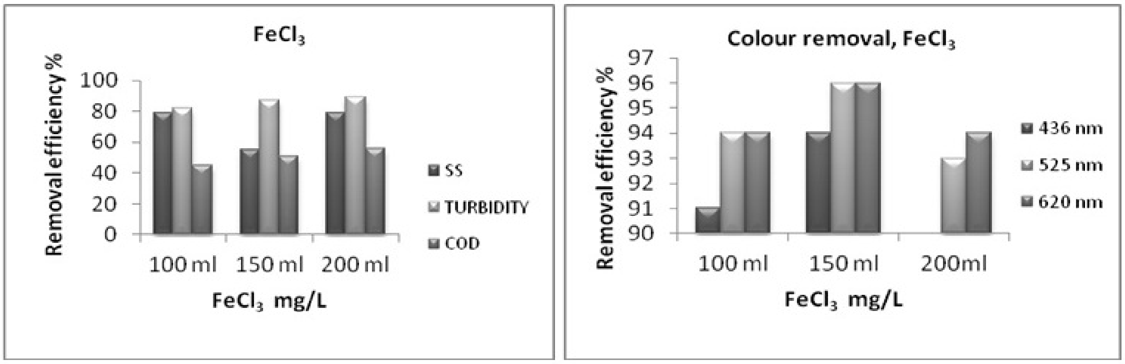

Figure 6: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $FeCl_3$ with Polymer of Neutralization Effluents

Addition of polymer caused an increase in removal efficiencies generally. SS and turbidity removal efficiency showed more increase than COD. Colour removal efficiency reached up to 90% from 60% with the use of $FeCl_3$. It was seen that there was a considerable increase with used coagulant from 100 mg/L to 150 mg/L, yet at use of 200 mg/L coagulant there was a decrease in removal efficiency. After a definite amount of coagulant removal efficiency did not be affected positively.

1.1.3. Addition of Natural Coagulant

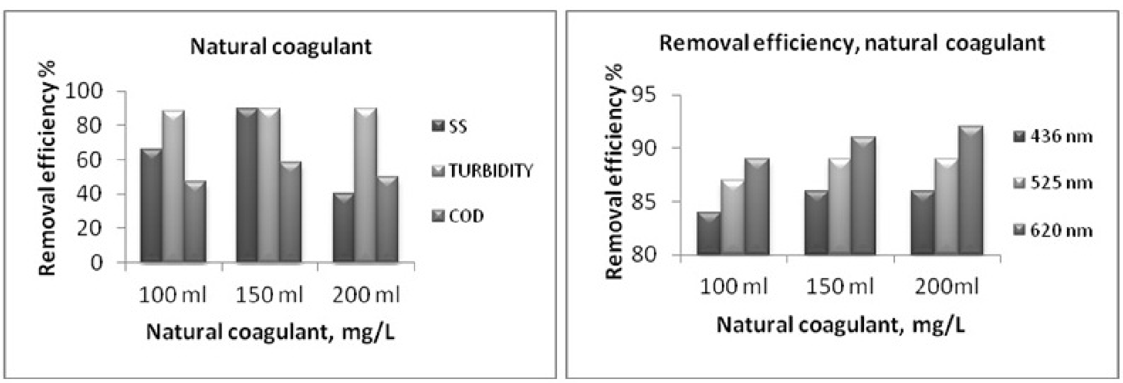

Figure 7: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of Natural Coagulant without Polymer of Neutralization Effluents

Turbidity removal efficiency in the experiment using natural coagulants has reached a certain level, but results are not very different from each other in different dosages. As seen from the graph the optimum dosage is 150 mg/L for SS and COD removal efficiencies and these values are found in the range 40-60% at other dosages. Use of 200 mg/L coagulant did not have any effect on removal efficiency. Colour removal efficiencies are more than 80% and increase with the amount of coagulants.

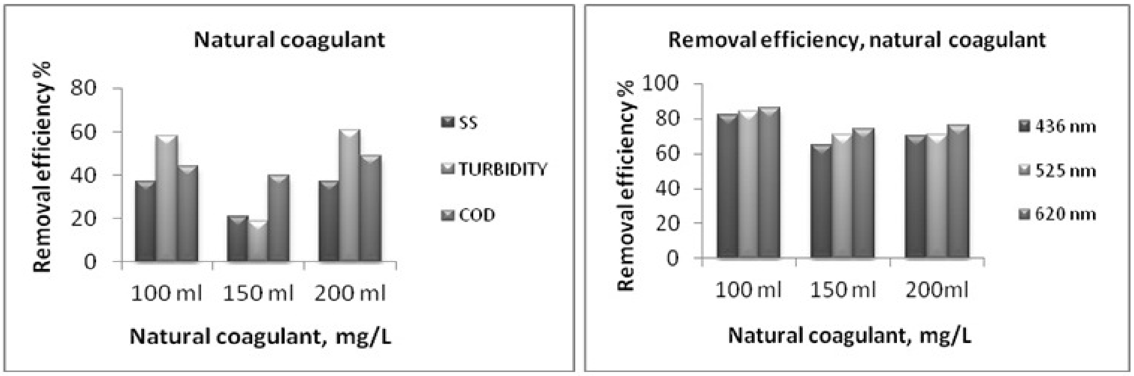

Figure 8: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of Natural Coagulant with Polymer of Neutralization Effluents

Addition of polymer with natural coagulant does not have a significant effect on COD removal. Removal of SS and turbidity showed a decrease in use of polymer. A decrease at 10% was seen in colour removal. According to this graph the most effective coagulant amount is 100 mg/L.

Experiments on Plant Effluents

Removal efficiencies of COD, suspended solid matter, colour, turbidity were calculated according to initial values of waste water parameters. These parameters belong to industry effluents are given in Table 2, 3, 4 and 5.

Addition of $Al_2(SO_4)_3$

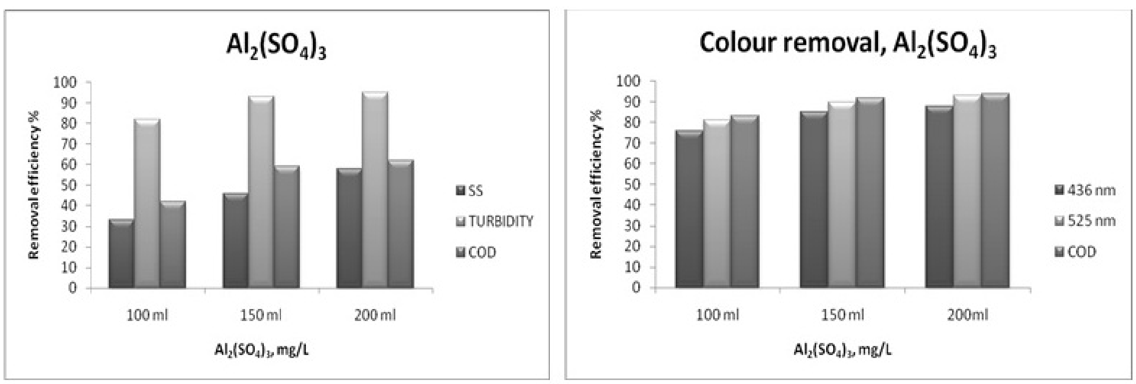

Figure 9: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $Al_3(SO_4)_3$ without Polymer of Plant Effluents

It is seen that when use of $Al_2(SO_4)_3$, removal efficiency of turbidity is very high, SS and COD removal efficiencies reached up more than 30% with the increase of coagulant dosage. Colour removal efficiency is more than 70% and increase due to amount of coagulant.

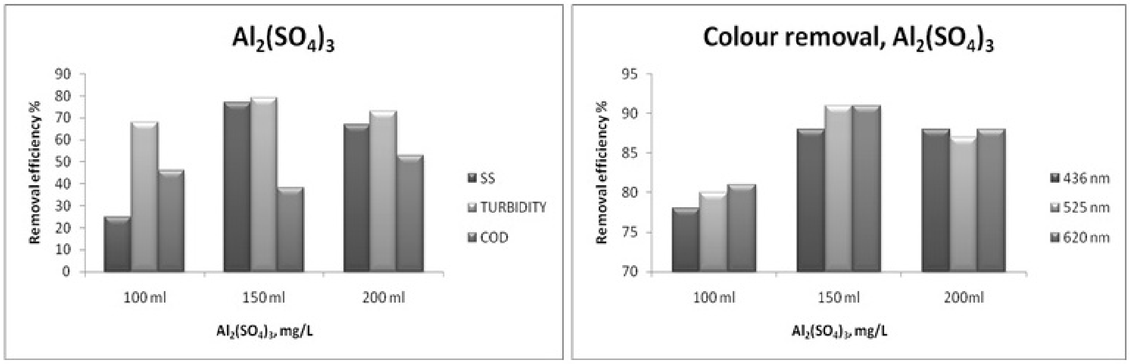

Figure 10: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $Al_2(SO_4)_3$ with Polymer of Plant Effluents

In use of polymer and $Al_2(SO_4)_3$, optimum removal efficiency of SS is at 150 mg/L concentration. Although turbidity removal efficiency showed higher value, it decreased with the amount of coagulant. 200 mg/L coagulant dosage was determined as the most optimum for COD removal. A linear increase at 100 and 150 mg/L, a decrease at 200 mg/L were seen in colour removal. It is indicated that removal efficiency decreased at this coagulant dosage. Despite the optimum dosage is 150 mg/L, the efficiencies are more than 75%.

Addition of $FeCl_3$:

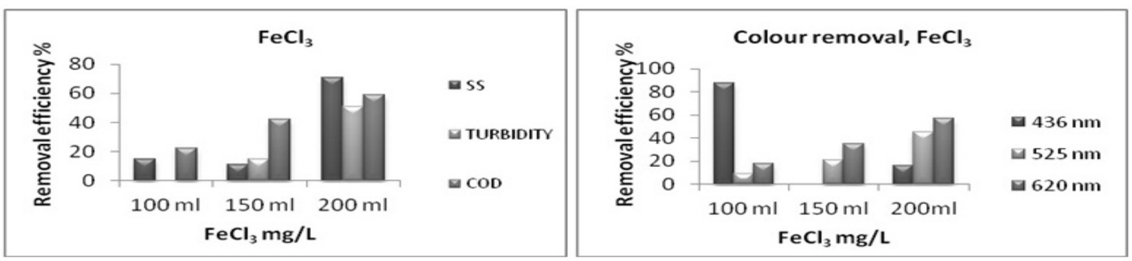

Figure 11: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $FeCl_3$ without Polymer of Plant Effluents

Although removal efficiencies are low with use of $FeCl_3$, they showed a linear increase. Despite the fact that, removal efficiencies are low at 100 and 150 mg/L coagulant dosages, a significant increase was seen at 200 mg/L dosage. Colour removal efficiencies increases linear at 525 and 620 nm wavelengths. Whereas high efficiency was obtained at 436 nm wavelength and 100 mg/L coagulant, low efficiencies were observed at 150 and 200 mg/L coagulants. Efficiency values increased with addition of polymer to $FeCl_3$. It was observed that there is a linear increase in SS and COD removal efficiencies. Despite the linear increase in turbidity values, there are high and similar efficiencies. Removal efficiencies are high and linear. Efficiency rise considerably according to results of the experiments using $FeCl_3$ without polymer. Besides efficiency findings are close to each other.

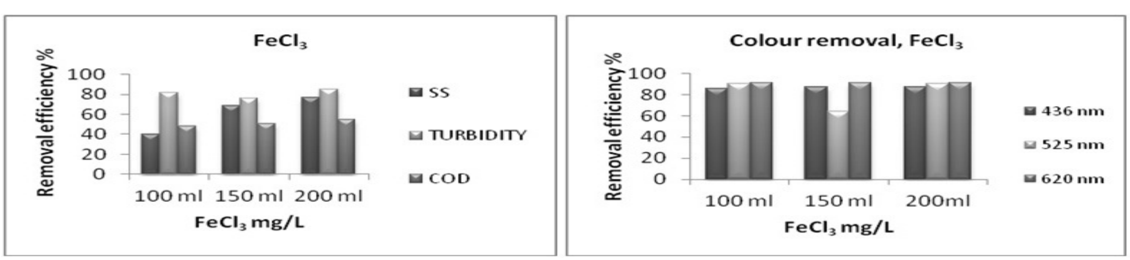

Figure 12: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of $FeCl_3$ with Polymer of Plant Effluents

Addition of Natural Coagulant

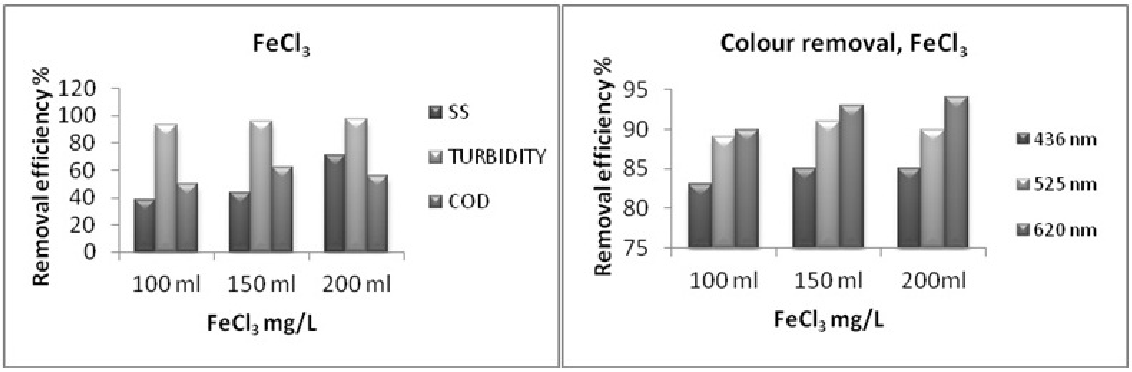

Figure 13: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of Natural Coagulant without Polymer of Plant Effluents

Measured parameters are found as very similar and close in the experiment with natural coagulants. Colour removal efficiencies are at high values and increase with the dosage of coagulant. As observed in the graphs that there was a linear increase in removal efficiency of SS and a decrease in turbidity removal efficiency with the addition of polymer to natural coagulant. COD values are comparable. There is an inconsiderable decrease in colour removal efficiency when 100 and 150 mg/L coagulants are added. The optimum efficiency is seen at 200 mg/L coagulant concentration.

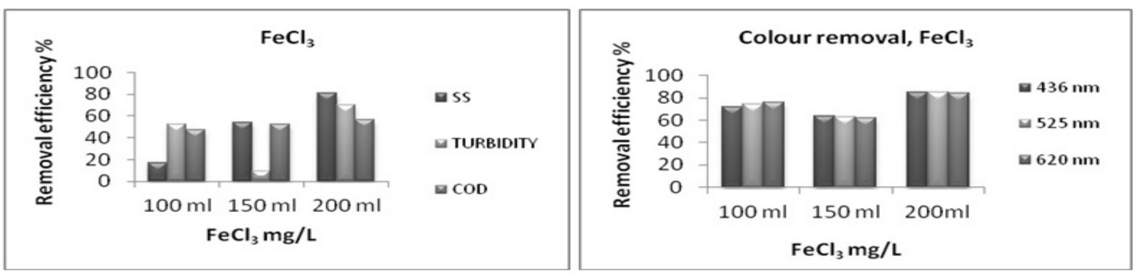

Figure 14: Removal Efficiencies of COD, SS, Colour and Turbidity with Use of Natural Coagulant with Polymer of Plant Effluents

Comparison of Coagulants

As results of experimental studies and graphs it is determined that the most effective amount of coagulant is 150 mg/L. Removal efficiencies of coagulants were compared in the graphs below.

Neutralization Effluent

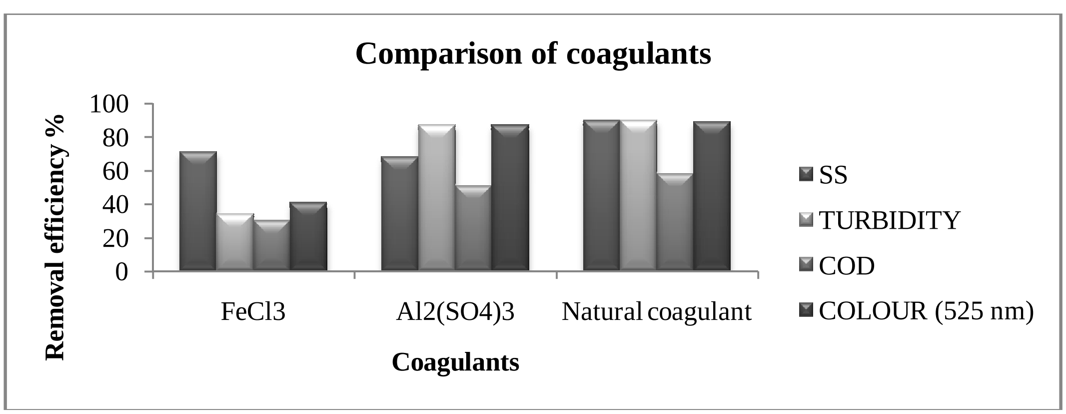

Figure 15: Comparison of Coagulants at 150 mg/L Coagulant Concentration

As seen from this graph the most effective coagulants are determined as natural coagulant and $Al_2(SO_4)_3$ in experiments using 150 mg / L coagulant dosage.

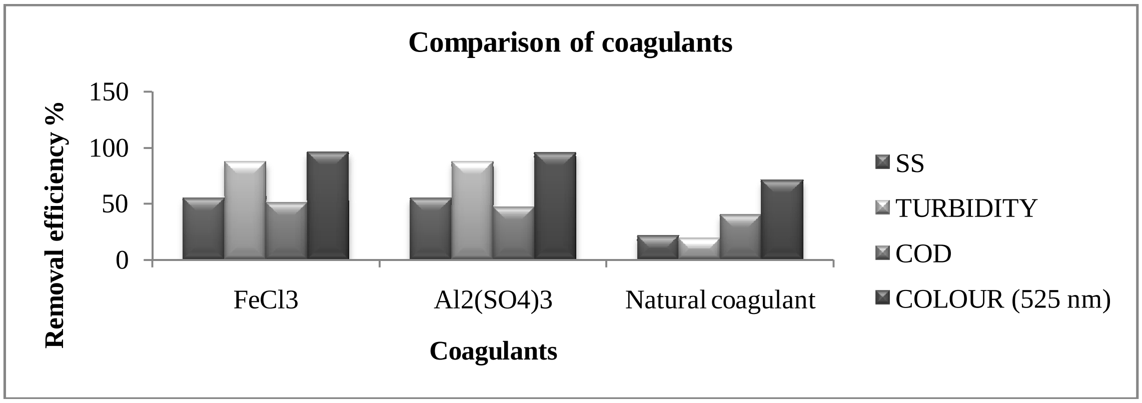

Figure 16: Comparison of Coagulants at 150 mg / L Coagulant Concentration with Addition of Polymer

It is observed that removal efficiency in experiments using $FeCl_3$ with polymer is affected by positively. On the other hand it has an opposite effect on natural coagulant. Accordingly it is considered that polymer has a negative impact on natural coagulant and reduces the efficiency of coagulant.

Plant Effluent

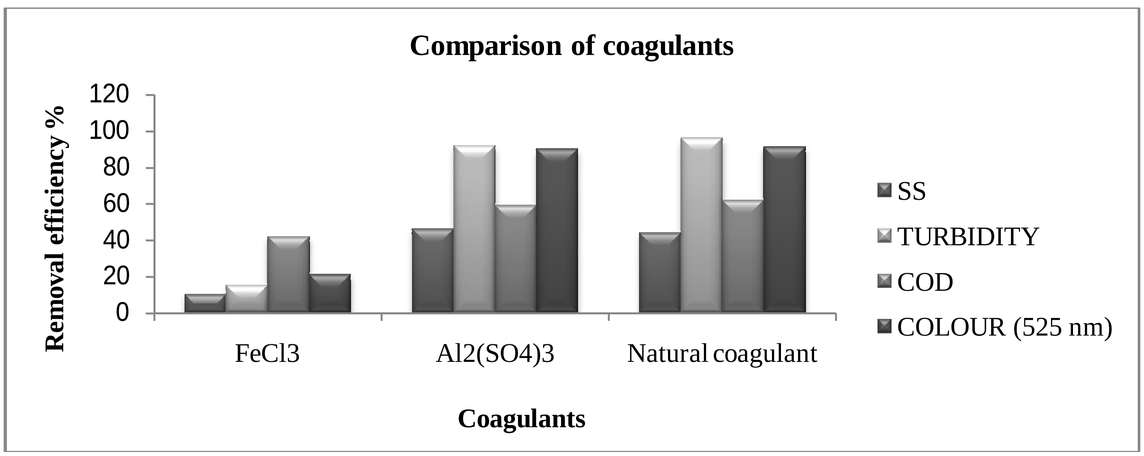

Figure 17: Comparison of Coagulants at 150 mg / L Coagulant Concentration

As seen in neutralization experiments, it was determined that removal efficiencies by $FeCl_3$ were lower, by $Al_2(SO_4)_3$ and natural coagulants were higher in studies without polymer. Therefore higher removal efficiencies were observed with use of $Al_2(SO_4)_3$ and natural coagulant.

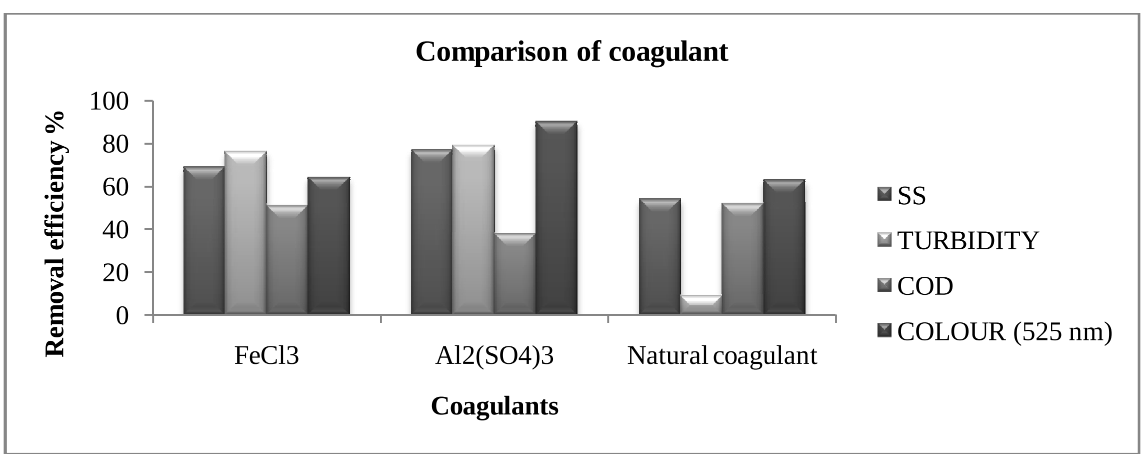

Figure 18: Comparison of Coagulants at 150 mg / L Coagulant Concentration with Addition of Polymer

It was observed that $Al_2(SO_4)_3$ provided higher removal efficiency in experiments with polymer than other coagulants.

Conclusion

The jar test experiments were performed on textile wastewater. As consideration of results, the optimum coagulant dose is 150 mg/L and the optimum removal efficiency is obtained using $Al_2(SO_4)_3$ with polymer in treatment of hose dyeing industry effluents. In experiments without using polymer, natural coagulant supplied the optimum efficiency. Besides it was seen that the efficiencies are very low in the experiments of $FeCl_3$ without polymer, but it was similar to $Al_2(SO_4)_3$ with polymer addition. Whereas with polymer addition efficiency of $FeCl_3$ increased, natural coagulant was affected from polymer negatively. In case of polymer addition to industry output, it has been determined that efficiency of $FeCl_3$ is higher than natural coagulant efficiency. $Al_2(SO_4)_3$ could be preferred as a coagulant due to having the highest removal efficiency in hose dyeing industry effluents. However due to the problem of sulphate in textile industries, $FeCl_3$ with polymer addition or natural coagulant without using polymer being similar to $Al_2 (SO_4)_3$ should be used.

Acknowledgements

Authors thank Ipek Textile for providing the samples.

References

APHA. (1998). Standard methods for the examination of water and wastewater. 19th Ed., Washington D.C.

Aragones-Beltran, P., Mendoza-Roca, J. A., Bes-Pia, A., Garcia-Melon, M., & Parra-Ruiz. E. (2009). Application of multicriteria decision analysis to jar-test results for chemicals selection in the physical–chemical treatment of textile wastewater. Journal of Hazardous Materials 164, 288–295.

ASTM. (1995). Standard practice for coagulation-flocculation jar-tests of water.

Bes-Piá, A., Mendoza-Roca, J. A., Alcaina-Miranda, M. I., Iborra-Clar, A., & Iborraclar, M. I. (2002). Reuse of wastewater of the textile industry alter its treatment with a combination of physico-chemical treatment and membrane technologies. Desalination 149, 169–174.

Bes-Piá, A., Mendoza-Roca, J. A., Alcaina-Miranda, M. I., Iborra-Clar, A., & Iborra-Clar, M.I. (2003). Combination of physico-chemical treatment and nanofiltration to reuse wastewater of a printing, dyeing and finishing textile industry. Desalination 157, 73–80.

Bouyer, D., Liné, A., Cockx, A., & Doquang, Z. (2001). Experimental analysis of floc size distribution and hydrodynamics in a jar-test. Trans IChemE 79 (A), pp. 1017–1024.

Bouyer, D., Escudié, R., & Liné, A. (2005). Experimental Analysis of hydrodynamics in a Jar-test. Process Safety and Environmental Protection, 83 (B1): 22-30.

Clark, T., & Stephenson, T. (1999). Development of a jar-testing protocol for chemical phosphorous removal in activated sludge using statistical experimental design. Water Research 33 (7), 1730–1734.

Gao, B., Wang, Y., Yue, Q-Y., Wei, J., & Li, Q. (2006). Color removal from simulated dye water and actual textile wastewater using a composite coagulant prepared by ployferric chloride and polydimethyldiallylammonium chloride. Seperation and Purification Technology, Vol. 54, pp. 157-163.

Georgia, D., Aivazidis, A., Hatiras, J., & Gimouhopoulus, K. (2003). Treatment of cotton textile wastewater using lime and ferrous sulphate. Water Research 37, 2248–2250.

Karthikeyan, S., Titus, A., Gnanamani, A., Mandal, A. B., & Sekaran, G. (2011). Treatment of textile wastewater by homogeneous and heterogeneous Fenton oxidation processes. Desalination 281 438–445.

Sahinkaya, E., Uzal, N., Yetis, U., & Dilek, F. Z. (2008). Biological treatment and nanofiltration of denim textile wastewater for reuse. Journal of Hazardous Materials 153, 1142–1148

Wang, X., Zeng, G., Zhu, & G. J. (2008). Treatment of jean-wash wastewater by combined coagulation, hydrolysis/acidification and Fenton oxidation. Journal of Hazardous Materials 153, 810–816.

Yue, Q. Y. Gao, B. Y., Wang, Y., Zhang, H., Sun, X., Wang, S. G., & Roy R. Gu. (2008). Synthesis of polyamine flocculants and their potential use in treating dye wastewater. Journal of Hazardous Materials 152, 221–227.