Treatment of Textile Wastewater Using a Combined Coagulation and DAF Processes, Iran, 2016

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Background & Aims of the Study: There are three different types of fibers used in the manufacture of various textile products: cellulose fibers, protein fibers and synthetic fibers. Textile wastewater discharge into the environment leads to irreparable damages. The main purpose of this study was treatment of textile wastewater, using a combined coagulation and dissolved air flotation (DAF) processes, Iran in 2016.

Materials and Methods: This study was an empirical-lab study which the Jar tests and DAF were used in laboratory scale. After determination of the optimal condition of pH and the optimum of concentration of poly-aluminum chloride by Jar test, the effect of the effective parameters including the concentration of the coagulant (10, 20, 30, 40, 60 mg/L), coagulation time (5, 10, 15 and 20 min), flotation time (5, 10, 15 and 20 sec), saturation pressure (3, 3.5, 4 and 4,5 atm) and turbidity (10, 20 , 30, 40, 60 NTU) on the removal efficiency of COD, BOD_5 and TSS by DAF were studied.

Results: Results of this study showed that the DAF process can treatment COD, BOD_5 and TSS up to85.7%, 80.68% and 95.6%, respectively. The appropriate condition was as follows: pH=6, initial concentration of aniline= 200 mg/L, flocculation time = 10 min, flotation time= 20 sec and the air pressure= 4 atm. Also, this study indicates that the DAF process to conclusion requires a lower dosage of poly-aluminum chloride.

Conclusion: The coagulation and DAF processes can be effective to treat textile wastewater from industries.

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Background

Industry has an important role in the development of any country and communities. Textile industry is one of my countries needed (1). The textile industry is classified into three parts: cellulose fibers, protein fibers and synthetic fibers. The type of dyes and chemicals used in the textile industry are depends on the fiber production (2). The textile wastewater has a high color, high BOD/COD and salt (TDS) load. The textile wastewater begotten from cotton dyeing industry is very polluted due to presence of reactive dyes which are not readily amenable to biological treatment (1,3). Thus, Without suitable treatment, discharge of wastewaters into water can Undesirable effects on aquatic environment by reducing light infiltration and photosynthesis; being hazardous and toxic to aquatic life (4,5). The textile wastewater must be properly treated before their discharge to the water resources and the environment (6).

There are several methods for the elimination of textile wastewaters, including the application of photo decomposition (7), electrolysis (8), adsorption (9), oxidation (10), biodegradation (11) and other processes.

Flotation is a physical approach in which the solid particles are transported to the surface layer from the liquid phase. The main preference of this approach over the sedimentation is that in the former method, fine particles with densities close to that of water and slow settlement can be withdrawn more efficiently and in shorter period of time (12). Dissolved air flotation (DAF) is one of the novel techniques for industrial wastes and waste water treatment (13). Flotation is performed by releasing air bubbles into the flotation tank, using pressure and then, by decreasing in the pressure as it encounters the atmospheric pressure (13,14). Coagulation and flocculation chemistry are important factors in DAF process. Particle mobilization for bubble particle attachment requires coagulation. This will result in the efficient removal of the particles (12,13). Employing a coagulants DAF process has been shown to improve textile wastewater removal efficiency (13). Poly-aluminum chloride (PAC) and organic polymers have been widely used in many countries, extensively (14,15). Some of the advantages of the PAC offer over simple salts are broader pH operating range, lower temperature sensitivity, smaller sludge production and better sludge dewater ability (13). It is widely used in dealing with municipal sewage and purifying industrial wastewater such as refinery, cutting oil/water and poultry slaughterhouse wastewater (14,16).

Aims of the study:

The purpose of this study was to determine the operational parameters, PAC concentration, saturation pressure, coagulation time and time flotation for treatment of textile wastewater, using a combined coagulation and dissolved air flotation processes.

Materials & Methods

Collection and preparation of samples

This experimental study was conducted on a laboratory scale reactor using a semi-batch mode. In this study, the effect of useful parameters such as Biological Oxygen Demand (BOD_5), Chemical Oxygen Demand(COD), NH_3–N, Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN) and pH were measured (by Standard Methods of Water and Wastewater) (ERRATA) (17).

The textile wastewater sample was provided from textile industries in Zahedan city of Iran. Then, the sample was transported to the laboratory in plastic containers stored in a refrigerator at 4 ◦C. The stock solution of the poly-aluminum which used for the experiments was 1000 mg/L. The experimental DAF system consisted of a flotation column, a compressor, an unpack saturator column and a pressure gauge as shown in Fig 1. Jar test apparatus (Phipps and Bird, JLT6) were performed coagulation, equipped with six beakers one-liter volume. The coagulation and DAF processes were performed in four steps: (i) the pH of the wastewater (4 L)was adjusted according to the experiment and the sample was added to the flotation cell, (ii) PAC was added to the cell according to the design of experiment (iii) the wastewater and PAC were rapidly mixed (380 rpm for 2 min) and slow mixed(30±2 rpm for 10min), (iv) water saturated with air was injected from the saturator into the flotation cell for 5s, (v) flotation was allowed to occur and samples were collected From the sampling point. After flocculation, appropriate quantities of saturated water were introduced, flotation was allowed to proceed and samples were collected for analysis. The pH was adjusted by a pH meter (model MIT65); HCl and NaOH were used to adjust pH in this study. The COD was readied by the dichromate method, colorimetric method at wavelength 600 nm (14, 18) with Hach spectrophotometer (HACH DR/5000), the TSS was determined by gravimetric standard method in 103 °C to 105 °C. TDS and EC were determined by EC meter (model HACH) and NH_3-N was tested by the Nessler's reagent spectrophotometry.

Analysis of samples

The removal of the studied parameters was calculated according Eq1 (18,19):

$$R=\left[\frac{(C_i-C_f)}{C_i}\right]\times 100 \qquad (1)$$

Where C_i (initial concentration) and C_f (final concentration)

Data analysis

All conducted analyses were performed triplicate in the present study. The calculated data are represented as mean values±standard deviation (SD). The statistical analysis of obtained data was conducted, using Excel.

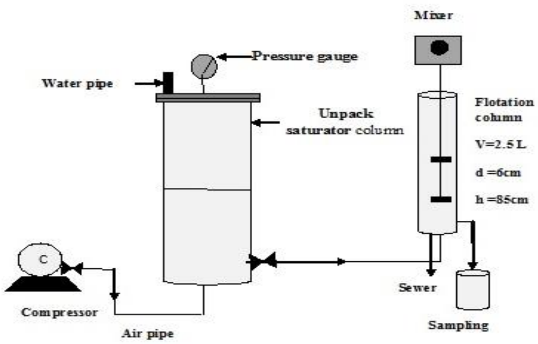

Figure 1).image of the experimental DAF

Results

The characteristics of raw textile wastewater (COD, BOD_5, NH_3–N, TSS, TKN and pH) are as shown in Table1. Initial stage of the experiment was designed to determine optimum amount of PAC coagulant 90mg/l for textile wastewater in coagulation reaction. Figure 2 shows COD, BOD_5 and TSS highest removal efficiency in the coagulation process is 53.45%, 43.2% and 79.01% at 90 mg/l poly-aluminum chloride dose.

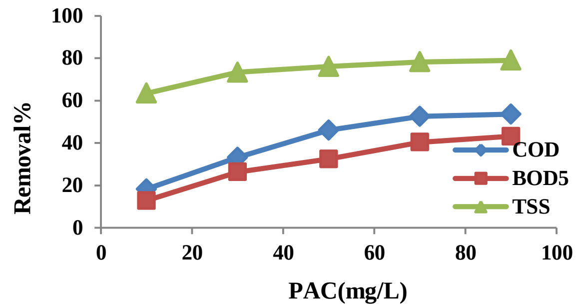

Figure 2) Effect of different doses of coagulant PAC on coagulation

Table1) Textile wastewater characterizations

The standard deviation	average	maximum	minimum	unit	Parameter
349.4	4954	5320	3940	mg/L	COD
218.66	2851	3050	2200	mg/L	BOD
36.36	147	195	70	mg/L	TKN
7.68	38	48	25	mg/L	TP
40.2	398	465	320	mg/L	TSS
0.76	7.7	8.6	6.4	---	PH

The data in figure 3 show the effect of PAC dose on DAF process (flocculation time 10 min, flotation time5s and pressure 3.5atm at pH 7.7). the optimum coagulant for the wastewater was PAC, which has the best COD,BOD_5 and TSS removal efficiencies about 51.53%,48.34% and 68.82%, respectively; increasing the concentration of coagulant decreases removal.

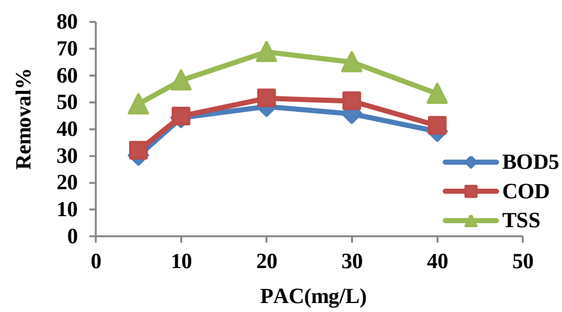

Figure 3) Effect of different doses of coagulant PAC on DAF

The flocculation time is one of the operating parameters. Figure 4 represents the effect of flocculation time, using 20mg/L dose of coagulants, for removal of COD, BOD_5 and TSS. The consistence increment of removals was revealed with increasing the flocculation time up to 10 min, and then after removals, it was decreased. Figure 4 also shows the impact of flocculation time in this study that contaminant removal performance was evaluated in 5 to 20 min (PAC concentration of 20 ppm, flotation time of 5s and air pressure 3.5atm). The optimum flocculation time was found to be 10min. The highest removal of COD, BOD_5 and TSS were found to be 57.37%, 56.18% and 76.4%, using DAF respectively, at 10min.

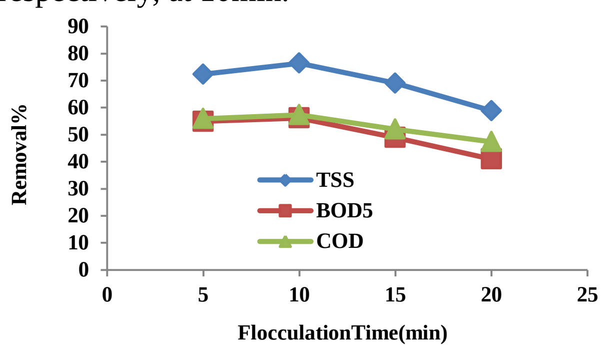

Figure 4) Effect of flocculation time different on DAF in removal COD, BOD_5 and TSS

The effect of flotation time under the optimal conditions is shown in Figure 5 (PAC 20 mg/L, flocculation time10min) where the highest removal ratio of COD, BOD_5 and TSS were 70%, 67.31% and 80.3%, respectively. On the other hand, the optimum flotation time for the DAF process, at the flotation time of 20s.

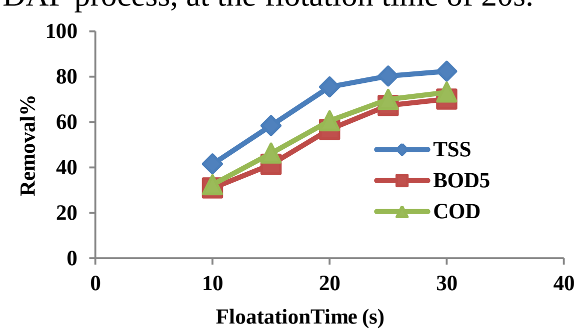

Figure 5) Effect of flotation time different on DAF in removal COD, BOD_5 and TSS

The effect of air pressure on COD, BOD_5 and TSS removal at optimum condition of PAC 20 mg/l, flocculation time of 10min and flotation time 20s was indicating an optimum pressure which shown in Figure 6. It is observed that the COD, BOD_5 and TSS maximum removal occurred at a pressure 4 atm of 69.6%, 66.31% and 79.88 % respectively.

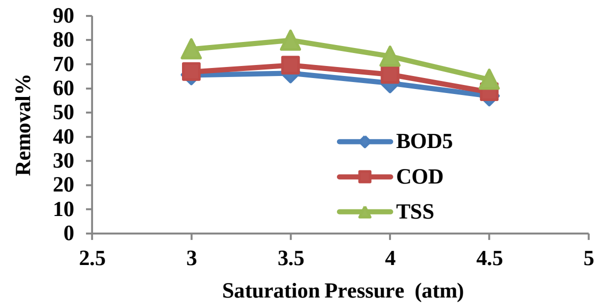

Figure 6) Effect of saturation pressure different on DAF in removal COD, BOD_5 and TSS

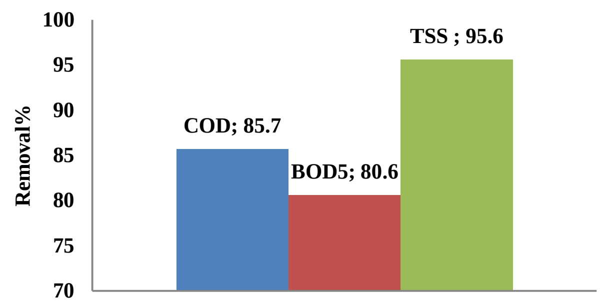

Figure 7) Overall efficiency Coagulation and DAF in treatment textile wastewater

Discussion

This study is investigated the effects of saturation pressure, PAC concentrations, flocculation time and time flotation on DAF performance. Studies have shown that conditions are necessary for favorable flotation such as charge neutralization of the particles, production of hydrophobic particles, floc diameter, bubbles diameter and rising velocity (12,13). Good coagulation chemistry depends on coagulant dose (20). There is an optimum chemical additive concentration at an optimum wastewater pH range (20,21). Poly-aluminum Chloride affect the removal of organic contaminants and COD (13). Another characteristic of the PAC is included hydroxide ions; the hydroxide ions cause a small collection polymer of AL in the PAC. The main part of PAC sets up AL_{13}^{+7}; these polymer structures have better effects on unstable colloids (22,23). Sedimentation processes require large floc particles (100µm) with densities greater than water. Flotation does not require large floc particles and heavy. Floc particle densities less than water are required and are achieved by the attachment of air bubbles to floc particles (13,14). Total dissolved air flotation system is require a dose which should be less than the material of poly-aluminum chloride. DAF technique does not require long flocculation time, and shorter time would be more efficient and cost-effective (13). A study has shown that DAF is successful when less-dense or pointed and spongy flocs are produced in the process (24). At longer flotation times, due to sufficient time for connecting bubble to particle and production of larger bubbles, more raising the bubble-particle happens. Karhu in 2014 reported that the maximum removal was at the flotation time of 20 sec (25).

With increase in the saturation pressure up to 4.5, the bubble size decreases elevating spherically under the conditions of laminar flow and in accordance with the Stokes theorem. In contrast, in low saturation pressures, DAF produces larger elliptical bubbles with higher rising velocities that break the flocs (12,13). Kord Mostafapour in 2010 reported that the maximum removal was at the pressure saturated of 4 atm (16,23). The study showed an optimum pressure saturated 4.5 atm. As the optimal bubble size for typical wastewater systems is in the order of 100 mm or below (as will be described later) pressure differences of 4–5 atm are usually selected (16,26). Overall, the pressure to be as important as other factors indicate that slight enhanced removal of COD, BOD_5 and TSS.

Conclusion

The highest removal of this study for parameters of COD, BOD_5 and TSS removal is 85.7%, 80.68% and 95.6%. Dissolved air flotation process is influenced by different parameters. The results of this study indicate that the dissolved air flotation process to conclusion requires a lower dosage of poly-aluminum chloride. Optimum conditions for the operation of the system dissolved air flotation with flotation time of 20 seconds and pressure of 4 atmospheres can remove a large impact on the concentration of COD, BOD_5 and TSS.

Footnotes

Conflict of Interest:

The authors declared no conflict of interest.

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