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Efficient removal of dyes in textile effluents using aluminum-based coagulant

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ABSTRACT

The study was conducted to examine the effectiveness of aluminum-based coagulant on textile wastewater quality. Taking into account the environmental and economic factor, aluminum chloride was employed individually on wastewater as well as in combination with alum to remove the COD, turbidity and color. Four batches of 50 mL of wastewater were prepared then, 5 mL of $AlCl_3$ and 1 mL alum was added in first batch named treatment T1. To optimize the treatment process for maximum reduction of COD, color and turbidity, dose of coagulants was increased by 5 mL of $AlCl_3$ and 1 mL of alum per batch labeled with (T2, T3, T4) at original pH 9. Further study was conducted to evaluate the effect of pH on removal of color, turbidity and COD. Consequences of each treatment reveals that maximum reduction was obtained with neutral pH values as compared to pH 3, 9 and 11. Treatment T3 presented remarkable results, 98% reduction in both COD and color whereas, 99% in turbidity was observed at pH 7. Results demonstrated the effective application of aluminum-based coagulant to treat the textile wastewater.

Capsule Summary: This study evaluates the aluminum-based coagulants for treatment of textile wastewater. The results showed that aluminum-based coagulant is efficient for color, COD and turbidity removal and improve the water quality significantly pH 7.

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INTRODUCTION

Water has been one of the most vital renewable resources, essence of food and basic component of life. The necessity of water has been greatly ascending and has a diversified purpose in every life. It is not only vital for drinking, but also important for various developmental activities (Shishaye and Abdi, 2016). It has never been possible to substitute water with any other alternative, water transportation is very hard and expensive, (Singh and Gupta, 2016). Many areas of the world including developed countries are lacking freshwater resources for drinking and agriculture use. The water resources have been polluted due to anthropogenic activity including urbanization, industry, agriculture along with other human activities etc. Environmental agencies have been directed them to limit their industrial growth. The groundwater and surface water resources perform a significant part in hydropower generation, agriculture, livestock production, industrial activities, fisheries, navigation, forestry, recreational activities and many more (Singh and Gupta, 2016).

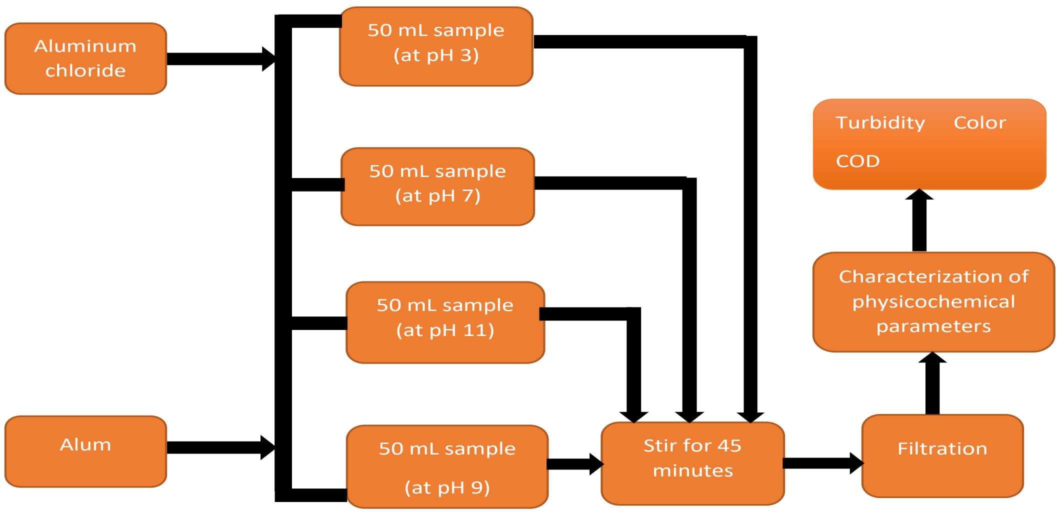

Fig. 1: Schematic protocol designed for research work

The release of wastewater from industries causing pollution not only in the rivers and ponds but chemicals are seeping down into the ground water. The exploitation of water is persisting a significant problem because of its unalloyed necessities. Groundwater has become massively significant for the diverse water source in rural and urban areas equally of both developing and developed states (Al-Garni, 2009). Amongst the entire resources of water available to the ecosystem, only 3% of the total water occurs in the form of fresh water. Rivers comprise 0.1% of the area of the land, and river channels include only 0.01% of the earth's total water. Though, the sources of the freshwater have been totally become peril which is being badly damaging the lifestyle in recent years (He and HU, 2010; Nakhate et al., 2020). Rapid industrialization is considered as one of the major aspects in generating an imbalance in the ecosystem and in the available water resources. The ecosystem has been experiencing over exploitation of the industries over the last two centuries which results in the degradation of the water quality. Usage of water and its removal has become increasingly expensive due to higher costs of fresh water used in industrial processes and its discharge as effluent (Banat and Al-Bastaki, 2004).

Among the other industries, textile industry is one of the most important and oldest industries existed since ages (Premarathne et al., 2019; Restiani, 2016). Constant and enormous supply of fresh water is required to accomplish various textile processes. Water is frequently used during dyeing and finishing procedures, containing 70-80 % of the total effluents rich with dyes such as azo, vat dyes as well as organics effluents (Godin et al., 2012; Nakhate et al., 2020). Amongst all of the dyes, synthetic dyes have been frequently employed in textile industries because of their high stability, temperature and less flexibility (Wang and Chu, 2011). Centre for Science and Environment (CSE) conducted a study which reveals that approximately 200-250 m^3 water has been used per ton of fabric and releases in the form of wastewater (Nakhate et al., 2020).

Wastewater bearing textile pigments have not only been displeasing the resources of water aesthetically as well as, leaving the high impacts on penetration of the light deep into water which leads to the damaging the aquatic life (Fu et al., 2011). Nearly 30 % of dyes lose the binding ability and reside in dyeing tank at the end of process. Residuals of dyes in dyeing bath produce mutagenic amines, which are hazardous to environment if discharge untreated (Arslan-Alaton and Alaton, 2007). It is predicted that 10-15% of the total dyes are released into the environment during various processes of the dying operations annually (Dotto et al., 2012; Owamah et al., 2013; Shertate and Thorat, 2013). Presence of dyes in wastewater has been a main concern because of their harmful effects (Rafatullah et al., 2010). The pollution generated by textile wastewater is considered as a microplastics. Microplastics are the particles of plastics lesser than 5mm in size, which are derived from vast sources of manufacturing of polymer, production of clothing, processes industries and cosmetics industries etc. (Xu et al., 2018).

International cotton advisory committee 2017 reported that production of natural and synthetic fibers has reached upto100 million tons, whereas, individually synthetic fiber is considered as a plastic (Committee, 2017). Microfibers released during different processes have a capacity to absorb variety of other pollutants already present in aquatic environment and have toxic impacts on marine life such as polychlorinated biphenyl and polycyclic aromatic hydrocarbons (Keshavarzifard et al., 2015).

Table 1: Physicochemical parameters before treatment along with NEQS standard

Sr. No.	Physicochemical parameters	Units	Raw consequences	NEQS values	Instruments used
1	pH	-	9	9-10	pH meter (JENCO 6173)
2	COD	mg/L	2,000±2.6	150	COD reactor
3	Turbidity	NTU	107±1.2	4.0	Turbidity meter (LP 2000-11) ETLl 18
4	Color	Pt-Co Hazen	1010±3.0	-	Tintometer (Lovibond PFX 995)
5	Conductivity	µS/ cm	17600±3.3	3500	Conductometer JANWAY 4010
6	TSS	mg/L	69,000±2.0	150	Suction assembly
7	TDS	mg/L	21,666.6±3.0	3500	Drying Oven

Table 2: Analysis of variance for color (Pt-Co /Hazen)–Alum-$AlCl_3$

Source of variation	DF	Sum of squares	Mean squares	F-value
Treatment	3	18018	6006	3076.02**
pH level	4	8969766	2242442	1150014.00**
Treatment x pH	12	6407	534	273.43**
Error	40	78	2	
Total	59	8994269		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01), DF = Degrees of freedom

Breaking down of the bonds between microfibers which assist to degradation and decolorizing the dyes have been the utmost stage of eradicating the color and toxicity of the dye. Lots of chemical methods have been introduced such as, electro-flocculation (Pensini et al., 2019), ozonation (Li et al., 2019), oxidation (Chávez et al., 2019), electrochemical destruction (Chaplin, 2019), coagulation (Abiola, 2019), ultra-filtration (Jönsson and Wallberg, 2009; Pathiraja, 2014) for depolluting the water and save the ecosystem for living being. Effluents from industrial wastewater hold complex matrix of water and carries noxious properties which is hard to depict. Conventional methodologies, such as ultra-filtration, chemical oxidation, biological oxidation and electrochemical oxidation have been failed one way or another by the reason of infeasible efficiency, poor economy or reliability (Woisetschläger et al., 2013).

Though, numerous treatment methods consume detrimental chemicals and require extensive power for initiation and other unit operations along with production of gases, effluents and sludge (Godin et al., 2012). Apart from chemical coagulants natural coagulants are not appreciated for treatment of highly turbulent water yet can be use by the combination of natural and synthetic coagulants (Muruganandam et al., 2017). The effluents containing huge amounts of metals, salts, bases and acids are not suitable for the biological reactor because of its high-cost treatment. The combination of natural and synthetic coagulants was suggested for better result (Verma et al., 2012).

Chemical coagulation is one of the best processes reported in literature for removing the organic matters and numerous particulates (Can et al., 2019). Aluminum based salts and its alloys have been extensively used in various industries for different purposes (Junussova and Chicherin, 2020). Numerous processes have been introduced to treat industrial wastewater but the application and demand of coagulation does not diminish. Certainly, it is believed one of the most cost effective, easy to handle and simple methods. Among the various vital research, Coagulation is a popular subject for many researchers for investigating the ability of coagulation in the field of wastewater treatment. Global market of coagulant and flocculant reported that estimated use of coagulants would reach up to 6.01 billion USD by 2022 (USD 4.35 billion in 2016), the annual growth range of 5.9% amongst 2017 and 2022 (Markets and Markets Research Private Ltd., 2017). Natural coagulants have been extensively applied on wastewater treatment, it is easily available and less challenging to handle. Researchers reveal that exclusive use of natural coagulant show less capability but combining natural coagulant with inorganic coagulant surge the efficiency of treatment (Ang and Mohammad, 2020).

Aluminum hydroxide (alum) has been one of the most common and traditional coagulant used to treat wastewater. The purpose of alum is to improve the color removal productivity and settling down the suspended solids (Mahmudov and Zuttah, 2019). Aluminum based coagulants such as aluminum chloride ($AlCl_3$) and alum $Al_2(SO_4)_3$ have been extensively used for coagulating the smaller particulates into bigger floc which are subsequently filtered (Hu et al., 2006; Matilainen et al., 2010) . Various designs were proposed to treat wastewater through inorganic coagulants such as aluminum chloride (Genovese and González, 1998; Hu et al., 2006; Wang et al., 2019). Benschoten et al, pointed out the hydrolytic reaction of Al (transition metal), and the coordination bond of metal either with organic or inorganic ligands. They evaluated the interaction of both aluminum chloride and alum in aqueous solution (Mahajan et al., 2019) .

Table 3: Interaction of mean±SE and reduction efficiency of color removal at various pH by increasing the dose

Initial	1010.00±0.00a								Mean
pH	Treatment + % reduction efficiency								(Initial) 1010.00±0.00A
	T1	%R	T2	%R	T3	%R	T4	%R	
pH3	64.00±1.37c	93	46.00±0.28e	94	28.00±0.18f	97	22.00±0.68gh	97	40.00±4.97D
pH7	59.00±1.29d	94	59.00±0.89d	95	19.00±0.54hij	98	15.00±0.42j	95	38.00±6.36E
pH9	80.00±1.25b	92	80.00±1.01b	92	21.00±0.53hi	97	17.00±0.43ij	98	49.50±9.21B
pH11	66.00±1.84c	93	66.00±0.61c	93	27.00±0.87f	97	26.00±0.28fg	97	46.25±5.97C
Mean	255.80±100.80A		252.20±101.31B		221.00±105.44C		218.00±105.84D		

Table 4: Analysis of variance for COD (mg/L)–Alum-$AlCl_3$

Source of variation	DF	Sum of squares	Mean squares	F-value
Treatment	3	767325	255775	2547.46**
pH level	4	29270000	7317953	72885.00**
Treatment x pH	12	198150	16512	164.46**
Error	40	4016	100	
Total	59	30240000		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01), DF = Degrees of freedom

Table 5: Interaction of mean±SE and reduction efficiency of COD removal at various pH by increasing the dose.

Initial	2000.00±0.00a								Mean
pH	Treatment + % reduction efficiency								(Initial) 2000.00±0.00A
	T1	%R	T2	%R	T3	%R	T4	%R	
pH3	500.00±8.82b	75	390.00±12.59ef	80	210.00±2.74h	89	180.00±5.77h	91	320.00±39.76B
pH7	410.00±9.58de	79	280.00±1.65g	86	60.00±1.15kl	97	40.00±0.70l	98	197.50±46.68E
pH9	430.00±6.90cd	78	300.00±6.08g	85	120.00±1.46i	94	80.00±1.54jk	96	232.50±42.55D
pH11	460.00±10.35c	77	360.00±9.39f	82	180.00±2.85h	91	110.00±1.89ij	94	277.50±42.13C
Mean	760.00±165.93A		666.00±178.60B		514.00±199.05C		482.00±203.22D		

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

Coagulation by metal salts has optimum method for minimizing the level of COD to the recommended limit and exhibits maximum reduction efficiency of various pollutants (Dotto et al., 2019; Huang et al., 2014). Two coagulants exhibit the potential for improving the coagulation (Zin et al., 2018). Generally, efficiency of the coagulating agents was enhanced by the operational situations such as alternation of pH and dose (Sun et al., 2019). However, few of the coagulating agents were discarded even at initial testing such as silver nitrate, hydrogen peroxide, anionic polymers due to their negligible effect. The study of Jiang and Graham illustratedthat aluminum based inorganic salts have been predominantly introduced for wastewater0 treatment. Aluminum ions rapidly hydrolyze, when added into wastewater in an uncontrollable way for producing a series of species of hydrolyzed metals (Jiang and Graham, 1998). A traditional coagulating agent Alum, was used to assist the coagulation process with aluminum chloride and to make the coagulation even fast (Zin et al., 2018). The investigations were made to justify the properties of alum, also used alum for removing the undesired matters from the water. Alum has been extensively used as a coagulating agent and carries significant properties (Haydar and Aziz, 2009; Nkalane et al., 2019; Omoike, 1999). Prakash et al, also significantly reported the extensive use of alum as a coagulating agent because of its relatively low price and simpler pathway of application (Prakash et al., 2014).

The study of the Prakash and his coworkers reported that Alum has been best agent for removing the color around 76% whereas 80% of the turbidity at pH 7. They concluded that optimum concentration of Alum is 120 mg/L and it has 98.9% removal efficiency under specific conditions (Prakash et al., 2014).

Table 6: Analysis of variance for turbidity (mg/L)–Alum-$AlCl_3$

Source of variation	DF	Sum of squares	Mean squares	F-value
Treatment	3	4861.4	1620.5	5115.15**
pH level	4	83908.5	20977.1	66216.80**
Treatment x pH	12	1255.6	104.6	330.30**
Error	40	12.7	0.3	
Total	59	90038.2		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01), DF = Degrees of freedom

Table 7: Interaction mean±SE and reduction efficiency of turbidity at various pH

Initial	107.00±0.00a								Mean
pH	Treatment + % reduction efficiency								(Initial) 107.00±0.00A
	T1	%R	T2	%R	T3	%R	T4	%R	
pH3	33.00±0.56b	69	22.40±0.36d	79	4.87±0.07f	95	4.70±0.09fg	95	16.24±3.64B
pH7	24.00±0.51d	77	19.60±0.56e	83	0.80±0.02i	99	1.00±0.02i	99	11.35±3.19E
pH9	27.00±0.37c	74	20.20±0.41e	81	2.20±0.03hi	97	1.20±0.04i	98	12.65±3.38D
pH11	28.00±0.53c	73	22.50±0.71d	79	3.10±0.08gh	97	3.00±0.02gh	97	14.15±3.40C
Mean	43.80±8.48A		38.34±9.18B		23.59±11.15C		23.38±11.18C		

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

The process of coagulation was carried out with subsequent objectives. To compare the effectiveness of optimize pH of coagulating agents used in terms of %age reduction of COD, turbidity and color of the effluent. To analyze the optimum dosing rate for coagulant agent at different pH for maximum reduction in COD, turbidity and color. To indicate the superiority of aluminum-based coagulation in relation to cost, time and dosage over other processes.

MATERIAL AND METHODS

Sampling

Sample of textile wastewater was collected from M/s Hafiz textile and dying industry Gujranwala. The wastewater was transported into the laboratory and samples were preserved according to the standard methods for further analysis of color, COD, TDS, TSS, conductivity, turbidity and odour (APHA. 1992). All the chemicals used in research were of analytical grade. pH of the wastewater sample was measured at site with pH meter.

Physicochemical analysis of textile wastewater

For the purpose of estimating the efficiency of the treated wastewater by using different coagulating and flocculating agents, raw samples were examined through parameters like color, chemical oxygen demand (COD), turbidity, (TSS), total dissolved solids (TDS), pH and electrical conductivity by using standard methods for examination of water and wastewater (APHA 2017). A huge amount of suspended and dissolved solids in the water flow increases the chemical oxygen demand and biological oxygen demand. Likewise, TDS and TSS reduce the level of oxygen in the water system (Zhou et al., 2019). Analysis of physicochemical parameters are described in detail below in Table 1.

Experimental scheme

The raw sample was characterized typically by evaluating the COD, TSS, TDS, color, turbidity and other metals. Though, eliminating the color, lowering down the COD and turbidity have been challenging (Lau and Ismail, 2009). The major chemicals used in research work was aluminum chloride ($AlCl_3$) and Alum [$Al_2(SO_4)_3.nH_2O$]. A 5% stock solution of each coagulant was prepared. The following research was run by varying the dose of coagulant by keeping the volume of sample constant. To optimize removal efficiency, pH of the sample was altered with different concentration of alum-based coagulants. The calculated amount of the coagulants was added into the wastewater to check out the efficiency.

In this research, 50 mL of the wastewater was taken while, the concentration of coagulants was increased from 5 mL to 20 mL. pH meter (JENCO 6173) was used for measuring the pH of the samples, which was adjusted by using sodium hydroxide and sulphuric acid. The prepared sample was vigorously stirred for 15 min at 150 rpm, which subsequently stirred at 50 rpm for 30 min. Thereafter the treated sample was left to settle down for sedimentation for next 30 minutes (Irfan et al., 2017). The designed protocol of research work is shown in Figure 1.

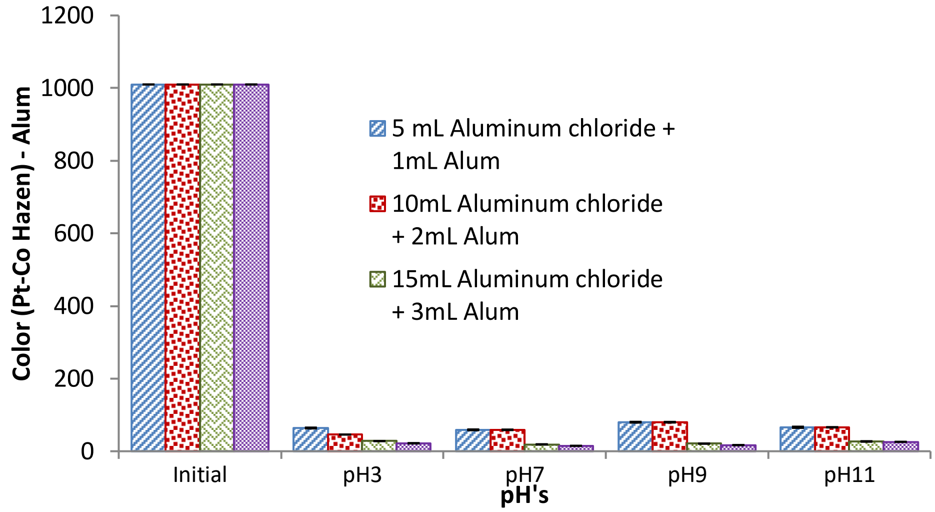

Fig. 2: Color reduction at varying pH by increasing the dose

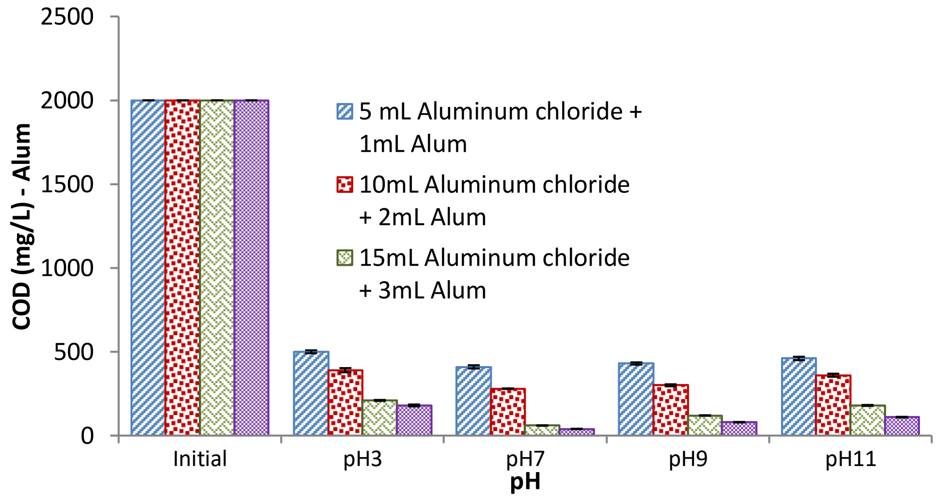

Fig. 3: COD reduction at varying pH by increasing the dose

Analytical procedure

Coagulation is believed to be a best process for removing the organic matters and numerous particulates using Alum and aluminum-based salts (Irfan et al., 2017). Dose of coagulant, nature of wastewater, temperature, pH and many other factors influence the performance of treatment. Various experiments were conducted to analyze the influence of concentration of dose and pH on the reduction capability of coagulants (Zin et al., 2018). By keeping the volume of the sample constant (50 mL) concentration of the 5% aluminum chloride and 5% alum were altered (5, 10, 15 and 20) and (1, 2, 3 and 4) respectively. Dose of 5 mL of aluminum chloride was taken with the combination of 1mL of alum which represented as treatment T1, similarly, following doses (10, 15, 20 mL) of aluminum chloride with (2, 3, 4 mL) of alum represented as treatment T2, treatment T3, treatment T4 respectively. All the treatments were conducted twice, to check the reliability of results. The experimental error was found below 2%, and average data have reported (Can et al., 2019).

RESULTS AND DISCUSSION

The physicochemical parameters of wastewater were studied in terms of total dissolved solids (TDS), turbidity, color, chemical oxygen demand (COD), conductivity, pH, total suspended solids (TSS) The influence of such parameters strongly varies in different textile wastewater due to the rate of load of organic and inorganic matters in the wastewater (Abiola, 2019).

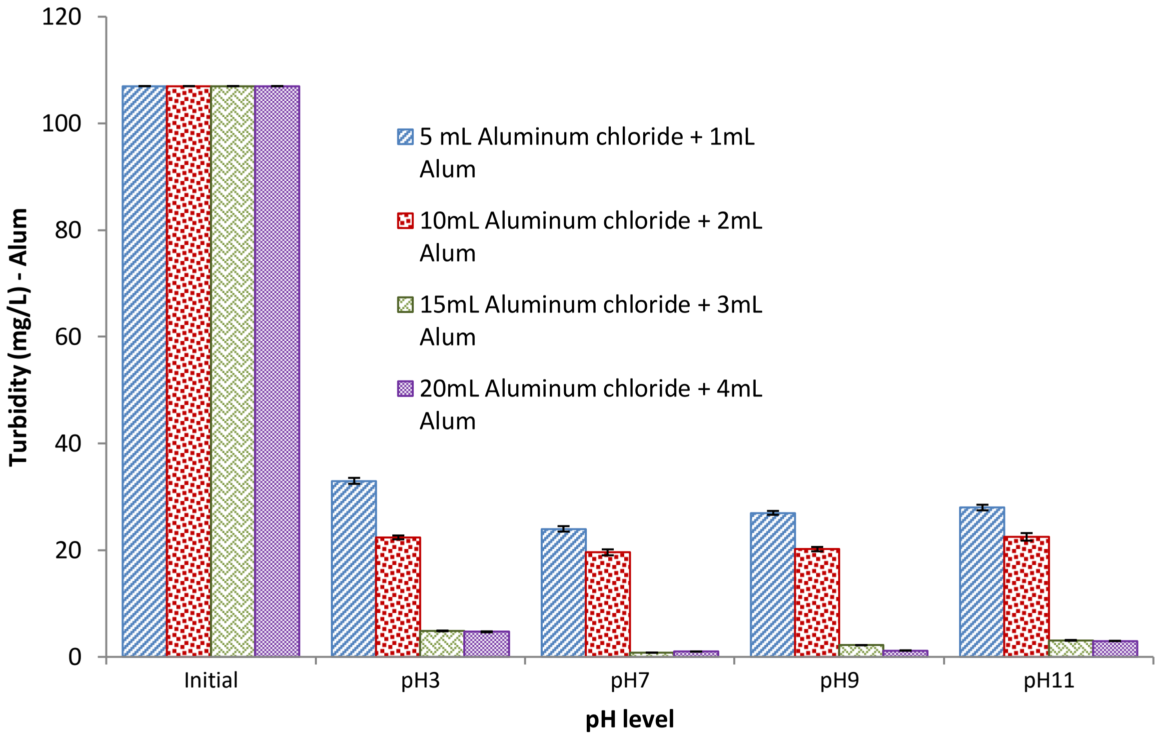

Fig. 4: Turbidity reduction at varying pH by increasing the dose

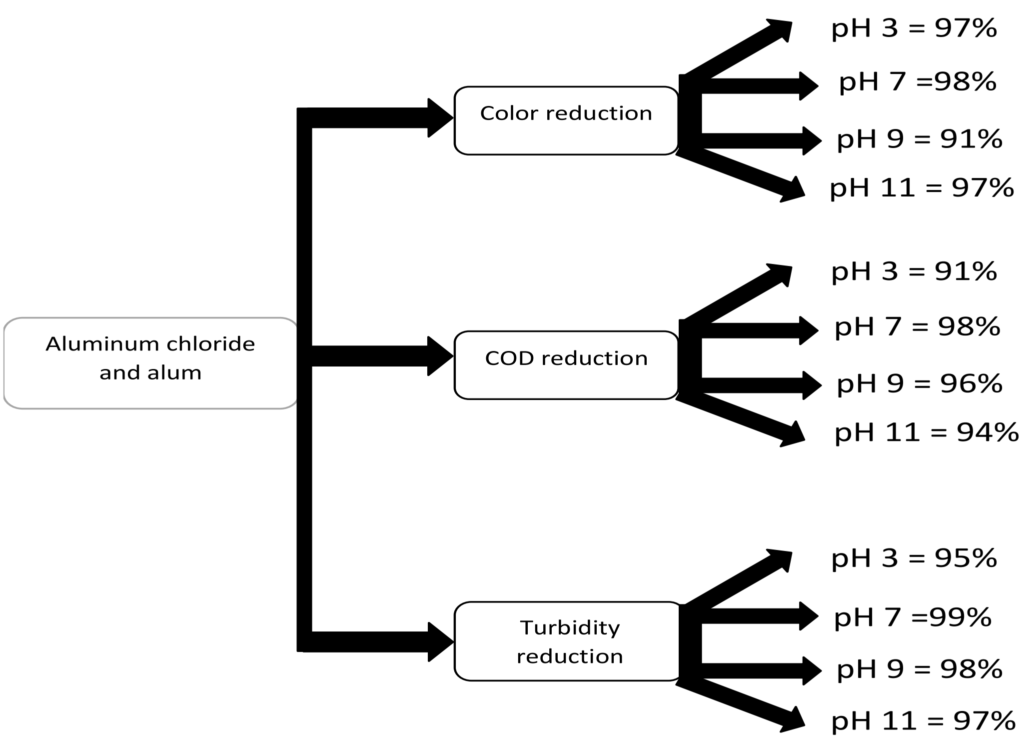

Fig. 5: Percentage reduction of all parameters with treatment T5 at different pH

Following parameters such as COD (2,000±2.6 mg/L), TDS (21,666.6±3.0 mg/L), TSS (69,000±2.0 mg/L), color (1010±3.0 mg/L), turbidity (107±1.2 NTU) pH (9) and conductivity (17600±3.3 µS/cm) were remarkably higher than NEQS standards shown in Table 1 (Ho et al., 2020). Results and observation of the coagulant are shown in Tables (2-8) and Figures (2-4).

Color reduction

Color of unprocessed textile wastewater was typically found 1010 Pt-Co Hazen. The following research work illustrated that 98% of the color removal was done successfully. It was observed that up to 94% of color removal was analyzed at treatment T1 (5 mL $AlCl_3$ and 2 mL alum), similarly, 95% and 98% reduction is observed with T2 (10 mL $AlCl_3$ and 2 mL alum) and T3 (15 mL $AlCl_3$ and 2 mL alum) respectively. whereas, 98% of results were noticed with treatment T4 (20 mL $AlCl_3$ and 4 mL alum), it was observed that further increase in dose showed less significant results because the binding color pigment was reached to optimum dosage. This is because the color particles start to re-stabilizing them through excessive use of alum hydrolysis species (Wong et al., 2007). Whereas, maximum result was found with pH 7 at treatment T3. The pH indicted practically significant result in treating color removal present in wastewater, meanwhile acidic conditions my lead to discharge of acidic wastewater since, percentage of color removal at acidic conditions are less significant as compare to neutral pH. The efficiency of color removal with acidic and alkaline solution moderately effected, however, pH 3 and 9 made nearly equal result in between of acidic and basic medium (Mohamed et al., 2014). Liu et al, conducted an experiment to exhibit the impact of Al-based coagulants (Liu et al., 2019). Color removing efficiency was gradually improved with increasing the dose of the coagulating agents as shown in Figure 2. The ANOVA analysis for color indication with treatment of aluminum chloride and alum have been significant as shown in Table 2. Means of various treatments were compared which proved treatment T1 at pH 3, 7, 9, 11 along with treatment T2 at pH 7, 9, 11 and treatment T3 at pH 3, 11 statistically non-significant. However, rest of the treatments were statistically significant as shown in Table 3.

COD reduction

Chemical oxygen demand (COD) has been one of the extensively used parameters for analysis of wastewater, it has been the indicator for identifying the effluents which are organic matters. The reporting results of the analysis must give approximate quantitative indication of uncertainty. (Drolc et al., 2003). The effect of pH and dose of coagulant on the removal of COD from textile wastewater is shown below. Among all the different pH's, pH 7 (neutral) was observed as optimum pH for lowering the COD from textile wastewater. Surprisingly reduction of COD observed nearly equal at acidic and basic pH. Production of OH^- or rerelease of dioxide gas lowers down the level of COD. COD reduction enhanced progressively by increasing the concertation of the coagulating agents as shown in Figure 3. Maximum percentage of COD removal is observed with T3 (15mL $AlCl_3$ and 3 mL alum) and amount of COD was slightly increased with T4 (20 mL $AlCl_3$ and 4 mL alum) because coagulant reduces efficiency since reach at optimum condition. Excessive use of chemical dose resulted in surging the level of COD, since T4 showed dropping of percentage of COD removal (Hua et al., 2019). The study of Piotr Marcinowski et al, proclaimed that inorganic coagulants such as aluminum chloride and alum have been significantly suitable for decreasing the level of COD in wastewater (Marcinowski et al., 2019). The ANOVA analysis of COD with different doses were significant as presented in Table 4. Means of various treatments were compared which proved T2 at pH 7, 9 along with treatment T3 at pH 3, and treatment T4 at pH 3 statistically non-significant. However, rest of the treatments were statistically significant as shown in Table 5.

Turbidity

Aluminum chloride and alum together were able to remove the turbidity from wastewater with efficiency rate of up to 77%, 82%, 99% and 99% at treatment T1 (5 mL $AlCl_3$ and 1 mL alum), treatment T2 (10 mL $AlCl_3$ and 2 mL alum), treatment T3 (15 mL $AlCl_3$ and 3 mL alum) and treatment T4 (20 mL $AlCl_3$ and 4 mL alum), respectively. At alkaline and acidic pH, decrease in removal of turbidity happens because of production of excessive OH^- production and significant sludge is also produced (Dotto et al., 2019). The working efficiency of coagulants at acidic pH was less so far, acidic medium increases the production of sludge somehow, which is why slightly better percentage found out with neutral pH. The study of Paul et al., demonstrated the potency of metal coagulants like as alum and aluminum chloride and reported the reduction in turbidity from wastewater (Chadik and Amy, 1983; Mazloomi et al., 2019) . The maximum removal of turbidity was found at pH 7 in case of treatment T3 and treatment T4 whereas, minimum reduction in turbidity was obtained at acidic pH. The results of treatment revealed that removal in turbidity was increased with the increase in dosage of coagulating agents (Nkalane et al., 2019). The linear reduction efficiency was observed with each of treatment, suchlike by the increase in concentration of the coagulants the rate of % age reduction was increasing as sown in Figure 4. The ANOVA table for the analysis of turbidity with different doses were significant as presented in Table 4. Means of various treatments were compared which proved treatment T1 at pH 7, 9, 11 along with treatment T2 at pH 3, 7, 9, 11 and treatment T3 at pH 7, 11 and treatment T4 at pH 7, 9, 11statistically non-significant. However, rest of the treatments were statistically significant as shown in Tables 6-7. Coagulation has been renowned process for wastewater treatment. Aluminum based salts are most commonly applied such as aluminum chloride and alum (Kristianto et al., 2019). It has been extensively known that application of metal coagulants causes serious drawbacks. The study of Michael J. and coworkers reported that alum was found out to be significant coagulant and the removal with such coagulant was dependent on concentration of coagulant and pH (Semmens and Field, 1980). The effect of coagulating agents on removal of color, COD and turbidity was studied/checked with treatment T2, treatment T3, treatment T4 and treatment T5. Each of the treatment was further investigated by varying the pH of sample (Jin et al., 2018).

CONCLUSIONS

Coagulation process was successfully implemented to treat textile wastewater. This study investigated that, aluminum-based salts such as aluminum chloride and alum were proved best combination for treating wastewater. Concentration of both coagulants were increased successively to find out the maximum reduction. In addition to that pH of the wastewater was altered to acidic and basic as well. Statistical data demonstrated that pH 6.5-7.5 found out to be an appropriate medium for maximum reduction of COD, color and turbidity. Treatment T5 reduced coloring content to 98% at pH 7, likewise 98% and 99% reduction in COD and turbidity were examined respectively. The investigation was made that pH 3 was least efficient pH for treating the wastewater for instance COD reduced to 98% with pH 7 whereas, 91% reduction was noticed at pH 3, same trend was observed for color and turbidity. Treatment T4 results were quite closer to T5, and it was observed that linear increase in reduction was happened with the increase in dose of coagulants. Though alum leaves high level of aluminum in treated water at low pH, so, making that view in consideration minimum amount of alum was added.

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