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Performance Evaluation and Treatment Optimization of ETP and STP- Review

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ABSTRACT

Textile industrial Effluent Treatment Plants (ETP) and Sewage Treatment Plants (STP) are constructed to protect the environment from excessive overloading from different kinds of pollutants. The effluent must meet the appropriate discharge standards as per pollution control board before discharging it to the environment. Improper treatment process conditions at treatment plants result in the release of effluent that may contain toxins and unacceptable high levels of dangerous organic and inorganic materials into various water bodies and the land environment so it is necessary to adopt proper treatment technology for the treatment. The present paper is reviewed for performance evaluation of ETP, STP and Coagulation and Flocculation process. Coagulation and Flocculation is not an Eco-friendly approach so Electrocoagulation (EC) is also reviewed to know the removal efficiencies of pollutant loads.

Keywords: *ETP, STP, Performance Evaluation, Process Optimization.*

1. INTRODUCTION

The textile industry is one of the leading sectors in the Indian economy as it contributes nearly 14 percent to the total industrial production. It is one of the oldest and most technologically complex of all industries. Among the many chemicals in textile wastewater, dyes are considered important pollutants (Khan and Malik, 2013). The untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources due to its high BOD value (Desai and Kore, 2011). So many offensive characteristics like strong odor, strong color, turbidity, alkalinity, toxicity etc. increase the content of objectionable properties results into adverse effects which influence the aquatic life of water bodies through the excess growth of algae. So treating the textile effluent becomes necessary in order to reuse the water, either for domestic purposes or for industrial jobs (Nageswara Rao, 2015). Some pollutants remain in treated wastewater discharged into surface waters. Partially treated wastewater may contain grit, debris, disease-causing bacteria, nutrients, and hundreds of chemicals such as those in drugs and in personal care products like shampoo and cosmetics. Nowadays, society demands that all processes, product or services must also be analyzed from an environmental point of view (Prachi *et al.*, 2014). The textile effluent is a cause of the significant amount of environmental degradation and human illnesses. About 40% of globally used colorants contain organically bound chlorine, a known carcinogen. Chemicals evaporate into the air we breathe or are absorbed through our skin and show up as allergic reactions and may cause harm to children even before birth. Also, it is responsible for the impairment like respiration osmoregulation, reproduction, and even mortality. Thus, untreated or incompletely treated textile effluent can be harmful to both aquatic and terrestrial life by adversely affecting the natural ecosystem and causing long-term health effects (Khan and Malik, 2013). For the treatment purpose Coagulation and flocculation technique are simple and rapid technique and the most often used pretreatment techniques for treating the textile effluent. Coagulation and flocculation technique is well known for its operation and its maintenance. The choice of coagulant aids based on suitability of particular waste, availability and the cost of coagulant. Normally, the coagulants used were an alum, polyelectrolyte, and lime. Coagulation and flocculation process is the dye and heavy metal removal, but the problem with this technique is there a possible link of Alzheimer's disease with conventional aluminum-based coagulants (Abu Hassan *et al*).

So EC is also reviewed to overcome this problem. EC is an electrochemical technique for treating wastewater using electricity instead of expensive chemical reagents and it is an exact replacement of Coagulation and flocculation technique to avoid the Alzheimer's disease. An electrocoagulation process has been attracted a great attention on the treatment of industrial wastewater because of the versatility and environmental compatibility. This technique has several advantages as compared to conventional methods in terms of use of simple equipment, ease of operation, less treatment time, reduction or absence of chemicals addition. Moreover, an electrocoagulation process provides rapid sedimentation of electro generated flocs and a less amount of sludge production. Electrocoagulation has the advantage of removing the smallest colloidal particles compared with traditional coagulation and flocculation, such charged particles have a greater probability of being coagulated and destabilized because of the electric field that sets them in motion (Dohare and Sisodia, 2014).

1.1 Performance Evaluation of Sewage Treatment Plants (STP)

STPs are constructed in most of the places to reduce the degradation of water quality of the receiving water bodies by reducing the pollution load on the same and to ensure a healthy environment (Sharma and Singh, 2013). The performance evaluation process helps in understanding the design and operating difficulties of each unit in the plant. The efficiency of STPs can be illustrated by a study on the evaluation of pollutant levels of the influent and the effluent at the treatment plant (Prachi *et al.,* 2014). The STP at Kaithal town was based on SBR technology. Samples were collected from inlets and outlet of STP for 3 months on daily basis. Wastewater samples were analysed for pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Turbidity, Nitrate, Phosphate, Total Nitrogen (TN) and Total Phosphorous (TP). The parameter removal efficiencies were 97.2%, 92.0%, 97.8% and 93% for TSS, COD, BOD, and Turbidity respectively, Pipraiya (2016). Sharma and Singh (2016) have worked on the performance of STP based on the advanced aerobic BIO FOR technology located in Delhi for handling and treating the domestic wastewater. The considered parameters were pH, TSS, BOD, COD, Mixed Liquor Suspended Solids (MLSS), Total Coliform (TC) and Fecal Coliform (FC). Results of STPs based on BIO FOR Technology indicate that BOD, COD and Suspended Solids (SS) removal efficiencies were 95.2%, 93.4%, and 97% respectively, the technology was found to be quite satisfactory in the removal of FC from the wastewater though not efficient enough in the removal of TC. Prachi *et al.,* (2016) study was aimed to evaluate the performance of 25 MLD STP located at Adharwadi, Kalyan. Here the STP was based on Sequential Batch Reactor (SBR). Sewage samples were collected from different locations i.e. Inlet, Distribution Chamber and Outlet of the Treatment Plant and analysed for the major wastewater quality parameters, such as pH, BOD, DO, COD, TSS, TN, and TP. Sample collection was done for 3 months on daily basis (December to February). The obtained result shows 95.62% of BOD, 92.08% of TSS, 96.14% of COD, 81.43% of Nitrogen and 79.06% of Phosphate reduction. Kumar (2016) has undertaken a study to evaluate performance efficiency of a Sewage treatment plant at Nesapakkam to assess the existing effluent quality and to meet higher treatment requirements and, to know about the treatment plant whether it is possible to handle higher hydraulic and organic loadings. They collected wastewater samples at different stages of treatment units and analyzed for the major parameters such as BOD, COD, TSS, and TDS. The evaluation was based on the plant operation data such as Flow, BOD, Total Suspended Solids measurements for the period of 6 months. He observed overall treatment efficiency for the BOD removal was 94.56% and that of TSS was 93.72%. He used regression analysis, a variation of influent BOD with the influent TSS and variation of removal efficiency of BOD with removal efficiency of TSS was determined. He stated that because of the rapidity with which TSS test can be conducted, the correlation can be very useful as BOD measurement will take 5 days. Once the correlation has been established, TSS measurement can be a good advantage for treatment plant control and operation.

1.2 Performance Evaluation of Effluent Treatment Plants (ETP)

Textile wastewater is one of the industrial wastewater which is very difficult to deal with the difficulty is due to the large variability of characteristics (Sheng et al., 1994). The quality of such effluent can be analyzed by their physicochemical and biological analysis. Monitoring of the environmental parameters of the effluent would allow having, at any time, a precise idea on performance evaluation of ETP and if necessary, appropriate measures may be undertaken to prevent adverse impact on the environment (Patel et al., 2013). A study was carried out to Evaluate Performance Efficiency of an ETP of a textile industry located at Ramtek, Nagpur (Maharashtra). In the study pH value was found to be very high at equalization (13.1) due to use of sodium hydroxide in manufacturing. A jar test was conducted as pre-treatment to determine the optimum dose of alum with respect to COD removal. After experimentation, 42.48% of COD reduction was documented. The efficiency of biological treatment for COD, BOD and alkalinity was 88%, 98%, and 93%, whereas for TDS and TSS found 44 & 45% respectively. By providing tertiary treatment the percentage removal efficiency for TS, TDS, TSS and COD was 96%, 97%, 88% and 98% respectively, whereas for BOD and alkalinity reduced to 99% Karekar *et al.,* (2014). Another study was carried out by Assefa and Sahu, (2016) on the performance of a textile industrial wastewater treatment plant with physicochemical characterizations. Samples were collected from ETP inlet, aeration tank, primary clarifier and ETP outlet and analysed for pH, TDS, TSS, COD and BOD. Based on the results obtained from the analysis 95.48% of TSS, 43.79% of TDS, 87.03% of COD, and 78.36% of BOD reduction was achieved. The reasons for fewer efficiencies were inadequate treatment due to incorrect dosing of chemicals required in the treatment process and inactivity and even death of necessary micro-organisms due to insufficient oxygen or lack of nutrients, overloading to the treatment plant capacity, lack of skill for operation and maintenance for ETP and also the operating conditions are different from designed values. Desai and Kore, (2011), conducted a study on "Performance Evaluation of Effluent Treatment Plant for Textile Industry in Kolhapur of Maharashtra". An effluent treatment plant was operating on biological treatment method (Fluidized Aerobic Bio-Reactor) with an average wastewater inflow of 2MLD. The effluent samples were collected on a daily basis for a period of one month and analyzed for the major parameters such as pH, BOD, COD, and TDS. The result says incomplete use and the washing operations gave the textile wastewater a considerable amount of dyes. It has been documented that residual color is usually due to insoluble dyes which have low biodegradability as reactive blue 21, direct blue 80 and vat violet with COD/BOD ratio of 59.0, 17.7 and 10.8 respectively. The coagulation and flocculation helped to remove the color of the effluent. After coagulation and flocculation process the BOD, COD, and TDS removal efficiency according to graph analysis were 89%, 87%, and 20% respectively.

2. COAGULATION AND FLOCCULATION TREATMENT FOR TEXTILE INDUSTRIAL WASTEWATER

Coagulation and flocculation is a commonly used physicochemical treatment procedure that can be employed in textile wastewater treatment plants to decolorize effluent and also to reduce the total load of pollutants Papic *et al.,* (2004). The main advantage of the coagulation-flocculation method is that the textile wastewater can be decolorized through the removal of dye molecules from the effluents, and not by partial decomposition of dyes, which could produce potentially harmful and toxic aromatic compounds Golob *et al.,* (2005). The efficiency of this method depends on the characteristics of raw wastewater, pH and temperature of the solution, the type and dosage of coagulants, and the intensity and duration of mixing Rossini *et al.,* (1999).

2.1 Effect of Dosage

Dosage was one of the most important parameter that has been considered to determine the optimum condition for the performance of chitosan in coagulation and flocculation. Basically, insufficient dosage or overdosing would result in the poor performance in flocculation. Therefore, it was crucial to determine the optimum dosage in order to minimize the dosing cost and obtain the optimum performance in treatment. For the optimum chitosan dosage of 30 mg/l, chitosan recorded the highest reduction of parameters, which were the reduction of 94.90% and 72.50 % for turbidity and COD respectively Abu *et al.,* Sabur *et al* (2012) observed best treatment with a dosage 5.0 mL of PAC solution and 4.0 mL of 10% SAFI solution. Nageswara Rao (2015) observed that at dosage level of 12 - 30 mg/L formation bridges between flocs increases due to more sites are available on particle surfaces for the formation of interparticle bridges whereas dosage between 30-66 mg/L, formation of flocs decreases due to no sites available on particle surfaces for the formation of interparticle bridges due to excess polymer (coagulant) was adsorbed on the colloidal particles and producing restabilized colloids. According to Seif and Malak (2001) the effective and economic dose was 2.00 mg/L of polyelectrolyte for the removal of SS, BOD, COD and SO_4 and he obtained SS, BOD, COD and SO_4 efficiencies as 98.3%, 91.2%, 95% and 92% respectively. Alum with 1 mg/L of polymer could remove about 95% of colour, 75% of turbidity, 76% of COD and 90% of PO_4 Mahmoud (2009). According to Solanki *et al.,* (2009) results the most effective and economic dose was 45 mg/L and BOD, COD and TDS removal were 83.34%, 64.04%, and 62.97%. Alen and Vinodha (2014) observed 0.05g of moringa removed 98% of color. Madhavi (2014) used 450 mg/L of alum to remove 99% of color.

2.2 Effect of pH

The pH will not only affects the surface charge of coagulants, but also affects the stabilization of the suspension. Besides, the solubility of chitosan in aqueous solution is influenced by pH value. Overall 72.5% of COD reduction and 94.9% of turbidity reduction was achieved at pH 4 Abu et al., Takahashi *et al.,* (2005) proved that the solubility of chitosan decreases as the pH varies towards the basic condition. Chitosan dissolves in aqueous solution at pH less than 6.0. Over pH 6.0, it becomes insoluble in solution and exists as solid particles. Sabur (2012) observed best treatment with a dosage 5.0 mL of PAC solution and 4.0 mL of SAFI solution at pH 6. When alum was added to water immediately follow coagulation process, which involved hydrolysis of aluminum salts and enter into a series of hydrolytic reaction and for a series of multivalent charged hydrous oxide species aluminum and iron salts react with water or with alkalinity present in water. Depending upon pH these compounds exist in ionic form in the positive range at the lower pH values to negative at the more basic pH values Patel and Vashi (2005). Chitosan is more soluble in acidic medium when compared to in basic medium and it also more efficient in acidic medium. At pH 4, the floc produced by chitosan appears rapidly and form a large size, which can be easily settled and at pH 6 chitosan is insoluble and exists as solid particles Nageswara Rao (2015). By adjusting the pH 6.7-7.5 Seif (2001) obtained SS, BOD, COD and SO_4 removal efficiencies as 98.3%, 91.2%, 95% and 92% respectively. At pH 7.2 alum with 1 mg/L of polymer could remove about 95% of colour, 75% of turbidity, 76% of COD and 90% of PO_4 Mahmoud (2009). At pH 6.9 the percentage removal of BOD, COD, and TDS were 83.34%, 64.04%, and 62.97% respectively Solanki et al., (2009). Likhar and Shivramwar (2013) observed 75% and 65% of Color and COD removal for PACl at pH 4, 80% and 65% of Color and COD removal for $FeCl_3$ at pH 2. Alen and Vinodha (2014) maintained pH between 8-9 to get 100% color removal efficiency. Madhavi (2014) observed 99% of color removal at pH 8.

2.3 Effect of Mixing Time

Besides the effect of dosage and pH, mixing time also play an important role on flocs formation and growth in flocculation process. Polymeric flocculent disperses throughout the medium and adsorbs on the colloidal particle surfaces for interparticle bridging or charge neutralization during the mixing period. Overall 70.9% of COD reduction and 93.3% of turbidity reduction was achieved at pH 4. Therefore, the optimum mixing time condition of the treatment system was 20 minutes and it was observed lower percentage of reductions at longer mixing time (i.e. 30 minutes) Abu et al., Nageswara Rao (2015) studied the effect of mixing time and concluded that at low mixing time (i.e. 10 minutes) there is no formation of flocs because the collisions between chitosan and suspended particles are low and lead to lower flocculation rate and at long mixing time (30 minutes) observed that there is a breaking of flocculate chains/bridges and this lead to limiting the size of flocs formed. He observed maximum removal of COD (63 -64 %) at 20min time duration. Mahmoud (2009) carried out the experiment by adding polymer to the wastewater and it was stirred for one minute at 160 rpm and slowly stirred at 20 rpm for 10 minutes. The wastewater was then allowed to settle for 60 minute later he observed about 95% of colour, 75% of turbidity, 76% of COD and 90% of $PO_{4.}$ Solanki (2009) maintained 400rpm agitator speed and observed the settling time of the flocs treated with PAC and Alum between 15-17 min whereas for magnesium chloride the settling time is less than 3 min. Likhar and Shivramwar (2013) after dosing of each beaker the sample were stirred for 2 minute and the wastewater with coagulant was left undisturbed for 60 minutes. Results shown that the Color and COD removal were 75% and 65% for PACl, 80% and 65% for $FeCl_{3.}$ When time was maintained 20 minutes the efficiency was nearly 100%. This may be due to the increased formation of flocs when there was increase in the time. But again the efficiency started decreasing when the time was further increased to 30 minutes and more Alen and Vinodha (2014).

3. ELECTROCOAGULATION TREATMENT FOR TEXTILE INDUSTRIAL WASTEWATER

Electrocoagulation is an electrochemical technique for treating wastewater using electricity instead of expensive chemical reagents. This technique has several advantages as compared to conventional methods in terms of use of simple equipment, ease of operation, less treatment time, reduction or absence of chemicals addition. Moreover, an electrocoagulation process provides rapid sedimentation of electro generated flocs and a less amount of sludge production Dohare and Sisodia (2014).

3.1 Electrode Types

Different types and shapes of electrodes have been used by different workers for effective electrocoagulation. The process of electrocoagulation is totally dependent on the electrodes and the shape and size of its influence the process. Most common electrode types are iron and aluminum while steel and other metals have also been used by some. Naje *et al.,* (2013) carried out a combination of Electrocoagulation and Electro-Oxidation Processes for Textile Wastewater Treatment, here he has used Aluminum and Iron electrodes for COD removal. The electrode set consist of five Aluminum (or Iron) plate electrodes and six Titanium plates, each having a surface area of 144 cm2 (12 cm width × 12 cm height) The maximum COD removal value is 90.0% that was recorded by Aluminum electrodes, whereas 77.3% was obtained with Iron electrodes. Therefore the optimal results were recorded with Aluminum at COD Removal 90.0%. $Al(OH)_3$ large surface areas that are beneficial for rapid adsorption of organic compounds and trapping of colloidal particles. Raghu and Basha (2007) also carried out electrocoagulation process by using same electrode materials and the optimum conditions for effective removal of COD, color, and minimum energy consumption have been studied at different current densities in a batch reactor and maximum COD removal of about 92.31%. Zerrouki *et al.,* (2014) conducted an experiment by two aluminum electrodes which are rectangular plates with 5.3 cm width and 4.5 cm height (active area = 23.85 cm2) and they observed a reduction in color from 87% to 97%. Borislav (2014) used aluminum and steel electrode with an effective electrode area of 22.2 cm^2 with removal efficiency 99.1%. Rusdianasari (2014) used Aluminum electrodes with dimensions of 50mm x 75mm x 10mm and removal of turbidity, TSS, TDS, BOD and COD value were 99.634%, 49.679%, 17.243%, 91.778%, and 97.26% respectively. Eslami et al (2013) used a pair of iron electrodes, having a dimension of 10×4×0.1 cm, the best COD removal, and decolorization efficiencies were 70.6% and 72.9% respectively. From the literature review, it is known that Al is superior compared to Fe, but Al is more expensive that of Fe Baklan and Kolsenikova (2014). Wang (2014) used six iron plates of size 100mm × 80mm ×2mm and the removal rates of the COD, ammonia nitrogen, and color were 79.45%, 23.89%, and 87.50%, respectively. Naje (2015) used six aluminum plates and 5 aluminum plates. Each electrode had a surface area of $120cm^2$ (12cm×10cm) these electrodes were implemented in a bipolar form. The implementation of these parameters on textile wastewater revealed a relatively high removal efficiency of COD (92.6%), TSS (96.4%), color (96.5%), BOD_5 (88%), TDS (87%), turbidity (96%), phenols (over 99%), and phosphate (95%).

3.2 Electrolysis Time

According to Naje et al., (2013) the initial set treatment times vary from 30 to 90 minutes, the COD concentration was stable between 20 and 40 min and then decreased after 60 minutes electrolysis to achieve a maximum removal of COD (90%) at 90 minutes of electrolysis. The minimum value of COD 98.5 mg/L was recorded at 80 minutes of the treatment. Zerrouki et al., (2014) carried out a study on Treatment of Textile Wastewater by electrocoagulation where the electrolysis time was 1 h, for this time period they have observed a reduction in color from 87 to 97 %. Borislav et al., (2016) carried out a study by keeping 30-minute operating time in the reactor with the SS: SS electrode combination and got 99.15% efficiency also got 99.8 % efficiency for 15 minutes operating time in the reactor with the Fe: SS electrode combination. Rusdianasari (2014) varied the processing time from 60, 75, 90, 105, 120 minutes and the best conditions for the processing time between 90 and 120 minutes. The effectiveness of electrocoagulation method to decrease the turbidity, TSS, TDS, BOD, COD, and Conductivity was 99.634%, 49.679%, 17.243% 91.778%, 97.26% and 23.63% respectively. Naje et al., (2015) has fixed electrolysis time as 90 min and obtained high removal efficiency of COD (92.6%), TSS (96.4%), color (96.5%), BOD_5 (88%), TDS (87%), turbidity (96%), phenols (over 99%), and phosphate (95%). Wang (2016) et al., had done an experiment by keeping the duration of time 15 minutes. The color removal rate was found to be the highest at 15 minutes. However, with the increase of time, the color basically remained unchanged. The removal rate of the ammonia nitrogen was determined to be the highest at 12 minutes. If the electrolysis time is too lengthy, overly abundant amounts of insoluble substances will also be produced which wrap up the colloidal particles. Then, these particles will lose absorption activity, which increases the resistance of electrodes, and reduces the flocculation performance, slowing the oxidation. The removal rates of the COD, ammonia nitrogen, and color were 79.45%, 23.89%, and 87.50%, respectively.

3.3 Current Density

The current is the most important factor that is influencing the treatment efficiency. Current density is varied between 0.2 to 0.8A. The applied current in the cell caused an anodic dissolution of Iron or Aluminum electrodes into wastewater. $Al(OH)_3$ or $Fe(OH)_2$ have large surface areas that are beneficial for rapid adsorption of organic compounds and trapping of colloidal particles (Asselin et al. 2008). The maximum value of the COD removal was (90%) recorded at 0.6A current intensity. Choosing the optimal current should not consider only on the COD, but also the amount of Turbidity, the cost of the energy consumed and the TSS removal. The maximum removal value of the TSS was (98.0%) recorded at the current 0.6A and for the turbidity (98.5%) was recorded also at 0.2A and 0.4A current intensity Naje et al., (2013). Raghu and Basha (2007) maintained current density at 0.25 A/dm^2, the maximum COD removal achieved was 92.31% in iron electrode and 80% of COD removal in the aluminum electrode for 0.25 A/dm^2 current density. Therefore, an optimum point must be carefully determined. According to Zerrouki et al., (2014) when the current density increases the processing time reduces due to the strong dissolution of the anode. The abatement rate increased from 80% to 82% when I= 0.1A and from 89% to 91% when I=0.8A. For a Current density of 34 mA/cm^2 they observed a reduction in color from 87 to 97 %.

Kobya et al. (2006) confirmed that at higher current densities, the anodic dissolution of aluminum increases, causing a greater rate of the precipitates necessary for pollutant removal. Borislav et al., (2016) obtained a maximal color efficiency of 97 % for the current density 25 A/cm^2. Lower values of current densities like 10 A/cm^2 (72 - 92.5 %), 15 A/cm^2 (89.5 - 91.5 %) and 20 A/cm^2 (92 %) was also reached satisfactory values of efficiency. Electrical current which is responsible for the generation of metal ions within the electrochemical cell. This parameter directly determines the extent of anodic dissolution of the iron electrode. In fact, in addition to electrolysis Eslami (2013)

3.4 pH

pH is one of the most important parameters that influence the electrochemical performance. According to Mollah et al. (2001), the initial PH affects the stability of the generated hydroxide species. It consequently influences the efficiencies of the removal (Jolivet 1994). The maximum value of COD removal was 90% at initial pH and reached its highest value which was recorded at pH 6 Naje et al., (2013). Zerrouki et al., (2014) got max removal efficiency of Blue Thio Bezathren R for the pH 7.5 to 9.7, Blue Turquoise Cibacron P-GR for the pH 6.9 to 7.9 and Black Dianix RXN for the pH 6.3 to 6.5 respectively. Naje et al., (2015) achieved up to 84% of COD, 90% of TSS and 91% of color removal efficiencies at pH 6. According to Wang (2016) et al., the removal results were the most effective when the pH is between 5 and 7. The removal rate of ammonia nitrogen increased with the increase of pH and then dropped, and the removal effect was the best when the pH was between 6 and 9. The results mentioned above were due to the fact that, under the condition of being overly acid, the iron plates reacted with the H$^+$ in water, and existed in the form of iron ions, thereby losing the flocculation effects. When the pH value was too high, the plates easily passivated, and the Fe^{2+} and Fe^{3+} sedimented in the form of hydroxides and was unable to produce polynuclear poly iron carbonyl complex ions for charge neutralization and adherence fiber bridges. Therefore, when the pH was controlled at between 5 and 7, the removal effect of color and COD was improved. The removal rates of the COD, ammonia nitrogen, and color were 79.45%, 23.89%, and 87.50%, respectively.

3.5 Inter-Electrode Distance

Zerrouki et al., (2014) had fixed the Inter-electrode distance of 2 cm and got 87 to 97% of eicffiency for color removal. Borislav et al., (2016) obtained a maximal color efficiency of 97% by fixing 30mm spacing between the electrodes. According to Naje et al., (2015) Daneshvar et al., (2003) Song et al., (2007) Daneshvar et al., (2004) Modirshahla et al., (2007) EC performance levels as a common function of inter-electrode distance is based on the pollutants nature, the electrodes structure, hydrodynamic properties, as well as other factors. Naje et al., (2015) in the experiment, the effect of inter-electrode distance were investigated using 0.5, 1, and 1.5 cm. the best performances were obtained at 0.5 cm and results were 90 to 91.3% of COD, 93 to 95% of TSS, and 94 to 95% of color removal for a change of 1 to 0.5 cm, respectively. An additional raise in the electrode gap of 1.5 cm leads to reduced removal efficiencies like 84% of COD, 88% of TSS, and 89% of color. As the spacing in the interelectrode increases, a lower amount of attraction by electrodes was observed on the generated aluminum polymers hence, they have a slower movement, and they were gathered in flocks. The greater inter-electrode distance causes the cell potential (V) to increase, which in turn increases the internal resistance among the electrodes (IRdrop) and adversely affects the EC process. The coagulant and molecule interactions are also weaker when there is a distance above 0.5 cm, which causes a decrease in the removal efficiency.

3.6 Stirring Speed

Mixing in the cell was achieved by a magnetic stirrer at a rotating velocity of 500 rpm by using a current of 0.6A during 90 min of treatment with pH adjustment approximately 6.0, high removal of COD (90.0%), TSS (98.0%), and BOD (87.0%), Oil &Grease (95.0%) were recorded. Under these conditions, 98.5 % of turbidity was eliminated and more than 96.0% of phosphate was removed Naje et al., (2013). Borislav et al., (2016) achieved 97% of color removal efficiency at the constant stirring speed 400 rpm. It has been proven that agitation may improve the kinetics of mass transfer. If coagulant matter does not efficiently disperse within the reactor, the reactor contents are not homogenous and, therefore, display regional differences. If the speed rates are too high, the flocks that are formed within the reactor will be damaged and create smaller flocks that are difficult to extract from the wastewater. The largest removal efficiency was shown at 500 rpm, with a COD removal efficiency of 91.3%, TSS of 95%, and color at 95%. A lower level of removal was seen at 250 rpm, with the COD at 84%, the TSS at 87%, and the color at 90%. Increasing the stirring speed from 250 to 500 rpm resulted in the $Al(OH)_3$ flocks attaching to each other, thereby precipitation process was easy. When the stirring speed was raised from 500 to 750 rpm, the COD removal efficiency dropped to 87%, TSS to 89%, and color to 91%. At this speed, the amount of flocks decreased, and the adsorbed pollutants were again desorbed, leading to a decrease in the overall removal efficiency Naje et al., (2015).

4. CONCLUSION

From the above literature review it is concluded that textile wastewater needs pre-treatment before it is feed into biological treatment units. The kind of pre-treatment depends on the strength and characteristics of textile wastewater. Aluminum sulfate (alum), ferrous sulfate, ferric chloride and ferric chloro-sulfate are commonly used coagulants for chemical coagulation. Electrocoagulation is also a kind of pre-treatment given to textile wastewater. In electrocoagulation there is no supplemental addition of anions and therefore, no increase in salinity of the treated water. Electrocoagulation is a treatment process that is capable of being an effective treatment process as conventional methods such as coagulation and flocculation. After pre-treatment the leftover nutrients can be removed through biological treatment process.

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