A REVIEW OF ELECTROCOAGULATION TECHNIQUE IN TREATMENT OF TEXTILE MILL WASTE WATER

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ABSTRACT: *Wastewater generated by the textile industry is rated as the most polluting among all industrial sectors considering both quality and quantity. The pollution load is mainly due to spent dye baths, which consist of unreacted dyes, dispersing agents, surfactants, salts, and organics. Dyes are formulated to produce colors that must be resistant to oxidizing and reducing agents, washing, and light exposure. This characteristic of dyes makes them highly resistant to treatment operations.Electro-coagulation proves to be a innovative technology in treatment of wastewater from Textile mills. Electro-coagulation is a complex process with many mechanisms acting simultaneously to remove pollutants.*

Keywords : Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Textile, Dye, Wastewater, Electro coagulation

1. INTRODUCTION

The wastewater which is outcome of dyeing and washing processes from textile industries are of special concern, due to their high volumes and wide range of chemicals used in the corresponding processes. It is estimated that about 15% dye is lost unused in wastewater. Currently there are more than 10,000 varieties of dye and pigments used in dyeing and printing processes. The effluent released from dyeing and printing processes contains mainly strong colourants, inorganic salts and toxic compounds. Dyes are made to produce colours which should be resistant to resistant to oxidizing and reducing agents, washing process, and light exposure. This property of dyes makes the wastewater highly inert in conventional treatment methods (Ehud N. Lesham, David Pines, Sarina Ergas,, March 2006). Dyes often receive the largest attention due to their colour and toxicity which is inherited by raw material used in synthesis of dyes as certain aromatic amines. The dye concentrations in effluents is usually lower than any other chemical found in the wastewater, but due to their colouring property they are visible at very low concentrations, thus causing serious aesthetic problem in wastewater disposal.Dyes in the wastewater undergo chemical as well as biological changes, consume dissolved oxygen from receiving stream and destroy aquatic life because of their toxicity (Ahmed, M.N., Ram, R.N., 1992). It is therefore necessary to treat the wastewater before discharge.

A study on different measures which can be adopted to treat the waste water discharged from textile chemical processing industries to protect and safeguard our surroundings from possible pollution problem has been the focus point of many recent investigations(T. Robinson, B. Chandran, P. Nigam, 2002).Various treatment which are proposed to treat effluent from Textile mills other than conventional treatments. In ozonation the molecular ozone reacts with dye molecules through indirect oxidation, decomposing in aqueous solution to form radical species having very strong oxidation potential. In electrochemical oxidation anodic electrolysis of water results in formation of hydroxyl radicals that get adsorbed onto active site of electrode. Dye molecules get oxidized by these adsorbed hydroxyl radicals. Whereas anaerobic biological treatment deals with decomposition of waste constituents in absence of molecular oxygen with the help of anaerobic bacteria for specified retention time.In granular activated carbon (GAC) adsorption, the wastewater is passed through column of GAC to reduce colour producing elements and other pollutants. Traditional coagulants as Ferric sulfate mixed with wastewater and after rapid mixing, settling is allowed. The polluting constituents get trapped and thus removed in settling operation.

The problems associated with above methods are as for ozonation treatment, the difficulty is in continuous production of ozone and ensuring its virgin action without separating into oxygen molecule. Textile wastewater, not having much organic content is difficult to treat by bacterial action. Also these biodegradation systems are ineffective against shock loading. The GAC adsorption method is superior in rest of all, but proves costly due to high cost of GAC and it's reactivation process. In recent years, special attention is being given to industrial wastewater treatment (Ehud N. Lesham, David Pines, Sarina Ergas,, March 2006)as the effluent discharge norms are becoming more and more stringent.

2. LITERATURE REVIEW

An extensive research has been done by many researchers in treating textile and dye wastewaters by using various technologies.

2.1 Coagulation

Conventional chemical treatment consists of electrolyte addition to cause coagulation of dyes and other colloidal solids, followed by precipitation. Partial decolourisation is visible and COD reduction reduces due to suspended solids removal(Tzitzi M, Vayenas DV, Lyberatos G, 1994)(Grau, 1991)observed 40-50% reduction in BOD, 35-40% reduction in COD and of colour as 80%. In decolourisation by coagulation/flocculation techniques using ferrous sulfate and/or lime,lime removed colour by 70-90% and COD reduction by 50-60%(Georgiou, May 2003). Moreover, the treatment with ferrous sulfate regulating the pH in the range 9.0±0.5 using lime was equally effective. Tropical peat soil is used as coagulantby (Uddin, 2003)concluding that Alum, PAC and peat soil have 100% color reduction capacity from dispersed dyes , but only peat soil can remove colour from reactive dyes till 94% at 3-5 pH range with 98% reduction in suspended soilids.Gordanaet. al.(Gordana, Aleksandra BUŽAROVSKA, Bojan DIMZOSKI,, 2008) used polyaluminum chloride for decolurisation of direct dye, CuprophenilBlau 3 GL, and achieved 100% efficiency at 7.1 pH and 15mg/L concentration of aluminum.

2.2 Enhanced Coagulation

Recently enhancing coagulation by addition of natural organic matter NOM is being studied. Although action dependent on pH. Ferric coagulants removed NOM in 4-5 pH range for aluminum coagulants desirable range of pH is 5 to 6.(Graham, 1996). Kimet. al.(KIM TAK-HYUN, PARKA CHULHWAN and LEE JINWON, 2002)combined the electrochemical process with fluidized biofilm process and chemical coagulation for the treatment of textile wastewater. In the pilot scale study, fluidized biofilm process was used prior to chemical coagulation and electrochemical oxidation processes. Effective COD and color removals of 95.4 % and 98.5 % were achieved by overall combined processes. PADMAVATHY et. al.(PADMAVATHY, 2003)report degradation of azo dyes by cosubstrates as glucose, starch, lactose, sewage and whey water and colour reduction. The results are starch was the best source of carbon for decolorization of reactive azo dyes. In presence of 250 mg/L of starch, all the reactive dyes decolorized within 24 hours with the reduction in COD in therange of 75.15–95.9%.

2.3 Adsorption

Colour removal can be done adsorption using GAC in packed bed or PAC. PAC with dose of 100 mg/L dose can provide 90% color removal.(Tozer, 1994.)Darus et al. (Darus, 2008-09)treated disperse dye Begacron Blue by palm ash as adsorbent. Study shows it can be cheap replacement for commercial activated carbon to get effective colour removal of 59.44% at pH 4 with contact time 120 minute. The data fits both Langmuir and Freundlich isotherms. Jong and park (Jong Chul and Park,, 2005)studied adsorption of acid dyes on specially prepared silica to get complete removal.

2.4 Chemical oxidation

Chlorine rapidly oxidizes azo dyes. After a dose of 100-160 mg/L, the samples were colourless in approximately 60 minutes. As per the absorbance test 95% colour reduction is achieved.Tunayet. al.(Tunay O., Kabdasli I., Eremektar G., Orhon, D., 1996). By using hydrogen peroxide the colour reduction is nearly zero at neutral pH, however at pH 12 and retention 24 hours significant colour reduction is achieved.(Tunay O., Kabdasli I., Eremektar G., Orhon, D., 1996).Konsowa, studied decolorization of wastewater containing direct dye (Isma Fast Red 8B) by ozone aeration. They found that decolourization time is proportional with dye concentrations with lesser time in alkaline solutions(Konsowa, A.H., 2003).Jessica Edwards(Jessica Edwards,, 2000) investigated textile wastewater treatment of red and blue dye solutions (colour ADMI 300 units) with by different methods as ClO_2, UV treatment, UV with ClO_2 and UV with hydrogen peroxide. The reduction in colour till 300 ADMI units is achieved by any method but most effective was UV with 5mg/L ClO_2. Use of ClO_2 was alternate choice but at cost of dose of 30mg/L.

2.5 Biological Methods

Studies show that dyes are slightly biodegradable, as they are designed to surpass action of body fluids. (Hitz, 1978). Joanne and Chris (Joanne Bell, Chris A Buckley, April 2003)treated textile wastewater in anaerobic baffled reactor to get COD reduction above 90% and colour reduction of 86%. It is assumed that colour reduction is due to adsorption on biomass.The sludge acclimatized to dyes is found to give better colour removal (Tunay O., Kabdasli I., Eremektar G., Orhon, D., 1996). Pisczek et al.(Pisczek, 2000) studied anoxic/aerobic treatment on reactive azo dyes and found that the rate of COD removal under aerobic conditions was twice the rate under anoxic conditions. The percent COD removal by the anoxic/aerobic process was 95% vs. 97% removal by the aerobic control. The percent color removal by the anoxic phase was five times the removal by the aerobic phase. Sharma et al.(Sharma, Feb-2008) studied degradation of textile azo dye Orange II by white rot fungus. Optimum decolourisation was observed on 5thday at 28-30°C and 5.0pH.

2.6Innovative Methods

Mahmoud et al. (Mahmoud, 2007)used various plant oils to remove dyes form textile wastewater. The results showed that the optimum conditions for the dye removal for various oils were at a pH of 13 and a temperature of 55°C. Colour removal efficiency for used cooking oil, olive oil was 95.45% and 87% respectively. Cottonseed, canola and sunflower oils achieved dye removal efficiencies below 58% hence were not recommended.Abuzaid et al.,(Abuzaid, N.S. Bukhari, A.A. Al-Hamouz, Z.M, 1998)had studied nitrite removal from aqueous solution by electrochemical process using stainless steel electrodes. Complete removal of nitrite was achieved at 2 A after a duration of ten minutes, when treating a total sample of 4.4 liter using six electrodes of 50 cm2 each. The study also dealt with the effect of various parameters like current input, volume of the solution, initial pH, and number of electrodes on removal of nitrite at a concentration. In addition to that a first order reaction model was developed to predict the effect of current on nitrite removal. Bandara et al. (Bandara, 2007)carried out electrochemical oxidation of textile dyes such as Eosin Y and Orange II by indium tin oxide (ITO) coated glass anode in the presence of KCl solution at pH 4.0 and 6.0. Eosin dye solution with a concentration of 5.0×10^{-2} mM is totally decolorized in 30 min at an electrical charge (Q) 0.067Ahm−3 while 5.0×10^{-2} mM Orange II degraded in a little less than an hour. Electrochemical degradation results show significant decrease in COD after electro degradation of textile dyes. The key advantage of the ITO conducting glass anode is that the deposition of polymeric materials on the anode surface during electro-degradation of textile dyes is absent and therefore the electrode fouling is not observed. Hence, the ITO anodes can be employed an extended period without loss of activity.Raghu et al.(Raghu S, CA Basha, 2007)treated procion black 5B (Remazol Reactive Black 5) using Ti/RuO2 as anode, stainless-steel as cathode in a cylindrical flow reactor. COD reduction was found to be 74.05% and colour removal was nearly 100% at 2.5 A/m2 for flow rate of 10L/h, respectively.Duran et al. (Duran, A., 2008) studied treatment of reactive blue 4 solution by photo-fenton process using a compound parabolic collector (CPC). Under the optimum conditions, ([H2O2] = 120 ppm, [Fe(II)] = 7 ppm, [(COOH)2] = 10 ppm, pH 2.5), color and COD were completely removed whereas TOC was reduced up to 66%.Kasaikin et al. (V A Kasaikin, J A Zakharova,, 2002)studied application of complexes of linear polyelectrolyte with oppositely charged surfactants as the main agents. This technique provides removal dyes up to 95% purification, 60 % reduction in COD and reduced content of toxic organic pollutants in wastewater.Cheimaand Fersi(Fersi, Cheima, 2005)proposed that membrane based separation technique can show 90% removal percentage for colour, turbidity and TDS.

3. DISUSSION

Various treatment methods although successful in treatment of textile mill/dye stuff industries but have faced with limitations.

Conventional physico-chemical treatment methods are not highly effective in the removal of colour, TSS, BOD and COD. Further, Treatment using physicochemical method produces more sludge, involves high cost and lower efficiency.(Raghu S, CA Basha, 2007).Although chlorine reduces colour, BOD and COD, but dissolved chlorine forms chloro-organic compounds which are carcinogenic. Also chlorine storage poses risks in operations due to chances of accidental release.The ozonation systems are highly advantageous over chlorine use. But system has to be tuned in for optimum performance. Ozone production and transportation needs special techniques as it decomposes into oxygen at rapid rate.Presence of trace elements which are normally found in the textile waste water like Cu, Zn, Fe and higher levels of TSS hampers the UV-Ozonation process.

The biological treatment methods had faced difficulties.The dyes and pigments used in textile industry are designed to be resistant to action of body fluids, weathering, and typically which makes them resistant to bio-degradation or take considerably longer time for action.High TDS can retard microbial growth, which in turn hampers efficiency.Due low BOD in textile effluents, conventional biological plant can not perform better i.e. low F/M ratio.The biodegradability of different dyes are different and are used at varying concentrates as per production needs of cloth. So the discharge load has fluctuating BOD and COD levels. Conventional biological treatment plant cannot withstand shock loads. So they are not able to give stable output.Compared with MBR, sludge production is higher in conventional plants, arising need of more area for secure land fill.To enhance breeding of bio-film and avoid fouling, various chemical have to be added which increases operating costs.

Although adsorption by PAC produced good results, but processing and disposalof sludge will be a problem. The cost of PAC powdered activated carbon is higher. The dosage requirements are high, raising the operational costs.Many innovative techniques are successful at pilot plant but failed to perform at actual cases. Many need higher cost for production or operations.

A typical electrocoagulation treatment process consists of two electrodes which act as anode and cathode. The electrodes are connected to power source and system is immersed in the aqueous solution. The current is allowed to passthrough the solution from electrodes. Simply, an electrolytic cell consists of two electrodes, anode and cathode, immersed in an electrical conducting solution (the electrolyte), and are connected together, external to the solution, via an electrical circuit which includes a current source and control device.

Electrocoagulation technology offers an alternative to conventional coagulation process, where the metal salts or polymers are added to break the stable suspensions of the colloidal particles. In electrocoagulation, coagulants are produced in-situ within the reactor without addition of any chemicals. Coagulants are produced by the electrolytic oxidation of appropriate anode materials, such as stainless steel and aluminum electrodes, which result in formation of highly charged metal hydroxyl species. These species neutralize the electrostatic charges on the suspended solids and facilitate agglomeration resulting in separation from the aqueous phase. The technologyremoves metals, colloids particles, and soluble organics pollutants from aqueous media by introducing highly charged polymeric hydroxide species. The treatment prompts the precipitation of certain metals and salts(Mohammad Y.A. Moolah, 2004).

4.1.3 Advantages of electrocoagulation technique:

The various advantages of electrocoagulation process, compared to the traditional conventional coagulation process, have been reported by Mollah et al.(Mollah, Schennach, Parga J. P., Cocke, 2001). Process avoids the use of chemicals, and there is no problem of neutralizing excess chemicals.The equipment required for Electro coagulation process is simple and compact and is easy to operate and handle the problems encountered during running. Simple and compact treatment facility results in relatively low cost and there is a possibility of complete automation.Electro coagulation process has the advantage of removing the smallest colloidal particles because the applied electric field sets them in faster motion thereby facilitating the agglomeration. It is a low sludge producing process, and the sludge formed during the process tends to be readily settable and easy to dewater, as it is mainly composed of metallic oxides/hydroxides. The flocks formed during the electro coagulation process tend to be much larger, more stable; therefore can be separated by filtration. Electro coagulation effluent can be reused with a lower water recovery cost, due to the low dissolved solids content as compared with other chemical treatment effluent. The gas bubbles produced during electrolysis can carry the pollutant on the top of the solution where it can be more easily concentrated, collected, and removed. The process has no moving parts and most of the process is controlled electrically, therefore requires less maintenance. The electrocoagulation technique can be conveniently used in rural areas where electricity is not available, as alternative power generated from solar panels can be used as power source.

4. CONCLUSION

India has set up Industry wise minimal national standards (MINAS) for output from treatment plants. To satisfy these standards the alternative treatment methods have been proposed. The electrocoagulation method shows promising aspects. The electrocoagulation treatment provides complete colour reduction in all treatment conditions while varying the current and voltage applied along with increasing the area of electrodes.This method will prove better alternative than the conventional systems.

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