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Tertiary Treatment for Textile Waste Water-A Review

Manali Desai[*1], Mehali Mehta[2]

[*1] Student, M.E Environmental Engineering, Sarvajanik College of Engineering & Technology, Gujarat, India

[2]Assistant Professor, Civil Engineering Department, Sarvajanik College of Engineering & Technology, Gujarat

desaimanalib1991@gmail.com

Abstract

Tertiary treatment is the Industrial waste water treatment process which removes stubborn contaminants that have not been removed in secondary treatment. Effluent becomes even cleaner by Tertiary treatment through the use of stronger and more advanced treatment systems.

The present work is an attempt to review all possible tertiary treatment methods for removal of dyestuff from textile effluent. Conventional method for treatment of textile effluent has own certain limitations that can be well overcome by tertiary waste water treatment.

Keywords: textile waste water, tertiary treatment, adsorption, ozonation, electrochemical, ultra filtration.

Introduction

Water resources which can be utilized are not infinite and hence have to be protected in order to preserve the public health and lives of the population. Considering the above, the discharge standards for wastewater effluents have been increasingly strengthened to reduce contaminants released into the water environment. Thus there has been an increasing emphasis and endeavour for reduction of total solids (TS) and their subsequent reuse for industrial applications. A high quality of treated wastewater reduces negative impacts on inland waterways, and thus widens the range of possible reuse options [34].

Now a day, Dye effluents are responsible for major environment concern in wastewater treatment. Textile industries consume huge amount of water and it create remarkable amount of wastewater which contain unconsumed dyes and its constituents [2]. Textile industry generates highly polluting wastewater which contains dyes and their decomposition is creating very serious problem to wastewater treatment plant. High colour, TDS, toxic metals are present in textile effluents which have been responsible for decrease the capacity of self degradation of pollutants in wastewater [3].Many methods are used for removal of dye by conventional methods including chemical oxidation, coagulation and adsorption process, biological process but they cannot be individually enough to remove dye from wastewater. For example, biological process is not suitable for decolourization of dyes because of most of the dye are in inorganic and toxic in nature to microorganism used in process. Coagulation technique is more suitable for insoluble dyes but not for soluble dyes, whereas activated carbon is only effective for soluble dyes. Most of the dyes particularly reactive dyes cause highly environment problem due to their decomposition products [4]. Degradation of dyes from textile effluent is very tricky because of complex structure and recalcitrant nature of dyes [1, 5].

Tertiary Treatment used for Treatment of Textile Waste Water

In the study of this paper we have covered different tertiary treatment used to treat textile waste water.

Characteristics of textile wastewater

Textile waste water contains natural impurities and chemicals used in the manufacturing process [11]. Characteristics of textile wastewater vary from plant to plant depending upon the processes used. The main parameters that characterize the textile wastewater are Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Suspended Solids (SS), Dissolved Solids (DS), pH, Chloride, Sodium, etc [12].

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Table 1: typical characteristics of textile wastewater

Sr No.	Parameters	Range
1	pH	6.0-10.0
2	Temperature	35-45°C
3	Biochemical oxygen demand (mg/l)	100-4,000
4	chemical oxygen demand (mg/l)	150-10,000
5	Total suspended solids (mg/l)	100-5,000
6	Total dissolved solids (mg/l)	1,000-6,000
7	chloride (mg/l)	1,000-6,000
8	Total alkalinity (mg/l)	500-800
9	Sodium (mg/l)	610-2,175
10	Total Kjeldahl nitrogen (mg/l)	70-80
11	Colour (Pt-Co)	50-2500

* Source [13-19]

Different Tertiary treatments applied to Textile waste water

Application of cationic surfactants (CS) in various fields like fabric softening, textile industry, road construction, disinfectants, biocides, emulsifiers, wetting agents, processing additives, mining, hair conditioning, cosmetics, etc. results to its massive discharge into the environment leading to an environmental concern. To protect public health, elimination of CS from wastewater has thus become very important. The reduction of these contaminants has received considerable attention during the last few decades. Common technologies that reduce the CS from water environment include ozonation or advanced oxidation process [29], adsorption and biological process [31-33].

Suman Koner and other find the use of Silica gel waste (SGW) as an adsorbent for adsorption of cationic surfactant and adsolubilization of organics from textile wastewater. It was found to be a very attractive alternative for removal of Cationic surfactant (CS) from industrial (textile) wastewater.

Sr No.	Parameters	Units	Values
1	Cationic surfactant	mg/l	362.0
2	Ph	-	9.2±0.1
3	Chloride	mg/l as Cl^-	325.0
4	Sulphate	mg/l as SO_4^{-2}	124.0
5	Total hardness	mg/l as $CaCO_3$	Not detected
6	Total dissolved solids	mg/l	720.0
7	COD	mg/l	1845.0
8	Colour	Pt-Co scale	610.0
9	Conductivity	µSiemens/cm	1220.0

*source [6]

Characteristics of actual textile waste water are as shown in table. In this work, the actual textile wastewater containing 362 mg/lit CS was treated by SGW in both batch and continuous modes. In batch mode, the optimum adsorbent dose and equilibrium time were found to be 10 gm/lit and 30 min respectively. Under optimized conditions, high removal efficiency of CS was achieved (~87%) by them and subsequent solubilization of other organic pollutants was found to occur through adsolubilization. The adsorption has followed the Freundlich isotherm model. The breakthrough and exhaust times were found to be 6.5 and 13 hr respectively for a column of depth 50 mm, maintaining the loading rate at 1.22 m^3/m^2/hr. The value of adsorption rate coefficient (^oK) and adsorption capacity coefficient (N) were obtained as 0.00149l/mg*hr and 88849 mg/lit respectively. Regeneration of SGW after its exhaustion was efficiently done using 18% HCL (Hydrochloric acid). The use of a solid waste as an adsorbent for removal of cationic surfactant and subsequent adsolubilization of organics made the process very cost effective alternative for textile wastewater treatment [6].

Effluent discharge from textile industries to neighbouring water bodies and wastewater treatment systems is currently causing significant health concerns to environmental regulatory agencies [30]. Esawy Kasem Mahmoued has performed some experiment on laboratory scale to test the efficiency of Cement kiln dust (CKD) and CKD + Coal filters in removing a colour, turbidity, and organic substances (BOD and COD) and heavy metals from textile wastewater. Cement kiln dust (CKD) is an alkaline waste material and its main components are calcium carbonate of 47.6%; oxides of aluminum of 4.2%; iron of 2.8% and magnesium of 2.3%; free lime of 4.8% and some alkali salts such as sodium and potassium. Its specific gravity was 2.92 and specific surface area 4440 cm2/g [7]. The results reveal that

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(CKD+Coal) filter could remove about 81–87% of COD and 100% of colour. Seed germination of treated water by CKD+Coal filter was higher than CKD filter. The higher efficiency of CKD+Coal than CKD filters for COD and colour removal of textile wastewater at hydraulic loading of 1.0 m3/m2 h. CKD+Coal filter could remove about 97% of colour, 76% of turbidity, 84% of COD, 77% of BOD and 94% of PO_4^{-3} from raw textile wastewater and it's increased in seed germination of cress (Lepidium sativum) to 100%. The experimental results confirmed that CKD+Coal filter can be adopted as a decolorization and heavy metals of textile industrial effluents [7].

The demand of textile products have increased dramatically and it caused proportional increase in textile industry and its wastewaters in India. Membranes are the excellent medium of separation without addition of mass separating agent (adsorption) or energy separating agent (distillation) [21]. In this study, the generated waste water effluents in textile industry are derived from wet processing of textiles. Modified poly(vinylidene fluoride) (PVDF) ultra filtration (UF) membranes were studied as a pre-treatment for the reuse of secondary effluent of textile wastewaters by Harsha P. Srivastava, G. Arthanareeswaran, N. Anantharaman, and Victor M. Starov. The treatment of reactive black 5 (RB5) and congo red (CR) dye solutions was investigated using modified PVDF and styrene-acrylonitrile (SAN) membranes. SAN composition in PVDF membrane was varied in 00:100, 10:90, and 20:80, 60:40 and 100: 00 ratios in the presence of DMF as the solvent. Effect of SAN on characteristics of PVDF membranes such as morphology, water uptake, porosity, average pore size, pure water permeability (PWP) and hydrophilicity was investigated. The morphological studies showed that the 60% of SAN content in 40% PVDF results in formation of a structure with a porous top and sub-layer with a number of pores. The pure water flux of membranes increased with an increase in SAN concentration. Conversely, the permeate flux of RB5 and CR dye solutions increased while dye rejection decreased with incorporation of SAN content in PVDF polymer matrix. Furthermore, all modified PVDF membranes showed moderate color removal, chemical oxygen demand (COD) reduction and lower membrane fouling for separation and purification of dye solutions [8].

Colored wastewater damages the esthetic nature of water and reduces light penetration through the water's surface, and also the photosynthetic activity of aquatic organisms. Textile wastewaters containing toxic and potential carcinogenic substances must be adequately treated before they can discharge into receiving water bodies [20]. Ozone is very effective in decolorizing textile effluents. The decomposition rate of ozone is affected by pH and initial dye concentration. At basic pH, ozone rapidly decomposes to yield the hydroxyl radical and other radical species in solution. Under acidic conditions, ozone can directly react with organic substrates as an electrophile [9]. In this study, Kadir Turhan, Ilknur Durukan, S. Arda Ozturkcan, and Zuhal Turgut investigated the factors affecting the rate of chemical oxygen demand (COD) of a synthetic waste solution containing a water soluble basic dye [Methylene Blue]. Decolorization of the dye was achieved by ozonation. The research was conducted using a batch bubble column to take the advantage of the intensive back-mixing that prevails in bubble columns. As a result, the COD of basic dyestuff wastewater was reduced to 64.96% and decolorization was observed under basic conditions (optimum pH 12), complete MB degradation occurring in 12 min. The reduction of the absorbance of the direct dyestuff wastewater was 94.56% after 28 min of reaction. The COD of direct dyestuff wastewater was reduced from 1136 mg/l to 398 mg/L when the pH was set to 12.0. Ozone consumption continued for a further 16 min after which time most of the degradation reactions were complete [9].

Electrochemical technology has been applied to effectively remove acids, as well as dispersed and metal complex dyes. The removal of dyes from aqueous solutions results from adsorption and degradation of the dye-stuff following interaction with iron electrodes [22]. If metal complex dyes are present, dye solubility and charge are important factors that determine the successful removal of heavy metals. In order to maximize dye insolubility, pH control is crucial [23-25]. Conventional methods involve generation of secondary pollutants (sludge), but sludge formation is absent in the electrochemical method [26]. In this process, the recovery of metals or chemicals is easily carried out. At the same time, the following environmental advantages are realized; emission of gases, solid waste, and liquid effluent are minimized [27, 28]. The advantage of this process seems to be its capacity for adaptation to different volumes and pollution loads. Its main disadvantage is that it generates iron hydroxide sludge (from the iron electrodes in the cell), which limits its use. Electro-coagulation has been successfully used to treat textile industrial wastewaters. The goal is to form flocs of metal hydroxides within the effluent to be cleaned by electro-dissolution of soluble anodes. Three main processes occur during electro-coagulation;

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electrolytic reactions at the electrodes; formation of coagulants in the aqueous phase and adsorption of soluble or colloidal pollutants on coagulants; and removal by sedimentation and floatation. Electro-coagulation is an efficient process, even at high pH, for the removal of color and total organic carbon. The efficiency of the process is strongly influenced by the current density and duration of the reaction. Under optimal conditions, decolorization yields between 90 and 95%, and COD removal between 30 and 36% can be achieved [22].

Comparative Study

Sr. No.	Method adopted as Tertiary treatment	Advantage
1	Use of Silica gel waste as an adsorbent for removal of Cationic surfactant (CS)	• High removal efficiency of CS was achieved (~87%) by use of silica gel waste as an adsorbent • Suspended solids and organic substances well reduced. • Cost effective alternative for textile waste water as it would reduce the use of raw adsorbent to a greater extent
2	Use of Cement kiln dust (CKD) and CKD + Coal filters for removal of a colour, turbidity, and organic substances (BOD and COD) and heavy metals from textile wastewater.	• CKD+Coal filter could remove about 97% of colour, 76% of turbidity, 84% of COD, 77% of BOD and 94% of PO_4^{-3}. • By this treatment seed germination of cress (Lepidium sativum) is increased upto 100%.
3	Use of Modified poly(vinylidene fluoride) (PVDF) ultrafiltration (UF) membranes as a pre-treatment for the reuse of secondary effluent	• permeate flux of RB5 and CR dye solutions was increased. • It showed moderate color removal, chemical oxygen demand (COD) reduction and lower membrane fouling for separation and purification of dye solutions
4	Ozonation as a tertiary treatment for color removal of textile waste	• COD of basic dye stuff was removed up to 64.96% • The reduction of the absorbance of the direct dyestuff wastewater was 94.56% after 28 min of reaction.
5	Electrochemical technology	• Emission of gases, solid waste, and liquid effluent are minimized. • decolorization yields between 90 and 95%, and COD removal between 30 and 36% can be achieved.

Conclusion

Textile wastewater treatment, before discharging, is of great importance in decreasing pollution load and production costs. This article provides a critical review on the current technologies available for the treatment of textile effluents and it suggests effective and economically attractive alternatives. There are different techniques available for reducing the different parameters like color, COD, BOD, organic substance and Suspended solids. As an example, efficiency of the electrochemical system in pollutant removal can often reach 90%. However, the process is expensive due to large energy requirements, limited life time of the electrode and uncontrolled radical reactions.

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