Textile Effluent Treatment- An Ecofriendly Approach

By:

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Research scholar, Dept.of Textiles and Clothing,

Avinashilingam University for Women, Coimbatore

Abstract

The textile processing mills consumes large volumes of water for various processes such as sizing, desizing, scouring, bleaching, mercerization, dyeing, printing, finishing and washing. Due to various chemical processing of textiles, large volumes of waste water with numerous pollutants are discharged. Among the processing industries textile dyeing units produced large volumes of high strength wastes.

The control of water pollution has become of increasing importance in recent years. The release of dyes into the environment constitutes only a small proportion of water pollution, but dyes are visible in small quantities due to their brilliance. Tightening government legislation is forcing textile industries to treat their waste effluent to an increasingly high standard. Currently, removal of dyes from effluents is by some physical and chemical methods such as adsorption, membrane filtration, photocatalytic degradation and ozonation are quite effective in decolorization of dyes. Such methods are often very costly and although the dyes are removed, accumulation of concentrated sludge creates a disposal problem. There is a need to find alternative treatments that are effective in removing dyes from large volumes of effluents and are low in cost, such as biological systems. This paper reviews the current available technologies and suggests several effective, cheaper alternatives for dye removal and decolourisation applicable on large scale.

Introduction

Economy and ecology have been the driving force in modern technology and therefore attempts are made to produce textiles more efficiently, with less water and less pollution. A society is now becoming more conscious of the needs to ensure that the environment is lease affected. Environment considerations are now becoming vital factors during the selection of consumer goods including textiles all over the world. However due to increased awareness of the polluting nature of textiles effluents social pressures are increasing on textile processing units.

In textile dyeing as well as other industrial applications, large amounts of dyestuffs are used. As a characteristic of the textile processing industry, a wide range of structurally diverse dyes can be used in a single factory, and therefore effluents from the industry are extremely variable in composition, strength and volume. This underlines the need for a largely unspecific process for treating textile waster water. It is known that 90% of reactive dyes entering activated sludge sewage treatment plants will through unchanged and be discharged in to rivers.

Of all the waste, color is the first contaminant to be recognized because of its visibility to human eye. The discharge of highly colored water is not only aesthetically displeasing, but also interferes with the transmission of light. This upsets the biological processes and the productivity in the receiving streams. In addition, many colorants are harmful to certain organisms and may cause direct destruction of aquatic communities. Color hinders the penetration of sunlight which is very much essential for the photosynthesis by marine plants. Even the discharge of highly colored waste water from city sewer has its damaging effect. From environmental protection point of view, color removal becomes an integral part of textile effluent treatment prior to its discharge to the environment for reuse. During the past two decades, several physico-chemical decolorization techniques have been reported, few, however, have been accepted by the textile industries. Their lack of implementation has been largely due to high cost, low efficiency and inapplicability to a wide variety of dyes. The ability of microorganisms to carry out dye decolorization has received much attention. Microbial decolorization and degradation of dyes is seen as a cost-effective method for removing these pollutants from the environment.

Effluent Generation Process

Effluent is generated under various processes during textile wet processing. These major processes include

i) Bleaching;

ii) Neutralizing;

iii) Washing;

iv) Dyeing;

v) Acid wash;

vi) Soaping;

vii) Hot wash;

viii) Fixing and softening.

The list of chemicals used in bleaching and dyeing are presented in Table-1.1 and Table-1.2

Table-1.1: List of chemicals used in bleaching

Chemical	**Utilization (per 100 kg of cloth)**	
	Soft flow machine	**Winch**
Wetting agent	0.5 kg	0.5 kg
Caustic soda	2.5 kg	4.0 kg
Peroxide	3.0 kg	4.0 kg
Lubricants	0.2 kg	0.3 kg
Stabilizers	0.2 kg	0.3 kg
Peroxide killer (oxidizing agent)	1.0 kg	1.0 kg
Acetic acid	2.0 kg	2.0 kg

Table-1.2: List of chemicals used in dyeing

Chemical	Utilization (per 100 kg of cloth)	
	Soft flow machine	**Winch**
Lubricants	0.3 kg	0.4 kg
Sequestering agent	0.6 kg	1 kg
Dye stuff	150 g for light shade 1.5 kg for medium shade 10 kg for dark shade	150 g for light shade 1.5 kg for medium shade 10 kg for dark shade
Soda ash	light shade- 6 g/L medium shade- 11 g/L dark shade- 20 g/L	light shade- 6 g/L medium shade- 11 g/L dark shade- 20 g/L
Sodium chloride	light shade- 15 g/L medium shade-45 g/L dark shade-90 g/L	light shade- 15 g/L medium shade-45 g/L dark shade-90 g/L
Acetic acid	2.5 kg	3.0 kg
Soap	1.0 kg	1.0 kg
fixing	1.0 kg	1.0 kg
softener	2.0 kg	2.0 kg

The selection of dye by dyeing units shall depend upon the type of fibres being dyed, desired shade, dyeing uniformity and fastness (stability or resistance of colourants to influences such as, light, alkali, etc.). Reactive dyes are normally used by most of the members while disperse and direct dyes are also used sometimes. Sulphur and Vat dyes are only rarely utilized. Some of the brand names of the dyes being used by the dyeing units are given here:

1) Procion dyes.
2) Remazol dyes.
3) Drimarene dyes.
4) Solophynyl dyes.

For 100 kg of cloth, the volume of water added in the dye bath shall be 800 L in the case of soft-flow machines, and 1500 L in the case of winch. The main pollutants generated by bleaching includes chlorinated organics, BOD, COD, oxidizing agents, alkali and acids. Dyeing process generate many pollutants viz., salts, surfactants, levellers, lubricants, alkali, volatile organics, cleaning solvents, stabilizers, catalysts, grease resisting agents, exhausting agents, soaping agents, softeners etc., apart from the unfixed dye in the bath, which is let out after dyeing operation is over. The typical raw effluent characteristics of textile waste water are presented in Table-1.3.

Table-1.3: Typical raw effluent characteristics of the textile waste water

Parameter	Range
P^H	6- 10
Temperature	35- 45° C
Total dissolved solids	8,000- 12,000 mg/L
BOD	300- 500 mg/L
COD	1000- 1500 mg/L
Total suspended solids	200- 400 mg/L
Chloride	3000- 6000 mg/L
Free chlorine	< 10 mg/L
Sodium	70 %
Trace elements ligands (Fe, Zn, Cu, As, Ni, B, F, Mn, V, Hg, PO_4, CN)	< 10 mg/L
Oil & grease	10- 30 mg/L
TNK (as - N)	10- 30 mg/L
No_3 –N	< 5 mg/L
Free ammonia	< 10 mg/L
So_4	600- 1000 mg/L
Silica	< 10 mg/L

With due considerations to the raw effluent characteristics given in Table-1.3, the above parameters require much attention with regard to implementing a good waste water treatment scheme.

Effluent Treatment Method

Biological treatments have been used to reduce the COD of textile effluents. Physical and chemical treatments are effective for colour removal but use more energy and chemicals than biological processes. They also concentrate the pollution into solid or liquid side streams that require additional treatments or disposal, on the contrary biological processes completely mineralize pollutants. Instead of using the chemical treatments, various biological methods can be used to treat the water from the textile industry. Recently, dye decolourization through biological means has gained momentum as these are cheap and can be applied to wide range of dyes. These methods include, biosorption, use of Enzymes, Aerobic and anaerobic treatments etc. Only biotechnological solutions can offer complete destruction of the dyestuff, with a co-reduction in BOD and COD. In addition, the biotechnological approach makes efficient use of the limited development space available in many traditional dye house sites.

Bioadsorption

Adsorption has been found to be superior to other techniques for dye waste water treatment in terms of cost, simplicity of design, ease of operation and insensitivity to toxic substances. A low cost adsorbent is defined as one which is abundant in nature, or is a by – product or waste material from another industry.

Now-a-days, several agricultural residues and organic wastes are used as natural adsorbents such as powdered peanut hull, sugarcane dust, apple pomace, wheat straw, tree fern, coir pith, neem saw dust, raw date pits, banana peel, wood, rice husk, cotton waste, bark, and various other materials such as coal, fly ash, silica gel, etc., to remove dyes and heavy metals in effluent streams. These materials are widely used because of its easy availability, potentiality towards adsorption and its low cost.

Uses of Enzymes

Enzymes represent an attractive option for waste water treatment for numerous reasons, which include their bio-compatibility as well as the ease and simplicity of process control. Most of the work related to lignolytic enzymes and decolorization of dyes has been concentrated on selected white rot bacidomycetes.Laccase enzyme offers an attractive solution because of its potential to degrade wide spectrum dyes having diverse chemical structure.

The use of lignin degrading white-rot fungi has attracted increasing scientific attention as these organisms are able to degrade a wide range of recalcitrant organic compounds such as polycyclic aromatic hydrocarbons, chlorophenol, and various azo, heterocyclic and polymeric dyes. The major enzymes associated with the lignin degradation are laccase, lignin peroxidase, and manganese peroxidase. The lacasses are the multicopper enzymes which catalyzes the oxidation of phenolic and non-phenolic compounds. The following fungi have been used for laccase production and for the decolorization of synthetic dyes. Trametes modesta, Trametes versicolor, Trametes hirsuta and Sclerotium rolfsii. It can be concluded that the structure of the dye as well as the enzymes play major role in the decolorization of dyes and it is evident that the laccase of Trametes modesta, may be used for decolorization of textile dyestuffs, effluent treatments, and bioremediation or as a bleaching agent.

Aerobic and Anaerobic Treatments

The synthetic dyes are designed in such a way that they become resistant to microbial degradation under the aerobic conditions. Also the water solubility and the high molecular weight inhibit the permeation through biological cell membranes. Anaerobic processes convert the organic contaminants principally occupy less space; treat wastes containing up to 30,000 mg/l of COD, have lower running costs and produce less sludge. Azo dyes are susceptible to anaerobic biodegradation but reduction of azo compounds can result in odor problems. Biological systems, such as biofilters and bioscrubbers, are now available for the removal of odor and other volatile compounds.

Use of Microorganisms in Decolorization

Microbial degradation and decolorization of dyes is an environment friendly and cost competitive alternative to chemical decomposition process. The bacterial isolate *Psedomonas aeruginosa* was capable of decolorizing 12 different dyes with varying decolorization efficiency. Dye degradation using isolated *Pseudomonas* species as biocatalysts has shown that biological and combination treatment can offer a low cost alternative system that involve the elimination of the reactive dyes.

The effectiveness of microbial decolorization depends on the adaptability and the activity of selected micro organisms. Wide range of micro organisms including bacteria, fungi, yeasts, actinomycetes and algae capable of degrading azo dyes. The mechanism of microbial degradation of azo dyes involves the reductive cleavage of azo bonds (-N = N-) with the help of azo reductase under anaerobic conditions resulted into the formation of colourless solutions. The resulting intermediate metabolites (aromatic amines) are further degraded aerobically or anaerobically.

Uses of Live Fungi in Decolorization

The fungal cell walls are composed of macromolecule which contains carboxyl group, amino group, phosphates, lipids, sulphates and hydroxides and these fungal groups act as metal sorption sites. Fungi remove the dyes essentially by absorption and oxido – reduction reaction.

Most of the research concerning bioremediation with these fungi has centered on a single species *Phanerochaete chrysosporium*, which is known to metabolize a wide range of xenobiotic compounds. Non-lignolytic fungi from basidiomycete group like various *Aspergillus* species have been reported to decolorize various dyes. Strain of *Aspergillus sojae* has shown decolorization of the azo dyes Amaranth, Congo red and Sudan III in nitrogen poor media. Several other wood rotting fungi like *Aspergillus fumigatus* and *Aspergillus oryza*, capable of decolorizing a wide range of structurally different dyes and found more effective than *Phanerochaete chrysosporium.*

Use of Dead Biomass in Decolorization

The use of biomass has its advantages, especially if the dye containing effluent is very toxic. Biomass adsorption is effective when conditions are not always favourable for the growth and maintenance of the microbial population.

Dead cells are obviously preferable for waste water treatment since they are not affected by toxic wastes and chemicals and do not pollute the environment by releasing toxins and or propagates. Dead and dried biomass can be stored for long periods at room temperature with little risk of putrefaction. This makes it easier to use and transport. Dead biomass is also generated as a waste product from established industrial process.

The use of dead microbial cells in biosorption is more advantageous for water treatment in that dead organisms do not require continuous supply of nutrients and they can be regenerated and reused for many cycles. Fungal biomass is not pathogenic to humans and animals and it can be produced cheaply using simple fermentation techniques or obtained as a waste from various industrial fermentation processes.

Conclusion

Waste minimization is of great importance in decreasing pollution load and production costs. Traditional technologies to treat textile waste water include combination of biological, physical and chemical methods, but these methods require high capital and operating costs. Biotechnology systems are among the best alternative methods that can be adopted for large-scale ecologically friendly treatment process.

Bibliography

1. Dirk Wesenberg, Irene Kyriakides and Spiros N. Agathos White-rot fungi and their enzymes for the treatment of industrial dye effluents, Biotechnology Advances, Vol. 22, Issue. 1-2, Dec 2003, P.p. 161-187

2. Prachi Kaushik and Anushree Malik**,** Fungal dye decolourization: Recent advances and future potential, Enviromental International, Vol.35, Issue.1, Jan 2009, P.p. 127-141.

3. Tim Robinson, Geoff McMullan, Roger Marchant and Poonam Nigam **,** Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative, Bioresource Technology, Vol.77, Issue.3, May 2001, P.p. 247-255.

4.http://www.scribd.com/doc/2608600/Advances-in-Textile-Wastewater-Treatment.

5. http://www.thesmarttime.com/pollution/pollution.htm.

Image Courtesy: http://2.imimg.com/