Removal of Dyes from Textile Industry Effluent: A Review
Harpreet Kaur¹, Gitanjali Sharma²

Lecture of Chemistry, Department of Applied Sciences and Humanities, Baddi University, Baddi, H.P., India.
Associate Professor, Department of Applied Sciences and Humanities, Baddi University, Baddi, H.P., India.

Abstract— Effluent from the textile industry contains toxic compounds. These compounds contaminate the surface water, thereby making it unfit for irrigation and drinking. Since farmers use water from the rivers for agricultural purposes and the residents of the town, use both the surface and underground water from the same area as potable water, it is quite unsafe to discharge this effluent into water body. Suspended solids can clog fish gills, either kill them or reduce their growth rate. They also reduce the ability of algae to produce food and oxygen. Therefore, proper treatment of effluent water and enforcement of pollution control by the regulatory authority on the indiscriminate discharge of textile wastewater into water bodies should be done. Batch adsorption experiments using Ashoka leaf powder, a low cost, locally available biomaterial as an adsorbent has been used for removal of cationic dyes such as Methylene blue, Malachite Green, Rhodamine B and Brilliant Green from effluent of textile industry.

I. INTRODUCTION

An industrial effluent is undesirable by-product of economic development and technological advancement. When improperly disposed off, it imperils human health and the environment. Effluent from textile industry is a complex mixture of chemicals varying in quantity and quality. These industries generate both inorganic and organic waste mixed with wastewater from the production processes, which leads to change in both biological and chemical parameters of the receiving water bodies [1]. Control of water pollution has gained 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 effluent is done by physico-chemical means. Such methods are often very costly and although the dyes are removed, accumulation of concentrated sludge creates a disposal problem [2]. Water pollution caused by industrial effluent discharges has become a worrisome phenomenon due to its impact on environmental health and safety. Textile industries contribute immensely to surface water deterioration and are categorized among the most polluting in all industrial sectors [3]. Textile industry is one of the most important and rapidly developing industrial sectors in Ludhiana city of Punjab, India. It has a great disadvantage in terms of its environmental impact because it consumes considerably high amount of processed water and produces highly polluted discharge water. To control the polluted discharge the textile mills in India have started to install treatment plants in the name of environmental protection. The wastewater from seven textile mills in the woven fabric and knit fabric finishing industry and one highly polluted drain, locally known as Buddha Nala, which receives discharge from many such industrial units, were collected for the study [4]. Textile wastewater includes a large variety of dyes and chemicals additions that make the environmental challenge for textile industry not only as liquid waste but also in its chemical composition [5]. Dyes contribute to overall toxicity at all process stages. Dye baths could also have high level of BOD/COD, color, toxicity, surfactants, fibers and turbidity and may contain heavy metals [6, 7, 8]. Textile processing employs a variety of chemicals depending on the nature of the raw material and product [9]. Dyeing process usually contributes chromium, lead, zinc and copper to wastewater [10]. Copper is toxic to aquatic plants at concentrations below 1.0 mg/l while concentrations near this level can be toxic to aquatic life [11]. The removal of color from
The textile industry and dyestuff manufacturing industry wastewaters represents a major environmental concern. Contaminated air, soil and water by effluents from the industries are associated with heavy disease burden (WHO, 2002).

The most important parameters in wastewater from textile industry are Chemical Oxygen Demand, Biological Oxygen Demand (BOD), pH value, suspended solids, total dissolved solid, color and total organic Carbon. The effluent characteristics of textile mills, most of which are cotton-fabric, polyester, wool, and acrylic refining mills were investigated in the study. The concentrations of BOD, COD, SS, TOC, TDS, pH, color were analyzed according to standard methods (Table 1).

TABLE 1
CHARACTERISTICS OF WASTEWATER SAMPLES

<table>
<thead>
<tr>
<th>NAME OF INDUSTRY</th>
<th>BOD mg/l</th>
<th>COD mg/l</th>
<th>TOC mg/l</th>
<th>TS mg/l</th>
<th>TDS mg/l</th>
<th>pH value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>552.35</td>
<td>1040</td>
<td>7784.0</td>
<td>2780</td>
<td>2560</td>
<td>4.30</td>
</tr>
<tr>
<td>B</td>
<td>210.0</td>
<td>3050</td>
<td>563.5</td>
<td>51450</td>
<td>49440</td>
<td>11.9</td>
</tr>
<tr>
<td>C</td>
<td>108.0</td>
<td>590.0</td>
<td>119.6</td>
<td>898.5</td>
<td>816.6</td>
<td>8.2</td>
</tr>
<tr>
<td>D</td>
<td>790.0</td>
<td>1230</td>
<td>535.6</td>
<td>1770</td>
<td>1590</td>
<td>7.22</td>
</tr>
<tr>
<td>E</td>
<td>245.0</td>
<td>970.0</td>
<td>158.0</td>
<td>6510</td>
<td>5690</td>
<td>9.80</td>
</tr>
<tr>
<td>F</td>
<td>548.0</td>
<td>550.0</td>
<td>211.6</td>
<td>2300</td>
<td>2120</td>
<td>8.16</td>
</tr>
<tr>
<td>G</td>
<td>156.0</td>
<td>195.0</td>
<td>101.1</td>
<td>450</td>
<td>430</td>
<td>8.03</td>
</tr>
<tr>
<td>BUDDHA NALA H</td>
<td>317.57</td>
<td>120</td>
<td>44.01</td>
<td>1570</td>
<td>1470</td>
<td>7.06</td>
</tr>
</tbody>
</table>

Disposal of dyes in precious water resources must be avoided and for this various effluent treatment methods are in use. Among various methods adsorption occupies a prominent place in dye removal. The growing demand for efficient and low-cost treatment methods and the importance of adsorption has given rise to low-cost alternative adsorbents (LCAs). Some LCAs, in addition to having wide availability, have fast kinetics and appreciable adsorption capacities too. Advantages and disadvantages of adsorbents, favorable conditions for particular adsorbate–adsorbent systems, and adsorption capacities of various low-cost adsorbents and commercial activated carbons are available [12].

Adsorption techniques are widely used to remove certain classes of pollutants from waters, especially those which are not easily biodegradable. The removal of MB, as a pollutant, from waste waters of textile, paper, printing and other industries has been addressed by the researchers. Currently, a combination of biological treatment and adsorption on activated carbon is becoming more common for removal of dyes from wastewater. Although commercial activated carbon is a preferred adsorbent for color removal, its widespread use is restricted due to its relatively high cost which led to the researches on alternative non-conventional and low-cost adsorbents [13]. Use of waste materials as low-cost adsorbents is attractive due to their
contribution in the reduction of costs for waste disposal, therefore contributing to environmental protection [14].

Three agricultural residues, wheat straw, wood chips and corn-cob shreds were tested for their ability to adsorb individual dyes and dye mixtures in solutions. Up to 70–75% color removal was achieved from 500 ppm dye solutions at room temperature using corn-cob shreds and wheat straw. Increasing the temperature had little effect on the adsorption capacity of the residues. The resulting dye-adsorbed residues were found to be suitable substrates for solid-state fermentation (SSF) by two white-rot fungi; Phanerochaete chrysosporium and Coriolus versicolor. Phanerochaete chrysosporium and Coriolus versicolor both strains grew uninhibited and produced a maximum protein content of 16, 25 and 35 g and 19, 23 and 50 g in SSF of 100 g dry weight wood chips, corn-cob shreds and wheat straw, respectively, supplemented with ammonical nitrogen to give a C:N ratio of 20:1. This approach provided preliminary results for the remediation of textile effluent and the conversion of agricultural residues into soil conditioner [15].

The use of a previously untried biosorbent, barley husk, for dye removal has also been compared to corncob by Robinson et. Al[16]. The effectiveness of adsorption as a means of dye removal has made it an ideal alternative to other more costly treatments. It deals with two low-cost, renewable biosorbents, which are agroindustrial by-products, for textile dye removal. The effects of initial dye concentration, biosorbent particle size, dose of biosorbent, effective adsorbance, and dye removal kinetics were examined. One gram (per 100 ml) of ≤600 μm corncob was found to be effective in removing a high percentage of dyes at a rapid rate (92% in 48 h). One gram of 1×4 mm barley husk was found to be the most effective weight and particle size combination for the removal of dyes (92% in 48 h). The results illustrated how barley husk and corncob are effective biosorbents concerning the removal of textile dyes from effluent.

The degradation of the dyes Methylene Blue (MB), Methyl Orange (MO) and Indigo (Ind) in water was carried out via a photocatalytic reaction. The porous nanocrystalline TiO2 photocatalysts used in the photocatalytic degradation were prepared using Polyethylene glycol (PEG) as a structure-directing agent in the sol–gel system [17].

Use of macroalgae for removal of dyes from industrial water effluent, specifically from textile industries is possible and after removal of dye, this dye can be used anywhere [18]. The feasibility of using brown macroalgae species Sargassum for dye removal from simulated textile water effluent streams in batch and continuous adsorption columns provides an energy efficient and low cost solution to treat waste water from textile industries.

The kinetic study provided a first-attempt model prediction to elucidate characteristics of azo dye decolorization in immobilized cell systems (ICSs) using indigenous Aeromonas hydrophila. This kinetic modeling coupled with graphical analysis could also provide a plausible evaluation to determine the most economically feasible biostimulation strategy for non-growth associated biodegradation (e.g., dye decolorization) in ICSs for possible industrial applications [19].

There has been exhaustive research on biosorption of dye wastewater. It presents an attractive option to supplement conventional treatment processes. The various biosorbents such as fungi, bacteria, algae, chitosan and peat, which are capable of decolorizing dye wastewaters, has been reviewed by Srinivasan and co-workers [20].

The decolourization of dye wastewaters through fungi can be done via two processes (biosorption and bioaccumulation) and various process
parameters like pH, temperature, dye concentration etc. affect the dye removing efficiency of different fungi. Various enzymes involved in the degradation of the dyes and the metabolites thus formed have been found. Genetic manipulations of microorganisms for production of more efficient biological agents, various bioreactor configurations and the application of purified enzymes for decolourization, which constitute some of the recent advances in this field, have also been reviewed. The study has shown that the fungal decolourization has a great potential to be developed further as a decentralized wastewater treatment technology for small textile or dyeing units [21]. Forgacs and co-workers have studied and compared various methods of removal of dyes such as adsorption on various sorbents, chemical decomposition by oxidation, photodegradation, and microbiological decoloration, employing activated sludge, pure cultures and microbe consortiums [22].

Chitin is the second most important natural polymer in the world. Chitosan is the most important derivative of chitin [23]. Application of chitinous products in wastewater treatment has received considerable attention in recent years in the literature [24]. In particular, the development of chitosan-based materials as useful adsorbent polymeric matrices is an expanding field in the area of adsorption science. The chitosan and its grafted and crosslinked derivatives are used for dye removal from aqueous solutions.

The adsorption of Remazol black 13 (Reactive) dye onto chitosan in aqueous solutions was investigated [25]. The equilibrium adsorption data of reactive dye on chitosan were analyzed by Langmuir and Freundlich models. The maximum adsorption capacity (qm) has been found to be 91.47–130.0 mg/g. The amino group nature of the chitosan provided reasonable dye removal capability. The kinetics of reactive dye adsorption nicely followed the pseudo-first and second-order rate expression which demonstrates that intraparticle diffusion plays a significant role in the adsorption mechanism.

Currently, removal of dyes from effluents is done by such methods which are often very costly and although the dyes are removed, accumulation of concentrated sludge creates a disposal problem. Therefore review is done on the current available technologies and suggests an effective, cheaper alternative for dye removal and decolourisation applicable on large scale [26].

II. CONCLUSION

Textile effluents cause bio-toxicity in the organisms which lead to growth inhibition and low chlorophyll content in plants. 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 chemical, biological or combination systems. However, further research work is required to study the toxicity of the metabolites of dye degradation and the possible fate of the utilized biomass in order to ensure the development of an eco-friendly technology.

REFERENCES


