Chapter 13
Bioremediation:
A Logical Approach for the Efficient Management of Textile Dye Effluents

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ABSTRACT

Synthetic dyes are extensively used in several industries and the dyes are great concern for the ecosystem. During the dyeing process, a certain percentage of the used dye is released into the wastewater, causing severe environmental and health hazards. The physiochemical methods are not sustainable due to high-cost, high-energy requirements and hazardous by-products. Among all the alternative technologies to conventional wastewater treatment, bioremediation has emerged as the most desirable approach to clean up the environment and to restore its original status. The ability of microbes in decolorizing the textile effluents is significant. The decolorization can be further enhanced using immobilization techniques. Immobilization increases the stability and reusability of the microorganisms. The microorganisms can be entrapped in calcium alginate beads, that can be used to construct a packed bed reactor in which dye decolorization can be carried out on a large scale. Thus, bioremediation serves as an effective, eco-friendly solution for the pollution caused by textile dye effluents.

DOI: 10.4018/978-1-7998-0369-0.ch013

INTRODUCTION

The wastewater effluent from the textile industry is considered as one of the most polluting agents among all other industries. The environmental and health effects of textile industry wastewater have been a subject to scientific scrutiny for a long time. The presence of even very low concentrations of dyes in the effluent is highly visible and undesirable (Nigam *et al.,* 2000). There are more than 100,000 commercially available dyes with over 700,000 ton of dyestuff produced annually (Al Fawaaz and Abdullah., 2016). Synthetic dyes are chemically diverse and can be divided into azo, triphenylmethane or heterocyclic/ polymeric structures (Gregory, 1993; Liu *et al*., 2004). They are used extensively in the biochemical, foodstuff, plastic and textile industries; where it is estimated that 10-14% of the dye is lost in the effluents during the dyeing process. The textile industry plays an important role in the world economy, but at the same time, it consumes a large quantity of water and generates a huge amount of wastewater (Wouter *et al*., 1998; Hai *et al*., 2007). Synthetic dyes are recalcitrant and are persistent when discharged into the environment and many of them are also toxic. Many dyes are difficult to decolorize due to their chemical structure and synthetic origin. The classification of industrial dyes is given in figure 1.

TREATMENT PROCESSES

The treatment of textile effluents is of paramount importance due to toxic and aesthetic impacts on receiving waters. The various methods of dye decolorization are listed in figure 2.

Various physical and chemical methods for the elimination of dyestuff havebeen developed during the past decades (Kandelbauer *et al*., 2004). The removal of color from textile industry effluents are mainly based on physical and chemical methods (Banat *et al*., 1996). The color removal techniques usually followed in these methods are coagulation or adsorption of dyes, ultra-filtration, ion-exchange, chemical oxidation, electrolysis, etc. However, these methods are not very much applied because of their high cost, high energy requirements and hazardous by-products. Also, these techniques generate a huge volume of sludge and cause secondary pollution due to the formation of sludge and hazardous by-products (Maier *et al*., 2004; Ramya *et al*., 2007).

The various physical and chemical methods of dye decolorization along with their advantages and disadvantages have been listed in table 1.

In the past few decades, there is an immense effort to develop a cost-effective and eco-friendly alternative to conventional waste treatment methods. Among all the technologies decolorization by bioremediation has emerged as the most desirable approach to clean up the environment and to restore its original status.

BIOREMEDIATION

Bioremediation is important, as it is cost effective and eco-friendly, and produces less sludge (Robinson *et al*., 2001; Chen *et al*., 2003; Binkley and Kandelbauer, 2003).