Environmental Toxicity of Textile Industrial Dyes and Treatment Strategies: Review

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Abstract

The textile industry is a substantial consumer of water which produces huge volumes of contaminated water. Textile effluent is one of the most polluted waste water due to the large variety of dyes and harmful chemicals contained in it, which complicates further treatment of the textile effluent and severely affects the quality of water, micro flora, micro fauna of the environment, soil, livestock and human population. Synthetic dyes and their toxic substances have to be removed from the effluent before their discharging to the environments. Frequently applied treatment methods for color removal from textile effluents consist of integrated processes such as physical, chemical and biological methods. The physical and chemical methods are less efficient, costly, limited applicability and produce sludge which are difficult to dispose. The biological methods which is mediated by microbial consortium is more acceptable compared to physical and chemical methods since, it is low cost and eco-friendly. Microorganism such as bacteria, fungi, yeasts and algae play great role in decolorization of textile dyes by enzymatic actions of laccase, azoreductase, lignin peroxidase, manganese peroxidase and manganese independent peroxidase. Factors

Table 1: Direct and indirect effects of textile wastewater discharged into the environment.

Strategies for Treatment of Textile Effluents

Commonly applied treatment methods for color removal from colored effluents consist of integrated processes such as physical, chemical and biological methods which are used for the treatment of textile waste water. The physical and chemical methods are less efficient, costly, limited applicability and produce wastes which are difficult to dispose. Due to the variety of existing dyes and effluents complexity, not all methods have the same efficiency and the combination of various methods may be required, since each method has advantages and limitations. Existing methods can be divided into three categories: physical, chemical and biological.

Biological Methods

The use of biological methods to remove color from textile effluent is usually a cheaper alternative, since it presents no major processing costs. In biological methods, the microbes such as bacteria, fungi and algae are being used for the treatment of wastewater generated from the textile, which could be a viable option as low-cost, environmental friendly, produce less secondary sludge and the end products of complete mineralization are not toxic. Now a days several species of bacteria such as Aeromonas spp., Escherichia, Citrobacter, Pseudomonas spp, Sphingomonas, Bacillus spp., Staphylococcus aureus, Proteus mirabilis, Clostridium, Nocardia, Paenibacillus, Streptomyces and Micrococcus luteus have been proved to be capable of decolorizing textile dye. Systems based on the use of mixed microbial populations are more effective due to synergistic metabolic activities of microbial community.

Algae are ubiquitous in nature and serve as one of the biomaterials with high capacity for removing dye from contaminated waters. They are known to be used in effective decolourization of dyes from textile wastewaters. The azo bond reduction is the mechanism of degradation followed by algae, thus aromatic amines formed can be then totally mineralized.

Microbial Enzymes in Degradation of Dyes

Microbial enzymes have been exploited in the decolorization and degradation of azo dyes. Strains of bacteria, actinomycetes, fungi, yeasts, and algae produce enzymes to bio remediate chemical compounds present in wastewater. Biodegradation is proposed as the most economical resource for the treatment of textile effluents when using extracellular enzymes, such as azoredutases, laccases and peroxidases secreted by microorganisms in order to transform or even mineralize textile dyes. In the case of enzymatic remediation of azo dyes, azo reductases and laccases seem to be the most promising enzymes. Laccases have been shown to decolorize a wide range of industrial dyes.

Among microorganisms, fungi are widely known for their superior capacities to produce a wide variety of extracellular enzymes, organic acids various metabolites, and for their capabilities to adapt severe environmental constraints than other microorganisms.

Dyes are removed by fungi through biosorption, biodegradation, bioaccumulation and enzymatic mineralization using lignin peroxidase, manganese peroxidase, manganese independent peroxidase and laccase. In particular laccase from Pleurotus ostreatus, Schizophyllum commune, Sclerotium rolfsii and Neurospora crassa, seemed to increase up to 25% the degree of decolorization of individual commercial triarylmethane, anthraquinonic and indigoid textile dyes using enzyme preparations. Phanerochaete chrysosporium fungi is capable of producing extracellular enzymes such as manganese peroxidase which is effective in decolourization of textile effluent. Bacterial degradation of azo dyes is often mediated by azoreductases, which are more efficient under static and anoxic conditions.

Physico-Chemical Methods

Various physicochemical methods, such as adsorption on activated carbon, electrocoagulation, flocculation, froth flotation, ion exchange, membrane filtration, ozonation, and reverse osmosis have been used for decolorization of dyes in wastewater. These methods can only transfer pollutants from one phase to another rather than eliminating the pollutants. Both flocculation and adsorption generate large solution containing dye, thereby increasing the diffusion rate of the dye molecules across the external boundary layer and in the internal pores of the adsorbent particles.

Concentration of dye: The effect of dye concentration strongly influences the rate of dye removal and also impacts the toxicity of dye molecule. Effluent concentration also affects the efficiency of color removal. The percentage of decolourisaton increased with increase in time regardless of initial dye concentration for bacteria, and decolourisation of dye decreases with increasing dye concentration. The fungal growth is affected by the presence of high concentration of dye.

Conclusion

Rapid industrialization has imposed the manufacture and use of different chemicals in day to day life. Many of structurally different dyes are extensively used in the textile industry because of their wide variety of color shades, high wet fastness profiles, ease of applications, brilliant colors, and minimal energy consumption. The improper disposal of textile effluent to the environment pose toxic effects on aquatic life, soil, plants, and human population. Before disposal to the environment, the treatment of textile effluents is interested to reduce toxic impacts on the environment. There are different methods used for treatments of textile effluents, these are; physical, chemical, and biological methods. The biological methods of dye degradation or decolorization by consortium of microbial based enzymatic action are more acceptable because of low cost and environmentally safe compare to physical and chemical methods. No single solution has been satisfactory for remediation of various textile waste rather than the combinations of these methods, even though each methods have their own advantages and disadvantages. Factors affecting degradation of dyes are temperature, pH and concentrations of dyes. Further assessment of toxicity of textile effluents to the biosphere must be recommendable to know that if there is a relationship between toxicological effects of textile effluents on the environments and climatic changes, and mitigation strategies.

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