Chapter 3
Biosorption of Dye Molecules

Aisha Zaman
Jadavpur University, India

Papita Das
Jadavpur University, India

Priya Banerjee
University of Calcutta, India

ABSTRACT

Water contamination due to dyes has drawn increased attention. Dyes in water bodies are greatly perceptible and pose tremendous threat to ecosystem. Thus removal of such dye molecules is a matter of concern. In the past various physical and chemical techniques have been employed for the removal of colour from wastewater. However most of these methods have certain drawbacks. Biological treatment is often efficient and economical. Many microorganisms are able to accumulate and degrade different pollutants. Yet even the biological methods have some shortcomings such as toxicity of biodegradation products and more.

INTRODUCTION

The price of progress clouds the air and fouls the water across the globe. With the growth of mankind, society, science and technology our world is attaining new heights of socio-economic development. However this is being achieved at the huge loss of natural resources posing a great threat to future generations. As a consequence of rapid industrialization, severe environmental degradation such as water pollution is emerging as a major obstacle in the path of sustainable development. The intake of water by agricultural, industrial and domestic sectors is increasing tremendously whereas due to the scarcity of water it is becoming difficult to fulfill their requirement. This has been attributed to the generation of large amounts of wastewater containing a number of 'pollutants'. This necessitates the proper utilization of water as well as minimization of pollution so as to make the future of mankind safe. Natural sources of water should be prohibited from pollution as they are utmost important for ecosystem and human development. However, the quality of our water resources is deteriorating day by day due to the continuous addition of undesirable chemicals in them. The main sources of water contamination are

DOI: 10.4018/978-1-4666-9734-8.ch003

industrialization, civilization, agricultural activities and other environmental and global changes. Dyes are known to be used by humankind for thousands of years. Till the late nineteenth century, all the dyes/ colourants were more or less natural with main sources like plants, insects and mollusks, and were generally prepared on small scale. It was only after Perkin's historic discovery of the first synthetic dye, mauveine, in 1856, (Hunger, 2003; Venkataraman, 1965) that dyes were manufactured synthetically and on a large scale. Synthetic dyestuffs are such compounds that are widely consumed by several industries that include textile, paper, plastic, printing industries and dye houses. As a consequent they generate substantial amount of coloured waste water. Therefore, colour removal has been a subject of increased attention in the past few years. The process of dying textile fibres is not an efficient process. The extent of efficiency depends on the method of dye delivery. Consequently a huge amount of coloured wastewater is discharged by the textile industries.

SYNTHETIC DYES AND RELATED ISSUES

Synthetic dyes contribute largely to the group of hazardous compounds that are not easily biodegradable. Their presence in water bodies is undesirable as they are difficult to eliminate due to their persistent and recalcitrant nature. Dyes display a significant diversity in their molecular structure and can be classified in several ways, sometimes based on their chemical structure while sometimes on the basis of their application to the fiber type and so on. A broad classification of the dyes based on the ionic charge on the dye molecules can be presented as follows:

- **Non-Ionic:** Disperse dyes
- **Cationic:** Basic dyes
- **Anionic:** Direct, acid, and reactive dyes

The properties of the dyes vary greatly with their molecular structure. The synthetic origin and complex molecular structure of the dyes makes them more stable and difficult to be biodegraded. Therefore they can pose tremendous threat on the environment and the natural ecosystems. Most of the dyes especially cationic dyes are highly toxic while their degradation products can be carcinogenic as well (El-Sayed, 2007). Generally either an anthroquione or an azo group is present in non-ionic and anionic dyes Anthraquinone containing dyes are greatly resistant to degradation because of their complex aromatic structures and therefore stay behind unaffected in the wastewater. Reactive dyes typically contain an azo group associated with different types of reactive groups such as chlorotriazine or vinyl sulphone. Most of the metal complex dyes contain chromium which is a potential carcinogenic. Disperse dyes remain undissociated in aqueous medium while there some disperse dyes that have a propensity to bioaccumulate.

The toxic components of the dyes can adversely affect the ecosystem in different ways, such as:

- Dyes may significantly affect rather hinder photosynthetic activity in aquatic life as they can absorb and reflect sunlight entering the water bodies resulting in reduced light penetration and hence interfering with the growth of microorganisms.
- Dyes can also be toxic to the aquatic life due to the presence of heavy metals, chlorides, aromatic compounds etc., in them.