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Treatment of Leather Effluents and Waste Using Fungi

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Abstract - Leather industry plays an important role in the economic development of the country and the wastewater from this industry is a major source of pollution among all industrial sectors considering both volume and composition of effluent. During leather processing, a number of size reduction, levelling and purification operations are carried out which results in generation of untanned and tanned proteinaceous waste materials which pose as a major environmental problem if not managed effectively. Large-scale production systems are adopted for leather processing and so this industry receives focus of environmentalists and society. Consequently, tremendous pressure is exerted by various pollution regulatory bodies to treat the effluents before disposal. The tannery effluents contain tannins, high suspended solids, and dissolved solids, BOD and some inorganic compounds such as chlorides, sulphides, sulphates, sodium and some toxic heavy metals, which affect the environment. Thus there is a need for innovative treatment technologies for the removal of these heavy metal ions from wastewater. Numerous physical and chemical methods such as screening, flow equalization, primary sedimentation, chemical flocculation, aerobic activated sludge treatment, secondary sedimentation have been employed for the disposal of wastes. These methods are very expensive and therefore the most reliable way seems to be the biological treatment using microorganisms that serve as efficient detoxifiers of pollutants. Fungi contribute a major role in the reduction of pollution by possessing superior aptitudes to produce a large variety of extracellular proteins, organic acids and other metabolites, and for their capacity to adapt to severe environmental constraints. Fungi are mainly used in leather production in different steps like soaking, dehairing, bating, dyeing, degreasing or in effluent and proteinaceous solid wastes treatment. During the bating process, fungi remove the degraded hairs and epidermis and promote the removal of non structural proteins and help on carbohydrates removal. Free mycelia, mycelia pellets, immobilized fungi or their enzymes have been reported in treatment of leather effluents. Thus the use of fungi to treat leather effluent is cost effective and therefore highly suitable for reduction of pollutant load of tannery effluents.

Keywords: Leather industry, tanning, effluent treatment, biological method, fungi

I. INTRODUCTION

The development and disorganized industrial growth has caused serious problems to people worldwide. It is, therefore, necessary that ideas of sustainable development, where natural resources are used for the reduction of pollution of air, soil and water. The tanning industry forms the backbone of the leather industry. Leather industries nowadays employ tanning processes because of their processing speed, low costs, and light color of leather and greater stability of the resulting leather.

II. POLLUTION BY LEATHER INDUSTRY

The leather industry is a major industry on international level and it is economically important for any country thus there is an increasing demand for leather and its related products. About 65% of the leather production is used in footwear. The United States, Germany, and other European countries remain major leather importers while countries like China, India, Thailand and Indonesia dominate the export of leather and leather products. Thus tanning industry is to be a major source of water pollution. Tannery wastes are identified as an activity generating pollution of mixed organic and inorganic constituents which occur at concentrations higher than other wastes. Tanneries are thus obligated to treat effluent to a level that cause less impact on the environment.

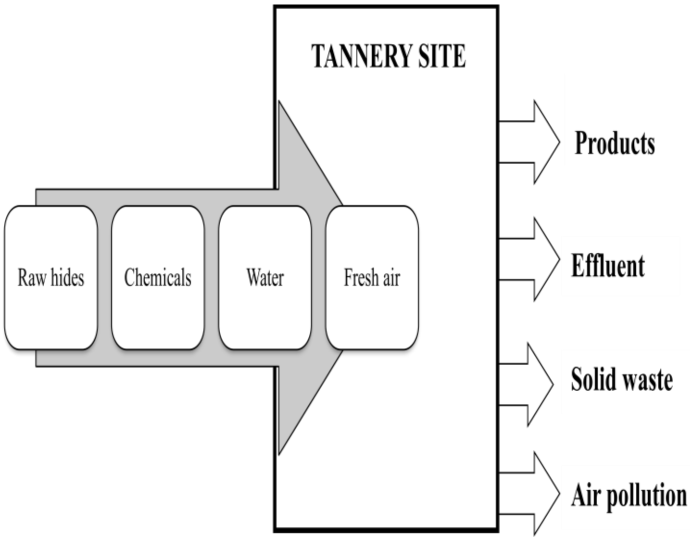

Figure 1: Overview of tanning industry

III. TANNERY WASTEWATER CHARACTERISTICS

Tannery wastewater is characterized by measurements of biochemical oxygen Demand (BOD), Chemical Oxygen Demand (COD), suspended solids (SS) and Total Dissolved Solids (TDS), chromium and sulphides etc. Generally tannery wastewaters are basic, dark brown in colour and also it has high content organic substances. These substances vary according to the chemicals used (Kongjao *et al*., 2008). These wastewaters also have high organic content it cause an environmental pollution (Leta *et al*., 2004).

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IV. TREATMENT OF LEATHER EFFLUENTS

Two methods are involved in the treatment of leather. They are physiochemical method and Biological method

4.1. Physiochemical method
Physiochemical method is also called as conventional method. Various physiochemical techniques are used in tannery wastewater treatment. Some conventional methods used include coagulation and activated carbon adsorption. But these processes are very expensive.

4.2. Biological treatment
Compared to the conventional method Biological treatment of wastewater is more favourable and also the cost effective method. Various microorganisms take part in reducing the pollutant content (Eddy 2003). Based on the oxygen utility biological treatment is classified into two types (aerobic treatment and anaerobic treatment). Aerobic treatment of tannery wastewater reduces chemical oxygen demand (COD) by 60- 80% and the biological oxygen demand (BOD) reduction is 95%. The efficiencies of removals are much higher than conventional aerobic systems (Ganesh *et al.*, 2006). Anaerobic treatment of wastewater converts the organic pollutants into a small amount of sludge and large amount of biogas (methane and carbon dioxide).

V. ENZYME IN WASTEWATER TREATMENT

In recent years, the use of living systems such as microorganisms is used to degrade pollutants (Movahedin *et al*., 2006). Policies regarding permitted levels of pollutants and high costs of chemicals for pollutant removal have led to the development of many effective, yet simple biological methods. These biological treatment processes can be collectively categorized under ‘bioremediation’ of wastewater (Mohapatra 2006). Biological systems degrade target chemicals mainly due to their enzymes.

Hence enzymes, both intracellular and extracellular can be explored as means for wastewater treatment as they are highly specific and extremely efficient catalysts (Nelson and Cox, 2004) and can selectively degrade the target pollutant without affecting the other components in the effluent. Thus enzymatic treatment is suitable for effluents that contain relatively large amounts of the target pollutants. More importantly enzymes can operate under mild reaction conditions. In this respect, enzymes outperform the regular catalysts (transition elements like Cu, Ni). Thus enzymes are more acceptable due to their biodegradable nature (Adam *et al*., 1999).

5.1. Delivery systems for enzymes in effluent treatment
Enzymes are versatile and are delivered to the target effluent in different ways. The selected delivery system must be simple, efficient and suited for purpose. Special attention should be taken care that the mode of delivery does not affect enzyme activity.

5.1.1 Enzyme delivery by direct use of biological source
Enzyme delivery is another method of treating the target effluent by introducing the cells or tissues which produces the enzyme into the effluent directly. This mode of enzyme delivery is adopted when suitably adapted strains of microorganisms are used to co-metabolize target contaminants or when the tissue producing the enzyme is introduced directly into the effluent.

5.1.2 Enzyme delivery as cell-free enzyme extracts
Enzymes are extracted from organisms and employed in wastewater treatment and are preferred for use over the intact organism, especially when the effluent to be treated contains pollutants which cannot support growth. The isolated enzymes could be used in either the pure form or as a crude extract. Enzymes also do not require a supply of nutrients for their growth and need not be acclimatized to the wastewater. Optimum treatment conditions are easier to standardize with isolated enzymes (Karam and Nicell 1997). The use of isolated enzymes also has an ease of handling and storage. The delivery of cell-free crude enzyme extract uses the least processed, yet functional form of the enzyme. The preparation of crude enzyme extracts typically includes simple processes such as grinding or homogenizing the source tissue in the presence of an appropriate buffer followed by filtration (Johnson and Pokora 1994). Crude enzyme extracts are preferred over pure enzymes because they are inexpensive.

5.1.3 Enzyme delivery in immobilized form
The function of an enzyme depends largely on their conformation. The conformation of an enzyme will change when exposed to harsh condition like high temperature, very low or high pH and high concentration of reaction. Enzymes may not function optimally under such drastic conditions which are often encountered in effluent streams (Karam and nicell 1997). Thus immobilization methods that can increase the reusability of enzymes by preventing the loss of enzyme during the course of the reaction and minimizing the loss of activity of enzymes under harsh treatment conditions have been developed. When an enzyme is physically confined to a certain region of space, retaining its catalytic activity with the capacity to be used repeatedly or continuously, then it is said to be immobilized (Pescod 1992). Compared to free enzymes, immobilized enzymes have many important advantages over the use of free enzymes including increased stability, localization, ease of handling, reusability and a consequent decrease in running cost (Karam and nicell 1997).

5.1.4 Enzyme delivery in the form of different nanoparticles
Use of nanotechnology in wastewater treatment is gaining importance in the recent years as it offers more effective methods to decontaminate xenobiotics in the environment. Nanoparticles have a very large surface area to volume ratio, high reactivity and sequestration properties which have immense potential for use in wastewater treatment. Remediation of waste streams containing dyestuffs, cleaning up of heavy metals from contaminated soil and water by absorption and sequestration are possible using nanoparticles. The use of nanoparticles in Reactive Remediation Technology is of great interest to wastewater treatment, since it involves the complete degradation of contaminants to harmless products such as carbon dioxide and water (Fulekar 2010).

The remediation of contaminated wastewater can be achieved by using a combination of enzyme technology and nanotechnology known as the SEN, i.e., Single Enzyme Nanoparticle (Watlington, Emerging 2005). A SEN may be described as an armored enzyme surrounded by a protective ‘cage’ like a silicate shell which is linked with its surface. The active site can be kept chemically accessible to maintain the functionality of the enzyme even when it is covered by the

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cage (Kim and Grate 2003). Enzymes involved in wastewater treatment that can be used for SEN synthesis include cell-free crude extracts or purified forms of enzymes that are capable of degrading a wide variety of recalcitrant organic contaminants (Regnnli and Bruns 2010).

VI. CONCLUSION

Tannery wastewater treatment is difficult because of the characteristics like high BOD, COD, suspended solids, sulfide and chromium. In wastewater treatment, enzymes can be utilized instead of conventional techniques due to their versatility and efficiency. Thus it reduces their adverse impact on the environment. Ecologically the enzymatic wastewater treatment is a suitable technique. The running cost is lowered. The nanoscience confluence and enzyme technology has resulted in an upcoming approach to wastewater treatment. Thus an innovative application of enzymes in leather industry is an upcoming process for effluent treatment.

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