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Review

A critical review on textile wastewater treatments: Possible approaches

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ABSTRACT

Waste water is a major environmental impediment for the growth of the textile industry besides the other minor issues like solid waste and resource waste management. Textile industry uses many kinds of synthetic dyes and discharge large amounts of highly colored wastewater as the uptake of these dyes by fabrics is very poor. This highly colored textile wastewater severely affects photosynthetic function in plant. It also has an impact on aquatic life due to low light penetration and oxygen consumption. It may also be lethal to certain forms of marine life due to the occurrence of component metals and chlorine present in the synthetic dyes. So, this textile wastewater must be treated before their discharge. In this article, different treatment methods to treat the textile wastewater have been presented along with cost per unit volume of treated water. Treatment methods discussed in this paper involve oxidation methods (cavitation, photocatalytic oxidation, ozone, H_2O_2, fentons process), physical methods (adsorption and filtration), biological methods (fungi, algae, bacteria, microbial fuel cell). This review article will also recommend the possible remedial measures to treat different types of effluent generated from each textile operation.

Contents

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1. Introduction

Industrialization plays an important role in the development of any country. Textile industry is a vital and quickly emerging industrial segment in India. The textile industry uses different resources/raw materials such as cotton, woolen and synthetic fibers. Cotton based textile industries are considered in this study. The textile industries can also be classified into two groups viz dry and wet fabric industry. Solid wastes are generated in dry fabric industry while liquid wastes are generated in wet fabric industries. All textile industries in the later category are considered in this study. Processing operation such as desizing, scouring, bleaching, mercerizing, dying, printing and finishing stages are included in wet fabric processing industry. During fabric formation, the water utilization and waste water generation from a wet processing textile industry depends upon the operations.

The textile industry is a main creator of effluent wastewater due to a more consumption of water for its different wet processing operations. These effluent wastewater contains chemicals like acids, alkalis, dyes, hydrogen peroxide, starch, surfactants dispersing agents and soaps of metals (Paul et al., 2012). So, in terms of its environmental impact, the textile industry is estimated to use more water than any other industry, globally and almost all wastewater discharged is highly polluted. Average sized textiles mills consume water about 200 L per kg of fabric processed per day (Wang et al., 2011; Kant, 2012). According to the World Bank estimation, textile dyeing and finishing treatment given to a fabric generates around 17 to 20 percent of industrial waste water (Kant, 2012).

In India, the textiles industry consumes around 80% of the total production of 1, 30,000 tons of dyestuff, due to high demand for polyester and cotton, globally (Naik et al., 2013). These dyes in wastewater severely affect photosynthetic function in plant. They also have an impact on aquatic life due to low light penetration and oxygen consumption. They may also be lethal to certain forms of marine life due to the occurrence of component metals and chlorine. Suspended particles can choke fish gills and kill them. They also decrease the capacity of algae to make food and oxygen. Dyes are also detected to hinder with certain municipal wastewater treatment operations such as ultraviolet decontamination etc. (Mazumber, 2011).

At present, aromatic and heterocyclic dyes are used in textile industry. The complicated and stable structure of dye is posing a greater difficulty in degradation when present not only in textile wastewater but also in any kind of complex matrix (Ding et al., 2010). The mineralization of dyes, organic compounds and hence the toxicity of the wastewater generated by textile industry and dyes manufacturing industry is a main challenge and an ecological concern. Hence, understanding and emerging real textile wastewater treatment is ecologically noteworthy.

Therefore, the main aim of this paper is to provide a complete survey about different wet processing steps in cotton textile industry and the cost of methods implemented for the treatment of the dyes in textile wastewater. This review also explains the critical study of the most generally used methods (chemical, physical and biological) of dye removal from textile industrial effluents.

2. Textile operations

Textile industries prepare fibers; transform fibers into yarn and alter the yarn into fabric and then these fabrics goes through several stages of wet processing. Some of the stages in wet processing of textile fabrics are revealed in Fig. 1 (Vigo, 2013) and are discussed in detail in the subsequent sections.

2.1. Sizing and desizing

Textile wet processes like dyeing and printing are affected by the existence of sizing chemicals in the fabric. For instance, the occurrence of starch hampers the diffusion of the dye molecule into the yarn/fabric, which needs the elimination of starch preceding to dyeing and then printing. Enzymatic or dilute mineral acid hydrolysis or oxidation is used to remove such a sizing chemicals. Such a hydrolysis or oxidation processes convert starch into simple water soluble products (Fu and Lu, 2014). Effluent from desizing has a more biological oxygen demand (BOD) in the range of 300–450 ppm and pH of 4-5- (Magdum et al., 2013) that renders it out of use. An oxidation by hydrogen peroxide can be used for the degradation of starch into CO_2 and H_2O. Alternatively, the problem of starch can also be eased by using enzymes that covert it into ethanol. Distillation is used to recover this ethanol which can be used as a fuel, thus reducing the ultimate biological oxygen demand (BOD) load on the treatment (Sarayu and Sandhya, 2012).

2.2. Bleaching

Natural color substance in the fabric is responsible for the creamy look to the fabric. In order to get a white fabric which enables the production of bright shades, it is essential to remove natural color matter from the fabric by the process of bleaching. In earlier days, hypochlorite was being used as bleaching agents. Now days, hypochlorite is exchanged by another bleaching agents such as H_2O_2 and peracetic acid. Peracetic acid is an environmentally benign alternative to hypochlorite bleaching agent. Higher luster along with less yarn destruction of the processed fabric is the one major benefits of peracetic acid (Abdel-Halim and Al-Deyab, 2013; Liang and Wang, 2015).

2.3. Mercerization

Mercerization of cotton fabrics are carried out after bleaching to give a shine and advance dye uptake. Basically, it is done by treating cotton fabric with a high concentration (about 18–24% by weight) of sodium hydroxide. In this process, cotton fabric goes through the longitudinal shrinkage during impregnation in the NaOH solution. Here, this longitudinal shrinkage can be avoided by elongating the fabric or holding the fabric under tension. The excess caustic is washed off after 1–3 min, while holding the cotton fabric under stress. Then, the material gains the preferred properties of luster, easy dye uptake and improved absorbency. Membrane techniques or multiple effect evaporators can be used to recover the sodium hydroxide in the wash water (Fu et al., 2013; Lee et al., 2014).