PERSPECTIVES OF PLANT-ASSOCIATED TEXTILE INDUSTRY WASTEWATER TREATMENT – A REVIEW

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ABSTRACT

The rapid pace of industrial activities results in the augmentation of waste generation. Though different industries are known to generate wastes in different quantities, textile industry is notably is the high wastewater generating industry. Besides, the nature of wastewater generated in these industries is also a challenge due to its toxicity. In the backdrop of textile industry wastewater treatment challenges, this study was carried out to review the present status of the treatment options with special reference to phytoremediation approach. This study used scientific literature published in standard scientific journals with science citation index number. The general methods of content analysis have been used to review the collected literature. The review highlighted need to carry out rigorous characterization of textile industry wastewater prior to finalization of phytoremediation process. Also, the selection of plants should be carried out on the basis of feasibility studies so that high performance can be achieved.

Keywords: Textile Industry, Wastewater, Treatment, Phytoremediation.

INTRODUCTION

The industrial development carries with it the liabilities towards the environment, by adding pollutants in the different environmental compartments. Like many other industries, textile dying and manufacturing industries are also polluting valuable water resources. Furthermore, the current knowledge of textile industry wastewater treatment also needs a lot of scientific scrutiny. However, in absence of the critical investigation of the literature, the researchers often end up with less tested strategies for mitigating environment pollution related problems.

Presently, with pressure increasing on potable water supplies worldwide, interest in using alternative water supplies including recycled wastewater for irrigation purposes is growing. For irrigation purpose, wastewater is derived from a number of sources including domestic sewage effluent or municipal wastewater, agricultural (farm effluents) and industrial effluents and storm water, with each having specific unique feature to deal with. Although wastewater irrigation has many positive effects like reliable water supply to farmers, better crop yield, pollution reduction of rivers and other surface water resources, there are problems associated with it such as health risks to irrigators, build-up of chemical pollutants (e.g., heavy metal(loid)s and pesticides) in soils and contamination of groundwater. Since the environment comprises soil, plants, and soil organisms, wastewater use is directly associated with environmental quality due to its immediate contact with the soil–plant system and consequently can impact on it. For example, it has been reported that the presence of organic matter in wastewater-irrigated sites significantly affects the mobility and bioavailability of heavy metal (loid)s in the soil. Wastewater irrigation can also act as a source of heavy metal (loid) input to soils and untreated textile wastewater is a typical source of heavy metal pollution in aquatic ecosystems. Thus, in view of the challenges involved in dealing with the irrigation related problems as well as wastewater treatment, this review has been specifically carried out to know the state-of-art of different approaches used for dealing with the wastewater treatment in general and textile industry wastewater in particular.

Methodology

In this study the scientific literature was reviewed using the principles of deductive reasoning, wherein care was taken to use all the facts published in standard scientific journals with science citation index number. The review is presented in a chronological order to ascertain the evolution in the concerned field. The terminology used in the published literature was used to preserve the originality of the views expressed. Moreover, the general methods of content analysis have been followed to review the collected literature. Based on the review, the discussion is presented hereunder.

Discussion

On the basis of systematic study, Noseen *et al*, (2000) have reported that characterization of the textile industry wastewater is the pre-requisite for delineating a robust wastewater treatment strategy. In addition authors indicated that if not treated properly, textile effluents are responsible for very high pollution. Pulford & Watson (2003) reviewed literature to study the potential for using trees for the phytoremediation of heavy metal-contaminated land. They considered following aspects: metal tolerance in trees, heavy metal uptake by trees grown on contaminated substrates, heavy metal compartmentalisation within trees, phytoremediation using trees like willow (*Salix* spp.). Tzanakakis *et al* (2003) established slow rate (SR) systems, which were planted with four plant species *Eucalyptus*, *Acacia*, *Poplars* and *Reeds* to evaluate their effects on wastewater treatment and produced biomass. Furthermore, on the basis of the study authors concluded that different plant species grow at different rates and use the pollutants in variable rates as well as biomass production hence, type of plant to be used for phytoremediation should be finalized on the basis of preliminary or pilot study data.

Aubert & Schwitzguébel (2004) tested four plant species under hydroponic conditions for their ability to treat model effluents contaminated with mono- and disulphonated anthraquinones. Among them, *Rheum rabarbarum* (Rhubarb) showed the most promising results and was chosen for further investigation. The apparent transpiration stream concentration factor obtained with this plant species reached up to 2.5, indicating a strong phytotreatment potential that should be further explored then exploited. Asamudo *et al.*, (2005) summarized the available information in the use of this fungus for bioremediation purposes and also assess the current status of the technology. They further stated that the discharge of textile industry waste residues into the environment are eventually poison, damage or affect one or more species in the environment, with resultant changes in the ecological balance. Moreover, they have stated that the biological breakdown of the chlorolignin residues and the chromophoric groups responsible for the dark coloration of the textile effluent can be accomplished by the use of enzymes from the white rot fungus, *Phanerochaete chrysosporium*.

Davies *et al.*, (2005) have reported that selected an azo dye, acid orange 7 (AO7) can be degraded by *Phragmites australis* peroxidases (POD) activity when used in a vertical flow constructed wetland. Crude plant extract was found to degrade AO7 and its aromatic amines, after 120 h in contact with H_2O_2. Nilratnisakorn *et al.,* (2007) studied narrow-leaved Cattails in synthetic reactive dye wastewater under caustic conditions and reported that 60% color removal can be achieved under soil conditions. The SEM image of narrow-leaved Cattail root after treatment with synthetic reactive dye wastewater indicated that the root cortex was damaged and the crystalline sodium salts deposited in the root cells which caused evaporation and transpiration decreased in synthetic reactive dye wastewater. Authors cautioned that narrow-leaved Cattails are known to avoid the textile dye and salt stress conditions during synthetic reactive dye wastewater treatment and hence, should be used judiciously. Malik (2007) presented a comprehensive view of the research related to water hyacinth. He further stated that in the rural areas, water hyacinth could be used in an integrated manner for decentralized wastewater treatment systems coupled to biogas and compost production from the resulting biomass. Bulc and Ojstršek (2008) examined the treatment efficiency of constructed wetlands for the dye-rich textile wastewater with special focus on colour reduction. They stated that the results unequivocally proved that the constructed wetlands could offer an optimal solution to meet the environmental legislation as well as requirements for effective and inexpensive textile wastewater treatment.

Carias *et al.* (2008) studied the role of antioxidant and detoxification enzymes of *Phragmites australis*, in the degradation of an azo dye, acid orange 7 (AO7) and reported that the study results suggest that *P. australis* effectively uses the ascorbate–glutathione pathway for the detoxification of AO7. Savin and Butnaru (2008) indicated a need to accurately analyze the sources of water pollution and loading concentrations in textile finishing mills. Kagalkar *et al.*, (2009) found tissue cultured shrub plants of *Blumea malcolmii* decolorized Malachite green, Red HE8B, Methyl orange, Reactive Red 2 and Direct Red 5B at 20 mg L^{-1} concentration to varying extent within three days. Most rapid decolorization was observed in case of Malachite Green (93.41% decolorization within 24 h) and the cells were capable of tolerating and degrading high concentrations of dye, thus making them remarkable systems for phytoremediation studies. Rathod and Naik (2009) analyzed the agricultural land use pattern in Yavatmal district and gave a detailed report of the vegetation of the District that can be used for varied purpose, with phytoremediation being one of them. Furthermore, Deepali *et al.*, (2009) assessed the heavy metal concentrations in untreated and treated samples of textile industry effluent in Bahadarabad, Hardwar, which revealed that the chromium concentration was highest while concentration of Cd, Fe, Mn and Cu were within the prescribed limits. They opined that knowledge of heavy metal concentration in the textile industry wastewater is necessary to select the plant species for phytoremediation purpose.

Gernaey and Sin (2011) reported that wastewater treatments should be carried out with focus on the modeling of wastewater treatment process. Besides, authors expressed that plant-wide modeling is set to advance further the practice of wastewater treatment. Efficient and good modeling practice therefore requires the use of a proper set of guidelines, thus grounding the modeling studies on a general and systematic framework. Khandare *et al.*, (2011) observed that wild and tissue cultured plants of *Portulaca grandiflora* Hook. have shown to be able to decolorize a sulfonated diazo dye Navy Blue HE2R (NBHE2R) up to 98% in 40 h. also, the phytotoxicity study revealed reduction in the toxicity due to metabolites formed after dye degradation.

Khandare *et al.*, (2011) explored the potential of *Aster amellus* Linn. to decolorize a sulfonated azo dye Remazol Red (RR), a mixture of dyes and a textile effluent. Induction in the activities of lignin peroxidase, tyrosinase, veratryl alcohol oxidase and riboflavin reductase was observed during RR decolorization, suggesting their involvement in the metabolism of RR. Textile effluent and mixture of dyes showed 47% and 62% decrease respectively in American Dye Manufacturers Institute value after the treatment by *A. amellus* for 60 h; this indicated that the plant can be used for cleaning textile effluents.

Khandare et al., (2011) observed that wild and tissue cultured plants of *Portulaca grandiflora* Hook. can decolorize a sulfonated diazo dye Navy Blue HE2R (NBHE2R) up to 98% in 40 h. moreover, Gupta et al., (2012) reported that phytoremediation techniques for the treatment of different types of wastewater should be evaluated to know the most suitable technique for a given geographical area as well as the type of wastewater. They suggested the use of Water hyacinth, water lettuce and vetiver grass as possible phytoremediation agents.

Laboratory studies have shown phytoremediation is a feasible method for remediating sludge contaminated with heavy metals. In view of this Latif et al., (2012) studied phytoremediation of industrial sludge contaminated with Al, Cd, Cr, Cu, Fe, Pb, Ni, Mn and Zn using *Cyperus Kyllingia-rasiga, Asystassia intrusa* and *Scindapsus pictus Var argyaeus.* Authors reported that all these plant species were able to significantly absorb the metals present in industrial sludge. Kabra *et al.*, (2012) performed decolorization of structurally different dyes to varying extent because of induction of different set of enzymes in response to specific dyes on plants of *Glandularia pulchella* (Sweet) Tronc. and concluded that it shows great potential as a phytoremediation agent. Khataee *et al.*, (2012) reported that duckweed (Lemna minor L.) has a potential for degradation of an azo dye C.I. Acid Blue 92 (AB92).

Azo dyes, as the largest group of synthetic dyes released from textile and dyestuff industries, have caused serious environmental problems. In view of its environmental significance Xie *et al.*, (2012) investigated the removal ability and physiological response of sunflowers to simulated wastewater containing azo dyes with concentration similar to real wastewater or above and concluded that sunflowers can be used for phytoremediation of wastewater containing azo dyes. Kurade *et al.,* (2012) achieved efficient decolorization of textile industry effluent containing disperse dye Scarlet RR by a developed bacterial-yeast consortium BL-GG within 48 h with 68 and 74% reduction in BOD and COD values respectively, while the same consortium decolorized the solution containing single dye Scarlet RR (50 mg l^{-1}) within 18 h (pH 9.0, 40 °C, static condition) with 98% reduction in color. Sekomo et al., (2012) evaluated the use of algae and duckweed ponds as post-treatment for textile wastewater under the hypothesis that differing conditions such as pH, redox potential and dissolved oxygen in these ponds would lead to different heavy metal removal efficiencies. Patil and Jadhav (2013) carried out in vitro decolorization and remediation of a textile dye Reactive Blue 160 by *Tagetes patula* and reported that it can be used as a phytoremediation agent. Bubba *et al.,* (2013) reported that root and shoot of *Nicotiana langsdorffii* can accumulate Cr^{6+} with no significant loss of biomass.

Conclusions

Enormous volumes of effluent are generated at different stages of textile manufacturing, as a result of the use of copious amounts of chemicals and dyes. Several tons of textiles required to meet up with societal demands are produced daily in this industry. Beside, the toxic nature (due to presence of toxic reactive dyes, chlorolignin residues and dark coloration) of the textile industry wastewater can provoke serious environmental impact in the neighboring receptor water bodies. Though nature has demonstrated its capacity to disperse, degrade, absorb or otherwise dispose of unwanted residues in the natural sinks of the atmosphere. It is realized however that this ability is not finite and hence, the literature cited in this study shows that numerous plant species used by different workers can aid in removing the toxic heavy metals and other chemicals from the wastewaters. Besides, phytoremediation is a novel and promising approach for the treatment of pollutants, especially in the areas where land treatment remains the only viable choice for wastewater treatment. In addition to above, due to the high cost and limited efficiency of existing physical–chemical treatments, alternative cheaper processes like phytoremediation appear to be viable option for wastewater treatment.

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