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REVIEW ARTICLE

BIOREMEDIATION OF TEXTILE EFFLUENT FOR DEGRADATION AND DECOLOURIZATION OF SYNTHETIC DYES: A REVIEW

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ABSTRACT

Wastewater released from textile industries causes a large burden to put environment on risk due to its low biodegradability and harmful quality. Due to complexity in their chemical structure, synthetic dyes are extremely difficult to be present for degradation. Therefore, the dye wastewaters are highly toxic to crop plants, both aquatic fauna and flora including human beings. Couple of strategies such as physico-engineered systems are used to treat textile effluent. Unfortunately, these methods are found to be intemperate due to delivering hazardous by-products. Biological decolorization is an economically viable method and environment friendly thus presents a good alternative to engineered process. Many organisms (bacteria, fungi and algae) have good shown good adsorption of dyes and degrade dyes as they possess several important dye degrading enzymes. Microbial processes are found to be potent for the mineralization of synthetic dyes. Nevertheless, real potential of the microbial strains and their enzyme could be tested in suitable bioreactors for its future application in treatment of textile effluent.

Key words: Decolourization, Dyes, Microbial Degradation, Phytoremediation

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INTRODUCTION

In today's life, rapid industrialization and urbanization realized the arrival of boundless measure of waste into nature. Water is critical for survival and nearness of life on planet earth. The waste water is released from the textile industries, that misuses are going into the water bodies, it is one of large cause of environment risk (Kaur *et al*, 2010; Ahmed *et al*, 2012). The most common issue went up against on account of the textile dye industry is that the business makes considerable volumes of high calibre of liquid waste effluents. The extra dyes from different sources, for instance, material organizations, magnificence care items, paper production lines. More than 80,000 tones of dye are conveyed in these organizations. Textile effluents containing large amount of dyes eventually go into rivers and lakes (Manikandan *et al.*, 2012). Untreated wastewater tends to have low biodegradability and of harmful quality. It is one of the huge sources of ate up phenol, sweet-noticing amines (Rajeswari *et al.*, 2013). Couples of fragmented amines are known mutagens. Moreover, dyes impact negatively on other organs such as kidney, liver, gastrointestinal tract. The reusing of these effluents is carried out by couple of strategies includes physical systems. Physico-engineered systems, for instance, adsorption, light, molecule exchange, oxidative strategy, ozonation, coagulation have been used to decolorize textile effluent however these methodologies are intemperate, inefficient and deliver hazardous by-products (Sriram *et al.*, 2013). Over the earlier decades, natural degradation has been investigated as system to degenerate textile effluents. Biological decolorization is an eco-friendly method and cost effective thus presents a good alternative to engineered process. Bioremediation through microbes are considered as a good strategy due to the metabolic activities of microorganisms. The application of biological processes are limited mainly due to confined biodegradability of water pollutants such as dyes, inhibitory effects of xenobiotic compounds for the microbial population and slow rate of biodegradation (Jeworski and Heinzle, 2000).

Dyes as environmental pollutants

Two major sources are there from which toxic dyes are released; textile and dyestuff industries. Dyes used in the industries must be selected based on their stability during washing and photo stability. It should also be resistant to microbial degradation, therefore it is a cumbersome task to remove them from water using conventional wastewater treatment systems. Mauevin was the first synthetic dye discovered in 1856 (Welham, 1963). Over 1,00,000 dyes are manufactured since then with total production of over 7×10^5 metric tones worldwide annually. Synthetic dyes have application in many industries such as paper, cosmetics, pharmaceuticals, food and textile industries.

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In general, 10-15% of unused dyestuff enters in to water bodies directly. First and straight forward indication of water being polluted by toxic dyes is colour. Highly coloured effluent directly pollutes the receiving water. Most often dyes have synthetic origin. Due to their complex aromatic molecular structures, they are highly stable and rarely present for biodegradation. Synthetic dyes are classified as triphenylmethane dyes, azo dyes, nitroso dyes, anthraquinone , and xanthane dyes based on the chemical structure of the chromophoric group. As synthetic dyes, due to their complex structure, are highly resistant to degradation, dye effluents are highly toxic to crop plants, both aquatic fauna and flora, including human beings (Lin *et al*., 2010). These dyes are referred as persistent pollutants because they are most stable towards exposure to light and aerobic condition (Anlinker, 1997). Some dyes with monoazo or anthraquinone structures are found to bring about overly sensitive responses, i.e. skin issue or dermatitis. Taking after oral route, these colours are metabolized to fragrant amines by enteric microflora or liver azoreductases (Chung and Cerniglia *et al*., 2009).

Microbial degradation of textile effluents

Microbial degradation and decolorization of dyes is considered as a economically effective method for removing these pollution from the environments (Pearce *et al*, 2003). Many microorganism from different bacterial, fungal and algal species are capable to adsorb and degrade dyes (Don Santoz, 2007). Decolorization of wastewater by microbes and plants are well discussed before in some literatures (Dwivedi and Cameotra, 2010). Decolourization and mineralization of dyes by bacteria is reasonably faster compared to fungal system (McMullan *et al*., 2001). Since numerous bacterial species including *Bacillus, Pseudomonas, Enterobacter and Halobacter* have been found to decolorize and detoxify a wide range of dyes whose toxicity is compared to phenylamine, benzenediazonium chloride or phenol (Mendes *et al*., 2011; Feng *et al*., 2012).

Bacteria

Bacillus spp, Alcaligenes spp, Acinetobacter spp are some imperative bacterium found supportive in bioremediation of halogenated fragrant mixes and textile effluent. Natural biotechnology relies on the waste water decolorizing ability by presenting microbial pool inside textile effluent. A group of *Pseudomona aeruginos,* and *P. putida* C15 was discovered as efficient group for decolorizing all the dyes when used as a consortia (Omar *et al*., 2009). For ideal degradation and decolourisation of synthetic dyes, optimum temperature of 29°C - 30°C (Robinson *et al*., 2001) was investigated. Previous studies showed that pH value of 7.0 was observed to be most appropriate for ideal decolourisation of several dyes (Verma and Madamwar *et al*., 2002). Zhou and Zimmerman (1993) attempted bacterial degradation with receptive colours (anthraquinone, phthalocyanine, azo and metal complex colours). The underlying stride in bacterial azo colour digestion system under anaerobic conditions includes the reductive cleavage of the azo linkage. This procedure is catalyzed by an assortment of dissolvable cytoplasmic proteins with low-substrate specificity, which are known as "azoreductases". Under hypoxic/anoxic conditions, these catalysts encourage the exchange of electrons through solvent flavins to the azo colour. The work of Russ and associates (2000) disclosed that the "azoreductases" (cytoplasmic in location) are probably flavin reductases and they have inconsequential significance in the *in vivo* decolourisation of sulfonated azo mixes. A membrane "azoreductase" was discovered by Kudlich and colleagues (1997) in the cell mass of a *Sphingomonas sp.* This strain had both cytoplasmic and layer bound azoreductase activity. Rafii recommended an extracellular azoreductase movement in studies with microorganisms isolated from human digestive system, basically *Eubacterium sp.* and *Clostridium sp.* (Rafii *et al*., 1990). *Bacillus sp*., isolated from a discharge effluent of a textile industry, was also tested and observed for the sequential decolorization and detoxification of the azo dyes; Acid red, Remazol black, and anthraquinone dye; Reactive blue (Dwivedi and Tomar, 2017). More recently, *Serratia liquefaciens* was suggested as a potential bacterium for azo dye (Azure –B) degradation and found effective in reducing phytotoxicity, genotoxicity and cytotoxicity of the dye (Haq *et al*., 2018). Strains belonging to the genus *Acinetobacter* and *Klebsiella* showed excellent results for decolorizing and degrading mono and di-azo dyes commonly applied in textile production (Meerbergen *et al*., 2017).

Fungi

Numerous fungi are capable of decolourize and mineralize pollutant compounds because of their ligninolytic enzymes which are oxidative and non-specific . The most considered colour decolourising type of fungi are the white-rot fungi like *Phanerochaete chrysosporium* (Glenn and Gold 1983), *Trametes versicolor, Bjerkandera adusta* (Field *et al*. 1992), and *Coriolus versicolor* (Kapdan and Kargi 2002). These fungi produces dye degrading enzymes such as manganese peroxidase (MnP), lignin peroxidase and laccase (Bergsten-Torralba, 2009). Under static *in vitro* condition the decolorization capabilities of the fungal species were assessed by Namdhari *et al*. (2012) for reactive blue MR dye (100-300mg L^{-1}) in carbon limited Czapek Dox broth. *Aspergillus allhabadii* and *A. sulphureus* showed higher decolorization (95.13±0.11%), (93.01±0.25%) in concentration of 200mg L^{-1} dye, while *A. niger* showed little lesser decolorization (83%) with 100 mg L^{-1} after ten days of incubation. Basidiomycetes fungi decolourize dyes by adsorption of the dyes to the mycelial surface mainly and further metabolic breakdown thereof by both batch mode and continuous mode. For the treatment of azo dyes and textile dye industry effluent, *Schizophyllum commune* was found to be more efficient than *Lenzites eximia* (Selvam and Shanmuga Priya *et al*., 2012). High and low level of manganese peroxidase and lignin peroxidase activities respectively were observed during the decolorization process of azo dyes from the supernatant of *Trichoderma tomentosum* culture (He *et al*., 2018). Optimization of conditions for decolorization of azo-based textile dyes by multiple fungal species was evaluated for their ability to decolorize toxic azo dyes and conditions were optimized to achieve maximum decolourization (Abd El-Rahim *et al*., 2017).

Yeasts

Yeasts have some advanced features in comparison to bacteria and filamentous fungi. Therefore, it is coming up as a promising alternative to existing methods of treatment which includes bacteria and fungi. (Das *et al*., 2012). Decolorizing ability of *Kluyveromyces marxianus* IMB3 was investigated in Remazol Black-B dye and colour removal of 98% was achieved at 37°C (Meehan *et al*, 2000). Several yeast strains showed similar decolorizing behavior. The yeast-mediated decolourisation process demands an alternative carbon and energy source and is not dependent on earlier exposure to the dyes. Ramalho *et al*., 2005 reported *Saccharomyces cerevisiae* mutant strains which showed decolorizing capability. First methylotrophic yeast, *Candida boidinii* MM 4035, with dye decolorizing ability was characterized. Manganese dependent peroxidase activity could be detected during decolouration process (Martorell *et al*., 2017).

Phytoremediation of textile effluents

The utilization of green growth for the debasement of colours is specified in just few reports and is accomplished by algae species such as *Chlorella* (Acuner and Dilek *et al*., 2004), *Oscillateria* and *Spirogyra* (Mohan *et al*. 2002). The degradation rate appears to be related to the molecular complexity of the dyes and algal species used. Enzyme azo reductase from algae is capable to cleave azo linkage and thus responsible for degrading azo dyes into aromatic amine. Further metabolism of the aromatic amine is then carried out by algae. Mono and di azo dye were also decolorized by green algae, cyanobacteria and diatoms in an investigation carried out by Hanan *et al*., 2008. There are some studies that depict the utilization of plants for the colour expulsion from wastewaters. Decent expulsion limit of sulphonated anthraquinones with *Rheum rabarbarum* was evaluated albeit just showed preparatory results that should be further researched. This plant has proteins that acknowledge anthraquinones as substrates and in cell society could evacuate up to 700-800 mgL^{-1} of anthraquinones with sulphonate bunches in various positions (Aubert and Schwitzguébel *et al*., 2004). Phytoremediation assisted by biological organism has recently made its place among innovative cleanup approaches in which microorganisms and plants altogether work to detoxify xenobiotic dyes and transform in to nontoxic and less harmful products. This method relies on synergy and competence between plant and microbe to treat dyestuffs (Tahir *et al*., 2017).

Enzymes from microbes involved in decolourisation of dyes

Microbial degradation of textile dyes is catalyzed by enzymes. Few names of the prominent enzymes are; laccases, azoreductase, manganese peroxidase, lignin peroxidase, and hydroxylases. Azoreductase and Laccase are well known for their ability to degenerate azo dyes (Reyes *et al*., 1999). Only few enzymes are capable to degrade dye molecules due to high structural variety of dyes. Enzymatic processes are found to be very promising for the decolorization of synthetic azo dyes. Genome mining of *Pleurotus ostreatus* revealed the presence of 53 lipase and 34 carboxylesterase putative coding-genes. Of which novel lipase was also discovered (Piscitelli *et al*., 2017).

Conclusion

Mineralization and degradation of dyes remains as a challenge to waste water treatment as well as textile industries. Findings from various literatures suggest a great potential for microorganism to be utilized for removal of colour from dye wastewaters. Considering the fact that microbes are adaptive in nature, have ability to degrade contaminants, and high tolerance to toxic dyes which provide several advantages for microbial remediation of textile industry effluent. However, real potential of the microbial strains and their enzyme could be tested in suitable bioreactors for its future application in treatment of textile effluent. Another recent trend of this project would be to explore the efficiency of some thermophilic strains for the degradation at higher temperatures and wider range of pH. We can also explore other biological organism such as algae and plants as bioremediation agents of textile dyes.

REFERENCES

Abd El-Rahim W.M., Moawad H., Abdel Azeiz A.Z., Sadowsky M.J. 2017. Optimization of conditions for decolorization of azo-based textile dyes by multiple fungal species. *J Biotechnol.* 260:11-17.

Acuner E, and Dilek FB. 2004. Treatment of tectilon yellow 2G by *Chlorella vulgaris*. *Process Biochemistry* 39: 623-631.

Ahmed T F, Sushil M and Krishna M. 2012 *International Research Journal of Environment Sciences* 1(2): 41-45.

Anlinker R. 1997. Color chemistry and environment. *Exotoxicol Environ Saf* 1: 211-237.

Aubert S, and Schwitzguebel JP. 2004. Screening of plant species for the phytotreatment of wastewater containing sulphonated anthraquinones. *Water Res* 38: 3569-75.

Bergsten-Torralba, L.R., Nishikawa, M.M., Baptista, D.F., Magalhães, D.P., da Silva, M. 2009. Decolorization of different textile dyes by *Penicillium simplicissimum* and toxicity evaluation after fungal treatment. *Brazilian Journal of Microbiology* 40: 808-817.

Chung KT, and Cerniglia CE. 2009. Mutagenicity of azo dyes: structure-activity relationships. *Mutat Res* 277: 201-20.

Das N. and Charumathi D. 2012. Remediation of synthetic dyes from wastewater using yeast- an review. *Indian journal of Biotechnology.* 11: 369-380

Dos santos A.B., Cervantes F.J., Van Luer J.B. 2007. "Review paper on current technnologies for decolorization of textile waste water" Prospectives for anaerobic biotechnol. *Bioresour.Technol.* 98:2369-2385.

Dwivedi P. and Cameotra S. S. 2010. Decolorization of toxic dyes in wastewater. *In Trends in Bioremediation and Phytoremediation*, ISBN 978-81-308-0424-8, Ed.Grazyna Plaza, Poland, 173-187.

Dwivedi P. and Tomar R. S. 2017. Microbial Degradation and Decolorization of Azo and Anthraquinone Textile Dyes. *International Journal of Pharma and Bio Sciences*. 8(2): (B): 989-998

Feng J., Cernigila C.E. and Chen H. 2012. Toxicological singnificance of azo dyes.

Field J.A., de Jong E., Feijoo Costa G., and de Bont J.A. 1992. Biodegradation of polycyclic aromatic hydrocarbons by new isolates of white rot fungi. *Appl Environ Microbiol* 58: 2219-26

Glenn J, and Gold M.H. 1983. Decolorization of several polymeric dyes by the lignin-degrading basidiomycete *Phanerochaete chrysosporium*. *Applied and Environmental Technology* 45: 1741-1747.

Haq I., Raj A, Markandeya. 2018. Biodegradation of Azure-B dye by *Serratia liquefaciens* and its validation by phytotoxicity, genotoxicity and cytotoxicity studies. *Chemosphere* 96:58-68.

He X.L., Song C., Li Y.Y., Wang N., Xu L., Han X., Wei D.S. 2018. Efficient degradation of Azo dyes by a newly isolated fungus *Trichoderma tomentosum* under non-sterile conditions. *Ecotoxicol Environ Saf* 150:232-239.

Jeworski M, and Heinzle E. 2000. Combined chemical-biological treatment of wastewater containing refractory pollutants. *Biotechnol Annu Rev* 6: 163-96.

Kapdan I. K., and Kargi F. 2002. Biological decolorization of textile dyestuff containing wastewater by *Coriolus versicolor* in a rotating biological contactor. *Enzyme and Microbial Technology* 30: 195-199.

Kaur A., Vats S., Rekhi S., Bhardwaj A., Goel J., Tanwar R.S. and Gaur K. K. 2010. *Procedia Environmental Sciences*. 2:595–599.

Kudlich M., Keck A., Klein J., and Stolz A. 1997. Localization of the Enzyme System Involved in Anaerobic Reduction of Azo Dyes by *Sphingomonas sp*. Strain BN6 and Effect of Artificial Redox Mediators on the Rate of Azo Dye Reduction. *Applied and Environmental Microbiology* 63: 3691-3694.

Lin J., Zhang X., Li Z., Lei L. 2010. Biodegradation of Reactive Blue 13 in a Two-stage anaerobic/aerobic fluidized beds system with a *Pseudomonas sp.* isolate. *Bioresource Technology.* 101(1): 34-40.

Martorell M.M., Pajot H.F., Ahmed P.M., de Figueroa L.I.C. 2017. Biodecoloration of Reactive Black 5 by the methylotrophic yeast *Candida boidinii* MM 4035. *J Environ Sci (China)* 53:78-87.

Meerbergen K., Willems K.A., Dewil R., Van Impe J., Appels L., Lievens B.2017. Isolation and screening of bacterial isolates from wastewater treatment plants to decolorize azo dyes. *J Biosci Bioeng*. pii: S1389-1723(17)30864-2. doi: 10.1016/j.jbiosc.2017.11.008. [Epub ahead of print] PubMed PMID: 29273268.

Manikandan N., SurumbarKuzhali S. and Kumuthakalavalli R. 2012. *J. Microbiol. Biotech. Res.* 2 (1):57-62.

McMullan G., Meehan C., Conneely A., Kirby N., Robinson T., Nigam P., Banat I.M., Marchant R., and Smyth W.F. 2001. Microbial decolourisation and degradation of textile dyes. *Appl Microbiol Biotechnol* 56: 81-7.

Mendes S., Pereira L., Batisa C., Martins L.O. 2011. Molecular determinants of azoreduction activity in the strain *Pseudomonas putida* MET94", *Applied Microbiology and Biotechnology* 92(2): 393-405

Mohan S.V., Rao N.C., Srinivas S., Prasad K.K., and Karthikeyan J. 2002. Treatment of simulated Reactive Yellow 22 (azo) dye effluents using *Spirogyra species*. *Waste Manag* 22: 575-82.

Namdhari, B.S., Rohilla, S.K., Salar, R.K., Gahlawat, S.K., Bansal, P and Saran, A.K. 2012. Decolorization of Reactive Blue MR, using *Aspergillus species* Isolated from Textile Waste Water. *ISCA J. Biological Sci* 1(1): 24-29.

Omar, K., Lee, K. K., and Mohammed, F. A. 2009. Isolation screening and development of local bacterial consortia with azo dyes decolourising capability. *Malaysian Journal of Microbiology* 5(1): 25-32.

Omar H.H. 2008. Algal Decolorization and Degradation of Monoazo and Diazo Dyes. *Pakistan Journal of Biological Sciences* 11: 1310-1316.

Pearce C.I., Lloyd J.R., and Guthrie J.T. 2003. The removal of colour from textile wastewater using whole bacterial cells: a review. *Dyes and Pigments* 58: 179-196.

Piscitelli A., Tarallo V., Guarino L., Sannia G., Birolo L., Pezzella C. 2017. New lipases by mining of *Pleurotus ostreatus* genome. *PLoS One*12(9):e0185377.

Rafii F., Franklin W., and Cerniglia C.E. 1990. Azoreductase activity of anaerobic bacteria isolated from human intestinal microflora. *Appl Environ Microbiol* 56: 2146-51.

Rajeswari K., Subashkumar R. and Vijayaraman K. 2013. *J. Microbiol. Biotech. Res* 3 (5): 37-41.

Russ R., Rau J., and Stolz A. 2000. The Function of Cytoplasmic Flavin Reductases in the Reduction of Azo Dyes by Bacteria. *Applied and Environmental microbiology*. doi: 10.1128/AEM.66.4.1429-1434.

Ramalho P. A., Paiva S., Paulo A.C., Casal M., Cardoso M. H. and Ramalho M.T. 2005. Azo reductase activity of intact *Saccharomyces cerevisiae* cells is dependent on the Fre1p component of the plasma memberane ferric reductase. *Appl.Environ Micrbiol.*

Reyes P., Pickard M.A., and Vazquez-Duhal R. 1999. Hydroxybenzotriazole increases the range of textile dyes decolorized by immobilized laccase. *Biotechnol Lett.* 21: 875-880.

Robinson T., McMullan G., Merchant R., and Nigam P. 2009. Remediation of Dyes in Textile Effluent: A Critical Review on Current Treatment Technologies with Proposed Alternative. *Journal of Bioresource Technology*. 77:247-255.

Selvam K. and Shanmuga Priya M. 2012. Biological treatment of Azo dyes and textile industry effluent by newly isolated White rot fungi *Schizophyllum commune* and *Lenzites eximia*, *International Journal of Environmental Sciences* 2: (4).

Sriram N., Reetha D. and Saranraj P. 2013. *Middle-East Journal of Scientific Research* 17 (12):1695-1700.

Tahir U., Sohail S., Khan U.H. 2017. Concurrent uptake and metabolism of dyestuffs through bio-assisted phytoremediation: a symbiotic approach. *Environ Sci Pollut Res Int.* (29):22914-22931.

Verma P. and Madamwar D. 2003. Decolourisation of synthetic dyes by a newly isolated strain of *Serratia marcescens*. *World Journal of Microbiology.Biotechnology* 19: 615-618.

Welham R.D. 1963. The Early History of the Synthetic Dye Industry. Wiley online library, 79(3): 98-105.

Zhou W. and Zimmermann W. 1993. Decolorization of industrial effluents containing reactive dyes by actinomycetes. *FEMS Microbiol Lett* 107: 157-61.

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