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Microbes From Textile Effluents Sites Potential Source Of Bioremediation: A Review

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Abstract

Effluents throw from many tannery industry consist of very toxic chemical and dyes. Treatment process including physical and chemical protocol has been not efficient due to the high process costs, and complex operational system therefore suitable alternative will be required, also these methods unable to destroy dyes and detergents completely. Therefore present review revealed by using microbes having effective potential to biodegrade of toxic compounds contaminated with environmental soil. Little bacterial as well as fungal strain belonged to Genera *Bacillus*, *Exiguobacterium*, *Acinetobacter* and *Aspergillus* presence in effluents discharge. The potential microorganism having dye degrading property could be isolated and mass multiply under lab condition. Our hypothesis is textile effluents consisting resistance strain identified from selection pressure sites utilize food source for survival. ultimate aim of review to critically discuss and suggested novel cost effective and efficient bioreactor system for complete removal of toxic chemicals and dyes originated from textile mills.

Key words: Environments; Untreated; Heavy metals; Detergents; Textile mills

Introduction

Water pollution control is the most important concern worldwide. The major contributors to air and water pollution are industries. Textile industry need large amount of water during processing of textile and further discharge in near wise cultivated land. (Asia 2006, Andre 2007). The textile effluents are dumped into the river and cultivated land is now global concern (Mubarak 2011). The discharge of these dye-containing effluents, throw directly into the water environment and makes it unfavourable because of their colour, and degrade product either toxic or carcinogenic or both to life particularly due to the presence of carcinogens, such as naphthalene, benzidine and several other aromatic compounds. These untreated industrial effluents flowed into the river as well as dumped on land are toxic to living organism and environments (Malarkodi 2007), and it is one of the major concerns of food contamination (Ramachandran 2013). These effluents loaded with heavy concentration

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of heavy metals which have carcinogenic property (Bhagat 2013; Ramachandran 2013; Tamburlini 2002). However, efforts for reducing water and soil contamination are very limited. Therefore, efficient and environmental friendly approaches are required for treatment of textile effluents before and after discharge into cultivated land. Many textile industry released dye consisting of heavy metal (Chromium, lead, Iron and Zinc) which further effect quality of drinking water. Water in affected area contaminated with high levels of chlorides and fluorides. Many physical and chemical methods have been use during treatment process. Some of the industries have the effluent treatment plants but has not been much satisfactory. Also treatment of textile effluents using physiochemical methods are difficult and very expensive, resulting in the deposition of large amounts of sludge and toxic substances, which also creates the secondary level of land pollution (Banat 1996). These methods are only effective when the volume is small. Biodegradation is an effective approach for the remediation of dyes wastewater because of cost effectiveness and environment friendly nature in disposing textile effluent (Ponraj 2011). Several microorganisms can completely decolorize many dyes which includes fungi, bacteria, yeasts, and algae (Tripathi et. al., 2011 Feng 2012). Various studies have investigated many bacterial species (aerobic or anaerobic) have capability to degrade and decolourize depends on its adaptability either (Wong 1998, Banat 1996). Several aerobic and anaerobic bacterias such as *Bacillus sp* (Abraham et. al., 2014), *Pseudomonas putida* (Tripathi et. al., 2011), *Pseudomonas putida* (Wei Wang et. al., 2012), *Pseudomonas sp*. (Shah et. al., 2013), *Bacillus subtilis* (Milikli G. et. al., 2012, Saleh 2013), *Bacillus subtilis* SPR42 (Baljeet 2011), *Bacillus sp*. (Srinivasan et al, 2013), *Exiguobaterium* sp. RD3 (Dhanve 2008) degrade reactive blue colour.

Approaches towards the industrial wastewater treatment

For the colour removal from industrial effluents several attempts have been made. These are divided into physical, chemical and biological. High cost are involve in Physical and chemical processes are costly due to including cost of chlorinated lignins, toxicants, colours, suspended solids. However limitation in complete excluding of BOD (Singh and Thakur, 2006). Colour removal by biological technique is found to be very attractive as in addition to the removal of colour and reduction in COD, it has also reduced BOD and chlorolignins which is of low molecular weight (Barton 1996; Nagarathnamma 1999). Anaerobic treatment is a secondary treatment process implemented on the industrial wastewater (Pearson, 1990; Welander 1999, Mishra 2006). Electro-Fenton process is used to remove the mixture of synthetic dyes, so as to remove colour from water and it was observed their toxicological

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effects on aquatic environment (Lahkimi 2007). Approximately 75% of the dyes are throw in rivers/pounds and lake by textile processing industries which consist of mineral salts media reactive 36%, 25% of acids and 15 % of direct dyes (Shah 2014).

Fig.1: Pros and cons of different methods for inhibition of dyes from textile effluents. (Robinson *et al*, 2001b)

Physical/Chemical Methods	Merit	Demerit
Fenton Reagent	decolaration of all dyes	Sludge formation
Ozonation	Introduced in gaseous state, no change in volume	very little half life
Photochemical Sodium hypochlorite	Nil sludge formation Increase Azo bond cleavage	Formation of by-products Discharge of aromatic compounds
Electrochemical destruction	Break-down compounds are nonhazardous	High electricity consumption
Activated carbon	Used for wide range of dye	High cost
Peat	Higher Adsorbent at cellular level	specific surface area comparatively less than activated carbon
chips	Higher sorption for acidic dyes	longer retention time
Silica gel	Reduced accumulation of basic dye	limitation with commercial production
Membrane filtration	applicable for all dyes	sludge Reaction
Ion-exchange	Nil adsorbent loss	Not applicable for all dyes
Irradiation	more oxidation in control condition	Comparatively high Amount of dissolved oxygen

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Electrokinetic coagulation	Low cost	More sludge formation

Bioremediation

Bioremediation is an upcoming innovative technique that is frequently being used for cleaning the contaminated sites. Recent research and work is expanding the capabilities of this technology which along with an advantage of cost effectiveness has led bioremediation becoming an increasingly efficient cleanup technology for science. The process of bioremediation increases the rate of microbial degradation of contaminants at the polluted sites either naturally or by introducing these microorganisms with optimized nutrients, carbon source and by varying some environmental factors. This can be achived by using potential microorganisms or by adding culture of enriched microorganisms (bacteria/fungus etc) having specific characteristics that allow them to act on the desired site and degrade it at a faster rate in an effective way creating no hazards and harm. Therefore, the result of bioremediation is the complete mineralization of contaminants to water and carbon dioxide without the formation of intermediates. The most attractive nature of technology is due to low cost. Hence role of the bioremediation wide range of area including treatment plants, industry effluents sites as well as contaminated soil and environments.

Biological techniques

Biological techniques of decolourization use various microorganisms mainly bacteria, fungi and algae to capability to reduced level of dyes/detergents from industrial effluents. . Many researchers investigated partial as well as complete degradation of the dyes and detergents when inoculated effluents with microbes either in the form of pure culture or mixed culture.

Fungal decolourization

Fungi are another class of microorganism and its economic importance and value and its pathogenicity are not unknown to us. Many investigation found that fungi with greater potential for degradation of chemical dyes for example, heterocyclic dyes, azo, triphenyl methane, polymeric and phthalocyanine (Chulhwan 2004). Many lignolytic fungi, called as *Phanerochaete chrysosporium*, *Pleurotus* sp., *Trichophyton rubrum* LSK-27, *Irpex lacteus*, were commercially exploited for decolourization of textile dyes (Novotny 2004; Zille 2005; Nilsson 2006; Yesiladal 2006). It is well known that white-rot fungi release enzyme laccases, Mn peroxidase (MnP) and lignin peroxidase (LiP), that has the ability of the degradation of lignin (Duran 2002). Fungal dye decolorization possible by two methods such as biosorption as well as biodegradation. Textile dye waste also decolorised by yeast biomass (Jadhav and

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Govindwar 2006). White rot fungus *S. Commune* maily used in paper and polp industry for complete degradion (Belsare and Prasad 1988). *Tinctoporia borbonica* called white rot fungi consisting of enzyme for decolourize waste liquor release from kraft industry (Fukuzumi 1980). Wide range of *Penicillum* species also investigated for dye decolorization potential by many authors (Shedbalkar 2008). Recently isolated fungal strain *Penicillium* sp can also decolorize azo dyes present in effluents (Gou 2009).

Algal Decolourization

Algal are also useful for absorption of dyes from textile effluents, for example *Chlorella species*, *Chlorella kessleri*, *Chlorella vulgaris*, some *Scenedesmus sp*. *Scenedesmus bijugatus* and *Scenedesmus obliquus* and cyanobacteria strains. *Nostoc muscourm*, *Oscillatoria angusta*, *Anabaena laxa*, *Anabaena subcylindrica*, *Nitzschia perminuta* including *Cosmarium* sp. and *Enteromorpha prolifera* found to be efficient technology to decolorization triphenyl methane dyes (Ozer et al., 2005; Omar 2008; Yesiladal 2006).

Bacterial Decolourization

Many bacterial species degrade azo dyes from textile effluents paves (Patil 2009; Patil 2010). Operational costs turn out to be very low and produce non toxic end product. Moreover, process of mineralisation. Several forms of the bacterial degradation of synthetic dyes have been previously studied (Pandey, 2006). Decomposition of azo dyes under anaerobic bacteria is highly reproducible process which contains degradation of azo dyes and also releases degradative products such as aromatic amines. Anaerobic bacteria species degrade azo bond and produce non toxin amines Some of them are *Pseudomonas* sp. SUK (Kalyani 2008); *Exiguobacterium* sp. RD3 (Dhanve 2008); *Bacillus* sp. UVS (Dawkar 2008), *Pseudomonas aeruginosa* strain BCH (Jadhav 2010); *Commamonas* sp. VUS (Jadhav 2008).

Anaerobic Decolorization Process

Anaerobic reduction of dyes containing azo bond by the use of microbes is an effective and economically best treatment process for the removal of colour from effluent treatment plants. Few study reported that anaerobic bacteria break Azo bound of dyes (Razo-Flores *et al.*, 1997). Many of the aromatic compounds easily destroy by anaerobic digestion. In anaerobic environment, there are also some of the results which show that some azo dye and their intermediates may get completely stabilized or degraded (Razo-Flores, 1997). Investigation conducted using major anaerobes and revealed the degradability of seven azo dyes (Chung et al., 1998). Various studies were also followed by using isolated bacterial strains under *in vitro* culture exploited for complete removal of dyes from effluents discharge sites. Also, some of the intermediates have been found to be mutagenic. The degradation of these dyes can be possible in both anaerobic and aerobic systems (Brown et al. 1987). They investigated the degradability of twenty two commercial azo dyes anaerobic microbes (Brown and Hamburger, 1987). It was confirmed by the azo bonds cleavage and the production of intermediates was also observed. In such case anaerobic bacteria were used for dye degradation. The results both observed was showing good decolourization with minimal nutrient removal (Llyod and Ganesh, 1992).Thus, it was concluded that high degradation of dyes from textile effluents and declourization is achieved in anaerobic condition (Kothari 2002; Kothari 2006).

Aerobic Decolorization Process

For the reduction of organic pollutants in wastewater system, activated sludge treatment of wastes proved to be efficient and highly economic. However, aerobic treatment of azo dye wastes was found to be less effective in some of the cases, but proved itself a typical method of treatment being used today (Edwards, 2000). As aerobic microbes unable to destroy azo linkages, however, anaerobic bacterium able to digest degrades (Brown and Laboureur 1983b). Aromatic compound lead to accumulate in living tissue and further create health hazard and found severe disease complication. Several investigators recently reported the aerobic decolorization of azo dyes (Adedayo *et al.*, 2004; Mona *et al.*, 2008). A batch experiment was conducted by *Bacillus subtilis* which degrades *p*-aminoazobenzene, an aromatic amine (Zissi 1997).

Anaerobic-Aerobic Process

Basically, azo dye degradation successfully reported by bacterial action. Initially reduction of azo dyes by anaerobic-aerobic produce non hazardous compounds. The second way consisting the complete detoxification of toxic aromatic amines under anaerobic conditions, whereas, biodegradation using microbes contains aromatic amines is purely an aerobic process (Vander jee, 2005). The best idea for removing azo dyes from effluent is the treatment which involves the combination of anaerobic and aerobic conditions subsequently. Azo dyes removed by anaerobic reduction followed by treatment of aromatic amines by aerobic oxidation of the dyes which are generally hazardous and carcinogenic. Studies on

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anaerobic aerobic reactor perform greater o color removal capacity. Furthermore, several studies have provided a lot of evidence for removal of aromatic amines by the use of combined anaerobic-aerobic treatment. Thus, it is a known as most reliable and efficient tool for the complete degradation of azo dyes from effluent (Naimabadi *et al.*, 2009). Much investigation, deal anaerobic with aerobic efficient systems for degrading textile dyes (O'Neill *et al.*, 2000; Kothari and Kothari 2002, 2006). The major route for the release of azo dyes to soil and environment is indirectly via the disposal of wastewater sludge to agricultural land or for the landfill purpose. Due to the insoluble nature of dyes, some of this dye will remain in soils when released to land and environment get disturbed. Some azo colourants bio transform into aromatic amines in soil (McMullan 2001).

Bioremediation: Current limitation and Industrial resources in India

There have been various reports on use of indigenous microorganisms such as dye degrading bacteria as well as fungi being used for the simultaneous removal of colour from industrial wastewater. There are so many industries like chemical, sugar, distillery, paints, dyes as well as textiles in Chennai, Coimbatore, Tirupur, Kurur in Tamil Nadu. A large piece of work has been done the textile effluents of southern region. From where potential dye decolourising bacteria have been isolated showing the property of bioremediation. Some places of Uttar Pradesh like Tanda, Varanasi, Lucknow etc has industries and especially carpet industry of Bhadohi, many work has been going on to treat the effluent discharged. Bacteria with effective bioremediative property are isolated from their native habitat. Inspite of having thousands of textile and dyeing firms in Bhilwara and nearby places of Rajasthan least are from these regions. This region is suffering a lot with water pollution (Bhagat 2013). This Bhilwara region suffers a major pollution from textile industries. Cities of Punjab and Haryana like Jalandhar, Ludhiyana, Chandigarh posses many of the wool mills and textile mills. Table (2) is listed with the Industrial resources in India from where work is going on.

Table 2. Textile Industrial Resources in India

S.No.	Place	Reference
1.	Ambedkar Nagar, Uttar Pradesh	Singh et. al., 2014
2.	Carpet Industry, Bhadohi, UP	Singh. et.al., 2015

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3.	Textile Industry, Raipur	Srivastava, 2010
4.	Tirupur, Tamil Nadu	Prasad and Rao, 2010; Rajeshwari 2011
5.	Jodhpur, Rajasthan	Khan and Mathur 2015
6.	Upillipalayam, Erode	Srinivasan 2014
7.	Oswal Textile, Ludhiana,Punjab	Kochher and Kumar 2011
8.	Ankeleshwar, Gujrat	Shah et. al., 2013; Pandit et. al., 2013
9.	Kurur, Tamil Nadu	Karthikeyanan et. al., 2012
10.	Bhilwara, Rajasthan	Kumar et.al., 2016: Kumar and Sexana, 2019
11.	Bhilwara, Rajasthan	Bhagat et. al., 2013

Current and Future Aspect of Biochemical and Molecular Studies

Bacteria were traditionally identified by microscopy and morphological study which were time consuming. Thus, molecular and biochemical characters are an important supplement to morphological characters used to define and relate taxa. Before phylogenetic analysis of bacterial DNA sequences it is first necessary to identify the correct species through morphological observation through electron microscopy and then by various biochemical tests. For the morphological analysis DNA extraction is done and amplified by using universal primers. 16S rDNA sequence from bacterial species analyzed by NCBI online public database using BLAST tool and the corresponding sequences were downloaded from public database. Neighbor-joining method was drawn by the help of clustal-W alignment program and preparation of phylogenetic tree (Patil *et al.*, 2008; Dhanve *et al.*, 2009). Thus, these advance methods gives a complete detail of the isolated bacterium. The present work primarily involves the study on biological degradation of effluent from common effluent treatment plant. Bacteria were isolated from the various samples and observed for effective decolourization of dyes followed by biochemical analysis and molecular analysis. Previous

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report of Rajeshwari in 2011 showed that Bacillus sp. gave maximum declourization on optimizing various factors like pH, glucose and nitrate concentration. Effluent adapted strains of *Acinetobacter, Bacillus* showed a good potential for colour removal (Feng 2012). With potential degradation, bacterium is subjected to identification based on 16 SrRNA sequencing. Hassan *et al.*(2013) found that many bacterial species showed decolourizing activity. Isolation and screening of microorganisms capable of decolourizing various azo dyes from sludge samples collected from dye containing wastewater treatment sites (Mahmood, 2012; Karthikeyan 2013).

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