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6. Integrated Treatment of Carpet Effluent Using Packed Bed Reactor

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LIST of ABBREVIATIONS

COD	:	Chemical Oxygen Demand
TSS	:	Total Suspended Solids
TVSS	:	Total volatile suspended solids
MPN	:	Most Probable Number
HPLC	:	High Performance Liquid Chromatography
FTIR	:	Fourier transform infrared spectroscopy
DCIP	:	Dichloro-phenol indophenol
NADH	:	Nicotinamide adenine dinucleotide
NADPH	:	Nicotinamide adenine dinucleotide phosphate
AQDS	:	Anthraquinone-2, 6-disulfonate
MSM	:	Mineral Salt Media
NCBI	:	National Center for Biotechnology Information
BLAST	:	Basic Local Alignment Search Tool
CDRI	:	Central Drug Research Institute
BMM	:	Basal Mineral Medium
NADH-DCIP		Nicotinamide adenine dinucleotide Dichloroindophenol
MSM	**:**	Mineral Salt Media
DCIP	**:**	Dichloro-phenol indophenols
GC-MS	**:**	Gas chromatography–mass spectrometry
PCR	**:**	Polymerase chain reaction
DNA	**:**	Deoxyribonucleic acid
rRNA	**:**	Ribosomal ribonucleic acid
IAA	**:**	Indole Acetic Acid

NaCl	**:**	Sodium chloride
NaOH	**:**	Sodium hydroxide
HCl	**:**	hydrochloric acid
ABTS	**:**	2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)

PREFACE

Carpets were probably first made by nomadic peoples to cover the earthen floor in their tents. Carpets were known in India as early as 500 B.C. references to woven mats and floor coverings can be found in ancient and medieval Indian literature. Indian Carpet Industry comprises of Hand knotted carpet, Hand tufted and Machine made carpet. However, Indian hand-knotted carpets receive worldwide acclaim. Perhaps the most famous carpet-producing region in India is the "carpet belt" of Uttar Pradesh. This belt is located near Varanasi in the south eastern corner of U.P., one of the state's poorest regions, and is capable of producing virtually every variety of carpet. Production and trade activities are primarily concentrated in the Mirzapur-Bhadohi area and extend outwards to surrounding districts. This industry is endowed with a fully large and diversified production base with an estimated 3 lakhs looms. Providing employment to 1.6 million as carpet weavers and others engaged in allied activities. Bhadohi-Mirzapur belt in U. P. accounts for around 80% of activities pertain to production & export**.** The Industry is export oriented and positive Net Foreign Exchange (NFE) earner contributing to the growth of Indian Economy in general and textile industry in particular Bhadohi.

Changing fashion trends and through away attitude as resulted into drastic increase in the use of azo dyes due to their bright shades and lasting fastness property. More than ten thousand sets of azo dyes are currently being used amounting to total production of approximately one million tons per annum. The industries which are major consumers of synthetic azo dyes are textile, carpet, lather, printing, food, cosmetics,

pharmaceuticals, paints etc. Due to the presence of conjugated bond and its aromatic structures, azo dyes are very stable and high resistant to light, washing and microbial attack. Synthetic dyes are classified according to chemical structure, molecular structure and their application. The effluents being generated from a dying plant is generally large in amount and complex in nature as it is the sum of dying and washing processes. Out of the coloring compound being used for dying, azo dyes are most prominent. Thus effluent coming out of these industries contain large amount of hazardous chemical and dyes and it has been as as one of the worst anthropogenic polluters. Various physico-chemical treatment techniques were attempted for treatment but they have limitation of large energy consumption and generation of secondary products (Singh and Arora, 2011, Toor *et al.*, 2012, Liao *et al.*, 2012 Pandey *et al.*, 2007, Forgacs *et al.* 2004, Bafana *et al.*, 2008). Although earlier investigations show that these effluents exhibits very slow degradation and are resistant to conventional biological treatment due to their complex aromatic nature. Bioremediation, utilizing microorganisms/enzymes (Ryan *et al.* 2005), is a potential technique for treatment of industrial wastewater. present investigation aims at complete treatment of carpet effluent using bioremediation and its integration with tertiary treatment using adsorption. Batch investigation using pure and mixed consortia indigenously isolated from contaminated soil from study area were used for the said treatment. Operating parameters such as pH, temperature, initial dye con etc were optimized during the batch studies. The most efficient mixed consortia were again tested for its efficacy in a sequential batch reactor. For the final treatment to obtain nearly 100%

degradation biologically treated effluent were sent for adsorptive treatment onto TiO2 coated clinkers, in a cylindrical reactor. The detail discussion as under:

Chapter-1 starts with the general introduction describing the carpet industries and steps involving the manufacturing of the Carpet Industries near Bhadohi, Uttar Pradesh, India. The use of synthetic dye and its effects on the environments have been discussed briefly. The physicochemical characteristics of dye wastewater produced by these industries were discussed. The wastewater coming from dye based industries contaminates nearby water bodies like river, ground water and other water ways. A review literature pertaining different methods of treatment of dye wastewater and most significant method utilized for treatment of dye wastewater were bioremediation has been presented under 'Literature Review'. The scope and objective of the present investigation have been highlighted at the end of this chapter.

Chapter-2 describes the collection of dye wastewater and dye contaminated soil sample at different sites of study area. The isolation of bacterial strain from dye contaminated soil for degradation of various dyes. This chapters also heighlights the characterization and identification of isolated bacterial strains by using morphological, biochemical and 16S rRNA gene sequence analysis. This chapter deals with the various optimizations of parameters such as pH, temperature, dye concentration, static and agitation speed condition for efficient degradation of dye. The protocol describes for the identification enzyme involved in dye degradation. The dye control sample and after degradation were characterize by using analytical techquni such as UV-Visible Spectrophotometer (UV-Spectrophotometer), Fourier Transform Infrared Spectroscopy (FTIR) and High

Performance Liquid Chromatography (HPLC). The dye and dye degradation pathway were studies by using Gas chromatography–mass spectrometry (GC-MS). Phytotoxicity of dye and dye degrded metabolites were examined by using different types seeds.

Chapter-3 Biodegradation of Navy N5RL1, a widely used acidic azo dye in carpet industry was studied by bacterial strain isolated from the dye contaminated soil collected from a carpet industry premises located in Bhadohi, Sant Ravidas Nagar and Uttar Pradesh, India. The isolated strain was identified as *Staphylococcus saprophyticus* BHUSS X3 on the basis of morphological, biochemical and 16S rRNA gene sequencing analysis. The strain BHUSS X3 decolorized 95.7% of dye (100 mg/l) within 6h at optimum pH-8, temperature 35 °C, inoculum 4.0% under static condition during 24h incubation. The isolated BHUSS X 3 can treat higher concentration upto dye 1000 mg/l. The dye degradation metabolites were confirmed by analysis of degraded products using UV-Vis spectrophotometric, HPLC and FTIR technique. The phytotoxicity analysis was also conducted on *Phaseolus aureus* and enhanced seed germination was recorded.

Chapter-4 A significant proportion of xenobiotic recalcitrant azo dyes are being released in environment during carpet dyeing. The bacterial strain *Stenotrophomonas* sp. BHUSSp X2 was isolated from dye contaminated soil of carpet industry, Bhadohi, India. The isolated bacterial strain was identified morphologically, biochemically and on the basis of 16S rRNA gene sequence. The isolate decolorized 97% of C.I. Acid Red 1 (Acid RED G) at the concentration of 200 mg/l within 6 h under optimum static conditions (temperature-35°C, pH-8 and initial cell concentration-7×10^7 cell/ml). Drastic reduction in dye degradation rate was observed beyond initial dye concentration from 500 mg/l

(90%) and it reaches to 25% at 1000 mg/l under same set of conditions. The analysis related to decolorization and degradation were done using UV-Vis spectrophotometer, HPLC, and FTIR, whereas, the GC-MS technique was utilized for the identification of degradation products. Phytotoxicity analysis revealed that degradation products are less toxic as compared to the original dye.

Chapter-5 in the present chapter mixed consortia bacterial starin was isolated from soil from the drain caring dying effluent of various industries. The mixed consortia were identified by 16S rRNA gene sequence analysis. The microbial consortium was dye degradation. In addition they have good bioflim forming ability and have high resistance to higher concentration developed in the laboratory and used batch methods. The mixed consortia three ifferent dye such. The degradation and dye metabolites were analysis by using UV-Spectrophotometer and HPLC.

Chapter-6 The mixed consortia of microorganism isolated from soil sample of carpet effluent fared alot better as compared to individual microorganism. Bioremediation experiment in indigenously designed and fabricated bioreactor using clinkers as packing material resultant into resign ably good decolorization upto 72%. To achieve surface discharge conditions the treated sample was sent for adsorptive treatment using packed bed reactor having TiO_2 coated clinkers as adsorbent. The decolorization upto 96% could be achieved with this integrated scheme of treatment. Phytotoxicity studies through germination of *P. mungo* seeds in this treated water was comparable to this control whereas only 66% and 26% germination was observed in case biologically treated and pure effluent, respectively.

Chapter-7 This chapter describes the salient features, main observations, key finding followed by feature works.

A consolidated list of books and Journal patents consulted during this study has been given at the end of thesis under references heading.