International Journal of Research in BioSciences
Vol. 6 Issue 4, pp. (40-51), October 2017
Available online at http://www.ijrbs.in
ISSN 2319-2844

Research Paper

Development of fungal consortium for the biodecolorization of textile effluent

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(Received July 26, 2017, Accepted August 15, 2017)

Abstract

In the current five fungal species (*Aspergillus sp.*, and *Penicillium sp.*) screened from 5 fungal isolates respectively, were used in different combinations for the biotreatment of textile waste water collected from Sanagner, Jaipur, Rajasthan districts under optimized conditions. The chemical oxygen demand (COD), total solids (TS) total dissolved solids (TDS) & total suspended solids (TSS), hardness, and color intensity of the textile effluent was found to be very high than the permissible limits before treatment. After treatment one particular combination was capable of reducing the COD of the effluent sample by 75%. About five combinations of microbes efficiently reduced the color of the effluent by more than 50%. Another combination was found to be the most effective in the reduction of TS and TDS by 90% and 69%, respectively. Though there was no drastic change in the pH of the sample, it was not of great concern as the pH of the sample was well within the permissible limits for the discharge of the wastewater in to natural sources after treatment.

Keywords: Microbial consortium, biodegradation, biodecolorization, textile effluents.

Introduction

Our biosphere is under constant threat from continuing environmental pollution. Impact on its atmosphere, hydrosphere and lithosphere by anthropogenic activities on water, air and land have negative influence over biotic and abiotic components on different natural ecosystems. In recent years different approaches have been discussed to tackle man made environmental hazards. Clean technology, eco-mark and green chemistry are some of the most highlighted practices in preventing and or reducing the adverse effect on our surroundings. Among many engineering disciplines, Textile Engineering has direct connection with environmental aspects to be explicitly and abundantly considered. The main reason is that the textile industry plays an important role in a country like India and it accounts for around one third of total export. Out of various activities in textile industry, chemical processing contributes about 70% of pollution. It is well known that cotton mills consume large volume of water for various processes such as sizing, desizing, scouring, bleaching, mercerization, dyeing, printing, finishing, and washing. Various chemical processing of textiles, large volumes of wastewater with numerous pollutants are discharged. Since the stream of water affect the aquatic eco-system due to the nature of dyes and auxiliaries a number of ways such as depleting the dissolved oxygen content or settlement of suspended substances in anaerobic condition, a special attention needs to be demanded. The control of water pollution has found increasing attention in the recent year by the governments especially after record findings of cancer cases of unidentified causes.

A known case where azo dyes were found to be potential carcinogenic in the Cristais River of Brazil close to a textile azo dye processing plant where its effluent is disposed and has impacts on a drinking water of the surrounding area[1]. The release of dyes into the environment constitutes only a small proportion of water pollution, but dyes are visible in small quantities due to their brilliance. Sanganer “a concentration of textile mills especially wet processing for a long time. It is called the

Manchester of West India" is thriving mostly on the wealth generated by the textile industries at large. Though it brings in more investment, more jobs more profit, the processing and dyeing part of the industry brings in more organic content and color to the final effluent which when released to the natural water body creates havoc in the surrounding environment. Without suitable treatment, such wastewater would destroy the natural water environment[2].

The azo-dyes, including reactive, acid, direct dyes and vat dyes are commonly used in the textile industry. The water consumption and wastewater generation from a textile industry depends upon the processing operations employed during the conversion of fiber to textile fabric. On the basis of waste and wastewater (or effluent) generation, the textile mills can be classified into two main groups viz., Dry processing mill and Woven fabric finishing mills. These stages consume approximately 2400 to 2700 m^3/day of raw water. The wastewater characteristics depend upon the processing stages. In general, the wastewater from a typical cotton textile industry is characterized by high values of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), color, and pH[3]. Because of the high BOD, the untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources causing a great damage to environment.

The high color renders the water unfit for use at the downstream of the disposal point. The advanced oxidation processes are costly in terms of installation, operation and maintenance costs. Biological processes are cheaper than the others. Investment costs for biological processes are five to twenty times less than chemical ones such as ozone or hydrogen peroxide and the running costs are three to ten times less. In view of the above adverse effects, the textile industry effluent is to be treated and discharged according to the standards prescribed under Central Water (Prevention and Control of Pollution) Act, 1974. This work aims to isolate indigenous predominant adapted bacterial and fungal strains from textile effluents which possess the ability to decolorize and degrade a variety of textile effluents. These isolates were used to develop a microbial consortium that can decolorize and biodegrade the organic load in the effluent at a faster time and can be used further to develop a continuous process of the treatment of textile effluents containing a wide variety of textile dyes including reactive dyes.

Reactive dye a chromospheres contains a substituent that is activated and allowed to directly react to the surface of the substrate. Reactive dyes have good fastness properties owing to the bonding that occurs during dyeing. Reactive dyes are most commonly used in dyeing of cellulose like cotton or flax, but also wool is dye able with reactive dyes. Acid Dyes, any dyes including acid dyes have the ability to induce sensitization in humans due to their complex molecular structure and the way in which they are metabolized in the body. Direct dyes, Direct or substantive dyeing is normally carried out in a neutral or slightly alkaline dyebath, at or near boiling point, with the addition of either sodium chloride (NaCl) or sodium sulfate (Na_2SO_4). Direct dyes are used on cotton, paper, leather, wool, silk and nylon. Vat dyes are an ancient class of dyes, based on the natural dye, indigo, which is now produced synthetically. Plus Textile auxiliaries, such as caustic soda, acetic acid, sodium silicate and other more chemicals.

Materials and Methods

Collection of effluent samples

The effluent samples were collected from the treatment plants located at various common effluent treatment plants located in the areas of Sanganer, Jaipur districts Rajasthan. The effluent samples were pooled together and used for the isolation of microbial strains and treatment trials.

Physicochemical characterization of pooled untreated effluent

Various physical and chemical parameters Chemical Oxygen Demand (COD), Total Hardness, Total Solids (TS), Total Dissolved Solids (TDS), Total suspended solids (TSS, Color, Turbidity and pH) were assessed using Table 1 for the pooled untreated effluent by standard methods[4].

Isolation, screening and Identification of Indigenous adapted bacterial and fungal strains from textile effluents

The microbial source (pooled effluent sample) was enriched in culture media for bacteria and for fungi as cited in Khelifi et al. (2008). The enriched culture was then serially diluted and plated in the respective solid media. Those colonies on the isolation plates which were morphologically distinct and predominant were selected and screened were studied for their decolorization pattern on the three commonly used tough dyes Reactive Red. About 1 mg of dye was incorporated in 100 ml of Nutrient broth (fungi) separately with each isolate and the decolorization was studied for these three dyes by measuring the optical density of the sample in a UV-Visible spectrophotometer[5]. The efficient isolates of bacteria and fungi were selected and identified based on colony morphology, standard biochemical and Microbiological tests[6-8].

Design of microbial consortia and Treatment trials

Various combinations of screened fungal cultures were used to form consortia and designated as group I, II, III and IV. All the optimum conditions were used to study the decolorization potential of the fungal consortia. In Group I 100 ml of sterile optimized enrichment medium containing effluent was inoculated with dual combination[9]. 500µl inoculum of each fungal culture was added in Erlenmeyer flasks and was incubated at 30^0C. Flasks were checked for contamination every 24 hours. After 15 days of incubation. Finally decolorization was analyzed by determining the absorbance at appropriate wavelength and expressed as relative percentage taking the non-inoculated control as 100% absorbance. Optical density was measured UV-VIS spectrophotometer at wavelengths 695nm. The experiments were carried out in triplicates and the mean values were taken[9]. In Group II 100 ml of sterile optimized enrichment medium containing effluent was inoculated with dual alternate combination. Same protocol was followed as for Group I. Followed by Group III 100 ml of sterile optimized enrichment medium containing effluent was inoculated with four fungal culture combinations, leaving one isolate. 250µl inoculum of each fungal culture was added in Erlenmeyer flasks and was incubated at 30^0C. Same protocol was followed as for Group I. Another Group IV was made by 100 ml of sterile optimized enrichment medium containing effluent was inoculated with all the isolated fungi. 170µl inoculum of each fungal culture was added in Erlenmeyer flasks and was incubated at 30°C. Same protocol was followed as for Group I.

Results and Discussion

Study of physicochemical parameters of textile effluent after treatment with adaptive fungi and fungal consortium

The physicochemical parameters were analyzed after the treatment with adaptive fungi and consortium. In 1000ml flask, 250ml of effluent, 2ml of crude fungal culture and 100ml of enrichment medium was added and incubated at 30°C for 15 days. Readings were taken on daily basis. Decolorization was observed by UV-VIS spectrophotometer.

Analysis of physicochemical parameters of textile industrial effluent

Results of the analysis of the physicochemical parameters of untreated industrial effluent twice in a year (December 2011 and June 2012) are depicted in Table 1. Statistical analysis was also carried out. The results of the study revealed that colour of the untreated industrial effluent were blackish with offensive odour. This colour and odour could be due to decomposition of organic or inorganic matter[10]. A large number of pollutants can impart colour, taste and odour to the receiving water, thereby making them unaesthetic and unfit for domestic consumption[11]. pH of the textile effluent was found to be alkaline December 2011 is 10.76 ± 0.03 and June 2012 13.87 ± 0.01. Discharge of such effluent with alkaline pH into ponds, rivers, etc may be detrimental to aquatic biota such as zooplankton and fishes.

Untreated effluent showed higher level of Electrical Conductivity (EC) (7.6 mS/cm and 11.5 mS/cm) which could reflect the presence of organic and inorganic substances and salts that would have increased the conductivity[12]. It may be due to high concentration of acid base and salt in the effluent[13].

Level of turbidity was found to be higher in the effluent (57.77NTU and 55.09 NTU) when compared to the permissible limit prescribed by CPCB (1995) for effluent discharge. High amounts of suspended particles have detrimental effects on aquatic flora and fauna and reduce the diversity of life in aquatic system and promote depletion of oxygen and silting in ponds during rainy season[14].

The composition of solids present in a natural body of water depends on the nature of the area and the presence of industries nearby. High levels of TDS 630 ppt and 640 ppt may be due to high salt content and also renders it unsuitable for irrigation hence further treatment or dilution would be required[15]. The presence of high level of TSS and TDS may be due to the insoluble organic and inorganic substances present in the effluent[16].

Determination of BOD is one of the important parameters used in water pollution to evaluate the impact of wastewaters on receiving water bodies. The present study revealed high levels of BOD (140 - 190 mg/l) in the effluent due to the presence of considerable amount of organic matter. High BOD levels have also been reported for effluent discharged from textile industries and dairy effluent[17,18]. Increase in BOD which is a reflection of microbial oxygen demand leads to depletion of DO which may cause hypoxia conditions with consequent adverse effects on aquatic biota[20]. COD test is the best method for organic matter estimation and rapid test for the determination of total oxygen demand by organic matter present in the sample. The present investigation revealed high levels of COD (410 mg/l and 430mg/l) which surpassed the standards limit for COD (250 mg/l) prescribed by CPCB (1995) for effluent discharge into inland surface waters. This indicates that the effluent is unsuitable for the existence of aquatic organisms due to the reduction in Dissolved Oxygen content[20].

Cadmium, Chromium, copper and Lead levels were more than the permissible limits of CPCB (1995), the physicochemical properties and heavy metals concentration of the effluent varies depending on the presence of dye adopted in various industries[21]. Thus the analysis of physicochemical parameters of untreated effluent twice in a year (December 2011 to June 2012) confirms that the wastewater released from the textile industry has higher concentration of EC, BOD, COD, and TDS, which surpassed the permissible limits prescribed by CPCB (1995). The discharge of this industrial effluent into inland surface water as well as a land for irrigation is thus not advisable. Alkaline pH, high values of TDS, BOD and COD of the effluent reveal that the effluent is highly polluted and it has to be treated before disposal.

Hence, it is imperative to adopt technologies to reduce or degrade the effluent. The most reliable method seems to be the biological treatment in which microorganisms serve as efficient detoxifiers of pollutants. Microorganisms degrade organic contaminants as they use it for their growth and reproduction. The microorganism obtained energy by catalyzing energy producing chemical reactions and this energy is used in the production of new cell[22].

Table 1: Physicochemical property in wastewater samples from the discharge units of the local textile dyeing industries, Jaipur, Rajasthan state. December 2011 and June 2012

Physicochemical Properties	Textile Effluent December'11	Textile Effluent June'12	Standards
pH	10.76±0.03	13.87±0.01	5.5 – 9.0
Color	Colored	Colored	Colorless
Temperature (°C)	30.3±0.28	31.8±0.42	<40
Turbidity (NTU)	57.77±0.18	55.09±0.06	-
Conductivity (mS/cm)	7.6±0.42	11.5±0.06	2
Salinity (ppt)	860±0.1	910±0.1	-
TDS (ppt)	630±0.14	640±0.06	<500
BOD_5 (mg/l)	140±1.56	190±2.83	350[1]/100[2]
COD (mg/l)	410±1.90	410±0.13	250[3]
BOD/COD	0.34±0.89	0.46±0.98	0.12
Cadmium(Cd)(mg/l)	4.090±0.90	4.897±0.89	2.0
Chromium(Cr) (mg/l)	5.604±0.98	6.690±0.23	0.1
Copper(Cu) (mg/l)	5.901±0.12	5.098±0.76	3.0
Lead(Pb) (mg/l)	6.433±0.45	6.098±0.45	0.1

*Values in **Bold** are exceeding the limits of General Indian Standards for Discharge of Environmental Pollutants IS: 10500.
1. To be discharged into public sewers
2. To be discharged on land of irrigation
3. To be discharged into inland surface waters

Fungal identification and enumeration

Fungal population of effluent was determined by plating on Potato Dextrose agar and Czapek Dox agar. Czapek Dox media were used for further identification. The two efficient fungal strains were identified as *Aspergillus* sp., and *Penicillium* sp., based on their microscopic observation. The first strain showed a septate and dichotomous hyphae, at 45^o angle branching. Conidial heads are radiate to loosely columnar. Conidiophores are coarsely roughened, uncolored, vesicles spherical, metulae covering nearly the entire vesicle in biseriate species. Conidial heads radiate, uni- and biseriate, however, some isolates may remain uniseriate, producing only phialides covering the vesicle which are the characteristic features of *Aspergillus* sp.[23].

For the second fungus, the hyphae were terverticillate and the conidia were spherical to elliptical in shape. Conidia were smooth and had a green color reflection in the mass. These microscopic features were found to be that of *Penicillium* sp.[6]. Identification of fungal isolates was carried out using fungal taxonomic identification key at the Agriculture University, Durgapura, Jaipur. The fungal strains were identified as *A. flavus, A. fumigatus, A. niger, A. oryzae and P. notatum*[9].

Formation of consortium using screened fungi

Various combinations of fungal isolates which were screened for better decolorization potential and laccase assay were used to form selected consortia designated as group I, II, III, and IV. Samples were withdrawn at an interval of every 24 hours and decolorization was recorded for all the different combinations. A pattern of increase in decolorization percentage was observed in all the combinations, which showed a continuous reduction of color from the first day and a maximum color reduction was observed on fifteenth day of incubation. Most of the combinations of fungi were found to be efficient in the reduction of color. The reason for the other combinations of fungi that were not so efficient might be because of their incompatible nature or because of the action of the extracellular enzymes produced by one on the other.

Group I

Sterile optimized media containing effluent with fungal culture in dual combination showed maximum decolorization percentage for *A. niger* + *A. oryzae* 90±0.20% (Figure 1). *A. oryzae* + *P. notatum* 80.9±0.15% was the maximum value of decolorization% for this consortium. The minimum decolorization% was shown by *A. fumigatus* + *A. niger* 74±0.19% and *A. flavus* + *A. fumigatus* 68±0.13% (Figure 2).

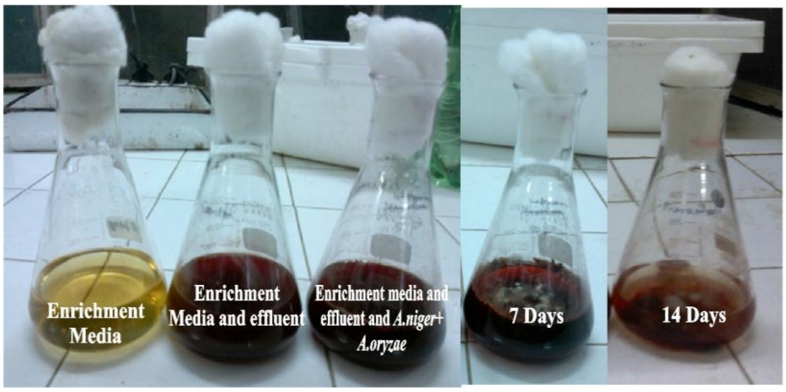

Figure 1: Decolorization observed for Group I fungal consortia *A.niger*+ *A.oryzae* when grown in optimized media

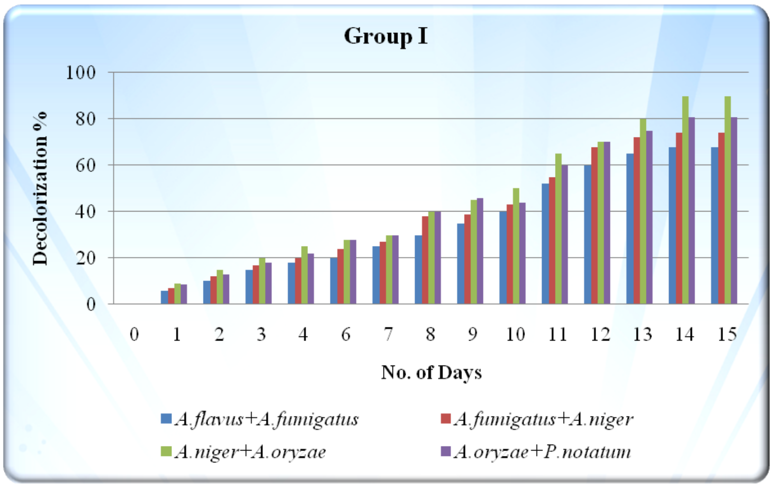

Figure 2: Percent decolorization observed for group I fungal consortia when grown on optimized media

Group II

Maximum decolorization was observed with *A. fumigatus* + *Penicillium notatum* + 79.9±0.27% followed by *A. niger* + *P. notatum* 78.09±0.28%. The combination of *A. fumigatus* + *A. oryzae* 73±0.24%, *A. flavus* + *A. oryzae* 72.4 ± 0.26%, *A. flavus* + *A. niger* 70±0.21% and *A. flavus* + *P. notatum* 60.8 ± 0.23% showed minimum decolorization (Figure 3).

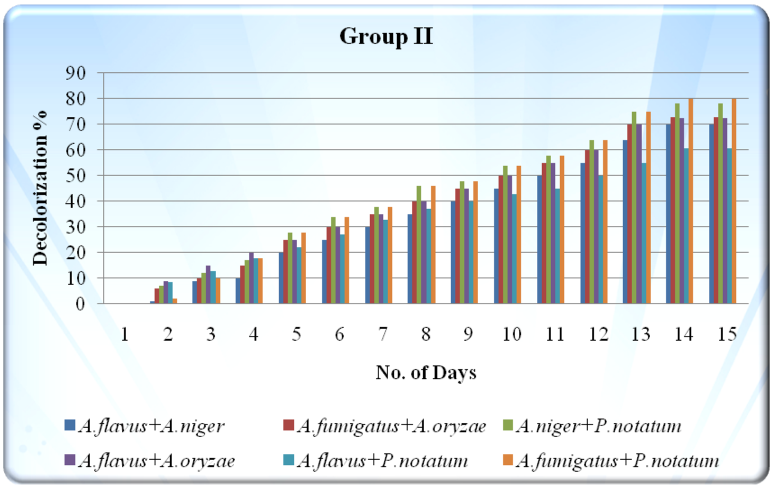

Figure 3 Percent decolorization observed for Group II fungal consortia when grown on optimized media

Group III

In this group optimized sterile media containing effluent were inoculated with a combination of four fungal isolates leaving one out of the five fungi isolated. The maximum decolorization percentage of effluent was shown by *A. niger* + *A. oryzae* + *P. notatum* + *A. flavus* 87±0.30% consortium. This was followed by *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 84±0.26% which was found to be almost 3% less than the first consortium. Decolorization percentage shown by *P. notatum* + *A. flavus* + *A. fumigatus* + *A. niger* was 79.6±0.23% and by *A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae it was* 79±0.24% this is equivalent to the one observed in case of above consortium. The minimum decolorization% was shown by *A. oryzae* + *P. notatum* + *A. flavus* + *A. fumigatus* 72.8±0.29 consortium (Figure 4).

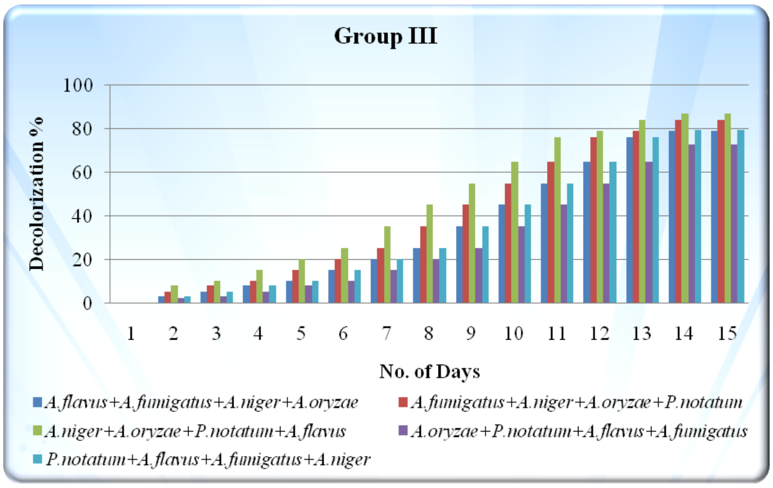

Figure 4: Percent decolorization observed for Group III fungal consortia when grown on optimized media

Group IV

All the five fungal form the consortium of this group *A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* Optimized sterile media containing effluent were inoculated with consortium with all fungi isolated. *A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* it was 94±0.36 % was maximum as compared to the above consortia studied (Figure 5 and 6).

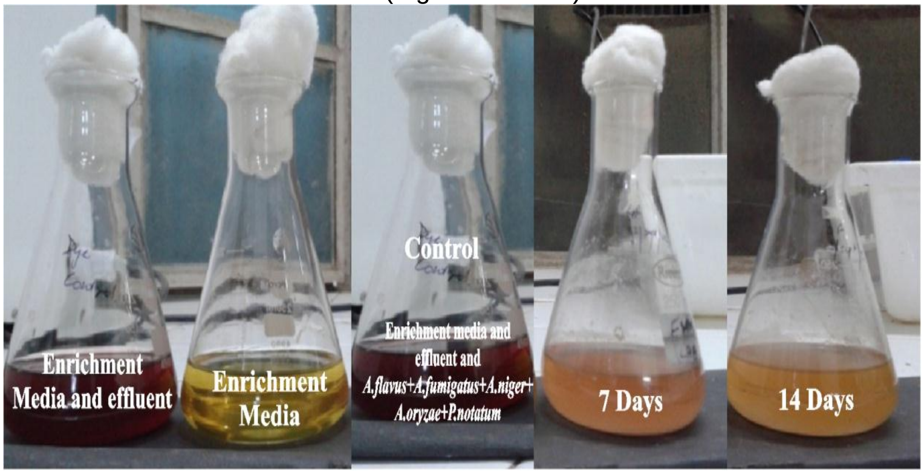

Figure 5: Decolorization observed for Group IV fungal consortia when grown in optimized media

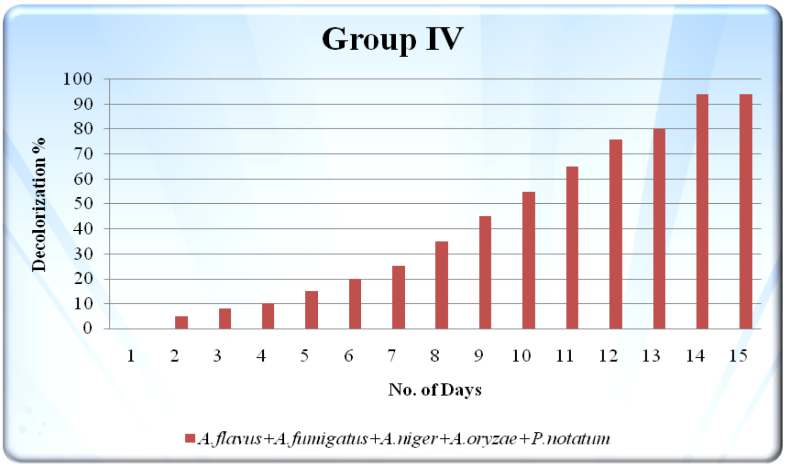

Figure 6: Percent decolorization observed for group IV fungal consortium when grown on optimized media

Analysis of changes in physicochemical parameters changes in industrial effluent after the biotreatment with isolated fungi

There was a color reduction seen to almost colorless effluent after the treatment with fungi. It was seen in case of each fungus which treated the effluent. Different combinations of fungal isolates which were screened for better decolorization potential and laccase assay were used to form selected consortia designated as Group I, II, III, and IV. From all the four groups best consortium was chosen to study their effect on different physicochemical parameters.

Samples were withdrawn at an interval of every 24 hours and all the physicochemical parameters were recorded for all the different combinations of fungi. A pattern of reduction in physicochemical parameters was observed in all the fungal consortia, which showed a continuous color reduction from the first day and a maximum reduction in color was observed on fifteenth day of incubation. The maximum decolorizing combinations were also efficient in reducing the values of physicochemical parameters. These combinations were:

Group I	*A. niger* + *A. oryzae*
Group II	*A. niger* + *P. notatum, A. fumigatus* + *P. notatum*
Group III	*A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum,*
	A. niger + *A. oryzae* + *P. notatum* + *A. flavus*
Group IV	*A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum*

There was a color reduction seen in the effluent samples in almost all the consortia studied.

As compared to the textile effluent (pH 12.315±0.01) the pH values were reduced and were found in the permissible limit i.e. 5.5 – 9.0. The maximum reduction was shown by Group III, *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* pH 6.32 ± 0.02, *A. niger* + *A. oryzae* + *P. notatum* + *A. flavus*, pH 6.2 ± 0.8 and Group II *A. fumigatus* + *P. notatum* showed pH 6.8 ± 0.1. The lesser reduction was shown by Group II *A. niger* + *P. notatum where* pH was 7.32 ± 0.0286 and Group I *A. niger* + *A. oryzae* 7.9 ± 0.03 (Table 2).

The conductivity was reduced after the treatment. The maximum reduction was shown by Group IV *A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 2.78±0.19mS (79%) and Group III *A. niger* + *A. oryzae* + *P. notatum* + *A. flavus* 2.99±0.02 mS (78.02%). The lesser reduction was found in Group III, *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 3.1±0.3mS (72.44%), Group II, *A. fumigatus* + *P. notatum* 3.22±0.13 mS (68.7%), *A. niger* + *P. notatum* 3.45±0.1 mS (65.44%) and Group I, *A. niger* + *A. oryzae* 4.02±0.13 mS (60.60%). The value of conductivity of effluent was 9.55±0.23mS and standard limit of conductivity is 2mS/cm (Table 2).

Turbidity in the effluent was found to be 56.385±0.12NTU which was reduced when observed after decolorization with fungal consortium. The maximum turbidity was reduced by Group III, *A. niger* + *A. oryzae* + *P. notatum* + *A.flavus*15.7±0.01 NTU (70.5%), Group IV*, A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 16.04±0.02 NTU (67%) and Group III*, A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 17.3±0.02 NTU (66.3%). The minimum reduction as compared to these fungi was shown by Group II *A. fumigatus* + *P. notatum* 20.03±0.02 NTU (64.3%), *A. niger* + *P. notatum* 23.13±0.12 NTU (58.3%) and *Group I, A. niger* + *A. oryzae* 24.03±0.09 NTU (57.37%) (Table 2).

Salinity in the effluent was recorded as 885±0.1ppt which was reduced when observed after treatment with fungal consortia. The maximum salinity was reduced by Group III, *A. niger* + *A. oryzae* + *P. notatum* + *A. flavus* 230.5±0.14 ppt (78.4%), Group IV, *A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 221.5±0.12 ppt (74.2%) and Group III*, A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 235.5±0.14 ppt (73.34%). The minimum reduction in salinity as compared to these fungi was shown by *A. fumigatus* + *P. notatum* 242.5±0.9 ppt (70.7%), Group II, *A. niger* + *P. notatum* 445.5±0.14 ppt (52.34%) and Group I, *A. niger* + *A. oryzae* 442.5±0.9 ppt (50.7%) (Table 2).

The TDS was reduced after the treatment with fungal consortium. The maximum reduction was shown by Group III, *A. niger* + *A. oryzae* + *P. notatum* + *A. flavus* 202.5±0.012ppt (69.8%) and Group IV*, A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 204.4±0.015ppt(66.3%). The lesser reduction was found as Group III, *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 209.5±0.012ppt (64%), Group II, *A. fumigatus* + *P. notatum* 222.5±0.12ppt(63.9%), *A. niger* + *P. notatum* 310.5±0.012ppt (53.3%) and Group I, *A. niger* + *A. oryzae* 322.5±0.09ppt (50.9%). The values of effluent were 635±0.10ppt and standard limit is <500ppt (Table 2).

BOD value of effluent was 165±1.52 mg/l and standard limit is $350_1/100_3$mg/l. The BOD values were also reduced after the treatment. The maximum reduction was shown by Group III, *A. niger* + *A. oryzae* + *P. notatum* + *A. flavus* 40.1±0.32mg/l(73.9%), Group IV, *A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 45±0.36 mg/l (73%) and Group III, *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 46.4±0.4 mg/l (71.9%). The lesser reduction was found in Group II, *A. niger* + *P. notatum* 49.4±0.5 mg/l (69.9%), *A. fumigatus* + *P. notatum* 47.3±0.12 mg/l (69.2%) and Group I, *A. niger* + *A. oryzae* 50.1±0.3mg/l (66.2%) (Table 2).

The effluent had COD value as 420±1.15mg/l and the standard value of COD is 250_3mg/l. was The COD values observed a reduction after treatment with consortium. The reduction was seen maximum by treatment with Group IV, *A. flavus* + *A. fumigatus* + *A. niger* + *A. oryzae* + *P. notatum* 249±0.3mg/l (75%) and *A. niger* + *A. oryzae* + *P. notatum* + *A. flavus* 250±0.4mg/l (74%). There was less reduction observed with Group III*, A. fumigatus* + *A.niger* + *A. oryzae* + *P. notatum* 252±0.2mg/l (72%), Group II *A. niger* + *P. notatum* 255.4±0.2mg/l (70.8%) *A. fumigatus* + *P. notatum* 253.3±0.1mg/l (70.6%) and *Group I A. niger* + *A. oryzae* 253.3±0.1mg/l (70.6%)(Table 2).

Table 2: Analysis of physicochemical parameters of industrial dye effluent before (control) and after treatment with fungal consortium in different groups

S No.	Parameters	Standard values	Control (Untreated)	Group I	Group II		Group III		Group IV
				A. niger + A. oryzae	***A. niger + P. notatum***	***A. fumigatus + P. notatum***	***A. fumigatus + A. niger + A. oryzae + P. notatum***	***A. niger + A. oryzae + P. notatum + A. flavus***	***A. flavus + A. fumigatus + A. niger + A. oryzae + P. notatum***
1.	**pH**	5.5 – 9.0	12.315±0.01	7.9 ± 0.03	7.32 ± 0.0286	**6.8 ± 0.1**	**6.32 ± 0.02**	**6.2 ± 0.8**	7.32 ± 0.0286
2.	**Color**	Color-less	Blackish	Almost Colorless	Almost Colorless	Almost Colorless	Almost Colorless	Almost Colorless	Almost Colorless
3.	**Temperature (°C)**	<40°C	31.05±0.021	30.1± 0.032	31.05± 0.021	30.1± 0.032	31.05± 0.021	31.05± 0.021	31± 0.039
4.	**Conductivity (mS/cm)**	2 mS	9.55± 0.23	4.02±0.13 (60.60%)	3.45±0.1 (65.44%)	3.22±0.13 (68.7%)	3.1±0.3 (72.44%)	2.99±0.02 (78.02%)	2.78±0.19 (79%)
5.	**Turbidity (NTU)**	-	56.385±0.12	24.03±0.09 (57.37%)	23.13±0.12 (58.3%)	20.03±0.02 (64.3%)	17.3±0.02 (66.3%)	15.7±0.01 (70.5%)	16.04±0.02 (67%)
6.	**Salinity (ppt)**	-	885±0.1	442.5±0.9 (50.7%)	445.5±0.14 (52.34%)	242.5±0.9 (70.7%)	235.5±0.14 (73.34%)	230.5±0.14 (78.4%)	221.5±0.12 (74.2%)
7.	**TDS (ppt)**	<500	635±0.10	322.5±0.09 (50.9%)	310.5±0.012 (53.3%)	222.5±0.12 (63.9%)	209.5±0.012 (66.3%)	202.5±0.012 (69.8%)	204.4±0.015 (66.3%)
8.	**BOD_5 (mg/l)**	30	165±1.52	50.1±0.3 (66.2%)	49.4±0.5 (69.9%)	47.3±0.12 (69.2%)	46.4±0.4 (71.9%)	40.1±0.32 (73.9%)	45±0.36 (73%)
9.	**COD (mg/l)**	250	420±1.15	253.3±0.1 (70.6%)	255.4±0.2 (70.8%)	253.3±0.1 (70.6%)	255.4±0.2 (70.8%)	255.4±0.2 (70.8%)	249±0.3 (75%)

Biological treatment process is a cost effective method for hazardous substance disposal. The researchers have clearly indicated that aquatic fungi play a key role in the productivity of streams, estuaries and oceans[11]. There are many fungi occurring naturally in ecologically substrate i.e. the wastes from the industries. The present study indicates the possibilities of employing such organisms under controlled conditions to degrade the waste. The spectacular array of fungal populations adorning aquatic habitats has been reviewed by Noorjahan et al. (2004) and Jerine (2011)[17,18], which prompted to analyse the native microbial population in the effluent and to use it for biodegradation instead of introducing other microbes.

The use of a biological treatment with the aid of developed fungal consortium *A. niger + A. oryzae, A. oryzae + P. notatum, A. niger + A. oryzae + P. chrysosporium, A. flavus + A. fumigatus + A. niger + A. oryzae, and A. niger + A. oryzae + P. notatum + A. flavus* for decolorization of the textile effluent. The reason for effective and faster decolorization of the effluent by consortium might be associated with the combined metabolic activities and interactions of these strains. Similar results were previously quoted in case of dye decolorization studies by using combined cultures[22]. Fungal cultures such as white rot fungi requires 7–20 days time for 90% decolorization of a diverse range of synthetic dyes.

Compared to the several mixed microbial cultures reported in the literature, either bacterial or fungal, our fungal consortium showed significantly faster dye decolorizing potential. Efficiency of mixed microbial cultures depends upon adaptability and activities of versatile enzymes systems produced by the microorganisms[23]. Consortium *A. niger + A. oryzae, A. oryzae + P. notatum, A. niger + A. oryzae + P. chrysosporium, A. flavus + A. fumigatus + A. niger + A. oryzae, and A. niger + A. oryzae + P. notatum + A. flavus* showed presence of all the effluent decolorizing enzymes, which might be the reason for efficient decolorizing potential of the consortium, compared to the individual fungal strain. Induced enzyme activities leading to efficient decolorization in case of consortium have been reported earlier[24,25], they showed the combination of fungi and bacteria consortium.

The fungal cultures *A. flavus, A. fumigatus, A. niger, A. oryzae, P. notatum* and *P. chrysosporium* strains were isolated from the dye contaminated sludge and found to have significant potential to decolorize the dye effluent. Similar results were previously quoted in case of dye decolorization studies by using combined cultures. Fungal cultures such as white rot fungi requires 7–20 days time for 90% decolorization of a diverse range of effluent. Efficiency of microbial cultures depends upon adaptability and activities of versatile enzymes systems produced by the microorganisms[1]. Optimization of the growth conditions were maintained for better cell growth. High metal ion concentration is one of the problems associated with textile effluent, which arises from usage of higher amount of metal containing dyes in dying process[5,8]. As utilization of fungal consortia has been reported for metal sorption[16,11].

We have checked our microbial cultures for metal removal efficiency from the textile effluent. Metal concentration, when evaluated after 15 days of contact time, it was observed to have significant reduction compared to control effluent (untreated). The metals like copper, lead and chromium were found to be completely removed from the effluent, whereas trace amount of iron, nickel, zinc remains.

The COD of the industrial effluent mainly depends upon the organic load of the effluent. Reduction in COD and BOD indicates mineralization of the textile effluent. The *A. oryzae* and *A. niger* among the isolated ones shows maximum reduction in COD and BOD. The ultimate aim of bioremediation and biodegradation is to reduce the concentration of environmental pollutant as well as its toxicity. The untreated dyeing effluents may be hazardous to the environment, when straight used for agriculture. Thus, it is the matter of concern to assess the toxicity of the effluent before and after decolorization. The results of the toxicity study revealed that the metabolites generated after the biodegradation of effluent were less toxic in nature as compared to the untreated effluent. Based on the results of cytotoxic and genotoxic effects. It can be concluded that the dye effluent possess significant toxicity, which in turn gets reduced after microbial treatment.

Conclusion

Based upon these findings, it can be concluded that fungi present in the vicinity of discharged effluent possess a great potential for use in decontamination of soils. Fungal *A. niger and A. oryzae* strain was developed for this study which consisted of three potential isolates exhibited greatest ability in decolorizing the dye. The performance of *A. niger and A. oryzae* also exceeds the performance of the individual and the results show that the advantages of cultures are apparent and further exploitation of the selected strain will be beneficial in textile wastewater treatment. Fungal consortium provides a new innovative of biological decolorization of textile dye effluent. The combination of all fungi showed maximum decolorization and the combination comprising *A. niger + A. oryzae* showed maximum decolorization which revealed that a new prospect can be set up for the biodecolorization of effluent.

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