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Research Paper

Textile Effluent Treatment Using Marine Cyanobacterium (Oscillatoria Subuliformis) with Coir Pith and Removal of Heavy Metals

Microbiology

KEYWORDS : Textile effluent, coir pith, Oscillatoria subuliformis, heavy metalst

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ABSTRACT

A study was carried out using marine cyanobacterium Oscillatoria subuliformis with coir pith for the reduction of physico-chemical parameters and simultaneous removal of heavy metals such as zinc, lead, mercury, cadmium, copper and chromium in textile effluent. Better result was shown in combined treatment using O. subuliformis along with coir pith when compared to control.

Introduction

Dyes are used in the coloration of a wide range of substrates, including paper, leather, and plastics but by far their most important outlet is on textiles. Textile materials are used in a wide variety of products, including all types of clothing, curtains, and carpets (Christie, 2001). The disposal of untreated waste effluent water on land and the Amaravathi river has affected the quality of surface water, ground water and the soil not only in the Karur but in surrounding downstream (Kannan, 2005).

Coir pith was allowed to degrade upto 30 days by *Oscillatoria annae* by inoculating in fresh BG11 medium (Rippka et. al., 1979) of 1:10 (Wet: dry) ratio. Cyanobacteria can degrade selected lignocellulosic Agro waste coir pith (Anandhraj et. al., 2012; Viswajith and Malliga, 2008). Industrial wastes such as Lignin have adsorption capacities of heavy metals lead ($Pb^{2+)}$) and of Zinc ($Zn2^{+}$) (Aloki and Munemori, 1982). Coir pith has the ability to remove number of dyes such as BASIC BLUE 9 OF 120.43 QMAX AND BASIC VIOLET 10 OF 94.73 QMAX (NAMASIVAYAM *ET. AL.*, 2001B).

Marine microorganisms are immensely used in the decolorization of dye because most of the industrial effluents contain high concentrations of salts, especially chlorides. Besides, marine microbial enzyme would act efficiently at neutral/alkaline PH and wide range of temperatures to combat the neutral/alkaline dye effluents (Chandramohan, 1997). In addition, some of the factor such as pH, carbon dioxide, organic matter, alkalinity, nitrates and phosphates are important in determining the distribution of cyanobacteria (Podda et. al., 2000). The marine cyanobacterium, *Oscillatoria formosa* NTDMO2, which decolorize the textile effluent efficiently in short period of time and can be used for the bioremediation (Mubarak Ali et. al., 2011).

As synthetic dyes are relatively resistant to biodegradation, the elimination of colored effluents in wastewater is based mainly on physical and chemical methods. Although these methods are effective, they suffer from short-comings such as high cost, formation of hazardous by-products and intensive energy requirements. Hence, the present study was to investigate the dye effluent degradation potential of cyanobacteria along with coir pith.

Materials and methods
Effluent collection

The textile dye effluent sample used for this study was obtained from textile industry located at Karur in Tamilnadu, India.

Coir pith

Coir pith was collected from coir industry in Musiri, Tamil Nadu, India.

Microorganism

The marine cyanobacterium *O. subuliformis* was obtained from germplasm of National Facility for Marine Cyanobacteria, Department of Marine Biotechnology, Bharathidasan University, Tiruchirappalli, India and maintained in ASNIII medium with alternative illumination of light/dark for 10/14 hrs under 1500lux.

Inoculum preparation

For individual treatment 6g dry weight of coir pith and 3g wet weight *O. subuliformis* in 1000ml of textile dye effluent were taken in separate flasks. In combined treatment log phase *O. subuliformis* 3g and 6g of coir pith were taken and inoculated in flask containing 1000ml of textile dye effluent. All the flasks were kept with control at 25°C with L/D cycle (10/14 hrs) of light under 1500 lux in static conditions and all the experiments were carried out in triplicates.

Determination of pH

pH of the sample was determined using pH meter which has been initially standardized by using buffer solution of known value before analysis.

Determination of colour reduction

Decolorization of textile dye effluent was determined by measuring the absorbance at the pre-determined absorbance maximum at 580nm (Mohandass Ramya et. al., 2007).

Determination of physico-chemical parameters
Estimation of chlorophyll *a*

Chlorophyll *a* has been determined by (Mac Kinney, 1941) method.

Estimation of heavy metals

Estimation of mercury, lead, cadmium, chromium, zinc, copper and nickel have been determined by (AOAC method, 2000).

Results and discussion
Effect on pH

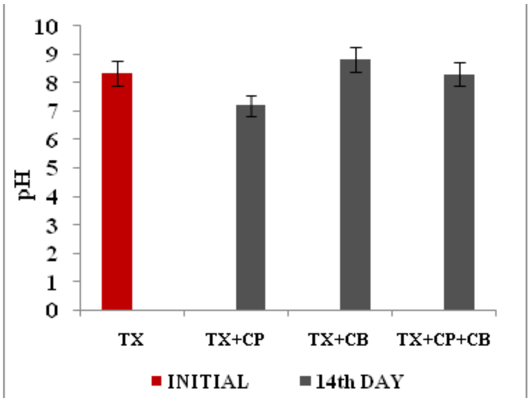
Reduction in pH was observed in coir pith with effluent treatment and increased in cyanobacterial treatment as well as combined treatment (Fig. 1). This is mainly because of the acidic nature of coir pith and renders H+ ions to the solution. During growth, cyanobacteria significantly increase the hydroxyl ion (OH-) concentration which is directly proportional to pH level. Similar results were obtained by Jenny & Malliga, (2013) and stating that pH increased in Biological treatment using *Lyngbya* sp. but the combined treatment of coir pith with *Lyngbya* sp. showed decrease in pH level. Certain studies showed that the *Phormidium valderianum* could remove more than 90% textile dyes acid red 119 and direct black 115 from the solution in the pH range higher than pH 11(Vishal Shah et. al., 2001).

Effect on colour reduction

The effluent was decolorized by the individual treatment such as addition of only coir pith and *O. subuliformis* alone. The combined treatment of coir pith with *O. subuliformis* showed better decolorization when compared to individual treatments (Fig. 2). The dye particles get easily adsorbed by the addition of coir pith and it showed reduction in optical density of the treated effluent on 14th day. Supporting evidence showed that almost

35-50% of colouring matter present in the raw dye sample is reduced after treatment with coir pith method (Shanmugam, 2012). Similarly, Vijayakumar and Manoharan (2012) investigated that the efficiency of cyanobacteria on the removal of textile dye industry effluents and reported that both in *Oscillatoria* and *Westiellopsis* and reduction in color from the dye effluent in both free and immobilized conditions significantly. Similar observations were made in textile dyes by using various fungi (Kousar et. al., 2000). They reported that *Aspergillus niger* and *Trichoderma viride* proved to be efficient in decolourization of scarlet red upto 80%. Other fungal isolates showed more than 70% decolourization of brilliant violet. Reports on marine cyanobacterium *Lyngbya* sp. along with coir pith renders the properties such as adsorption of particles present in the dye, decolorization of the dye and degradation of coir pith (Jenny and Malliga, 2013). Degradation of coir pith was carried out by variety of enzymes released by cyanobacteria which is having lignin degrading ability and thereby using lignocellulosic coir pith as an excellent and inexpensive carrier for cyanobacterial inoculum (Malliga et. al., 1996; Malliga and Viswajith, 2008).

Fig. 1: Effect of coir pith and *O. subuliformis* on pH properties of the textile dye industry effluents on 14th day

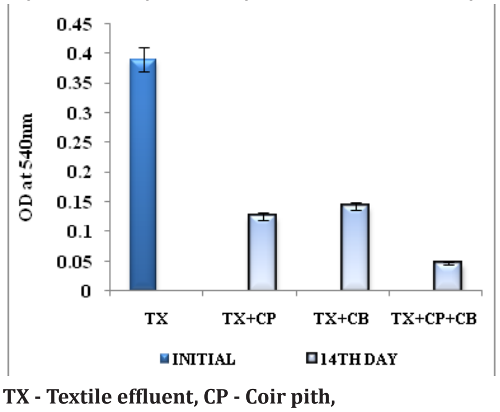


TX - Textile effluent, CP - Coir pith,
CB – Cyanobacterium (*O. subuliformis*)

Effect on chlorophyll *a*

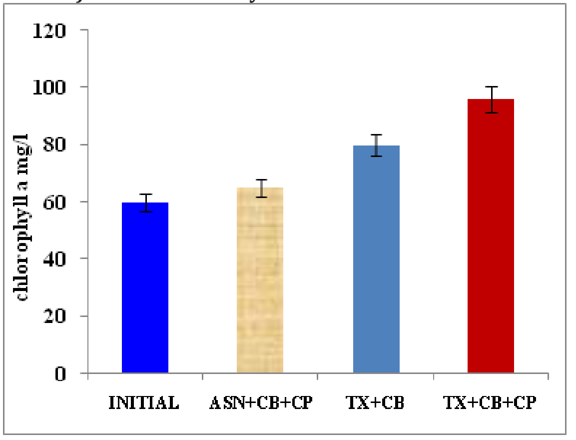
Chlorophyll *a* content is one of the important parameter for the determination of growth of the cyanobacteria. Here in this study, the growth of cyanobacterium was determined by the quantification of chlorophyll *a* pigment. The Chlorophyll *a* content was found to be higher in the combined treatment (Coir pith + Cyanobacterium) followed by individual treatments of cyanobacterium (*O. subuliformis*) alone (Fig. 3). The textile effluent enhances the growth of the inoculated *O. subuliformis.* This is because of the presence of organic compounds in textile effluent, which act as nutrient source and stimulates the growth of *O. subuliformis*.

Fig. 2: Effect of coir pith and *O. subuliformis* on optical density of textile dye industry effluents on 14th day



TX - Textile effluent, CP - Coir pith,
CB – Cyanobacterium (*O. subuliformis*)

Fig. 3: Effect of textile dye industry effluent on the growth of *O. subuliformis* on 14th day



ASN – Artificial sea nutrient, TX – Textile effluent, CP - Coir pith, CB – Cyanobacterium (*O. subuliformis*)

Moreover, addition of coir pith along with *O. subuliformis* gave luxuriant growth of cyanobacterium as these organisms are able to degrade the coir pith and hence, utilize the available nutrients from the surrounding medium, thereby showing profuse growth in biomass and therefore increased chlorophyll *a* content is evident. *Oscillatoria laetevirens* grown with *Prosopis juliflora* with different particle size and ratio showed a high amount of chlorophyll *a* content when compared to control (Prabha, et. al., 2005). Increase of chlorophyll *a* in *Oscillatoria annae* when grown with coir pith has also been reported (Anadharaj, et. al., 2012).

Estimation of heavy metals

Effect on chromium, zinc and copper

Reduction in chromium, copper, and zinc content (Table. 1) of textile effluent was observed on 14th day with addition of coir pith, *O. Subuliformis*, this is mainly because of addition of coir pith which is rich in lignin content decreases the pH of the effluent making it acidic. This acidic condition stimulates the redox reaction between the sorbent surface groups and sorbent, and improves the adsorption process. This results are supported by the studies made by Gobala Krishnan and Jeyadoss, (2010) stating that adsorption of chromium, zinc and copper increases at acidic pH because of ionic interaction between the metal and adsorbent increases.

The metal removal capacity of cultures of two capsulated, exopolysaccharide – producing cyanobacteria, *Cyanospira capsulata* and *Nostoc* PCC7936 were tested using copper II as the model metal by (De phillippies et.al., 2007), *C. capsulata* and *Nostoc* PCC 7936 cultures removed the greatest amount of copper.

Effect on lead and mercury

Lead and Mercury contents of textile dye industry effluent were reduced on 14th day when compared to the initial level with coir pith, *O. subuliformis* individual treatments and combination of both coir pith along with *O. subuliformis* treatments (Table. 1). Reduction of Lead (Pb) and Mercury (Hg) contents showed decrease in pH level, this was due to addition of coir pith which in turn increases the degree of protonation of the adsorbent functional group and hence removal of these heavy metals. Also, *O. subuliformis* provides binding sites for the complexion of the heavy metals facilitating adsorption process and the similar results were obtained by Ging et. al., (2005). Stating large surface area of the biomass *Spirulina platensis* increases the available binding sites for the complexion of the heavy metals.

Modified coconut coir dust has been shown to remove lead, copper and nickel successfully from aqueous solution and it has been suggested that coconut coir has a good potential as an adsorbent of heavy metals present in industrial effluents (Venkatesweralu and Stotzty, 1989). Similarly, Alpana et. al., (2007) observed 97% removal of Pb2+ by *Pithophora odeogonia* and 89% removal by *Spirogyra neglecta* in 30 min from a solution containing 5mg-1 initial concentration of Pb2+ by a biomass concentration of 1g-1. Rezaee et. al., (2006) achieved 90% adsorption of Hg by *Spirogyra* species within 15 min and equilibrium reached at 30 min. Mendoza-Cozatl et. al., (2006) recorded efficient Cd2+ removal by *Euglena gracilis* (80%) however, it was found to be less efficient for Pb with less than 15% removal.

Effect on nickel and cadmium
Removal of nickel and cadmium content in textile effluent was found higher in the textile dye industry effluent inoculated with coir pith along with *O. subuliformis* than the textile effluent inoculated with coir pith and cyanobacterium (*O. subuliformis*) separately at the end of 14th day (Table. 1). Low pH rendered by coir pith facilitate specific binding process of these heavy metals to the surface of coir pith also to the surface of *O. subuliformis* as it provide binding sites for metal ions.

Table 1: Reduction of heavy metals in all treatments on 14th day

S. No	Heavy metals (ppm/l)	Textile effluent	Tx+cp	Tx+cb	Tx+cp+cb
1	Zinc	1.9616	0.7846	0.6864	0.5884
2	Chromium	0.1837	0.0423	0.0265	0.0192
3	Nickel	0.146	0.138	0.102	0.050
4	Copper	1.2773	0.8306	0.6491	0.3001
5	Lead	0.000052	0.000042	0.000011	0.000006
6	Cadmium	0.00049	0.00018	0.00014	0.00009
7	Mercury	0.0022	0.0014	0.0012	0.0008

TX - Textile effluent, CP - Coir pith, CB – Cyanobacterium (O. subuliformis)

Supporting evidence showed that the adsorption of nickel by the bio-sorbent is optimum at pH 5.0 and it is suggesting that the adsorption is controlled by ionic attraction (Suman Das, 2012). Report showed cadmium metal uptake efficiency of brown marine alga *Sargassum matons* was 135 mg/g (Holan et. al., 1993).

Conclusion
Textile dye industries are produced large amounts of waste water and released directly to the water bodies near to industries and polluting the environment. Textile effluent treatment before discharge is important to reduce the environmental damage. Here, in this study three different treatments were carried out to reduce the pollutant in the effluents. The textile effluent inoculated individually with coir pith and *Oscillatoria subuliformis* (combined treatments) resulted significant improvement on the growth of cyanobacterium, removal of colors and metals. Among all the three treatments, the textile effluent inoculated with *O. subuliformis* and coir pith showed very good results in the removal of effluent color, heavy metals and also in growth of cyanobacterium.

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