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EVALUATION OF TEXTILE MILL EFFLUENTS BEFORE AND AFTER TREATMENT WITH CYANOBACTERIA

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ABSTRACT

Textile effluents are of large-scale environmental concern because they colour and diminish the quality of water bodies into which they are released. The ability of microorganisms to degrade a wide variety of compounds in the effluents has been recognized and exploited in various biotreatment processes. In this study, the effectiveness of cyanobacterial treatment system for bioremediation of textile effluents was investigated. In the biotreatment system, *Oscillatoria* was employed for the bioremediation of textile effluents. The percent removal of colour, biological oxygen demand (BOD) and chemical oxygen demand (COD) of the effluents were studied. Other analyses involved the physiochemical and elemental studies of the effluents. The results revealed that there was a 30.4%, 57.6% and 39.82% decrease in BOD, COD and colouration of the textile effluents after 4 weeks of treatment with *Oscillatoria*.

INTRODUCTION

With the world moving towards rapid urbanization and industrial development it has become a tedious job to dispose the industrial wastes and effluents properly. Effective disposal systems like landfills and composting yards are often mistreated and the waste effluents are released into the natural environment, particularly water resources. Only about 7 to 8% of industrial wastewaters have been disposed off in municipal sewer systems and they constitute about half the total municipal load. Most of the rivers and fresh-water streams are seriously polluted by industrial wastes which come from different industries such as those of petro-chemicals, fertilizers, oil refineries, pulp, paper, textiles, sugar mills, steel, tanneries, distilleries, drugs and pharmaceuticals, fibres, rubber, plastics etc.

The textile industries produce effluents that contain several types of chemicals such as dispersants, levelling agents, acids, alkalis, carriers and various dyes (Cooper, 1995). Major constituents of such effluents include detergents, petroleum products, acids, alkalis, phenols, carbonates, alcohols, cyanide, heavy metals etc. They also contain inorganic nitrates, phosphates, chlorides and fluorides, organic pesticides, dyes and other such components that possess a high threat to the living system. The release of these effluents into aquatic ecosystems alters the pH, increases the BOD and COD and gives the water intense

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colourations (Ajayi and Osibanjo, 1980).

Several methods are used in the treatment of textile effluents to reduce their toxicity and aid in their degradation. These include physiochemical methods such as filtration, specific coagulation, use of activated carbon and chemical flocculation (Olukanni *et al*. 2006). These methods appear effective but are quite expensive and needs intense set-up (Do *et al*. 2002; Maier *et al*. 2004). On the other hand, biological treatment methods offer a cheaper and ecofriendly alternative for degradation of textile effluents. Various bacteria, cyanobacteria and fungi are considered ubiquitous tools in effluent biotreatment. In this current research, cyanobacteria were employed in bioremediation of textile effluents.

MATERIALS AND METHODS

Sample collection

Effluent samples were collected from a textile industry situated in Tamil Nadu, India. The effluents were collected in sterile glass bottles, transported in cold condition to the laboratory at VIT University, Vellore, India, for physiochemical and microbiological analysis.

Physiochemical analysis

Physiochemical analyses of the textile effluents were performed following the standard methods by APHA (1992). The parameters analysed were colour, conductivity, pH, total dissolved solids (TDS) (Valentine, 1996), BOD, COD and total nitrogen. Methods described by APHA (1980) were followed for determination of bicarbonate, carbonate, sulphite and sulphate. Gravimetric estimation for chloride was performed (Strickland and Parson, 1972) and phosphate was estimated by procedures described by Murphy and Riley (1962). The pH and electrical conductivity of the samples were measured using a glass electrode pH meter and conductivity meter, respectively. Total nitrogen was estimated using Kjeldhal N-analyzer.

Elemental analysis

Metals in the effluents were determined by atomic absorption spectrophotometer following wet oxidation of the effluent sample by di-acid digestion method with a mixture of concentrated HNO_3:$HClO_4$ (3:1 v/v) (Hossner, 1996).

Source of organism and culture

The cyanobacteria *Oscillatoria* was isolated from the effluent samples and cultured in BG11 medium in Erlenmeyer flasks at 30 °C and 190 rpm (Yoon *et al.* 2002) for about 20 days. The culture environment was illuminated properly to facilitate the cyanobacterial growth. The organism was obtained in mats and maintained for further analysis on the effluent samples.

Determination of biodegradability

Effluent samples were inoculated with *Oscillatoria* in Erlenmeyer flasks and kept under illumination at 30 °C for 28 days under aerobic condition. For first 48 hours of incubation, the flasks were kept in an incubator shaker at 100 rpm for the purpose of uniform mixing of cyanobacteria and effluents. Periodic weekly monitoring of the samples was done for investigating the physiochemical characteristics and biodegradability of the effluents. Potential decolourization with BOD and COD removal of the effluent by *Oscillatoria* was investigated for 4 weeks. Decolorization of the effluent was determined by measuring the absorbance of the simulated effluent at 485 nm wavelength.

RESULTS AND DISCUSSIONS

Effluent samples were analyzed for their physiochemical and elemental characteristics before and after treatment with *Oscillatoria*. Table 1 makes a comparison between the effluent parameters before and after treatment. A change in colour of the effluent was an initial indication of biodegradation. The initial effluent colour at the time of collection was intense brown and finally after cyanobacterial treatment for 4 weeks it turned tan. The colour is a contribution of dissolved solids and minerals of vegetable origin, tannins, synthetic dyes etc. The dyes colour the water bodies and hampers light penetration which is a very critical factor for aquatic life forms (Goncalves *et al.* 2000). However, after a due course of discharge of the effluents in the water bodies there is a marked loss in colouration between 10–15% (Vaidya and Datye, 1982). The acceptable limits for discharge of wastewaters to both surface waters and sewers vary, ranging between from pH 5.5 to 10 (Bosnic *et al*. 2000). The initial pH of the effluent was 8.8 ± 0.2. This alkalinity may be due to the rate of aerobic decomposition. Formation of NH_3 from NH_4^+ is favoured by an alkaline pH which might result in NH_3 volatilization (Contreras-Ramos *et al*. 2004). This interaction can be related to the total N of the effluents. The total N of the effluents on day 28 was 871.4 ± 5.5 mg/L which is a considerable de-

Table 1. Physiochemical and elemental characteristics of textile effluents before and after treatment with *Oscillatoria*

Parameter	Concentration	Before treatment Day 14	After treatment Day 28
Physiochemical analysis			
Colour	Intense brown	Light brown	Tan
Electrical conductivity (dSm/L)	33.2 ± 0.5	24.9 ± 0.5	17.5 ± 0.5
pH	8.8 ± 0.2	8.1 ± 0.2	7.7 ± 0.2
Total dissolved solids (mg/L)	2200.0 ± 20.0	1480.0 ± 15.0	1130.5 ± 13.0
Biological oxygen demand (mg/L)	892.0 ± 44.5	770.0 ± 31.2	621.0 ± 26.5
Chemical oxygen demand (mg/L)	740.0 ± 36.2	471.0 ± 31.2	314.1 ± 27.0
Total nitrogen (mg/L)	1550.0 ± 10.5	1102.2 ± 5.5	871.4 ± 5.5
Bicarbonate (%)	8.67 ± 0.3	6.21 ± 0.1	4.32 ± 0.1
Carbonate (%)	8.77 ± 0.5	6.89 ± 0.2	4.78 ± 0.2
Chloride (mg/L)	3100 ± 15.0	2568 ± 14.0	1532 ± 10.0
Phosphate (mg/L)	3.84 ± 0.01	2.23 ± 0.01	1.41 ± 0.01
Sulphite (mg/L)	8.0 ± 1.0	6.90 ± 0.5	4.81 ± 0.5
Sulphate (mg/L)	195 ± 2.5	127.0 ± 2.0	85.1 ± 2.0
Elemental analysis			
Arsenic (mg/L)	6.8 ± 0.2	4.5 ± 0.2	2.3 ± 0.2
Calcium (mg/L)	4318.0 ± 22.5	2267.2 ± 15.5	985.6 ± 15.5
Cadmium (mg/L)	15.0 ± 1.0	10.3 ± 0.5	7.4 ± 0.5
Cobalt(mg/L)	13.4 ± 0.1	7.3 ± 0.01	3.2 ± 0.01
Chromium (mg/L)	49.1 ± 0.8	26.0 ± 0.5	12.1 ± 0.01
Copper (mg/L)	34.1 ± 0.1	24.0 ± 0.01	12.1 ± 0.01
Iron (mg/L)	484.0 ± 5.0	412.0 ± 2.0	376.0 ± 2.0
Lead (mg/L)	451.0 ± 2.2	310.0 ± 1.5	178.0 ± 1.5
Magnesium (mg/L)	885.5 ± 8.5	698.1 ± 6.0	521.2 ± 6.0
Sodium (mg/L)	4263.3 ± 13.5	3013.0 ± 10.5	1489.0 ± 10.5
Zinc (mg/L)	25.6 ± 0.1	14.8 ± 0.2	8.7 ± 0.2

Note: Mean ± standard deviation (n = 5)

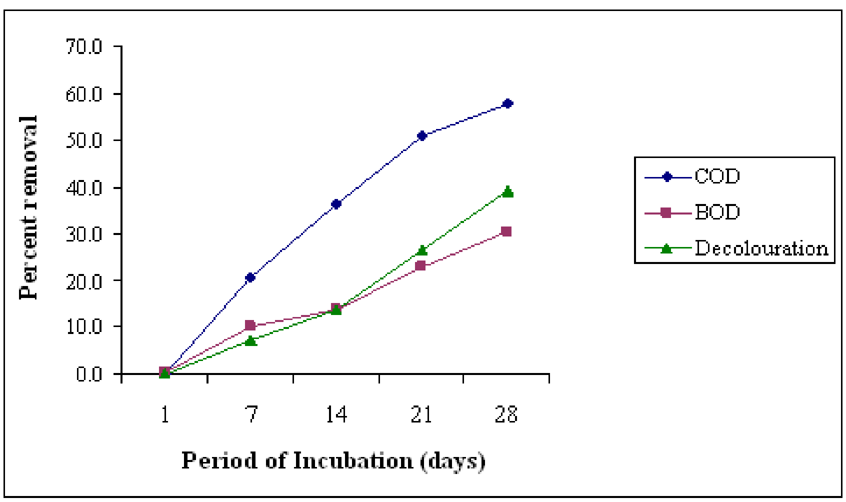

Fig. 1 Percent removal of BOD and COD and colouration of textile effluents under aerobic condition

crease from 1550 ± 10.5 mg/L as of before treatment. The textile effluents were initially characterized with a high electrical conductivity of 33.2 ± 0.5 dSm/L and after treatment a satisfactory decrease to 17.5 ± 0.5 dSm/L was found. The high conductivity however appeared not to have affected cyanobacterial activity during bioremediation. Santamaria-Romero and Ferrera-Cerrato (2001) reported that salt concentration above 8.0 dSm/L negatively affected the microbial populations as well as biotransformation of organic matter. TDS were almost halved after the cyanobacterial treatment i.e. from 2200 ± 20.0 mg/L to 1130.5 ± 13.0 mg/L as on the final day of treatment. Figure 1 gives the percent removal of BOD and COD with decolouration of the effluent after *Oscillatoria* treatment for 28 days. On day 28 of treatment, the percent degradation for BOD, COD and colouration were 30.4, 57.6 and 39.2, respectively. The elemental analysis implies that the effluent is rich in calcium and sodium followed by magnesium, iron and lead. With increasing heavy metal pollution, cyanobacteria are found indispensable tools for their bioremediation (Nriagu and Pacyna, 1988). Removal of heavy metals, especially cadmium by cyanobacteria has been extensively studied (Matsunaga *et al*. 1999; Les and Walker, 1984). The pH enhanced the heavy metal bioremediation by Oscillatoria. The pH of the effluents varied between 7.5 and 8.5 during cell growth, which is similar to the natural variations in seawater, thus indicating no significant precipitation of heavy metals by alkalinization (Matsunaga *et al*. 1999). An acceptable decrease in the heavy metals concentration was evident on day 28 of cyanobacterial treatment. As an attempt for exploiting cyanobacteria in bioremediation, we discovered promising potency of *Oscillatoria* in treating textile effluents.

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