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Cyanobacteria as a Potential Source of Phycoremediation from Textile Industry Effluent

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Abstract

Application of Cyanobacteria in the remediation of textile industry effluent can be a cost effective and a best alternative for costly and laborious physical and chemical methods of effluent treatment. This paper deals with the application of four native species of Cyanobacteria in the reduction of various physico-chemical parameters from the untreated textile industry effluent. Effluent samples collected from textile industry located in Chinnalapatty, Dindigul district, Tamil Nadu, India, were subjected in present investigation. Native Cyanobacteriel species such as Nostoc muscorum, Anabaena variabilis, Lyngbya majuscula and Oscillatoria salina were used for biotreatment which were cultured in BG11 media and inoculated onto the untreated effluent. A significant raise in pH value and reduction in COD, BOD, Ca, Mg, sulphate, zinc, nickel and Color was observed in 25 days of treatment. From the results, it is evident that Cyanobacteria can effectively remediate the pollutants from textile industry effluent.

Keywords: Cyanobacteria; Textile industry; COD; BOD; Decolourization

Introduction

The textile industry is one of the oldest and largest industries in India centered in Kanpur, Mumbai, Ahamadabad, and Coimbatore. Textile industries depend on various stages of processing operation during the conversion of fiber to textile fabric which consume large volumes of water and generate waste water approximately 2400 to 2700 m^3/day [1]. Synthetic dyes are extensively used in the textile dyeing commonly used dyes are azodyes (orange3R), anthraquinone (blue3R) and indigo dyes. More than 100,000 types of dyes including azo dyes and different pigments are widely used in various stages of processing in the textile industries thus the pollution generated by dye materials is unavoidable. Dye presence, as little as 10 to 20 mg/l, in water affects water transparency and causes a part of aesthetic deterioration [2]. Further, Because of the high BOD, the untreated textile waste water from a typical cotton textile can cause rapid depletion of dissolved oxygen if it is directly discharged into the surfaces water sources. In addition to that, textile industry effluents with high levels of COD are toxic to biological life [3]. Treatment of textile effluent involves mainly physical and chemical methods that are very costly [4]. Therefore there has been increased interest in using biological methods for remediation of textile effluent [5]. In recent years, the use of microalgae in bioremediation of colored waste water has attracted great interest due to their central role in carbon dioxide fixation [6]. Although, bacteria play a key role in the biodegradation of organic pollutants, recent studies have indicated that in addition to providing oxygen for aerobacterial biodegraders, microalgae can also degrade organic pollutants directly [7]. It was reported that more than 30 azo compounds were biodegraded and decolorized by *Chlorella pyrenoidosa, Chlorella vulgaris* and *Oscillatoria tenuis* in which azo dyes were decomposed into simpler aromatic amines [8]. *Cyanobacteria* are unique organisms which occupy and predominate a vast array of habitats as a result of several general characteristics; some belonging to bacteria and others unique to higher plants. The application of *cyanobacteria* showed immense potential in waste water and industrial effluent treatment, bioremediation of aquatic and terrestrial habitats, chemical industries, biofertilizers, food, feed, fuel etc [9]. The main objectives of this study were (1) To isolate naturally occurring *cyanobacterial* sp from the textile industry effluents (2) To study their potential to reduce chemical parameters such as COD, BOD, Calcium, Sulphate, Magnesium, Zinc, Nickel and color from untreated textile industry effluent.

Materials and Methods

Study area

The study area was Chinnalapatti which is a township located at the foothills of Sirumalai in Dindigul district, Tamil Nadu, India, comprising about 89 small and large scale textile industries. Most of the units discharge untreated effluent to the environment. Hence causing intense pollution to the environment.

Culture media

Physico-chemical parameters of textile industry effluent were analyzed as per the standard methods [10]. Cyanobacterial species such as *Anabaena variabilis, Oscillatoria salina, Nostoc muscorum* and *Lyngbya majuscula* were isolated from textile industry effluent identified and cultured in BG 11 media in conical flasks at 30°C and 190 rpm for about 15 days. The culture environment was illuminated properly to facilitate the algal growth. The organisms were maintained for further analysis on effluent samples.

Determination of biodegradability

50 ml of textile industry effluent samples were added to 250 ml of BG11 media inoculated with the identified algal species separately in Erlenmeyer flasks and kept under illumination at 30°C for 25 d under aerobic condition. For control, 50 ml of sterile effluents were added to 250 ml BG11 media without inoculation of algal species. For first 48 h

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of incubation, the flasks were kept in an incubator shaker at 100 rpm for the purpose of uniform mixing of the media and effluents. Periodic weekly monitoring of the samples was done for investigating the physio-chemical characteristics and biodegradability of the effluents. For determining decolouration of the effluents, the media were centrifuged at 5000 rpm for 15 mins to get cell free filtrate. The clear filtrate was analysed in the spectrophotometer for measuring its absorbance at 485 nm wavelength. Decolorization was expressed in terms of percentage decolorization. This was calculated using the following formula% of decolorization=(Initial ab.-final ab.)/initial ab.*100. COD was measured after removing algal cells by centrifugation at 3000 rpm.

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) [11].

Results

Physico-chemical parameters of untreated textile industry effluent are presented in (Table 1). Most of the physico-chemical parameters such as TDS, BOD, Magnesium, Calcium, and Zinc are beyond the discharge range proposed by WHO [12]. After 25 days of incubation with Cyanobacterialsp such as *Nostoc muscorum, Anabaena variabilis, Lyngbya majuscula* and *Oscillatoria salina,* the physico-chemical parameters and color from the textile industry effluent were analyzed (Tables 2-5). The selected native cyanobacteria such as *Oscillatoria salina*, *Nostoc muscorum*, *Lyngbya majuscula*and *Anabaena variabilis* were found to be effective degraders of pollutants from textile industry effluent. pH of the effluent has been enhanced from the initial 7.3 to 9.8 by *Nostoc muscorum* (Table 2). pH has been lifted from7.3 to 9.6 by *Anabaena variabilis* (Table 3). pH has been changed from 7.3 to 9 by *Lyngbya majuscule* (Table 4) *Oscillatoria salina* drifted pH from 7.3 to 8.7 (Table 5) on 25th day. *Nostoc muscorum* increased 34.2% of

Parameters	Average Values	WHO
pH	7.3	6.5
Electrical Conductivity µmhos/cm	2900	-
Total Dissolved Solids mg/l	4301.6	2000
COD mg/l	459.3	-
BOD mg/l	104	50
Magnesium mg/l	78	50
Calcium mg/l	108	75
Sodium mg/l	63.2	-
Potassium mg/l	97.2	-
Sulphate mg/l	256	-
Nickel mg/l	8.4	-
Zinc mg/l	12.1	5.0

Table 1: Physico-chemical parameters of untreated textile industry effluent.

Parameters studied	Concentration						
	0th day		5th day	10th day	15th day	20th day	25th day
	Control		Sample				
pH	7.3	7.3	7.9	8.3	8.8	9.3	9.8
Calcium mg/l	108	108	98.2	90	83.1	76.1	65.1
Magnesium mg/l	78	78	73	65	60.2	53	44.1
Sulphate mg/l	256	256	235	201.1	165.2	159.2	109
COD mg/l	459.3	459.3	336.2	319.4	288.7	246.6	204.2
BOD mg/l	104	104	89.2	74.1	51	49.2	28.1
Nickel mg/l	8.4	8.4	7.2	6.1	5.3	4.1	2.2
Zinc mg/l	12.1	12.1	9.2	7.1	6.5	5.1	4
Decolourization	1.83	1.83	-	-	-	-	0.45

Table 2: Variability in physico-chemical properties of textile industry effluent during phycoremediation by *Nostoc muscorum*.

Parameters studied	Concentration						
	0th day		5th day	10th day	15th day	20th day	25th day
	Control		Sample				
pH	7.3	7.3	8.2	8.5	8.9	9.4	9.6
Calcium mg/l	108	108	99.2	96.3	92.2	87	89
Magnesium mg/l	78	78	74.3	69.4	64.2	61	56.4
Sulphate mg/l	256	256	242	212	187	156.1	114
COD mg/l	459.3	459.3	304	281	242.6	201	184.7
BOD mg/l	104	104	90	78	55.3	31	17.4
Nickel mg/l	8.4	8.4	7.4	6.3	5.2	4.1	3.1
Zinc mg/l	12.1	12.1	10.2	9.1	8.3	7.1	5.2
Decolourization	1.83	1.83	-	-	-	-	0.25

Table 3: Variability in physico-chemical properties of textile industry effluent during phycoremediation by *Anabaena variabilis*.

Parameters studied	Concentration						
	0th day		5th day	10th day	15th day	20th day	25th day
	Control		Sample				
pH	7.3	7.3	7.9	8.3	8.5	8.7	9
Calcium mg/l	108	108	101	97.3	90	87.2	78.1
Magnesium mg/l	78	78	73	65	61	57	50
Sulphate mg/l	256	256	223	185	157.1	132.2	89
COD mg/l	459.3	459.3	302.1	246.3	224.2	198.2	172.6
BOD mg/l	104	104	96.2	85	64	48.1	21.5
Nickel mg/l	8.4	8.4	7	6.4	5.4	3.1	2
Zinc mg/l	12.1	12.1	100	8.4	7.6	5.4	3.3
Decolourization	1.83	1.83	-	-	-	-	0.75

Table 4: Variability in physico-chemical properties of textile industry effluent during phycoremediation by *Lyngbya majuscule*.

Parameters studied	Concentration						
	0th day		5th day	10th day	15th day	20th day	25th day
	Control		Sample				
pH	7.3	7.3	7.6	7.9	8.0	8.3	8.7
Calcium mg/l	108	108	94.3	89.4	70.1	62.3	59.7
Magnesium mg/l	78	78	74	65	57	49.2	38
Sulphate mg/l	256	256	213	185.2	156	132.1	76
COD mg/l	459.3	459.3	414.7	343	301.2	278.2	154.1
BOD mg/l	104	104	94.1	79	64	39.4	14.7
Nickel mg/l	8.4	8.4	7.3	6.3	5.4	3.2	2
Zinc mg/l	12.1	12.1	10.1	8.1	7.4	5.3	3.2
Decolourization	1.83	1.83	-	-	-	-	0.63

Table 5: Variability in physico-chemical properties of textile industry effluent during phycoremediation by *Oscillotoria salina*.

Parameters studied	Nostocmuscorum $[(C_0-C_{25})]/C_0]\times100$	Anabaena variabilis $[(C_0-C_{25})]/C_0]\times100$	Lyngbyamajuscula$[(C_0-_{25})]/C_0]\times100$	Oscillotoriasalina $[(C_0-C_{25})]/C_0]\times100$
pH	34.2	32	23.2	20
Calcium mg/l	40	17.5	28	44
Magnesiummg/l	43.4	28	36	51.2
Sulphate mg/l	57.4	55.4	65.2	70.3
COD mg/l	55.5	75.0	62.4	66.4
BOD mg/l	73	83.2	79.3	86
Nickel mg/l	74	63	76.1	76.1
Zinc mg/l	57	67	73	73.5

Table 6: Bioremediation efficiency of *Nostoc muscorum, Anabaena variabilis, Lyngbya majuscule* and *Oscillotoria salina*.

pH in the textile industry effluent (Table 6). 108 mg/l of calcium had been reduced to 65.1 mg/l in the effluent sample treated with *Nostoc muscorum* (Table 2) whereas *Anabaena variabilis* reduced from 108 mgl/l to 89 mg/l (Table 3). The concentration of calcium in the effluent sample treated with *Lyngbya* has been reduced from 108 mg/l to 78.1 m/l (Table 4). Whereas *Oscillatoria salina* reduced from 108 mg/l to 59.7 mg/l (Table 5). Calcium uptake efficiency of *Anabaena variabilis* (17.5%) was greater than other Cyanobacterial sp. Magnesium of the sample treated with *Nostoc muscorum* has been changed from 78 mg/l to 44.1 mg/l (Table 2) whereas *Anabaena variabilis* reduced magnesium to 56.4 mg/l (Table 3) *Lyngbya majuscula* reduced from 78 mg/l to 50 mg/l (Table 4) and *Oscillatoria salina* reduced magnesium from 78 mg/l to 38 mg/l on 25th day (Table 5). 28% decrease in the magnesium content has been observed in the effluent sample treated with *Anabaena variabilis* (Table 6). The amount of sulphate in the textile effluent sample treated with *Nostoc muscorum* reduced from 256 mg/l to 109 mg/l (Table 2). The concentration of sulphate has been decreased from 256 mg/l to 114 mg/l when treated with *Anabaena variabilis* (Table 3). The concentrationof sulphate in the sample treated with *Lyngbya* majuscula was reducedto 89 mg/l, whereas *Oscillatoria salina* reduced sulphate from 256 mg/l to 76 mg/l. *Anabaena variabilis* showed maximum absorbtion% of sulphate that is 55.4. The COD in the effluent sample treated with *Nostoc muscorum* wasreduced from 459.3 mg/l to 204.2 mg/l (Table 2) whereas *Anabaena variabilis* reduced COD from 459.3 mgl/l to 184.7 mg/l (Table 3) *Lyngbya majuscula* reduced from 459.3 mg/l to 172.6 mg/l (Table 4) and *Oscillatoria salina* reduced from 459.3 mg/l to 154.1 mg/l on 25th day (Table 5). COD reduction efficiency of *Nostoc muscorum* was 55% (Table 6). The amount of BOD in the effluent sample treated with *Nostoc muscorum* was reduced from 104 mg/l to 28.1 mg/l. It showed maximum reduction% of BOD (73) and zinc (57) than other algae (Table 6). *Nostoc muscorum* reduced nickel in the effluent sample from 8.4 mg/l to 2.2 mg/l whereas Zinc was reduced from 12.1 mg/l to 4 mg/l by *Nostoc muscorum* on 25thday (Table 2). *Anabaena variabilis* reduced BOD in the effluent sample from 104 mg/l to 17.4 mg/l, Nickel in the effluent sample was reduced from 8.4 mg/l to 3.1 mg/l by *Anabaena variabilis*, 63% reduction in the nickel content has been observed in effluent sample treated with *Anabaena variabilis* (Table 6). Similarly it reduced Zinc reduced from 12.1 mg/l to 5.2 mg/l (Table 3). The BOD in the effluent sample treated with *Lyngbya majuscula* was reduced from 104 mg/l to 21.5 mg/l whereas it reduced Nickelfrom 8.4 mgl/l to 2 mg/l and itreduced Zinc from 12.1 mg/l to 3.3 mg/l (Table 4) on 25th day. *Oscillatoria salina* reduced BOD from 104 mg/l to 14.7 mg/l, itreduced Nickel from 8.4 mg/l to 2 mg/l whereas it reduced Zinc from 12.1 mg/l to 3.2 mg/l (Table 5) on 25th day. As far as decolourization potential of studied Cyanobacterialsp was concerned *Nostoc* reduced color from the initial OD value1.83 to 0.45 mg/l (Table 2). Whereas *Anabaena variabilis* reduced to 0.25 mg/l (Table 3) *Lyngbya majuscula* reduced to 0.75 mg/l (Table 4) and *Oscillatoria salina* reduced color from 1.83 to 0.63 (Table 5).

Discussion

Phycoremediation is a novel technique that uses algae to clean up untreated industrial discharges. It takes advantage of the alga's natural ability to take up, accumulate and degrade the constituents that are present in their growth environment. Photosynthesis can be effectively exploited to generate oxygen from waste water remediation by algae. The potential of Cyanobacterialsp such as *Anabaena variabilis, Oscillatoria salina, Nostoc muscorum* and *Lyngbya majuscula* to reduce the pollutants of effluent sample collected from textile industry has been studied and compared. Analysis of various physio-chemical parameters before and after treatment revealed that the Cyanobacterialsp such as *Anabaena variabilis, Oscillatoria salina, Nostoc muscorum* and *Lyngbya majuscula* could effectively remove the pollutants from textile industry effluent. All the four microalgae showed high efficiency in the removal of pollutants. pH of the effluent sample treated with *Anabaena variabilis* showed a drastic change from 7.3 to 9.6 pH raise has also been observed in the effluent sample treated with other Cyanobacterial sp. Kotteswari [13] reported a pH change from 5.62 to 9.82. Manoharan and Subrahmanian [14] have also reported a rise in the pH value up to 10th day of growth. 46.43% increase in the pH has been reported in diary waste water treatedwith cyanobacteria. Vijayakumar [15] reported increase in pH in the dye effluent treated with *Oscillatoria sp*. [16] reported the buffering effect of *Chroococcus turgidus* in the sense the lower pH values were raised and the higher pH values were reduced. BOD, COD, Calcium, magnesium, and sulphate were reduced by all four treated Cyanobacterial sp. On day 28 of treatment by Cyanobacterial sp, the percent degradation for BOD, COD, TDS and colour was 57.5%, 37.8%, 48.6% and 66.1%, respectively [17]. Level of COD (368 mg/l) and BOD (104 mg/l) was reported in textile effluent [18]. High BOD, COD, and calcium could have been the other factors for the growth of cyanobacteria in the effluent. Similar result was suggested by many authors [19]. As far as reduction of heavy metals such as nickel and zinc is concerned a considerable quantityof reduction was recorded. With increasing heavy metal pollution, cyanobacteria are found indispensable tools for their bioremediation [20]. Phycoremediation potential of *Nostoc muscorum* and *Anabaena variabilis* is more among the other algae. *Anabaena variabilis* exhibited maximum decolourization potential. The color factor is contributed by TDS. The dyes color the water bodies and hamper the light penetration which is a crucial factor for aquatic life forms [21]. In the present study, Initial color of the effluent was intense brown, after treatment it was decolorized. Microalgae like *Oscillatoria* have been reported to reduce azo dyes by the soluble cytoplasmic reductases known as azoreductase. These enzymes convert azo dyes into aromatic amines thereby removal is achieved [22].

Conclusion

The active role of native Cyanobacteria isolated from textile industry effluent in the reduction of pollution level may be due to the acclimatization to its source of isolation. Studies on physiological and biochemical aspects of cyanobacterial cultivation of various species are required to be carried out to learn the symbiotic interaction among them that will enhance the synergistic effect of remediation. Bological treatment by activated sludge is better to reduce pollution from textile industry effluent because of its natural system of purification. Therefore Cyanobacteria being a photosynthetic alga may be introduced as a secondary stage for industrial textile effluent treatment in the textile units.

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