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Treatment of textile dye effluent using marine cyanobacterium *Lyngbya* sp. with different agrowastes and its effect on the growth of cyanobacterium

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Abstract

The potential application of *Lyngbya* sp. BDU90901 for treatment of textile wastewater was investigated using different agrowastes namely sugarcane trash, corn waste, banana trunk fibre and ground nut shell. The mechanism trailed by cyanobacteria for colour removal was biosorption. Cyanobacteria *Lyngbya* sp. inoculated in textile effluent along with agrowastes survived and growth flourished with increased chlorophyll content of 106μg ml^{-1} inoculated with Ground nut shell on 10^{th} day of cultivation. The decolourisation efficiency of *Lyngbya* sp. was found to be 79.48%.

Key words

Chlorophyll *a*, Cyanobacterium, Decolourisation, Growth rate, Untreated adsorbents

Introduction

Outsized quantity of synthetic dyes are produced and used in various industries every day. About50% of the dyes are lost in the effluents of textile units, due to inefficiencies of industrial dyeing process portraying them highly coloured. Among the various classes of dyes, reactive dyes are more difficult to remove. High levels of conventional and physiochemical methods to treat industrial effluents with dyes have been described. Methods like adsorption (Annadurai *et al*., 2002; Chiou and Li, 2002), oxidative and reductive treatments (Aplin and White, 2000; Tokuda *et al*., 1999; Yoshida *et al*., 2001; Alvarez and Pletcher, 1999), electrochemical treatment with flocculation (Marzinkowaki and Van Clewe, 1998) and membrane separation processes (Diaper *et al*., 1996) are extensively used for textile dyes and effluent treatments.

The physico-chemical methods implied for the treatment of effluents containing dyes have their own disadvantages like high cost, high salt content in the effluent, problem of disposal of the concentrate; above all the treated effluents contain high BOD and strong oxidants. These may affect normal flora and fauna of the receiving water bodies (Bhunia*et al*., 2001; Lin and Peng, 1994).

Biological methods are considered to be simple and most efficient in removal of various biohazardous dyes and their intermediate and are also eco-friendly. Several microorganisms like fungi, bacteria, actinomycetes, algae and blue green algae are extensively used to remove the azo dye breakdown products by two processes namely adsorption and degradation. Most studies have concentrated on the use of fungi and bacteria to treat coloured wastewater (Tastan *et al*., 2010; McMullan *et al*., 2001). In recent years, the use of microalgae in bioremediation of coloured wastewater has attracted great interest due to their central role in carbon dioxide fixation. The mechanism involved includes biosorption and bioconversion (Khalaf, 2008). Bio treatment offers a cheaper and environmentally more friendly alternative for colour removal in textile effluents. Numerous natural materials have good adsorption efficiency and are used to remove ionic species dissolved in aqueous media.

Adsorption is an efficient and economical method for removing dyes from industrial effluents. In this process, a substance (soluble dye) from liquid phase wastewater is transferred to the surface of solid and binds physically or chemically (Zaharia and Suteu, 2012). The adsorption technique is preferable to other wastewater treatment techniques in terms of efficiency, low cost, simplicity, ease of operation and inactivity towards toxic substances. Moreover, the specific advantage of this method is that adsorbent can be chosen from a large variety of materials. Some applications of bio adsorbents in removal of dyes are peel of *Cucumis sativa* fruit for dye, wheat shells for methylene blue (Bulut and Aydin, 2006), rice husk ash for methylene blue and congo red (Chowdhary*et al*., 2011).

Cyanobacteria are capable of abating various kinds of pollutants and have been used in the production of energy, fertilizer, human food, animal feed, polysaccharides, biochemicals and pharmaceuticals. The ubiquitous nature of cyanobacteria makes them invaluable tools in effluent bio-treatment (Malliga and Vishwajith, 2005).

Hence, in the present study dye industry effluent was treated with marine cyanobacterium *Lyngbya* sp. BDU 90901 for removing colour along with easily available agro wastes and to monitor their effect on the growth of *Lyngbya* sp.

Materials and Methods

Strain of *Lyngbya* sp. BDU 90901 was obtained from the germplasm of National Facility for Marine Cyanobacteria (NFMC), Bharathidasan University, Tiruchirappalli, Tamil Nadu, previously maintained in Artificial Sea Nutrient (ASNIII) (Rippka*et al*., 1979). The culture was maintained at temperature of 27±2˚C and illuminated with day light fluoroscent tubes under 1500 lux with light/dark cycle of 14/10 hr.

The textile dye industry effluent was collected from the cotton dyeing factory located at Karur district, Tamilnadu, India. The factory employs a combination of mostly Proacin dyes, salt, caustic soda and hydrochloric acid. The textile wastewater is stored in holding tank before discharge. Physical and chemical methods are used to treat wastewater. Despite treatment processes, the textile effluent still contains colour at the point of discharge. The physical and chemical properties of effluent were determined using standard methods of APHA (2005).

Experimental set up : For current study, raw effluent was taken as control. Four sets of experiment were carried out. The effluent was inoculated with cyanobacterium and in combination with agro wastes (sugarcane trash, corn waste, banana trunk fibre and groundnut shell) in 1:5 ratio (fresh: dry weight; cyanobacteria; agro wastes) per 20ml of effluent sample. All the experimental test tubes were kept for incubation at 27±2 ºC for 10 days with light/dark cycle of 14/10 hr. under fluorescent light.

All colour measurements were carried out operating in the visible range in absorbance mode. Absorbance values were recorded at 490 nm wavelength (lambda max). Decolourisation efficiency was calculated and pH was measured on the 10^{th} day of study, using pH meter to analyse variations during decolourisation process.

Cyanobacterial growth was measured by extracting chlorophyll *a* of the culture. The methanol extracted supernatant was estimated for cellular chlorophyll *a* by employing the standard extinction coefficient (12.63) (Mackinney, 1941).

Statistical analysis : The effect of each parameter was studied in triplicate and data were graphically presented as mean ± S.D. of triplicates. All the graphs were prepared using Microsoft Excel 2007.

Results and Discussion

Lyngbya sp. demonstrates the ability, along with agro wastes, to commendably remove coloured residue from effluent. Cyanobacterium alone showed maximum decolourisation efficiency with colour removal of 79.48%. Interestingly, effluent with groundnut shell and *Lyngbya* sp.showed 78.20% colour removal followed by effluent with corn waste and *Lyngbya* sp. (66.66%), effluent with banana trunk fiber and *Lyngbya* sp. (47.43%) and effluent with sugarcane trash and *Lyngbya* sp. (44.87%) respectively on 10^{th} day (Fig. 1). The result suggests that relatively rapid removal could be mainly due to adsorption of coloured residues onto cell surface of *Lyngbya* sp. Accumulation of dye particles by biomass may involve a combination of active metabolism dependent and passive transport mechanisms starting with diffusion of absorbed solute to the surface of microbial cell (O' Mahony*et al*., 2002; Aksu and Tezer, 2005; Veglio and Beolchini, 1997). Once the dye has diffused to the surface, it will bind to the sites on the cell surface. The precise binding may range from physical (electrostatic and vanderwaal's forces) to chemical binding (ionic and covalent). Studies show the ability of 30 mg dry weight of *Phormidium valderianum* to effectively remove more than 90% of dye up to concentration of 700, 500 and 400 mg l^{-1} of Acid Red 119 and Direct Black 155, respectively (Shah*et al*., 2001).

Textile effluent displayed an alkaline pH of 10.27. On treatment with different agro wastes the pH remained alkaline with slight declination as manifested in Fig. 2. Correspondingly, in combined treatment *i.e.,* agro wastes with cyanobacterium, the pH dropped and obstinated in alkaline condition. During growth, cyanobacteria significantly increased the hydroxyl ion concentration which is directly proportional to the pH level.

Chlorophyll *a* was estimated to ascertain growth rate and was found to decrease in effluent with cyanobacterium, but increased when supplied with different agro wastes, among all, ground nut shell attaining maximum of 106µg ml^{-1} (Fig. 3).

In the present investigation, addition of agro wastes increased chlorophyll *a*, ascertaining their growth as a result of utilization of organic and inorganic compounds present in agrowastes and waste water. Giorgos and Dimitris (2010) findings support that agro industrial sector generates

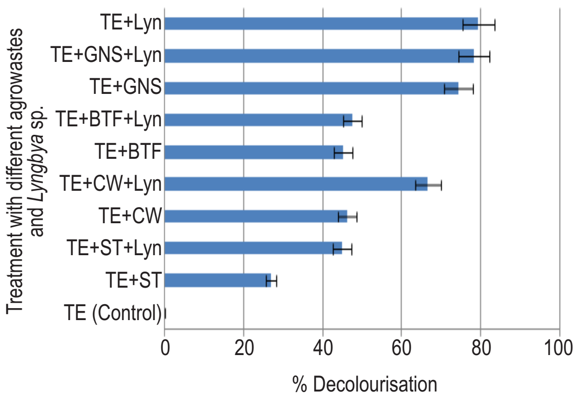

Fig. 1 : Effect of different agro wastes with and without *Lyngbya* sp. on percent decolourisation of textile effluent on 10th day ; Lyn- *Lyngbya* sp.; GNS-Ground nut shell; ST- Sugarcane trash; BTF- Banana trunk Fibre; CW- Corn waste

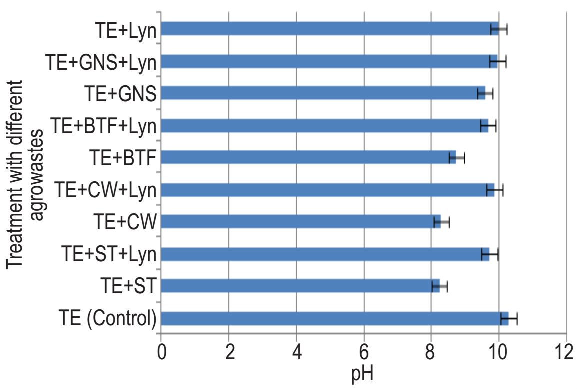

Fig. 2 : Effect of different agrowastes with *Lyngbya* sp. on pH of textile effluent on 10th Day; Lyn- *Lyngbya* sp.; GNS-Ground nut shell; ST- Sugarcane trash; BTF- Banana trunk Fibre; CW- Corn waste

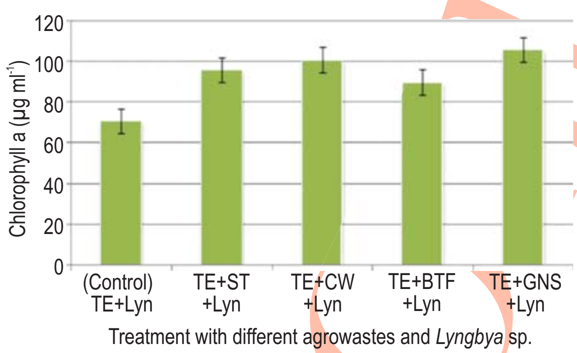

Fig. 3 : Estimation of chlorophyll a content of *Lyngbya* sp. in textile effluent on 10th day; Lyn- *Lyngbya* sp.; GNS-Ground nut shell; ST- Sugarcane trash; BTF- Banana trunk Fibre; CW- Corn waste

considerable amount of waste and wastewater, most of which are rich in organic or/and inorganic pollutants. Therefore, cyanobacterial cells are capable to utilize inorganic and organic compounds present in wastewater as energy and carbon sources. On the contrary, Chen *et al.* (2011) reported that at high cell densities, cell mutual shading takes place and light intensity decreases due to increase in turbidity of the culture causing reduction in photosynthetic activity.

Especially in cultivation in waste water which contains particulate matter and has higher turbidity, a further reduction in light intensity may occur (Larsdotter, 2006). Low nitrogen and high phosphorus conditions often favour cyanobacteria in fresh and saltwater systems (Selner, 1997). In the present study, *Lyngbya* sp. took the nutrients from both textile dye wastewater and agro wastes for their growth and metabolism.

The obtained result gives some insight with respect of utilization of agro wastes as an ecofriendly adsorbent in textile industry wastewater treatment. At the same time endorsing, growth of cyanobacterium in acquaintance with increase in chlorophyll *a* content, thereby acting as a source of nutrient.

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