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Bioremediation of tannery effluent using Cyanobacterium

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ABSTRACT

The healthier industry is indeed booming in our economy but the wastes given off from tannery contribute towards the problem of pollution. Bioremediation of metals by cyanobacteria has been recognized as a potential alternative for the existing technologies for removal of metal pollutants from industrial or urban wastewater. The heavy metal chromium, discharged from tanneries causes photo toxicity, and also enters the food chain resulting in toxins found in is extremely in animals and carcinogenic in nature to human beings. In study showed, chromium removal by using cyanobacterium, the potential of cyanobacterium, for bioremediation of metals has been studied. They are found to accumulate in metals by means of metabolic dependence uptake systems or by adsorption on to cell wall surfaces and external envelopes. The present study also reveals that cyanobacterium *Oscillatoria sp* is a bioremediation agent which brings about the reduction of metals which cause pollution. It is also observed to serve as a simple and sensitive, bio-economic component of the rapid tannery recycling process of effluents.

Key words: Tannery effluent, *Oscillatoria* sp, Bioremediation.

INTRODUCTION

One of the major industries giving off wastewater and causing great concern is the pollution from India's leather industry. The problem of treatment of the wastewater is also as old as the industry itself. The effluent from the tannery contain chromium which when discharged on land surface is used for irrigational purposes. Presence of excess amount of chromium beyond the permissible limit makes it unsuitable for growth of crops (Berka and Kanta Bokaria, 1999). Several reports have confirmed the presence of high levels of ammonia, copper, chromium, cadmium, iron, manganese and lead which are toxic in nature tannery wastewater. Biological methods reported to be very effective in reduction of the pollution load of the effluent (Chakraborthy, 1985); (Ryan, 1988). In the environment, chromium (Cr^{6+}) compounds are comparatively more toxic than those of trivalent chromium (Cr^{3+}) (Ishibashi *et al*., 1990); (Katza, 1991). Bioremediation of heavy metals by microorganisms has been recognized as a potential for alternative existing technologies in the removal of metal pollutants from industrial or urban waste. The potential of Cyanobacteria for bioremediation of chromium has been well documented as these can accumulate or remove metals by means of metabolic dependence uptake systems or by adsorption on to cell wall surfaces and external envelopes. They are found to be very effective in removal of absorption of chromium. The study showed that cyanobacterium *Oscillatoria sp* has been used for the purification and recycling of tannery wastewater.

MATERIAL AND METHODS

Tannery effluent was collected from Chrompet (a suburb of Chennai). In order to select an organism for the treatment process, cyanobacterial populations were collected from different places from where the effluent was collected, isolated and identified by using the standard manual (Desikachary, 1959) and were maintained in CFTRI medium (1985). The following taxa was collected and identified. *Chroococcus*, *Oscillatoria, Lyngbya, Scytonema and Spirulina* sp and indicate the polluted status of the water body. Among the various cyanobacteria, *Oscillatoria* sp alone acclimatized well with the tannery effluent, and this was why the organism was selected for the treatment process. To study the role of cyanobacterium in tannery effluent, the following protocols were employed. i) Effluent treated with *Oscillatoria* sp and ii) Effluent treated without *Oscillatoria* sp (control). Experiments were conducted in trials and repeated three times. Two ml of uniform suspension of *Oscillatoria* sp as initial inoculums in each flask containing 2 liters of effluent The experiment was conducted for a total duration of 30 days under laboratory condition. Samples were periodically (every 6th day) analyzed for various physico-chemical parameters using standard methods[4]. The effluent was dark red in colour, the growth of *Oscillatoria* sp was very slow. However, the growth of alga was enhanced after fifteen days. Therefore a period of one month was provided to observe the exponential growth of alga.

RESULTS AND DISCUSSION

As the problem of effluent disposal consists of complex dimensions, it becomes essential either to find a suitable safe disposal of these wastes or to suggest a novel use, considering them as by-products. Until then these would remain as accumulated wastes, significantly threatening to environmental pollution. The results of biodegradation studies are illustrated in Table 1.

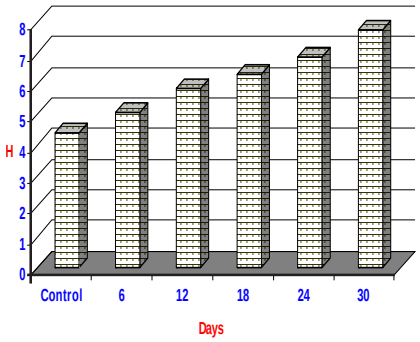
In the present study, pH was found to increase in tannery effluent treated with alga, whereas there was no change in pH in control (Fig.1a). Interestingly, the pH of the tannery effluent increased from 5.1 to 7.8. Along the limited nutrients from wastewater for improvement of over growth metabolism, they produce oxygen. The byproduct oxygen released during algal metabolism was utilized by the aerobic bacteria for biological oxidation of dissolved organics in effluent. These bacteria oxidize the effluent into simpler compounds which could serve as a carbon source for algal species. The *Oscillatoria* sp and aerobic bacteria thus showed mutualism in the culture unit proving their co-metabolism in tannery effluent treatment. The present study shows as pH is observed to increase on the 6th day itself. Manoharan and Subramanian (1992a,b) found a rise in pH value

Table 1: Physico-chemical characteristics of *Oscillatoria* sp control and treated with tannery effluent

S.No	Parameter	Control	Final	% of Reduction
1	Colour	Black	Green	-
2	pH	4.41	7.8	+5.65
3	Alkalinity tot	452	268	40.70
4	Iron	4.55	1.22	73.18
5	Total Kjedal Nitrogen	61.6	2.24	96.36
6	BOD	1590	535	66.35
7	COD	5526	2608	52.80
8	Cadmium	0.00216	0.00062	71.29
9	Copper	0.0301	0.00065	97.84
10	Chromium	1.929	0.593	69.25
11	Zinc	0.151	0.093	38.41

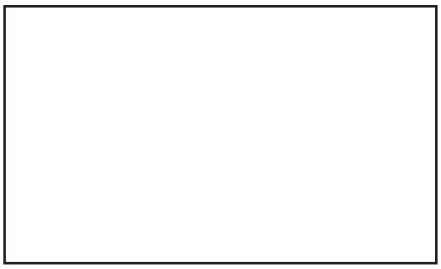
upto 10th day of growth in paper mills wastewater. Initially there was no carbonate, but fairly high levels of bicarbonate were present with the maximum level in treated effluent. The reduction of this carbonate source effectively by *Oscillatoria* sp as observed can be seen in the table (Fig.1b). The decrease in alkalinity was 40.70 percent at the end of the experiment. The ability to utilize bicarbonate has been demonstrated in a variety of algae (Beardall *et al.,* 1976); (Jolliffe and Tregunna, 1970).

In the study, 73.18 present iron was removed from the tannery effluent when treated with *Oscillatoria* sp (Fig.1c). Most of algal forms occurring in the polluted fields have a well defined sheath. Only the ensheathed forms of blue-green algae were found to be tolerating high concentrations of industrial effluents in laboratory culture (Adihary and Sahu, 1988). Thus it is fairly convincing that these outermost surface structures play an important role for forming ensheathed forms

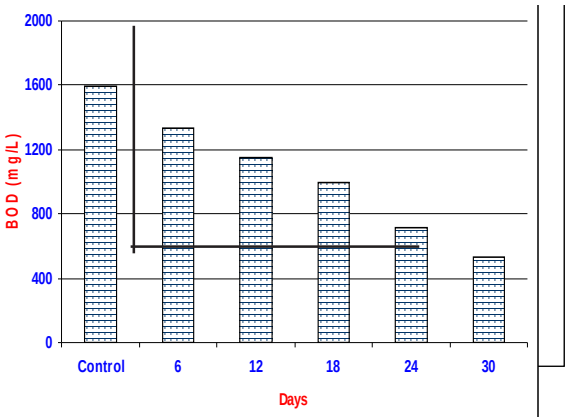


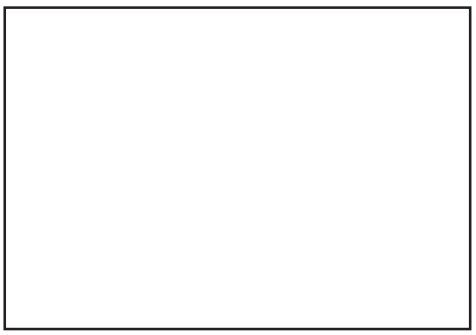
(a)

(b)

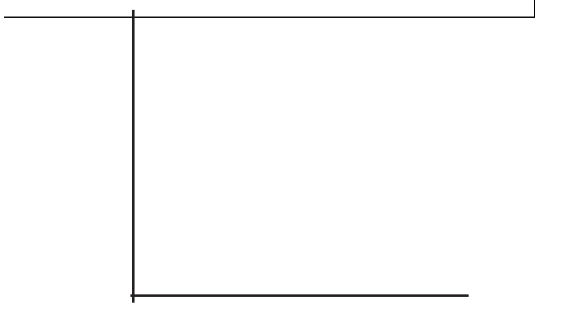


(c)





(e)

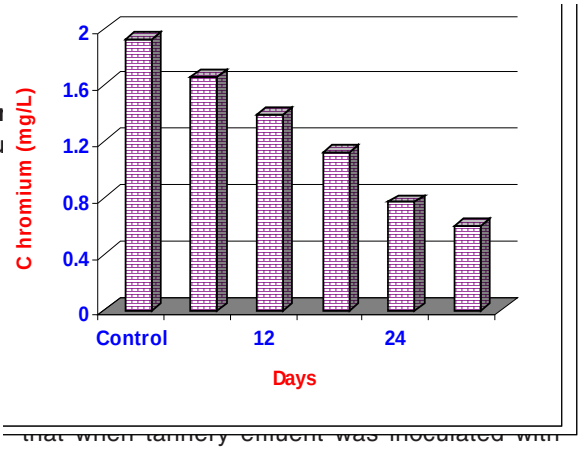


(f)

(g) **(h)**

(i)

Fig. 1: Changes in the concentratio
d) Nitrogen e) BOD f) COD g) Cadmiu



of blue green algae to thrive under adverse conditions.

The study also showed the reduction of 96.36 percent total nitrogen from the tannery effluent treated with *Oscillatoria* sp (Fig.1d). The nitrogen utilization by algae was significant as its growth rate was much higher. The reduction of nitrogen due to nitrification was marginal as the concentration of NO_2-N and NO_3-N were low in the treated wastewater.

The study, also revealed that the BOD was reduced to 66.35 percent in the tannery effluent when treated with *Oscillatoria* sp (Fig.1e). In this case the combined effect of *Oscillatoria* sp with natural population of microbes resulted in significant reduction of BOD. The importance of algal-bacterial symbiosis in BOD reduction has already been well established (Ganapathy and Amin, 1972). The use

that which tannery effluent was inoculated with *Oscillatoria* sp the COD values were found to decrease from 6th day onwards. The decrease in COD was 52.08 percent at end of the experiment (Fig.1f). This implied that *Oscillatoria* sp utilizes the organic matter in the effluent and intermediate metabolite which are not further oxidisable. The use of algal cultures for reducing COD from different types of wastewater has also been reported (Govindan, 1984; (Manoharan and Subramanian, 1992a, b).

Tannery effluent contains an appreciable amount of heavy metals which can pollute the water

and soil (Koe *et al*., 1976). Heavy metals not only cause, photo toxicity (Saxsexa *et al.,* 1991; Sharma and Bisht, 1990), but also enter into the food chain resulting in toxicity in animals and cariconogeny in human being. Among the heavy metals (cadmium, copper, zinc and chromium) reduction of cadmium was maximum (97.84%) when the effluent was treated with *Oscillatoria* sp. (Fig.1g). The toxicity of a metal may depend on the mechanism and efficiency of the uptake.

Many cyanobacteria require combined inorganic nitrogen sources for growth. Such an obligate requirement for growth may not be exhibited by hetrocystous forms which thrive in low nitrogen environment and fix nitrogen (Fogg, 1974). In the present study the copper reduction occurs up to 97.84 percent when the effluent treated with *Oscillatoria* sp (Fig.1h). Similar observations were made by (Rana and Kumar, 1974) with zinc and by (Dashora and Gupta, 1978) with copper. The results thus suggested that nutritional status of an organism may be an important factor while determining heavy metal toxicity.

Chromium may cause serious harm to the human and animal metabolic systems. Excess chromium interferes with the wastewater treatment to a great extent (Law, 1977). The chromium concentration in the effluent was found to be 1.929 mg/L and a maximum of 69.25 percent reduction was observed when the tannery effluent was treated with *Oscillatoria* sp (Fig.1i). It was observed that as the pH increases, the floc formed is more which carries the suspended particles and the removal of chromium along with other contaminants increases till its optimum pH. From the analysis, it is found that the *Oscillatoria* sp is most economical in removal of chromium and other toxic substances from effluents.

In the study the zinc reduction occurs up to 38.41 percent when the effluent treated with *Oscillatoria* sp (Fig.1j). Zinc is an essential element for many enzymatic activities ((Cheblowshi and Coleman, 1986) in plants. However, zinc at toxic concentration affects the growth and metabolism of green plants (Shrotri *et al*., 1981). The effect of heavy metals on growth on different organisms i.e. *Nostoc muscurum, Anabaena azollae, Hapalosiphon stuhlmani, Chlorogloea fritschii, Synechocystis* sps were studied by (Pandey Usha, and Pandey, 1959); (Reddy *et al*., 1997).

This study thus established the fact that the cyanobacteria *Oscillatoria* sp can be used as a bioremediation agent as it brings about reduction of pollutants like inorganic, organic and heavy metals. Furthermore, the better performance in field conditions gave positive indication of their usefulness in treatment of tannery wastewater. It is a simple, sensitive, biological, and a rapid effluent treatment agent. The system when standardized would not only be economical but also eco-friendly and sustainable.

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