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Biotreatment of sewage (Cooum) wastewater by Cyanobacteria

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ABSTRACT

Sewage discharges are a major component of water pollution, contributing to oxygen demand and nutrient loading of the water bodies, promoting toxic algal blooms and leading to a destabilized aquatic ecosystem. The problem is compounded in areas where wastewater treatment systems are simple and not efficient. This study reports the levels of pH, conductivity, COD, nitrates, phosphates, ammonium-N in the sewage wastewater

Key words: Sewage wastewater-cyanobacteria-nutrients removal.

INTRODUCTION

In recent years, the importance of biological waste treatment systems has caught the attention of workers all over the world and has helped in developing relatively efficient, low cost waste treatment system. The usefulness of algal systems, more particularly cyanobacteria, in not only treating the wastes but also producing a variety of useful byproducts from their biomass is being understood (Subramanian and Shanmugasundaram, 1983).

Phycoremediation applied to the removal of nutrients from wastewater and other high organic content wastewater is a field with a great potential and demand considering that surface and underground water bodies in several regions of the world are suffering of eutrophication. However, the development of more efficient nutrient removal algal systems requires further research in key areas.

When considering biological wastewater treatment for a particular application, it is important to understand the sources of the wastewater generated, typical wastewater composition, discharge requirements, events and practices within a facility that can affect the quantity and quality of the wastewater, and pretreatment ramifications. Consideration of these factors will allow you to maximize the benefits your plant gains from effective biological treatment.

This study aims to analyse physico-chemical properties of untreated and treated wastewater and to evolve effective and economic biological treatment method for the sewage wastewater using micro algae.

MATERIAL AND METHODS

Sewage wastewater was collected from the Cooum in Chennai city. In order to select organism for the treatment process, micro algal populations were collected at 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).

To study the role of cyanobacteria in sewage water, the following protocols were employed. i) Effluent treated without *Oscillatoria* sp and *Scytonema* sp (control) and ii) Effluent treated with *Oscillatoria* sp and *Scytonema* sp. Experiments were conducted in duplicates and repeated three times.

Two ml of uniform suspension of *Oscillatoria* sp and *Scytonema* sp were inoculated in each flask containing 2 liter of effluent (i). The experiment was conducted under controlled conditions (temperature 27 ± 2°C) with a light intensity of 2000 lux, provided from overhead cool light white fluorescent tubes (16L+8D) for a total duration of 15 days. Samples were periodically (every 5th day) analyzed for various physico-chemical parameters such as pH, carbonate, bicarbonate, calcium, magnesium, sodium, potassium, nitrate, phosphate, chloride, iron, BOD and COD etc., using standard methods (APHA, 2000).

RESULTS AND DISCUSSION

The study revealed that the sewage water was blackish in colour with disagreeable odour which may be due to decomposition of organic matter or presence of various aromatic and volatile organic compounds (Singh *et al*., 1998) due to microbial activity. These changes in colour and odour of the sewage water may be due to the action of algae which decomposed the organic matter present in both untreated and treated sewage water made the water clear and these findings are in accordance with the work (Verma *et al*., 2002).

Turbidity is a measure of the light-scattering potential of wastewater, caused by the presence of colloidal and suspended material. Effluent filtration can decrease turbidity levels. In the study turbidity was reduced to 65.51 percent by *Oscillatoria* sp and 86.63 percent by *Scytonema* sp.

The amount of total solids was reduced to 56.89 percent by when the sewage water was treated with *Oscillatoria* sp and 58.03 percent when the sewage water was treated with *Scytonema* sp.. Veeralakshmi *et al.,* (2007). reported 19.50 percent reduction of total solids when the petroleum effluent was treated with *Oscillatoria sp.*

Table 1: Physico-chemical parameters of sewage wastewater treated with *Oscillatoria* sp.

S. No.	Parameters (mg/L-1)	Control	5thday	10thday	15thday	%of reduction
1.	Appearance	Blackish	Blackish green	Palegreen	green	-
2.	Turbidity	23.2	18.3	12.6	8.0	65.51
3.	Total Solids	28202	22866	17602	12156	56.89
4.	TDS	28666	22826	17392	12144	56.88
5.	TSS	36	29	20	12	66.66
6.	Conductivity	37272	30092	22916	15359	58.79
7.	pH	7.07	7.14	7.22	7.33	+3.54
8.	Alkalinity tot	184	167	149	132	28.26
9.	Tot Hardness	5000	3817	2630	1450	71.00
10.	Calcium	1360	1030	690	368	72.94
11.	Magnesium	528	395	261	127	75.94
12.	Sodium	6400	5384	4370	3350	47.65
13.	Potassium	300	330	365	400	+25.00
14.	Iron	0.09	0.14	0.27	0.43	+79.06
15.	Free Ammonia	10.08	7.03	4.28	1.12	88.88
16.	Nitrate	4	6	9	10	+60.00
17.	Chloride	14216	13920	10520	7301	48.64
18.	Fluoride	0.56	0.56	0.57	0.58	+3.44
19.	Phosphate	10.13	7.3	5.57	2.72	73.14
20.	Silica	21.35	28.81	34.38	46.65	+54.23
21.	BOD	90	81	72	60	33.33
22.	COD	249	221	193	166	33.33

Total dissolved solids in the present study were reduced to 56.88 percent when the effluent was treated with *Oscillatoria* sp and 58.74 percent by *Scytonema* sp. With regard to TDS, both treated and untreated sewage water were found to contain high levels of TDS compared to the permissible limits of CPCB (1995) and these high levels of TDS may be due to salt content present in the same and also renders it unsuitable for irrigation. Veeralakshmi *et al.,* (2007) reported 19.16 percent reduction of TDS when the petroleum effluent was treated with *Oscillatoria sp.*

Total suspended solids were reduced to 66.66 percent when the sewage water was treated with *Oscillatoria* sp and 72.22 percent by *Scytonema* sp. The total suspended solids were found to be beyond the permissible limit (100 mg/L) of ISI (1979) in the raw sewage water which could lead to various environmental factors like reducing the diversity of aquatic life and in oxygen depletion. The study confirmed that due to reduction of suspended solids the sewage water is suitable for safe disposal on land through irrigation. The untreated sewage water contains a considerable amount of total suspended and total dissolved solids. It is an important parameter (Feign *et al*., 1991) for evaluating the suitability of the sewage water for irrigation purpose since these solids might clog both the soil pore and components of water distribution system.

Electrical conductivity of the treated sewage water was reduced to 58.79 percent by *Oscillatoria* sp and 57.13 percent by *Scytonema* sp. The higher level of electrical conductivity in untreated effluent could be attributed to the use of inorganic chemicals in dairy manufacturing. A high level of conductivity is due to increased concentration of salts. Electrical conductivity were found to be within the permissible limits (3000 µS/cm) issued by irrigation guidelines (Hamoda and Al-Awadii, 1996).

Table 2: Physico-chemical parameters of sewage wastewater treated with *Scytonema* sp.

S. No.	Parameters (mg/L-1)	Control	5^{th}day	10^{th}day	15^{th}day	% of reduction
1.	Appearance	Blackish	Blackish green	Palegreen	Dark green	-
2.	Turbidity	23.2	16.3	10.4	3.1	86.63
3.	Total Solids	28202	22747	17347	11836	58.03
4.	TDS	28666	23070	17500	11826	58.74
5.	TSS	36	29	20	10	72.22
6.	Conductivity	37272	30172	22900	15977	57.13
7.	pH	7.07	7.32	7.64	7.8	+9.35
8.	Alkalinity tot	184	167	144	128	30.43
9.	Tot Hardness	5000	3800	2640	1250	75.0
10.	Calcium	1360	1016	662	328	75.88
11.	Magnesium	528	396	251	103	80.49
12.	Sodium	6400	5270	4173	3000	53.12
13.	Potassium	300	283	267	250	16.66
14.	Iron	0.09	0.45	0.83	1.22	+92.62
15.	Free Ammonia	10.08	42.17	74.41	109.76	+90.81
16.	Nitrate	4	5	5	6	+33.33
17.	Chloride	14216	11301	9008	5439	61.74
18.	Fluoride	0.56	0.53	0.49	0.46	17.85
19.	Phosphate	10.13	7.3	4.46	1.62	84.00
20.	Silica	21.35	35.14	50.39	63.36	+66.30
21.	BOD	90	76	62	45	50.00
22.	COD	249	217	184	153	38.55

When sewage water was treated with algae the pH was increased and became alkaline, hence, the pH affect the treatment efficiency was investigated. Manoharan and Subramanian (1992b) have also reported that the rise in pH value up to 10th day of growth. In the present study interestingly, the pH of the sewage water increased to 7.33 by *Oscillatoria* sp and 7.80 by *Scytonema* sp. Along the limited nutrients from wastewater for their improvement over growth metabolism, they produce oxygen (Vijayakumar *et al.,*2005) reported increase of pH in dye effluent, when treated with *Oscillatoria* sp.

Alkalinity is the capacity of water to neutralize the strong acid, depending upon the capacity of hydroxyl ions to combine with hydrogen ions. Alkaline nature of effluent showed gradual reduction. Alkalinity of the effluent was reduced to 28.26 percent by *Oscillatoria* sp and 30.43 percent by *Scytonema* sp. Alkalinity was found to be high which is harmful to aquatic organism (Nemerow, 1978). The bicarbonate affects the uptake and metabolism of nutrients by plants (Richard, 1968). Vijayakumar *et al.,.*(2005) reported reduction of carbonate in dye effluent, when treated with *Oscillatoria* sp.

Wastewater treatment processes generally have little effect on the hardness of wastewater. Total hardness was reduced to 71.00 percent when the sewage water was treated with *Oscillatoria* sp and 75.00 percent by *Scytonema* sp proving that efficient nutrient uptake of micro algae. In the present study calcium level was reduced to 72.94 percent when the sewage water was treated with *Oscillatoria* sp and 75.88 percent by *Scytonema* sp. Although, calcium is undoubtedly required for cyanobacterial growth (Fogg, 1973), substantial reduction in calcium level cannot be explained by uptake. Divalent cations such as calcium and magnesium are known to be essential for flocculation and would co-flocculate (Richmond and Becker, 1986). Similarly the magnesium level was reduced to 75.94 percent when the sewage water was treated with *Oscillatoria* sp and 80.49 percent by *Scytonema* sp. Veeralakshmi *et al*., (2007) reported 53.33 percent of calcium and 52.94 percent magnesium reduction when the petroleum effluent was treated with *Oscillatoria sp.*

In the present study sodium level was reduced to 47.65 percent when the sewage water was treated with *Oscillatoria* sp and 53.12 percent by *Scytonema* sp. Similarly the level of potassium was increased to 25.00 percent when treated with *Oscillatoria* sp and reduced to 16.66 percent when the sewage water was treated with *Scytonema* sp. The treated sewage water contains increased amount of potassium was due to the addition of nutrients in the treatment process (Somashekar, 1984). Veeralakshmi *et al*.,(2007) reported 57.50 percent of sodium and 33.33 percent potassium reduction when the petroleum effluent was treated with *Oscillatoria sp.*

Iron content in the present study was increased to 79.06 percent when the effluent was treated with *Oscillatoria* sp and 92.62 percent by *Scytonema* sp. Most of algal forms occurring in the polluted fields have well defined sheath. Only the ensheathed forms of blue-green algae were found tolerating high concentrations of industrial effluents in laboratory culture (Adhikary, 1985; Adhikary and Sahu, 1988). Thus it is fairly convincing that these outermost surface structures play an important role for making ensheathed forms of blue green algae to thrive in adverse conditions. Veeralakshmi *et al*.,,(2007) reported 87.47 percent reduction of iron when the petroleum effluent was treated with *Oscillatoria sp.*

The specific use of cyanobacterium in the efficient removal of different forms of combined nitrogen and phosphorus. Ammonia is also discharged in a wide variety of industrial and sewage effluents. In the present study 88.88 percent removal of free ammonia takes place from sewage water by *Oscillatoria* sp. There was an enormous increase of free ammonia (90.81%) by *Scytonema* sp. The increase of free ammonia is due to the conversion of nitrogenous compounds from unavailable form to available form.. Lee and Lee *et al*., (2001) working with *Chlorella kestrel* reported that the higher removal of ammonium from wastewaters. Muthukumaran *et al*.,(2005) working with industrial effluent found *Thalassiosira weissflogii* to be better organism for removal of ammonium from wastewaters.

Nitrate content in the present study was increased to 60.00 percent when the sewage water was treated with *Oscillatoria* sp and 33.33 percent by *Scytonema* sp. Biological nitrogen removal of an effluent without substrate addition is possible if the effluent contains enough biodegradable organics to denitrify all its nitrifiable nitrogen content. When sewage water is discharged to sensitive receiving water with low dilution, the nitrification process in wastewater treatment is encouraged to reduce effluent toxicity resulting from ammonia-N. In the aqueous environment, the effects of nitrate and nitrite are largely associated with increased algal and plant growth where nitrogen is the limiting nutrient.

In the present study the sewage water was treated with *Oscillatoria* sp and the chloride content was reduced to 48.65 percent and 61.74 percent by *Scytonema* sp. Similar observation attributing 30.00 percent chloride reduction under laboratory conditions by *Halobacterium* and only an additional 12 to 17 percent with cyanobacterium was reported in ossein factory effluent (Uma *et al*., 2002). Vijayakumar *et al*.(2005) reported 40 percent reduction of chloride in dye effluent, when treated with *Oscillatoria* sp. Kotteswari *et al*.,(2007) reported 25.98 percent reduction of chloride when the dairy effluent was treated with *Spirulina platensis.*

Fluoride content in the present study was increased to 3.44 percent when the sewage water was treated with *Oscillatoria* sp and reduced to 17.85 percent by *Scytonema* sp. Fluoride also enters aquatic systems as a result of its addition to domestic water supplies and resulting in effluent discharge. Kotteswari *et al.*,(2007) reported 45.28 percent reduction of fluoride when the dairy effluent was treated with *Spirulina platensis*

Phosphates showed a gradual decline. Reduction of phosphate in sewage water and its uptake by micro algae has been reported by Mittal and Senegar (1989). The effluent was treated with *Oscillatoria* sp phosphate content was reduced to 73.14 and 84.00 percent when the sewage water was treated with *Scytonema* sp on the 15th day. Tam and Wong (1990) have reported over 90 percent removal in total phosphorus within 10 days of algal cultivation.

Silica content was increased to 54.23 percent when the sewage water was treated with *Oscillatoria* sp and 66.30 percent by *Scytonema* sp. Kotteswari *et al*.,(2007) reported 80.77 percent reduction of silica when the dairy effluent was treated with *Spirulina platensis.*

The BOD level was reduced to 33.33 percent by *Oscillatoria* sp and 50.00 percent by *Scytonema* sp, similarly, the COD level was reduced to 33.33 percent by *Oscillatoria* sp and 38.55 percent by *Scytonema* sp. It thus becomes evident that reduction in COD was less compared to reduction in BOD. Thus it is obvious that the degradation sought was through biological activity and not through a chemical agent. Kotteswari *et al*.,(2007) reported 47.14 percent of BOD and 24.69 percent COD reduction when the dairy effluent was treated with *Spirulina platensis.* Similarly, Veeralakshmi *et al*., (2005) reported 50.00 percent of BOD and 11.54 percent COD reduction when the petroleum effluent was treated with *Oscillatoria* sp.

Cyanobacteria have a potential to serve as agents for the engineered or intrinsic remediation of surface water *in situ*. Possibility of reprocessing and utilization of cyanobacterial biomass generated during remediation, by a variety of biotechnologies (Kerby and Rowell, 1992). It is also possible that further research may lead to the discovery of novel genetic systems and enzymes of biodegradation in cyanobacteria.

From this study it was clear that when the growth rate of cyanobacteria in sewage water increases, the rate of reduction of different pollutants also increased. It was clear that new bioremediation technologies can be better monitor and better control many types of societal wastes from fast emerging. However, there is little incentive to find and develop new tools. Education is important in achieving the widespread practices of prevention, recycling, and remediation for the purpose of improving the future environmental and quality of life. Through education, societal customs could change ways that could both reduce and recycle waste products and preserve out environment for future generations.

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