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Phyco-Remediation of Sugar Mill Effluent using Chlorella Vulgaris

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***Abstract*:- Sugar is second largest agro industry in India. Thus, its importance is immense from economics point of view. However, the industry needs environment friendly and sustainable effluent treatment technologies considering the water and energy situations at global level. In the present experiment, alga *Chlorella* was experimented to treat sugar mill effluent (SME). Chemical oxygen demand (COD) of approx 6000 mg/L of SME was successfully reduced by >80% in the experiment with 144 h (6 days) of retention period. Produced algal biomass showed calorific value of approx 3,000 cal/g i.e. the treatment technology can produce energy and thus, important in near future for achieving sustainability.**

Key words: Phyco-remediation, sugar mill effluent, Chlorella

1. INTRODUCTION

Being agro-based industry, the sugar mills play an important role in the economic development of rural India. Its significance enhanced due to ethanol blended petrol programme initiated by the Government of India. However, sugar industry produces sizable amount of wastewater. According to the prevailing norms/guidelines, the industry produces 100 L of effluent and 100 L of spray pond overflow wastewater per ton of sugar cane crushed. The effluents contain a high amount of organic pollutants that contributes to chemical oxygen demand (COD. Thus, if effluent discharged untreated or partially treated outside the mill premises, it likely to cause pollution in recipient ecosystem i.e. aquatic and/or terrestrial. The physico-chemical characteristics of the receiving aquatic bodies likely to get altered due to the effluent. Similarly, aquatic flora and fauna gets affected in such situation.

2. SUGAR INDUSTRY AND WASTEWATER

Wastewater with varying levels of pollution load is generated at different stages of sugar production. Pollution load is mainly observed due to oil, grease, sugar/juiceentrainment, bagasse or dust, floor washing and acids/bases or chemicals used for the processes. SME shows a chemical oxygen demand in the range of 1,500 to 5,000 mg/L. This load may increase due to operational issues of individual factory. This is mainly due to organic pollutants. Therefore, SME, if discharge untreated could deteriorate the water quality of receiving bodies and/or affect the soil and associate terrestrial ecosystem. It may cause an impact of various a magnitude on animals who consumes it. Wastewater from sugar industry is having BOD in the range of 1,000-1,500mg/l, could rapidly deplete available oxygen, endangering aquatic life. Considering this and due to legal enforcement sugar factories have installed effluent treatment plants (ETPs). These plants are mainly based on activated sludge process. Several issues have been observed in treating SME through these conventional ETP. Some of them are –

- Inadequate & unskilled manpower: Usually ETP is operated by unskilled labor. Often, labor is seasonal or works on daily wage basis; Sometimes, supervising person is having low knowledge of ETP operation. Ultimately, the end result is ETP not serving its purpose.
- Consumption of higher energy: Considerable amount of energy is spent on pumping activities as well as artificial aeration activity. Floating or sub-merged aerator are used for the said purpose.
- Consumption of chemicals, improper operation of ETP, frequently changing hydrolique loads, etc. are other prime reasons for the search of an alternative treatment for SME.

The research team has already worked on the SME treatment using algae. Algae is immerging as a biofuel source, its cultivation cost can be controlled by cultivating it using wastewater and nutrients. EPA has specifically identified conventional wastewater treatment plants as major contributors to greenhouse gases. Algae based wastewater treatment also releases carbon dioxide (CO_2) but the algae consume more CO_2 while growing than that is being released by the plant, this makes the entire system carbon negative, so this research could give a new idea of a more modern concept or approach to sugar industries for better management of their wastewater.

In algal wastewater treatment facilities, the main objective of sludge management is to maximize algal biomass production. The resulting sludge with algal biomass is energy rich which can be further processed to make biofuel or other valuable products such as fertilizers.

In short, the present work was planned with an objective to study the effectiveness of the treatment for reducing COD/BOD of SME as well as estimate the *Chlorella* biomass production using SME.

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3. MATERIALS AND METHOD

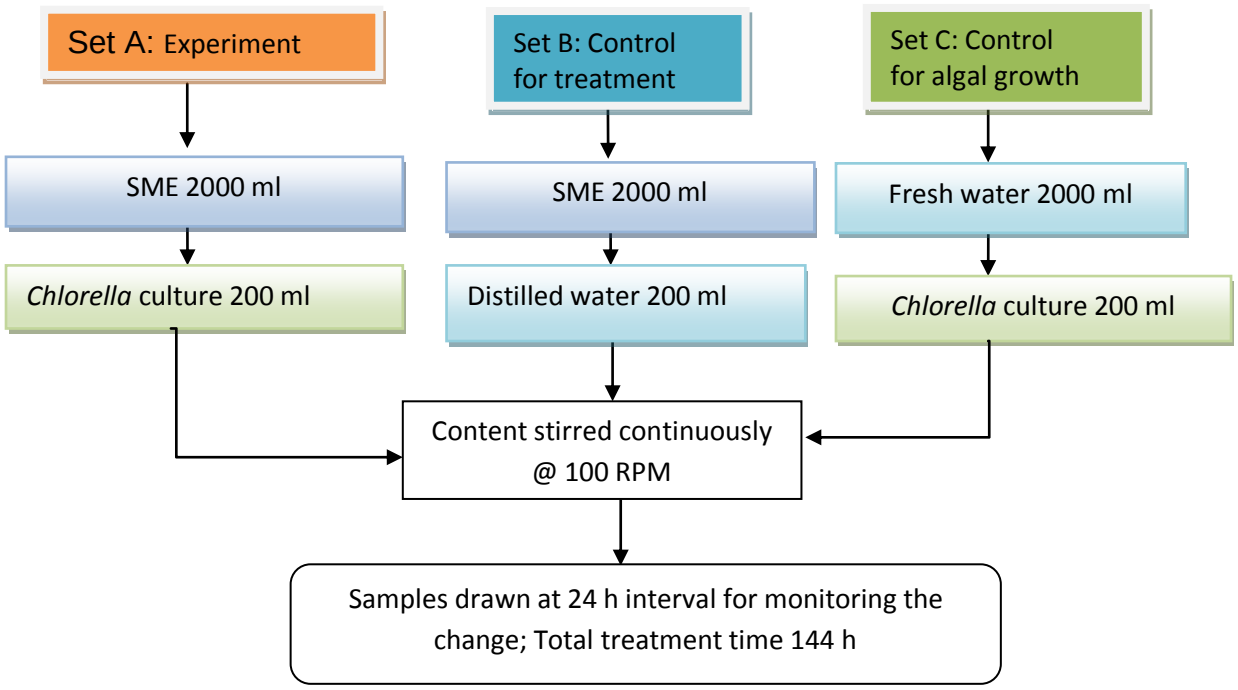

Figure 1: Schematic of experimental setup

SME was collected from Shreenath Mhaskoba Sugar Limited, Pune. Raw effluent (Untreated effluent) was collected from the surface of holding pond in 20 L bucket & transferred to clean plastic can of 35 L. Then collected effluent was stored in cold storage till the day of analysis. It was brought to ambient temperature before commencing any testing & experiments with it. It is used as per requirement of the experiment.

A culture of *Chlorella* collected and isolated from natural fresh waterbody near to the laboratory. The same was maintained at Department of Environment science of Vasantdada Sugar Institute, Pune.

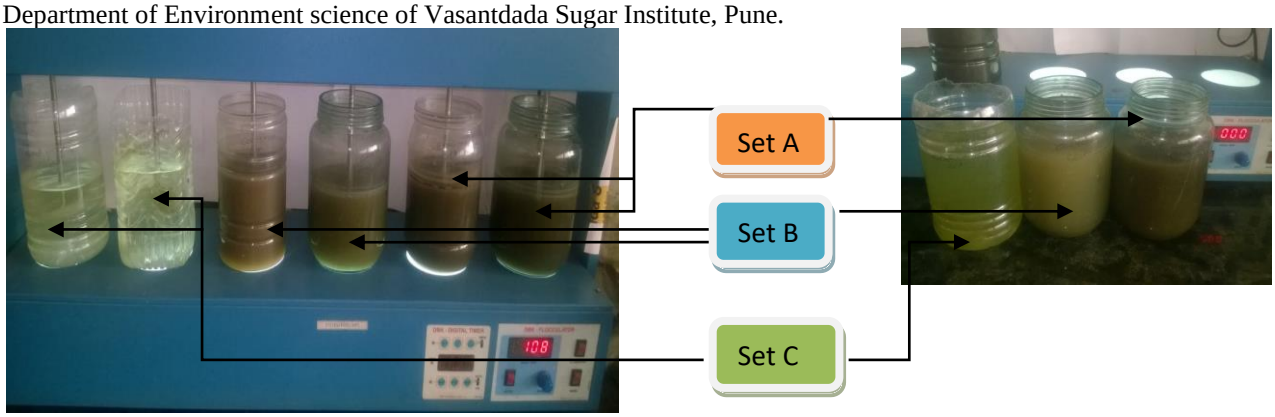

Figure 2: a) Experimental setup at zero hour i.e. initial b) Set A, B and C after 144 h treatment

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The experimental set up is illustrated in the figure 1. Explained here in short, 2,000 ml SME was taken in a container and in which 200 ml of *Chlorella* cells were added. The cell density of the *Chlorella* maintained by measuring its optical density at 660 nm and maintained at 0.613 ±0.050. This mixture was poured in 1.5 L flat bottom jars (as shown in figure 2). Set B and Set C prepared as per the figure 1 and content transferred to the jars. The content of the jar stirred continuously at 100 RPM ±10. During the experiment Laboratory temperature was observed 33^{0}C± 3 during day time and 27^{0}C ± 2 during night. Artificial light of 1000 lux provided for 12 h every day during experimental period.

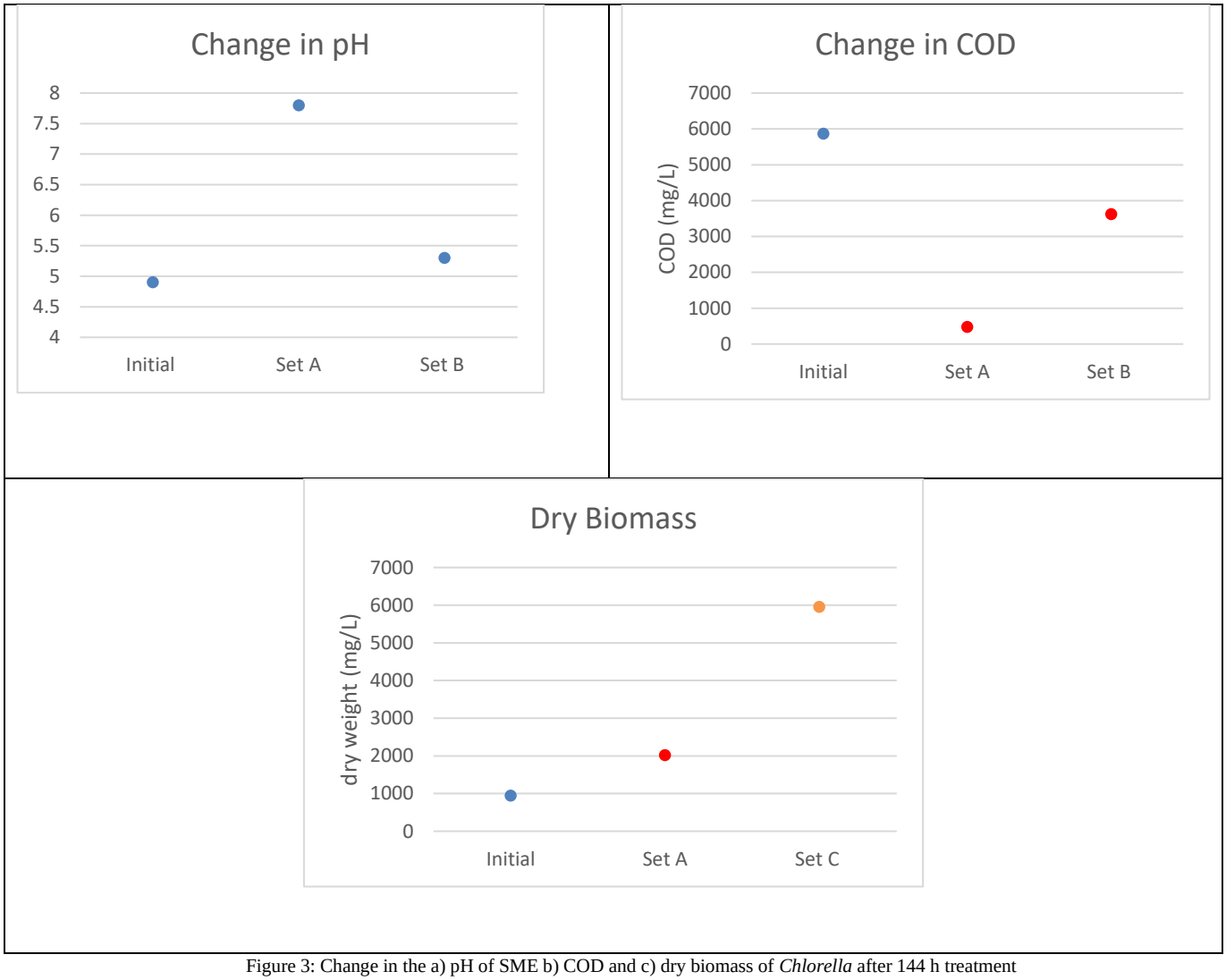

Figure 3: Change in the a) pH of SME b) COD and c) dry biomass of *Chlorella* after 144 h treatment

Figure 4: Dry biomass generated during the experiment

	Gross Calorific value (cal/g)
Chlorella dry biomass	3,356± 153
Dry sludge of SME including *Chlorella*	3,896 ± 93

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4. DISCUSSION

The major achievement of the experiment is efficient COD reduction without any expensive chemicals. Overall, COD reduction of > 80% achieved in 144 h (i.e. 6 days) treatment. This is very similar to the observation reported by Goncalves *et al.* (2017), who reported pollutant removal ability of algae as 2–14 dHRT. He *et al.,* (2013) and Wang *et al.* (2015) reported that algae can grow well only in wastewater having lower COD (below 5,000 mg L_1). But, the present study showed that, *Chlorella* can survive and treat industrial effluent having COD of > 5,000 mg/L. This treatment time may get reduced if the experiment carried out in the actual sun light (Deshmane et al. 2022).

The second objective of the experiment focused on bio-energy from the treatment process. If, the dry sludge (95%+ dry) from the treatment process used as a fuel it has excellent calorific value. On an average 5 to 6 g of sludge generated per litre of SME. A sugar mill of 5,000 ton per day crushing capacity produces 500 m3 of SME. Thus, 2.5 to 3 tons of sludge anticipated which is sizable. In short, the results indicate that, SME is having good potential to serve as a growth medium for algae. Dry algal biomass can be used for the feedstock to produce bio-energy.

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