Design and Development of a Simple Stirred Tank Photobioreactor for Algal Production

R. N. Singh[1], Shaishav Sharma[1,*], Anand Krishna Singh[2] and Nilay Srivastava[1]

[1]*School of Energy and Environmental Studies, Devi Ahilya Vishwavidyalaya, Indore-452001, India*

[2]*School of Life Science, Devi Ahilya Vishwavidyalaya, Indore-452001, India*

Abstract: A simple and efficient stirred tank photobioreactor was designed and developed for micro algal culture. The culture system was made of glass and consists of four major parts: culture system container, stirrer, aerator rod and aerator pump. The reactor had proved to be well suited for the cultivation of micro alga Chlorella sp. Two different trials were run for microalgal culture. The lux intensity at the photobioreactor was maintained at 200lux. The algal biomass volumetric output rate was 5.85g l^{-1} d^{-1}.

Keywords: Stirred tank photobioreactor, microalgae.

1. INTRODUCTION

Energy is the most important factor for sustaining a civilization as well as for its development but our dependence on fossil fuels as our primary energy source contributes to global climate change, environmental degradation and health problems (Sharma Shaishav, R N Singh and Tripathi Satyendra; 2013). The rising pressure on the conventional sources of energy and food has brought algae in the spotlight for developing various products such as biofuels, nutraceuticals, feed for aquatic animals etc. The culture of algae can be done through open pond systems but the uncontrolled environment and problem of contamination in the open ponds makes it difficult for the production of axenic cultures. There are various photobioreactors designed and used for algal production [1]. Photobioreactors are complex and capital intensive approaches for microalgal production [2]. In this study, a simple and low cost stirred tank photobioreactor has been designed, developed and applied for the cultivation of *Chlorella* sp.

2. MATERIALS AND METHODS

The photobioreactor and light setup was designed and developed as shown in Figure **1**(**a** and **b**). The photobioreactor consist of culture system; stirrer; aeration rod and aerator pump. The culture system is a cuboidal vessel made of glass which has dimensions as 38 x 23 x 30cm. The light setup had 5 fluorescent tube-lights (40W each) with individual control. To provide proper illumination to culture system, 2 tube-lights were arranged vertically and 3 were arranged horizontally. The light intensity at the photobioreactor was measured using Lux meter (Mastech-MS6610) and it was maintained at 200 lux throughout the experiment.

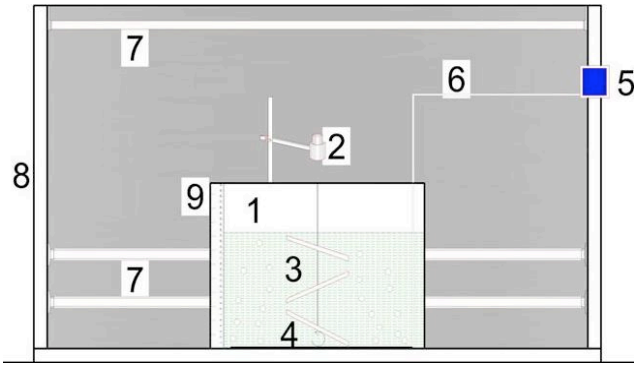

Figure 1: Design of stirred tank photobioreactor. 1. Photobioreactor Container; 2. Stirrer Motor; 3. Stirrer; 4. Aerator Rod; 5. Aerator Pump; 6. Aerator Pipe; 7. Florescent Lights; 8. Lighting Pipe; 9. Scale.

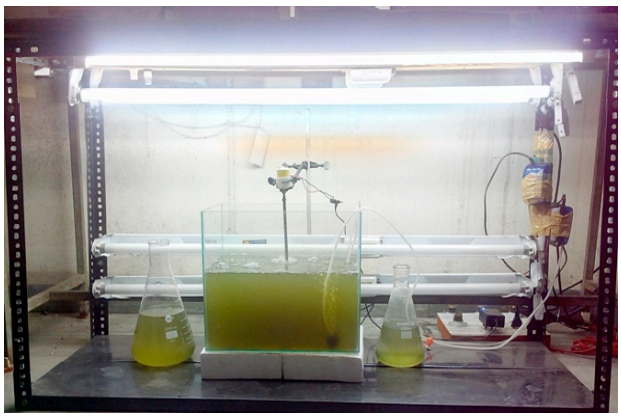

Figure 2: Actual stirred tank photobioreactor installed.

Algae species *Chlorella* were obtained from Botany department, Holkar Science College Indore. It was grown in Fog's medium + 0.2% KNO_3 (Table **1**).

*Address correspondence to this author at theSchool of Energy and Environmental Studies, Devi Ahilya Vishwavidyalaya, Indore-452001, India; Tel: +91 731 2466309; Fax: +91 731 2467378; E-mail: shaishav.bt@gmail.com

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Table 1: Fog's Medium (For Algae)

MgSO4.7H2O	0.2g
K_2HPO_4	0.2g
Micronutrient Solution	1.0ml
$CaCl_2.H_2O$	0.1g
Fe-EDTA solution	5.0ml
Distilled Water	1.0ml
Agar	12.0g
Micronutrient Solution	
H_3BO_3	286.0 mg
$MnCl_2.4H_2O$	181.0 mg
$ZnSO_4.7H_2O$	22.0 Mg
$Na_2MoO_4.2H_2O$	39.0 mg
$CuSO_4.5H_2O$	8.0 mg
Distilled Water	100.0ml

*0.2% KNO_3 is added.

The algal growth intensity was measured by two methods: 1. Through optical density method 2. Through dry weight method.

In optical density method, spectrophotometer (SHIMADZU UV-1601) was used to measure optical density at 600nm.

In dry weight method, the algae was centrifuged at 10,000r.p.m for 10minutes. After centrifugation, the supernatant was removed and the pellet was weighed after drying.

Two trials were performed at the School of Energy And Environment Studies of DAVV Indore.

3. RESULT AND DISCUSSION

The trials for growth of *chlorella* sp. in the stirred tank photobioreactor were performed twice. The pH of the culture was obtained in the range of 6.5–7.9 and temperature was in the range of 23–28 ^0C. The light intensity was maintained at 200Lux through florescent lights in the lighting setup. The lighting cycle was maintained at 12hours light/12 hours dark every day. The aeration to the culture was provided through aerator pump and uniformly supplied to the culture through an aeration rod placed in the centre of the culture vessel. Both the trials were initiated by introducing 20% algal inoculum (v/v) (Table **2**). The range of optical density during the two trials was 0.131–0.25. The Average Volumetric Productivity

Table 2: Experimental Conditions during the Experimental Trials

Experimental Parameters	Trial I	Trial II
pH Range	6.8-7.8	6.5-7.9
Temperature Range	25-28	23-27.6
Inoculum (%)	20	20
Light Intensity (Lux)	200	200

obtained was 5.84–5.86g $l^{-1}d^{-1}$. (Table **3**; Figure **2a** and **b**; Figure **3a** and **b**).

Table 3: Results during the Two Trials

Optical Density	0.131-0.249	0.134-0.25
Dry Weight (g/l/day)	5.84	5.86

Trial I:

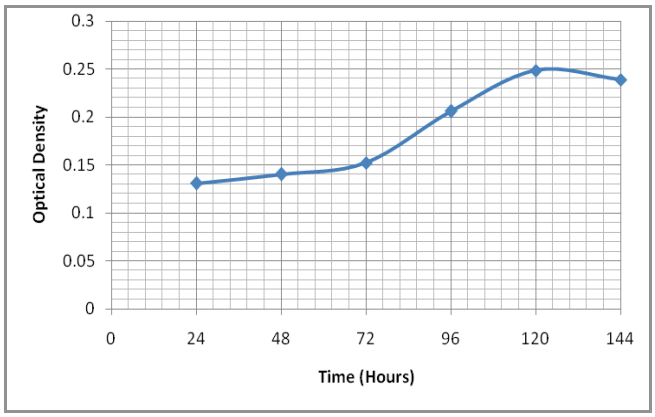

Figure 2a: Optical Density v/s Time.

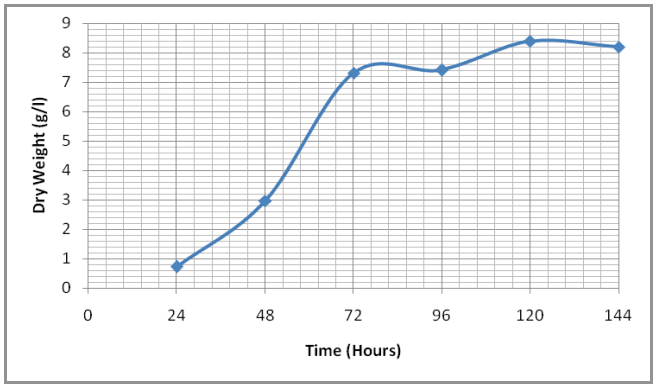

Figure 2b: Dry Weight v/s Time.

4. CONCLUSION

The stirred tank photobioreactor developed has shown encouraging results for the production of

Trial II:

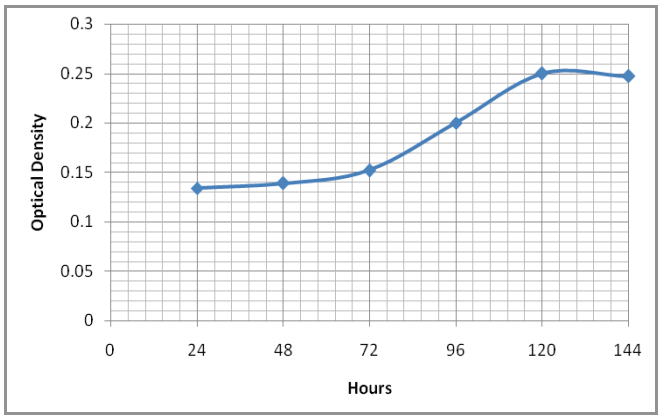

Figure 3a: Optical Density v/s Time.

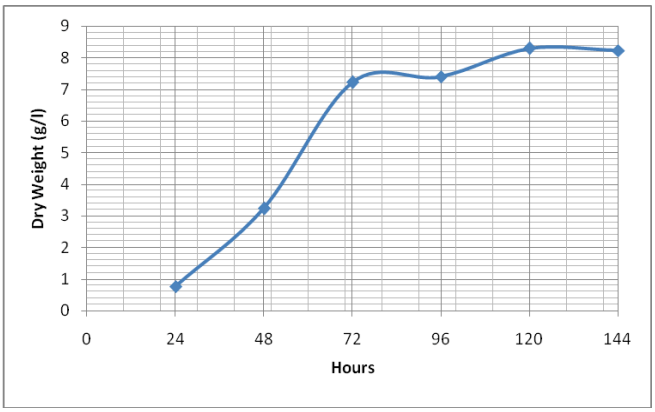

Figure 3b: Dry Weight v/s Time.

microalgae. The comparative analysis of this photobioreactor with other photobioreactors and also with the natural environment would further help to modify this photobioreactor for microalgal production.

5. ACKNOWLEDGEMENT

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