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Biomass of algae growth on natural water medium

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ABSTRACT

Algae are the dominant primary producers in aquatic ecosystems. Since algae are highly varied group organisms, which have important functions in ecosystem, and their biomass is an essential biological resource. Currently, algae have been applied increasingly to diverse range of biomass applications. Therefore, this study was aimed to investigate the ecological algae features of microalgal production by natural medium, ecological function by lab scale of the symbiotic reactor which is imitated nature ecosystem, and atmospheric CO_2 absorption that was related the algal growth of biomass to understand algae in natural water body better. Consequently, this study took advantages of using the unsupplemented freshwater natural medium to produce microalgae. Algal biomass by direct measurement of total suspended solids (TSS) and volatile suspended solids (VSS) resulted as 0.14 g/L and 0.08 g/L respectively. The biomass measurements of TSS and VSS are the sensible biomass index for algae production. The laboratory results obtained in the present study proved the production of algae by the natural water medium is potentially feasible.

1. Introduction

Algal community plays an important role as the primary producer and as a major biotic component in the nutrient/energy cycle in any aquatic habitats [1,2]. In addition to the producer role, algae are involving in symbiosis with bacteria in various ecosystems [3]. Algal abundance, density, and diversity are ideal indicators of the health of aquatic ecosystems and water quality [4]. Because algae are ideal organisms for biological and chemical modulators in aquatic ecosystems [5], they not only provide a specific niche of food and oxygen in the environment but also keep CO_2 of carbon cycle work via photosynthesis to balance CO_2 concentration in atmosphere. The potential of fresh water algal biomass to mitigate global problems of food and energy and its significance as a carbon sink have been recognized [6].

Algae have critical functions of energy cycle in nature ecosystem as well as in human society, and their biomass is widely applied for the production of pharmaceutics, food, bioactive compounds and bioenergy application [2]. Sustainable energy production represents one of the most important issues of the 21st century, and plant-based biofuel offers a significant promise. Nowadays, many studies have been conducted on biomass to provide a source of biofuel to reduce the world's dependence on fossil fuels [7]. Among all the potential alternatives of energy crops, microalgae growth rate is the highest [2,6]; conventional terrestrial plants are relatively inefficient in capturing and converting less than 0.5% of the solar energy received [2,4,5] in contrast, the photosynthetic efficiency of microalgae can exceed 10% potentially [5,6]. Because of higher light conversion efficiency, algae biofuel production requires significantly less land area than plant-based, even agricultural crop-based biofuel systems. Besides, algae can offer additional ecological benefits by reducing anthropogenic pollutant in environment, and lowering the concentration of CO_2 in air to keep CO_2 balance in carbon cycle if we adopt ecological engineering process of algae technology to design efficient growth system to utilize this natural resource sustainably.

Since the algae can be one of the most important crops with efficient energy conversion and a significant niche of food web structure in ponds, lakes and reservoir [2,4]. As there are the enormous potential, if we could grow algae with natural water, there were lots of advantages such as (1) economic benefits compared to artificial medium i.e. without any extra CO_2 adding, (2) environmental advantages for water quality improvement [1,4,5] without further water contaminations, and (3) ecological sustainability promotion from the cooperation of watershed management with the symbiosis algal biomass system with energy conversion, greenhouse gas CO_2 sequestration [1–7]. Surprisingly, the existing literature is lacking information describing the microalgal growth potential of 'natural media' of the untreated/unfractionated water samples from natural ecosystems and the noticeable absence of

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reports describing the efficacy of unsupplemented natural water as a medium to produce algal biomass. Consequently, we used natural water with natural algae culture to mimic the natural system to accomplish the basic aim of the understanding of the nature better. Additionally, air CO_2 is one of the major carbon sources to support the algal growth in freshwater body [6] and our design was very suitable to study the natural CO_2 absorption of algae. Therefore, in the present study, we investigated the potential of the natural freshwater without external carbon supplements to support microalgal growth.

2. Materials and methods

The mixed culture microalgae were collected from Sustainable Resources and Sustainable Engineering research laboratory (SRSE-LAB), Department of Soil and Water Conservation, National Chung-Hsing University, Taichung, Taiwan. The algae are grown in autotrophic condition with 10 day detention time, continuously for over two year's period with batch fed culture in 4 L continuously stirred rank reactor (CSTR) under room temperature and illumination through fluorescent lamps. We used three production units: P1, P2, P3 for triplicate and the growth system was shown in Fig. 1. Neighboring river water was collected at Fu–Te Dao-temple in Green river (24°7′ 27.35″N; 120°40′ 22.79″E), Taichung, Taiwan where is near to National Chung-Hsing University. After the collection, the water filtered by 0.45 μm filter paper to take as medium.

Algae biomass was estimated gravimetrically by total suspended solids (TSS), volatile suspended solids (VSS) and fixed suspended solids (FSS). TSS was measured by Method 209C with Whatman GF/C filter paper; VSS and FSS were estimated by Method 209D and all physico-chemical analyses were carried out whole growth period according to the standard method [8] and detailed methods was presented in Table 1. Chlorophyll-a (Chl-a), Chlorophyll-b (Chl-b) and Chlorophyll-(a + b) (Chl-a + b) was extracted with acetone by boiling [9]. The entire experiments were done in triplicate.

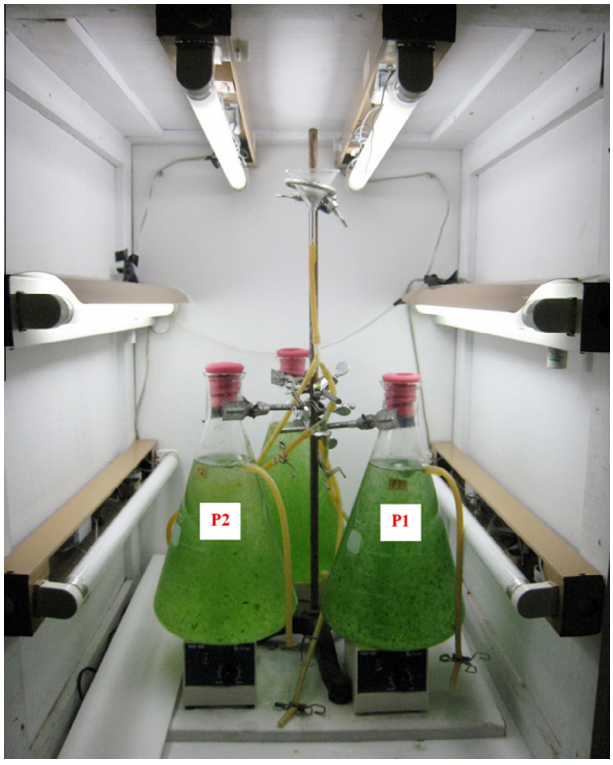

Fig. 1. Photo-bioreactor.

Table 1
Physiochemical and algal biomass parameter.

Parameter	Equipment or method
Growth condition	
Light intensity	LI-COR light meter (LI-250)
Water temperature	Thermometer
Settleable solid	Imhoff cone
Species	Microscope
Water quality analysis	
pH	Method 423 (standard methods)
DO	Method 421B (standard methods)
COD	Method 508B (standard methods)
NH_4^+–N	Method 417D (standard methods)
TKN	Method 420A (standard methods)
NO_2^-–N	Method 419 (standard methods)
NO_3^-–N	Method 418A (standard methods)
TP	Method 424D (standard methods)
Algal biomass measurement	
TSS	Method 209 (standard methods)
FSS	Method 209 (standard methods)
VSS	Method 209 (standard methods)
Chlorophyll a	Becker method
Chlorophyll b	Becker method
Chlorophyll a + b	Becker method

For the CO_2 source, we did not use any artificial control or any extra CO_2 addition and used the open reactor to make the reactor gas exchangeable with atmosphere. CSTR type of design could mimic the real condition in the natural ecosystem best. The CO_2 uptake calculations were computed by mass balance which was adopted from literature [10,11]. We chose two indexes in this study: (i) CO_2 uptake rate indicated as mass per unit of reactor volume-time to express the measurement as the term specified [12,13]. (ii) CO_2 consumption efficiency defined as CO_2 weight/biomass ratio [14], which is one of the most direct methods to examine the CO_2, consumed mass per unit of algae biomass production. Statistical analysis was performed with the use of SAS software [15].

3. Results and discussion

3.1. Algae growth conditions

The mean values of measured physicochemical and biological parameters in the microalgal growth conditions of this study are summarized in Table 2, with 10 days hydraulic detention time. Growth system was setup under room temperature (avg. 27.5 °C) and continuous illumination light through fluorescent lamps; light intensity was average as 30.12 ($\mu mol^{-1}\ m^{-2}$ per μA). The microalgal species in the culture were microscopically identified according to stand methods [8]. The mixed culture microalgae, comprising predominantly the species of the genera *Anabaena*, *Chlorella*, *Oedogonium* and *Oscillatoria* were grown in autotrophic conditions of CSTR type photobioreactor, along with several other minor microalgae including the species of the genera *Lyngbya*, *Scenedesmus*, *Phytoconis*, *Coccochloris* and *Phormidium* and a few unidentified microalgae.

3.2. Biomass

3.2.1. Total suspended solids

TSS represents the total amount of suspended solids in the algae growth units. TSS refers to the total solids retained by 0.45 μm filter paper and can be used as a measurement of algal biomass after drying [8,16]. Results were shown in Fig. 2. In our algae growth