A Study on Seaweed Beds in Eutrophic Regions assuming CO_2 Dissolving and Fixation

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***Abstract*— CO_2 dissolving experiments in marine areas may cause some negative impact including changes in pH levels in the surrounding environment. Based on a CO_2 dissolving experiment in both human waste water as well as artificial seawater using microbubbles, we conducted a basic study on a seaweed bed in Eutrophic Regions assuming CO_2 fixation. if we check CO_2 levels and operating time to avoid rapid elevation of pH levels in sewage treatment facilities, thus having the advantages of both techniques.**

Keywords*— CO_2; Eutrophic Region; membrane process water; microbubble

INTRODUCTION

This study was conducted by the Organization of Advanced Science and Technology, Kobe University and the EcoTopia Science Institute, Nagoya University. We looked at a "system of algaculture and its energy production" for use in conjunction with coal-fired power plants that emit a large scale of carbon dioxide. However, the main purpose was to verify the engineering possibilities of turning alga into fuel. Studies on culturing algae in eutrophication areas or their equivalents have not yet been sufficiently performed with regard to fisheries science and this will be important if we are to operate a biological energy production system. In order to operate "a system of algaculture and energy production" in the future, the current study "A Study on Seaweed Beds in Eutrophic Regions assuming CO_2 Dissolving and Fixation." examines the mechanism of dissolution of carbon dioxide in the ocean and its effects, also the selection of algae, and promotion of dissolution and photosynthesis of carbon dioxide in the marine.

I. EXPERIMENT METHODS

A. Nutrient medium and Alga

We show the handling of human effluent waste water and the process of membrane Bioreactor treatment in Fig.2. Film segregation activated sludge process filtration treated water (membrane process water), we added 38 g of artificial ocean water salt (Vee salt) into the treated water mentioned above. This was done to adjusted the salinity (to approximately 36 ‰) like seawater, as a nutrient medium. Table 1 shows the composition of the membrane process water. We used *Ulva meridionalis* (Fig.1) for culture. It is the alga with the use results in Suzuki (2013)[1]. Generally, seaweed , including green string lettuce, grows on rocks. Thus, in past seaweed cultures, it was important to fix the seaweed seeds and saplings to a net. However, this method had problems. It only cultured in two dimensions, and high density culture was difficult and also the growth varied. Therefore, to raise the harvest per tank unit, "Spore method conglomeration", which enables floating algae to breed at high density, was developed. I used this method because it allows plural seaweed bodies to connect to each other at the spore stage, which cultivates agglomerations of the sprouting bodies in large quantities[2]. We applied to *U. meridionalis.*

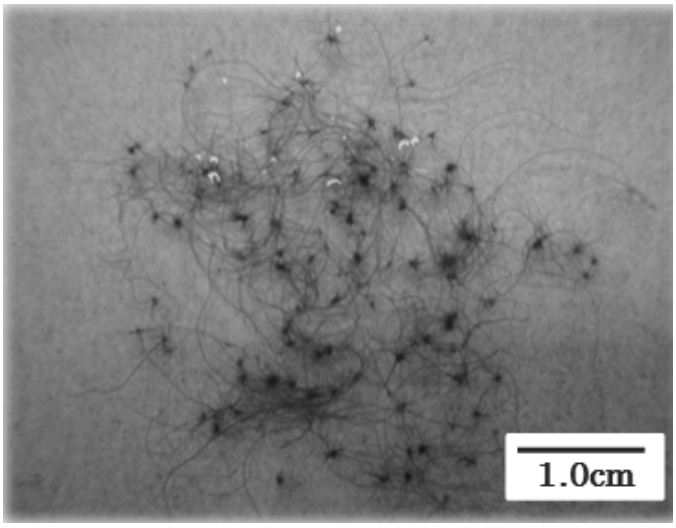

Fig. 1. *Ulva meridionalis*

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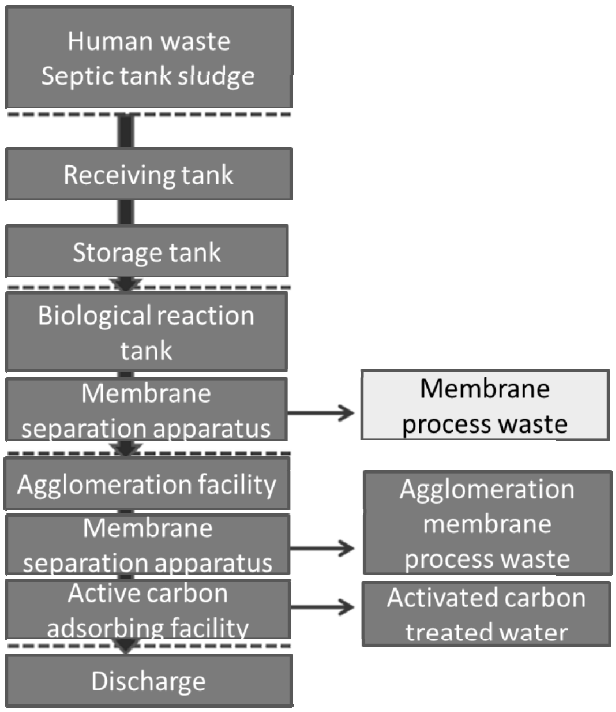

Fig. 2. *Membraine Bioreactor*

Table 1. the composition of the membrane process water

N(mM)	P(mM)	Zn(mM)	Fe(mM)	Mn(mM)	Co(mM)
1.03	1.42	1.78×10^{-3}	10.1×10^{-4}	5.95×10^{-4}	4.12×10^{-5}

B. An experimental device and experiment condition

A diagram of the experimental device is shown in Fig.3. It was maintained at 25 ℃ using an incubator (NRB-14A: Nihon Freezer). I used hydrochloric acid (1.1 mol / L) and sodium hydroxide (4 mol / L) to adjust the initial pH. All culture containers were sterilized at a high temperature (120 ℃), using an autoclave for 20 minutes (HVE-25: HIRAYAMA MANUFACTURING CORPORATION). We used air bubbling to simulate an open system culture. Since the water decreased by evaporation we added distilled water every 2days. For CO_2, we used a Soda Stream (Synergy Trading Corporation). We assumed lighting time-temperature tolerance of 12 hour / day using fluorescent fixture (12W *2) as a light source. We wrote down the conditions for each experiment, including the initial pH, capacity, and whether it was an open system or a closed system.

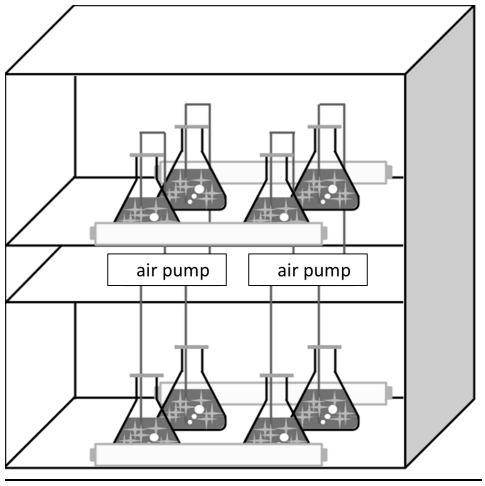

Fig. 3. *A diagram of the experimental device*

II. A MEASURED ITEMS AND EVALUATION METHOD

A. Growth evaluation

We measured wet weight every 2days. We calculated interval growth rate (DGR) with the following expressions using daily the results and evaluated it[3].

$$DGR = \left[\left(W_t / W_o \right)^{1/t} - 1 \right] \times 100 \quad (1.1)$$

DGR: Dayly interval growth rate (%)

Wo: Initial wet weight (g)

Wt: Wet weight after t day (g)

We define the growth of *U. meridionalis*, as "a growth rate of per day more than 5%".

B. Total organic carbon analyzer

The inorganic carbon solution is measured with a total organic carbon analyzer (TOC － VE: Shimadzu Corporation).Underwater inorganic carbon exists as a carbonate ion (CO_3^{2-}) , hydrogen carbonate ion (HCO_3^-), and carbonate (H_2CO_3). They generally become carbon dioxide when the pH is below 4. After acidifying sample of algae we ventilate the gas (which does not include carbon dioxide). We release inorganic carbon from the sample as CO_2 gas and measure the CO_2 concentration using a specific thermal conductivity detector sensor (TCD).

C. CHN CORDER

The unknown quantity of carbon present in the algae sample is measured using The Yanaco MT-S C H N CORDER Technique. A weighted sample is inserted in a combustion tube, and exposed to helium and oxygen. Ignition of the gas, results in a flash combustion, converting all the organic and in organic substances into products of combustion. The sample combustion gases are completely oxidized here, and are sent to the reduction pipe. The reduction pipe, reduces the nitrogen oxide in the combustion gases to nitrogen, and the surplus oxygen, halogen, and sulfer are removed. This way combustion gases are treated with a reduction pipe and the gross quantity of H_2O, CO_2, and N_2 gas are gathered with helium by a fixed-quantity pump. The pump then sends each element to the detection department in the thermal conductivity detector (TCD) to be measured. We calculated the C, H, and N quantities that were constituent elements of the sample.

D. Calculating the amount of Carbon CO_2 fixation

By using formula 1.2 we calculated the algal growth rate.

$$I = \frac{(W_t - W_o)}{t} \tag{1.2}$$

Where I= growth rate (g/day)

Wo=Initial wet weight (g)

Wt=Wet weight after t day (g)

Once the initial growth rate has been calculated, the next step is to input the value for the growth rate, into formula 1.3, to calculate the CO_2 fixation value F.

$$F = I \times \frac{D}{100} \times \frac{C}{100} \times \frac{M}{N \cdot S} \tag{1.3}$$

Where F= Quantity of CO_2 fixation (g/m^2/day)

I= Growth rate (g/day)

D= Dry weight (%)

C= Carbon content (%)

N= Carbon atomic weight (g/mol)

M= CO_2 molecular weight (g/mol)

S= Area (m^2)

E. Microbubble

The device consists of a microbubble nozzle, a water meter able to measure many kinds of water quality, a carbon gas densimeter, a gas cylinder, a water tank, and on underwater pump (gas pressure 0.15MPa, gas flow quantity 10L/min). The water temperature was 25℃ and we measured how long it took CO_2 to be dissolved by microbubbles in 20 minutes. The trial used artificial sea water.

III. EXPERIMENTAL RESULTS AND CONSIDERATION

A. Change of pH with growing culture

We tested the following culture conditions to investigate the influence that pH has on the growth of the *U. meridionalis* .

initial pH: 7.9±0.1 capacity: 500mL system: open system

We show the change of wet weight and pH in the culture in figure 3.1. After 1day a change was confirmed in the pH, and this change occurred at regular intervals. In addition, the maximum pH became big with growth. The Quantity of photosynthesis increases with this growth, and this is thought to be due to the fact that HCO_3^- in solution decreases, as seen in the expression below.

$$HCO_3^- + H^+ \leftrightarrows CO_3^{2-} + 2\,H^+$$

B. Influence on photosynthesis by inorganic carbon

As a prerequisite, the initial pH level and inorganic carbon were regarded to change simultaneously. Therefore, in order to examine the possibility of growing an alga culture in membrane filtered water with varied inorganic carbon concentrations, an incubation experiment was conducted based on the following conditions. (Initial pH: 7.9±0.1, Capacity: 70mL, System: Closed system, Initial $NaHCO_3$ concentration: 0, 0.05, 0.10, 0.50,1.0, 2.0g/L) Regarding changes in the daily growth rate, and wet weight, as well as changes in inorganic carbon during the incubation using membrane treated water, the growth was enhanced when the initial NaHCO3 concentration was ≤0.5g/L but inhibited when it was ≥1g/L. In case of membrane treated water with an initial $NaHCO_3$ concentration ≥1g/L, insoluble carbonate of unknown components precipitated at the bottom of the container where algae had also precipitated. It is believed that this precipitation covered the algae and reduced the amount of light for the algae, resulting in inhibited photosynthesis. In addition, organic acid produced by the respiration of algae is discharged as CO_2 causing inorganic carbon in the solution to increase. It is believed that algal respiration is more frequent in low light environments making it harder to grow.

C. *Influence on photosynthesis, and breathing by dissolving CO_2*

Subsequently, we conducted an incubation experiment using membrane treated water in which CO_2 was dissolved based on the following conditions. (Initial pH: Dependent on dissolved amount of CO_2, Capacity: 70mL, System: Closed system) From changes in wet weight, daily growth rate, inorganic carbon, and pH level during incubation using membrane treated water, it has been proven possible to culture algae with an initial pH level ranging from 6.5 to 7.9. Furthermore, growth of algae was enhanced when the initial pH level was 7.0 compared with that of 7.9. On the other hand, when trying to estimate whether the growth of algae was inhibited by dissolving CO_2, from the relationship between inorganic carbon and daily growth rate, it was confirmed that algae grew under a concentration of dissolved carbon ≤44.4mg/L but not confirmed under a concentration of ≥120mg/ L .

D. *Dissolution promotion by microbubbles*

Moreover, in the CO_2 dissolving experiment using microbubbles, rapid pH level reduction (pH7.8~4.9) and an increase of dissolved CO_2 concentration was observed. Large CO_2 bubbles adhere to algal respiration pores which tends to limit growth, but microbubbles should increase growth because they can permeate the pores. It may be possible to place microbubble nozzles at seaweed beds in eutrophic regions as long as we check CO_2 levels and operating time to avoid rapid elevation of pH levels from sewage treatment facilities, thus having the advantages of both techniques.

Acknowledgment

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