EVALUATING NUTRIENTS REMOVAL AND MEMBRANE FOULING OF MEMBRANE PHOTOBIOREACTOR USING URINE AS SUBSTRATE AND MICROALGAE-BACTERIA AS CO-CULTURES UNDER TWO LIGHT - DARK CYCLES

Xuan-Thanh Bui¹, Thanh Tin Nguyen², Hong Hai Nguyen³*, Thi Dieu Hien Vo⁴, Tra My Ngo¹

¹Faculty of Environment & Natural Resources, Ho Chi Minh city University of Technology, Vietnam
²School of Earth Science and Environmental Engineering, Gwangju Institute of Science and Technology, South Korea
³Institute of Environmental Science, Nguyen Tat Thanh University, Vietnam
⁴Faculty of Environmental and Food Engineering, Nguyen Tat Thanh University, HCM city, Vietnam

*Corresponding author: hai240196@gmail.com

ABSTRACT

Human urine from domestic wastewater has been considered as an ideal nutrient source for microalgae cultivation due to the high concentration of nitrogen and phosphorus. Moreover, pollution caused by nutrient (N, P) is difficult to treat and costly. In this study, membrane fouling and nutrient removal was evaluated in a membrane photobioreactor (MPBR) system using urine as substrate and microalgae-bacteria as co-cultures under two light - dark cycles. The MPBR system was operated at microalgae retention time (MRT) and hydraulic retention times (HRT) of 5 days and 1 days. The results indicated that the higher TN and TP removal rate (20.43±13.38 mg N/L.day and 15.65±15.01 mg P/L.day) in a 24 h light - 0 h dark cycle when compared with that in 12 h light - 12 h dark cycle.

Keywords: Membrane photobioreactor, nutrient removal, microalgae-bacteria, two light - dark cycles.

1. INTRODUCTION

Only 10% of the total urban domestic wastewater entering the sewage system is treated, 90% of domestic wastewater is simply treated by septic tanks before being discharged into the water system [1]. In particular, the domestic wastewater after the septic tank has not met the quality standards according to the discharge standards [1, 2], especially human urine which contains most of nutrient loading of domestic wastewater (more than 80% (N) and 60% (P)) [3]. High concentrations of nutrients of human urine in domestic wastewater, can cause eutrophication in water sources and upset the balance of ecosystems [4].

The application of microalgae-based wastewater treatment systems using wastewater as a source of nutrient have been developed successfully in recent years, especially using human urine that has brought positive results in the ability to handle N and P and recover algae biomass [5, 6]. In addition, microalgae biomass has been founded as a potential resource in producing of bio-products such as biofuels, fertilizer, food, cosmetics, etc. [7-9]. Therefore, separating urine at the source to cultivate microalgae can help to improve effluent quality, save cost for wastewater treatment, and recover the investment cost by the products from microalgae biomass.
2. MATERIALS AND METHODS

Membrane photobioreactor system

The membrane photobioreactor (MPBR) system was installed in a wooden box with a thickness of 10 mm to prevent temperature change. The system is illuminated by four 18W white fluorescent lamps with the total light intensity was 4.4 kLux. 8L MPBR tank was made from transparent acrylic and designed with an internal diameter of 100 mm and 1200 mm in height. A submerged hollow fiber membrane module, which was made from polyvinylidene fluoride (PVDF) (Mitsubishi, Japan) and had a pore size of 0.4 µm and surface area of 0.035 m². The permeate flow was intermittently withdrawn in a cycle (8 min of operation and 2 min idle) by a suction pump.

The fresh human urine was collected in the University toilet and stored at 4°C in a refrigerator to reduce the effect of urea hydrolysis before use. The influent was diluted (with tap water) 30 times fresh human urine. As a result, the physicochemical parameters of the influent varied at the following intervals: pH (8.4 ±0.3), TKN (173± 57.15 mg/L), NH₄⁺ (141.55±42.52 mg/L), NO₂⁻ (<0.1 mg/L), NO₃⁻ (0.33±0.12 mg/L), TP (11.63±5.75 mg/L). Co-culture of microalgae-bacteria was used Chlorella vulgaris mixed with activated sludge (from industrial wastewater treatment system) in the 5:1 ratio, the initial dry biomass of co-culture was 800 mg/L.

To determine the optimum light:dark cycle, the MPBR system was operated in two phases were 24h:0h and 12h:12h of light:dark cycles with microalgae retention time (MRT) and hydraulic retention times (HRT) of 5 days and 1 days, respectively.

3. RESULTS AND DISCUSSION

Biomass growth

The results demonstrated that the variation of co-culture biomass concentration in MPBR operated at different light:dark cycles during the entire cultivation period of 65 days. Under 24h light:0h dark condition, the biomass concentration began to decrease from 800 mg/L (day 1) to 470 mg/L (day 8); it then fluctuate between 470-730 mg/L before decreasing to 224 mg/L (day 30). At this stage, average biomass concentration and biomass productivity achieved 602.73 mg/L and 120.55 mg/L.day, respectively. The lower average biomass concentration and productivity was recorded under 12h light:12h dark condition of 427 mg/L and 85.4 mg/L/day, respectively. As the consequence, the biomass concentration under this condition decrease significantly from 830 mg/L (day 45) to 180 mg/l (day 65).

Nutrient removal performance

The conversion efficiency of NH₄⁺ -N into NO₃⁻ by co-culture in different light and dark conditions is recorded with average conversion efficiency of 48.72% (24h:0h) and 51.02% (12h:12h). Concurrently, NO₃⁻ concentration was increased significantly from 0.33 mg/L (day 1) to 65 mg/L (day 5), it then fluctuate slightly around 65-84 mg/L during 40 days of 24h light:0h dark cycle. The same results were recorded during 25 days of 12h light:12h dark cycle, which reached the average NO₃⁻ concentration of 82 mg/L.

The removal rate of TN and TP showed the highest values of 20.43±13.38 mgN/L.day and 15.65±15.01 mgP/L.day under 24h light:0h dark cycle.

Acknowledgement

The authors would like to thank for the research grant from National Foundation for Science and Technology Development (NAFOSTED) No. 105.99-2019.27, Ministry of Science and Technology, Vietnam

REFERENCES


[16]. Adapt online on 20th September, 2019 from http://www.agarscientific.net/haemocytometers-you-can-count-on-us/

