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Polyhydroxyalkanoate Production from Sequencing Batch Reactor System Treating Domestic Wastewater Mixed with Glycerol Waste

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Abstract

The study aimed to determine the polyhydroxyalkanoate (PHA) production and treatment efficiency of sequencing batch reactor (SBR) system treating synthetic domestic wastewater (DW) and synthetic domestic wastewater mixed with glycerol waste (DW+GW). The system with a total sequence of 24 h consisted of filling phase (20 min), reaction phase (22 h), settling phase (1 h), and withdrawal phase (40 min). The two-step SBR operation comprised anoxic/aerobic steps of 4/18 h was employed at reaction phase. The system fed with DW+GW produced higher PHA than the system fed with DW. In addition, PHA accumulation in activated sludge obtained from the anoxic step was higher than the aerobic step in which the highest PHA concentration and PHA yield at 1,086.87 mg/L and 61.42% as dry sludge weight, respectively, were attained. The results of treatment efficiency revealed that the anoxic step performed higher removal efficiencies of total kjeldahl nitrogen and total phosphate than the aerobic step, while an opposite result of COD removal efficiency was found.

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Keywords: Polyhydroxyalkanoate, glycerol waste, sequencing batch reactor, domestic wastewater

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1. Introduction

Polyhydroxyalkanoate (PHA) is intracellular bacterial polyester which plays a role in carbon and energy storage [1]. Basically, bacteria accumulate PHA when growing under a limitation of essential components such as nitrogen, phosphorus, sulfur and oxygen and a presence of excess carbon source [2]. Presently, PHA are considered as the best environmentally bioplastic due to the completeness of biodegradation in nature. However their uses are still limited because of the high production costs. The cost for sugar as a carbon source accounts for 70-80% of the total expense [3]. Presently, a wastewater treatment system is approved as a cost effective and environmentally friendly approach for PHA production [4]. Domestic wastewater is an attractive substrate for PHA production due to a large amount of wastewater produced daily but its low level of organic carbon possesses one drawback [5]. Glycerol waste, a by-product from biodiesel production, has a high organic carbon and may potentially lead to environmental problems [6]. Presently, it is expected to become a potential raw material for biorefinery industries [7]. An achievement of PHA production from glycerol waste via fermentation system was noted [1] [4] and [8]. However, there is very little information in PHA production from glycerol waste via wastewater treatment system. Therefore, this study aimed to investigate the performance of a sequencing batch reactor system treating DW and DW+GW for PHA production. A *Bacillus aryabhattai* MSU 504, a PHA-producing bacterial strain, was seeded into the system in order to enhance PHA accumulation in activated sludge. Treatment efficiencies of the system were also determined.

2. Materials and Methods

2.1. Microorganism

B. aryabhattai MSU 504 used in this study was isolated from glycerol waste in biodiesel production on the basis of ability to produce PHA from glycerol waste. The inoculum was prepared in TSB medium (Himedia Laboratories, India) in 200 mL and incubated for 48 h at 37°C and shaken at 100 rpm. The cells were harvested by centrifuged at 10,000*g* for 20 min and used as inoculum culture.

2.2. Glycerol Waste

Glycerol waste was obtained from a biodiesel production plant at the Faculty of Engineering, Khon Kaen University, Thailand. It was preserved in plastic bottles at room temperature and sterilized at 121ºC for 15 min before using. The chemical oxygen demand (COD) concentration of glycerol waste was 26,222 mg/L.

2.3. Experimental Set-Up

The reactor had a total volume of 12 L and a working volume of 5 L. It was operated under non-sterile conditions and at room temperature. Agitation was performed with the speed varying from 250-300 rpm using a stirrer motor (IKA works Inc., Germany). When needed, operation was provided by using an air pump.

2.4. Experimental Procedure

A synthetic domestic wastewater (DW) used in this study was composed of NH_4Cl, KH_2PO_4, $CaCl_2$, $MgSO_4.7H_2O$, $FeCl_3$, $MnCl_2.4H_2O$ and sugar 120 mg/L which provided COD concentration at 320 mg/L [9]. For preparation of a synthetic domestic wastewater mixed with glycerol waste (DW+GW), 0.2% (v/v) of glycerol waste was added to the DW which provided COD concentration at 3,280 mg/L. The initial pH of the