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Efficiency Evaluation of Biofilter for Hydrogen Sulfide Removal from Palm Oil Mill Biogas

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Abstract

Hydrogen sulfide (H_2S) is one of the most problematic contaminants in biogas. The removal of H_2S from biogas is necessary in order to clean biogas and prevent gas engine. The efficiency evaluation on H_2S removal from palm oil mill biogas by biofilter was investigated. Eight sludge samples from biofilter systems of palm oil mill biogas were tested for H_2S removal by grown in thiosulfate mineral medium under an anaerobic condition at atmospheric pressure. Analytical data demonstrated that average amounts of CH_4, CO_2, and H_2S in inlet biogas were 62%, 35%, and 0.95%, respectively. The highest H_2S removal rate of 0.35 g/L/d was found sludge A (Asian palm oil company). It also found that the major product for sludge A was elemental sulfur of 13,650 mg/L and could produce the highest sulfate concentration of 300 mg/L. In contrast, sludge I (Thai Indo palm oil factory) has the lowest H_2S removal with rate (0.09 g/L/d.) Microbial activity for H_2S removal was increased with the decrease in pH from 7.12 to 6.40 due to H_2S dissolved medium. The suitable condition for the growth of sulfur oxidizing bacteria affected on H_2S removal efficiency from palm oil mill biogas by biofilter systems.

Keywords: *Biogas, Hydrogen sulfide, Biofilter, Sulfur oxidizing bacteria*

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1. Introduction

Biogas is usually derived from anaerobic digestion of sewage sludge, livestock manure or agro-industry biowastes. Biogas has the following components CH_4 (53–70 %), CO_2 (30–47 %), N_2 (0–3 %), H_2O (5–10 %), O_2 (0–1 %), H_2S (0–10,000 ppmv), NH_3 (0–100 ppmv), hydrocarbons (0–200 mg m^{-3}) and siloxanes (0–41 mg m^{-3}) [1]. The high concentrations of H_2S in biogas will reduce the quality of biogas because it caused corrosion of concrete and steel, compromises the functions of cogeneration units, produces pollution from odors, toxic to humans and emissions of sulfur dioxide during combustion. In addition, sulfide in the liquid stage caused corrosion of water transport systems and the accumulation of metal sulfides. Furthermore, sulfide is toxic to methanogens at concentrations above 50 mg/L and may effect of inhibition anaerobic process [2].

Normally treatment technologies for removal of H_2S in the gas stage were physical (adsorption, absorption, and dilution), chemical (chemical absorption, neutralization, and combustion) and biological (activated sludge and biofilter) methods [3]. The physical and chemical methods have some disadvantage with high operating costs and production of secondary pollutants, particularly when the H_2S concentration is high [4]. In contrast, the biological methods are cost-effective compared to the physical and chemical processes for the removal of H_2S from biogas [5]. Therefore, an important technology for biological treatments of H_2S such as biotrickling filters, biofilters, and bioscrubber.

Biological removal of sulfides is based on the activities of sulfur-oxidizing bacteria (SOB). Chemolithotrophic SOB obtains energy for their metabolism from the oxidizing reactions, where oxygen (aerobic species) or nitrates or nitrites (anoxic species) serve as the acceptor of electrons released during the oxidation of sulfides. From a technological point of view for the biological removal of sulfides, chemolithotrophic sulfur-oxidizing bacteria (*Thiobacillus*, *Sulfolobus*, *Thermothrix*, *Beggiatoa* and *Thiothrix*) are most appropriate microorganisms for H_2S removal. They are also suitable for the high rate of sulfide oxidation with modest nutritional requirements and extremely high affinity for sulfides and oxygen. These properties allow them to successfully compete with chemical oxidation of sulfides in both the natural environment and bioreactors with a limited supply of oxygen [6,7].

The main objective of this study is to focus on the efficiency evaluation of biofilter systems from palm oil mill biogas plant for hydrogen sulfide treatment and activity of sulfur-oxidizing bacteria.

2. Methodology

2.1. Sampling

Eight sludge samples from biofilter systems of palm oil mill biogas including (A) Asian palm oil company, (I) Thai Indo palm oil factory, (L) Lam soon (Thailand) Public Co. Ltd., (N) Nam Hong palm oil Co. Ltd., (P) Pitak palm oil Co., Ltd., (S) United palm oil industry, (T) Thai tallow and oil Co., Ltd., (U) Univanich Palm Oil Public Co. Ltd., were collected i and stored in a refrigerator at 4 ° C.

2.2. Culture media

TSM medium was used for enrichment and culturing for sulfide-oxidizing bacteria (SOB) [8]. Thiosulfate mineral medium contained the following (g/L): 5.1 $Na_2S_2O_3$, 2.0 K_2HPO_4, 2.0 KH_2PO_4, 0.4 NH_4Cl, 0.2 $MgCl_2·7H_2O$, 0.01 $FeSO_4·7H_2O$ and pH adjusted at 7.0±2. Thiosulfate mineral medium was sterilized by autoclaving at 15 psi and 121 °C for 15 min. SOB was cultured under mesophilic conditions (35 °C).

2.3. Evaluate activity of sulfide-oxidation bacteria

The SOB from sludge samples of biofilters system was tested for H_2S removal activity. The H_2S removal activity was tested in a 500-ml serum vial with working volume is 250 ml by using TSM medium with 10% v/v sludge samples. $Na_2S_2O_3.5H_2O$ was used as a substrate for growth and closed with a rubber stopper and sealed with aluminum caps. Sludge samples were grown with NaS_2 for one month under mesophilic conditions (35 °C) after that biogas (CH_4, CO_2, and H_2S in 62%, 35%, and 0.95%, respectively) was feed into vial test. The samples were collected for hydrogen sulfide, dissolved sulfide sulfate, element sulfur and pH analysis every day for 5 days.