CHAPTER 8

Co-digestion of Palm Oil Mill Effluent and Pineapple Peel Wastes for Biogas Production

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8.1 INTRODUCTION

Biogas has been generally regarded as a promising source of renewable energy worldwide. It has the potential to be directly applied for a sustainable generation of heat and electricity (Hagos et al., 2017; Ohimain & Izah, 2017; Suryani et al., 2021). Biogas can be produced through the Anaerobic Digestion (AD) process. The AD is typically a biological degradation process of raw materials (organic matters) into simpler metabolites by the action of microorganism. It involves four main stages. First, is the hydrolysis phase where complex organic matter in the raw substrates is broken down into soluble components. Next, is the formation of Volatile Fatty Acids (VFAs) and Hydrogen (H_2) compounds through the acidogenesis and acetogenesis phases, respectively. In acidogenesis, soluble organic molecules from the previous stage namely fatty acids, sugars and amino acids are furthermore decomposed into short chains volatile organic acids i.e., the VFAs, and a little bit of hydrogen gases. Concurrently, acetogenesis step is taken place where the VFAs are converted into acetic acid, Carbon Dioxide (CO_2) and hydrogen. In the final stage, methanogenesis occurs where hydrogen and acetate

are being consumed by methanogens and *Acetoclastics* methanogens to produce methane and CO_2 gases (Khedkar et al., 2017; Menzel et al., 2020). The composition of the final gases (mainly CO_2 and methane) is highly depending on the nature of the raw materials used, and the anaerobic process conditions i.e., pH, hydraulic retention times and temperature (Aili et al., 2021; Matheri et al., 2018; Zhang et al., 2020).

Recent trends have showed that higher biogas yield is achievable through the co-digestion approach by utilizing cheap substrates such as animal manure, food waste and/or agricultural waste (Aili et al., 2022; Dahunsi et al., 2019; Hagos et al., 2017; Shen et al., 2019). Co-digestion is an approach where two raw substrates (i.e., organic waste) are anaerobically digested within the same reactor platform (Neshat et al., 2017). Among the potential substrates for co-digestion approach in biogas production are the Palm Oil Mill Effluent (POME) and the pineapple waste (Aili et al., 2021; Gumilar et al., 2019). POME is a thick brown coloured liquid wastewater generated from the production of crude palm oil. It is estimated that for every tonne of CPO produced, approximately 3-3.75 tonnes of POME is generated. Reports (Gumilar et al., 2019; Jia et al., 2013) show that POME has a very high Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) where it ranges between 25000 and 80000 mg/L. Moreover, the presence of solid content (i.e., >18000-40000 mg/L) and acidity of liquid POME (pH 4-5) made it unsuitable to be directly discharge to any public waterways. Nevertheless, high organic contents and the presence of microbial community in POME are indeed a good source for generation of methane gas through anaerobic digestion process. Presently, a ponding system has been established for decomposition of POME but in most palm oil mill, the biogas produced was not recovered for further use.

Under normal conditions, about 1.5 L/min/m^2 of biogas containing methane as high as 55 %v/v is released into the atmosphere (Jia et al., 2013).

There is also a growing concern over the generation of pineapple waste that came not only from the growing pineapple plantation industry but also from local markets and consumers. Pineapple wastes typically comprises of residual pulps, leaves, peel and core of the fruit (Dahunsi, 2019; Lun et al., 2014). In Malaysia, approximately 140 000 tonnes of pineapple wastes are generated each year. The waste is generally treated through incineration and landfilling. The latter has become an environmental problem as the wastes release bad odour and attract pets which led to the spreading of dangerous diseases. Nevertheless, pineapple waste also contains high sugar and nitrogen content (Dahunsi, 2019; Lun et al., 2014). Instead of dumping of the wastes into an open land area, alternative solution would be to utilize it as a feedstock in anaerobic digestion process (i.e., as carbon and nitrogen supply for the microbes) and thereby, compliments POME waste as its co-substrates for biogas production. Such alternative could open the opportunity for the establishment biogas plants near or on-site palm oil mill and pineapple growing areas.

Both, POME and Pineapple Wastes (PW) have been considered as potential substrates for a renewable biogas production. Biogas yield ranging between 20 mL gas substrates and few hundreds millilitre gas substrates have been reported (Aili et al., 2022; Joni et al., 2018; Prasetyo et al., 2018; Survani et al., 2021). However, imbalance characteristic of POME discharge from the crude palm oil processing does not yield a consistent amount of biogas. Also, in current pond system, a long retention time is needed (i.e., about 10-14 days) not only for breaking down the complex substrate within POME and but