Available online at www.sciencedirect.com

ScienceDirect

APCBEE Procedia 9 (2014) 65 – 69

Procedia APCBEE

www.elsevier.com/locate/procedia

2013 5th International Conference on Chemical, Biological and Environmental Engineering (ICBEE 2013)
2013 2nd International Conference on Civil Engineering (ICCEN 2013)

Biogas Production in the Anaerobic Digestion of Paper Sludge

Cindy Priadi*, Dwica Wulandari, Iftita Rahmatika and Setyo Sarwanto Moersidik

Environmental Engineering Study Program, Civil Engineering Department, Engineering Faculty, Universitas Indonesia, Kampus UI Depok, 16424, Indonesia

Abstract

Pulp and paper industry generates large quantity of sludge, up to 1 m^3 /ton paper produced. Anaerobic digestion (AD) is a potential treatment to stabilize sludge and produce biogas for renewable energy. The aim of this study was to investigate the potential of AD of paper sludge (PS) generated from primary and secondary wastewater treatment and to compare the effect of cow manure to paper sludge. For the reactor with PS only, biogas production was observed starting on the 5^{th} day with 6.3% of methane with a steady increase. The cumulative methane yield attained to 14.7 ml/g volatile solid (VS) until day 28. The second reactor containing PS and cow manure produced methane 269 ml/g VS until day 28. This study shows a more optimal AD process of paper sludge mixed with cow manure due to a more optimum C/N ratio and also higher VS.

Selection and peer review under responsibility of Asia-Pacific Chemical, Biological & Environmental Engineering Society

Keywords: Clean Production, Wastewater, Kinetics, Lab-Scale

1. Introduction

Pulp and paper is considered as one of the most polluted industry in the world [1] and energy and water intensive [2]. These processes generate wastewater which are then treated using physical, chemical as well as biological treatment. Wastewater treatment eventually produces paper sludge (PS) from chemical and biological treatment in large quantities, ranging from 0,3 to 1 m^3 of PS/ton paper produced. The sludge generally contains chlorinated organics, pathogens and trace amount of heavy metals [3]. In Indonesia, land application and hazardous waste treatment are the typical choices for sludge stabilization. However, land

* Corresponding author. Tel.: +62-21-7270029; fax: +62-21-7270028
E-mail address: cindy.priadi@eng.ui.ac.id

Selection and peer review under responsibility of Asia-Pacific Chemical, Biological & Environmental Engineering Society
doi:10.1016/j.apcbee.2014.01.012

application rarely pays attention to long-term effect to soil and hazardous waste treatment is very costly. Thus, on-site treatment of paper sludge must be considered in order to reduce production cost and also draw benefit from nutrients contained in the PS.

Anaerobic digestion (AD) is the most common method for sludge stabilization. Moreover, this digestion process using various anaerobic bacteria produces biogas including methane that can be an alternative source of energy. AD has been successfully used for sludge treatments of various kinds for example sewage sludge [4], waste activated sludge [5] and cow manure [6]. However, very few studies have applied AD for PS treatment. Lin et al [7] demonstrated that PS combined with monosodium glutamate waste liquor can produce up to 200 ml methane/g volatile solid $(VS)_{added}$, with methane reaching up to 80% of the total biogas composition. However, this study was conducted under a maintained temperature of 37°C, a condition that can be costly for medium-scale industries. A local study by Soetopo et al [8] showed that the highest biogas methane content from AD of PS is 51.5% at the rate of 140 ml/g VS in 28 days. Nevertheless, this study was conducted using only sludge from secondary biological wastewater treatment. This is also less applicable considering that in most industries; PS originating from primary physical-chemical wastewater treatment can make up to 98% of sludge produced by the pulp and paper industry. Thus, this study aims to investigate the potential of biogas production derived from primary and secondary sludge of pulp and paper wastewater treatment under uncontrolled temperature, where both conditions are found to be more applicable to medium-scale pulp and paper industry.

2. Material and method

2.1. Substrate

The sludge originated from a pulp and paper industry in East Java, Indonesia. After the production process, wastewater goes through primary physical treatment of sedimentation and secondary treatment using aerobic suspended growth tank. Afterwards, sludge volume from both the primary and secondary treatment is reduced through primary clarifier and belt press. Sludge used in this study was collected from the sludge holding tank from primary and secondary clarifier that is composed of both primary and secondary sludge. Samples were collected in jerry cans, conserved at 4^{o}C before feeding the reactors the day after.

Two sets of experiments were conducted in two separate reactors run in parallel, labeled R1 and R2. Sludge characteristics on day one (feedstock) were measured and presented in Table 1. The first experimental set (Reactor 1-R1) is aimed to test the effectivity of AD of PS without any seeding and co-substrate. The second experimental set (Reactor 2-R2) combined paper sludge and cow manure as seed sludge as well as to adjust C/N ratio to fit the ideal 20-30 range. Total solid (TS) of cow manure was diluted using water to approximately 20% of total solid (TS) and afterwards combined with PS sludge with a 57% to 36% volumetric composition of PS and diluted cow manure, respectively.

2.2. Experimental Devices

Anaerobic digestion was carried out in batch experiments using a 15 L capacity bioreactor. Empty reactors and gas bags was purged with nitrogen and afterwards filled quickly with substrate to the top. Continous mixing was performed using an 80 rpm impeller. Temperature and pH probes were installed for daily monitoring. Each reactor had two outlets equipped with valves. The first outlet was for substrate sampling and the second outlet was connected using a 3 mm hose equipped with a valve to a 1 L polypropylene gas bag (Tedlar Bag CEL scientific corp).