A NOVEL STUDY ON BIOGAS PRODUCTION FROM PALM OIL MILL EFFLUENT WITH TWO-STAGE ANAEROBIC DIGESTER AND NANO MEMBRANE

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ABSTRACT: *This paper describes the problem of poor treatment performance of palm mill effluent (POME); and also presents an economically and environmentally sustainable solution achieved from an experimental research. This research investigates the effects of organic loading rate (OLR), hydraulic retention time (HRT), sludge retention time (SRT), pH, and carbon to Nitrogen ratio (C/N) as the input factors with the Nano membrane that contribute to increase biogas production performance. A two-stage continuous stirred tank anaerobic reactor (CSTR) and cross flow membrane have used in series with C/N enriched inoculum for the POME digestion. The anaerobic digester and membrane were operated at temperature 35^{0}C with various range of inputs. The research findings demonstrated that OLR,HRT,SRT, and pH have played a significant (p-value<0.05) role in producing biogas with substrate utilization rate 92.50 percent (R^2=92.5), while other inputs used for digestion process were positively affected on the production of biogas and quality effluent. The findings of this research would be useful in palm oil mills for optimizing the production of biogas and recyclable water from the POME as Waste to Resource [WtR]. However, the novelty of this research is to use 'C/N enriched inoculum (11<C/N< 40) prepared from banana peel in digestion process with two stage CSTR and the cross-flow membrane for increasing POME treatment performance.*

Keywords: Palm Oil Mill Effluent, Carbon-to-nitrogen Ratio, Anaerobic Digestion, Waste Biomass, Waste to Energy [WtE], Renewable Energy, Cross Flow Membrane

RESEARCH BACKGROUND

This paper presents a research conducted on biogas and recyclable water production from POME. The fundamental theme of this research was to evaluate the effects of OLR, C/N, HRT, pH, SRT and cross flow Nano membrane on biogas and fresh water production from POME. Various reports on biogas production from POME suggested a significant percentage of palm oil mills have been using traditional waste stabilization pond (WSP) instead of anaerobic digester. The WSP is a potential source of CH_4 and CO_2 emission; and these gases are recognized as the Greenhouse Gas (GHG) and the global warming potentials [1]. It was also reported that the biogas production performance of the currently available CSRT based anaerobic reactor is significantly poor and not technically and financially feasible to use [1-3]. It has also been claimed that due to the poor performance of CSTR digester, the palm oil mills are reluctant to install this technology [1-3]; and continuing with the traditional treatment method [4]. However, this scenario suggests that a research gap exists in the processing of waste biomass of POME for which the treatment performance of this effluent is reported to be the poor. Indeed, this research has undertaken to identify the ways to reduce gap for improving biogas production performance. *However, the novelty of this research is to use C/N enriched inoculum (11<C/N<40) prepared from banana peel in digestion process with two stage CSTR and the cross-flow membrane for increasing POME treatment performance.*

LITERATURE REVIEW

This section describes the literature review published on research in POME treatment in the recent years. The aims of this review were to update the knowledge on producing biogas and water from the POME for contributing to achieve economic and environmental sustainability. The emphasis has given on the published papers described the effects of HRT, SRT, OLR, pH and C/N; and as well as membrane on biogas and water production from the POME.

The POME is a bio-effluent generate during the extraction of crude palm oil (CPO) from the fresh fruit bunch (FFB). Tis effluent contains water and a large quantity of organic materials [4], [5]. The organic materials of this bio-effluent include carbohydrates, proteins, lipid, and other micronutrients to be known as the sources of biogas [6]. The properties of biogas and water potential of the POME are listed in Table 1.

Table 1: The Biogas and Water potential of the POME [7]

Parameter	Range
Organic Material (mg/L)	15,000–100,000
Total Solids (TS-mg/L)	11,500–79,000
Volatile Suspended Solids (VSS-mg/L)	9,000–72,000
Water	92%–96%

During biodegradation process of the POME, methane (CH_4), carbon dioxide (CO_2) and hydrogen sulphate (H_2S) are produced and emitted to the air as greenhouse gas (GHG). In order to minimize GHG emission, various types of anaerobic reactor have been used to digest organic materials aiming to produce biogas and other resources [3, [3, 8].

The C/N, pH, HRT, SRT, temperature and OLR of substrate inside the reactor have been playing a vital role in producing biogas from biomass of the POME [1, 2, 9]. It was also reported that these variables have a significant (p-value <0.05) contribution in breaking down the organic elements of biomass to form biogas and water [8].

The OLR in the digestion process is one of the determinants of biogas production performance. The higher OLR affects process stability by interrupting of the fermentation process; and also build-up volatile fatty acid (VFA) concentration, which tends to decrease pH in the POME substrate and adversely affects methanogenesis activities [10]. The lower OLR indicates the inefficient organic materials concentration in the digestion process and at this condition, the production of fatty acid reduce at the hydrolysis and acidogenesis process. The ultimate results is the decreasing of biogas production [11, 12].