OPTIMIZING PRODUCTIVITY IN SEPARATING BIOMASS AND ORGANIC MATERIALS FROM PALM OIL MILL EFFLUENT: EXPERIMENT TOWARDS REDUCING CARBON EMISSION FOR CLIMATE CHANGE AFFECT

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ABSTRACT: *This paper describes a problem that exists in palm mill effluent treatment; and also presents a technologically and environmentally sustainable solution achieved from experimental research. At the first stage, a two-stage continuous anaerobic reactor with carbon to Nitrogen ratio enriched inoculum has used for the digestion biomass and organic materials of POME. In the second stage, Nanomembranes have used for separating biomass and organic materials from effluent discharge from TBAR. This research investigated the performance of the anaerobic reactor and the Nano membrane in reducing organic materials and biomass from POME for producing dischargeable effluent. The anaerobic reactor was operated at temperature 35^{0}C with various range of manipulating variables; the outcome of research had demonstrated a 62.5 % digesting performance of biomass and organic materials. The Nano membrane system was operated at a feed pressure range of 60 psi to 120 psi, which had demonstrated over 95% performance in separating biomass and organic materials from the effluent discharged from the anaerobic reactor. The findings of this research would be useful in POME treatment for optimizing the environmentally friendly effluent production for recycling as process water for the crude palm oil process. However, the novelty of this research is to use a two-stage anaerobic reactor and Nanomembranes system in series in optimizing the performance and operating cost in POME treatment.*

Keywords: Palm Oil Mill Effluent, Bio-Technology, Anaerobic Digestion, Bio-Effluent, Waste to Energy [WtE], Renewable Energy, Production and Productivity, Nano- Membrane; Environmental Sustainability, Climate Change

1.0 RESEARCH BACKGROUND

This paper presents research outcomes conducted on Palm Oil Mill Effluent (POME) to optimize treatment performance in producing dischargeable (environmentally friendly) effluent. The broad objective of this study was to reduce total organic materials (TOM) from POME for reducing carbon emission towards mitigating climate change effects in line with global sustainable Agenda 2030 [1]. This research conducted with Batch Anaerobic Reactor (BAR) to convert TOM to biogas. And, the Nano membrane (NM) was also used separate TOM from effluent. However, this work is a continuation of previous studies that were published in various journals [2–5]. Published reports suggested that palm oil mills have been using anaerobic technologies for POME treatment [4]–[6]. It was also reported that biogas and quality effluent production performance of currently available BAR and other anaerobic technologies have appeared to be poor and not technically and financially feasible to use [3, 6, 7]. It has been also claimed that due to the poor performance of anaerobic digesters, the palm oil mills are not showing interest to install anaerobic technology [3, 6, 7]; thereby they continuing with the traditional POME treatment method [8]. However, this scenario suggests that a research gap exists in POME treatment in reducing TOM. Indeed, this research was undertaken to reduce the gap that exists in improving the performance of POME treatment for producing dischargeable effluent. The novelty of this research is to use a two-stage anaerobic reactor and Nanomembranes in series in optimizing performance in POME treatment for *contributing to achieving SDG-7(clean energy) and SDG-13(climate actions) towards achieving the UN Agenda 2030.* [1, 9].

1.1 Problem Statement

Shahbandeh (2020) reported in the global production volume 2012/13-2019/20 that the global Crude Palm Oil (CPO) potential was about 74.0 million metric tons in the marketing year 2019/2020 [10]. Indeed, the CPO processing is an identified Greenhouse Gases (GHG) emission source and a primary driver of climate change. Malaysia is about 40% of the global CPO producer. The carbon (CO_2eq) emission potential of this country from the CPO process and POME is approximately 25m^3(ton POME)$^{-1}$ to 28m^3(ton POME)$^{-1}$. It was also reported that the carbon (CO_2eq) emits from POME contain Methane (CH_4 ≥65%) which is about 25 times higher global warming potentials compared to carbon dioxide (CO_2). One the other hand, biogas is a source of POME based energy [11]. The estimated energy potential of POME in Malaysia is about 13,600 MWh (Year)$^{-1}$ [9, 12].

The estimated water potential of POME in Malaysia is about 25 million tons a year [13]. This information demonstrates that by deploying efficient technologies, the organic wastes materials of POME could be converted to clean energy and water could be produced. In addition to resources recovery, the problem relating to POME in carbon emission and pollution could be solved in line with SDG-6(clean water), SDG-7 (clean energy), and SD-13 (climate action) for achieving economic and environmental sustainability of this country by 2030[9].

It is also reported that a few mills are discharging poor quality effluent from palm oil mills to the environment due to a lack of required technology. However, it was found that palm mills are struggling to comply with environmental regulations and they need an affordable and efficient technology for POME treatment [12, 14]. A few types of research have reported that the performance in TOM conversion to biogas and other products is about 65% which has appeared an environmental sustainable problem to society and palm oil mills [2, 5, 15]. However, the reported problem in the palm oil mill domain demonstrated that in many cases, the process used for decomposing TOM is not fully able to meet the requirement of the Department of Environment (DOE) [2, 5, 15, 16]. Indeed, this research