OPTIMIZING ORGANIC MATERIALS REDUCTION FROM HAZARDOUS INDUSTRIAL BIO-EFFLUENT BY THE AID OF C/N ENRICHED INOCULUM: AN APPROACH TO USE TRADITIONAL ANAEROBIC REACTOR TO ACHIEVE ENVIRONMENTAL SUSTAINABILITY

Eugene J.J., *Shahidul M.I., and Mamunur R.
Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Malaysia Sarawak 94300, Kota Samarahan, Sarawak, Malaysia
*Corresponding author: Shahidul M.I. (mislam@unimas.my)

ABSTRACT: *The aim of this paper is to present research conducted to increase organic materials reduction from waste bio-mass enriched palm oil mill effluent (POME). This POME is also known to be the hazardous bio-effluent responsible for the air, water and soil pollution. This research conducted to address the problem of poor performance experienced by the industries while using the anaerobic reactor for reducing effluent quality. The novelty of this research is of using C/N enriched inoculum (11<C/N< 40) in a two-stage continuous stirred tank reactor (CSTR) based anaerobic process at different pH for increasing COD reduction performance to a sustainable level. The research findings demonstrated that COD reduction has mostly occurred at the C/N of 20 to 32. The optimum level of COD reduction was 80% at C/N 32.5 with pH 7.0. The COD digestion performance as COD reduction was found significant at 95% level (p-value <0.05) with 53.2% input utilization factor (R^2=53.2). The study concludes that POME digestion process for achieving higher COD reduction, CSTR based anaerobic*

Keywords: Chemical Oxygen Demand; Palm Oil Mill Effluent; Carbon-to-Nitrogen Ratio; Continuous Stirred Tank Reactor; Anaerobic Digestion

1.0 INTRODUCTION AND RESEARCH BACKGROUND

This paper aims to present research conducted on improving COD reduction performance from POME by using a two-stage standard CSTR based anaerobic reactor by the aid of inoculum with higher C/N (11<C/N<40). Indeed, over 90 percent of palm oil mills have been using traditional waste stabilization pond (WSP) instead of anaerobic digester. Various published papers have suggested that the performance of the currently available CSRT based anaerobic reactors is significantly poor and not technically and financially feasible to use [1, 2]. It is also claimed that due to the poor performance of CSTR base anaerobic reactor, the palm oil mills are reluctant to install this machinery [1, 2]. And the consequences of this, industries are continuing with WSP as their means for POME treatment. Indeed, WSP process is a potential source of CH_4 and CO_2 emission. Both CH_4 and CO_2 are known to be the greenhouse gases (GHG) and the sources of global warming potentials [3]. This research was designed to address this vital issue.

The novelty of this research is of using a two-stage traditional engineered CSTR based anaerobic reactor wian an inoculum of C/N between 11 to 40 to measure the effects on COD reduction performance of POME.

2.0 LITERATURE REVIEW

. POME is generated during the extraction of crude palm oil (CPO) from the fresh fruit bunch (FFB). In one tonne of CPO production requires about 1.0 to 2.5 m³ of water whiturns as as a POME [4, 5]. POME contains water, biomass and a larnumberity of organic materials of FFB. These organic materials include carbohydrates, proteins, lipid, and other micronutrients to be known as chemical oxygen demand (COD). To decompose all these materials require oxygen which is known to be Biochemical Oxygen Demand (BOD) [6]. The properties of POME are listed in Table 1.

Table 1: Elements of POME Effects on Biodegradation [7]

Parameter	Properties of POME	
	Units	Range
Organic Material	mg/L	15,000–100,000
pH	-	3.4–5.2
Total Solids (TS)	mg/L	11,500–79,000
Volatile Suspended Solids (VSS)	mg/L	9,000–72,000
Oil and Grease	mg/L	130–18,000
Ammoniacal Nitrogen	mg/L	4–80
Total Nitrogen	mg/L	180–1,400
C/N	-	7-10

POME tends to utilize available oxygen from the water bodies to decompose biodegradable organic materi, andand make water pollute.

Durithe ng the biodegrading process, methane (CH_4) and carbon dioxide (CO_2) produce and emits to air [8] These both gases known to be the greenhouse gas(GHG). In order to reduce water pollution and to minimize GHG emission from POME, various types of anaerobic reactor have been used to digest organic materials of POME [9]. The outputs of these anaerobic reactors are methane ($CH_4 \approx$ 65%), carbon dioxide ($CO_2 \approx$ 33%), and hydrogen sulphide ($H_2S \approx$ 2.5%) and some other gases [10]. These gases are captured and being used as biogas.

It has been reported that the major independent manipulating variables of anaerobic digestion process are C/N, pH, HRT, SRT, temperature, OLR, and velocity of POME inside reactor [2, 11, 12]. It was also reported that among these variables, pH, HRT, C/N, and OLR have a significant (p-vale <0.05) contribution in breaking down the COD elements and accelerate to reduce COD in POME.

Several authors statth at an an optimal C/N between 20 to 35 [13, 14] exhibited a moderate Nitrogen concentration for an anaerobic digestion process. A study conducted by Sidik *et al*. on POME digestion process with a C/N range of 25 to 30. Their research finding demonstratthat thethe highest COD removal efficiency was 67% [15].