EFFECT OF EM ON BIOGAS PRODUCTION IN UASB REACTOR TREATING DOMESTIC WASTEWATER UNDER TROPICAL CONDITIONS

MAALIM M.K.*, MGANA S.M., MBULIGWE S.E.**, KASSENGA G.R.** and MOHAMED S.M.***

*Institute of marine sciences, University of Dar es Salaam, p.o. box 668, Zanzibar Tanzania
**School of environmental science and technology, Ardhi University, p.o. box 35176, Dar es Salaam Tanzania
E-mail: maalim@ims.udsm.ac.tz

ABSTRACT

Anaerobic processes in the UASB reactor are concluded by biogas production that has a great potential for energy recovery. This study aimed at investigating the impact of Effective Microorganisms (EM) consortium on biogas production (quantity and quality) when inoculated in the UASB reactor during treatment of domestic wastewater under tropical conditions.

Two laboratory scale UASB reactors of 4 L effective volume, made of PVC pipe with internal diameter 100mm were run for 30 days to establish comparative study with and without EM consortium. Liquid displacement method was used to measure the gas quantity produced, and the gas analyzer was used to measure the content and composition of the biogas.

The average biogas production and yield were higher in the UASB-EM reactor than the UASB control reactor. The latter produced methane for at 0.062±0.049 L/day with a yield of 0.018±0.012 L/g COD per day. Meanwhile in UASB-EM methane production was 0.135±0.066 L/day with a yield of 0.034±0.019 L/g COD per day. Likewise, UASB-EM reactor depicted higher methane content (78±4%) compared to 72±6% of the UASB control. Furthermore, EM consortium improved the quality of biogas by producing relatively lower H_2S and NH_3 of 1.05±1.54 mg/L and 80.11±52.73 mg/L respectively. The control were over 100 mg/L and over 200 mg/L respectively.

This study indicates that EM consortium not only enhances biogas production but also improves the biogas quality in the UASB reactor during the treatment of domestic wastewater. Further studies are needed to investigate the mechanisms of EM consortium to augment biogas quantity and improve its quality in UASB reactor.

Keywords: UASB reactor, Effective Microorganisms, EM, methane and biogas

1. Introduction

The UASB reactor is a most popular high-rate anaerobic reactor configuration that has been effectively employed for the treatment of various wastewaters (Lettinga and Hulshoff Pol, 1991; Rajeshwari *et al.,* 2000; Dinsdale *et al.,* 1997). Compared with other anaerobic processes, the UASB reactor is relatively simple, economical and easy to operate and does not need packing material to support biomass (Aslan and Skerdag, 2008). Several studies have shown that the use of such reactors in different areas and different environments is feasible option for domestic wastewater treatment (Florencio and Kato, 2001; Mgana, 2003; Azimi and Zamanzadeh, 2004). Biogas which essentially contains methane, carbon dioxide and other minute gases is produced in anaerobic processed through involvement of complex, natural, multi-stage process of degradation of organic compound via variety of intermediates, by the action of a consortium of microorganisms (Gujer and Zehnder, 1983; Noykova *et al.,* 2002)

The ability of the UASB reactor to produce biogas during the treatment of organic wastes is a precious advantage as biogas can subsidize energy needs in different countries that can help a community economically, environmentally socially and ecologically (Sims, 2003; Ghosh *et al.,* 2000; Kaseva and Gupta, 1996)). The biogas production is particularly significant in energy-starved countries like Tanzania (Mbuligwe, 2004). Therefore, the role of UASB reactor to produce biogas must always be taken into consideration during its design and operation, as only proper design, and operational conditions can ultimately facilitate biogas production in substantial amounts.

The EM is microbial consortium proved to have positive impact in the diverse application including wastewater treatment (Higa, 1995; Higa, 1998). For more than one decade, EM has been showing great promise in wastewater treatment. The main objective of this study was to investigate the impact of EM consortium on biogas production in UASB reactor treating domestic wastewater under tropical conditions.

2. Materials and methods

2.1. Experimental set-up and experimentation planning

Two Lab-scale UASB reactors were made using 100 mm diameter PVC pipe with the volume of about 4 L (Figure 1). Each reactor was fed with 3 L UASB sludge where one was also fed with EM consortium identified as R2 or UASB-EM while reactor without inoculation of EM consortium identified as R1 or UASB control reactor

2.2. Analytical methods

Determination of all physico-chemical parameters were done as illustrated in the "Standard Methods for the Examination of Water and Wastewater" (APHA, 1998) with minor modification. The detailed procedures for the analysis of these parameters have been described in the previous chapters. The biogas production was measured using displacement method as described by Lettinga *et al.,* (1991) and arranged as shown in Figure 1. However in some cases Biogas meter *Valley Air Solution Biogas FT2 Plus* was used to measure biogas and its impurities. The detailed procedure for measurement of biogas production is depicted below.

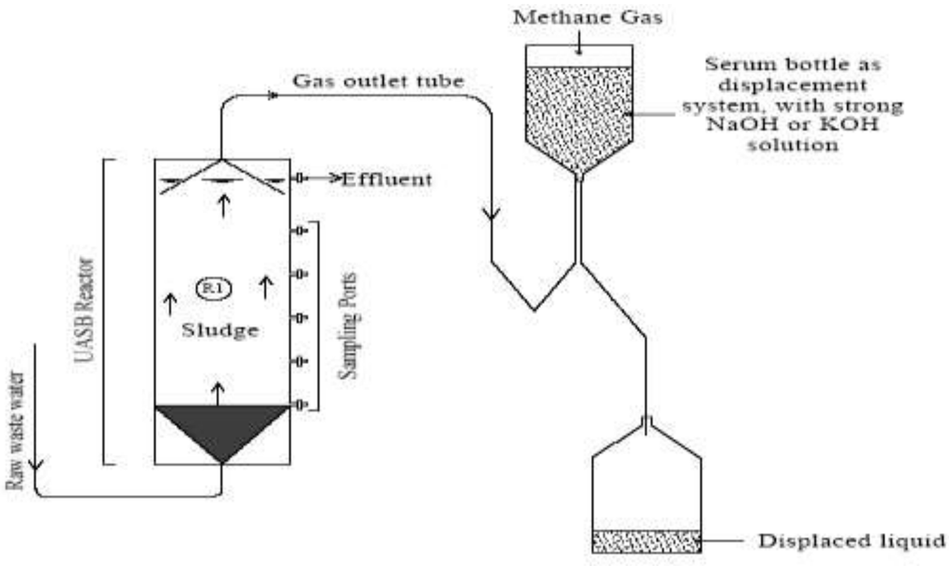

Figure 1: Schematic diagram of Methane production experimental set-up (similar set-up was used for EM consortium inoculation)

3. Results and discussion

As indicated in Figure 2 and Figure.3 both daily biogas production and cumulative gas production was relatively higher in the UASB-EM reactor compared to UASB control. The average biogas production was 35.08±33.84 mL/day and 64.04±35.06 mL/day in the UASB-control and UASB-EM reactor respectively while biogas accumulation was respectively 1052 mL and 1921 mL. The results show that the UASB-EM reactor average biogas daily production and accumulative was 45% more compared to UASB control. It, therefore, suggests that EM consortium not only favour biodegradation of organic material but also create a conducive environment for methanogenic bacteria to proliferate. It also speeds up overall anaerobic biodegradation processes including acetogenesis that facilitate the biochemical of VFA to acetate as a preferable substrate for methanogenic bacteria. The pH remained within favourable range for methane producing bacteria, suggesting that VFA was rapidly converted into acetate. The trends control the drop of pH to a level that could impair methanogenesis. Most of the methane producing bacteria are sensitive to pH and cannot proliferate when the pH drops below 6.5 and thus reduce the methane production (de Mes *et al.*, 2003).

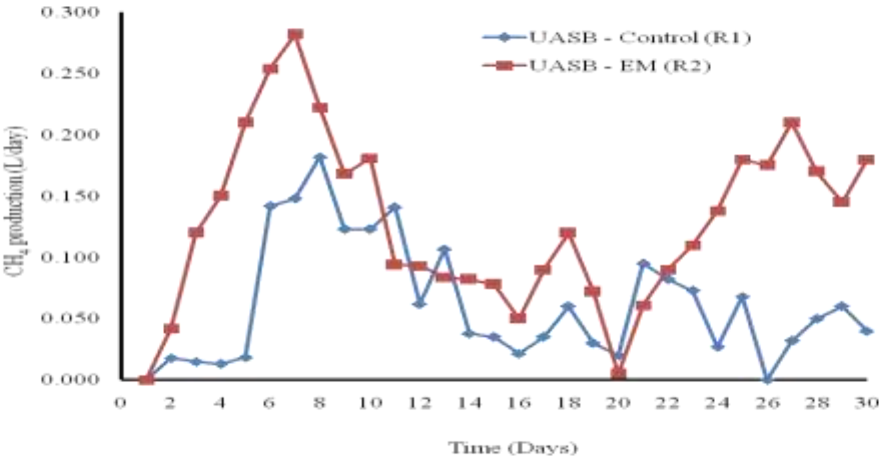

Figure 2: Daily methane production in UASB-EM and UASB-control reactors

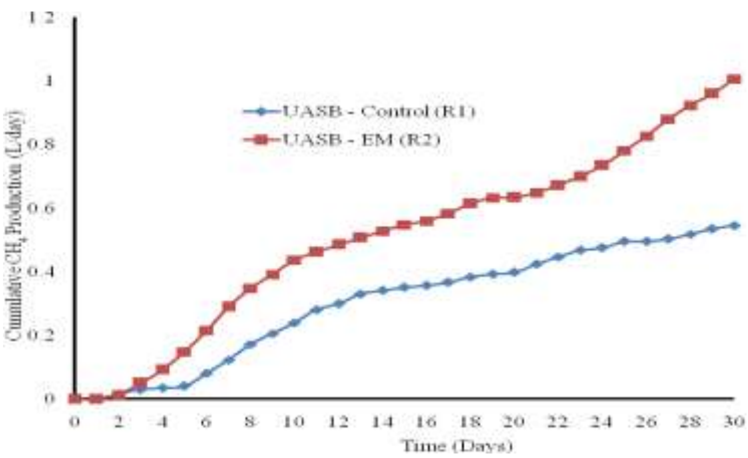

Figure 3: Cumulative Daily Methane production at room temperature in UASB-EM and UASB-control reactors

The UASB-EM produced biogas with higher methane content (78%) compared to that 72% of UASB control reactor. Such range also obtained by Neeranart, (2005) who found methane composition ranged from 60.56 to 82.03%. Minza (2009) revealed that the methane content increased while carbon dioxide with increasing EM dose in biogas digester treating kitchen wastes. The biogas impurities was relatively lower in the UASB-EM reactor by showing concentration of H_2S and NH_3 of 1.05 mg/L and 80.11 mg/L where UASB control revealed concentration H_2S and NH_3 of greater than 100mg/L and greater than 200mg/L respectively. It indicates that EM consortium not only augment biogas production but only improves its quality by increasing methane content and reducing obnoxious gases such as NH_3 and H_2S thus producing what is so called sweet methane (Higa, 1998). EM America, (2009) states that application of EM in anaerobic digester free Ammonia is bound to carbon and H_2S is removed from the influent and generating sweet methane can be produced thereby increasing amount of clean methane gas by 30% or more.

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