Bio Methane Production from Food Waste and Sewage Sludge Using Microbial Fuel Cell

Ashique Hussain[1], Maryam Arain[1], Khan Mohammad Brohi[1], Abdul Mubeen[1], Muhammad Waleed Khan[1], Muhammad Tehseen[1]

[1]*Mehran UET-Jamshoro, Sindh, Pakistan*

***Abstract*: To achieve the quick start-up and steady process of microbial fuel cell, an efficient inoculum is required. The correlation of bio electricity with methane production from food waste and sewage sludge in a double chamber microbial fuel cell (DCMFC) was studied. Three different ratios of food waste with sewage sludge was run to analyze the best ratio among food waste and sewage sludge. The best ratio among all were found to take equal amount of both, food waste with sewage sludge. Results showed that the electricity generation starts at 4th day whereas, the maximum output voltage 600 mv noted on 17th day. Similarly, methanogens in the anode chamber of DCMFC, results in an enhanced methane yield of 168 mL.**

***Keywords*: Microbial fuel cell, Bio-Methane, Bio-electricity, Bio Fuel, Food Waste, Sewage Sludge.**

I. INTRODUCTION

A microbial fuel cell (MFC) produce green energy through converting biomass which includes organic and inorganic waste. MFC is a type of bio-electrochemical systems that transform chemical energy into different forms of renewable energy such as electricity, methane and hydrogen, by the reaction of microorganisms [1]. Biomethane produced from food waste and sewage sludge is a potential fuel to reduce greenhouse gas (GHG) emissions from domestic and transport use of non-renewable fuels [2]. The increasing condition of methanogens bacteria are same as exoelectrogens, because in the process of MFC, methanogenesis is a common process, particularly when mixed with sewage sludge [3]. Energy can be generated from variety of wastewaters and waste through MFC [3], such as sewage sludge, starch processing water, and food waste. Internationally the demand for energy is increasing by about one third for the period 2013 - 2040 [4]. At present about 88% of this increasing demand globally is delivered by non-renewable fuels which are expected to become lessen or vanish. In order to save fuels that are non-renewable, the generation of renewable energy is being encouraged [5]. By anaerobic digestion (AD) of biomass, renewable energy can be produced such as electricity, methane and hydrogen cheaply. The organic waste includes Food waste (FW) and Sewage Sludge (SS) can be collected from many sources i.e. restaurants, domestic and commercial kitchen, food plants and waste treatment plants. About 1.3 billion tonnes of FW are wasted annually as reported by Food and Agriculture Organization (FAO) [6][9]. The FWs are increasing and expected to grow more in next 25 years only in Asian countries [7], the growing pollution increases the risks such as health, environmental, shortage of dumping land leads to create critical problems, if they are not managed properly. Managing the FW can reduces the impact on environment by utilizing this as biomass to harvest clean energy. As AD of FW in MFC has been considered the most beneficial and advanced technology to increase the retrieval and generation of bio-fuels [8]. Bio-fuels can help in reducing green house gas (GHG) from the atmosphere. Normally AD process can produce methane 50-75% in a controlled reactor [11]. So if using waste a source for generating bio-fuels will be more beneficial through MFC which is a best example of control reactor and advance technology. It is a latest technology which couples an AD with a MFC has been developed to improve the generation and purity of gas [13]. In this study a dual chamber microbial fuel cell was developed to generate eco-friendly fuel and further improving the MFC technology.

II. MATERIALS & METHODS

MFC and its Operation

A dual chamber microbial fuel cell (MFC) was constructed that each have volume of 800 ml. The anode and cathode were separated by salt bridge. Holes were drilled to connect salt bridge between two bottles. Salt bridge employed here is made up of 1M NaCL with 4.5 g of agar [12]. The anode and cathode were graphite rod 10 cm and carbon cloth 5 x 5 cm. and 5x5 cm. The anode and cathode electrode were connected with a Arduino setup. The MFC was operated on room temperature (25-34 ℃) in batch mode. Three different ratios of food waste (FW) and sewage sludge (SS) were set to find the potential of biogas that's 90:10, 50:50 and 10:90 respectively. Each ratio was operated for the time of 30 days. The FW and SS was mixed by using magnetic stirrer. The cathode chamber was provided air pump for aeration. The pH of the substrate was not adjusted. Characteristics of the substrate were analyzed before every and operation and at the end of operation. COD were analyzed by using RD-125 COD Digester and Lovibond MD-200 COD Meter while total suspended solids and volatile suspended solids, was measured according to the standard methods [10]. Biogas composition were gauged by using a gas chromatograph (GC-2010, Shimadzu, Kyoto, Japan). The volume of the gas measured by water displacement technique through a unit attached to the reactor.

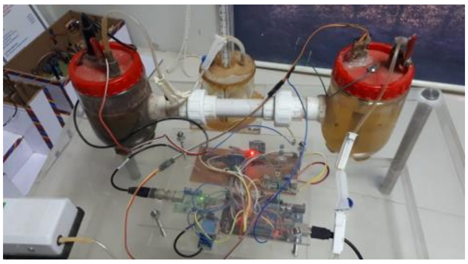

Fig 1: Photograph of Microbial Fuel Cell

III. RESULTS

Methane Production from Food Waste and Sewage Sludge

Methane production in the anode chamber of MFC was detected by using water displacement technique. The gas that were produced by three different ratios were measured and analyzed by gas chromatography. It was measured that the methane production from ratio 1, 2 and 3 was 91.75 ml, 168 ml and 145 ml as shown in Fig 1, Fig 2 and Fig 3 respectively.

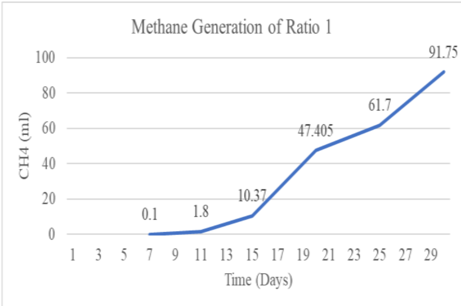

Fig 2: Gas production from ratio 1 of FW to SS

From Fig 1 it can be seen the gas production from ratio 1 started from 7th day and slowly increasing up to 15th day after that a rapid increase in production comes from 15th to 25th day and starts to decrease after 25th day.

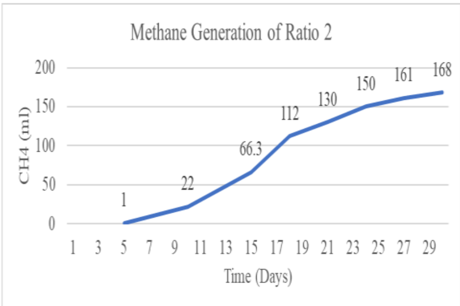

Fig 3: Gas production from ratio 2 of FW to SS

From fig 2 it can be seen the gas production from ratio 2 started from 5th day and slowly increasing up to 15th day after that a rapid increase in production comes from 15th to 21st day and starts to decrease after 21st day.

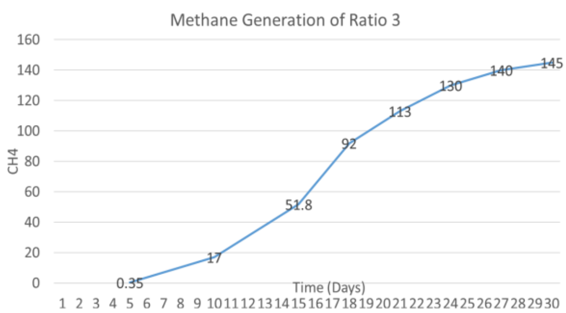

Fig 4: Gas production from ratio 3 of FW to SS

From Fig 3 it can be seen the gas production from ratio 3 started from 5th day and slowly increasing up to 10th day after that a rapid increase in production comes from 10th to 18th day and starts to decrease after 18th day.

Electricity production from food waste and sewage sludge

The electricity production of three ratios of food waste and sewage sludge was determined. The electricity production through MFC was observed and the electricity producing process was detected in three stages 0 d -11 d, 11 d – 16 d and 16 d – 30 d. It was observed that the voltage generation from ratio 1 was 550 mv on 10th day, the voltage generation from ratio 2 was 600 mv on 17th day and the voltage generation from ratio 3 was 530 mv noted on 15th day as show in Fig 4, 5 and 6.

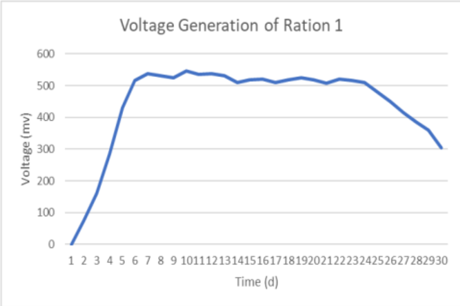

Fig 5: Voltage generation of ratio 1

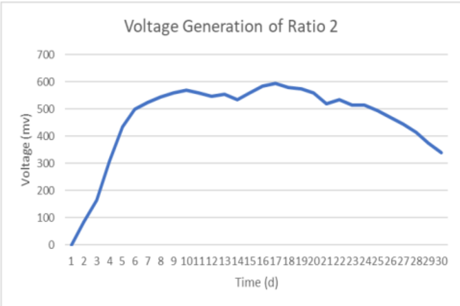

Fig 6: Vltage generation of ratio 2

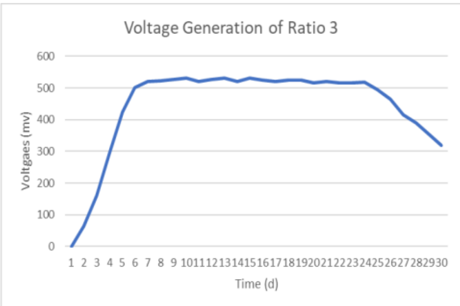

Fig 7: Voltgae generation of ratio 3

IV. CONCLUSIONS

The double chamber microbial fuel successfully fabricated and operated in batch-mode. The production of methane in the anode chamber using food waste and sewage sludge as substrate could increase generation of electricity along and improve the performance of the MFC. The maximum output voltages for ratio 1 was 550 mv that was noted on 10th day, whereas the maximum output voltage of ratio 2 was 600 mv noted on 17th day and the maximum output voltage of ratio 3 was 530 mv noted on 15th day similarly, methanogens in the anode chamber results in an enhanced methane yield of 91.75 ml in ratio 1, 168 mL in ratio 2 and 145 mL in ratio 3 respectively.

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