Potential of Electric Power Production from Microbial Fuel Cell (MFC) in Evapotranspiration Reactor for Leachate Treatment Using Alocasia macrorrhiza Plant and Eleusine indica Grass

by Badrus Zaman

Potential of Electric Power Production from Microbial Fuel Cell (MFC) in Evapotranspiration Reactor for Leachate Treatment Using *Alocasia macrorrhiza* Plant and *Eleusine indica* Grass

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Abstract. Microbial fuel cell is one of attractive electric power generator from nature bacterial activity. While, Evapotranspiration is one of the waste water treatment system which developed to eliminate biological weakness that utilize the natural evaporation process and bacterial activity on plant roots and plant media. This study aims to determine the potential of electrical energy from leachate treatment using evapotranspiration reactor. The study was conducted using local plant, namely *Alocasia macrorrhiza* and local grass, namely *Eleusine Indica*. The system was using horizontal MFC by placing the cathodes and anodes at different chamber (i.e. in the leachate reactor and reactor with plant media). Carbon plates was used for chatode-anodes material with size of 40 cm x 10 cm x1 cm. Electrical power production was measure by a digital multimeter for 30 days reactor operation. The result shows electric power production was fluctuated during reactor operation from all reactors. The electric power generated from each reactor was fluctuated, but from the reactor using *Alocasia macrorrhiza* plant reach to 70 µwatt average. From the reactor using *Eleusine Indica* grass was reached 60 µwatt average. Electric power production fluctuation is related to the bacterial growth pattern in the soil media and on the plant roots which undergo the adaptation process until the middle of the operational period and then in stable growth condition until the end of the reactor operation. The results indicate that the evapotranspiration reactor using *Alocasia macrorrhiza* plant was 60-95% higher electric power potential than using *Eleusine Indica* grass in short- term (30-day) operation. Although, MFC system in evapotranspiration reactor system was one of potential system for renewable electric power generation.

1 Introduction

Leachate generation is a major problem for municipal solid waste (MSW) landfills as a liquid that passes through a landfill and has extracted dissolved and suspended matter from it. Leachate results from precipitation entering the landfill from moisture that exists in the waste when it is composed [1]. The most critical aspect is related to several high concentrations pollutants that can be divided into four main groups namely: dissolved organic material, inorganic compounds, heavy metals and xenobiotic organic substances [2,3]. Evapotranspiration system which using plant and microbial activity on plant root and in planting media was promising for leachate treatment [4].

Meanwhile, the cleaner generation of energy is a vital concept to ensure the survival of our current lifestyle past the depletion of the Earth's fossil fuel supply, where MFC systems are recognized as one of energy production systems with great potentials [5]. MFC was believed as a promising technology that can be used to produce bioenergy in the form of hydrogen and/or electricity directly from various oxidation process of organic and inorganic compounds [6,7,8,9]. MFC can generates electrical power while accomplishing simultaneous treatment of biodegradable contaminants in wastewater by utilizing microorganisms [10,11].

Most microbes can produce current if active oxidation- reduction (Redox) mediator was added into the system or settled on the electrode. In practice, the system was designed with self-mediated or directly transferable electron to anode through contact between membrane- anode (extracellular transfer Electrons through a protein membrane and/or a bacterial nano cable) [12].

MFC technology in wetlands in rice plants was using rhizodeposition substrate to be oxidized by microbes, thus generating electrical energy [13]. MFC system utilization using waste residue at wetland forest as substrates that are oxidized by microbes, whereas in sediments it in eutrophication lake condition which generates maximum electricity was 294 mW/m^2 at the same time can remove of nitrate more than 90% [14,15]. MFC operated with continuous flow can remove of 50% COD from wastewater with the result of electrical energy was 464 mW/m^2 [16]. Constructed Wetlands (CW) to COD from textile waste when the system was combined with MFC. Thus CW-MFC system is capable

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to remove 75% COD and generates a maximum power was 15.73 mW/m^2 with current Maximum was 69.75 mA/m^2 [17].

This study aims to determine the potential of electrical energy from leachate treatment using evapotranspiration reactor. The study was conducted using local plant, namely *Alocasia macrorrhiza* and local grass, namely *Eleusine Indica*. The system was using horizontal MFC by placing the cathodes and anodes at different chamber (i.e. in the leachate reactor and reactor with plant media).

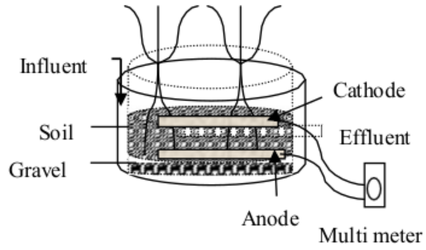

Fig. 1. Evapotranspiration-MFC reactor

2 Materials and Methods

2.1 Raw Leachate, plants and soil

Raw leachate collected from the Jatibarang landfill, Semarang City, Indonesia and store in the tank container with 4000lt capacity. Two plants species were used in the experiment namely *Eleusine indica* and *Alocasia macrorrhiza*, where thus species are growing in around the landfill. Soil media obtained from the Jatibarang landfill in Semarang City, Indonesia.

2.2 Reactors Set up

Main evapotranspiration-MFC reactor consists of two plastic containers with the size 80 gallons (h: 26 cm, d: 70 cm) and 70 gallons (h: 20 cm, d: 60 cm) each. Smaller container used for plants media which had maked ±1 cm^2 hole at the bottom and then put into large container. It's system design for 15 lt liquid volume. Electrode (carbon plate: w:10 cm, l:40 cm, t:1 cm) were put in the soil media as anode and under smaller container (in the large container) as cathode with horizontal position each (fig. 1).

2.3 Plants cultivation

After evapotranspiration reactors were ready, the gravel put into container as a bottom layer. Then, soil added with 20 cm high layer as plants cultivation media and put electrode. In each container was cultivated with 2 individual for *Eleusine indica* and Alocasia macrorrhiza. Then, put in the large container. All plants were maintained for 20 days, where each set reactor was made in duplo.

2.4 Experiment Set up

The reactors was operated at 30 days and the leachate sample was taken every 3 days from sample point above in accordance with the residence time of main reactor. Electricity was measure continuously using multimeter.

3 Results and Discussion

3.1 Using *Alocasia macrorrhiza* Plant

A long 30 days reactor operation, electric power has produce from the reactor. It's shows electric power production was fluctuation during reactor operation from all reactors. Electric power generated from reactor were using *Alocasia macrorrhiza* plant at at the first day was reached 30 µwatt average. It's condition was similarity with control pattern. Thus shows at first operation (about 3 days) the plant and bacteria on plant roots are still in the adaptation stage condition by leachate presence, where more bacteria in the soil media was treat it's leachate.

Furthermore, the electric power generated has increased and reach to 60 µWatt and then decrease less than control, but during overall reactor operation, electric power generated has increase were up to 100 µWatt an average. Thus, pattern is influenced by *Alocasia macrorrhiza* leaves growth pattern. Where every 4-7 days will grow new leaves but old ones begin to wither. This condition causes its performance will decrease and then increase, but after leaf growth was stagnant, its' will reach maximum performance condition. The pattern will be repeated but in line with the growth of leaves and also roots develop and increase the number of bacteria (fig.2). It's bacteria was simultaneously Organic matter removal carried out by means of aerobic respiration, denitrification, sulphate reduction, fermentation or methanogenesis [19]

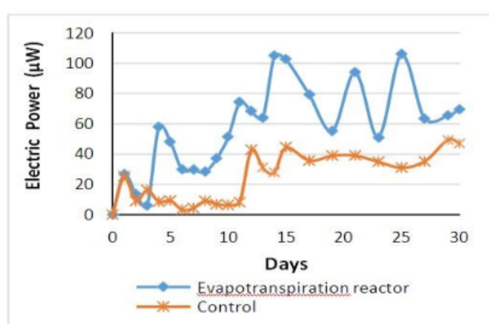

Fig.2. Electric power production from reactor using *Alocasia macrorrhiza Plant* and control

3.2 Using *Eleusine indica* Grass

From the reactor using *Eleusine Indica* grass on the first day was resulting electric power reach to 50 µwatt average and decreased until the 9th day was 10 µwatt average, but then gradually increased until 30th day was reached 60 µ watt average. This electric power production fluctuation is related to the bacterial growth pattern in the soil media and on the plant roots which undergo the adaptation process until the middle of the operational period and then in stable growth condition until the end of the reactor operation (fig.3).

The overall results indicate that the evapotranspiration reactor using *Alocasia macrorrhiza* plant was 60-95% higher electric power potential then using *Eleusine Indica* grass in short-term (30-day) operation. It's plants influence reactors performance by their ability to release oxygen or easily biodegradable substrates through the root system, also influence the redox conditions within the treatment bed due their ability to evapotranspirate water and influencing MFC performance. It's performance also influenced by biological, chemical and electrical factors [20].

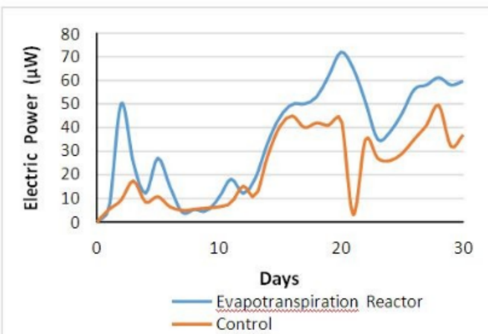

Fig. 3. Electric power production from reactor using *Eleusine indica* grass and control

Parameters defining MFCs performance are consists of substrate conversion rate, over potentials at the anode, over potentials at the cathode, proton exchange membrane related factors, and internal resistance of the MFC [21]. Also, concentration of chemical oxygen demand (COD) pH or temperature, distance of electrode [22].

Electric power generation from evapotranspiration system for leachate treatment was potential technology in the future but need to improve treatment and electric power performance according to parameters performancefactors.

4 Conclusions

The results indicate that the evapotranspiration reactor using *Alocasia macrorrhiza* plant was 60-95% higher electric power potential then using *Eleusine Indica* grass in short-term (30-day) operation. MFC system in evapotranspiration reactor system was one of potential system for renewable electric power generation.

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