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Euro Green Chemistry-2018-Improved Performance of Soil Microbial Fuel Cell by Adding Earthworms-Hiroshi Yukimoto- Kindai University

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1. Introduction:

At present, energy demand is enhancing in the world, and it has been reported that 80 percent of the energy supply source was formed from fossil fuels such as petroleum, coal and natural gas in 2016. However, this energy supply sources have troubles such as depletion of petroleum and emission of greenhouse gases. Under the situation, demand for renewable and sustainable energy are increasing and the alternative energy sources other than fossil fuels are expected .Microbial fuel cells are strategy that utilize microorganisms as biocatalysts to directly alter chemical energy to electricity through the oxidization of organic and inorganic matters . MFCs can utilize wastewater and wastes as the fuel source of electricity generation and are expected in the current years as an application that can produce sustainable energy. There are numerous kinds of MFCs, and a kind of MFC that use soil as the fuel source is called soil MFCs (SMFCs). There are diverse kinds of bacteria in the soil and the number of bacterial species per gram of soil is estimated to be between 2000 to 8.3 million. There exist different bacterial populations, and some bacteria in the soil such as metal or sulfate-reducing bacteria generate electricity in the MFCs. while the cathode rests on the surface of the soil. Basic principles of MFC and SMFC are same, but the SMFC doesn't need proton exchange membrane and it can be low-cost and easy to be constructed. However, it is a long way to go before the SMFC is practically applied. One difficulty is the low power generation by SMFC operation. Numerous studies are being conducted to increase the power generation. It has been noticed that increased power generation was experiential by reducing the internal resistance through the addition of graphite powder, silica colloid or sodium chloride in the soil. In other studies, optimization of electrode distance or addition of substrate such as rice straw was effective for SMFC to enhance the power generation. Most studies for SMFC have been focused on soil composition, bacteria in the soil or on the shape and materials of device. Another method for improving the power generation was a hybrid system with other organisms, such as plants. Joining SMFCs with the rice plant in the rice paddy field allows the electricity generation efficiently in the daytime, but it is not at nighttime because of the photosynthesis. We tried different hybrid systems that uses earthworms, which degrade fallen leaves or plant litter. Moreover, there have been reports that plant growth is promoted by addition of earthworms to soil and plant pathogens are inhibited by microorganisms derived from earthworms.

MATERIALS METHOD

2.1. Soil and earthworm sampling

The soil and earthworms use in this study were collected at the campus of Kindai University in Wakayama, Japan. The upper layer of the soil was collected at a depth of about 0-10 cm, and was sieved with 2 mm mesh to remove the big particles such as pebbles, rocks and twigs, and the fine earth fraction of the sample (less than 2 mm) was used. The external form of earthworm species were analysed, and the collected earthworms were identified from external shape and position of the annulus. The earthworms with annulus were determined as Megascolecidae family and remaining without annulus were immature earthworms, because the immature earthworms don't have the annulus.

2.2. Analysis of soil component

The pH and electrical conductivity (EC) of soil in the MFC were calculated by the standard procedure. Soil and water solution in the ratio of 1:2 were mixed together for 10 minutes, followed by centrifugation at 25,000×g. The supernatant of the soil was used to measure the pH and EC by the pH meter.

3. RESULTS AND DISCUSSION

3.1. Effect of earthworm on microbial fuel cell

The soil MFCs used in this study was operating without any external source of substrate and inoculation. SMFC with earthworms showed the higher voltage than SMFC without them.

3.2. Effect of earthworm to microbes in soil

The effect of further added earthworms on the number of microorganisms in the soil was examined by counting the colony forming units (CFU) per gram of dry soil on the media with the different nutritional condition. It was suggested that enhancing the power was not due to the increasing the number of microbes, because the CFU per gram of dry soil in the SMFCs with and without earthworms were similar.

3.3. Effect of earthworm to soil component and structure:

The soil structure with earthworms was really very different from that without earthworms. This
structure was made with passaging soil through the earthworm gut. Both pH and EC of the soil samples with and without earthworms were measured. The values of pH and EC from the soil with earthworms were 7.9 and 0.26, respectively. The soil with earthworms showed slightly alkaline pH, and higher EC than those of control SMFC.

This work is partly presented at 9th World Congress on Green Chemistry and Technology, September 17-19, 2018, Amsterdam, Netherlands

4. CONCLUSION

It was noticed that the soil environments were changed biologically and physicochemically by addition of earthworms into SMFC. These changes had a positive influence on SMFC. There was no report of hybrid type SMFC combined with the earthworms. It was a very new approach to use earthworm as enhanced power generation through the SMFC and we would like to call this eMFC (earthworm MFC).

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