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Bio-electrochemical response to selected experimental treatments of a soil-type microbial fuel cell for sustainable bioelectricity generation.

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The need to protect the environment has triggered a search for alternative and sustainable energies to replace or drastically reduce the world's dependence on fossil fuels. Bio-electrochemical systems (BES) are among the leading research topics in alternative energy sources due to their multi-functional potentials. However, their low energy production rate limits their application in the real world. Therefore, architectural and biological optimization is required to take BES beyond laboratory-scale experiments. In this study, we investigated the interactive influence of electrode materials, electrode spacing, and frequent substrate feeding on microbial community diversity and electrochemical behavior of a soil BES for sustainable power generation. Two electrode materials (carbon felt (CF) and stainless steel/epoxy/carbon black composite (SEC) were tested in a soil microbial fuel cell (S-MFC) under three levels of electrode spacings (2, 5, and 8 cm) and treatment frequencies (4, 6, and 8 days). After 30 days of operation, all MFCs achieved an Open-circuit voltage of 782+12.2 mV regardless of the treatment. However, the maximum power of the CF-MFCs was 12.19 + 1.6 mW/m^2 at a current of 15.8 mA/m2, while the SEC-MFCs produced 125.69 + 9.3 mW/m^2 at a current of 277.4 + 19.3 mA/m^2 under the same experimental conditions. The overall best and sustainable performance (145.3 + 8.03 mW/m^2) during the 66-day operating period was obtained with SEC-MFC at 5 cm electrode spacing and treatment frequency of 8 days. 16S rDNA gene amplicon sequencing of DNA samples from the anode, cathode, and point of maximum power (MPP) revealed complex microbial diversity that showed significant compositional changes at the electrodes and MPP. The results showed that too small or too large electrode spacing and frequent substrate loading were not suitable for the MFC configuration in this study, and the electrode material had the greatest impact on S-MFC performance.

Keywords: Energy, sustainable, electrode, microbial fuel cell, soil