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Rhizosphere mediated electrogenesis with the function of anode placement for harnessing bioenergy through CO_2 sequestration

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HIGHLIGHTS

- ▶ Rhizodeposits of *Pennisetum setaceum* showed feasibility of electrogenic activity.
- ▶ Electrode assemblies in root vicinity were effective than distant electrodes.
- ▶ Power output variation with different anodes evidenced key role of root exudates.
- ▶ Day time operation and saturated soil water condition showed effective electrogenesis.

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ABSTRACT

The feasibility of power generation by non-destructive usage of rhizodeposits of *Pennisetum setaceum* plant formed mainly due to photosynthesis-carbon sequestration mechanism was studied in rhizosphere based microbial fuel-cell (R-MFC). Four fuel-cell assemblies (non-catalyzed graphite-plates; membrane-less operation; air–cathode) were evaluated for their electrogenic activity by varying anode distances from root in rhizosphere [A1 – 0; A2 – 8; A3 – 12 and A4 – 16 cm] at 2 cm depth from soil-layer and analyzed their electrogenic potential. The fuel-cell assembly near to the root zone showed maximum electrogenic-activity (R1, 1007 mV/4.52 mA) followed by R2 (780 mV/4.11 mA), R3 (720 mV/3.4 mA) and R4 (220 mV/1.2 mA). The observed maximum electrogenesis with R1 and minimum with R4 electrode-assemblies enumerated the critical role of root-exudates as substrates. All fuel-cell assemblies showed 10% higher electrogenic activity during day-time operation which can be directly attributed to plant's photosynthetic activity. The study enumerated the potential of plant to harness power in a sustainable way by optimum placement of fuel-cell setup in their rhizosphere.

1. Introduction

With increasing concern about sustainable energy supplies, solar energy gained much attention to plug enormous resource for powering future generations. Photosynthesis is the only biological process that can harvest light energy through CO_2 sequestration. A large fraction of the planet's energy resources i.e., fossil fuels was resulted from photosynthetic mechanism (Taiz and Zeiger, 2010). Solar energy fixes carbon dioxide (CO_2) in the form of carbohydrates by photosynthesizing in leaves of the plants. Terrestrial ecosystem fixes 15% of CO_2 photosynthetically (450 billion tons annually), which is the largest global flux of carbon between land and atmosphere (Beer et al., 2010). About 70% of the fixed carbon translocates to the roots of the plants which finally gets released into the rhizosphere (Lynch and Whipps, 1990; Liljeroth et al., 1994). The plant root system releases different types of organic compounds viz., exudates (sugars, organic acids, etc.), secretions (polymeric carbohydrates and enzymes), lysates (dead cell materials) and gases (ethylene and CO_2) into the rhizosphere by the process of rhizodeposition (Uren, 2001; Bais et al., 2006). Rhizosphere provides favorable environment to proliferate microbial consortia which is beneficial to the soil microenvironment. In turn, microorganisms provides nutrients in simpler form to absorb by the plant root system (Dakora and Phillips, 2002; Venkata Mohan et al., 2009, 2011). The components of plant root exudates not only serves as a carbon source for microbial growth, but also contain chemical molecules that promote chemotaxis of soil microbes to the rhizosphere (Dakora and Phillips, 2002; Dommergues and Krupa, 2001). Chemical components such as flavonoids, aromatic acids, amino acids and dicarboxylic acids function as specific chemo attractants to attract rhizobia to root hairs in the rhizosphere (Dakora and Phillips, 2002). Several root exudates and microbial metabolites viz., formic acid, succinic acid, biotin, etc., are reported to mediate electron transfer (Schroder, 2007). It can therefore

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