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Abstract

An eco-electrogenic engineered system (EES) was designed to mimic the functional role of natural aquatic ecosystems and evaluated their response to bio-electrogenic activity by cascadically interlinking three tanks with functionally diverse biota viz., floating macrophytes (Tank 1), submerged plants (Tank 2) and filter feeders (fish and snails) (Tank 3). Tank-1 showed efficient power generation (voltage (series): 0.86 V; current density (parallel): 37 mA/m^2) than Tank-2 (voltage (series): 0.76 V; current density (Parallel): 34 mA/m^2) and Tank-3 (voltage (series):0.65 V; current density (parallel): 22 mA/m^2). Integrating all three tanks enabled maximum power generation in parallel-series (P-S) connection (9.5 mW/m^2) than individual series and parallel connections (6.5/5 mW/m^2). Interaction of microbes and plant studied at the interface of electrochemical and engineering aspects illustrated the feasibility of EES as a self-sustainable system with innate diverse functional aquatic biota and rhizo-microbiome to produce bioelectricity.

Keywords: Aquatic Macrophytes; Bioelectricity; Water Ecosystem; Electric Circuit.

1. Introduction

Ecological water bodies are inhabited by numerous aquatic living forms functioning symbiotically to balance the ecological status of aquatic ecosystem and fulfilling their characteristic roles (Baron et al., 2003; Aoki, 2006; Venkata Mohan et al., 2010). The congregations of diversified biota ranging from exo-electrogenic bacteria to CO_2 assimilating phototrophic macrophytes make the ecological water bodies a natural source to harness energy (Venkata Mohan et al., 2009). The core sustenance of ecological water bodies depends on primary phototrophic producers which are phytoplankton and hydrophytes (Pennak, 1971; Wiley et al., 1984). The ecosystem balance is dependent on both abiotic factors including light, temperature, nutrients, and sediment composition and biotic factors which includes mainly the plant-microbial interactions (rhizosphere) to sustain the nutrient cycles (Bond et al., 2002). Plants actively recruit and sustain microorganisms in the rhizosphere by translocation of organic compounds from leaves to the roots that serves as growth substrate for rhizospheric microbes by the translocation of organic compounds from the leaves to the roots and into the rhizosphere that serves as growth substrates (Nitisoravut and Regmi, 2017). Rhizosphere bacterial community is dependent on root exudates which serve as a wide range of complex organic compounds ranging from border cells and root debris i.e., soluble and insoluble organic compounds. However, exudation of low weight molecules (organic acids, amino acids, and sugars) is a continuous process that is driven by passive diffusion and migration (Deng et al., 2012; Timmer et al., 2011). Root exudates which are produced during the photosynthetic process are uptaken by root