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Bio-electrochemical post-treatment of anaerobically treated landfill leachate

A. Evren Tugtas *, Pelin Cavdar, Baris Calli

Marmara University, Environmental Engineering Department, 34722 Goztepe, Istanbul, Turkey

HIGHLIGHTS

- Pre-treated leachate resembling medium aged landfill leachate was treated with MFC.
- The maximum power and current densities of 525 mA/m^2 and 158 mW/m^2 were achieved.
- Partial nitrification was observed at the cathode at HRT of 5 days.
- High VFA utilization was achieved in MFC.

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ABSTRACT

Bio-electrochemical treatment of anaerobically pre-treated landfill leachate was investigated in batch and continuous-flow two-chambered microbial fuel cells (MFCs). A high strength young landfill leachate was pre-treated using an upflow anaerobic sludge blanket reactor and the effluent resembling medium-aged landfill leachate was fed to the anode chamber of MFCs. The highest maximum current and power densities achieved in continuous-flow MFC with hydraulic retention time (HRT) of five days were 525 mA/m^2 (8227 mA/m^3) and 158 mW/m^2 (2482 mW/m^3), respectively. Increase of HRT from one day to five days resulted in the occurrence of partial nitrification, where influent ammonia was converted into nitrite presumably due to the inhibitory effects of free ammonia. The maximum power and current densities obtained in this study were higher compared to other studies with similar leachate characteristics. The results of this study suggest that MFCs can be exploited as a polishing step for anaerobically pre-treated landfill leachate.

1. Introduction

Leachate generated from municipal solid waste landfills contains significant amounts of dissolved organic/inorganic matter, heavy metals, xenobiotic organic compounds, and refractory organics (Christensen et al., 2001; Kjeldsen et al., 2002; Li et al., 2009). Leachate characteristics are generally affected by the age of the landfill, waste composition, and seasonal weather variations (Renou et al., 2008). In particular, chemical composition of a landfill leachate depends greatly on the age of landfill; new landfills contain large amounts of biodegradable material, a rapid anaerobic digestion takes place resulting in volatile fatty acids (VFAs) as the main fermentation products, whereas with the aging of landfill, the biodegradability of leachate decreases (Calli et al., 2005; Li et al., 2009; Renou et al., 2008). Landfill leachate is among the most difficult effluents to deal with due to its highly variable characteristics, strength, and complex composition (Gálvez et al., 2009). Generally, landfill leachate treatment can be classified as: (a) combined treatment with domestic sewage, (b) biological treatment: aerobic and anaerobic, and (c) chemical and physical treatment: floatation, chemical precipitation, coagulation/flocculation, adsorption, air stripping and oxidation (Renou et al., 2008). Biological treatment methods are used as simple, cost-effective and reliable methods for the treatment of leachate containing high concentrations of organic carbon and/or nitrogen (Renou et al., 2008). Physical/chemical or biological treatment processes have benefits and drawbacks, therefore; in general these processes are used in combination in order to achieve an effective leachate treatment (Kjeldsen et al., 2002; Li et al., 2009; Mehmood et al., 2009; Renou et al., 2008).

Microbial fuel cells (MFCs) have recently received significant attention as they enable the use of microorganisms as catalysts to convert chemical energy of the electron donors into electrical energy (Franks and Nevin, 2010; Freguia et al., 2010; Logan et al., 2006; Rabaey and Verstraete, 2005). Recently, in addition to electricity generation, MFCs have been utilized in various treatment/recovery processes such as reductive dechlorination (Huang et al., 2012), valuable chemical production such as H_2O_2 from wastewater organics (Modin and Fukushi, 2012), and treatment of pharmaceutical wastewaters (Velvizhi and Venkata Mohan, 2011). MFCs have also

* Corresponding author. Tel.: +90 216 348 0292x519; fax: +90 216 348 1369.
E-mail address: evren.tugtas@marmara.edu.tr (A.E. Tugtas).

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