QUARTERLY PROGRESS REPORT

September 1 to November 31, 2011

PROJECT TITLE: Usage of Microbial Fuel Cell Technology in Landfills. Year II. Enhanced Organic Compound Decomposition and Nitrogen Removal

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Low cost, low maintenance and energy-generating onsite systems for the treatment of landfill leachate with high ammonium content are in urgent need, especially for landfills located in low population areas where landfills are smaller and often at a distance from sewage systems and lack trained personnel. The purpose of this study is to design and test two continuous microbial fuel cell (MFC) reactors, i.e., an ammonium oxidation/MFC reactor and a MFC/Anammox reactor for power generation as well as organic compound decomposition and nitrogen removal from landfill leachate. Specific objectives of this research include:

- Landfill leachate collected from landfills located in Northwest Florida will be treated in a laboratory scale continuous ammonium oxidation/MFC reactor, which is composed of an in-line nitrification column and a MFC reactor. Impact factors such as the organic load, retention time, pH, and alkalinity as well as nitrification reaction time will be investigated.
- Landfill leachate collected from landfills located in Northwest Florida will be treated in a laboratory scale continuous MFC/Anammox reactor. Besides factors impacting organic removal such as the organic load and retention time, factors that may impact the nitrite accumulation in the Anammox reaction such as the dissolved oxygen concentration and alkalinity will be explored. The MFC/Anammox reactor will be compared with the ammonium oxidation/MFC reactor in terms of power generation as well as organic compound decomposition and nitrogen removal.

WORK ACCOMPLISHED DURING THIS REPORTING PERIOD:

Landfill Leachate Treatment in Ammonium Oxidation/MFC Reactor

An ammonium oxidation/MFC reactor was set up and examined for the treatment of collected landfill leachate. The laboratory scale continuous ammonium oxidation/MFC reactor included an in-line ammonium oxidation column (Figure 1). In the MFC reactor, a graphite rod, without catalyst coating, was used as the anode. The anode was inoculated with the cultured *S. putrefaciens*. During the operation, collected landfill leachate was introduced to ammonium

oxidation column for ammonium to be oxidized to nitrate, after which, the leachate was introduced to the anodic chamber for organic decomposition.

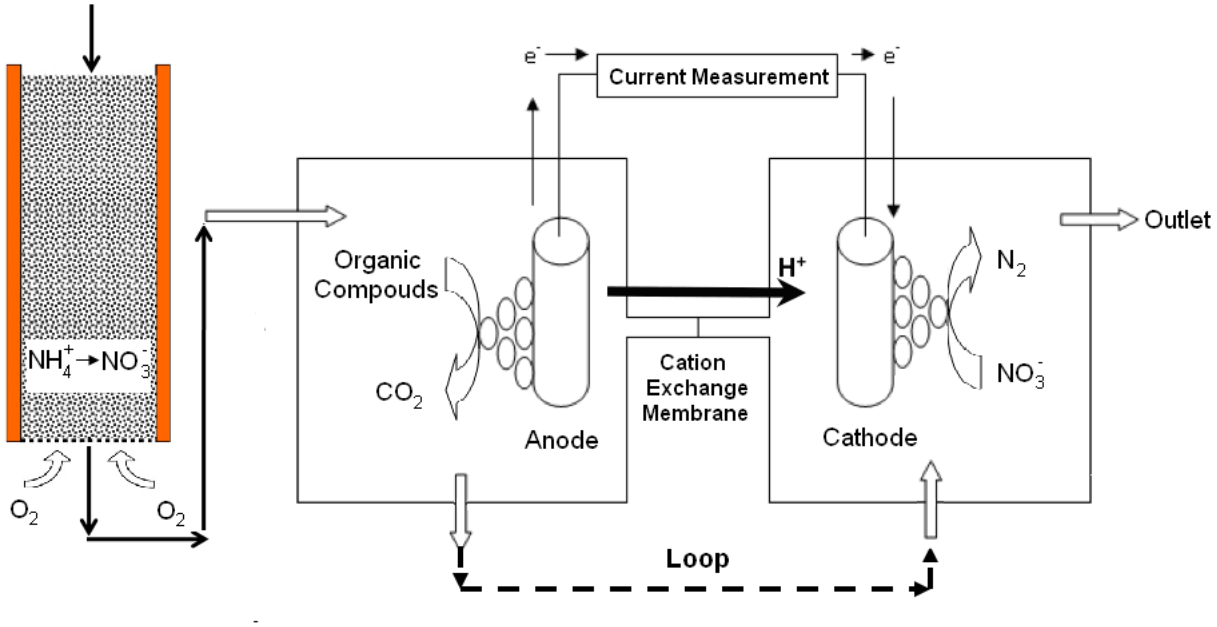

Figure 1. Ammonium Oxidation/MFC Reactor Setup

For this research period, we have cultured the ammonia oxidizing bacteria and studied ammonia oxidation in our laboratory. Specifically, 1 L regurgitant sludge with a suspended solid (SS) of 4.85 $g \cdot L^{-1}$ from the secondary sedimentation tank was inoculated into a reactor to initiate the nitrification system. The dissolve oxygen (DO) concentration of the bulk liquor in the reactor was maintained around 8.5 $mg \cdot L^{-1}$ and the ammonium concentration in the reactor was maintained at 500 $mg \cdot L^{-1}$ NH_4^+-N. After around one month's adaptation, the inocula began working functionally with a bulk liquor SS maintained at ~ 1000 $mg \cdot L^{-1}$ and volatile suspended solid (VSS) at ~ 820 $mg \cdot L^{-1}$. The sludge volume and sludge volumetric index (SVI) of the bulk liquor were kept at 5% and 50 $mL \cdot g^{-1}$ respectively. After cultivation, the landfill leachate was treated in a nitrifying reactor (Figure 2). The landfill leachate was collected from the leachate sumps of Leon County Landfill located in Tallahassee, FL, which was opened in 1991 and closed in 2005. After collection, the leachate was stored in temperature-controlled containers at 4^oC and transported to the laboratory immediately. The leachate was stored under refrigeration at 4^oC until the reaction. As a young landfill, the initial characterization indicated that the landfill leachate of this landfill had a composition of BOD_5 of 2023 mg/l, NH_4^+ of 509 mg/l, NO_3^{-1} of 61.4 mg/l, Mg^{2+} of 178 mg/l and PO_4^{3-} of 192 mg/l. The pH of the landfill leachate was 7.36.

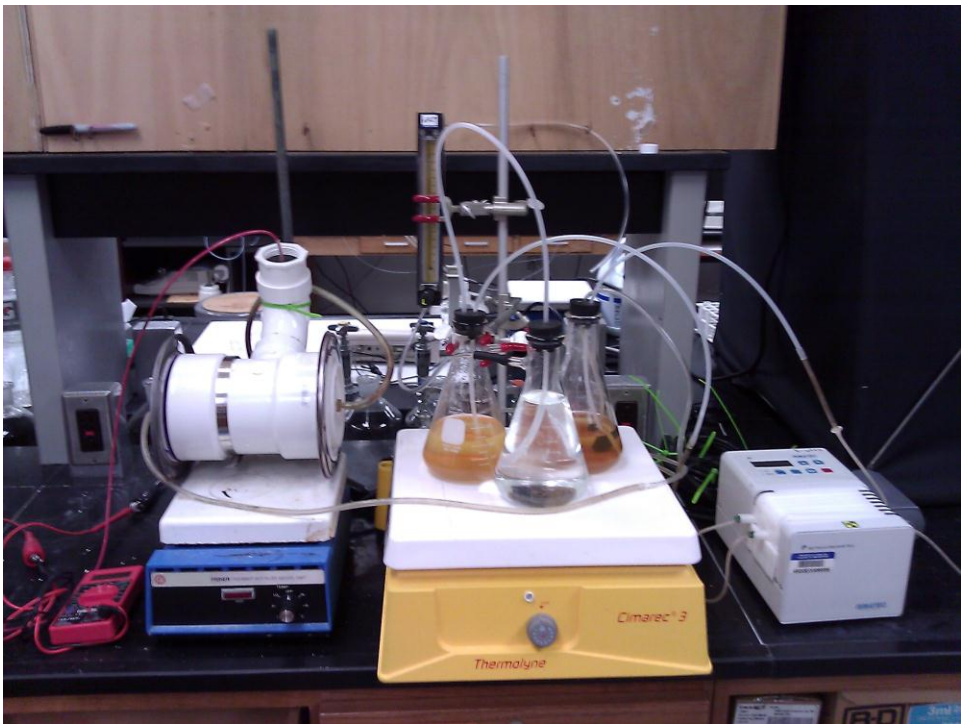

Figure 2. Laboratory Setup for Ammonium Oxidation and MFC

At dissolved oxygen (DO) concentrations of 2 $mg \cdot L^{-1}$ to 8.5 $mg \cdot L^{-1}$, ammonia was able to be converted to nitrate within 10 hours (Figure 3 and Figure 4). The ammonia depletion rate and nitrate production rate (slope of curves in Figure 3 and 4) increased with the increase of the DO concentration.

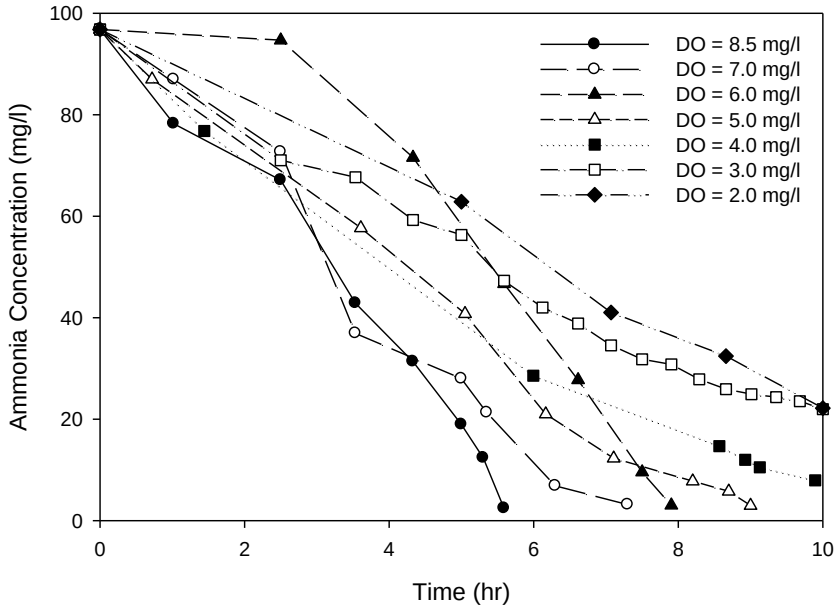

Figure 3. Ammonia Depletion as a Function of Time

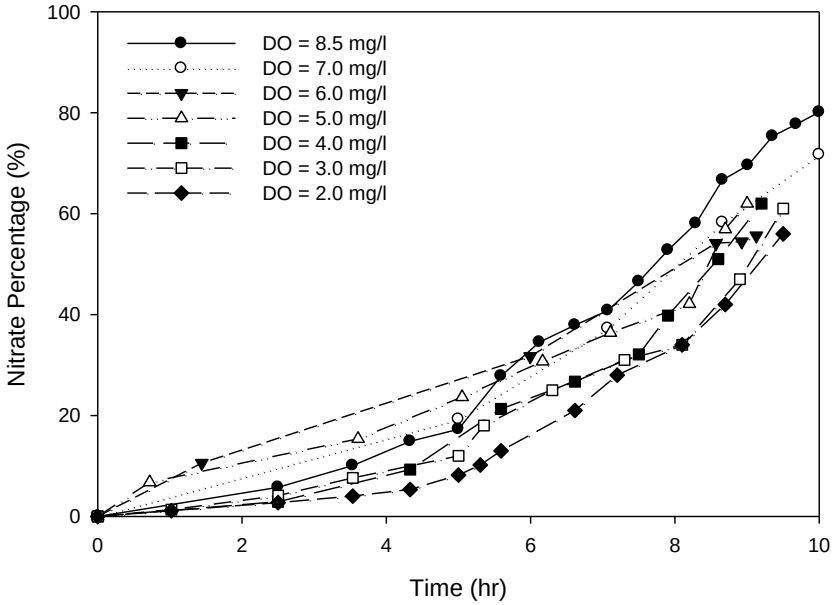

Figure 4. Nitrate Production as a Function of Time

INFORMATION DISSEMINATION ACTIVITIES:
TAG members: Lee Martin, Peter Grasel, Casey Taylor, and Michael Watts

TAG meetings: First TAG meeting will be held in January, 2011 at FAMU-FSU College of Engineering. The meeting minute will be available at www.eng.fsu.edu/~gchen.

A website has been created for this project (URL): www.eng.fsu.edu/~gchen (MFC Year II Details)

CONFERENCE PRESENTATION:
Subramaniam, P. K. and Chen, G., Ammonium Removal from Landfill Leachate through Anammox, 97th Annual ASM Southeastern Branch Conference, November, 2011.