FAMU - FSU COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
2525 Pottsdamer Street
Tallahassee, Florida

Tag Meeting No. 1

Friday, October 16, 2015
11:00 am – 12:30 pm, Room Building A 127A

Project Title: Suspended Fiber Biofiltration for the Treatment of Landfill Leachate. Year II. Incorporation of Advanced Oxidation and Phosphorous Removal in a Single Unit
Tag Members: Peter Grasel, Gary Millington, John Hallas, Chen Lin, Hafiz Ahmad and Matthew Hendrix
Principle Investigators: Gang Chen and Kamal Tawfiq
In Attendance: John Hallas, Chen Lin, Matthew Hendrix, Tim Vinson, Youneng Tang, Houzhen Wei, Boya Wang, Gang Chen and Hafiz Ahmad (through Gotomeeting)

This TAG meeting presentation has been presented at Leon County Landfill on Sep. 17, 2015 and Springhill Regional Landfill on Oct. 5, 2015. Leon County Solid Waste Management Director Robert Mills, Solid Waste Superintendent Shawn Abbott as well as two other staff members attended the Leon County Landfill presentation. David Steiner, District Manager of Waste Management Springhill, Brian Dolihite, Market Area Engineer of Waste Management, Inc., Michele Lersch, Environmental Protection Manager of Waste Management, Inc. and two more staff members attended the Springhill Regional Landfill presentation. Comments and questions from these two presentations are included in the discussion section.

A website has been developed for this research (www.eng.fsu.edu/~gchen). All the information regarding this project has been uploaded to this site to facilitate the dissemination of the research discovery.

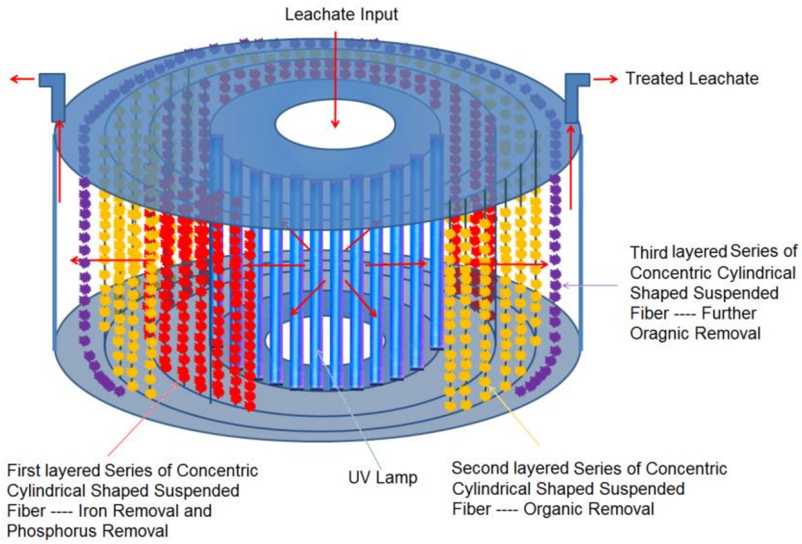
Agenda

1. Project Overview

Detailed information is available at http://www.eng.fsu.edu/~gchen

2. Experimental Setup

In the first year, suspended fiber biofilter has been tested for the treatment of landfill leachate in terms of organic, iron and chloride removal. For the second year, advanced oxidizing processes will be introduced to the suspended fiber biofilter. For this purpose, a laboratory scale novel reactor will be designed for the treatment of landfill leachate with combined advanced oxidation and phosphorous removal in a single unit.



3. Reactor Design and Parameter Characterization

The center section of the reactor is designed for advanced oxidization. The experimental setup shows UV irradiation is used as the major means of advanced oxidation. If other advanced oxidation methods instead of UV are selected, the UV lamps will be replaced with a layer of suspended fiber to separate the advanced oxidation chamber from the rest of the reactor. When landfill leachate is introduced to the reactor, the leachate will first pass through UV lamps (with possible combination with O_3, H_2O_2 or both) for advanced oxidation, after which the leachate will be further treated in a series of layer-by-layer suspended biofibers. The suspended fibers (polypropylene) will be arranged in concentric cylindrical shapes in series. The first series of the suspended fiber will be coated by iron hydroxides by contact oxidation after advanced oxidation, which also have high binding strength for phosphorus. The second and third series of suspended fibers will be inoculated with bacterial strains that are responsible for organic decomposition. During advanced oxidation, xenobiotics will be destructed and these suspended fibers with inoculated microorganisms can further degrade residuals of the organics.

4. Reactor Operation

Through advanced oxidation, besides xenobiotic destruction, most organics in the leachate will be decomposed. In addition, the suspended fiber biofilters can further degrade residuals of the organics and remove phosphorous. Landfill leachate will be collected from the Leon County Landfill, Springhill Landfill (Jackson County) and Perdido Landfill (Escambia County). We will also sample other landfills in Northwest Florida to identify the leachate with noticeable xenobiotic concentrations for this research. The advanced oxidation of the leachate will be conducted using the combinations of ozone, hydrogen peroxide and UV radiation. Specifically, ozone, hydrogen peroxide and UV radiation will be tested with the following four combinations: (1) ozone + hydrogen peroxide (O_3/H_2O_2), (2) ozone-UV radiation (O_3/UV), (3) hydrogen peroxide-UV radiation (H_2O_2/UV) and (4) ozone-hydrogen peroxide-UV radiation (O_3/H_2O_2/UV).

The following dosage will be tested in this research: (1) O_3/H_2O_2, O_3 2 to 6 mg/L and H_2O_2 1 to 5 mg/L; (2) O_3/UV, O_3 2 to 6 mg/L and UV 10 to 100 mJ/cm^2 (by varying the exposure time from 0 to 15 min); (3) H_2O_2/UV, H_2O_2 1 to 5 mg/L and UV 10 to 100 mJ/cm^2; and

(4) O_3/H_2O_2/UV, O_3 1 to 3 mg/L, H_2O_2 1 to 2.5 mg/L, and UV 10 to 50 mJ/cm^2. Since all the oxidation reactions are impacted by pH, above reactions will be investigated at pH of 4, 5, 6, 7, 8, 9 and 10 respectively by adjusting the pH with hydrochloric acid or sodium hydroxide. The reaction time will be arranged for 0, 1, 5, 10 and 15 min. Advanced oxidation is designed to destruct xenobiotic compounds present in the leachate including aromatic hydrocarbons, halogenated hydrocarbons, polychlorinated biphenyls (PCBs), dioxins, naphthalene, and phenanthrene, etc. This process is also affected by alkalinity. Therefore, alkalinity of the leachate will be adjusted to 100, 200, 300, 400, 500 and 600 mg/L as $CaCO_3$ with lime. After advanced oxidation, organics will be removed in the suspended biofilters though contact oxidation, during which low biomass will be produced. Therefore, the suspended biofilters can last a long operation period. Once the biofilter capacity is reached, the polypropylene filters can be taken out for washing and repacked to the reactor. During the experiments, oxidation/reduction potential (ORP) will be closely monitored. Effluent will be measured for xenobiotic, iron, phosphorous and organic concentrations (BOD and COD) throughout the course of the experiments.

5. Phosphorous Removal Consideration

Phosphorous will be removed mainly in the first layered series of concentric cylindrical shaped suspended fiber. After advanced oxidation, the fiber will be coated with iron hydroxides by contact oxidation, which will remove phosphorous by adsorption. In our prior research, we have discovered that a low pH is preferred for phosphorous adsorption in iron oxide-coated fiber. This process is also affected by alkalinity. Therefore, alkalinity of 100, 200, 300, 400, 500 and 600 mg/L as $CaCO_3$ (adjusted with lime) and pH of 5, 6, 7, 8, 9 and 10 (adjusted with hydrochloric acid or sodium hydroxide) will be tested for iron coating and the subsequent phosphorous removal. It is expected that the microbial accumulation in the first layer of suspended fiber will be low owing to the short separation distance from the advanced oxidation region, which may gradually increase with the increase of the separation distance from the oxidation region.

The mechanism of phosphorous adsorption onto iron hydroxides will be further investigated based on infrared analysis of the iron hydroxides coated on the polypropylene fiber. It is believed that phosphorous adsorption on iron hydroxides is generally dominated by ligand exchange in which two singly coordinated hydroxyl groups or water molecules are replaced by a single phosphate anion. Since H_2O is a more mobile ligand than OH^-, adsorption is therefore favored at lower pH. It is believed that four key characteristics impact phosphorus adsorption on the iron hydroxide surfaces, i.e., the easiness of hydroxyl release, the specificity toward binding sites, hysteresis, and the surface charges. Iron hydroxides formed under different operation conditions will be examined to identify the best operation conditions for phosphorus removal.

6. Dissemination Plan for this Project

Two research presentations have been made to Leon County Landfill and Springhill Regional Landfill respectively.

7. Potential Funding Sources for the Continuation of Related Research

— NSF/CBET/Environmental Engineering
— EREF

8. Discussion

During the presentation at Leon County presentation, the managers are more interested in the operation costs of the treatment system of this research. They recommend cost analysis be conducted for this research.

Springhill Regional Landfill has concerns about the high ammonium and arsenic concentrations in their leachate.

Tim Vinson pointed that a shield layer may be introduced to the reactor to prevent the possible effects of UV radiation on microorganisms that are responsible for organic degradation. The shield layer may be combined with a hydroxyl-producing catalyst such as nano-TiO_2/Ag catalyst to offer more extensive oxidation.

Impact of pH and alkalinity on microbial activity is discussed. It is suggested the impact of pH and alkalinity be tested on microbial activities. pH also affects iron oxidation and precipitation.

Ferric iron has much stronger adsorption of phosphorous than ferrous iron. The coated iron should be in the oxidized state to enhance phosphorous removal.

The fiber surface area and cell density are discussed. A consensus was reached that suspended fiber can provide a tremendous amount of surface areas in a small volume. Microorganisms can grow around the fibers at a density of greater than 1×10^8 cells per ml, the only means to culture cells at in vivo-like cell density.

The PI's prior experience of pressured fiber technology application was discussed, which would help the PI to apply this technology to leachate treatment.