QUARTERLY PROGRESS REPORT

February 1, 2015 to April 30, 2015

PROJECT TITLE: Design and Testing of a Multifunctional Energy and Space-Saving Reactor for the Treatment of Landfill Leachate

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COMPLETION DATE: February 1, 2015 to April 30, 2015

PROJECT WEBSITE ADDRESS (URL): http://www.eng.fsu.edu/~gchen (Multifunctional Reactor)

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In this research, a multifunctional energy- and space-saving reactor will be designed and tested for the treatment of landfill leachate with high ammonium, chloride, phosphorous and heavy metal contents. This approach will provide an efficient and energy- and space-saving means of on-site management of landfill leachate. This reactor can also be configured for potential valuable commodity recovery from landfill leachate treatment.

Work Accomplished During This Reporting Period:

1. Chloride Removal in the Multifunctional Reactor

A laboratory scale recirculation bioreactor followed by a multifunctional reactor was set up for this research (Figure 1). Through leachate recirculation, most organics and solid components can be removed from the landfill leachate. The following multifunctional reactor was designed for the removal of chloride, ammonia, phosphorous and iron. Physicochemical means was adopted in the multifunctional reactor for an efficient removal of these contaminants. Subsequently, rapid reaction and effective separation were the key to the success of the multifunctional reactor.

For chloride removal, chloride was removed as calcium chloroaluminate [$Ca_4Al_2Cl_2(OH)_{12}$] through precipitation in the presence of calcium and aluminum at high pH. The chloride content of the leachate was 408 mg/L. The leachate was added $Al_2(SO_4)_3 \cdot 12H_2O$ at concentrations up to 80 mg/L with pH adjustment with lime. Chloride removal increased until $Al_2(SO_4)_3 \cdot 12H_2O$ addition reached 20 mg/L, after which chloride removal decreased (Figure 2). For the same $Al_2(SO_4)_3 \cdot 12H_2O$ dosage, high pH led to enhanced chloride removal (Figure 3). In the presence of 20 mg/L $Al_2(SO_4)_3 \cdot 12H_2O$, pH 9 led to 77% chloride removal and pH 10 led to 93% chloride removal.

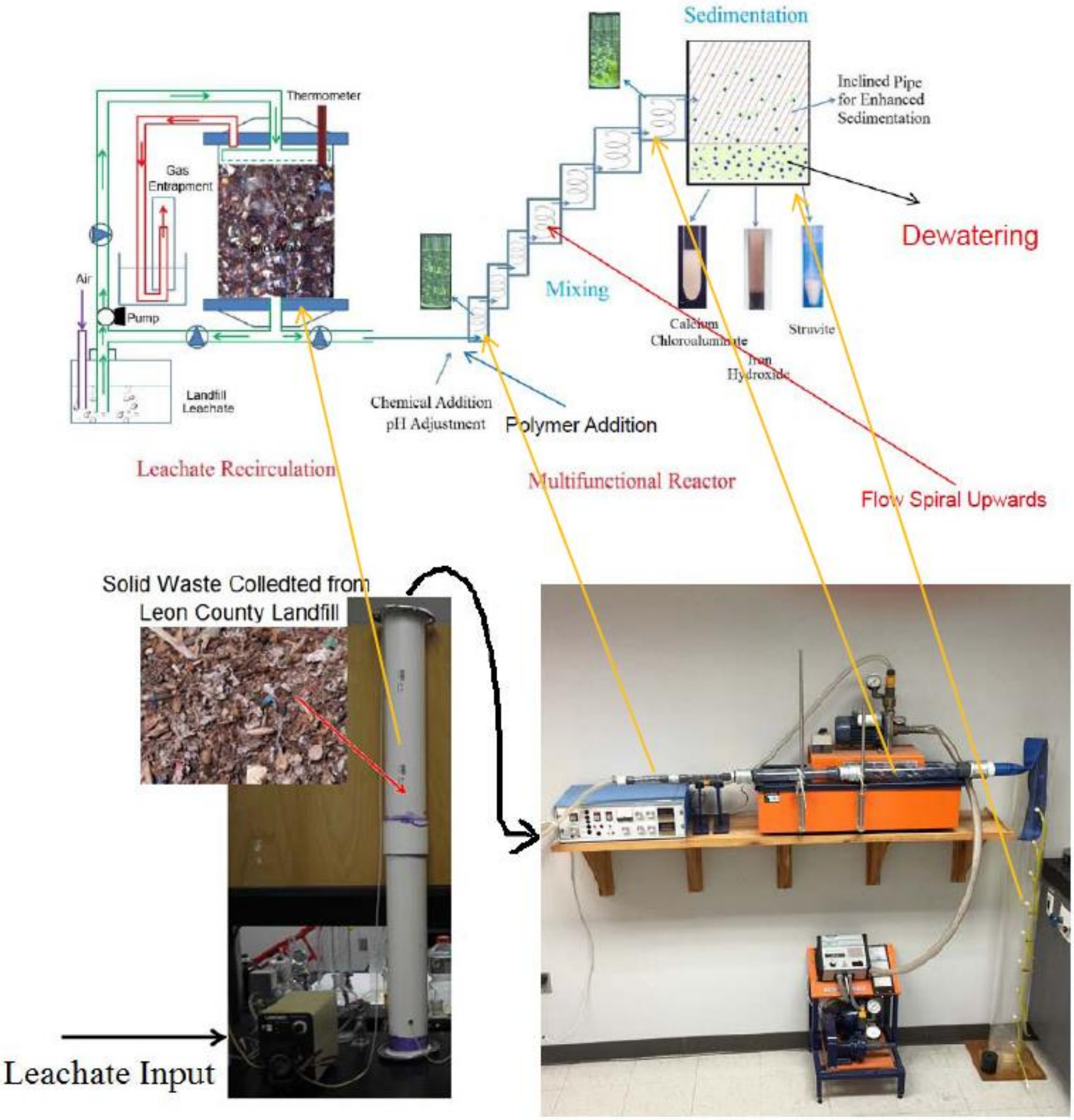

Figure 1. Experimental Setup of This Research

2. Iron Removal in the Multifunctional Reactor

For iron removal, iron was removed as iron hydroxide precipitate. However, the micro-sized iron hydroxide cannot settle efficiently. $Al_2(SO_4)_3 \cdot 12H_2O$ addition can help iron removal by precipitating the micro-sized iron hydroxide. In the presence of $Al_2(SO_4)_3 \cdot 12H_2O$, iron removal increased until $Al_2(SO_4)_3 \cdot 12H_2O$ addition reached 20 mg/L, after which the increase of iron removal became moderate (Figure 4). Compared to chloride removal, iron removal with $Al_2(SO_4)_3 \cdot 12H_2O$ addition was more pronounced. In addition, iron removal was not every sensitive to pH. In the presence of 20 mg/L $Al_2(SO_4)_3 \cdot 12H_2O$, pH 6 led to 97.8% iron removal and pH 10 led to 99.3% iron removal.

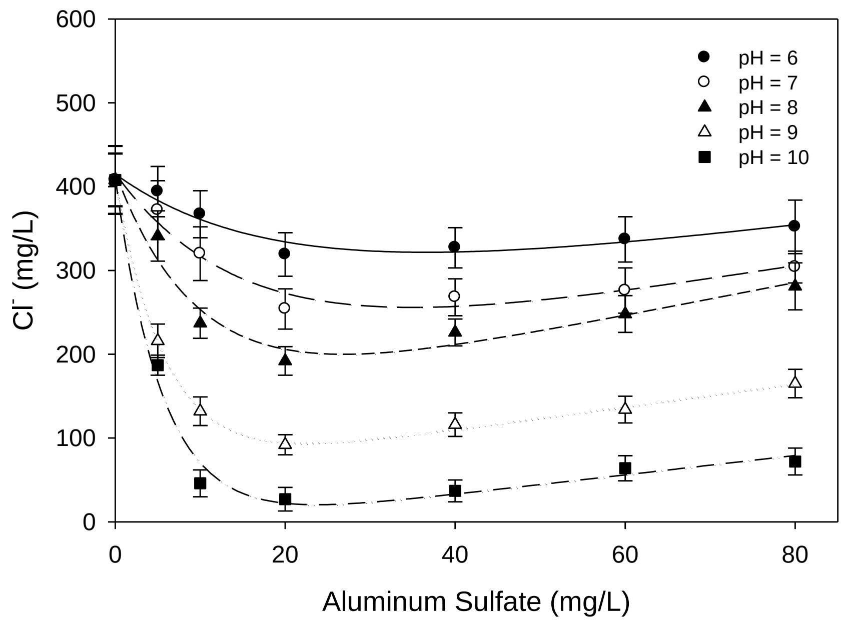

Figure 2. Chloride Removal as a Function of Alum Concentration

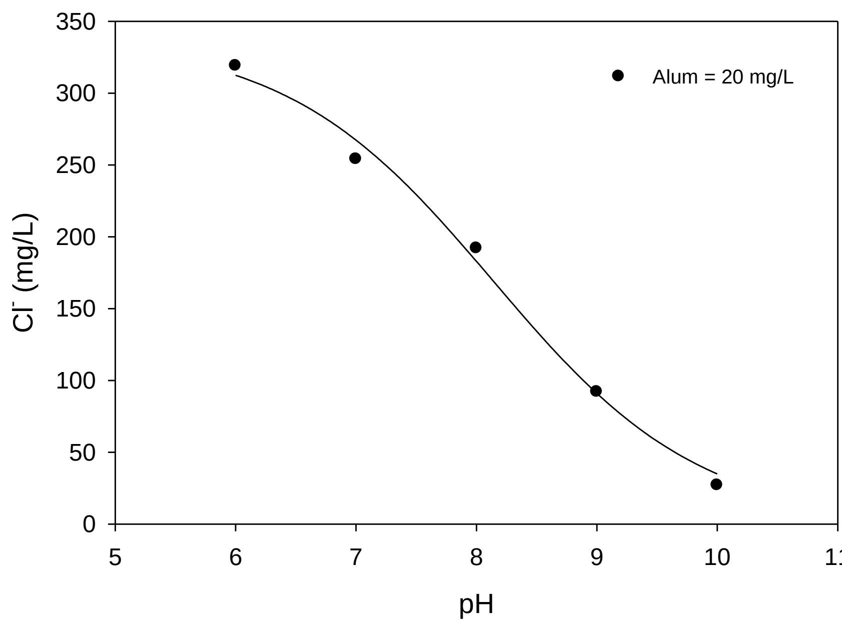

Figure 3. Residual Chloride Concentration as a Function of pH

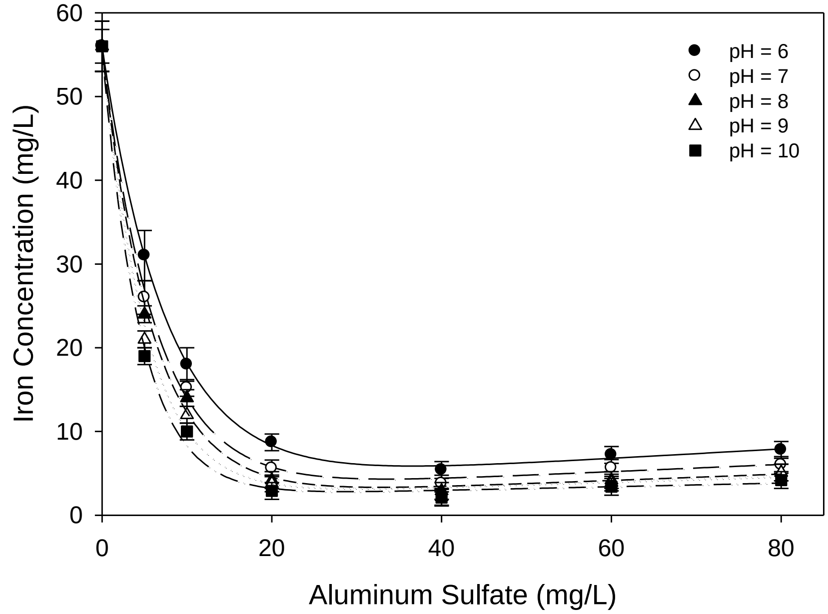

Figure 4. Iron Removal as a Function of Alum Concentration

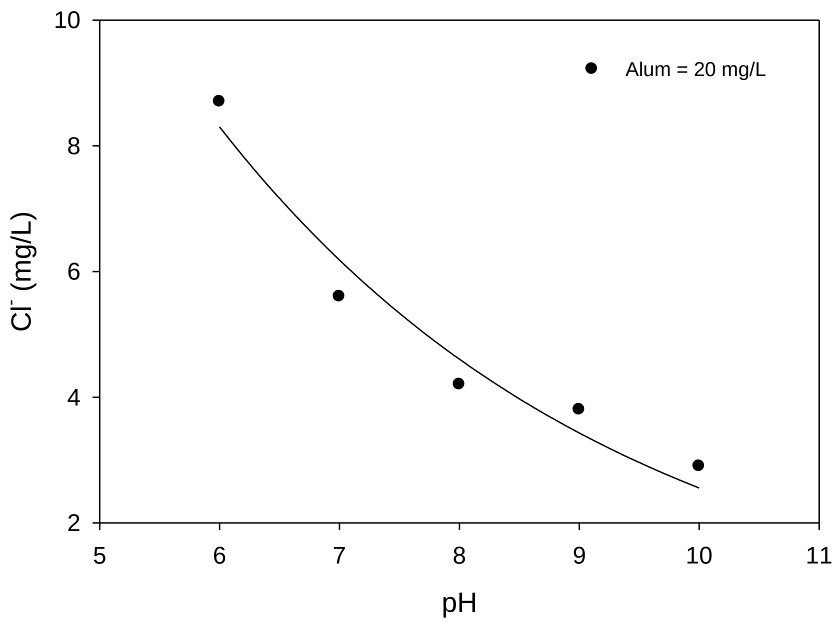

Figure 5. Residual Iron Concentration as a Function of pH

Information Dissemination Activities:

Metrics:

1. List graduate or postdoctoral researchers funded by this Hinkley Center project

Last name, first name	**Rank**	**Department**	**Professor**	**Institution**
Boya Wang	M.S.	Civil and Environmental Engineering	Gang Chen	Florida State University
Kien Vu	Ph.D.	Civil and Environmental Engineering	Gang Chen	Florida State University
Houzhen Wei	Visiting Scientist	Civil and Environmental Engineering	Gang Chen	Florida State University

2. List undergraduate researchers working on this Hinkley Center project

Last name, first name	**Department**	**Professor**	**Institution**

3. List research publications resulting from this Hinkley Center project
   Wang, B., Tawfiq, K. and Chen, G. "Design and Testing of a Multifunctional Energy and Space-Saving Reactor for the Treatment of Landfill Leachate", Environ. Technol., to be submitted (2015).

4. List research presentations resulting from this Hinkley Center project
   Chen, G., Wang, B. and Tawfiq, K. "Design and Testing of a Multifunctional Energy and Space-Saving Reactor for the Treatment of Landfill Leachate", South Carolina Environmental Conference, Myrtle Beach, SC, March 14 to March 17, 2015.

5. How have the research results from this Hinkley Center project been leveraged to secure additional research funding?
   A proposal of "Nitrous Oxide Emission from Landfills under Different Operation Conditions" by Gang Chen has been submitted to Environmental Research and Education Foundation in response to Request for Proposals – Research in Sustainable Solid Waste Management.

6. What new collaborations were initiated based on this Hinkley Center project?
   We have initiated collaboration with John Hallas from Talquin Electric Cooperative, Inc. and Hafiz Ahmad from Florida State University at Panama City Campus from this research.

7. How have the results from this Hinkley Center funded project been used (not will be used) by the FDEP or other stakeholders? (1 paragraph maximum).
   We shared our research results of iron and chloride removal with Patrick Johnson, Solid Waste Director and Brent Schneider of Escambia County Solid Waste Management. In addition, we discussed the results with FDEP Solid Waste Section through TAG

members of Gary Millington and Peter Grasel. We also consulted the results with Talquin Electric Cooperative, Inc., which operates seven wastewater treatment plants as well as Leon County Division of Solid Waste. At the South Carolina Environmental Conference, Craig Sherwood from Ni America showed interests in our research work and discussed possible future collaboration with us.

TAG members: Peter Grasel, Gary Millington, John Hallas, Chen Lin and Hafiz Ahmad

TAG meetings: First TAG meeting was held at FAMU-FSU College of Engineering on January 16, 2015. The meeting minutes and presentation and discussion were available at www.eng.fsu.edu/~gchen. The second TAG meeting will be held at FAMU-FSU College of Engineering in mid July.