QUARTERLY PROGRESS REPORT

June 1, 2016 to August 31, 2016

PROJECT TITLE: Multifunctional Energy- and Space-Saving Reactor for the Treatment of Landfill Leachate. Year II. Incorporation of Electrocoagulation

PRINCIPAL INVESTIGATOR(S): Gang Chen and Kamal Tawfiq

AFFILIATION: Department of Civil and Environmental Engineering, FAMU-FSU College of Engineering

COMPLETION DATE: June 1, 2016 to Augus 31, 2016

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In this research, electrocoagulation is incorporated into the multifunctional energy- and space-saving reactor and arsenic and phosphorus removal was investigated. Limestone biofiltration is included to for the removal of residual organic contaminants.

Work Accomplished during This Reporting Period:

1. Experimental Design and Setup

Multiple anodic electrodes (arranged in parallel) were coupled with coagulation, flocculation and filtration in this research (Figure 1).

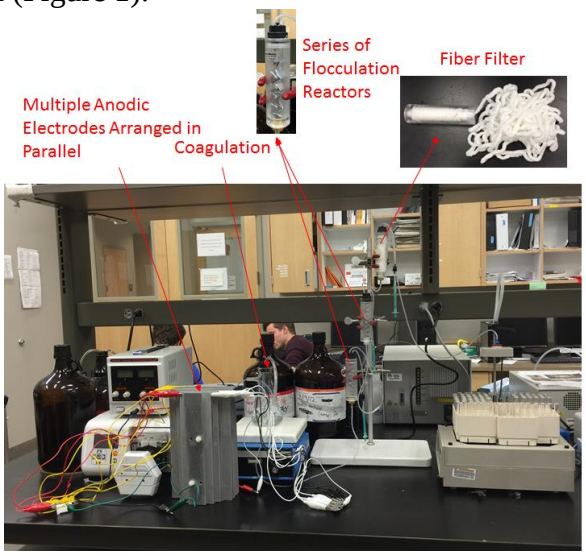

Figure 1. Experimental Setup of This Research

2. Experimental Results

Arsenic removal was found to be influenced by electrical current (i.e., current density), reaction time and pH during electrocoagulation (Figure 2). With electrocoagulation, the released iron was subjected to hydrolysis and arsenic removal was achieved by its strong adsorption with precipitated ferric iron hydroxide. Therefore, desired hydrolysis time is required for arsenic removal. From this research, it was discovered that reaction time of 30 minutes was required for proper arsenic removal by electrocoagulation. High current density led to increased decomposition of the electrode material and enhanced arsenic removal.

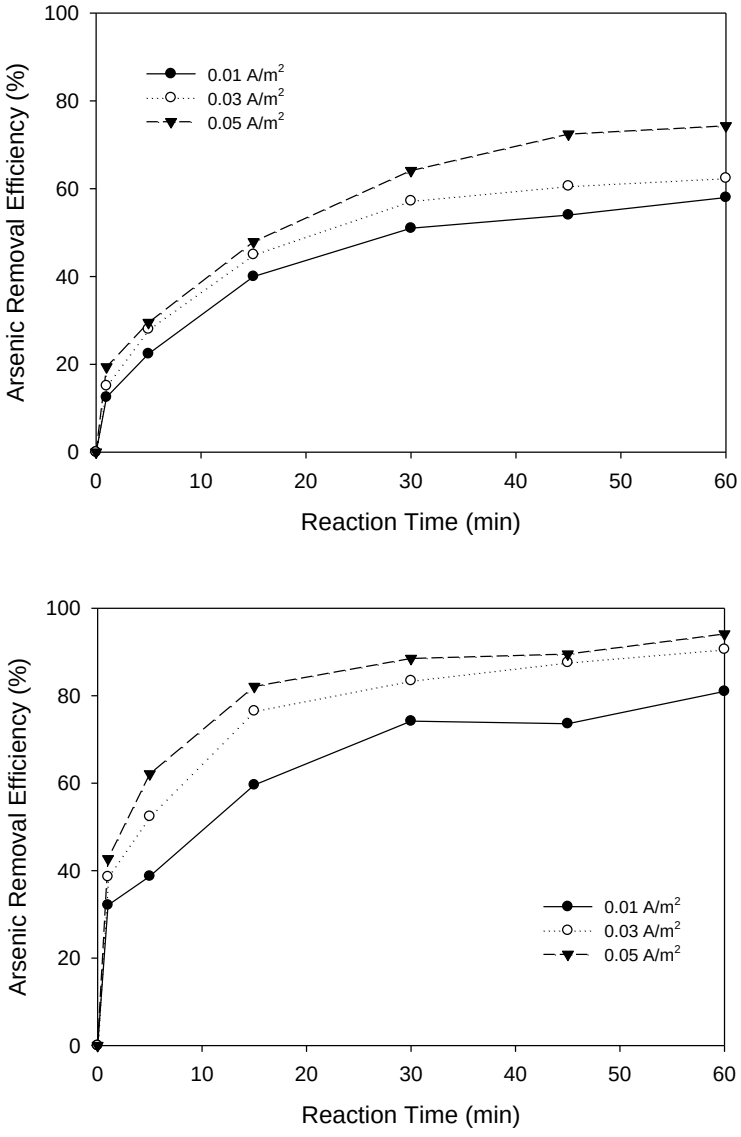

Figure 2. Arsenic Removal by Electrocoagulation as a Function of Current Intensity, Time and pH (pH 8 for Upper Image and 10 for Bottom Image)

Phosphorus removal was found to be influenced by pH during electrocoagulation (Figure 3). With electrocoagulation, the released iron formed ferric iron hydroxide through hydrolysis, which had strong adsorption for phosphorus. In this research, we discovered that neutral pH was preferred for phosphorous removal. During adsorption, phosphorus replaced singly coordinated OH^- groups and then reorganized into a very stable binuclear bridge between the cations. This adsorption process was coupled with the release of OH^- ions, thus this process was favored by low pH values. However, low pH prevented ferric iron hydrolysis. Neutral pH seemed to be the suitable range for phosphorous removal by electrocoagulation.

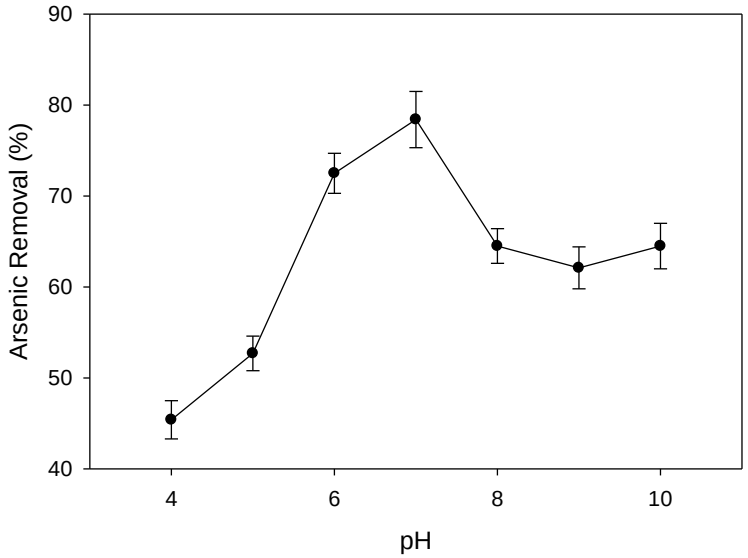

Figure 3. Phosphorus Removal by Electrocoagulation as a Function of pH

Information Dissemination Activities:

Metrics:

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

Last name, first name	Rank	Department	Professor	Institution
Simeng Li	Ph.D.	Civil and Environmental Engineering	Gang Chen	Florida State University
Boya Wang	Ph.D.	Civil and Environmental Engineering	Gang Chen	Florida State University
Houzhen Wei	Postdoctoral Researcher	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
Quinn Zacharias	Civil and Environmental Engineering	Gang Chen	Florida State University

3. List research publications resulting from this Hinkley Center project

Xue, H., Xie, W., Ahmad, H., Tawfiq, K. and Chen, G., 2016, Arsenic adsorption and reduction in iron-rich soils nearby landfills in northwest Florida. Journal of Urban and Environmental Engineering, 10, 98-105.

Chen, G., Grasel, P., Millington, G., Hallas, J., Ahmad, H. and Tawfiq, K., 2016, Chloride removal from landfill leachate by the ultra-high lime with aluminum process. Journal of Urban and Environmental Engineering, under review.

Li, S., Tawfiq, K. and Chen, G., 2016, Landfill leachate treatment by electrocoagulation, Environmental Technology, to be submitted.

4. List research presentations resulting from this Hinkley Center project

Wang, B. and Chen, G. "Multifunctional Energy- and Space-Saving Reactor for the Treatment of Landfill Leachate". 101th Annual American Society of Microbiology Southeastern Branch Conference, Kennesaw, GA. Nov 13-15, 2015.

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.

Li, S., Wang, B. and Chen, G. "Arsenic Removal from Landfill Leachate", Florida Branch ASM 2016 Annual Meeting, Miami, FL, October 15 to October 16, 2016.

5. List who has referenced or cited your publications from this project?

Current research is in process and/or just published. No citation information is available currently.

6. How have the research results from this Hinkley Center project been leveraged to secure additional research funding?

"Electromagnetic Waves-Induced Heavy Metal Removal for Biosolids" by Gang Chen and Youneng Tang has been submitted to Environmental Research and Education Foundation in response to "High Need Topics in Solid Waste Research".

7. 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. In addition, we have been contacted by Jeffrey Cunningham from University of South Florida and requested for collaboration through an EPA-funded research center (http://usf-reclaim.org/). They are interested in investigating the removal and recovery of

nutrients (nitrogen and phosphorus) at centralized wastewater treatment plants. They are currently conducting research on recovery and removal of N and P through a combination of engineered struvite precipitation and microbial fuel cells, which we have investigated through the projects sponsored by the Hinkley Center. They learned about our research through our web sites and requested for collaboration. Other people involved in the collaboration include Daniel Yeh (USF), Treavor Boyer (UF), and Jim Mihelcic (USF).

8. 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 presented our research at Leon County Landfill and Springhill Regional Landfill. Leon County Solid Waste Management Director, Leon County Solid Waste Superintendent, District Manager of Waste Management at Springhill, Market Area Engineer of Waste Management, Inc. and Environmental Protection Manager of Waste Management, Inc., etc. attended the presentation. The technical achievement of this project was discussed and suggestions were provided for further research. We also shared the results with FDEP through TAG members of Owete Owete and Peter Grasel, who are in charge of groundwater modeling and monitoring and old landfills. In addition, we discussed the results with Talquin Electric Cooperative, Inc., which operates seven wastewater treatment plants.

TAG members: Peter Grasel, Owete Owete, John Hallas, Chen Lin, Hafiz Ahmad and Matthew Hendrix

TAG meetings: The first TAG meeting was held at FAMU-FSU College of Engineering on April 8, 2016. The second TAG meeting will be held at FAMU-FSU College of Engineering on October 7, 2016. The meeting minutes and presentation and discussion were available at www.eng.fsu.edu/~gchen (Multifunctional Reactor II).