QUARTERLY PROGRESS REPORT

July 1, 2017 to September 30, 2017

PROJECT TITLE: Electromagnetic Wave-Induced Heavy Metal Removal for Dewatered Biosolids Composting

PRINCIPAL INVESTIGATOR(S): Gang Chen, Youneng Tang and Kamal Tawfiq

AFFILIATION: Department of Civil and Environmental Engineering, FAMU-FSU College of Engineering, 2525 Pottsdamer Street, Tallahassee, FL, 32310

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PROJECT WEBSITE ADDRESS (URL):
http://www.eng.famu.fsu.edu/~gchen/index_files/Page570.htm

EMAIL ADDRESS: Gang Chen gchen@eng.famu.fsu.edu, Youneng Tang ytang@eng.famu.fsu.edu and Kamal Tawfiq tawfiq@eng.famu.fsu.edu

PHONE NUMBER: 850-410-6303

Project Summary

Heavy metal contents in dewatered biosolids prevent the nutrient-rich organic materials from being used in composting. Variable chemical extraction methods have been investigated for heavy metal extraction from biosolids and the results are not very satisfactory owing to the high costs as well as the potential environmental impact. Electromagnetic wave (EW)-induced heavy metal removal offers a sound solution for this problem. After heavy metal extraction, dewatered biosolids can be composted with yard trash.

Work Accomplished during This Reporting Period

With heavy metal extraction and subsequent composting, heavy metals may be possibly leaked from the leachate to the soil. These heavy metals have high adsorption capacity to the soil grains since they are positively charged and the soil grains are negatively charged. However, negatively charged microbial strains may also leak from the dewatered biosolids. The transport of microbes in the subsurface soil may facilitate the transport of heavy metals with a possibility of groundwater contamination.

Six heavy metals, including copper, zinc, nickel, lead, cadmium and iron were extracted in this research. Using cadmium as an example, we investigated the possible microbial-facilitated cadmium transport for four bacterial strains, *E. coli*, *P. putida*, *P. aeruginosa* and *B. subtilis*. We performed column experiments and evaluated the microbial-facilitated cadmium transport with cadmium being introduced in three different ways: (1) cadmium and bacterial mixture, (2)

cadmium and bacteria being introduced at the same time but separately, and (3) cadmium pre-deposited in the soil.

Cadmium adsorbed strongly to the soil. With the help of bacteria, cadmium can be transported in the subsurface soil. Bacterial-facilitated cadmium transport was characterized by a self-sharpening front, which became broader and diffuser at the elution limb (Figures 1-3). The long-lasting tails of the breakthrough curves indicated kinetic-controlled cadmium retention in the column. For the three different introduction scenarios, *P. aeruginosa* and *B. subtilis* had greater facilitated transport results than those of *E. coli* and *P. putida*. The facilitated transport results were more obvious when cadmium and bacteria were introduced as a mixture or introduced at the same time than that of being pre-deposited in the soil. The experimental results demonstrated that heavy metal transport would be facilitated in the subsurface soil with composting leachate.

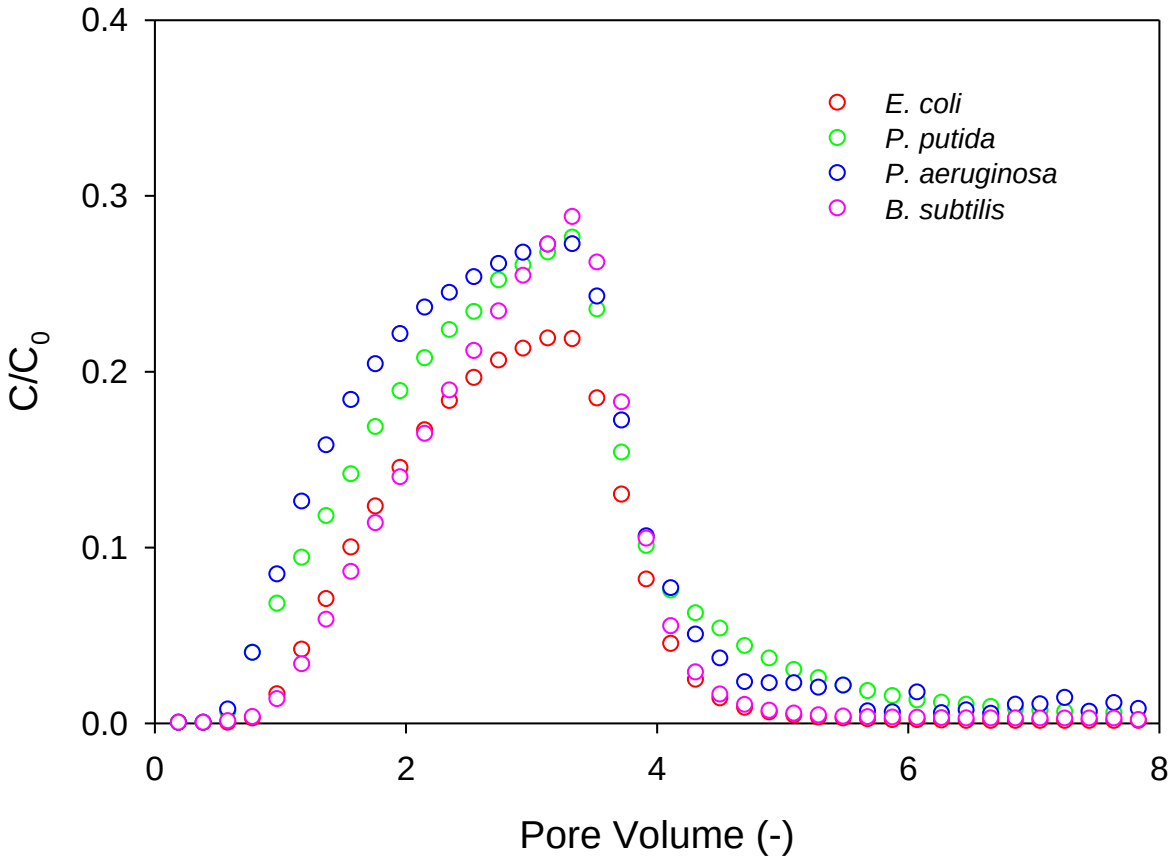

Figure 1. Microbial-Facilitated Cadmium Transport for Cadmium and Bacterial Mixture

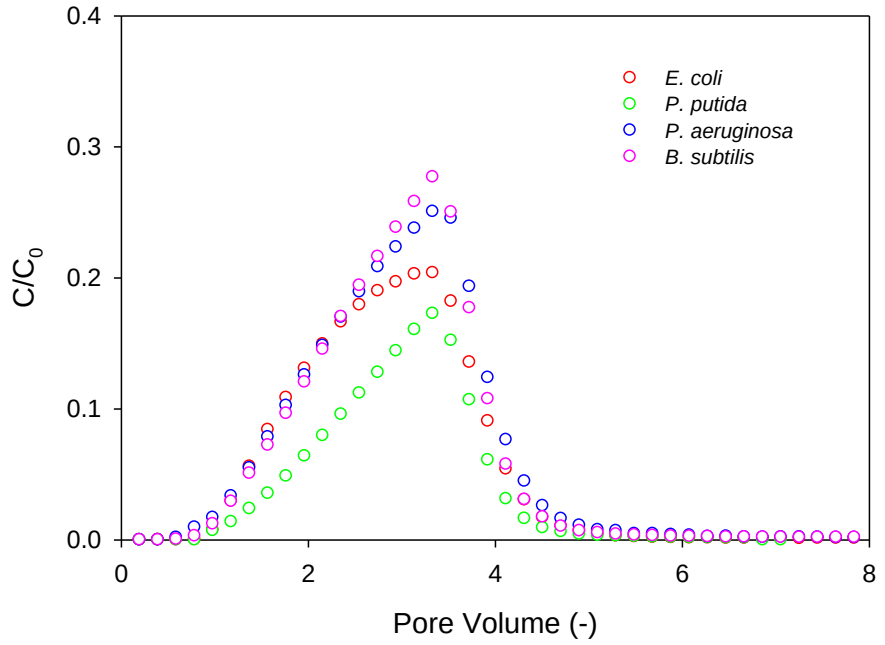

Figure 2. Microbial-Facilitated Cadmium Transport with Cadmium and Bacteria Being Introduced at the Same Time but Separately

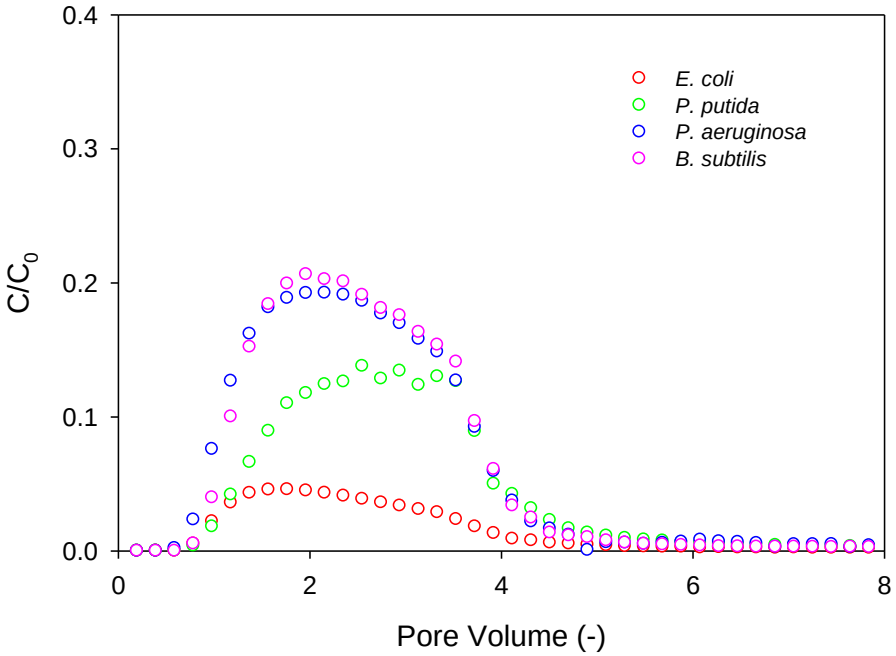

Figure 3. Microbial-Facilitated Cadmium Transport with Pre-Deposited Cadmium

Work of Next Steps

After heavy metal removal, biosolids will be composted with sawdust, wood chips, yard clippings, or crop residues. Due to their alternating natures, electromagnetic waves would most likely not alter reactions (e.g., oxidation). Therefore, electromagnetic waves would not interfere with the microbial activities. We will follow "Berkeley method" or "fast composting" for the composting investigation, which usually takes 14 to 21 days. 50-60% moisture content will be maintained. Within two days of composting, the mixture will be turned for the first time and turnings will be repeated every other day. During composting, compressed air will be applied whenever is needed based on the dissolved oxygen reading, especially during turnings.

Physical and chemical properties such as bulk density, water content, and pH and soluble salts as well as nutrient and heavy metal contents of the compost (including controls) will be determined using the standard testing methods.

Information Dissemination Activities:

Metrics:

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

Last name, first name	Rank	Department	Professor	Institution
Runwei Li	Ph.D.	Civil and Environmental Engineering	Gang Chen	Florida State University
Fude Liu	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
Kadeem Rowe	Civil and Environmental Engineering	Gang Chen	Florida State University

3. List research publications resulting from this Hinkley Center project

   Li, R., Tang, Y., Tawfiq, K. and Chen, G., 2017, Electromagnetic Wave-Induced Heavy Metal Removal for Dewatered Biosolids Composting, Environmental Technology, in preparation.

4. List research presentations resulting from this Hinkley Center project

   Li, R., Tang, Y., Tawfiq, K. and Chen, G. "Electromagnetic Wave-Induced Heavy Metal Removal for Dewatered Biosolids Composting". Florida Branch Meeting of American Society for Microbiology, Clearwater Beach, October 13-15, 2017.

5. List who has referenced or cited your publications from this project?
   Current research is in process. Our prior research on composted sewage sludge that was published in 2007 has been cited 123 times:

   Cheng, H., W. Xu, J. Liu, Q. Zhao, Y. He and G. Chen, 2007, Application of composed sewage sludge (CSS) as a soil amendment for turfgrass growth. Ecological. Eng., 29, 96-104.

   Cited by 123
   https://scholar.google.com/scholar?hl=en&as_sdt=0%2C10&q=Application+of+composed+sewage+sludge+%28CSS%29+as+a+soil+amendment+for+turfgrass+growth&btnG=

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 will be submitted to Environmental Research and Education Foundation in response to Environmental Research and Education Foundation Request for Proposals: 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/). We are now working with Dr. Sarina J. Ergas on nutrient management in solid waste.

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 keep close contact with managers of Leon County Landfill, Springhill Regional Landfill (Jackson County) and Perdido Landfill (Escambia County). We have been contacted by Deborah Buckhalter from the Jackson County Floridan newspaper in Marianna, FL and George Sweeney from Jackson County Chamber of Commerce with request to help them understand the landfill leachate management. In addition, we work closely with Thomas P. Smith Water Reclamation Facility located in Tallahassee, FL. We discuss the technical achievement of this project with the managers and request for suggestions to further our research. We also share the results with FDEP through TAG members of Joe Dertien and Owete Owete. We also discuss the results with Talquin Electric Cooperative, Inc., which operates seven wastewater treatment plants.

Tag Members: Joe Dertien, Owete Owete, John Hallas, Chen Lin, Hafiz Ahmad, and Matthew Hendrix

TAG meetings: Information of this project is available through http://www.eng.famu.fsu.edu/~gchen/index_files/Page570.htm. The first TAG meeting was held

on May 4 at FAMU-FSU College of Engineering. The second TAG meeting will be held on October 27, 2017. The meeting minutes and presentation are available at the project website.