QUARTERLY PROGRESS REPORT

December 2019 – February 2020

PROJECT TITLE: ASSESSMENT OF LOW-COST ADSORBENTS FOR SILOXANES REMOVAL FROM LANDFILL GAS

PRINCIPAL INVESTIGATOR(S):

John N. Kuhn
Department of Chemical & Biomedical Engineering
University of South Florida
Email: jnkuhn@usf.edu
Phone: (813) 974 – 6498

Babu Joseph
Department of Chemical & Biomedical Engineering
University of South Florida
Email: bjoseph@usf.edu
Phone: (813) 974 - 0692

Student Researchers: Rarosue Amaraibi (PhD) and Seth Williams (BS)

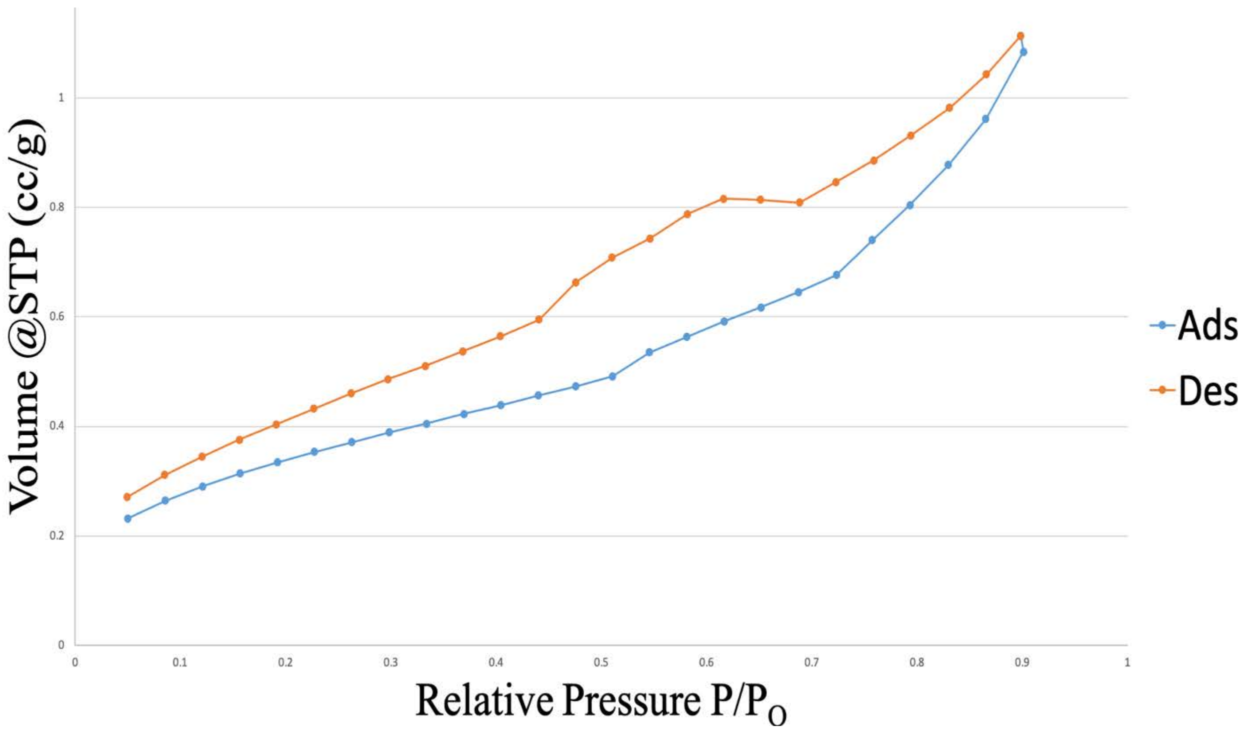
PROJECT WEBSITE: **http://www.eng.usf.edu/~jnkuhn/Hinkley2019.html**

Research Description:
Landfill gas (LFG) is increasingly used and researched as a feedstock for a variety of traditional and proposed Waste-to-Energy (WTE) technologies, which includes electricity generation, compressed natural gas, or liquid hydrocarbon fuels. In these various scenarios, contaminants in the LFG can have substantial economic and environmental consequences in the WTE processes.

Siloxane is an increasing contaminant of LFG as a lot of consumer products being land-filled contains this compound. Siloxanes in biogas cause damages to machines if not removed because it thermally decomposes to silica. This leads to high maintenance cost of WTE technologies thereby serving as a disadvantage to the economics of the entire process. Current purification techniques available for siloxanes removal are too expensive; it costs less to repair damaged engine parts than to adopt current siloxane purification techniques. In order to accelerate adoption of WTE processes, a need for more economical methods for removing siloxanes from LFG exists. The goal of this research project is to develop low cost strategies for siloxane removal from LFG. The study will be evaluating the economic potential and environmental impact of selected scrubbing technologies using low cost adsorbents.

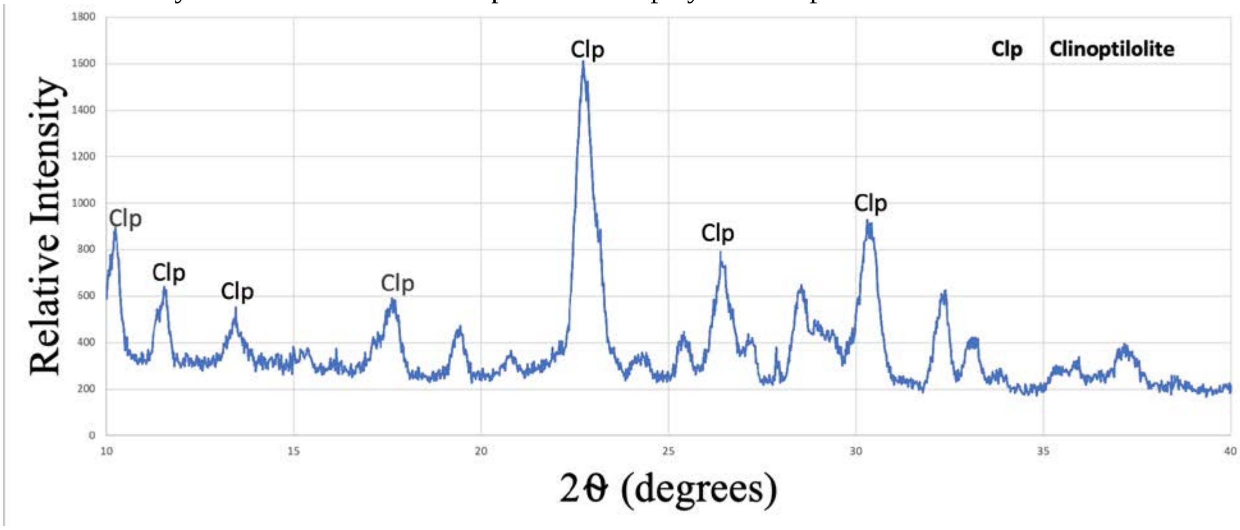
Work accomplished during this reporting period:
For the period outlined in this first report, background research has been done to find appropriate low cost adsorbents for siloxane removal from Landfill Gas and also, the most appropriate technique for determining the adsorption capacity for selected siloxanes on the different low cost adsorbents evaluated. Four low cost and/or waste materials were selected for examination as adsorbents for this study: Clinoptilolite, Diatomaceous Earth (DE), biochar, and crushed glass. To determine the adsorption capacity of the selected siloxanes on the chosen low-cost adsorbents, breakthrough experiments to generate breakthrough curves and vapor sorption experiments to generate adsorption isotherms will be conducted.

Clinoptilolite is a natural zeolite with complex chemical formula: $(Na, K, Ca)_{2-3}Al_3(Al, Si)_2Si_{13}O_{36}\cdot 12H_2O$. KMI clinoptilolite with a 97% minimum purity was purchased. N_2 physisorption and XRD analysis were used for the characterization of clinoptilolite. The samples used for the N_2 physisorption were outgassed using a soak time of 300 min at 300 ℃. The N_2 physisorption results for KMI clinoptilolite are shown in the figure and table below.

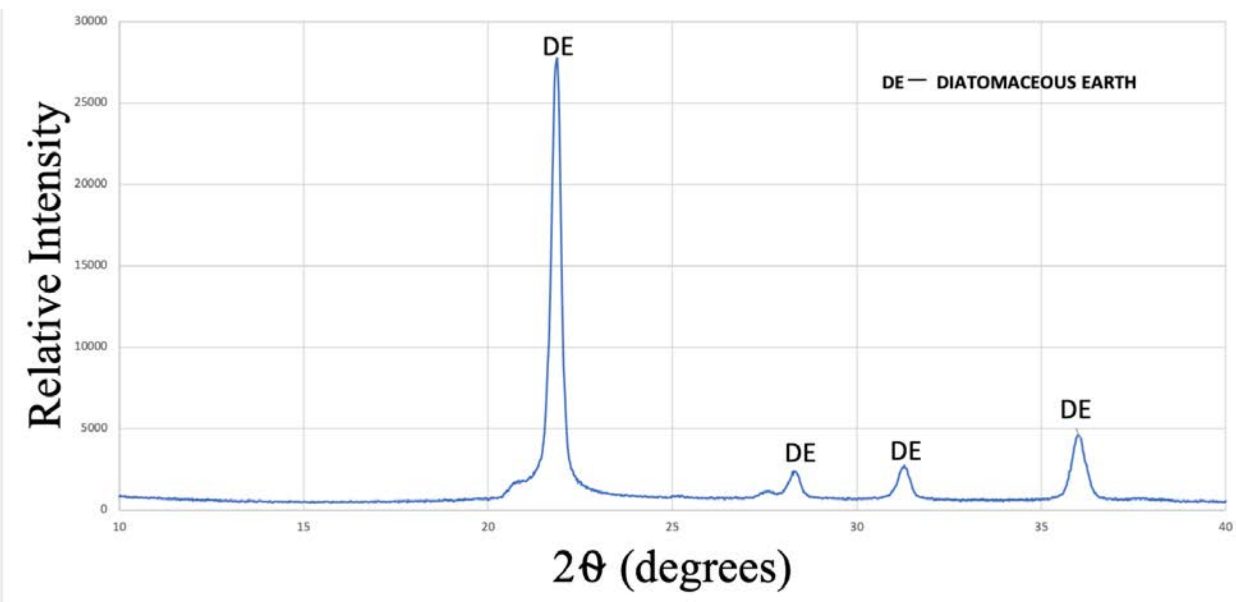


Clinoptilolite Sample	Specific Surface Area [m²/g]		Pore Volume [cc/g]	Pore Diameter [nm]
	S_{BET}	S_{BJH}	V_{BJH}	D_{BJH}
Pellets (Washed/Air-dried)	17	10	0.02	4.34

The XRD analysis data for the KMI clinoptilolite is displayed in the plot below:



Diatomaceous Earth (DE) is a naturally occurring fossilized remains of diatoms—single-celled aquatic algae. It contains 90% silica, 4% Alumina, 2% iron oxide with chemical formula: SiO_2. It is commonly used as swimming pool filters, hence will be readily available. For this research, Dicalite Natural Diatomaceous Earth (DE) was purchased. XRD analysis was used for the characterization of the Dicalite Diatomaceous Earth. The XRD analysis for Dicalite Diatomaceous Earth is displayed in the plot below.



Future Tasks:

The future work would be to:

- Characterize Diatomaceous Earth (conduct N_2 Physisorption), Biochar and crushed glass.
- Conduct breakthrough experiments on the selected adsorbents using siloxanes in inert gas, surrogate biogas and real landfill Gas.
- Conduct vapor sorption experiments for selected adsorbents to create adsorption isotherms.
- Determine adsorption capacity and regenerability of adsorbents for selected siloxanes in inert and surrogate LFG.

- Test low cost/waste inorganic materials (crushed glass) for thermal degradation performance of selected siloxanes in inert and surrogate LFG.
- Design a process flowsheet and conduct techno-economic analyses of the siloxanes adsorbents evaluated and the siloxanes thermal degradation process evaluated in this project.

TAG meeting:
Our first TAG meeting has been scheduled for March 4, 2020. A number of TAG members (list can be found here (**http://www.eng.usf.edu/~jnkuhn/Hinkley2019.html**) will be attending either in person or remotely.

Metrics:

*1. List research publications resulting from **THIS** Hinkley Center projects.*

None up to this point.

*2. List research presentations resulting from **THIS** Hinkley Center project.*

None up to this point.

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

None up to this point.

4. Provide an explanation of how the research results from this Hinkley Center project and previous projects have been leveraged to secure additional research funding.

None up to this point.

5. List new collaborations that were initiated based on this Hinkley Center project.

None up to this point.

6. *Provide an explanation of how have the results from this Hinkley Center funded project have been used (not will be used) by the FDEP or other stakeholders?*

To date, the results have not been used by the shareholders.

Pictures:

A compilation of current pictures can be found here: (**http://www.eng.usf.edu/~jnkuhn/Hinkley2019.html**)