Executive Summary

WERF

Promising, less costly siloxane removal treatment options

Evaluation of the Efficiency of Biogas Treatment for the Removal of Siloxanes (OWSO10C10)

Central Issue

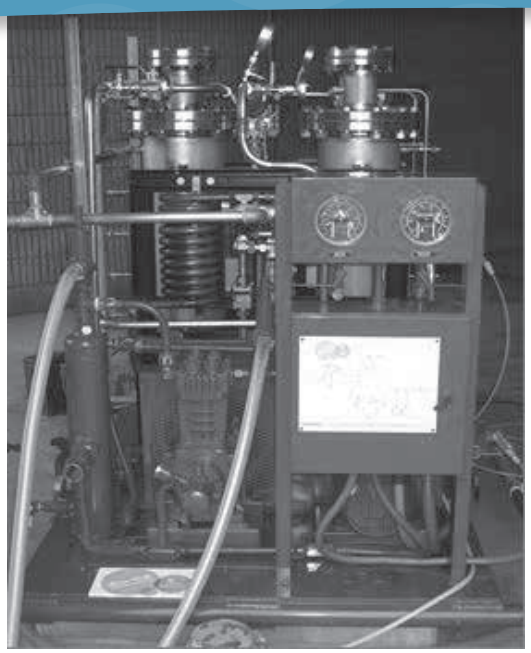
Siloxanes, contaminants in biogas, are often costly to remove, but removal is a necessity to use the biogas for energy recovery. This extra cost often impedes energy recovery projects from moving forward. A cost-effective removal method is needed.

Context and Background

The anaerobic digestion of biosolids to produce a methane containing gas called biogas is an established technology. Biogas contains contaminants that need to be removed before heat and power can actually be generated. There are very specific requirements for removing those contaminants to avoid damaging equipment which make their removal expensive. One category of contaminants that needs to be removed is siloxanes.

Findings and Conclusions

This research demonstrates that silica gel media, tested on biogas generated from anaerobic digestion (AD) of biosolids, is a potential, less costly alternative to Granular Activated Carbon, a common media currently used to remove siloxanes. The siloxane media tested and compared included vapor phase GAC, polymorphous graphite media (PMG) manufactured from graphite electrode grade anthracite, silica gels with narrow range of pore sizes, and polymeric resin DOWEX V503. Comparison of the four different adsorbent materials showed that silica gel had the highest siloxane removal capacity and was also the cheapest.



The Nansemond WWTP pilot unit was designed to compare various types of adsorption media and different operation conditions in the evaluation of the siloxane removal efficiency.

Management and Policy Implication

Plant operators, vendors of energy recovery technologies, and consultants can all benefit from understanding that silica gel media may be a less costly alternative to Granular Activated Carbon for removing siloxane contaminants in biogas, particularly if the biogas has high H_2S, as well as siloxane content. The supplemental WERF report *State of the Science on Biogas: Treatment, Co-Generation, and Utilization in High Temperature Fuel Cells and as a Vehicle Fuel* (OWSO10C10a) may be of further interest.

Related WERF Research

Project Title	Research Focus
Energy Efficiency in Wastewater Treatment in North America: A Compendium of Best Practices and Case Studies of Novel for Approaches (OWSO4R07e)	Showcases many of the types of CHP systems addressed in the CHP-SET tool and elsewhere. Details the application of systems that recover heat and power from biogas, including the co-digestion of food waste with biosolids in anaerobic digesters.
Site Demonstration of the Life Cycle Assessment Manager for Energy Recovery – LCAMER (OWSO4R07f)	Presents two case studies on the application of the Life Cycle Assessment Manager for Energy Recovery (LCAMER) developed by WERF for the purpose of onsite energy recovery using biogas. Observations, comments, and suggestions from the case studies were the basis for future versions of LCAMER.

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Life Cycle Assessment Manager for Energy Recovery Tool – LCAMER Version 2 (OWSO4R07T) **Tool User's Manual (OWSO4R07h)**	LCAMER was originally developed to compare the relative economic merits of one Energy Recovery System (ERS) to another over the life of the systems for municipal wastewater treatment plants. The tool was updated related to the use of Stirling engines and fuel cell technology operating with biogas from wastewater recovery facilities in North America. Updated tool allows co-digestion scenarios to be modeled.
Co-Digestion of Organic Waste Products with Wastewater Solids (OWSO5R07)	Evaluates co-digestion of organic waste such as food waste with wastewater solids in anaerobic digesters at lab, pilot, and full-scale to increase biogas production at wastewater treatment facilities. This project includes: ■ A plan for identification of potential organic wastes (including fats and grease). ■ Parameters to assess co-digestion operational stability. ■ An economic model of co-digestion.
Sustainable Food Waste Evaluation (OWSO5R07e)	Estimates the economic and environmental costs and benefits of different food waste management alternatives not tailored to a specific location. Efforts were made to generalize the assumptions used to serve as a comparative study and provide general guidance regarding the sustainable food waste management alternatives.
State of the Science on Biogas: Treatment, Co-Generation, and Utilization in High Temperature Fuel Cells and as a Vehicle Fuel (OWSO10C10a)	Details four key areas related to energy recovery from biogas. ■ The wide range of technologies available to remove or reduce the contaminants in biogas to make it suitable for energy recovery. ■ CHP technologies that simultaneously generate heat and electricity from biogas. ■ High-temperature fuel cells and their application using biogas as a fuel source. ■ Direct use of biogas in natural gas vehicles or sold to the natural gas grid.
Barriers to Biogas Use for Renewable Energy (OWSO11C10)	Includes an evaluation of the social, business model, regulatory, technical, or other type of barriers to greater implementation of biogas energy or heat recovery by the wastewater industry. Explores the potential use of biogas for vehicle fuel.
Energy Balance and Reduction Opportunities, Case Studies of Energy-Neutral Wastewater Facilities and Triple Bottom Line Research Planning Support (ENER1C12)	Investigates energy efficiency and production opportunities that achieve energy-neutral wastewater treatment and have the potential to expand energy production by, and implement energy efficiency improvements at, wastewater facilities. Includes energy balances, ways to optimize carbon management, and expand generation of biogas through co-digestion of organic wastes. Case studies include the use of co-digestion to reach net zero energy status.
Advancing Anaerobic Wastewater and Solids Treatment Processes (ENER5R12)	The first part of this project evaluates the feasibility and applicability of high-rate anaerobic treatment for municipal wastewater. The research includes laboratory and pilot analysis to understand process limitations, solids and gas (methane) separation techniques, and design considerations for this technology at treatment facilities in the U.S. The second part of this project uses acoustic Doppler meters to record actual velocity measurements within an active digester. The collected data will allow the first-ever profile of the measured velocities within an active anaerobic digester. This protocol will provide valuable information needed to design and optimize the efficacy and biogas production of anaerobic digesters. The acoustic Doppler for anaerobic digester diagnostics methodology will improve digester operation by allowing inactive volume to be assessed and cleaning intervals scheduled based on actual digester condition; which can result in lowering operational expenses.
Wastewater Treatment Anaerobic Digester Foaming Prevention and Control Methods (INFR1SG10)	Synthesized critical literature findings, collected survey data and testing results to elucidate significant findings on anaerobic digester foaming and control. Includes a guidance document that discusses a systematic method to evaluate and control anaerobic digester foaming due to all possible causes.

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