Pathogen Destruction Efficiency in High-Temperature Digestion

Since the advent of the U.S. Environmental Protection Agency’s 40 CFR Part 503 Regulations in 1993, more wastewater utilities have focused on the use of thermophilic anaerobic digestion (TAD) in the production of Class A biosolids. The higher temperatures of TAD allow for increased organic destruction and pathogen reduction, broadening the range of biosolids recycling opportunities. This method, however, is not without its drawbacks. High energy consumption for heating, lack of process stability, and odor-related problems are just a few of the associated issues.

Wastewater treatment facilities are looking at TAD as a way to achieve U.S. EPA Class A standards, which require the virtual elimination of pathogens from biosolids. Although meeting these standards would significantly broaden the range of opportunities for biosolids recycling, existing processes for achieving Class A pathogen levels are often cost prohibitive. An effective, low-cost method of conversion is needed. This research examines thermophilic anaerobic digestion processes as cost-effective alternatives to meet Class A standards.

By all accounts the research for this project was a success. In fact, this project resulted in a patent that was obtained by WERF for a cost-effective process to produce pathogen-free Class A biosolids. WERF and the partnering East Bay Municipal Utility District donated the patent to the public in order to preserve the process for use by the water quality community. In addition, this project presents comparable data on pathogen destruction and process performance for several thermophilic anaerobic digestion process configurations, and demonstrates at bench scale that two thermophilic anaerobic digestion process configurations can achieve Class A requirements at 50°C.

In the final phase of this project, EB MUD successfully implemented the single-stage thermophilic anaerobic digestion process on a full-scale digester.

Three Phases of Thermophilic Processes

This study was conducted in three phases. Phase 1 screened three bench-scale thermophilic anaerobic process configurations at three different thermophilic temperatures (48°C, 53°C, and 62°C) based on their ability to destroy fecal coliform. These processes were: 1) thermophilic acid phase; 2) one-stage thermophilic; and 3) two-phase, mesophilic acid phase/thermophilic methane phase. All three of the configurations tested were capable of achieving the Class A fecal coliform standard and were included in Phase 2.

In Phase 2, bench-scale anaerobic digesters were fed primary sludge seeded with E. coli, heminth ovx, poliovirus, and Salmonella to evaluate pathogen destruction. Two process configurations, the thermophilic single-stage and the two-stage mesophilic acid phase/thermophilic methane-phase system, met Class A requirements at 50°C.

For Phase 3, the single-stage thermophilic anaerobic digestion process was

BENEFITS

- Provides novel, patented (U.S. Patent No. 6,447,683 B1) thermophilic processes for meeting U.S. EPA Class A pathogen standards.
- Presents directly comparable data on pathogen destruction and process performance for several thermophilic anaerobic digestion process configurations.
- Demonstrates at bench scale that two thermophilic anaerobic digestion process configurations can achieve Class A requirements at 50°C.
- Provides an empirical model for quantitatively evaluating the disinfection capabilities of different thermophilic anaerobic digestion process configurations based on fecal coliform destruction.

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carried out on a full-scale digester (1.9 MG capacity) that met Class A fecal coliform requirements when operated at 50°C. The full-scale digester also met U.S. EPA’s vector attraction reduction (VAR) requirement. (It should be noted that when the Class A biosolids are applied to land, the VAR requirements should also be met.) The digested sludge dewatered well without odor problems.

Based on fecal coliform data, an empirical model was developed for quantitatively comparing multiple-stage and single-stage thermophilic anaerobic digester performance. The model demonstrates that various combinations of thermophilic temperatures, staging and mean cell residence times (MCRT) can achieve the Class A fecal coliform requirement. The study also demonstrates that anaerobic digesters operating in the lower thermophilic temperature range (approximately 50°C) are not only capable of achieving Class A requirements, but may also produce digested sludge with less odor and lower volatile solids than digesters operating at higher thermophilic temperatures.

Conclusions

The research team reached several conclusions of note throughout the project. The first is that staging anaerobic digesters improves fecal coliform destruction. The team discovered, however, that single-stage thermophilic digesters operating in the fill/hold/draw sequence can outperform two-stage digesters by further reducing fecal coliforms when single-stage digesters are operated at higher temperatures or longer thermophilic MCRTs or both.

The team also concluded that anaerobic digesters operated at lower thermophilic temperatures (45-50°C) may generate less odor than digesters operated at higher thermophilic temperatures (53-62°C) because less volatile acids are formed at the lower thermophilic temperatures. Additionally, anaerobic digesters operated at similar temperatures provide for higher volatile solids reduction than digesters operated at the higher thermophilic temperatures (53-62°C).

More importantly, the team determined that anaerobic digesters operated at lower thermophilic temperatures can reliably meet U.S. EPA Alternatives 3 and 4 Class A criteria if an adequate thermophilic MCRT is maintained. Because of its other potential benefits (e.g., less odor, higher volatile solids reduction, and less energy consumed) operating anaerobic digesters in the lower thermophilic temperature range (45-50°C) may be preferable to operating at higher thermophilic temperatures (53-62°C).

Finally, depending on the thermophilic MCRT and temperature used, this study demonstrates that the three anaerobic digester configurations evaluated here have the potential to achieve U.S. EPA Class A pathogen requirements. This may provide wastewater treatment agencies with the flexibility to select a thermophilic system more adaptable to their existing facilities, rather than being forced to accept a particular thermophilic process.

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