Performance of Advance Class-A Anaerobic Digestion at OWASA, North Carolina

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The anaerobic digestion system at the Mason Farm Wastewater Treatment Plant (WWTP) in Chapel Hill, North Carolina, has been operating under thermophilic digestion conditions since the fall of 2000. The plant, with a capacity of 12 million gallons a day (mgd), is operated by the Orange Water and Sewer Authority (OWASA). Current flows are about 9 mgd.

The plant is a biological phosphorus removal facility that has primary sedimentation and activated sludge/clarification systei

mented at the Mason Farm WWTP is shown in Figure 1 It features the following four-stage system:

- Digester 4 receives thickened raw sludge. The vast majority of digestion takes place in this thermophilic reactor. Designed for 10-day Solids Retenion Time (SRT), this tank currently provides about 20-day SRT on average.
- Digester 3 provides definitive Class-A pathogen control by specifically meeting the time/temperature batch criterion. A 22-hour batch period is achieved in this digester during every 24-hour period. This occurs by first discharging one day's worth of sludge to Digester 2 within a one-hour period, then accepting one day's worth of sludge production from Digester 4 within a one-hour period. For the remaining 22 hours, the sludge is held in batch thermophilic digestion mode in Digester 3 at a temperature of at least 55.3 C. Designed for five-day SRT, this digester currently has about a 10-day SRT.
- Digester 2 also operates as a thermophilic digester, although temperature is not as critical here since Class-A pathogen requirements have already been met in Digester 3.
- Digester 1 operates as a mesophilic digester. This is designed purposely to provide maximum volatile solids reduction (VSR) and to insure that the biosolids product has minimum odor associated with it. Until recently, this digester was out of service for maintenance. As such, all data presented herein are from operation of the thermophilic vessels alone.

The overall process provides a Class-A product with a high degree of digestion (maximum VSR) and a stable, low-odor product. These criteria were determined to be important for the long-term success of OWASA's beneficial-use program for biosolids.

Digester gas is burned either in boilers for hot-water production or in engine-driven aeration blowers for energy recovery, or wasted at a new gas flare. The thermophilic gas, being considerably hotter than mesophilic digester gas, carries significantly more water. A central condensate trap and accumulator with automatic condensate evacuation mitigat

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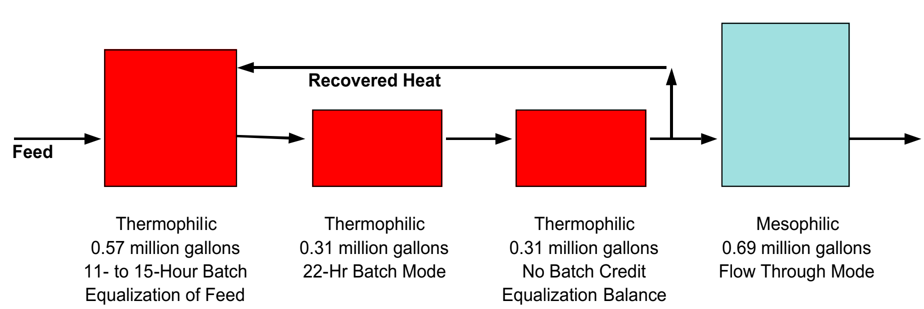

Figure 1: Process Flow Schematic

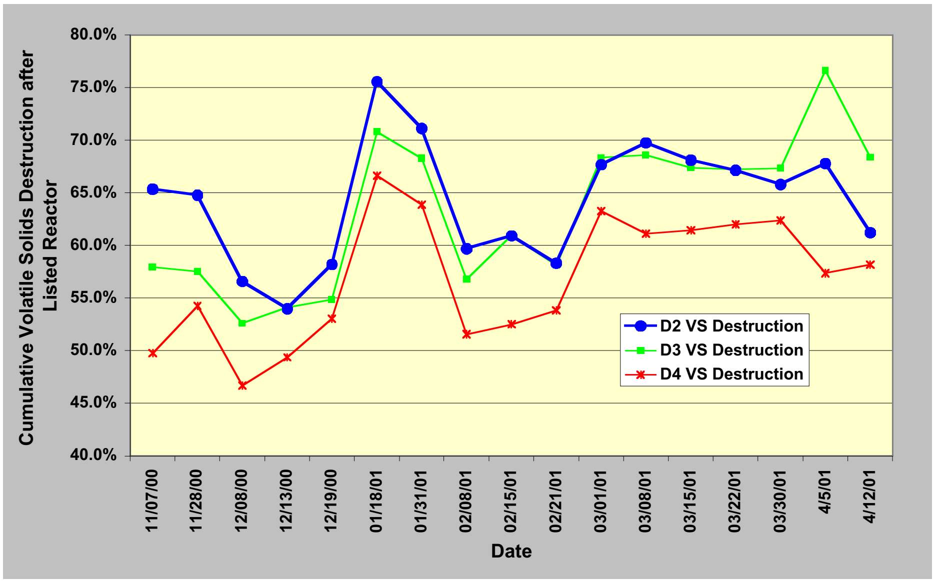

Figure 2: VSR Performance Summary

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Process Performance

Performance of the prior mesophilic digestion system at the Mason Farm WWTP showed that VSR hovered around 40 percent, perhaps slightly more at times. Early data for the performance of the three thermophilic digesters operating in series is shown in Figure 2

The first thermophilic digester (Digester 4) achieves at least 55 percent VSR on average, significantly outpacing the prior mesophilic system at similar retention times. The second-stage thermophilic digester (Digester 3) adds several percentage points of VSR (about 6 percentage points–see Figure 2), but the third thermophilic digester (Digester 2) may add relatively little additional VSR. The combined performance of these three reactors in series is averaging 64 percent VSR.

While OWASA had historically calculated VSR using the Van Kleeck formula, the data presented herein use the mass balance approach. Performance prior to March 2001 was somewhat erratic due to temperature fluctuations in the thermophilic digesters. Data has shown that consistent temperatures provide improved performance (Willis, 2001).

Digester 1's return to service is expected to provide an improvement in VSR due to the different biological population in the mesophilic stage. Of equal importance, this digester will improve the odor characteristics of the final product. During 2001, the thermophilic sludge from Digester 2 was discharged directly to two open-topped biosolids storage tanks located at the plant. The temperature of the biosolids in these tanks drops over time, but this material is still more odorous than a mesophilic product and the plant staff is looking forward to a reduced odor-emitting product with the mesophilic digester on-line. Brown and Caldwell is currently designing covers and odor control for these on-site storage tanks.

Following a few days of on-site storage, the Class-A biosolids slurry product is trucked off-site for land application. Two off-site storage tanks with a total volume of 2.5 million gallons, located about 10 miles away, are used during periods of inclement weather. The land application of the product has not caused odor problems, although by the time the product is land applied, the product temperature has dropped to nearer-to-ambient temperatures.

Class-A Status

Although the digestion system has been operating with batch time and temperature that would qualify as a Class-A process, OWASA has, up to now, managed the product as if it were Class B. OWASA is confirming process reliability and performance before finalizing regulatory details to formally claim a Class-A process. This is expected to occur in in the summer of 2003. Key issues for this determination are the ability to consistently (every day) meet the required temperature and time requirements. Reliability of temperature above 55.3 degrees Celsius is occurring in Digester 3, especially with Digester 4 at thermophilic temperature upstream of Digester 3. Even a small dip in temperature in Digester 4 can be overcome easily with separate heating in Digester 3.

During the first two years of operation, several tests were conducted for fecal coliform in the final product (following Digester 2) and showed extremely low levels–typically in the range of 10 to 100 MPN/gram dry weight or less using the multiple tube technique.

Operational Issues

Several operational issues are important in the system as it is currently operating:

- All digesters have floating covers initially intended to accommodate the variable volume operation. Annular space odor emissions (around the covers) have been identified as a major odor source at the plant, and the digester covers are being retrofit with a fixed cover design as part of upgrades scheduled to be in place by the end of 2004.
- Of more concern is a foam problem at Digester 4. It appears that Nocardia-based foam from the activated-sludge system is the source of the foam problem, but gas mixing in Digester 4 and the high percentage of waste-activated feedstock may also contribute to foam production. Thermophilic foam moves onto the cover surface at times, causing housekeeping problems and exacerbating odor problems. The conversion to fixed covers is anticipated to address this issue.
- Up until now, the plant has only fed the digestion system (Digester 4) over a 10- to 14-hours-per-day format. The plant intends to convert to a 24-hours-per-day wasting scheme in order to better stabilize the operation of Digester 4 and hopefully reduce the incidence of foaming.
- A sludge-to-sludge heat exchanger (spiral-type) is designed to recover/recycle heat from Digester 2 discharge to the incoming cold raw sludge. Although not necessary for operating currently, it will be desirable from an energy use standpoint to bring this heat exchanger into service. In addition, maintenance of the spiral heat exchangers is proving to be problematic due to the units' propensity to clog. The plant is currently piloting the use of grinders upstream of the heat exchangers to see if they can adequately address this issue.
- The planned upgrades include provisions to increase the solids capture rate at the primary sludge fermenter (increases from approximately 20 percent to over 85 percent are planned). This will shift the ratio of primary to waste-activated digester feedstock from 10:90 to closer to 50:50, which should also help alleviate the foaming problems.

With changes in thickening that have occurred at the plant, the digestion system as currently sized and configured probably has capacity for the sludge production from a 20-mgd WWTP; therefore, as the Mason Farm liquid treatment capacity expands in the future, little change to the digestion system may be needed.

Summary

OWASA is pleased with its overall advanced Class-A digestion system, which destroys many more volatile solids than the previous operation and produces more digester gas. Long-term, these factors will be of major benefit, since a dewatering system may eventually be required and the energy value of gas is likely to become more important with time. Also, the system is producing Class-A biosolids on a reliable basis.

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