4 Different Pathways to Advanced Biosolids Stabilization: Assessing Drivers & Results to Date

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Although much of the biosolids generated from wastewater treatment plants in the United States are recycled to agricultural land following treatment for Class B pathogen reduction, there is increased uncertainty regarding continued widespread reliance on this practice. Questions have been raised about the adequacy of the Part 503 regulations, and the U.S. Environmental Protection Agency (EPA) has been criticized for insufficient regulatory oversight of publicly owned treatment works (POTWs).

In some areas of the U.S., public opposition to land application of biosolids and increased regulatory requirements have made continued use of this practice difficult. The Florida Department of Environmental Protection (FDEP) is preparing to revise its regulations governing the use of biosolids on land in response to growing concerns of deteriorating water quality. Several local governments have recently adopted or are considering restrictive residuals ordinances.

These developments in the U.S. are consistent with the current tightening of regulations for biosolids management in the United Kingdom (UK) and European Union. As a result, there has been increased interest in the U.S. in more advanced solids stabilization processes to meet Class A requirements.

With composting losing much of the popularity it held in the 1980s, much of the focus for achieving Class A stabilization in the U.S. has been on advanced digestion, thermal drying, or chemical stabilization. Advanced digestion to meet Class A requirements has been implemented by utilities that have a successful liquid or dewatered land application program and desire to continue this practice. Thermal drying has been used by utilities seeking a dry granulated product that can be marketed as a fertilizer or soil amendment and easily shipped long distances to maximize access to different markets.

In contrast to U.S. practice, European counterparts seeking to improve digester performance have embraced more innovative technologies, including pasteurization and thermal hydrolysis, to meet enhanced treatment standards.

Over the last few years, many projects have been implemented in the U.S. and Europe to improve solids treatment. This article will review the drivers, the key design elements, and the results to date from four recent projects in the U.S. and Europe, operating different processes designed to meet Class A or similar enhanced performance standards:

- The Madison Metropolitan Sewerage District implemented a temperature-phased anaerobic digestion system at its Nine Springs Wastewater Treatment Plant (Nine Springs WWTP) to continue reliance on liquid land application while also producing a product that meets Class A standards.
- The Louisville and Jefferson County Metropolitan Sewer District selected thermal drying at its Morris Forman WWTP to produce a pelletized product for beneficial reuse on agricultural land.
- The Reading Sewage Treatment Works owned by Thames Water opted for pre-digestion pasteurization to achieve enhanced treatment standards.
- The CAMBITM system for thermal hydrolysis of solids prior to digestion was chosen at one of Black & Veatch's (B&V) projects in Ireland to improve the efficiency of the digestion process and to reduce downstream capacity requirements for producing Class A biosolids.

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Temperature-Phased Anaerobic Digestion at Nine Springs WWTP in Madison, Wisconsin

The Nine Springs WWTP operated by the Madison Metropolitan Sewerage District is an advanced secondary plant with a capacity of 50 million gallons per day (mgd). Primary solids (PS) from the clarifiers are gravity thickened to approximately 5 percent solids, and waste activated solids (WAS) are thickened in dissolved air flotation units to approximately 4 percent solids. The thickened solids are then combined (at approximately 40 to 60 mixture of PS and WAS) and fed to anaerobic digesters. Prior to the solids treatment improvements, the digesters were operated in a conventional mesophilic mode, treating the solids to Class B standards.

The organic loadings to the anaerobic digestion facilities at the plant were exceeding design parameters, and at times only a nominal 14-day solids retention time was being achieved in the digesters. In winter months, the capacity of the digesters was further reduced because of recurrent foaming episodes. Consequently, improvements to the digestion facilities were included in the facility planning evaluation for the 10th Addition project. The other improvements included a new headworks facility, construction of new biosolids processing facilities, and modifications to the energy utilization and recovery facilities.

There was no immediate regulatory requirement for the sewerage district to upgrade biosolids treatment to Class A standards, but district officials thought it was prudent to ensure Class A compliance with the capacity-related digester improvements because increased public scrutiny and growing resistance to land application of Class B biosolids in many parts of the country had raised questions about the continued reliance on this practice. Also, since the district had developed a very successful liquid biosolids application program, officials were looking for a treatment option that would be compatible with continued use of this program.

The 10th Addition project also included installation of a new dewatering centrifuge to enable the district to diversify its biosolids program. Officials planned to dewater 10 to 25 percent of their biosolids production and later combine the dewatered solids with amendments to generate a soil-like material that could be used by non-agricultural users. The final product had to comply with Class A requirements to qualify for unrestricted distribution and marketing.

Process Description & Key Design Elements

The temperature-phased anaerobic

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digestion (TPAD) process involves operation of the first stage of digestion at thermophilic temperatures (131ºF), followed by mesophilic operation (95ºF) in the second-stage. When initially developed, the TPAD system was envisioned to operate in a continuous or semi-continuous mode, which does not satisfy the time-temperature criterion for Class A operational compliance.

The 40 CFR Part 503 standards for Class A pathogen reduction consist of performance and operational requirements, both of which must be satisfied. Performance compliance calls for reducing the densities of fecal coliform to less than 1,000 MPN per gram TS, or salmonella to less than three MPN per four grams TS. Operational compliance requires the treatment process to provide sufficient retention time at a particular temperature to ensure that "every particle" has been exposed to conditions known to be effective in rendering the biosolids essentially "pathogen-free." For the latter, there are essentially two routes for compliance:

- Satisfy the time-temperature criteria specified in Part 503 through either batch or plug-flow operation ("Alternative 1", Subpart D) with retention times ranging from 24 hours at 55ºC (131ºF) to 12 hours at 57ºC (135ºF).
- Obtain approval from the Pathogen Equivalency Committee for a process to further reduce pathogens (PFRP)-equivalent process based on a comprehensive demonstration of the process capability to effectively reduce pathogens to non-detectable levels. ("Alternative 6", Subpart D).

Efforts by others to demonstrate the "equivalency" of novel processes have proved to be difficult and expensive; therefore, the district recognized that in developing the TPAD scheme, it would need to focus on achieving the time-temperature conditions specified in Part 503 through a batch, sequential-batch, or similar mode to ensure that "every particle" has been exposed to the stipulated conditions.

Operation in the sequential-batch mode (withdrawing a portion of the digester contents, refilling the digester, and holding for a period without further feeding) appeared to be a workable solution for eliminating short-circuiting concerns and meeting the time-temperature requirements. Lab-scale studies at Iowa State University sponsored by the district's design consultant, B&V, confirmed the stability and performance of the sequencing-batch TPAD scheme.

The multi-stage, sequential TPAD system with carefully scheduled transfers between stages is more complex than the conventional mesophilic system and required several modifications to the digestion facilities. Some of the issues that had to be appraised while converting from conventional mesophilic to TPAD operation included:

- ***Higher Energy Requirement.*** The energy requirement for thermophilic operation was approximately double that for conventional mesophilic digestion; however, with heat recovery, the net heating requirements could be reduced to levels comparable to conventional digestion. Retrofitting the existing digesters to operate in the sequential-batch TPAD mode required the existing heat exchangers, originally designed for mesophilic operation, to be replaced or supplemented by additional units. A system of tube-in-shell heat exchangers with a pumped circulation water loop was selected for solids-to-solids heat recovery and pre-heating application. The heating system modifications consisted of two new heat exchangers for heat recovery and influent pre-heating and one new heat exchanger for supplemental heating to raise the feed temperature to the thermophilic range. Existing heat exchangers were to be used to maintain thermophilic temperatures in the first-stage digesters.
- ***Cooling Thermophilic Effluent for Downstream Processing.*** During lab-scale experimentation, the district found that the polymer demand for gravity belt thickening of digested biosolids was nearly 50 percent higher when the second stage of TPAD was operated at 110ºF compared to 95ºF. Volatile solids reduction was also adversely affected under these conditions and the district had odor concerns with second-stage digesters operating at elevated temperatures; therefore, provisions were made for supplemental cooling of solids using plant effluent in the transitional digester to reduce the operating temperature in the mesophilic stage to less that 100ºF during summer. Provisions were also made to heat the mesophilic digesters, if necessary, to maintain appropriate digestion temperatures.
- ***Feeding Schedule.*** To maximize heat recovery, effluent discharge from a thermophilic digester and raw solids feed to another thermophilic digester had to occur simultaneously at nearly the same flow rates, preferably on a continuous basis. To maintain approximately the same feed and discharge rates, it was necessary for the drawdown phase to account for any anticipated changes in the raw solids feed to the digesters. It was also advisable to recycle excess solids to head of the plant instead of pumping into the digesters for ensuring that the pre-arranged volume available for refilling was not exceeded.
- ***Higher Moisture Content in Digester Gas.*** Digester gas characteristics are expected to change after implementation of thermophilic treatment. Digester gas at thermophilic temperatures would contain more than three times the moisture content as the gas from conventional mesophilic digestion, which would increase condensation in the digester gas system, so the existing gas handling system was modified to accommodate additional condensation, including the use of orifice plates for gas flow measurement and larger condensation traps.
- ***Mixing Improvements.*** Proper mixing of

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digester contents plays an important role in distributing the heat input and ensuring uniform operating temperatures throughout the digester. Since draw-fill-hold would be the operating norm in the thermophilic digesters, the digester mixing system had to cope with varying liquid levels. The eductor tubes of the gas mixing systems in the thermophilic tanks were shortened to allow operation even during times of low liquid levels. The transitional tank was also equipped with similar mixing to allow its use as a backup to the thermophilic digesters.

Operating Experience & Results To-Date

Installation of the facilities to permit the conversion from conventional mesophilic to TPAD operation resulted in no significant construction issues. The TPAD system is currently in the initial stages of startup. A review of the system performance will be provided in future technical papers/presentations.

Thermal Drying at Morris Forman WWTP In Louisville, Kentucky

The Louisville and Jefferson County Metropolitan Sewer District selected thermal drying for its Morris Forman WWTP to produce a granulated product that could be used beneficially as a soil amendment or fertilizer.

The Morris Forman plant processes solids generated at the facility itself and additional solids that are pumped or trucked in from other district plants to the facility. PS from the primary clarification process are digested. WAS from the high-purity oxygen activated sludge process are thickened in dissolved air-floatation units and blended with the stabilized PS prior to dewatering. The plant has a treatment capacity of 105 mgd with a design year solids production of 225 dry tons per day (dtpd).

Before the thermal drying process was implemented, biosolids generated at the plant were thermally conditioned in a Zimpro system, dewatered, and trucked for disposal in a landfill. The thermal conditioning system was effective in improving the dewaterability of the solids, but odors associated with the process had become a source of public complaints and the equipment had deteriorated with age and required increased maintenance.

The district decided to implement an Alternative Solids Project (ASP) at the plant, with the following goals:

- To implement new solids processing facilities, enabling the existing thermal conditioning system to be decommissioned, reducing odors and air emissions from the plant.
- To position the district for future beneficial use of biosolids by using processing methods that would enable distribution of a Class A biosolids product.

In 1999, the district solicited design/build proposals from three pre-qualified teams based on constructing TPAD facilities at a site near the Morris Forman plant. Alternative proposals were welcomed along with the base proposal. An alternate proposal for a digestion, dewatering, and heat drying project at the Morris Forman plant site was selected for implementation. Among the advantages of the alternative proposal were:

- Re-used existing building structures and tanks to retain solids processing on site at the plant, substantially reducing project costs and avoiding the need to staff both onsite and off-site solids processing operations. Reuse of the existing structures reduced capital costs about $30 million.
- Enabled beneficial use of biosolids. Produced a biosolids product that was appealing to prospective users and could be transported economically to outlets beyond the immediate Louisville area.
- Greatly reduced the volume and mass of solids, minimizing disposal costs during periods when production exceeds market demand.
- Enabled beneficial use of digester gas. Existing tanks were used as anaerobic digesters to "scalp" a portion of the volatile solids, reduce potential for odors, and generate digester gas. The use of digester gas by the thermal dryers avoided the need for gas cleaning and supplied a significant portion of the energy required for that process. Waste heat from drying is used for digester heating.

The ASP project included the following items:

- Restoration of four existing 110-foot (34-meter) diameter anaerobic digesters with new covers, mixing, heating, and gas storage systems.
- Removal and replacement of the existing dewatering and conveyance systems in the existing Main Equipment Building (MEB) with five new high solids centrifuges, each with a maximum design solids loading rate of 75 dtpd.
- Removal of the abandoned incinerators in the existing MEB and installation of four triple-pass rotary drum dryers, each dryer sized with a nominal capacity of 78 dtpd at a feed solids concentration of 26 percent. The drying trains included recycle and screening equipment to produce a pelletized product, regenerative thermal oxidizers for odor control, and two product storage silos, each with a capacity of 250 tons.

Operating Experience & Results To-Date

The thermal drying facilities at Louisville were commissioned in 2002. The planned commissioning sequence was to startup the new digestion and dewatering facilities before operation of the drying system. The anaerobic digestion process would have broken down the fibrous materials and provided a consistent feed to the centrifuges, which in turn could have supplied more consistent cake to drying.

The original sequence was altered, however, to address increasing maintenance issues with the Zimpro system. Because of the

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increased safety concerns with the continued use of the equipment and the desire to demonstrate progress regarding odor issues at the plant, the district decided to decommission the thermal conditioning system. Without the solids reduction and improved dewaterability associated with the thermal conditioning system, the amount of dewatered cake sent to the landfill nearly doubled, so the district requested that the drying systems be started up before activation of the digestion system so that the amount of material sent to the landfill could be reduced.

The use of temporary facilities to supply solids to the drying system created several dryer startup problems from the use of undigested solids and the variability in the feed solids. Without digestion, it was difficult to maintain consistent feed to the centrifuges. The solids storage tanks that were temporarily used to feed the centrifuges did not have mixing, resulting in stratification of solids within the tanks and wide variation in feed solids concentrations to the centrifuges. When the feed characteristics to the centrifuges varied, it was difficult to maintain the required cake solids to the dryers. Poor material characteristics caused dryer process malfunctions and posed safety concerns.

In addition to the issues with material characteristics, drying presented a new level of operational complexity for plant personnel. The level of monitoring and control needed to operate the new drying facility efficiently was unlike most processes in place at the plant. Mastering the new process was made more difficult by the different types of equipment and the large operating area of the drying system. The staff also had to learn how the new digestion and dewatering system components affected the drying system.

During startup of the new drying facilities, a set of optimization procedures were established to monitor the solids concentrations at critical stages during the drying process, which included the dewatered cake, wet feed mix to the dryers, and the dried product. The solids concentration range for each material with which the drying system produced an acceptable product was determined, and a systematic measurement procedure was developed to ensure that the materials stayed within the acceptable ranges.

Implementing the optimization procedures significantly reduced the number of dryer process malfunctions. Once the acceptable operating ranges were established, the operators were able to identify conditions that would lead to problems and take corrective action by monitoring solids concentrations. As a result of the optimization plan, operational issues and costs associated with landfilling the solids and cleaning the drying equipment were greatly reduced.

The district also encountered some problems in the initial marketing efforts for the heat-dried biosolids. There is a learning curve for both operations staff to produce an acceptable product and for marketing staff to develop local and regional acceptance of a new fertilizer.

The most significant problems in pellet production included dust generation during transportation and handling, pellet size to match specific market needs, and odors. Of these, odor was initially the primary issue that negatively impacted the marketability of the pellets.

Currently, the district digests only PS which comprise about 50 percent of the total solids production. The WAS are not digested and are the main cause of odors. To minimize odors, the district is adding ferric chloride to WAS in the storage tanks prior to dewatering.

The district currently markets the heat-dried product under the trade name "Louisville Green." The amount that is distributed has consistently increased since startup. More than 90 percent of the solids production was marketed in 2005.

Regional bulk agriculture is the largest consumer of the product, which is applied on farmland for both animal and crop production. It is also used locally on Louisville golf courses and parks and is shipped to fertilizer blenders in Arkansas and Georgia.

Pasteurization at Reading Sewage Treatment Works in the United Kingdom

Pasteurization processes have not yet generated much attention in North America, but interest is growing along with recognition of the uncertainties of satisfying Class A requirements with continuous-flow digestion schemes. In most cases, pasteurization is thought of as an "add-on" to conventional anaerobic digestion, although it is also potentially applicable with aerobic digestion.

Where Class A pathogen reduction is the main reason for digester improvements, pasteurization provides a reliable process for meeting these standards and should be considered as an option. This process was selected by Thames Water Utilities to achieve the UK equivalent of Class A.

The Reading Sewage Treatment Works operated by Thames Water Utilities is a waste-activated treatment plant with a capacity of 42 mgd. Wastewater treatment at the plant includes preliminary treatment, primary lamellas settlers, activated sludge aeration, and tertiary filtration.

PS from the settlers is gravity thickened to approximately 9 percent solids and WAS is also gravity thickened to approximately 6 percent solids. The thickened solids are then sent to two thickened solids storage tanks before being fed to the pre-pasteurization process.

A pre-pasteurization process which met enhanced treatment standards was selected for the Readings Sewage Treatment Works so that the biosolids could be beneficially reused through land application. The pre-pasteurization process was viewed as a good match for the site conditions because the process could make efficient use of waste heat available from existing plant engines and it could

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fit within the available area of the solids processing building.

To evaluate which pre-pasteurization process was the most advantageous for the facility, Thames Water Utilities solicited technical proposals from a number of suppliers. To ensure that the systems being evaluated were comparable, all pre-pasteurization systems were required to meet the following process guarantees:

- System requirements for heating water, non-potable water, and potable water to the process and the quantity of odorous air from the process.
- Adequate heat recovery from the pasteurized biosolids to heat the digesters and ensure good digester temperature control.
- Product quality, including no measured Salmonella *spp* and minimum levels of Escherichia Coli (E. Coli).
- Guaranteed limits of instantaneous heat energy.
- Flexible operation to accommodate shutdown of engine heating supply.
- The ability to process feed solids as high as 10 percent.

A two-stage evaluation procedure was then used to evaluate the available suppliers. In the first stage of the evaluation, systems were eliminated for the following reasons:

- ***Systems which used steam***—to eliminate the complexity of having a heating system that included both steam and hot-water components.
- ***Systems which did not have comparably sized systems operating elsewhere***—to eliminate the risk associated with technology not proven for the capacity of the facilities.
- ***Systems which could not guarantee the processing of solids with concentrations above 8 percent.***

The Alpha Biotherm and Passavant Roediger systems were the only two under consideration after the first-stage evaluation. A second-stage evaluation of these systems was conducted based on cost, reference sites, waste heat utilization efficiency, space requirements, electricity usage, odorous air characteristics, maintenance requirements, and the ability to process high solids content. The Alpha Biotherm process was selected as the preferred technology, primarily since it had more demonstrated experience processing solids with high solids concentrations.

The pre-pasteurization system is designed to be energy efficient. Residual heat in the treated solids from the pasteurization process is used to provide heating for the digesters. The preferential heat source for the pre-pasteurization plant is waste heat from the plant's engines, with a back-up source provided by boilers. Finally, heat recovery in the solids-to-solids heat exchangers minimizes the amount of energy required by the process.

Operating Experience & Results To-Date

The plant was commissioned in early 2004. Based on the operating experience to date, the pasteurization plant has been successful in achieving the required pathogen kill. Testing results of the pasteurization process showed that the pasteurized and digested solids contained less than 41 CFU (colony forming units) per gram of E. coli and there were no Salmonella present in 2 grams of solids.

There is no evidence that pasteurization improves digestibility of the solids. The digesters are stable and do not foam. The current organic loading to the digesters is less than 0.187 lbs/cf/d at a hydraulic retention time of 18 days. The current volatile destruction is 45 percent, yielding 14.5 cubic feet of biogas per pound of volatile solids destroyed. The average dry solids in the digester feed during the test period were 5.6 percent.

Some of the operating issues still being resolved include:

- ***Solids Throughput.*** The pasteurization system was designed to process solids at 7 to 8 percent solids. To treat the daily solids production at the plant, approximately 20 or more batches of solids have to be processed per day; however, difficulties are being encountered with pumping, mixing, and heating the solids at concentrations above 6 percent. Consequently, the operators have had to thin the solids to less than 6 percent, resulting in at least 25 percent more batches per day. Currently, the system has not been able to handle all the solids production. The solids in excess of the pasteurization system throughput is dewatered and trucked off-site.
- ***Heat Transfer.*** The low pasteurization system throughput is attributed to mechanical issues relating to rheology of the solids at higher solids concentrations. The mixer in the solids-to-solids batch heat exchanger, which is designed to create an upflow around the coil for better mixing and heat transfer, does not function properly at higher solids concentrations. This has resulted in low heat transfer efficiencies in the batch heat exchanger. The supplier has planned modifications to add more blades and increase the power of the mixer. Poor heat transfer in the heat exchanger has also affected the ability to cool the pasteurized solids prior to feeding the digesters. This has imposed the need to cool the digesters for lowering the operating temperatures to the mesophilic range. The provision to cool the digesters was included in the design in anticipation of higher temperatures during the summer months, but it is being used continuously with the hot pasteurized feed. The plant is considering automating the cooling cycle for continuous use.

Thermal Hydrolysis (CAMBI)/ Anaerobic Digestion/Drying in Ireland

Thermal hydrolysis in conjunction with mesophilic anaerobic digestion can also satisfy Class A performance requirements, but the thermal hydrolysis process is seldom used

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Parameters	Conventional Digestion	CAMBI™ - Digestion
Feed Solids, *%*	5 %	11 - 12%
Digester Volume Required, *MG*	8.06 MG	3.4 MG
Volatile Solids Reduction (15-d SRT), *%*	42%	62%
Dewatered Cake Solids, *%*	25%	34%
Dewatered Cake, *tons*	101,700 tons	59,700 tons
Dryer Evaporative Capacity, *tons H_2O/h*	12.3 tons H_2O/h	6.3 tons H_2O/h

Table 1

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solely for achieving Class A compliance. The process has been used to enhance digester performance and solids dewaterability, while providing Class A pathogen destruction as an incidental side benefit.

A number of innovative hydrolysis systems are being installed in Europe. One technology sold under the trade name CAMBI™ has been used in a number of wastewater treatment plants in Norway, Denmark, and Ireland.

The plant in Ireland where the CAMBI™ system is installed is designed to treat a design flow of 160 mgd, including an allowance for industrial loads. It was a primary-only facility until 2002, with settled sewage discharged to the Dublin Bay. The raw solids were dewatered and dried in two Swiss Combi drum dryers to meet the enhanced treatment standards as required by the European Directives and implemented under Irish regulations. The dried product was marketed to local agriculture.

In 2002, European Urban Wastewater Directive (UWWD) classified Dublin Bay as sensitive waters and required full secondary treatment. To comply with the UWWD rules, the WWTP was upgraded to a tertiary facility in 2002 under a design, build and operate contract. As part of this upgrade, new screens, grit removal, primary lamella clarifiers, sequencing batch reactors, and UV disinfection were added to the facility. This increase in the solids production required additional treatment capacity.

The plant site was extremely constrained, so space efficient technologies were required to achieve both liquid effluent and biosolids quality specifications. In order to reduce the footprint of facilities required for solids stabilization to Class A standards, a 110-tons-per-day CAMBI™ system was installed for thermal disintegration of solids prior to mesophilic anaerobic digestion.

Thermal hydrolysis of feed solids helped the digesters operate at higher organic loading rates than conventional systems, reducing the digester capacity requirements, and also reduced the final solids disposal costs by increasing solids destruction in the digesters. The CAMBI™ system installed at the plant is the largest to date, with two parallel streams and four reactors in each stream.

The CAMBI™ process utilizes high temperature and pressure to hydrolyze and disrupt the solids, producing a pasteurized/sterilized feed that is more homogeneous and more amenable to high rate mesophilic anaerobic digestion.

Operating Experience & Results To-Date

The WWTP has a combined sewer that results in long retention times in the collection system during dry-weather flows; consequently, the wastewater undergoes partial fermentation in the collection lines, making it partially septic by the time it reaches the plant. Also, approximately 30 percent of the influent load to the plant is allocated to industrial discharges and contains a high fraction of fibrous matter and carbohydrates. Fats, oils and greases (FOG) also bind to the primary solids and enter the hydrolysis process with the primary solids flow.

During heat treatment, the organic components in the solids were partly transformed to fatty acids, which decreased the pH of the hydrolyzed solids to approximately 5.5. The low pH caused the fibers and fats to segregate easily from the water phase, forming large gelatinous lumps that blocked the heat exchanger tubes. This wax-like layer built up rapidly after short periods of operation. Diluting the hydrolyzed solids with cold water exacerbated the problem.

Currently, a portion of the digesting solids from the anaerobic digesters is recycled to increase the pH of the hydrolyzed solids. The digesting solids have a pH close to 8 with ammonia concentrations of approximately 2,500 mg/l. The recycle stream helped minimize the use of dilution water, resulting in a more concentrated feed to the digesters—typically 11 percent solids. This resulted in higher solids concentrations within the digesters and more stable process conditions.

After one month of stable operation, the recycle system eliminated all deposit build-up on the solids side of the heat exchangers. This setup for recycling digesting solids also achieved good mixing in the digesters, even when the digester mixing system was not operating.

In the beginning, the performance of the digesters was monitored by daily measurements of the digesting solids pH and the biogas quality. After a few weeks of operation, analytical measurement of the volatile solids content in the digester feed and the digested biosolids was initiated. The results indicate a VSR between 60 and 70 percent, and a total solids reduction greater than 50 percent. Table 1 provides a comparison of digestion performance between conventional and thermally treated solids.

The biogas from the digestion process is utilized in four one-megawatt (MW) engines that generate approximately 2.5 MW of electricity. The waste heat from the engines is used to generate 70 percent of the steam required for the thermal hydrolysis process. The thermal hydrolysis process provides all the heat required for the mesophilic digestion process in the form of hydrolyzed feed, eliminating the need for an external heat source.

The thermal hydrolysis-digestion process is currently operating at the required throughput and digester loadings. The retrofits to the plant have overcome initial difficulties caused primarily by the fibrous nature of the solids.

Conclusions

Utilities seeking to implement Class A treatment of their biosolids have a variety of options. The review of four recent projects to upgrade biosolids treatment illustrates that plant-specific conditions and experience will influence project objectives, which in turn will impact which process is most advantageous for a particular facility.

TPAD systems are relatively simple to operate and are compatible with continued use of successful land application programs, although the resultant product does not provide significant flexibility with distribution and marketing. In contrast, thermal drying can produce an optimal product for distribution and marketing, but effort can be expected in developing markets and optimizing the drying process itself, as the process is relatively complex and requires stable feed conditions.

Several innovative technologies such as thermal hydrolysis and pasteurization, which have not yet found widespread use in the U.S., can be used to enhance digester performance, with Class A treatment as an additional benefit. While these technologies have shown themselves to be effective in reducing pathogens in Europe, like thermal drying they are relatively complex processes and can be subject to solids handling issues.