THE BIG AND SMALL OF BIOSOLIDS COMPOSTING

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INTRODUCTION

Biosolids composting continues to be one of the more popular methods of biosolids management utilized in North America. According to the most recent BioCycle survey (Goldstein, 1995), 228 biosolids composting facilities were operational by the end of 1995 in the United States. The aerated static pile is still the most popular biosolids technology used with 101 facilities or 44% of the total being that variety. Many communities evaluating biosolids management options are concerned with the cost of composting biosolids, the technology used, and odors associated with the process. The technology used needs to have flexibility to manage varying quantities and characteristics of biosolids. Composting facilities must be operated free of odor problems and they must be able to process materials in a cost-effective manner. Two new biosolids composting facilities which utilize the aerated static pile method of composting began operation in 1995. One facility is a large 28 dry ton per day composting facility that processes yard wastes as well as biosolids in Davenport, Iowa. This facility is totally enclosed for maximal odor control. The other is a smaller 5.5 dry ton per day facility which is owned and operated by the Harrisonburg-Rockingham Regional Sewer Authority in Mount Crawford (Harrisonburg area), Virginia. This paper provides a detailed description of the equipment and facilities included in each of these two static pile operations, provides a summary of the initial stages of operation, and provides a detailed cost comparison of actual capital costs and operation and maintenance costs of the two facilities. This information will provide valuable insight to various communities considering composting as part of their biosolids management programs.

DAVENPORT, IOWA

The City of Davenport, Iowa operates a 26 million gallons per day (MGD) capacity secondary treatment plant which serves approximately 150,000 persons. Thickened sludge from the treatment plant is anaerobically digested prior to dewatering. The resultant biosolids are dewatered using three two-meter belt filter presses to between 13% and 20% total solids. The dewatered biosolids were previously landfilled at the Scott County landfill. Increasing landfilling costs and environmental concern over this practice prompted the City to consider alternative biosolids management techniques. After an evaluation of all existing management options, lime stabilization, and composting were evaluated fully. The City visited numerous operating facilities in 1992 and early 1993 to gather first-hand information about operating performance, costs, and operator friendliness of these operations. It was after this evaluation that the City chose aerated static pile composting as the preferred management method.

After selecting composting as the method of choice, five issues were identified as crucial to the success of the project. These issues include the following:

- Evaluation of various alternative sites
- Manage City of Davenport and Scott County yard wastes
- Effectively manage odors
- Construct facility within budget
- Cease landfilling biosolids by early 1995
In 1992, several potential sites were considered for the construction of the composting facility. The existing Scott County Landfill and land adjacent to the existing wastewater treatment plant (WWTP) were considered as were other sites. A parcel of land adjacent to the existing WWTP was selected due to its proximity to biosolids production and the compatibility of surrounding land use.

The City also made a commitment to manage all collected yard wastes from the City and County at the composting facility since a 1991 statewide ban on landfelling yard wastes had been enacted. This required storage and processing areas and equipment.

Odor management at the composting facility was a critical planning consideration. Total enclosure of the mixing, composting, and drying areas with all offgases being treated through biofilters was provided in the design to contain and treat the majority of facility odors.

The construction of this facility needed to be done within the allotted budget. Through detailed design criteria review and the selection of prioritized components, the facility was able to have the design capacity required and those design features desired by the Owner, while remaining within the established budget.

Due to increased costs and regulatory pressures, the City committed to cease landfelling the dewatered biosolids in mid-1995. Design, permitting, and construction of the composting facility had to occur on a fast-track schedule in order to meet this timeframe. The design of this facility was initiated by E&A Environmental Consultants, Inc. and Shive-Hattery Engineers and Architects in May 1993 with conceptual design completed by August. Final design was begun in October 1993 and completed in March 1994. Six bids were received, three of which were within the allotted budget. After receipt of bids and selection of Eastes Company of Davenport as the contractor, construction began in June 1994. Substantial completion of the facility occurred in August of 1995.

Facility Description and Process Flow

The Davenport composting facility is designed to process 28 dry tons per day of 20% total solids digested biosolids cake on a five-day per week operating basis. In addition to managing biosolids, the facility is designed to manage up to 35,000 cubic yards per year of yard wastes. Figure 1 shows the process flow diagram for the facility. A description of the process flow and equipment features follows.

- **Site Characteristics** - The compost facility is located on a 15-acre rectangular parcel of land immediately south of the WWTP. This parcel abuts a railroad yard to the west and the Mississippi River to the east. City owned property on the southern border creates additional buffer area to the only residential areas within half a mile of the site. A 6-foot high, 3,500-foot long levee completely surrounds the site to prevent flooding during a 100-year flood event.

- **Materials Delivery and Processing** - Only clean yard wastes are accepted for processing. Yard wastes are delivered by private and public vehicles to a paved outside storage area. Yard waste quantities are estimated volumetrically by vehicle size by operations personnel for material billing. Yard wastes requiring size reduction are ground with an 800 horsepower horizontal grinder prior to use as a bulking agent. A 60% to 70% reduction in yard waste volume is achieved through grinding and stockpiling for one month. Wood chips and shredded tires are delivered and stored under cover in the bulking agent storage area. Dewatered biosolids are hauled via seven and ten cubic yard capacity dump trucks from the WWTP to one of the two biosolids receiving bins.

- **Bulking Agents** - The primary bulking agents used at the Davenport composting facility are paper mill quality wood chips and shredded rubber tires. Wood chips are supplemented with shredded rubber tires at a ratio of one volume shredded tires to two volumes of wood chips. Because the shredded rubber tires are 100% recovered through screening, the quantity and cost of new wood chips is reduced by one-third. Shredded yard wastes are also used to supplement this wood chip/tire mixture at a rate of one volume yard wastes for every four volumes of wood chips/tires. These materials, as well as recycled bulking agent, are stored under cover and then loaded into the automated mixing system. A variable bulking agent to
Figure 1
City of Davenport Composting Facility Process Flow Diagram

- Unground Yard Wastes Receiving
  - Grinder
  - Amendments
    - Yard Wastes
    - Wood Chips
    - Shredded Tires
  - Biosolids
    - 28 DTPD
    - 20% TS
  - Automated Mixing
    - 350 TPD
  - Aerated Static Pile Composting
    - 21 Days
  - Aerated Drying
    - 5 Days
  - Screening
  - Aerated Curing
    - 30 Days
  - Compost
    - 80 TPD
  - Recycled Amendment

E&A Environmental Consultants, Inc.
biosolids ratio was allowed for in the design with an average volumetric ratio of three to one (3:1). A pilot test was conducted to verify the correct ratio and to produce a product for market evaluation.

- **Mixing** - Mixing of the bulking agents with biosolids occurs in a totally enclosed, automated continuous feed system. Biosolids and bulking agents are loaded into live-bottom hoppers for metering to the automated mixing system. Two 50 cubic yard capacity biosolids hoppers and two 20 cubic yard capacity bulking agent hoppers are provided. Variable speed screw drives discharge biosolids and bulking agents onto a feed conveyor at a rate which is automatically controlled by weight belt sensors connected to a programmable controller. The bulking agents and biosolids are thoroughly blended in one of two continuous feed pugmill mixers with the resultant blend discharged into a concrete bunker at the south end of the composting building. Odorous gases from the mixing building are vented to the compost hall where they are collected for treatment in the biofiltration system.

- **Composting** - Composting of the biosolids occurs in a 66,000 square foot building which is totally enclosed and insulated. A 40 foot wide central access aisle separates the east and west aeration zones. Pre-cast polymerized concrete trenches are placed six feet on center to provide aeration to the compost piles. The facility design allows for a one-foot base of wood chips to be placed over the aeration trenches followed by eight feet of mix and a one-foot insulative cover of recycled compost. Compost piles are 90 feet long. A custom-designed hole pattern was used in heavy duty cast iron covers to provide uniform aeration down the length of each trench. Four trenches are serviced by one of 24 aeration stations each capable of providing 1,400 CFM at eight inches of water column. Each blower station is capable of operating in induced draft (negative) or forced (positive) aeration mode, depending on operator preference and the stage of the composting process. Negative aeration is practiced for the first 10 days of the composting process with exhaust gases being collected and vented directly to biofilters for treatment. The blowers are then switched to positive aeration mode for the remainder of the 21-day composting cycle to enhance drying of the mass. Offgas from the compost piles and the building are collected via centralized ducting for treatment with the compost pile exhaust through biofilters.

The aeration rate is controlled with a temperature feedback control system that is operated through the facility computer. Up to four aeration rates are provided for each individual compost pile based on variations in pile temperature. Higher temperatures result in an increased blower run time (on/off cycle). Three thermocouples placed in the pile provide temperature readouts with the low temperature thermocouple automatically selected as the temperature feedback controller. In this way, the oxygen, cooling, and drying requirements for each individual pile are controlled independently of other piles.

Allowance for up to five days of aerated drying is provided in the composting building for periodic times when additional drying is necessary. This area also serves as a yard waste pre-aeration area when large quantities of grass clippings are received.

- **Screening** - A six-foot diameter by 35-foot long trommel is provided in the covered portion of the facility at the east end of the compost building. The screening system is fed from a 15 cubic yard capacity hopper where front-end loaders deposit unscreened compost material. The screen separates oversize material for recycling into the compost process and a 3/8 inch minus compost product for curing and use.

- **Curing Aeration** - Aerated curing is provided utilizing portable blower stations and re-usable perforated high density polyethylene pipe. This area is located under cover adjacent to the screening area and is sized to handle 30 days of screened compost production. Cycling timers operated through the facility computer control aeration cycles as necessary in this stage of the process.

- **Odor Control** - Because of the high priority to effectively manage odors at this facility, all building and process exhaust from the mixing and composting buildings is collected and scrubbed through two large biofilters. Each filter is sized to process 105,000 CFM of exhaust gas at a residence time of 45 seconds. A 4 foot deep mixture of yard waste compost and wood chips is used as the biofilter media. Each filter is divided into four independent zones with an individual booster fan and controls. This allows for
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HARRISONBURG, VIRGINIA

The Harrisonburg-Rockingham Regional Sewer Authority (HRRSA) located in Mount Crawford, Virginia operates a 16 MGD capacity secondary treatment plant which serves approximately 40,000 persons and a significant amount of industrial wastes from four area poultry processors. The North River Wastewater Plant was recently expanded from 8 MGD to 16 MGD, and is currently treating 9.1 MGD of wastewater. Thickened sludge from the treatment plant is anaerobically digested prior to storage in a lagoon or dewatered with a new high solids belt filter press. The previous HRRSA management program included land application of approximately six million gallons annually of liquid biosolids at 4% solids on numerous farm land application sites. Rockingham County, in which the wastewater facility is located, is one of the largest poultry producing counties in the country. As a result, land application of poultry manure is common practice. A Karst soil geology combined with over application of these manures in some cases created isolated instances of groundwater nitrate contamination. HRRSA was, therefore, also concerned about the perception of their land application programs adding to the groundwater contamination problem. During recent years, siting of new land application sites, concerns over permitting issues, increased monitoring costs, and the potential concerns regarding groundwater nitrate problems all contributed towards spurring HRRSA's interest in developing another management technique such as composting to supplement land application.

After selecting aerated static pile composting as the method of choice, HRRSA contracted with the engineering team of E&A Environmental Consultants, Inc. , Patton Harris Rust & Associates, and Hazen & Sawyer p.c. for the design and construction of dewatering and composting facilities. The project was initiated in April 1994. The facility basis of design consisted of establishing design issues such as biosolids processing capacity, process flows, etc., as well as the performance of a dewatering pilot study, a bulking agent survey, a composting pilot study, and a compost marketing assessment. These tasks were conducted between May 1994 and August 1994. From these work activities, a preliminary conceptual design was developed and the final design initiated in the Fall of 1994. The design work was completed in January 1995 and six bids were received from contractors in February 1995 with three bids within HRRSA's budget. After selection of Harmon Construction in Harrisonburg as the general contractor, construction commenced in April 1995, and the facility was substantially completed in December 1995.

One of the key issues in the early planning stages of the project was the selection of appropriate dewatering equipment. Plate and frame presses, centrifuges, and high solids belt filter presses were evaluated for replacement of the existing vacuum filter presses at the North River Plant. Based on operating and maintenance costs, availability of spare parts, and the use of the existing structures, it was determined that the most cost-effective means of dewatering would be through the use of a high-solids belt filter press. Two premiere belt filter press manufacturers conducted pilot studies in June 1994 at the wastewater plant to determine dewatering performance under actual conditions. From this dewatering pilot study, it was determined that the Ashbrook High Solids Belt Filter Press resulted in superior performance. It was determined through economic analysis that the savings in the capital and O&M costs of the composting operation more than justified the additional capital cost of a high solids belt filter press being procured on a pre-qualified basis.

Facility Description and Process Flow

Although the design and construction of these facilities included dewatering and composting, this paper will discuss the composting portion of the facility only. The composting facility is designed to process 5.5 dry tons per day of 25% total solids digested biosolids cake on a five day per week operating basis. Figure 2 shows the process flow diagram for the facility. A description of the process flow and equipment features at this facility follows:

- **Site Characteristics** - The composting facility is located on a two acre parcel of land immediately adjacent to existing digesters and dewatering building at the North River Plant. Minimal site grading and other preparation activities were required for the construction of the composting facility. All biosolids receiving, mixing, composting, drying, screening, and curing and compost storage activities occur under a 40,000 square foot pre-engineered metal building.

- **Materials Delivery and Processing** - Dewatered biosolids are conveyed from the belt filter press to a concrete storage bunkers in the composting facility. Wood chips are delivered in dump or live-bottom trailers for use as the primary bulking agent. A portion of the wood chips (up to three operating days) can be stored under cover with the balance stored outside on an asphalt pad.
Figure 2
Harrisonburg-Rockingham Regional Sewer Authority Composting Facility Process Flow Flow Diagram

New Amendments

Biosolids
5.5 DTPD
25% TS

Mixing

Aerated Static Pile Composting
21 Days

Aerated Drying
5 Days

Screening

Aerated Curing
30 Days

Compost
13 TPD

Recycled Amendment
Mixing - Mixing of the bulking agents with biosolids occurs in an electrically-driven 18 cubic yard capacity batch mixer. The batch mixer is equipped with weigh scales to determine exact quantities of each of the bulking agents as well as the biosolids used in any given mix. A front-end loader is used to load the batch mixer with the biosolids and the bulking agent. After thoroughly mixing these materials, the initial mix is discharged into a 60 cubic yard capacity three-sided concrete storage bunker, which is also under cover in the composting building.

Composting - Composting of the biosolids occurs under cover in a 15,000 square foot area. A front-end loader picks up the mixture from the initial mix discharge bunker and places it in the static piles in the composting area. The facility is designed to allow a one-foot base of wood chips to be placed over aeration piping, followed by eight feet of mix, and a one-foot insulative cover of recycled compost. Compost piles are approximately 90 feet long. High-density polyethylene pipe is used to supply aeration to the compost piles. Sixteen aeration stations, each capable of providing 630 CFM at eight inches of water column service two high-density polyethylene headers spaced approximately four feet apart. A custom design hole pattern was used in the design of the aeration laterals to provide uniform aeration down the length of the compost piles. Each blower station is capable of operating in the induced draft (negative) or forced (positive) aeration mode depending on operator preference and the stage of the composting process. Negative aeration is practiced routinely for the first ten days of the composting process with exhaust gases being collected and vented directly to an open biofilter for treatment. Blowers are then switched to positive mode for the remainder of the 21-day composting cycle to enhance drying. The aeration rate delivered to the static piles is controlled based on operator adjustments through a central programmable logic controller system. Allowance for up to five days of aerated drying is also provided in the composting building for periodic times when additional drying is necessary.

Screening - After composting, the material is screened through a deck-type screen that has a three-foot by five-foot rectangular deck with punch plate holes to a 3/4-inch sized product. The screening system has a capacity of 40 cubic yards per hour and produces a 3/4-inch minus compost product for curing and use.

Curing Aeration - Aerated curing is provided under cover using portable blower stations and reusable perforated high density polyethylene pipe. This area is located adjacent to the composting area and is sized to handle 30 days of screened compost production. Six portable aeration stations are provided in the curing area for positive aeration. Cycling timers control aeration rates as necessary in this stage of the process. Upon completion of the curing period, the compost is moved outside to the storage area for marketing. The paved storage area provides up to two months capacity for the finished compost product.

Odor Control - Odor control at this composting facility consists of treating process offgas from the most odorous composting process and treatment through a biofilter system. Initial modelling at the facility indicated that the nearest receptors, approximately 1,000 feet from the facility, would not be adversely affected with this type of odor control approach. A 3,150 CFM biofilter has been provided to allow a 60-second residence time of odorous gases in the open bed biofilter system for treatment. Moisture control is provided through in-line humidification and surface irrigation.

Compost Utilization - A compost marketing assessment was performed in mid-1994 to determine potential demand for a compost product. Currently, the Authority is initiating a program to market the compost using in-house personnel. Pricing for the compost has not been established, but is anticipated to be approximately $5 to $8 per cubic yard.
Personnel

Two part-time operators are utilized to operate the composting facility two to three days per week. These operators also perform other plant operations such as dewatering, land application of liquid biosolids, and other duties within the wastewater plant operation.

Initial Operation

The HRRSA composting facility began processing biosolids intermittently in January 1996. Because the North River Plant has a biosolids storage lagoon which is maintained for the land application program, the Authority could begin operations at the facility at a slow controlled pace, thus allowing operators to gain knowledge and confidence in the process prior to increasing loading to the facility. Seven individual compost piles have been constructed and 34 dry tons of biosolids have been composted as of mid-March. The composting process has met PFRP temperature requirements and screened compost is being produced for curing. Odors at the facility are minimal. Full-time utilization of the biofilter will begin in April as loading to the facility increases.

COSTS

Comparing costs for both facilities is a very interesting exercise. Economies of scale play an important factor in the construction and operating costs of composting facilities. However, when comparing the costs of these two facilities, one should be cognizant of the basic differences in facility design which have the greatest impact on costs. The basic differences in the two facilities are summarized below by unit process for those which are impacted.

<table>
<thead>
<tr>
<th>Process</th>
<th>Davenport Facility Details</th>
<th>HRRSA Facility Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitework</td>
<td>The Davenport Facility includes cost of approximately $400,000 for installation of a flood protection levee.</td>
<td></td>
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<tr>
<td>Yard Waste Receiving</td>
<td>The Davenport facility includes a yard waste receiving area and grinding equipment.</td>
<td></td>
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<tr>
<td>Mixing</td>
<td>The Davenport facility includes two 50 cubic yard capacity biosolids bins and two 15 cubic yard capacity bulking agent bins with variable speed outfeed devices. Two pugmills are used to mix biosolids and bulking agent on a continuous basis. A weigh belt is used to weigh materials and to automatically adjust feed rates through a PC controller. HRRSA facility mixing system includes one 18 cubic yard capacity batch mixer with weigh scales to measure bulking agent to biosolids ratios.</td>
<td></td>
</tr>
<tr>
<td>Composting Aeration</td>
<td>The Davenport facility includes in-trench aeration, whereas HRRSA utilizes above ground high density polyethylene pipe. Davenport has pile temperature feedback to provide aeration rate adjustments. HRRSA has manual aeration rate adjustments through a central PLC system.</td>
<td></td>
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<tr>
<td>Enclosures</td>
<td>The mixing, composting, and drying processes are totally enclosed in insulated pre-engineered buildings at the Davenport facility. These processes are only covered at HRRSA.</td>
<td></td>
</tr>
<tr>
<td>Odor Control</td>
<td>The Davenport facility collects all offgases from mixing, composting, and drying processes and building air for treatment through biofiltration. HRRSA facility treats exhaust gases from composting piles when in negative aeration through biofiltration.</td>
<td></td>
</tr>
<tr>
<td>Biosolids Cake</td>
<td>The Davenport facility design was based on 20% total solids, whereas the HRRSA facility design was based on 25% total solids. This single factor increases the facility capacity by approximately one-third more biosolids on a dry weight basis because less volumes are managed per dry ton.</td>
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</tbody>
</table>
CAPITAL COSTS

The capital costs reported are in 1995 dollars and include all moving stock, stationary equipment, buildings, site improvements, engineering, permitting, and construction management. The cost of land acquisition is not included.

The Davenport and HRRSA composting facility capital costs are summarized in Table 1. Capital costs for Davenport are shown as is and then with the deletion of the flood protection levee and the yard waste receiving processing for comparison with HRRSA. This comparison shows that the large capacity totally enclosed static pile composting facility at Davenport has a similar unit cost of $275,000 per dry ton of biosolids capacity as the smaller HRRSA facility which is simply housed under cover. It should be noted that because of the higher solids content in the dewatered biosolids at HRRSA, a third more biosolids capacity on a dry weight basis is available at HRRSA, thereby reducing the resultant unit costs per dry or wet ton of biosolids capacity.

Table 1
COMPARISON OF CAPITAL COSTS

<table>
<thead>
<tr>
<th></th>
<th>Davenport</th>
<th>HRRSA</th>
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<tbody>
<tr>
<td>Total Capital Cost</td>
<td>$8.61 million</td>
<td>$1.51 million</td>
</tr>
<tr>
<td>Cost per Dry Ton per Day of Capacity</td>
<td>$307,400</td>
<td>$274,500</td>
</tr>
<tr>
<td>Cost per Wet Ton per Day of Capacity</td>
<td>$61,500</td>
<td>$68,600</td>
</tr>
<tr>
<td>Capital Cost minus Flood Levee and Yard Waste Receiving/Processing</td>
<td>$7.71 million</td>
<td>$1.51 Million</td>
</tr>
<tr>
<td>Adjusted Cost' per Dry Ton per Day of Capacity</td>
<td>$275,400</td>
<td>$274,500</td>
</tr>
<tr>
<td>Adjusted Cost' per Wet Ton per Day of Capacity</td>
<td>$55,100</td>
<td>$68,600</td>
</tr>
</tbody>
</table>

Note: 1Davenport costs based on 28 DTPD, 5 days per week, 20%TS cake  
2HRRSA costs based on 5.5 DTPD, 5 days per week, 25%TS cake  
3Includes all facilities, equipment, site work, engineering, permitting, and construction management. Land costs are not included.  
4Adjusted cost after deletion of flood levee and yard waste receiving/processing.

O&M COSTS

O&M costs for the two facilities are compared in Table 2. The O&M costs at Davenport are based on actual operating data for the first six months of operation. These costs include yard waste processing. The quantity of biosolids processed on average is only 21.3 dry tons per actual operating day. The 2,339 dry tons of biosolids processed over that period compares to a design quantity of 3,640 dry tons which translates to 64% of facility capacity. This lower throughput is due to start-up/shakedown of the system and loading/operational problems at the WWTP which resulted in much wetter biosolids cake during November through February (13% to 17%) as compared to the 19% to 20%TS which was being achieved in September and October.

O&M costs for HRRSA are estimated based on projections since no historical data is yet available. HRRSA is designed to operate only three days per week in the initial design year (1996). However, because of start-up/shakedown, the facility has not been operated at that type of schedule as of yet.

Labor accounts for the largest percentage of O&M costs at both facilities at roughly one-third of the budget. Typically, bulking agent costs are the next largest portion which is also true at the HRRSA facility. However, Davenport's bulking agent costs are greatly reduced by using shredded rubber tires and yard wastes to supplement new wood chips as the bulking agents. Utilities at Davenport are a higher percentage of the O&M cost due to the large amount of airflow which is collected for treatment through the biofilter system. Maintenance costs at both facilities are projected based on hourly costs and operating costs and hourly run times for moving stock and stationary equipment. Fuel is based on actual usage at Davenport to operate the front-end loaders and yard waste grinder. Miscellaneous includes product monitoring.
Table 2
COMPARISON OF O&M COSTS

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<tr>
<th>Category</th>
<th>Davenport¹</th>
<th>HRRSA²</th>
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<tr>
<td></td>
<td>$/Dry Ton of Biosolids</td>
<td>% of Total</td>
</tr>
<tr>
<td>Labor</td>
<td>49.74</td>
<td>36.1</td>
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<tr>
<td>Utilities</td>
<td>38.47</td>
<td>28.0</td>
</tr>
<tr>
<td>Maintenance</td>
<td>25.65</td>
<td>18.6</td>
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<tr>
<td>Bulkng Agent</td>
<td>16.67</td>
<td>12.1</td>
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<tr>
<td>Fuel</td>
<td>6.11</td>
<td>4.4</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1.07</td>
<td>0.8</td>
</tr>
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<td>TOTAL</td>
<td>137.71</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Notes: ¹Based on first six months of operation and actual costs to process 2,339 dry tons of biosolids and yard wastes. ²Based on projected first year quantity of 940 dry tons of biosolids. ³Based on first ten months of yard waste revenues adjusted for six months. ⁴Adjusted O&M cost after yard waste revenues. ⁵Adjusted O&M cost based on estimated compost production at both facilities and $5 per cubic yard sales revenue.

O&M costs are estimated to be $95 per dry ton of biosolids processed at HRRSA and $138 per dry ton of biosolids processed at Davenport. Figure 3 shows the relative cost impact of these costs categories. Actual O&M costs at Davenport will decrease as the dewatered biosolids cake solids content continues to improve. These costs compare very favorably with other operating biosolids composting facilities nationwide.

ANNUALIZED COSTS

Total annualized costs for both facilities are compared in Table 3. The capital costs were amortized at 5% interest as follows:
* Moving stock at 7 years
* Stationary equipment at 10 years
* Structures, sitework, and engineering at 20 years

Table 3
COMPARISON OF ANNUAL COSTS

<table>
<thead>
<tr>
<th></th>
<th>Davenport¹</th>
<th>HRRSA²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$ per Year</td>
<td>$ per Dry Ton</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>644,207</td>
<td>137.71</td>
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<tr>
<td>Amortized Capital</td>
<td>831,500</td>
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<tr>
<td>Subtotal</td>
<td>1,475,700</td>
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<tr>
<td>Yard Waste Tip Fee⁵</td>
<td>116,000</td>
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<tr>
<td>Subtotal</td>
<td>1,289,700</td>
<td>275.70</td>
</tr>
<tr>
<td>Compost Revenue⁶</td>
<td>133,700</td>
<td>28.58</td>
</tr>
<tr>
<td>Subtotal</td>
<td>1,156,000</td>
<td>247.12</td>
</tr>
</tbody>
</table>

Notes: ¹Based on first six months of operation and actual costs to process 2,339 dry tons of biosolids and yard wastes. ²Based on projected first year quantity of 940 dry tons of biosolids. ³Based on first ten months of yard waste revenues adjusted for six months. ⁴Adjusted O&M cost after yard waste tip fee revenues.
Figure 3
Comparison of O&M Costs

Cost per Dry Ton of Biosolids ($)

- Total
- Labor
- Utilities
- Maintenance
- Bulking Agent
- Fuel
- Miscellaneous

Davenport  HRRSA
Yard waste tip fee revenues are accounted for at Davenport. Compost revenues of $5 per cubic yard are assumed at both facilities based on preliminary market investigations and reported revenues from other similar facilities.

CONCLUSIONS

As this paper illustrates, two successful aerated static pile biosolids composting facilities began operation in the United States in 1995. The larger capacity facility in Davenport, Iowa uses a totally enclosed approach for environmental and odor control reasons. The smaller facility in Harrisonburg, Virginia utilizes a covered aerated static pile method of composting. Both facilities utilize the popular aerated static pile method of composting as well as unique process control features that have a proven track record at other facilities. Many of these most recent features have been incorporated into these facilities based on owner preference and the budgetary constraints. Odor control at both facilities has been completely satisfactory. The facilities were built within budgetary constraints, while at the same time incorporating the most important owner-desired features possible. Cost comparisons provided here show that cost-effective composting can be achieved using aerated static pile with a high degree of odor removal efficiency and varying characteristics of the feedstock biosolids and bulking agents available.

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