INTRODUCTION

Several local governments in the Triangle region have recently completed a study evaluating the economic, environmental, and technical feasibility of a regional biosolids composting facility. The study concluded that such a facility could save money for local governments through economies of scale.

For many communities, co-composting of wastewater biosolids with materials such as yard waste, clean wood waste, and mixed paper waste is becoming an increasingly attractive method for biosolids disposal. Increasingly stringent regulations, public concern over environmental issues, and decreasing availability of suitable land application sites within economical hauling distances combine to make sole reliance on land application of biosolids a less attractive alternative for wastewater treatment plants. Furthermore, composting of clean wood waste and mixed paper waste can be an important addition to an integrated approach to local government solid waste management.

The problem is that composting facilities are typically expensive to build, operate, and maintain. Many local governments cannot afford to independently develop these facilities.

The Town of Cary's recent need to develop a biosolids management plan for a wastewater treatment plant expansion project provided the impetus for an interlocal exploration of regional biosolids composting in the Triangle. Following several meetings organized by Triangle J Council of Governments, the Towns of Apex, Cary, Clayton, Garner, and Zebulon; the City of Durham; Durham County; and Orange Water and Sewer Authority agreed to cooperatively fund a $38,000 regional biosolids composting facility feasibility study. By working together, each participant received a study that would have cost much more undertaken alone.

The feasibility study was conducted by E&A Environmental Consultants, Inc. from Cary, North Carolina. Coordination of the study was provided by Triangle J Council of Governments.

The eight study participants currently manage a total of approximately 24 dry tons per day of biosolids, with individual amounts ranging from less than one ton to over nine tons per day. This amount is steadily increasing with the population growth in the region. The feasibility study compared the costs of capital, operations, and maintenance expenses for three different facility sizes based on the amount of biosolids handled each day: 10, 20, and 40 dry tons. This enabled individual governments to determine the potential economies of scale from forming partnerships with neighboring communities.

The feasibility study also evaluated and compared the costs of three different composting technologies: aerated static pile, agitated bed, and a combined aerated static pile and agitated bed technology.

STUDY ASSUMPTIONS AND DESIGN CRITERIA

The single most critical factor in terms of facility size and economics of a biosolids composting facility is the cake solids concentration of the biosolids. It was assumed for the purposes of this study that the biosolids arriving at the facility would be 18% solids cake. This value was based on the experience of participating entities in dewatering of biosolids. Currently, the City of Durham is the only study participant which actively dewater...
biosolids by mechanical means (i.e., belt filter press, plate and frame press, centrifuge, etc.). The City of Durham currently processes and dewateres digested biosolids to between 16% and 18% solids, which are then land applied. All the other participants are currently land applying digested liquid biosolids ranging in solids content from 2% to 6% total solids.

It was also assumed that all biosolids brought to the facility would be well within the metal concentrations limits set by state and U.S. EPA standards for exceptional quality biosolids. Current metal concentrations in biosolids from the participating entities is substantially below these limits.

Transportation costs to the facility were not included in the analysis. It was assumed that delivery costs would be the responsibility of the participating entity and that biosolids and other compostables would be transported to the facility in self-tipping vehicles, such as dump trucks, live-bottom trailers, or other vehicles with means for dumping loads into bins or open storage pads.

It was assumed that the facility would be operated on an eight hour per day basis, five days per week. In addition to this base operating schedule, it was assumed that the facility would be staffed and open for eight hours on Saturdays solely to receive yard wastes and to load compost for customers. It was assumed that a set of weight scales would be provided at the facility to determine weights of materials received and removed from the facility. Biosolids receiving would be in a paved, totally enclosed building, adjacent to the mixing system. A series of concrete bunkers or receiving bins would be used for participating entities to deposit their loads of biosolids. Space was provided in the facility designs to allow for storage of up to half a days biosolids production on average. Bulking agent storage was assumed to occur in an open asphalt storage pad with capacity to manage up to 60 days worth of yard waste in an unground form. In addition, 60 calendar days of storage would be provided for ground bulking agents which have been processed through the yard waste grinding unit. A two to one volume reduction was assumed through the yard waste grinding operation.

Processing was assumed to occur on a five day per week basis, approximately 6 1/2 hours per day, for a total of 32.5 operating hours per week. Processing equipment was sized to process the daily average quantities of incoming materials at a peaking factor of 1.5 or 150%.

Because no site had been established for a facility, a number of assumptions were made to allow for a generic site. They included the following:

- On-site utilities were assumed to be hooked up within 1,000 feet of the main building.
- Road access improvements would be necessary only for 1,000 feet of entry.
- Adjacent off-site infrastructure improvements were assumed at a cost of $500,000.
- The site was assumed to be fairly level, contain good soil, and have no unusual drainage problems.
- The composting and storage areas were assumed to be set back 200 feet from the perimeter.
- Fencing and a locking entry gate were assumed as costs in the cost estimate.

The cost of land was assumed at $40,000 per acre, amortized at 5% over 20 years. It was assumed that a tip fee of $15 per ton would be charged for yard waste and similar bulking agents. It was also assumed that the sale price of the finished compost product would be $4.00 to $6.00 per cubic yard. A $1.00 per cubic yard of compost marketing cost was also assumed, with sales only in bulk, not bags.

It was agreed by participants that biofiltration would be the technology used to treat odor from the composting process. All three composting technologies examined were based on a totally enclosed mixing and composting building with exhaust gases being treated through a biofiltration system. Curing, screening, and material storage areas were assumed to be in combinations of covered or open storage pad areas which would not be connected to the odor control system.

TECHNOLOGIES COMPARED

Two basic technology types -- aerated static pile and agitated bed -- were compared in the study, with a third hybrid technology added in order to determine whether it could be more efficient and cost-effective than either of the other two alone. Three sizes -- 10, 20, and 40 dry tons per day -- were examined for each technology type, for a total of nine different facility scenarios. Receiving, mixing, screening, and curing/storage areas would involve similar
equipment for all three technologies. The composting system itself is the part of the facility that would differ depending upon the technology.

For all three technology types, yard waste and similar bulking agents would be dumped on a concrete storage pad under cover. This area would have concrete pushwalls and could accommodate any type of bulking material that needed to be kept dry. A mobile tubgrinder would be used to process yard waste up to 10 inches in diameter. A discharge conveyor would allow stacking of the ground material into a surge pile which would be moved by front-end loader into the amendment storage area. Ground bulking agent would be placed into a batch mixing box for the 10 dry ton per day facility. The batch mixer has a capacity of 18 1/2 cubic yards and is outfitted with weigh scales such that precise quantities of bulking agent and biosolids can be measured and mixed. The mixed material would be discharged into a surge pile in a concrete bunker. Because of the large quantity of material which must be handled for the 20 and 40 dry tons per day facilities, a more automated mixing system was assumed. It would include two receiving hoppers for biosolids and two receiving hoppers for bulking agent, which would then discharge material onto conveyors for transport to a continuous feed pugmill type mixer and subsequent stockpiling of mix material in a surge pile in a three-sided concrete bunker. Both the batch mixer and the continuous feed mixer systems would be permanently mounted and electrically driven and in a totally enclosed area.

After composting, the screening system for all three technologies would be under cover and would involve a rotary trommel screen. The recovered bulking agent would be recycled back into the mixing process.

The subsequent aerated curing for all three technologies would take place over 30 days under cover on an asphalt pad. Aeration would be run in a positive aeration mode only, using reusable high density polyethylene aeration pipe. After 30 days, the compost would be moved outside onto an open asphalt storage pad until it is sent to market.

In the aerated static pile composting technology, composting would occur in a totally enclosed pre-engineered building with concrete flooring and pre-cast trenches to provide aeration. A base of wood chips would be laid down, on which an eight-foot layer of mix of biosolids and bulking agent would be placed, plus a one-foot cover of finished compost as an insulation layer. Offgases from the aeration blowers as well as the building air would be collected and treated through an open biofiltration treatment system.

In the agitated bed composting technology, mixed materials would be placed into the front end of individual agitated bed bays. The agitated bed system would be housed in a totally enclosed building with automated temperature feedback controlled blower stations extending down the length of agitated bays. Each concrete bay would be ten feet wide, seven feet deep, and 203 feet long. An automated turning device would ride on a series of rails to the rear of the bay, where it would start turning the material by picking it up with an elevating faced conveyor and throwing it over its shoulder, thus moving the material down the length of the bays. Eight bays and two agitators would be required for the 10 dry ton per day facility, 15 bays and three agitators would be required for the 20 dry ton per day facility, and 30 bays with six agitators would be required for the 40 dry ton per day facility. Only positive aeration would be provided, and offgases would be collected and treated through a biofilter system.

In the combination aerated static pile-agitated bed technology, the composting time within the agitated beds would be reduced from 21 to 14 days. This would reduce the length of the bays from 203 feet to 152 feet and reduce the number of agitators to two for the 10 and 20 dry ton per day facilities and four for the 40 dry ton per day facility.

BULKING AGENTS

The primary bulking agents assumed to be used in the composting facility were yard waste, clean wood waste, and mixed paper. The local governments participating in the study manage a total of approximately 11,500 tons per year of yard waste, and significant additional amounts are handled by neighboring jurisdictions. Based on waste characterization studies in the region, it was estimated that approximately 22,000 tons per year of clean wood waste in currently landfilled within the six-county region. It was also estimated that 17% to 20% of landfilled municipal solid waste in the region is mixed paper waste.

The study concluded that between 7,300 and 8,350 tons per year of new bulking agent would be required for the 10 dry tons per day facilities; between 14,600 and 16,700 tons per year of new bulking agent would be required for the 20 dry tons per day facilities; and between 29,250 and 33,400 tons per year of new bulking agent would be required for the 40 dry tons per day facilities. Because mixed paper does not possess the structural integrity to
increase pore space in a biosolids mix, mixed paper could not be used for more than one-third of the bulking agent requirement.

STUDY CONCLUSIONS

The study results confirmed the participants' expectations that there were significant economies of scale to be achieved through regional cooperation. This was true with regard to all three technologies. Figure 1 gives an overview of the annual cost per dry ton processed for all nine facilities examined in the study.

FIGURE 1

Triangle J Regional Composting Facility
Annualized Cost per Dry Ton Processed
vs. Biosolids Input Capacities

- Aerated Static Pile
- Agitated Bed
- Agitated Bed-Aerated Static Pile Combination
The annual costs in Figure 1 include capital, amortization, and operating and maintenance costs. They do not include revenue from tip fees or compost sales, and they do not include land acquisition costs. The aerated static pile technology was the least costly option: $321 per dry ton for the 10 dry ton per day facility, $261 per dry ton for the 20 dry ton per day facility, and $219 per dry ton for the 40 dry ton per day facility. The agitated bed technology was the most expensive option: $405 per dry ton for the 10 dry ton per day facility, $320 per dry ton for the 20 dry ton per day facility, and $262 per dry ton for the 40 dry ton per day facility. The combination facility fell in between the other two technologies in cost: $366 per dry ton for the 10 dry ton per day facility, $294 per dry ton for the 20 dry ton per day facility, and $239 per dry ton for the 40 dry ton per day facility.

The land area requirements for the processing areas of the 10, 20, and 40 dry ton per day sizes of aerated static pile facilities were 2.5, 4.5, and 8.4 acres. The land area requirements for the processing areas of the three sizes of aerated static pile-agitated bed facilities were 2.3, 4.1, and 7.6 acres. The land area requirements for the processing areas of the three sizes of agitated bed facilities were 2.4, 4.3, and 8.0 acres. With the 200-foot setback, the acreage requirements were considerably more, ranging from 13.9 to 33.0 acres.

Economies of scale and the relative costs of the three technologies were also apparent when factoring in the cost of land and the anticipated tip fee and compost sale revenues. These adjusted figures are included in Table 1. The adjusted annual cost per dry ton for the aerated static pile technology was $244 to $263 for the 10 dry ton per day facility, $186 to $205 for the 20 dry ton per day facility, and $135 to $153 for the 40 dry ton per day facility. The adjusted annual cost per dry ton for the agitated bed technology was $340 to $356 for the 10 dry ton per day facility, $250 to $266 for the 20 dry ton per day facility, and $190 to $206 for the 40 dry ton per day facility. The adjusted annual cost per dry ton for the combination facility was $293 to $310 for the 10 dry ton per day facility, $217 to $234 for the 20 dry ton per day facility, and $158 to $176 for the 40 dry ton per day facility. The range in cost is due to the range in composting revenue assumed: $4.00 to $6.00 per cubic yard.

**IMPLICATIONS FOR BIOSOLIDS MANAGEMENT**

Two of the study participants are currently paying a cost for biosolids management through land application that is higher than the cost they would incur by composting at an aerated static pile facility sized for 20 dry tons per day. These two entities combined are currently handling approximately 12 dry tons per day of biosolids, but they estimate that by the year 2006 they will be handling a combined total of approximately 20 dry tons per day. A regional facility appears to be a cost effective method for biosolids management for these two entities.

Other study participants are currently paying less for land application of biosolids than they would pay for composting at a regional facility. However, the availability of a composting option at a regional facility could be of great benefit to them during periods of inclement weather when land application is not feasible. For this reason, other study participants are potential users of a regional biosolids composting facility if such a facility should be built.

**IMPLICATIONS FOR SOLID WASTE MANAGEMENT**

The bulking agent requirements for a biosolids composting facility are such that all of the yard waste in the study region could be composted at the facility. A significant amount of clean wood waste from construction could also be composted in such a facility.

The study also concluded that food waste could be composted at the facility in the same ratio with bulking agent as 18% cake biosolids is composted with bulking agent. This ratio is one ton of biosolids or food waste for 578 tons bulking agent.

This factor can be significant in managing solid waste, in that food waste is approximately 6% of landfilled municipal solid waste. Composting merely a portion of this food waste would be extremely helpful to local governments trying to achieve waste reduction goals. Moreover, the composting of food waste opens up an opportunity to compost more bulking agent. Up to one-third of the bulking agent in a composting facility could be mixed paper, so more composted food waste would provide an opportunity to reduce the landfilling of mixed paper.

A further benefit of adding food waste to biosolids for composting is that it would result in even further economies of scale. If the facility were handling closer to 40 than 20 dry tons per day, the cost per dry ton would decrease significantly, and every user of the facility would incur lower costs.
### Table 1

**TRIANGLE J REGIONAL COMPOSTING FACILITY**

**FACILITY COST COMPARISON**

<table>
<thead>
<tr>
<th>Item</th>
<th>10 DTPD</th>
<th>20* DTPD</th>
<th>40 DTPD</th>
<th>10 DTPD</th>
<th>20* DTPD</th>
<th>40 DTPD</th>
<th>10 DTPD</th>
<th>20* DTPD</th>
<th>40 DTPD</th>
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<tbody>
<tr>
<td><strong>Capital</strong> ($)</td>
<td>5,183,000</td>
<td>8,307,000</td>
<td>13,416,000</td>
<td>6,885,000</td>
<td>10,716,000</td>
<td>18,136,000</td>
<td>6,076,000</td>
<td>9,557,000</td>
<td>15,618,000</td>
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<td><strong>Amortized Capital</strong> ($)</td>
<td>491,000</td>
<td>786,000</td>
<td>1,261,000</td>
<td>681,000</td>
<td>1,064,000</td>
<td>1,784,000</td>
<td>601,000</td>
<td>951,000</td>
<td>1,534,000</td>
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<td><strong>Annual O&amp;M Costs</strong> ($)</td>
<td>344,000</td>
<td>603,000</td>
<td>1,015,000</td>
<td>372,000</td>
<td>599,000</td>
<td>943,000</td>
<td>351,000</td>
<td>580,000</td>
<td>955,000</td>
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<td><strong>Total Annualized Cost</strong> ($)</td>
<td>835,000</td>
<td>1,389,000</td>
<td>2,276,000</td>
<td>1,053,000</td>
<td>1,663,000</td>
<td>2,727,000</td>
<td>952,000</td>
<td>1,531,000</td>
<td>2,489,000</td>
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<td><em>Cost per Dry Ton Biosolids Processed</em> ($)</td>
<td>321</td>
<td>267</td>
<td>219</td>
<td>405</td>
<td>320</td>
<td>262</td>
<td>366</td>
<td>294</td>
<td>239</td>
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<tr>
<td><em>Cost per Ton (as is) of New Materials Processed</em> ($)</td>
<td>36.63</td>
<td>30.47</td>
<td>24.96</td>
<td>48.40</td>
<td>38.22</td>
<td>31.33</td>
<td>42.18</td>
<td>33.92</td>
<td>27.57</td>
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<tr>
<td><em>Annual Net Revenue from Compost Sales</em> ($)</td>
<td>71,000-118,300</td>
<td>142,000-236,600</td>
<td>283,900-473,200</td>
<td>62,400-104,000</td>
<td>124,800-208,000</td>
<td>249,600-416,000</td>
<td>67,100-111,800</td>
<td>134,200-223,600</td>
<td>269,100-448,500</td>
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<td><em>Annual Revenue from Yard Waste Tip Fee</em> ($)</td>
<td>125,300</td>
<td>250,500</td>
<td>501,000</td>
<td>109,700</td>
<td>219,400</td>
<td>438,800</td>
<td>121,900</td>
<td>243,800</td>
<td>487,500</td>
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<td>Cost per Dry Ton Biosolids with Compost Revenue ($)</td>
<td>276-294</td>
<td>222-240</td>
<td>173-192</td>
<td>365-381</td>
<td>280-296</td>
<td>222-238</td>
<td>323-340</td>
<td>251-269</td>
<td>196-213</td>
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<tr>
<td>Cost per Dry Ton Biosolids with Yard Waste Tip Fee ($)</td>
<td>273</td>
<td>219</td>
<td>171</td>
<td>363</td>
<td>278</td>
<td>220</td>
<td>319</td>
<td>248</td>
<td>192</td>
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<td>Cost per Dry Ton Biosolids with Yard Waste Tip Fee and Compost Revenue ($)</td>
<td>227-246</td>
<td>173-192</td>
<td>125-143</td>
<td>323-339</td>
<td>238-254</td>
<td>180-196</td>
<td>276-293</td>
<td>205-222</td>
<td>149-167</td>
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<td><em>Cost per Dry Ton with Revenues and Land Acquisition Costs</em> ($)</td>
<td>244-263</td>
<td>186-205</td>
<td>135-153</td>
<td>340-356</td>
<td>250-266</td>
<td>190-206</td>
<td>293-310</td>
<td>217-234</td>
<td>158-176</td>
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**Notes:**
- **DTPD** - Dry tons per day of biosolids
- *Recommended facility size*
- *Design capacity per operating day, five days per week*
- *Based on 18% solids, 260 days per year, 5 days per week*
- *Includes total weight of biosolids and new bulking agent processed*
- *Assumes $1/CY for sales cost and revenue of $4-6 per cubic yard or a net revenue of $3-$5 per cubic yard (assumes 2 cubic yards per ton)*
- *Based on tip fee of $15 per ton at facility*
- *Assumes land cost of $40,000 per acre, and 200 feet setback from all processing facilities required. Cost of land amortized at 5% interest over 20 years.*
The annual adjusted cost per dry ton of biosolids for a 20 dry ton per day aerated static pile facility would be $186 to $205. This translates into a cost per 18% dry, or food waste, cost of $33 to 37 per ton. For a 40 dry ton per day aerated static pile facility, this cost would be $24 to $28 per ton.

NEXT STEPS

Two of the study participants are now working with Triangle J Council of Governments to evaluate the economic, environmental, and institutional feasibility of establishing a regional biosolids composting facility and to identify potential sites for such a facility. These participants have concluded that there are significant benefits from cooperating in a regional biosolids composting facility:

- economies of scale in constructing, operating, and maintaining a facility;
- economies of scale in marketing compost to end users;
- minimized potential for conflict and competition in compost marketing;
- a biosolids management option for periods when land application is not possible; and
- extended life for municipal solid waste landfills due to the opportunity to compost other materials with biosolids.

These study participants have made an initial determination that the aerated static pile composting technology is the preferred approach; that the facility should be publicly-owned and either publicly or privately operated; and that a 20 dry ton per day facility size is preferred, with land acquisition to allow for expansion to a 40 dry ton per day facility size.

The next products expected from this regional effort are a set of general principles for guiding the further development of a regional biosolids composting facility; recommendations concerning the legal structure for public ownership; and a draft interlocal agreement related to these objectives.