Preliminary Compost Market Assessment
Okeechobee, Florida Region

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Introduction

Many communities throughout the US are planning, and in some cases, operating composting facilities. In addition, many composting facilities have been established by the private sector in recent years. Consequently, the number of composting facilities has increased during the last two decades and the trend is continuing. There are over 4,400 composting facilities in the U.S., with 12 permitted facilities currently in operation in Florida.

The growth of the compost industry in the United States and Florida is being driven by the increase cost of landfill disposal, public support for resource conservation and state legislative mandates for waste diversion – not by demand for compost products in the marketplace. As a result, producers will have to devote attention to compost market development and meeting the product quality demands of users. Compost markets must become central to virtually all aspects of compost facility planning, design and operation.

Assuming Florida were to maximize compost production from all available municipal solid waste (MSW), including yard waste, researchers estimate that if the organic fraction of this stream were to be biologically decomposed, Florida would have the potential to generate over 5.5 million tons of compost annually. This value represents a theoretical maximum for purposes of defining compost production capacity from MSW as currently 66% of 3.5 million tons of yard wastes are converted to mulches (Rahmani et al. 2004). But key questions remain. Specifically, is the market capacity in Florida sufficient to use the compost produced? What is the present market capacity for composted products? And how can Florida build markets for composted products?

According to one study by Slivka et al. (1992), Florida's potential compost applications including landscape, topsoil, peat/bark, potting topsoil, landfills, container nurseries, field nurseries, sod, silviculture and agriculture totals nearly 42 million cubic yards. It was projected that the agricultural industry located within a 50-mile radius of urban centers with populations of more than 100,000 could use more than 20 million tons of compost annually. The researchers imposed the distance constraint of 50-miles by bulk. This is based on the limited economic viability of shipping bulk compost beyond 50 miles. Bagged products could be shipped a much longer distance.

Based on the Slivka et al. Florida market estimate of 42 million tons, the estimated potential compost production capacity of 5.5 million tons in Florida is less than 18% of the potential market capacity.

Included within Battelle's study (Slivka et al., 1992) are estimates that the average annual rate of compost penetration in US markets was less than 2% of its potential users. If the rate of compost penetration in the Florida market follows the national trend, compost use in the state would be approximately 840,000 tons a year. Clearly, Florida has a market development challenge, not a lack of market.

Several related compost studies in Florida have been conducted by the University of Florida's scientists through the Center of Biomass Programs. These studies include cost –benefits analysis for compost application in Florida (M. Rahmani et al., 1998), grower's and landowner's attitudes toward compost application in Florida (M. Rahmani et al., 2001), economics of yard debris conversion options in Florida (M. Rahmani et al., 2004), and developing market for recycled organic product in Florida (M. Rahmani et al., 2004). Other studies include a market development program for composts in Florida (Wayne H. Smith and Aziz Shiralipour, 1997), developing a market for compost product (Aziz Shiralipour, 1998) and strategies for compost market development in Florida, (Aziz Shiralipour and Wayne H. Smith, 1998). A brief summary of these studies is provided below.

<u>Rahmani, Mohammad, Alan W. Hodges, and Clyde F. Kiker. 1998. Cost –benefits analysis for compost application in Florida</u>

In this study costs and benefits of compost application for several specific sites and crops such as vegetables, turfs, ornamentals, and roadsides were surveyed. Efforts were made to measure costs and benefits of compost application possibly in monetary terms; however, it was identified that certain cost and benefits that were very difficult to measure in monetary terms. In general, the results of analysis showed that in all cases where sufficient data were available monetary benefit exceeded the total cost of compost application. In addition to monetary benefit, several other non-tangible benefit of compost application was defined. Overall, compost application showed positive economic benefit that usually last beyond the year of application and the particular crop applied involved.

<u>Rahmani, Mohammad, Alan W. Hodges, and Clyde F. Kiker. 2001 . Grower's and land owner's attitudes toward compost application in Florida.</u>

In this study a survey was conducted to explore the issues of concern and the attitudes of those who already use compost as well as non-compost users in Florida. Many growers didn't know the various benefits and the scope of potential compost application. The price of compost as reported by end-users ranged from $9 to $40 per ton. The average price was estimated at $29.05. Transportation and other cost such as labor for application (where transportation cost was reported separately) were estimated at $8.9 per ton.

Quality factors such as maturity, content of the weed seeds, and odor were the most important issues reported. Quality of available compost together with adverse reaction due to weed seeds--also a quality matter-- was mentioned as main barriers by 53 percent of the respondents. When asked what would encourage using compost, availability of relevant information was the key. Interesting, three times more respondents indicated more information as enticement (79 percent) than those who cited delivery of compost at no cost (24 percent). About one-third of the respondents believed they need to be convinced that the benefits of compost exceed the cost of its application. Those who did not have interest in compost represented only 8 percent of the respondents. Results of this study suggested that to promote widespread compost use, information and product quality are the critical elements.

<u>Rahmani, Mohammad, Alan W. Hodges, and W. D. Mulkey. 2004. Economics of yard debris conversion options in Florida.</u>

Annual yard debris volume in Florida was estimated at 3.5 million tons. Yard debris usually has a significant tipping fee to be paid to those who take it for disposal. The present study was intended to study the economic value, and compare the advantages and disadvantages of using yard debris as a feedstock for organic recycling facilities for conversion to mulch, compost, or other soil amendments; as feedstocks for electric power plants for cofiring with other feedstocks to produce electricity; or for farm land spreading. For this study, primary data was collected by sending survey questionnaires by mail to the organic recycling facilities that use yard debris and produce mulch, compost or other products in Florida. Follow-up was made through personal and telephone contacts, with faxed or e-mailed copies of the questionnaire. Totals of 25 responses (50 percent responses rate) were received.

Overall, 88 percent of respondents received yard debris at their facilities. Organic recycling facilities in Florida converted yard debris primarily to mulch. While 91 percent of those receiving yard debris converted it to mulch, only half of them converted yard debris to compost, and less that 20 percent of them produced some kind of soil amendment. Most recycling facilities (77 percent of respondents receiving yard debris) received a tipping fee. Tipping fees varied from less than $20 per ton to more than $60 per ton. Weighted average tipping fees amounted to $29 per ton in 2003.

Collected information showed that most of the yard debris collected in Florida was hauled to organic recycling facilities. Mulch, compost and other soil amendments produced by organic recycling facilities were mostly used, whether sold or given free to customers. The price received by these facilities may be representative of monetary value. However, free of charge give away, and volatility in price received for various products by different facilities as well as different type of operation by these facilities, would make an average valuation statistically incorrect. Yard debris usage by electric power plants is still in a very initial stage, and has not developed to a common practice, and faces technical and financial challenges.

Rahmani, Mohammad, Alan W. Hodges, and Clyde F. Kiker. 2004. Developing markets for recycled organic products in Florida.

In this work the authors explore the existing and potential market for recycled organic products in Florida. The study is developed around data and information collected from the authors' previous studies on various aspects of demand and supply of recycled organic products in Florida. On the demand side, data were collected on issues such as problems experienced by compost users, sources of information about compost, barriers to using compost, and incentives for potential compost users. The surveys also included explorations into the issues of concern and the attitudes of those that already use compost as well as non-compost users in Florida. Addressed within the survey of organic recycling facilities in Florida were issues relevant to supply. These issues included capacity and actual volume and type of recycled organic products, customers, percent of product shipped, and shipping distance. Marketing efforts by producers as well as demand improvement initiatives and customers concerns were addressed in the survey.

It was concluded that it is through market improvement and by improving demand that organic recycling facilities that increased product use will be realized. Results from the demand issues study indicated that quality, information, and consistent availability are the key to demand improvement and eventually market improvement. To promote using compost, the product should be considered as a commodity that has some net benefit for the users. Marketing tools would have an important impact on encouraging greater compost usage and eventually development of a market for compost.

Compost Market Assessment for Okeechobee Region

The purpose of this preliminary compost market assessment is to provide HydroMentia, Inc. with data that will assist in developing a composting facility for plant biomass (water hyacinth and/or algae). The biomass will be recovered as a result of normal operations associated with Managed Aquatic Plant Systems (MAPS)—a biological treatment technology used for point and non-point source water treatment in Florida. This assessment is part of a broad effort to evaluate existing demand and develop markets for compost. Areas of study are outlined below:

1. Existing and potential compost users within100 miles radius of Okeechobee, Florida (study area).
2. The current use of compost in the study area (last year's utilization).
3. The potential yearly demand for compost.
4. The amount of money paid by potential users for compost.
5. The amount users are willing to pay for a delivered cubic yard of compost.
6. The amount users are willing to pay for an undelivered cubic yard of compost

Market Assessment Methodology

This market assessment was conducted in three stages. The first stage involved the identification of the parameters for potential user groups (see Appendix). The second stage consisted of contact with potential users through phone surveys, e-mail surveys and mail surveys. The mail survey methodology was chosen because it yielded more successful results at the beginning of the research project in comparison with the other two methodologies (about 35 phone calls were made, but only one person responded). The final stage involved market data analysis and report development. The questionnaires were mailed to two hundred potential compost users within the study area from our list server (the list server has the names, addresses, phone numbers and e-mails).

Findings

This study provides an initial assessment of present and potential markets for compost in the survey area (within 100 miles of City of Okeechobee). Two hundred potential end-users in the study region were contacted in the survey, with 21% responding. Based on survey data collected from the respondents it is estimated that the potential compost market in the area could range from minimum of 89,750 tons per year (Table 1) to approximately 427,300 tons per year. The higher end of the range was calculated based on the assumption that all 200 end-users would use compost at the same rate as the respondents.

Among the respondents in the area, the major potential users are citrus and vegetable growers. However, 66% of the citrus grower and 54% of the vegetable growers did not

use compost during the last 3 years. The percent of the growers that did not use compost during the last 3 years ranged from 0 to 100% for the rest of the markets.
The estimate is subject to some important qualifications, in terms of compost product quality, cost and transportation. From a facility planning perspective, these estimates should be used as a guidepost for additional, more focused market research and development. The most important lessons from this preliminary assessment are: 1) there is a significant potential market for compost in the area, and 2) the key potential user groups are very concerned about factors such as product quality, cost and transportation.

Actual and Potential Demand for Compost in Okeechobee Region

Based on the survey results, the amount of actual compost utilized by respondents last year (2004) was 84,395 tons and the potential yearly demand was estimated to be more than 89,750 tons (Table 1). Last year's actual compost applications and potential compost utilizations varied in different markets (Table 1). Citrus and vegetable growers were the major compost users among all respondents. The actual amount of compost application reported for last year by respondents in these two markets alone was 79,280 tons. This is over 93% of the total utilization reported by all respondents. It is estimated that the demand for compost by all citrus and vegetable growers in the surveyed area could reach approximately 377,500 tons per year (79,280 x 100 ÷ 21 = 377,500).

Table1. Compost Application during 2004 and Potential Demands by Various Growers

Compost Users Group	***Actual and Potential Demand for Compost (Tons)***	
	Compost Application During 2004	***Potential Demand***
Citrus (18 Respondents)	74,580	>80,100
Vegetable Crops (13 Respondents)	4,790	>3,800
Nurseries (4 Respondents)	1,500	>1,900
Landscapers (2 Respondents)	–	–
Sod (2 Respondents)	2,400	>2,700
Pasture (2 Respondents)	1,125	1,250
Sugarcane (1 Respondents)	–	–
Total	84,395	>89,750

Willingness to Pay for Delivered Compost

The compost users in the surveyed area were willing to pay $0 – 16/cubic yard or approximately $0 – 32/ton (Table 2). During the last year, three citrus growers used 3,780 tons of compost and paid $7/ton, which is equal to $26,460. If the total respondents are willing to pay an average of $7/ton, then the market for the region would be estimated at $590,700 (84,395 tons x $7/ton). Citrus and vegetable growers alone are willing to pay $554,960/year (79,280 tons x $7/ton). In this case, all potential citrus and vegetable growers in the surveyed area could pay approximately $2,642,600 annually (554,960 x 100 ÷ 21).

Table 2. Willingness of Various Growers to Pay for Delivered Compost

Compost Users Group	***Willingness to Pay***	
	$/cubic yard	***$/ton***
Citrus (18 Respondents)	1 – 10	1-20
Vegetable Crops (13 Respondents)	1 – 16	1-32
Nurseries (4 Respondents)	1 -10	1-20
Landscapers (2 Respondents)	0 -5	1-10
Sod (2 Respondents)	1 – 10	1-20
Pasture (2 Respondents)	0 -5	1-10
Sugarcane (1 Respondents)	0 – 5	1-10

Willingness to Pay for Undelivered Compost

All the compost users in the surveyed area were willing to pay $0 – 5/yard or $0-10/tons for undelivered compost (Table 3).

Table 3. Willingness of Various Growers to Pay for Undelivered Compost

Compost Users Group	***Willingness to Pay*** ***$/cubic yard***	***$/ton***
Citrus (18 Respondents)	0-5	0 -10
Vegetable Crops (13 Respondents)	0-5	0 - 10
Nurseries (4 Respondents)	0-5	0 -10
Landscapers (2 Respondents)	0-5	0 -10
Sod (2 Respondents)	0-5	0 -10
Pasture (2 Respondents)	0-5	0 -10
Sugarcane (1 Respondents)	0-5	0- 10

Assuming that the average willingness to pay in this case is half that of delivered compost ($3.5/ton), then all the calculations made for the delivered compost should be cut into half.

Potential Barriers to Compost Use in Various Markets

The survey results indicate that the most significant barriers to all potential compost users are:

1. **Quality:** All growers (100%) in the survey area are particularly concerned about the quality of the compost. In general, users are concern about salt content, pH, heavy metals, seed weeds, potential plant disease, glass and plastic contents and other contaminants. In addition, a consistent quality product is important because growers will need to rely on the continuing performance of a compost product over time.

2. **Cost:** Product cost is very important to all end-users. In general, the quality of compost determines the cost in various markets. Many growers are willing to pay more for good quality composts. For example, vegetable growers are willing to pay up to $32/ton for a good quality compost while sod growers, sugar cane growers and landscapers are more interested in less expensive compost product (up to $10/ton).

3. **Transportation:** Transportation could be a potential barrier to the use of compost in locations with more that 100 miles from compost facilities. For growers that don't use high quality/more expensive compost, transportation is a real barrier. However, good compost, especially if it is bagged, could be transported to longer distances for sale. The barriers to compost markets in different markets are shown in Table 4.

Table 4. Potential Barriers to Compost Use in Various Markets

Compost Users Group	***Potential Barriers to Compost Use***
Citrus (18 Respondents)	Cost, Quality, Transportation
Vegetable Crops (13 Respondents)	Cost, Quality, Transportation, Application
Nurseries (4 Respondents)	Cost, Quality, Transportation
Landscapers (2 Respondents)	Cost, Quality
Sod (2 Respondents)	Cost, Quality, Transportation
Pasture (2 Respondents)	Cost, Quality, Transportation
Sugarcane (1 Respondents)	Cost, Quality, Transportation

Conclusion

Florida is a leader in composting organics with 12 permitted composting facilities. Several of Florida's composting facilities are among the largest commercial facilities in the U.S. For example, the Enviro-Comp facility in Jacksonville is one of the largest yard trimming composting facilities, Palm Beach Solid Waste Authority operates one of the largest and most successful co-composting facilities (biosolids and yard trimming), and Sumter County composting facility is one of the nations longest operating MSW facilities.

Studies have shown that compost market capacity exists far in excess of the capacity to produce compost in Florida. While the Florida compost market may be as large as 42 million cubic yards per year, the survey of a 100-mile radius of the Okeechobee region shows current compost usage at 84,395 tons, with a potential market of 377,500 tons.

Appendix

The following questionnaires were prepared and sent to 200 end-users in the area for the compost market assessment:

Question 1: What is your type of business?
Citrus grower
Nursery
Landscaper
Golf course
Vegetable grower
Other

Question 2: Where is your business located?
Name of the town
Name of the county

Question 3: What is the approximate distance of your business from the Okeechobee town, north of the lake Miles
0 – 50
50 – 100

Question 4: Has your business used compost within the past three years?
Yes
No

Question 5: Approximately how much compost did you apply last year
Answer in tons
Answer in cubic yard

Question 6: Approximately what is the potential annual amount of compost your business could use?
0-20 cubic yard
21-50
51-100
More than 100

Question 7: Approximately how much did you pay?
$/per one ton of compost
$/per one cubic yard of compost
Not available

Question 8: What are your concerns in compost utilization?

Cost
Quality
Consistency in availability
Transportation
Others

Question 9: How much you are willing to pay for a delivered cubic yard of a good quality compost (good texture, rich in nutrients, low soluble salts, optimum moister content with no toxic material)?
$0 - $5
$6 – $10
$11 - $15
$16 - $20
More than $20

Question 10: How much you are willing to pay for an undelivered cubic yard of a top quality compost from a facility close to Okeechobee town?
$0 - $5
$6 – $10
$11 - $15
$16 - $20
More than $20

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Appropriate Technologies for Composting Aquatic Plants

Introduction

Aquatic plants are very high in water content. Consequently, composting such material would require a bulking agent. If the material after harvesting was air dried, the volume would be reduced significantly and the amount of bulking agent needed would be reduced.

Composting is an aerobic process. During composting the organic matter decomposes. The biological decomposition is the result of metabolic activity of microorganisms. During microbial decomposition heat is evolved. Temperature rises in the matrix and will change from mesophilic temperatures to thermophilic temperatures. As the microbial activity is reduced as the result of less available carbon, temperatures decrease from thermophilic to mesophilic and eventually reach ambient. The principal factors affecting the metabolic activity of the microorganisms are:

- Moisture
- Carbon to nitrogen ratio
- Temperature
- Oxygen

In composting the ideal moisture content of the matrix is in the range of 40 to 60 percent. Below 40 percent, microbial activity decreases and can cease at very low moisture. This results in reduced decomposition of the organic matter. Above 60 percent the pore space in the matrix is reduced to that oxygen cannot be available to the aerobic microorganisms. Consequently anaerobic conditions can occur which results in the formation of compounds that produce obnoxious odors.

Carbon and nitrogen are essential for metabolic activity of the microorganisms. Carbon provides the energy source, while nitrogen is used by microorganisms for cell growth and development.

As indicated, as a result of metabolic activity by the organisms, energy in the form of heat is released and temperatures in the matrix rise. Although the greatest rate of decomposition occurs under metabolic temperatures, thermophilic temperatures destroy pathogens and weed seeds.

Oxygen is necessary for aerobic decomposition. Both aerobic and facultative bacteria utilize oxygen. During aerobic decomposition primarily water and carbon dioxide are produced. If the piles become anaerobic compounds such as hydrogen sulfide, reduced sulfur compounds and amines are formed.

There are three technologies that could be appropriate for composting water hyacinths and algae that would be harvested from Florida waters. These are;

- Windrow
- Forced aeration or aerated static pile (ASP)
- Passive aeration (PAWS)

A combination of two of these technologies may be very appropriate for a specific site.

Windrow

The windrow method involves the formation of elongated windrows or piles. The width of the windrows depends on the type of equipment used. The machine traverses either through the pile and turns the material or the piles can be turned periodically with a front end loader (FEL).

Aeration in the windrows is primarily achieved through convective air flow. As the windrow heats in the center air is drawn in from the sides. Turning the windrow periodically achieves mixing and allows all the material to reach higher temperatures.

The advantages to this method are:

- Wetter materials could be handle resulting in lower materials handling
- Equipment could be transported and used at several facilities
- Less bulking agent may be needed
- Better homogenization or mixing is achieved in comparison to the static methods.
- No electric power is needed

The disadvantage to this method is the need for considerable space. However this depends on the equipment used. Windrow equipment can produce windrows ranging from 14 to 18 feet wide and four to seven feet high.

A screen may be needed to provide specific quality products especially if a bulking agent such as brush or bagasse is used

The block method is an adaptation of the windrow where large blocks are formed by either a specific type of windrow e.g. Scat or with an FEL. These blocks are moved periodically. The advantage to this method is the use of less space.

Forced Aeration or Aerated Static Pile (ASP)

This method shown in Figure 1 was developed by the United States Department of Agriculture for composting sewage sludge or biosolids.

The mixture of material to be composted is placed over an aeration system and air is either forced into the pile or withdrawn. Temperature control is achieved through aeration control.

The method requires a bulking agent such as brush or wood chips in order to provide porosity in the matrix. However, to reduce the volume of a relatively coarse bulking agent, compost can be used. The compost increases the solids content, thereby reducing the amount of the coarse bulking agent. Shredded rubber tires can be substituted for some or most of any wood chips or brush. These can be recovered by screening and reused.

The advantages to this method are:

- High temperatures are achieved rapidly resulting in disinfection and weed seed destruction
- Generally a shorter period of time is needed for composting and curing.
- The only equipment needed is a FEL.
- There is no turning during the composting or curing period

Another piece of equipment, while not essential, is a screen. The screen is valuable when it is cost effective to recover and reuse the bulking agent or when there is a higher paying market for a product having a specific particle size.

The major disadvantage is the need for electric power to run blowers.

Figure 1. Aerated Static Pile

Passive Aeration (PAWS)

This method is shown in Figure 2. It was developed in Canada and primarily used for fish waste and food waste. However, it has also been used for sewage sludge.

The method consists of placing the material to be composted over a series of perforated pipes that are open on both ends. As the pile is heated up air is drawn through the pipes.

The PAWS technology is employable for both short and long windrows. For the smallest short scale, the compost heaps are 1.5 meter (5 1/2 ft) high, trapezoidal in cross-section, with base and top planes of 3 m x 2 m (9.8 x 6.6 ft), and 2 m x 0.3 m (6.6 x 1 ft), respectively. A basal 10 to 15 cm (4" to 6") layer of peat or any mature compost is laid in a fluffy state on the ground. Two 3 m (9.8) long standard PVC or ABS soil pipes, 10 cm (4 inch) in diameter with perforations 1.2 cm (0.5 in) in diameter are placed lengthwise on the basal layer about 0.6 m (2 ft) from the margins. The two parallel rows of perforations at 5 cm (2 in) intervals are about 10 cm (4 in) apart on the two sides of the apex. Such pipes are routinely used for discharging and spreading effluents from septic tanks in North America, collecting leachates from landfills or drainage pipes. Mixtures of layers of materials to be composted are placed on the pipes to a height of about 1.3 meter (4.3 ft), and then the mass is covered with peat or any mature compost as an envelope.

Figure 2. Passive Aeration (PAWS)

On the medium scale, passively aerated windrow with one series of pipes placed cross the base can be of any length, 1.5 m (5 ft) high and 3.1 m (10 ft) wide.

Even larger passively aerated piles have been found to be effective for composting farm manures containing straw or wood shavings as litter. Two pipes were joined to provide aeration ducts of 6.1 m (20 ft) length to build windrows of 6 m (20 ft) width and 3 m (10 ft) height. A further modification recently achieved obviates the need for the aeration pipes by using a open plenum below the composting mass that is placed directly on a perforated platform. This has so far been tested successfully for farm manures only.

The length of the medium and large-scale passively aerated windrows has no technical limit.

Wood wastes and mature compost can be used instead of peat in some situations.

Temperatures in the interior of the windrows rise within 2 or 3 days, attaining the thermophilic range of 45 to 65^{o}C within 10 days even at ambient temperatures of 4 to 10^{o}C. The oxygen concentration decreases during the warming up phase to less than 5%, but as the mixture heats up to 45^{o}C or so fresh air starts to be pulled through the pipes. Thereafter, the oxygen concentration generally stays between 13 and 18% during the thermophilic phase which may last for as long as 8 weeks, depending upon the material to be composted. When the composting mass cools down to 30^{o}C or ambient conditions, the compost can be reheaped for curing and the pipes reused for another windrow.

The advantages to this method are:

- No power is needed except fuel for the FEL
- No turning during composting and curing
- The only equipment needed is and FEL and a screen. The latter depends on the product that is to be produced and the need to recover the bulking agent.
- A smaller area is needed in comparison to the windrow system
- High temperatures can be achieved in a shorter period of time than with the windrow system. These results in disinfection and destroying of weed seeds.

Disadvantages:

- A FEL and screen are needed
- Pipes are needed (these can be disposable or reusable)

Material Balance

Since both the ASP and PAWS systems would require a coarse bulking agent such as brush or bagasse, a materials balance is shown in Table 1. This was needed to develop the economic costs.

Table 1. Material for Biomass on a per Day Basis (260 days per year) for the ASP and PAWS Systems

Material	Volume	Wet Weight	Dry Weight	Volatile Solids	Bulk Density	Solids Content	Volatile Solids
	(CY)	(Tons)	(Tons)	(Tons)	(Lbs/CY)	(%)	(%)
Wet Biomass	51.6	41.8	2.7	2.7	1620	6.5	100
Wood waste	141.5	35.4	23	21.9	500	65	95
Recycle	126.7	44.0	24.2	22.5	695	55	93
Mixture	295.8	117.5	46.7	42.0	794	39.8	90
Composting losses		53.2	4.2	4.2			
Curing	212.9	83	45.7	39.8	780	55	87
Curing losses		3.6	2.0	2.0			
Screen feed	176.4	79.4	43.7	37.8	900	55	87
Recycle	126.7	44.0	24.2	22.5	695	55	93
Storage	78.6	35.4	19.4	15.3	900	55	79

It is apparent that the low solids content of the biomass greatly affects the materials balance. One option is to air dry the biomass prior to constructing piles or windrows. In Florida several communities use air drying bed to increase the solids content. This would be most appropriate in the dry season for a facility that would handle a large quantity of material.

Economics

The economics of composting is sensitive to facility size. Larger facilities are able to utilize a single piece of equipment and therefore the handling cost per unit is reduced. Since a specific site is not specified, the assumption in the analysis is for a single facility capable of handling 10,869 tons per year of biomass or 20 MGD facility.

In assessing the economics of the ASP or PAWS methods, the major issue is the availability and cost of the bulking agents. As indicated earlier, compost can be substituted for some of the coarse bulking agent but a certain amount of a coarse material is needed for porosity. Davenport, IA substitutes 1/3 of the bulking agent with shredded rubber tires. If a free source of chipped brush or wood chips is available e.g. from companies chipping brush, then the economics could be quite favorable. Furthermore, by air drying the biomass, a smaller volume of bulking agent would be used. In several facilities where bulking agents are used, shredded rubber tires, which are recoverable, are being used. The use of sugar cane bagasse would also be a good bulking agent.

The PAWS system should be the least cost system. The PAWS would need a FEL and possibly a screen. There are several factors, which could affect its cost. The purchase and amortization of a FEL and screen is the major capital cost. The pipe used could be either disposable or recoverable. In Table 2 the cost of purchasing new equipment and using disposable pipe is shown. As indicated these costs could be substantially reduced by purchasing use equipment and recovering and reusing the pipe. This is done in several facilities.

The estimated cost for the PAWS using new equipment and disposable pipe is shown in Table 2.

Table 2. Estimated cost for PAWS system not including site costs.

ITEM			
Capital Cost			**Cost -$**
FEL – 5 cy			160,000
Screen			80,000
Total			240,000
Amortization 10 yr@ 6%			31,980
O&M Cost			
Labor	Cost/unit	Units	
Equipment operator	$30/hr	2080 hrs	62,400
Facility manager	$40/hr	199 hrs	7,960
Laborer	$15/hr	2080 hrs	31,200
Equipment operating costs	$20/hr	1560 hrs	31,200
Pipe and fittings (disposable)	$2/ft	9,700 ft	19,400
Miscellaneous @ 10%			18,414
Total O&M cost			167,376
Total Annual Costs			**199,356**
Cost per cubic yard of biomass			**9.58**

Table 3 shows the sensitivity analysis depending on the sale of the compost. The production of compost is based on the material balance shown in Table 1.

Table 3 Cost Sensitivity Based on Product Value

Sale of product	$1	$3	$5	$10
Value of product	20,800	62,400	104,000	208,000
Operating Cost	199,358	199,358	199,358	199,358
Difference	178,556	136,956	95,356	+8,644
Cost/cy	8.58	6.58	4.58	+0.42

This Table indicates that if the product is sold for 10 dollars or more per cubic yard, with new equipment there would be a profit. Obviously, both the capital and operating costs could be greatly reduced.

Conclusion

The most appropriate and least cost method for composting biomass may be the PAWS method especially if there are multiple small sites. The equipment and personnel could be moved from site to site since there is no material handling during the composting and curing period.

It is recommended that since a site already exists, a pilot study be conducted over a 50-day period to assess the method and determine more exact economics.