Modeling the Design of Windrow Composting Operations to Maximize the Bottom Line

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ABSTRACT

Waste management planners and engineers are sometimes faced with questions of how much land, equipment, labor, and investment is required for a proposed composting operation. The numerous factors that impact process design and costs such as type of materials composted, location of facility, cost of labor, etc. make it tedious to make these assessments quickly. To address this situation, a user-friendly computer program was developed which can be used to design a composting operation based on current scientific and regulatory recommendations. The program uses critical user-inputs such as types of feedstocks, types of equipment, number of workers and location of the facility, to develop a preliminary design of the composting process and facility, and an estimate of capital and operating costs. The user can quickly generate many different design scenarios that can be used to estimate the feasibility of composting as a waste management option.

KEYWORDS. Composting, Process design, Computer tool, Cost

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INTRODUCTION

Composting is a biological process for stabilizing organic waste materials (feedstocks), where bacteria and fungi utilize the feedstocks as carbon and energy sources, converting them to stable value-added compost product used in landscaping or agriculture. Because composting is environmentally friendly and allows reuse of natural resources, it is becoming a popular waste management option. For example, the number operations that compost yard trimmings has risen 280% in the last decade to over 3,800 facilities nationwide (Goldstein and Madtes, 2000). Many states have goals of diverting and recycling 25 to 50 % of materials currently going to landfills. This trend has created opportunities for small businesses to start mid-scale composting operations (15 to 150 tonnes/day) targeting yard trimmings, livestock manure, food waste and some industrial organic byproducts.

Unlike backyard composting, commercial-scale composting is a complex operation requiring proper process design and management. A well-designed commercial operation has seven defined steps: [1] feedstock recovery, [2] feedstock preparation, [3] composting, [4] stabilization, [5] curing, [6] refining and [7] storing (USCC, 1994). Feedstock recovery is the process of removing the compostable fraction from a mixed waste stream. Feedstock preparation involves processes that initially establish optimal particle size, nutrient balance and moisture content of the feedstocks to facilitate microbial growth. Particle size reduction, addition of carbon or nitrogen amendments and addition of water are performed during this step. Recommended targets include particle sizes of 5 to 25 mm, a C:N ratio of 30 to 45 and a moisture content of 60 to 65% (Haug, 1993). Composting, stabilization and curing are steps where conditions are maintained to accelerate microbial decomposition and stabilization of the feedstock. Typically temperature is maintained in the thermophilic range [45-65°C] and feedstocks are mixed periodically to homogenize them and provide aeration. These processes require 30 to 180 days depending on the type of feedstocks and desired level of stability of the final product. A compost product is stable when its biological activity is minimal. This can be characterized by low oxygen uptake rates and low biological heat production. Stable compost is also likely to be odor-free. Refining of the compost involves screening, metals separation, removal of inert contaminants, etc. Refining and storing are optional steps that depend on market needs. Each of these seven process steps require adequate space and equipment, which can affect the capacity, efficiency and the cost of operation. An operation that is not sized and designed properly can have such common problems as poor product quality, high cost of operation, operating below capacity, and odor nuisances.

The cost of composting reported in the literature varies as a function of the scale of operation, type of feedstock and type of technology used (USCC, 1996). Operating costs of municipal solid waste composting range from $36 to $72/tonne (Curtis et al., 1992). In comparison, operating costs for operations composting yard trimmings range from $2 to 3/tonne (Renko et al., 1994). Total capital and operating costs for yard trimmings composting range between $9 and 28/tonne depending on amount of grinding, duration of composting and location of facility (Steuteville, 1996). Because of the wide range of conditions that impact cost, feasibility studies require information involving specific conditions to calculate the cost of composting.

The design of a composting facility is very complex because of the large number of variables that impact the process, facility size, equipment needs and operating cost. For this reason, a computer software tool can be particularly useful for preliminary screening in feasibility studies. Some software tools for composting process design have been developed in the past (Pike, 2000; Person and Shayya, 1994; Brodie, 1994). Of these, COMPOST© is the most comprehensive design program available (Person and Shayya, 1994). Other programs cover only the feedstock mixing ratios based on a target C:N ratio and moisture requirements. The computer software COMPOST© can be used for the design of an aerated composting system. COMPOST© uses feedstock characteristics as input and provides the required amendments, final compost moisture content and aeration requirements as design outputs. This design program, however, does not address turned windrow systems, leachate collection and treatment, nor the economics of the composting operation.

To address the limitations and needs discussed above, a user-friendly computer program for the design of a composting operation (Compost Wizard©) was developed by adapting techniques and information from a variety of sources. The design program is targeted for turned-windrow composting, because this is the most commonly used approach for mid-scale commercial composting (USCC, 1994). In this system, feedstocks are stacked in long piles (windrows) with a triangular cross-section approximately 4.9 m wide and 1.5 m tall. The contents of the windrows are periodically turned (mixed) to ensure homogeneity, increase porosity and to assist aeration.

A typical Compost Wizard© user would be a designer or project evaluator who will need to provide critical user-inputs such as feedstock properties, geographical location of proposed facility, etc. and obtains process information; i.e. facility size and cost information as outputs. The user can quickly vary inputs and rapidly generate several design scenarios from which the feasibility and the appropriateness of composting can be estimated. Once the Compost Wizard© has established a preliminary design, the final detailed design can be conducted or verified by a professional engineer.

DESCRIPTION OF DESIGN PROCESS

The design process for a turned windrow composting facility involves five steps, process design, composting area sizing, runoff collection pond sizing, land treatment design for runoff, and capital and operating cost estimation (Figure 1). The software program is in spreadsheet form in Microsoft Excel® with multiple sheets that are linked to each other. The modules of the design program utilize user-inputs and previously calculated outputs from other modules for calculations. The calculations conducted in each module are described in further detail below.

Composting process design

In order to maintain rapid composting, feedstocks are blended to provide an initial C:N ratio of approximately 30 and a moisture content of 60% (Haug, 1993; Epstein, 1997). It is assumed that feedstocks available for composting are free of contaminants and are reduced to a particle size of from 5 to 25 mm. Feedstock quantities (tonnes/day), feedstock properties (C:N ratio, moisture content and bulk density) and target process conditions are required as inputs. Starting with a randomly chosen mix ratio, the fraction of each feedstock in the mix is iteratively adjusted until a total C:N ratio of 30 (or other user selected value) is obtained. This provides the blending ratio of available feedstocks and the amount of additional amendment required.

Composting area sizing

The required land area for composting is calculated by Compost Wizard© by converting feedstock throughput from mass (tonnes/yr) to volume (m^3/yr) using individual feedstock bulk densities. The total daily throughput is calculated by a direct sum of individual feedstock throughputs and assuming 250 operating days per year. This calculation assumes that volumes are additive. The estimated facility size therefore is conservative because in practice blending two materials would result in a lesser volume than estimated.

The duration of composting, anticipated shrinkage and amount of product storage are input by the user. In addition, duration and shrinkage for the curing process, windrow dimensions and buffer distance required around the facility are input. Windrow dimensions and spacing between windrows are selected based on equipment choice. A specific windrow turner can be chosen based on cost and/or capacity. Choosing higher capacity equipment results in a lower calculated operator time. This impacts the labor requirements for the operation, which are calculated later in the economics module. Product storage period is specified by the user based on the desired amount of product needed for a seasonal market.

The user selects the windrow length. The total number of windrows is obtained by dividing the total feedstock on the composting pad by the volume of a windrow, which is calculated using windrow length and cross-sectional dimensions. The total amount of feedstock in the composting pad at any time is calculated with shrinkage assumed to be linear over time. This assumption adds a safety factor because most often during composting the volume reduction is more rapid during the initial stages.

The user inputs a buffer distance that is used to calculate additional land area requirements. Total composting area is the total of composting, curing, storage and buffer areas and is displayed as a graphical sketch along with numerical outputs of area required, product generated, additional amendment and water required.

Runoff collection pond sizing

In many states, depending on the type of feedstock processed, regulations require the collection and subsequent treatment of all surface runoff from a composting site. In Georgia, composting of biosolids or mixed wastes requires a collection pond with a capacity greater than the expected runoff from a 24 hour-25 year rainfall event (GA EPD, 1996). The design criterion used in Compost Wizard© is based on the highest monthly rainfall from a 30-year historical weather data set, which will provide a pond volume greater than the 24 hour-25 year rainfall event.

A brief summary of the pond and land treatment design is presented here, for additional details see US EPA (1981) and Crites and Tchobanoglous (1998). In Compost Wizard©, the user selects the geographical region where the facility will be located. The program then automatically references the 30-year historical weather data for that region and bases the design on the month with maximum precipitation in that region. The detention pond is sized to collect this projected maximum runoff. The user specifies desired pond depth and length at the surface. These variables can be changed to satisfy the available land area, e.g. increasing the pond depth in order to reduce surface acreage. The pond is sized and its volume, width at the surface, and surface acreage are calculated using the method described by Crites and Tchobanoglous (1998).

Land treatment design

The land treatment system design is adapted from regulatory guidelines (GA EPD, 1992; US EPA, 1981). Since the collected runoff is directly sprayed onto the land, the land area required for treatment is controlled by either the hydraulic budget of the soil, i.e. the water infiltration capacity of the soil, or the nitrogen balance of the cover crop that consumes the applied nutrients. The Compost Wizard© requires that the user input the soil hydraulic conductivity value, which can be obtained from the USDA-NRCS soils database. Typical values for Georgia soils range from 1.4×10^{-6} to 14×10^{-6} m/sec depending on soil type. Using the hydraulic budget calculation, the total land area required for treatment is determined.

To address nutrient loading, a nitrogen balance on the cover crop in the treatment area is conducted. The user specifies the cover crop and inputs values of total nitrogen and ammonia nitrogen concentrations in the runoff. Typical values for composting are 20 to 25 and 1 to 2 mg/L, respectively (Nutter and Overcash, 1999; Cabrera, et al., 1998). The nitrogen balance includes inputs to the system from the applied runoff and precipitation, and losses from the system through ammonia volatilization, denitrification and plant uptake. The amount of land base for treatment and the residual nitrate concentration in ground water are variables in solving the nitrogen balance. The land base required is varied to achieve the user specified residual nitrate concentration (typically 5-10 mg/L). The plant uptake rates are obtained from Plank (1989) while the ammonia volatilization and denitrification parameters are obtained from USEPA (1981). The greater of the two estimated land treatment areas, based on the hydraulic budget method and the nitrogen balance method, is used as required land area needed for treatment.

Capital and O&M Costs

The cost of composting is a function of the number of unit operations, type of equipment, number of employees and throughput of the operation. This module allows the user to input wages for skilled and unskilled labor, equipment, number of windrow turns per cycle, optional road access, land costs, construction costs, insurance, etc. Typical costs and capacities for equipment are provided. Information on wages, land costs, and construction costs can be obtained from State labor statistics (DCA, 2001), national statistics (USDA, 2000), and estimates from local construction engineering firms.

The number of operator hours for windrow turning is calculated based upon the total amount of material on the pad, the capacity of the turner and the number of turns for a given cycle. Similar calculations are performed for other unit operations and for general materials handling. The minimum required number of employees is calculated assuming one employee for every 2,000 person-hours per year operator time. The user can specify additional employees for miscellaneous operations such as, quality control laboratory, management, etc. Energy costs are calculated using the total power rating of all equipment, fuel consumption rate and total operating hours. Insurance is estimated as 10% of the total capital cost for facility insurance and the user-specified $/employee-month (typically 37% of wage) for individual insurance. Annual maintenance and repair costs are estimated to be equal to 10% of the total cost of equipment. Energy, insurance and maintenance levels are values typically used in engineering cost estimation (Peters and Timmerhaus, 1991; J. Sellers, personal communications, Athens, Georgia, 22 January, 2001).

The second portion of this module calculates a cash flow statement using adjustable inputs on tipping fee, bulk product sales, interest rate and life of loan. The total cash flow summary is provided to allow users to change inputs and estimate the $/tonne cost of processing and the expected net income.

EXAMPLE SIMULATION: Feasibility of proposed composting operation

The design software was used to conduct a preliminary design of a proposed mixed-waste composting site in southwest Georgia (Governo et al., 2000). Three southwest Georgia counties currently dispose of 26,000 tonnes of municipal solid waste (MSW) to landfills every year. The counties wanted to evaluate composting as an alternative option.

Historical data on MSW production were obtained from county and landfill records. A survey of wastewater treatment plants, industries, and farms in the area provided 5,261 tonnes per year of additional compostables such as cotton gin trash, peanut hulls and biosolids. These feedstocks were sampled and analyzed for bulk density, moisture content and C:N ratio using methods described in the test methods for evaluation of compost and compostable feedstocks (USCC, 2000). The data were input to the Composting Process Design and Area Sizing Module (Figure 2). Duration of composting, shrinkage factor, dimension of windrows, and spacing between windrows for composting and curing were inputted into the module. Buffer around the composting pad was selected to be 15 m and it was desired to store 30 days of saleable product on site.

The geographical location of the proposed facility is in Region 5 of Georgia (Figure 3). The detention pond was selected to be 3.7 m deep with one linear surface dimension to be 76.2 m long. The soil hydraulic conductivity was input as 7.1 X 10^{-6} m/sec and pine trees were chosen as the cover crop. The nutrient strength of the runoff was entered as 23.5 and 1.7 mg/L for total nitrogen and ammonia nitrogen, respectively (data not shown).

For this scenario a wage rate of $20/hr for skilled labor and $12/hr for unskilled labor was used (Figure 4). Two large self-propelled turners, three front-end loaders, one vibrating screen and four dump trucks were specified for required equipment. For the amount of materials on site, one turner would have been sufficient. However, because of its high usage demand, an additional windrow turner was specified in order to avoid situations where maintenance of one unit affects daily operations and throughput. Cost of land was specified as $4,942/ha based on local prices; construction costs were preliminary estimates obtained from a construction company; four skilled worker and 5 unskilled were specified for facility operation (Figure 4). Two skilled operators were required based on the number of operator-hours needed for the specialized equipment. Two additional skilled workers were specified as a general manager and a quality control/laboratory manager.

RESULTS OF SIMULATION AND DISCUSSIONS

The feedstocks available to compost were higher in total carbon than nitrogen, therefore to obtain a C:N ratio of 30, additional N-amendment was required. The results show that for processing 187 tonnes/day and product storage equivalent to 30 days of production, six hectares of composting, curing, storage and buffer area would be required (Figure 2). Additionally, 62.4 tonnes/day of a nitrogen amendment with a C:N ratio of 6 and moisture content of 83% and 3,783 m^3/day of water for moisture adjustment would be required. If the nitrogen amendment had different properties, e.g. lower moisture content or different C:N ratio, this can be easily entered into the process design module to recalculate the mixtures. When the operation is fully functional, 307 m^3 of product would be generated per day.

The amount of runoff from the 6-ha site under a worst-case scenario was calculated to be 16,975 m^3 (Figure 3). To collect this runoff, a pond with a surface area of 0.56 ha and a depth of 3.7 m would be required. The rainfall and evapotranspiration data used to calculate the amount of runoff that needs to be treated are shown in Table 4. It was determined that the highest leachate/runoff treatment needs occur in January and amounts to 15,164 m^3. Based on the hydraulic budget and the nitrogen balance, 7.39 or 14.26 ha would be required to handle this runoff in a land treatment system. The higher of these two, 14.26 ha would be used for designing this treatment system.

Total capital costs were found to be $1,335,000 or $7,139/tpd capacity. Annual operating costs were calculated to be $616,090 (Figure 4), translating to a total cost (operating + payments on capital) of processing equal to $22.26/tonne, which includes a 25% contingency buffer (Figure 5). The land costs represented less than 10% of total capital cost, while equipment represented 67% of total capital cost. Figure 5 outlines cash flow at this facility using revenue from the user defined tipping fee ($33/tonne) for some of the feedstocks. Product sale income was not accounted for in this feasibility study, however estimated revenue in $/tonne of compost can be input if market potential is clearly identified. Using a 7.5% interest rate and 10-year pay back period, the estimated yearly income at this facility would be $85,908. Because present costs of landfill-disposal is over $38.5/tonne, the composting option at an estimated cost of $22.26/tonne is concluded to be economically feasible. The operation would generate an income, employ nine persons and handle the municipal solid waste in an economical and environmentally advantageous manner.

SUMMARY AND CONCLUSIONS

Composting at the commercial scale of 15 to 150-tons/day is a complex process involving many steps. Often cost and feasibility of composting is not well understood because of the complexity of the design process. To facilitate the quick assessment of costs, feasibility and initial design of the composting operation, a spreadsheet based design program, Compost Wizard©, was developed. The program requests user input on the proposed operation and conducts a process and facility design. Useful process outputs include amount of additional amendment required, make up water required, amount of land required for composting, curing, storage, and land treatment, size of runoff collection pond and estimated capital and operating costs. The program was used in a real world feasibility study conducted at a southwestern Georgia county for a proposed 187-tonnes/day MSW composting operation and proved to be a valuable tool at analyzing the impacts of various design options on cost and feasibility. In particular, it allows the user to estimate processing costs and compare these to other alternatives

REFERENCES

Brodie, H.L. 1994. Multiple component compost recipe maker. ASAE Paper No. 94-3020/94-3063. St. Joseph, Mich.: ASAE.

Cabrera, M.L., J.A. Rema, D.E. Radcliffe and L.T. West. 1998. Monitoring water quality at a food waste composting site. In Proc. Composting in the Southeast Conference, 163-167, Athens, Georgia, 9-11 Sept. Athens, Georgia: The University of Georgia.

Crites, R. and G. Tchobanoglous. 1998. Small and decentralized wastewater management systems. Boston: McGraw Hill publishing company, Inc.

Curtis, C., G. Brenniman and W. Hallenbeck. 1992. Cost calculations at MSW composting sites. *BioCycle* 33(1): 70-72.

DCA, 2001. Department of community affairs wage and salary survey report. Atlanta: State of Georgia.

Epstein, E. 1997. The Science of Composting. Lancaster: Technomic Publishing Company, Inc.

GA EPD, 1992. Criteria for slow rate land treatment and urban water reuse. Atlanta: State of Georgia environmental protection division.

GA EPD, 1996. Rules and regulations for water quality control Chapter 391-3-6. Atlanta: State of Georgia environmental protection division.

Gies, G. 1995. Commercial and Institutional Organics: Composting Residential and Commercial Streams. *BioCycle* 36(5): 78-79.

Goldstein, N. and C. Madtes. 2000. The state of garbage in America. *BioCycle* 41(11): 40-47.

Governo, J., B. Kiepper, K.C. Das and J. Sellers. 2000. Bioconversion feasibility study for Clay, Quitman, and Randolph Counties, Georgia. University of Georgia Engineering Outreach Division, Athens, Georgia.

Haug, R.T. 1993. The Practical Handbook of Compost Engineering. Boca Raton: Lewis Publishers Inc.

Jones, B.J. 1992. The Farm Connection: Composting Food and Vegetative Waste. *BioCycle* 33(3): 69-71.

Nutter, W.A. and M. A. Overcash. 1999. Design development report land treatment system. Unpublished report to the University of Georgia: Bioconversion Facility. Athens: Nutter, Overcash and Associates, Inc.

Person, H.L. and W.H. Shayya. 1994. Composting process design computer model. *Applied Engineering in Agriculture* 10(2): 277-283.

Peters, M.S. and K.D. Timmerhaus. 1991. Plant design and economics for chemical engineers. New York: McGraw-Hill publishing company, Inc.

Pike, R. 2000. Compost Recipe-EZ. Pike Agri-Lab Supplies, Strong, ME.

Plank, C.O. 1989. Soil test handbook for Georgia. Georgia Cooperative Extension Service. AthensL The University of Georgia CAES.

Renko, M., C. Safley, and J. Chaffin. 1994. A cost analysis of municipal yard trimmings composting. *Compost Science and Utilization* 2(2): 22-34.

Riggle, D. 1991. Carolina Trials: Composting Rural Landfill Wastes. *BioCycle* 32(10): 62-65.

Rynk, R. 1992. On-Farm Composting Handbook. Ithaca: Natural Resource, Agriculture, and Engineering Service. Document No. NRAES-54.

Steuteville, R. 1996. How much does it cost to compost yard trimmings. *BioCycle* 37(9): 39-40.

USCC. 1994. Compost facility operating guide. Section 1.4, pp. 7. Alexandria: U.S. Composting Council.

USCC. 1996. Municipal-Scale Composting: A Decision Makers Guide to Technology Selection. Alexandria: U.S. Composting Council.

USCC. 2000. Test methods for the evaluation of composting and composted products. Alexandria: U.S. Composting Council.

USDA. 2000. Agricultural land values. Washington: USDA, Agricultural Statistics Board.

USEPA. 1981. Process design manual for land treatment of municipal wastewater. Document No: EPA 625/1-81-013.

Wei, Y.S., Y.B. Fan, M.J. Wang, and J.S. Wang. 2000. Composting and Compost Application in China. *Resources, Conservation and Recycling* 30, 277-300.

APPENDIX

Figure 1. Steps in the design of a turned windrow composting facility. Blocks on the left list user-inputs to each sub-section shown on the right. Blocks on the right show selected key outputs of the individual program modules.

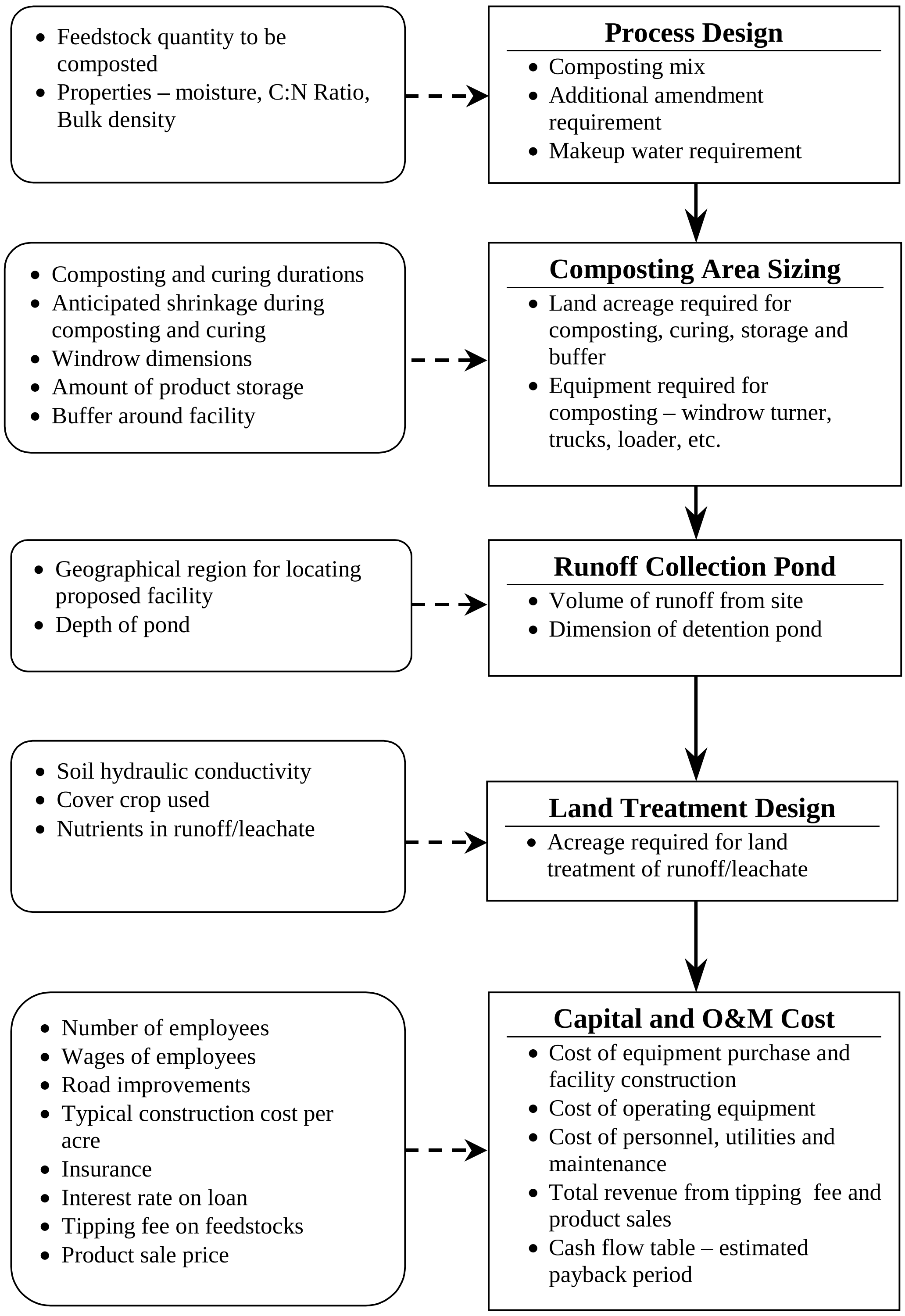


Figure 2. Composting process design and process area sizing module screen.

Compost Wizard 1.0

Composting Process Design and Area Sizing Module

INPUTS

Process Design Inputs

	Tonne/yr	Bulk Density [kg/m^3]	C:N	MC [%]
Carbonaceous Feedstocks				
MSW	25,945	255	33	39
Cotton Gin Trash	4,173	151	27	10
Peanut Hulls	181	208	51	17
Nitrogenous Feedstocks				
Biosolids	907	831	6	83
Additional required	15,604	831	6	83

Target Process Conditions		
C:N Ratio	30	[-]
Moisture content	60	[%]
Duration of product storage	30	days

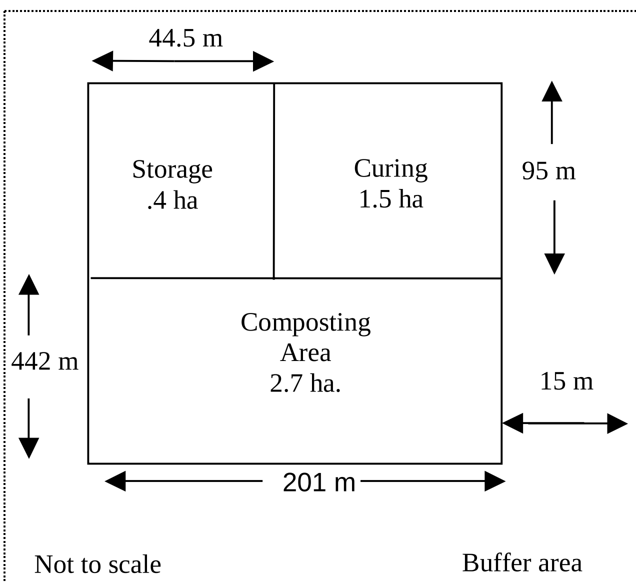
Area Sizing Inputs

Composting, Curing and Storage Parameters

Composting		
Duration period	70	Days
Shrinkage factor	40	%
Windrow length	198	m
Windrow height	2.4	m
Windrow width	5.5	m
Windrow spacing	1.5	m
Buffer around fence	15	m
Curing and Storage		
Duration period	70	Days
Shrinkage factor	10	%
Windrow height	2.4	m
Windrow width	5.5	m
Storage pile height	3.7	m
Storage pile width	6.1	M

OUTPUTS

Illustrative example of facility layout



Numerical design outputs

Daily composting throughput	187	tonne/d
Daily composting throughput	569	m^3/d
Windrow volume	1,767	m^3
Number of windrow required	19	[-]
Total material in composting	31,868	m^3
Composting area	2.7	ha.
Curing area	1.5	ha.
Storage area	0.4	ha.
Buffer area around fence	1.4	ha.
Total land area required	**6.0**	**ha.**
Total product expected	**307**	**m^3/d**
C amendment required	**0.0**	**tonne/d**
N amendment required	**62.4**	**tonne/d**
Make up water required	**3,783**	**m^3/d**

Figure 3. Runoff detention pond sizing module screen.

Compost Wizard 1.0
Detention Pond Sizing Module

INPUTS		
Select region for facility	**5**	
Depth of detention pond	3.7	m
Side slope of detention pond	45	deg
Length of pond at surface	76.2	m
OUTPUTS		
Total drained area	6.0	ha.
Volume of runoff from site	16,975	m^3
Pond width at surface	**74.6**	**m**
Volume of pond	**16,991**	**m^3**
Surface acreage of pond	**0.56**	**ha.**

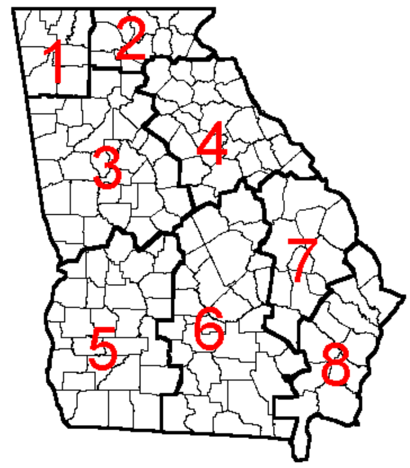


Figure 4. Capital and operating cost calculation module screen.

Compost Wizard 1.0
Capital and Operating Cost Estimation Module

EQUIPMENT AND LABOR COST INPUTS

Labor Cost Inputs		Units	Equipment Needs Inputs		
		Units	Equipment	Name	Units
Skilled labor cost per hour	20	$/hr	Turners[1]	Large Self Propelled	2
Unskilled labor cost per hour	12	$/hr	Loader	Large – 3 cubic yards	3
Amount of road needed	2090	m^2	Screener[2]	Vibrating, large	1
Avg. turns per windrow-cycle	10		Trucks[3]	Medium-size dump truck	4

[1]Typical equipment size, capacity and costs are obtained from NRAES On-farm composting handbook;
[2]Size based on screening of curing area compost;
[3]Working hours required based on transporting compost 30 min (1 hr round trip)

CAPITAL COST SUMMARY TABLE

Capital Costs	# of units	$/unit	Total Cost, $
Land cost			
Compost pad	6.0	4,942	29,800
Pond	0.56	4,942	2,800
Land treatment	14.4	4,942	71,000
Buffer	1.4	4,942	7,000
Total Land	**22.4**		**110,600**
Construction cost			
Compost pad	6.0	14,900	89,400
Pond	0.56	37,500	21,000
Land treatment	14.4	12,326	177,500
Road (m^2)	2,090	18	37,500
Total Construction			**325,400**
Equipment cost			
Windrow turner	2	100,000	200,000
Loader	3	111,000	333,000
Screener	1	120,000	120,000
Dump truck	4	39,000	156,000
Side discharge trailers	3	30,000	90,000
Total Equipment			**899,000**
		Total Capital Costs ($)	**1,335,000**

OPERATING COST SUMMARY TABLE

Operating Costs (annual)	$/employee-month	# of employee	Operating cost, $/yr
Skilled Labor – wages and benefits	3,333	4	160,000
Unskilled Labor – wages and benefits	2,000	5	120,000
Facility & Employee Insurance	600		78,150
Utilities & Supplies			64,840
Maintenance & Repair			89,900
Additional amendment cost[4]			103,200
	Total Operating Costs ($/yr)		**616,090**

[4]Additional nitrogenous amendment is purchased at $6.61/tonne.

Figure 5. Facility cash flow calculation screen.

Compost Wizard 1.0
Cash Flow Module

	REVENUE GENERATION		
	tonnes(unit)	**$/unit**	**Total**
Tipping Fees			
MSW	25,945	33.07	858,000
Biosolids	907	33.07	30,000
Total annual tipping fee income			**888,000**
Product Sales	**m^3/yr**		
Bulk Sales	71,134	0	0
Total Annual Revenue for Facility (tip+product sale)			**888,000**
Total Monthly Revenue for Facility			**74,000**
	MONTHLY CASH FLOW		
Interest Rate, %			7.50
Life of Loan, yrs			10
Monthly Loan Payment, $/mo			15,500
Monthly O&M, $/mo			51,341
Total Monthly Expenses (O&M + Loan Payment), $			**66,841**
Net Monthly Income, $/mo			**7,159**
Net Annual Income, $/yr			**85,908**
Total Processing Cost, $/tonne			**22.26**