Co-Composter Description and User's Manual
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Introduction

Cornell's Department of Biological and Environmental Engineering and Waste Management Institute have developed Co-Composter, an Excel spreadsheet for the planning of co-composting systems for mixtures of dairy manure and other organic wastes. Co-Composter provides mass and volume balances, area estimations, and a cost analysis of alternate composting systems based on inputs entered by the user.

The model was written by Douglas Haith, Thomas Crone, Adam Sherman, Julie Lincoln, Jeffrey Reed, Suzanne Saidi and Joshua Trembley. Valuable suggestions, data and model testing were provided by Peter Wright, Jean Bonhotal, Molly Moffe, Ellen Harrison, A. Edward Staehr and Wayne Knoblauch.

Although the model has been extensively tested, errors may remain, and the user is advised to interpret results with care. The spreadsheet is intended as a planning tool. Design and construction of actual co-composting systems should be based on professional engineering studies.

Co-Composter is divided into seven worksheets:

> User Input Page
> User Output Page
> Background
> Mass Balance
> Areas and Volumes
> Pad and Building Costs
> Turning and Handling Costs

Most users will rarely need to move beyond the first two sheets, which are the pages where most of the data is entered and the results are returned. The Background sheet describes Co-Composter computations, assumptions and data sources. The remaining sheets detail the intermediate calculations required to transform user inputs to outputs. Experienced users may wish to modify data in these sheets, particularly if they feel their data sources are superior to those used in Co-Composter. In all sheets, user inputs are limited to shaded cells. All other cells are password protected to prevent inadvertent deletion or modification of calculation formulae or other necessary entries.

Co-Composter requires the Analysis ToolPak in Excel. This is selected in Excel from the Add-Ins under the Tools menu. The box to the left of the Analysis ToolPak should be checked. If the Analysis ToolPak does not appear in the Add-Ins section, the Microsoft Office or Excel Setup program must be run to install the Analysis ToolPak.

The remainder of this document describes the User Input and Output pages. Descriptions of the remaining pages are found in the Background sheet.

User Input Section

This section consists of a series of questions through which the user provides information describing her/his composting system. However, every question may not be used, depending on the user's situation. In almost all cases if a question does not relate to a certain situation a zero can be entered. Typical values are also provided to help the user. These typical values have been taken from publications and are referenced in the model.

Co-Composter begins with two introductory questions. First it asks if dairy manure will be composted. This helps the user to find the appropriate first question. Although Co-Composter was initially developed to describe co-composting of dairy manure with other solid wastes, it may also be used to model municipal solid waste and yard waste systems which do not include dairy manure. The second question asks if the manure will be from a digester. This also sends the user to the appropriate first question. Co-Composter handles manure generation in two ways. The first method is calculating it based on herd size and individual cow manure production, and the second is based on user-specification of a daily volume of total digested manure.

Question #1: Manure Production. The user enters herd size and manure production. The herd is divided into heifers, dry cows, and lactating cows. The number of animals is entered for each category along with manure production in ft^3/cow-day. Typical numbers are provided for heifers and dry cows, and a table displaying manure production versus milk production is provided for the lactating cows.

Question #2: Manure Characteristics. The user enters the characteristics of the manure. Co-Composter asks the moisture content, nitrogen content, and C/N ratio.

The numbers entered in these two questions are used to calculate the quantities and characteristics of total raw manure production (nitrogen mass, carbon mass, water mass, etc.).

Question #3: Digested Manure Characteristics. This question is used only if the manure will be from a digester. The user must enter the daily volume of digested manure, density, moisture content, nitrogen content, C/N ratio, percent that will be separated, and percent that will be directly composted. This question then performs calculations similar to those in #1 and #2.

Question #4: Animal Bedding. A table is provided listing several bedding options. Characteristics for each are also provided. The user must select an option for each of the three groups of cows. The user then can enter an average volume of bedding and/or the average volume of flush water used per cow each day. Flush water implies a liquid manure handling system. Also, the percent of manure to be separated (routed through a solid separator) , and percent to be directly composted (without separation) is also asked. This question, along with the next one, help to determine the final characteristics of the manure before entering the separator or the composting system.

Question #5: Milkhouse Liquids. This is a yes or no question regarding wastewater from the milkhouse or parlor. If the wastewater is managed by a separate septic system or enters a different waste stream from the manure, the user should enter no. If wastewater is entering the system, the user must specify the approximate volume per cow. A table is provided to assist the

user with selecting a volume. This number is then multiplied by the number of lactating cows and added into the total manure mixture.

At this point the model returns the total manure (manure, bedding, flush water, and wastewater) and also the amount of the manure mixture that will be separated.

Question #6: Manure Separator Characteristics. This question deals with separator characteristics. Co-Composter asks the moisture content and density of the separated solids, as well as the percent of solids removed from the manure and the percent of separated solids that will be composted. These numbers are all used to calculate the characteristics of the manure that is entered into the composting system. Also in Question #6 the associated costs of a separator must be entered. The cost of the actual unit and the cost of the pipes and pumps associated with the separator must be entered. The cost of electricity must also be entered to calculate the operating cost for the separator.

A manure management diagram is then provided showing the flow of manure from sources to separator, to composting, and "managed by other means."

Question #7: Storage Time. The user must specify the maximum days manure or separated solids will be stored at the composting pad. This number will determine the size of the raw material storage area on the pad.

Question #8: Other Feedstock. The user enters the volume, days of storage and value of any additional materials that will be composted. An annual volume and days of storage must be entered, as well as a tipping fee (money paid to the composter from the provider of materials) or a cost (money paid by the composter to the provider of materials) for each of the materials. These entries are used to calculate a final volume, determine appropriate pad size, and calculate a value of materials (cost or profit).

Question #9: Other Bulking Materials. The user enters the volume, days of storage and value of any bulking agents that will be added to the mixture. Bulking agents are added to increase the porosity of the compost mixture, permitting better air flow. The user must also enter the annual volume, days of storage, and value of each bulking material.

Co-Composter then displays the Compost Mix Characteristics. These are moisture content, C/N ratio, and density. These numbers are calculated by performing a mass balance on all of the data that has been entered into the model. Co-Composter provides appropriate ranges for each of the three characteristics. These ranges provide the best situation for active composting. If a characteristic falls outside of the range it may be difficult to compost effectively. The volume of additional materials or the bulking agents can be adjusted to change mix characteristics. Arrows are provided in Question #8 and #9 to show how each material can affect each characteristic.

Question #10: Composting System. The user must select a composting system and provide the dimensions (height and width) for the windrow. Descriptions of six possibilities are given in the model. The systems are two basic types, a turned windrow system and a forced aeration system. The first five systems are turned windrow systems, 1: turning with bucket loader, 2.1: turning with a small tractor-drawn turner, 2.2: turning with a large tractor-drawn turner, 3.1: turning with a self-powered, tow turner, and 3.2: turning with a self-propelled turner. The last system (4) is a

forced aeration system that requires no windrows and no turning. This system requires a building to control the moisture of the compost and pipes and blowers to pump air through the piles or cells of compost.

The selection of a system has many impacts on the results that Co-Composter will calculate. The system will affect the area requirements for the necessary facilities. For example, Systems 2.1, 2.2, and 3.1 require larger aisles to maneuver a tractor through. Also, depending on the system and equipment, the size of the windrows will change allowing for bigger piles and a smaller pad. The system can also affect the time needed to handle and turn the compost. Each system uses a different type turner which has a different capacity. Therefore a dramatic change in hours needed can result.

The biggest difference that will result from system to system is the cost. Not only will the start-up cost be different, but also the operating and maintenance cost will vary. Depending on the amount of material composted, this difference can be substantial.

Question #11: Material Pile Sizes. This question requests the pile dimensions for the three other types of piles that will be on the composting pad. The first is the raw material storage, which is necessary because raw material will not be delivered every day, but perhaps once a week, month, or year. A curing pile is generally required, since once the material has finished actively composting it is often moved to a curing pile where materials continue to decompose and mature at a slower rate. A final pile may be required for storage of cured compost until it is either screened, used, or sold. If any of these piles is not required in the proposed system, a zero should be entered for row height. However, a zero should not be entered for raw materials storage if non-zero storage days have been entered in Questions 7, 8 or 9.

Question #12: Time for Composting Phases. The user must enter the compost period, turning interval, curing period, and final storage period. The numbers are all used in determining the pad size and the time used for turning.

Question #13: Leachate Collection. This question asks whether there will be a leachate detention pond. If no, the user may move on; if yes, the user must enter the annual precipitation and the desired depth of the pond. The pond is then designed to hold the runoff from the pad with a 20% freeboard. The surface area is then calculated using the user-specified depth.

Question #14: Cost Analysis Information. This question is divided into 3 parts. The first part requests the current year and the annual percent inflation rate between 1991 and the current year. Co-Composter provides a typical value based from the index of prices paid by farmers for equipment, and provides information on how to find this number. These numbers are used in calculating the typical capital investments and O&M costs. The user must also enter an hourly wage for labor and the maximum labor hours available for operating composting equipment. The latter determines which loaders are feasible, given the selected system.

The second part of the question deals with the loaders. Four loaders are shown, a small ($1/3$ yd^3) bucket, a medium (1 yd^3) bucket, a large (3 yd^3) bucket and a user-specified loader. For the first three loaders a capital cost and non-composting farm use hours must be given. This is required so that when determining the total cost of the composting system the capital can be separated into composting cost and non-composting farm costs. The fourth loader requires more input.

The user must enter the capital cost, O&M cost, bucket size, approximate horsepower, and non-composting farm use hours. This fourth loader provides a great deal of flexibility to the model. For example if the small loader is not feasible due to a great deal of material or too few available hours, then the user can create their own loader to meet the demands of the system.

The third part of question #14 concerns the turning equipment. Depending on the selected system, the appropriate equipment will appear in the table. The user then enters the capital cost for individual pieces of equipment. A rental option is also available here. If the user does not wish to purchase a turner then a rental fee can be entered and the appropriate cost will be calculated.

Question #15: Compost Pad Cost. The user enters the unit cost of the composting pad. Typical values are given for a variety of materials based on a pad thickness also provided by the user.

Question #16: Forced Air Building Cost. Only answered if system 4: forced aeration is selected. The user enters the cost of the building using two options. Option 1 is a default design consisting of pole barn with steel roof, two end retaining walls, 8 foot curtains on three sides and a concrete floor. If this option is selected, unit costs must be entered for the various components. Alternatively, the user may develop a different design and enter the gross unit cost as Option 2. The building size is determined from the volume of material composted.

Question #17: Screening Compost. This question asks whether the final compost will be screened. Screening helps to remove and recover some of the bulking agents for reuse, and produces a higher quality end product. If screening is not required, the user may move on to the next question. If the compost is screened, the capacity (cubic yards per hour) and the capital cost of the screener must be entered. A rental option is also available.

Question #18 and Question #19: Finance Costs. Both questions request economic factors for the building and equipment. The user must enter interest rate, years of expected use, salvage value as percentage of original cost and yearly insurance cost as a percentage of capital cost. These values are all used in annualizing the capital cost over the expected life of the building/equipment.

Question #20: Compost Net Value. This question asks the net value of the compost (if any). This number is used to determine any costs saved by composting. Examples are the on-farm value of compost as fertilizer, or net revenue from compost sales.

User Output Section

The User Output Section is where Co-Composter displays any important results that have been calculated. No data are entered on this page.

The initial portion of User Output Section is a System Mass-Flow Diagram, showing the flow of manure from the sources to either composting, separating, or "managed by other means".

Next, the selected composting system is displayed followed by a table showing the compost recipe. The table displays the yearly volume and mass of each additional material, bulking agent, and manure. The characteristics of the compost recipe are also given, with appropriate

ranges. The annual compost production is also given in ft^3, yd^3, and ton. The amount of manure and separated solids to be managed by other means is also given. <u>The volume estimate of compost production is very approximate</u>, since it is based on the initial bulk density of the compost mix. The final bulk density, which is influenced in unpredictable ways by weather and management, may be significantly different than the initial density.

<u>Land Areas and Dimensions</u> are the third set of outputs. The sizes of the leachate detention pond, raw material storage area, active composting area, curing area, final storage area, and screening area are given. If system 4 is selected, the building size is provided. The total land requirement is displayed in both square feet and acres. These areas do not include access roads or buildings for manure management, administration or equipment storage.

The fourth section is <u>Energy Use</u>. The total fuel and electrical use is displayed in a table in four columns, each for a different size loader. The amount of diesel fuel consumed is based on usage per horsepower per hour. This is given in gallons, and electricity used is given in kilowatt hours.

The final section is <u>Total Costs</u>. First the cost for each of the possible loaders is displayed. This cost is broken down by each composting task: handling cost, turning cost, and screening cost. The total costs are then displayed in two ways. First they are listed as fixed and variable costs. Second they are listed by task or group: handling cost, turning cost, screening cost, separating cost, pad and pond construction, material cost/value, building construction cost, and aeration cost. The first method shows a very descriptive breakdown of the costs, such as labor, insurance, electricity, and each individual piece of equipment. The second way shows a much more task specific breakdown of costs. Both methods produce the same final annual cost, which is described as a cost per yd^3 or ton of input and cost per yd^3 or ton of output.