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Pork Information Gateway

Composting Swine Mortality

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Introduction

Sound animal health and housing practices help to minimize mortality. However, there will always be a need to dispose of mortality. Rendering, composting, incineration, sanitary landfills, burial, and disposal pits are commonly available as options [1]. Composting is an attractive option because it is an environmentally friendly disposal method that captures the nutrient value of the mortality and organic amendments. Since composting usually takes place on the farm as the mortality occurs, the bio-security concerns associated with storing and transporting carcasses are greatly reduced. When properly managed, composting will generate few, if any, objectionable odors. However, as with any management practice, an understanding of the underlying principles, proper design, and proper management are required for successful results.

Objectives

- Review the principles of composting.
- Understand the special case of composting mortality.
- Describe the steps in composting mortality.
- Present the basic types of mortality composting facilities.
- Provide an overview of the steps to size a composting facility.
- Identify the important considerations when siting a composting facility.
- Provide a list of publications for additional information.

Composting Principles and Management: Composting-a natural process

Decomposition is a natural process where microorganisms convert organic carbonaceous material, like leaves, into a soil-like material called humus. During this decaying process, water, heat, and carbon dioxide are released. Composting is the process of controlling conditions so decomposition is accelerated. Under ideal conditions the organic material to be composted consists of small, well-mixed particles that meet the conditions described in Table 1. To achieve these ideal

Condition	Reasonable Range	Preferred range
Carbon to nitrogen ratio (C:N)	20:1 – 40:1	25:1 – 30:1
Moisture content	40 – 60 % water	50% - 60% water
Oxygen concentration	Greater than 5%	Much greater than 5%
Temperature	110 – 150 °F	130 – 140 °F

Table 1: Ideal conditions for rapid composting [2]

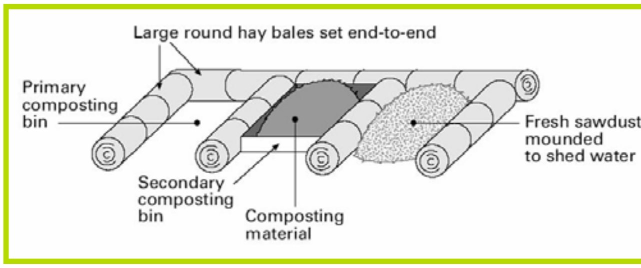
conditions high carbon ingredients (Table 2) are mixed with low carbon ingredients, such as animal mortality to obtain an acceptable Carbon to Nitrogen (C:N) ratio. The moisture content of the ingredients is also considered. If necessary, water is added to increase the moisture content to these optimal conditions.

When these conditions are met, the population of naturally occurring microorganisms will rapidly increase. This increased biological activity generates heat. Therefore the temperature of the compost mixture will increase to the ideal range of 110-150 °F. As long as the proper conditions exist, temperatures will be maintained, until the materials (substrate) are used up and the compost becomes stable.

However, ideal conditions do not persist, because available organic carbon is converted to carbon dioxide and is lost to the atmosphere. Water is also lost. As a result, the biological activity, decomposition, and temperatures all decrease. At this time, it is important to mix the compost and add water, if needed, to improve conditions enough to cause a second cycle of the composting process.

Corn stover	Wood shavings/chips
Peanut hulls	Recycled paper/cardboard
Sawdust	Leaves
Yard waste	Chicken litter
Hay	Turkey litter
Rice hulls	Finished Compost
Straw	Manure (horse, sheep, swine, cattle)
Chopped soybean stubble	

Table 2: Possible carbon sources/bulking agents for use in mortality composting [3]



Open bin composter made from round hay bales Adapted with permission from Stettler D. Livestock and poultry environmental stewardship curriculum: mortality management. Lesson 51. Ames, IA: Midwest Plan Service. 2001.

Mortality composting: a special case

Composting carcasses converts the carcass into a dark, humus-like material resembling potting soil, which is useful as a fertilizer and soil amendment. Mortality composting will also kill many disease causing pathogens as long as temperatures are maintained above 131°F for at least 3 days [3]. Composting also helps to maintain bio-security, by processing the mortality on-farm, eliminating the movement of dead animals between farms, thus significantly reducing the risk of spreading disease.

Composting animal mortality is a special type of composting. In traditional composting the material is well mixed and well aerated. Because it is often not practical to grind and mix the high nitrogen carcass with the high carbon bulking agent, initially, the mortality compost pile will not be a uniform mixture. Instead, mortality composting will form areas of high moisture, low C:N ratio, and low oxygen near the carcass, with the bulking agent surrounding the carcass having lower moisture, higher C:N ratio, and higher oxygen levels. In essence, rather than a homogeneous mixture, mortality composting is the above ground burial of mortality in carbon material. As a result adjustments need to be made for the mortality composting process to be successful.

The primary adjustment is simply the addition of extra bulking material beneath, to the sides, and on top of the carcass. The extra bulking material serves to absorb water that may be released from the mortality as it decomposes. This is important to prevent seepage (leachate) from escaping from the compost pile.

The extra bulking material also serves as a biological air filter. This is necessary because the area near the carcass will likely be anaerobic and generate objectionable odors. The extra bulking material provides the biological activity necessary to "scrub" or convert the odorous gasses. With proper management, a positive side effect of this odor control is there should be little odor to attract flies or scavengers, or be objectionable to neighbors.

A third benefit of the extra bulking material is its insulation value. Since temperature is critical to the composting process, the volume, or mass, of the compost is important. There needs to be enough mass to help retain the heat generated by the microorganisms, especially in cold weather. The extra bulking material, as long as the material does not allow too much air exchange, helps to maintain temperatures by adding mass and insulating the compost.

In short, the addition of extra bulking material makes mortality composting a process of burying mortality in an organic material that decomposes the carcass, absorbs excess water, and filters objectionable odors.

	Mortality Size (lb)								
	4	10	50	100	220	350	500	1000	1500
Primary Cycle (days)	10	16	35	50	75	95	115	160	195
Secondary Cycle (days)	10	10	12	15	25	30	40	55	65

Table 3: Calculated time requirements for mortality composting stages (cycles) based on animal weight. Times may vary based on temperatures, moisture, and porosity of bulking agent. [6]

Height (feet)	Width (feet)	Area (ft^2)
5	11	30
6	13	42
7	15	56

Table 4: Windrow heights, widths, and cross sectional areas [9,10]

A second adjustment made to composting mortality is the mixing process. Mixing is done by "turning" the compost either in place or moving the compost from the initial or "primary stage" location to the second or "secondary stage" location. Turning mixes the largely non-decomposed bulking material at the edges of the compost with the lower C:N ratio material where the carcasses were placed. At the time of turning, most of the soft tissue, small bones, and objectionable odors will be gone. A few of the larger bones, such as leg bones and skulls, may, remain. Turning aids the composting process because, oxygen is reintroduced into the system, the C:N ratio increased, and moisture content is assessed and modified as necessary. At this time any mortality remnants are mixed in to the pile and recovered. As a result, the conditions for composting are improved and a second cycle of composting is begun. At the end of the second composting cycle there will be no soft tissue left to degrade. If there are any bones left, they should be brittle and easily broken. If remain bones are not easily broken they can be added to the next composting cycle with the next mortality for complete decomposition.

General Mortality Composting management

Mortality composting management has two major components, building the primary compost piles, and managing the piles. Building the primary compost pile, as shown in Figure 1, is the process of establishing a base layer of bulking agent and adding carcasses mortality in layers.. During this process care needs to be taken to ensure that enough bulking material is used to absorb excess water and to adequately filter odors. The actual thickness of the base level (minimum of 1 foot), the material between the mortality layers (minimum of 6 inches), and the top cover (minimum of 1 foot in bins, 2 feet in static piles or windrows) depend on the type of bulking material used and whether the pile is exposed to the weather. Larger animals will require additional base depth due to the increased volume of liquid in the carcass. If there is any doubt on how much material to use it is usually better to use too much than not enough.

Managing the piles, as shown in Figure 2, deals with building the primary piles, allowing them to compost, turning them to start the secondary phase (second compost cycle), and knowing when and how to use the finished compost. The most significant factor in this process is the time it takes for the mortality to compost. Time is primarily affected by size of the mortality being composted, but is also affected by the bulking material used, the initial moisture content, and pile temperatures achieved. Smaller mortality such as baby pigs will compost more quickly than mature animals (Table 3). Unless separate piles are used for small mortality, the time to compost the largest animal dictates when the primary and secondary piles are ready to turn and mix. The secondary phase of composting is designed to complete degradation of bones and any remaining flesh and therefore requires about a third the time of primary phase (Table 3).

The primary indicator of compost pile rate of degradation and effectiveness is temperature. Active piles will maintain temperatures above 110° and more commonly operate in the range of 130-150° which is indicative of a proper composting conditions (moisture, porosity, C:N ratio). Using a compost thermometer with a 36 inch shaft at least twice a week to monitor will provide a log of temperatures that can be used to determine when to mix or turn a pile. Extended periods (1 or more weeks) of temperatures below 110°F indicate the pile should be turned to investigate degradation progress or assess which environmental constraints (moisture, porosity of bulking agent, or C:N ratio) is reducing degradation rate. Without a thermometer it is difficult to properly manage a mortality composting system.

After the second composting phase is completed the finished compost is ready to be used. The first primary use is a fertilizer source on crop or pasture land. When used in this way the compost nutrient content should be accounted for when determining the application rate. It is recommended that the farm develop a nutrient budget for each field as part of an overall farm nutrient management plan.

The second primary use is as part of the bulking material for the next compost pile. In this use the finished compost is blended with new bulking material. Up to 50% of the final bulking material can be finished compost. Reusing the finished compost reduces the amount on new bulking material needed. It can also "jump start" the next compost pile by inoculating it with actively growing microorganisms. Care should be taken to resist the temptation to use more than 50% finished compost as initial bulking agent. Fresh sawdust or bulking agent should always be introduced into the process, and using more than 50% finished compost can result in a carbon deficiency and a gradual deterioration of the process.

Closed Bin Volume (Open Bin Volume)								
Width (feet)	Depth in feet							
	5	6	7	8	9	10	11	12
5	125 (63)	150 (88)	175 (113)	200 (138)	225 (163)	250 (188)	275 (213)	300 (238)
6	150 (75)	180 (105)	210 (135)	240 (165)	270 (195)	300 (225)	330 (255)	360 (285)
7	175 (88)	210 (123)	245 (158)	280 (193)	315 (228)	350 (263)	385 (298)	420 (333)
8	200 (100)	240 (140)	280 (180)	320 (220)	360 (260)	400 (300)	440 (340)	480 (380)
9	225 (113)	270 (158)	315 (203)	360 (248)	405 (293)	450 (338)	495 (383)	540 (428)
10	250 (125)	300 (175)	350 (225)	400 (275)	450 (325)	500 (375)	550 (425)	600 (475)
11	275 (138)	330 (193)	385 (248)	440 (303)	495 (358)	550 (413)	605 (468)	660 (523)
12	300 (150)	360 (210)	420 (270)	480 (330)	540 (390)	600 (450)	660 (510)	720 (570)

Table 5: Estimated Bin Volumes in cubic feet.
Closed Volume=Depth x Height x Width
Open Volume=(((Depth-Height)xHeight)+((Height x Height)(2))xWidth
Assumes Height=5' and front slope on open front bins has 1:1 ratio

Types of composting facilities

Mortality Losses for Swine Production [10]				
Stage of Growth	Average Weight	Performance		
		Excellent	Good	Poor
Birth to Weaning	6 lbs	< 10%	10 – 12%	> 12%
Nursery	24 lbs	< 2%	2 – 4%	> 4%
Growing – Finishing	140 lbs	< 2%	2 – 4%	> 4%
Breeding Herd	350 lbs	< 2%	2 – 5%	> 5%

Figure 3: Estimating Average Daily Mortality Loss [3,6-9]

While there are different types of composting facilities, they are all based on the concept of a primary composting, followed by a secondary and or curing (storage) phase. All mortality composting facility designs need to have two areas designated for primary composting and one or more areas for primary and curing (storage) phases. Two factors often over looked in designing facilities is the storage of new bulking material and having a place to store the finished compost before it is used. If storage for these two materials is not available, management of the primary and secondary compost piles can become a significant challenge. Especially, if weather conditions and field access problems delay land application.

When deciding what type of facility to install, personal preferences and local regulations should be considered. Your local Extension, Conservation District, and Natural Resources Conservation Service offices should be able to provide information on local regulations. These offices may also have drawings and specifications for composter designs. The publications cited are also good sources of information.

Bin composters. As the name implies this type of composter has side walls to contain the compost. Typically there will be at least 3 equal sized bins, with .There will be at least two bins available for primary stage composting and at least one bin available for secondary stage composting. As a general rule, a larger number of smaller bins can provide more management flexibility. This is especially true on farrowing and farrow to finish operations. The extra bins will allow for the smaller mortality and placental material, which composts faster, to be composted separately from the larger animals. It is usually recommended to include at least one extra bin for storing the bulking agent and finished compost.

The most commonly recommended bin composters are free standing structures with concrete floors, wooden or concrete walls, and roofs. The concrete floors provide an impervious surface to prevent leaching and potential nutrient damage to ground water. Normally concrete aprons are recommended to provide all weather access to the bins for the front-end loaders used to load and unload the bins.

The front of the bins may be left open. However, another option is to use drop boards or solid gates to close the front of the bins [5], to hold in the compost, and provide additional protection from scavengers. If the bins are left open, they will need to be larger than a closed bin for the same capacity since the front edge of the compost will be sloped.

Mini composters. The main difference between mini composters and bin composters is size. Mini composters are typically about 40-48 inches along the side and about 36 inches tall. Due to their small size they don't have the thermal mass and capacity of the larger bins. Therefore, they should be located in buildings that are heated in cold weather. Often mini composters are loaded and turned by shovel. The size restrictions also limit the mortality to placental material and small pigs. Other than the size and location, mini composters are managed in the same manner as bin composters.

Number Pigs Produced Per Year
Live pigs born per year (pre-weaning)
_____ sows x _____ litters/sow/year x ______ live pigs/litter = _____ live pigs born/year
Number Nursery Pigs Per Year
_____ live pigs born/year x (1 - _____ % loss/100) = _____ nursery pigs/year
Number of Finishing Hogs Per Year
_____ nursery pigs/year x (1 - _____ % loss/100) = ______ finishing hogs/year
Total Pounds Death Loss Per Year
_____ sows x _____ lbs Avg. Wt. x _____ % loss = _____ lbs sow loss/year
_____ pigs born x _____ lbs Avg. Wt. x _____ % loss = _____ lbs pigs born loss/year
_____ nursery pigs x _____ lbs Avg. Wt. x _____ % loss = _____ lbs nursery pigs loss/year
_____ finish hog x _____ lbs Avg. Wt. x _____ % loss = _____ lbs finish hog loss/year
Total Lbs Death Loss/Year = _____
Average Daily Death Loss = _______ total lbs death loss/year / 365 = _____ lbs/day

Annual Bulking Agent Required: Annual Mortality Weight × 0.0069 = cubic yards per year

Bin composter showing typical features such as concrete pad, wooden bins with drop boards, and a roof. Adapted with permission from Stettler D. Livestock and poultry environmental stewardship curriculum: mortality management. Lesson 51. Ames, IA: Midwest Plan Service. 2001.

Open bin composters. A modification to bin composters is open bin composters. As the name implies, open bin composters do not have roofs. One variation uses round hay bales as side walls and does not have concrete or gravel floors. This approach depends on the use of sawdust for the bulking material. When properly mounded, sawdust tends to seal and shed water. This shedding of surface water, combined with the absorbency of the sawdust bed beneath the mortality, should prevent the leaching of nutrients and pathogens into the ground and surface water.

A second variation of open bin composters is the use of concrete floors and sidewalls. This variant is essentially the same as normal bin composters without the roof. Open bin composters should be less expensive to build than bin composters. However, being exposed to the weather is likely to increase the difficulty of properly managing the compost, increases the amount of bulking material required, and increases the potential for runoff from the compost which must be controlled.

Windrows (static pile) composting. In contrast to the bin composters, this approach does not use any type of retaining structure. Rather a pile or windrow is built using a front end loader to add the mortality and shape the windrow. For this reason, there needs to be access to all sides of the windrow. Since the piles are left exposed to the weather, they should always be shaped to enhance the shedding of water. To provide all weather access and limit the infiltration of water, the site needs to have an impervious pad. Concrete is an option; however, gravel over a geo-textile may be an acceptable alternative. This pad should be designed to shed water away from it in all directions. In addition, extra attention needs to be given to the handling of the runoff water from the site, with all runoff collected and directed to an appropriately designed vegetative filter strip.

It should be noted that while the investment cost for windrow composting may be less than for bin composters, there will likely be additional management challenges due to the weather. In addition, open windrows may be less acceptable in appearance to the public than a well built and maintained structure. However, with appropriate site planning (all weather access, packed, impervious base, fencing to control access), pile management (temperature monitoring, pile shape, adequate bulking agent), and attention to detail (aesthetics), windrow or static pile composting is an effective method of mortality disposal.

Sizing a composting facility

A critical element in designing a composting facility for an operation is determining how big to build it. While mortality composting has been demonstrated to be effective, it is still a fairly new science. As a result, there are variations in how facilities are sized. Therefore, the following discussion provides an overview of the process. For more detailed information, state or regional information should be sought, with the citations in this publication providing a good starting point.

Composter thermometer with 36 inch shaft inserted into an active compost pile.

A primary concern in sizing a facility is ensuring that it is large enough to process all of the routine mortality for your operation. However, it should not be excessively over sized so that unneeded expenses are incurred. Operator preferences also need to be considered.

Typically, composting facility design is based on the average number of pounds of mortality that need to be added to the facility each day. This is often called the average daily loss and has units of pounds/day. A consequence of this design concept is, if a catastrophic loss occurs, an alternative means of disposal will be required.

Ideally the average daily loss is determined from farm records. If this is not possible, average mortality estimates can be used as shown in Figure 3. The pounds of average daily loss is then multiplied by a volume factor to determine the total primary composting volume needed. The most commonly cited volume factor is 20 cubic feet of capacity for each pound of average daily loss. Normally the total secondary composting volume is set equal to the total primary volume.

After these total volumes are determined, it becomes necessary to determine the number of bins or piles that will be built. For windrow systems the process is fairly simple in that a windrow height is set, normally 5 to 7 feet. This determines the cross sectional area of the windrow (Table 4). Then the total primary volume is divided by the cross sectional area to determine how many feet of primary windrow is needed. This total length can be subdivided to provide the desired number of primary windrows. The number of secondary windrows is set equal to the number of primary windrows. At this point all that is left is to design the size of the pad where the windrows will be managed. Normally at least 10 feet of tractor working area is planned on each side of the windrows.

When determining the number of bins needed, a similar process is followed. A trial bin size is selected. The total primary volume is divided by the volume of the trial bin (Table 5) to determine the number of primary bins needed. This number should always be rounded up to a whole number. In addition, there should always be at least 2 primary bins. Normally the number of secondary bins is set equal to the number of primary bins. One alternative is to have 2 primary bins and 1 secondary bin [12]. However, this approach does not provide any storage for new bulking material or finished compost. As indicated earlier it is recommended to consider having extra bins for these purposes.

When establishing the bin dimensions, the length of the largest mortality needs to be considered. The bin should be large enough to hold the animal and allow for the necessary surrounding bulking material. In addition, since the bins will be loaded and unloaded with front end loaders, the bins need to be wider than the loader bucket. How much wider depends on personal preferences and other factors. If drop boards, or wooden gates are used the maximum practical bin width is 8 feet. This width provides minimal clearance for most loader buckets; therefore, care is required when operating the bucket. To address this issue some recommendations call for the bins to be 4 feet wider than the loader bucket [13] while other recommendations call for the bins to be at least twice the width of the loader bucket [14].

Siting a composting facility

There are several factors that need to be considered when determining where to locate a composting facility [16,17]. To help protect both animal and human health, the facility should be located somewhat remotely from the rest of the animal production facilities. However, there also needs to be ready access to the facility. The access roads to the facility and the working area around it should be surfaced to provide all-weather access. To help assure access, the site should be well drained. Any runoff water from the site should be handled as dictated by state and local regulations. Often this can be accomplished by vegetative filters. In some cases, especially if the bulking material contains manure, the water will need to be collected, stored, and land applied. If so, liquid waste permits may be required.

Another factor to consider is water and electrical supply to the compost site. Water may need to be added to the mixture so having a water supply available is recommended. Lighting needs should also be considered if nighttime work is anticipated.

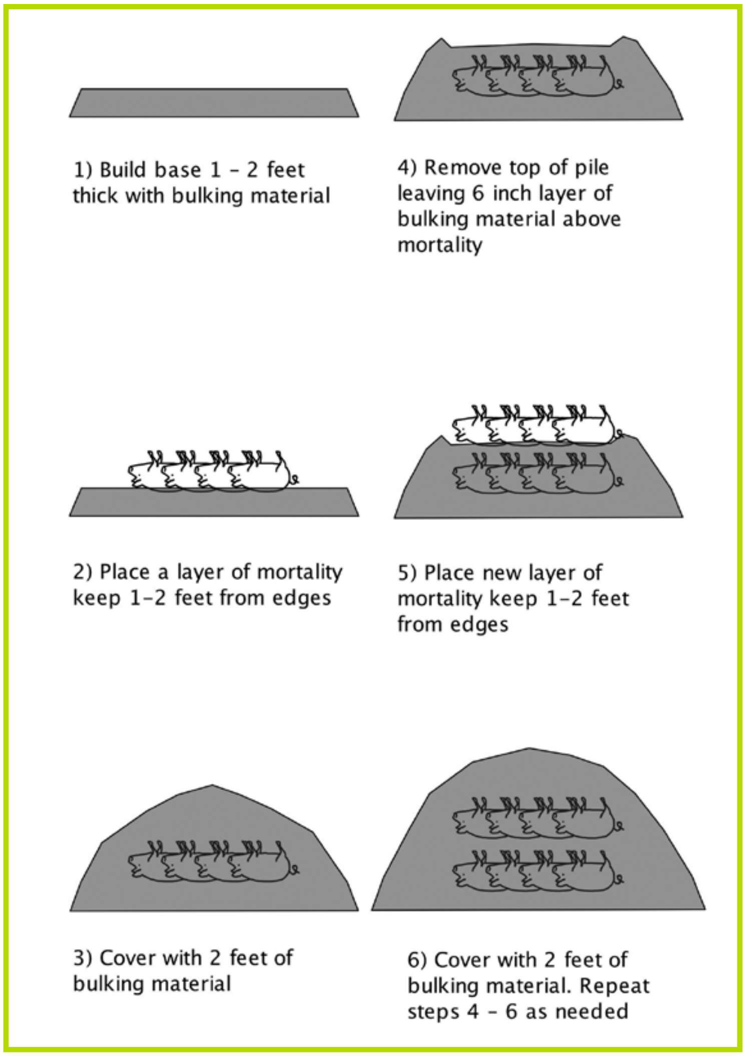


Figure 1: Building a Primary Compost Pile [3].

Facility appearance is often overlooked, but it is an important factor. Ideally the facility should not be visible to the public. If this is not possible, it should blend in with the rest of the facilities on the farm. The main concept is to not call unnecessary public attention to disposal of swine mortality. This means the composting facility, just like the rest of the farm, needs to be kept neat and orderly.

Summary

Composting is an attractive mortality management option because it is an effective, safe, and environmentally friendly method that utilizes the nutrients in the mortality. Since composting usually takes place on the farm as the mortality occurs, the bio-security concerns associated with storing and transporting carcasses are greatly reduced. When properly managed, composting will generate few if any objectionable odors. However, as with any management practice, an understanding of the underlying principles, proper design, and proper management are required for successful results. Working with information and professional assistance available through local University Extension, Natural Resources Conservation Service, and Conservation District offices can help producers design, and implement a composting facility that adequately addresses animal health, environmental, community relations, and farm management concerns.

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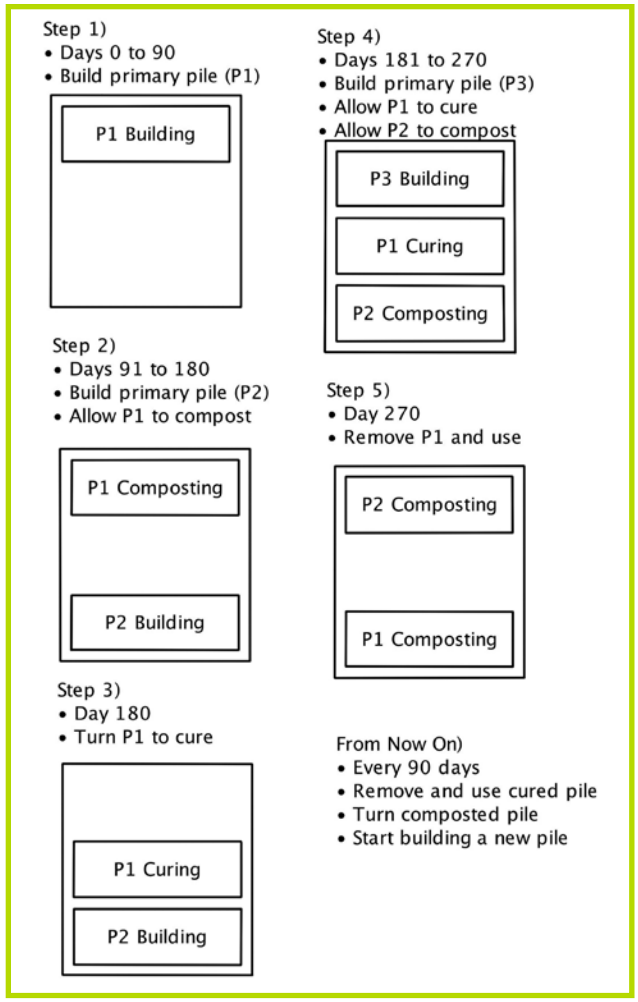

Figure 2: Steps to Compost Pile Management [3]. Assuming a 90-day cycle time for primary and secondary stages

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