



Compost Site Management

Monitoring Piles: Why and How

Monitoring Compost Piles

Monitoring compost piles is done for several reasons. Monitoring provides the composter with insight into activity in the compost pile, and this information in turn guides management choices regarding the specific piles you are monitoring, as well as how you make and manage compost on an ongoing basis. Monitoring provides you with a feedback loop for maintaining optimal composting conditions and producing a quality product. For example, temperature monitoring can be very useful in determining when a pile should be turned to sustain optimum microbial activity.

Additionally, pile monitoring is a requirement for many composters who operate within a regulatory framework, such as a solid waste permit or the organic standards. The monitoring requirements of solid waste permitted operations composting food scraps (source-separated organics or SSO) in

Vermont are covered in this guide, although the general practices described will apply to composters of farm wastes and other materials as well. Most regulatory requirements for pile monitoring, aim to ensure that a heat treatment called the Process to Further Reduce Pathogens or PFRP is achieved. In addition, consistent reduction in pile temperatures can be an indicator of compost maturity. These two important Vermont guidelines are covered in the Pile Temperature Monitoring section on this guide.

When To Monitor

To paraphrase an old Chinese proverb – “The best fertilizer is a farmer’s footsteps.” The composter’s attention is the best ingredient for making good compost. Diligent monitoring will help you correct small issues before they become big problems and help refine your practices over time. The Vermont Solid Waste rules require daily temperature monitoring



during the temperature treatment period and records of monitoring activities during this period are needed in order to remain in compliance. However, continuous monitoring outside of the treatment period is critical to producing quality compost, especially during the first two to three months when the pile is most active. Two times weekly is usually adequate for most turned windrow composters. Those using Aerated Static Pile and In-Vessel Methods usually benefit from continuing with a daily monitoring regime, since temperature swings can be dramatic with those systems. Since monitoring informs good management decisions, more regular monitoring is always beneficial, particularly for anyone who is new to the composting process.

How To Monitor Your Compost

In creating and managing compost, you are working to ensure that you have created suitable habitat for aerobic decomposer organisms. As a best management practice, pile monitoring is designed to assess the ongoing health of the pile as a microbial habitat.

There are four primary pile conditions to assess when employing monitoring practices:

- **Pile Temperature**
- **Pile Moisture Content**
- **Pile Structure**
- **Pile Odor**

The cause of problems can often be determined by crosschecking between multiple monitoring practices. For instance, if a pile is generating an ammonia smell, the operator may be able to determine that it is a result of pile dryness, using moisture monitoring to verify. While individual monitoring measurements can provide the operator with valuable information, only the results of the combined monitoring techniques collectively can tell the whole story. In addition to pile monitoring practices, consistent observation of the site may alert you to other issues.

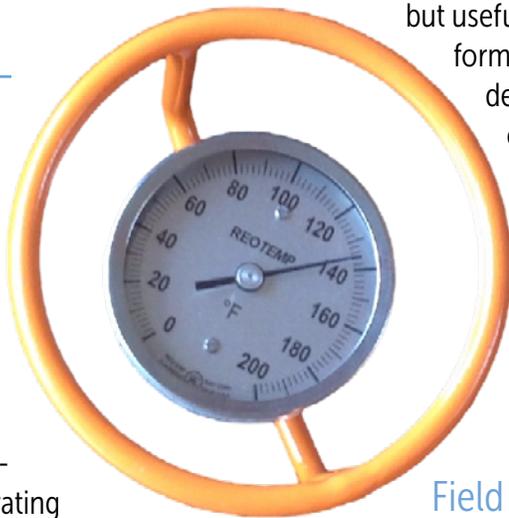
Techniques for performing these four pile monitoring practices are covered in the rest of this guide, including a short description of why the specific monitoring practice is used, the tools required, how the monitoring is performed, Vermont Solid Waste rules that relate to the practice, and general recommendations for the operator response to some conditions you might observe. When monitoring, it is important to consistently monitor the pile in the same locations to provide the operator with an accurate picture of the pile over time.

Note: While not discussed here, monitoring pile oxygen is also a useful practice to consider.

Pile Temperature

Function

The temperature of a compost pile is primarily a product of the metabolic heat being generated in the pile from microbial activity. Pile temperatures can also be affected by physical characteristics of the materials being composted (more versus less insulating), as well as chemical reactions (at high temperatures) and external environmental variables. Pile temperatures are an imperfect but useful indication of microbial activity. Newly formed piles commonly reach or exceed 130 degrees within several days to several weeks of pile construction. Piles constructed during extremely cold weather or with frozen feedstocks will take longer. If you are trying to ensure weed seed and pathogen destruction you will need to obtain 130+ degree temperatures for several days and obtain these temperatures again following multiple turnings.



Field Tools

- **Compost temperature probe**
For Turned Windrow Operations use a 3' probe with a 5/16" stem. For Aerated Static Piles systems, longer probes 4-6' are often beneficial. In colder climates or on large sites, multiple temperature probes with quick response stems can be useful for efficient monitoring.
- **Pile Monitoring Log**



How To Measure

Pile temperatures should be taken roughly every 5 – 20 feet along the pile, depending on the total pile length, and your regulatory status. Additionally, temperatures should be taken at depths of 12" and 36". The probe should be left in place for at least one minute or until the dial stops moving.

Record pile temperatures in a monitoring log and keep monitoring logs on file (see Monitoring Log documents, which are part of this resource package).

Vermont Solid Waste Rules

Permitted food scrap composters in Vermont are required to heat treat compost, meeting the Process to Further Reduce Pathogens (PFRP). Meeting PFRP is slightly different depending on the composting method utilized. The following are from the Vermont Solid Waste Rules:

- If using a turned windrow system, the temperature must be maintained at 131 degrees Fahrenheit (55 degrees Celsius), or higher, for at least 13 of 16 consecutive days, during which time the materials must be turned to ensure that all materials reach this temperature.
- If using an actively or passively aerated static pile (including static windrows), or the within vessel method (including bins), the temperature must be maintained at 131 degrees Fahrenheit (55 degrees Celsius), or higher, for at least three consecutive days.

Rules require that composters monitor every 5' along the pile at 12" and 36" depths and that composters keep monitoring records on file for at least 5 years.

In addition to meeting PFRP, temperature decline is one of the indicators used to determine compost maturity prior to distribution. To meet the temperature reduction criteria Vermont Solid Waste Rules state that the compost temperature must decline to near ambient conditions (less than 100° F) provided that the decline is not the result of improper management of the composting process. Composting

records shall indicate appropriate schedules for turning, monitoring of moisture within the required range, and an appropriate mix of composting feedstocks.

General Responses

Temperature will impact your decision to turn or not turn a pile, and may indicate that factors in your pile recipe need to be adjusted. There may be a number of reasons for depressed temperatures, such as a C:N ratio that is too low or too high, high or low moisture content, compaction in the pile, or excessive pile density. Low temperatures that correlate with a high or low moisture content can be addressed by remediating the moisture issue. If you are experiencing low pile temperatures and moisture is not the issue, your C:N ratio or the pile density are the next issues to explore. If everything in your pile recipe seems fine, try turning the pile once to mix and aerate it.

If your pile is heating, your temperature monitoring will help you determine when to turn the pile (or in the case of Aerated Static Pile Composting, what sort of aeration schedule to maintain). Based on temperature, you will want to turn your pile after your pile's initial heating has peaked and is beginning to decrease or if your pile temperatures at 12" are consistently 20 degrees different than those at 36" throughout the pile. Turning to meet PFRP will likely require turning the pile before the temperature spikes, in order to complete several turnings within 16 days. Additionally, if your pile is heating very well and your temperatures have gone above 160 degrees, you should consider turning your pile to cool it down and prevent excessive loss of nitrogen.



Pile Moisture Content

Function

Moisture in the pile is a critical factor regarding microbial activity and hence the decomposition process. If you have too much or too little moisture, microbes cannot function effectively. You are targeting a moisture content of roughly 60%. Pile moistures of 50-65% are okay, however moisture levels approaching the outside of this range should be closely monitored and if moisture moves outside 50-65% it should be addressed. Moisture surrounding the pile can also adversely affect the composting process, as it will inhibit oxygen intake through its sides. Standing water around the piles will result in the saturation of the pile base, creating undesirable, anaerobic conditions.

Field Tools

- **Hands**
- **Eyes**
- **Pile Monitoring Log**

How To Measure

Take a small handful of compost in one hand, remove excessively large particles and squeeze the material. Watch for water dripping freely from your hand, observe the space between the fingers and look for signs of excess moisture. If the contents in your hand begin to drip moisture from between your fingers, the moisture content is likely above 65%. If there is no dripping, but the moisture glistens between the fingers, the moisture content is roughly 60-65%. If no moisture is seen, open

the hand so that the contents remain on the



palm. If the contents remain in a ball, depending on how tightly they maintain their form, your moisture content is 50-60%. If the contents fall apart, your moisture level is below 50%.

A visual inspection of the pile and the surrounding site will also provide you with feedback regarding moisture. Site moisture and pile moisture may be connected or not, and therefore clarifying where the moisture is originating, from the pile or the site (including water coming onto the site from the surrounding environment), is important.

Record pile moisture content in a monitoring log and keep monitoring logs on record (see Monitoring Log documents, which are part of this resource package).

Vermont Solid Waste Rules

Permitted food scrap composters in Vermont are required to keep a record of moisture content monitoring along with their other pile monitoring records. The monitoring logs should show that moisture content was managed within an appropriate range.

General Responses

If your moisture content (MC) is high (above 65%) you need to dry out your mix. If the mix is not significantly above 65% MC, simply turning the pile may achieve the desired drying effect. Turning, as well as general exposure to dry climatic conditions can reduce pile moisture over time. In many cases, multiple turnings over several dry days may be sufficient. One further step along these lines is to open the top of the pile up with the tractor bucket to create more surface area from which the air and wind can wick away moisture. If the mix is significantly moister than 65% or in very wet times of year, the addition of dry matter is required. This can be done by opening the top of the pile with the bucket, forming a trough, adding some dry matter, and then rolling or otherwise turning the pile to incorporate the material. Windrow turners are particularly effective at drying the pile mechanically.

If your pile moisture is below 50%, the addition of moisture is required. In some cases impending rain may sufficiently wet the pile. When you are adjusting pile moisture up or down you need to be careful



not to adversely impact the pile recipe in other ways, such as C:N ratios. If you are bringing the MC down, the use of neutral C:N ingredients (those around 25-30:1) with low MC will help. Ingredients like dry, heavily bedded horse manure, hay or small ruminant bedding often meet these criteria. If you are bringing up your pile moisture, water may be an effective way of increasing the moisture while not impacting the C:N (rain may easily suffice). This can be a good use for leachate or dirty storm water collected from the site if the pile is still actively achieving thermophilic temperatures (to ensure pathogen destruction). If other indicators of pile health are good and your MC is on the low side, but within the acceptable range (50-55%), minimizing pile agitation will help to retain as much moisture as possible until the pile is naturally moistened by rains. Turning or flattening the pile during rain events will increase the volume of moisture that the compost is able to absorb. In dry climates (or in a dry Vermont summer) operators may mix to a higher moisture content to offset the climatic drying effects.

Moisture released from the pile, which is called leachate, is indicative of excessive pile moisture and that the pile moisture requires significant adjusting. Site moisture from rain, runoff or flooding may also impact your pile management. Ponding on the site is problematic and can limit site access, turning capabilities and reduce the pile's ability to passively respire. Addressing the reasons for site ponding is important to prevent on-going issues. Pile orientation should be roughly with the slope of the site to prevent ponding. Site management practices, such as scraping ruts after working on the site, will reduce low spots where moisture will accumulate.

Pile Structure

Function

Pile structure refers to the "architecture" of the pile. The pile's ability to maintain its shape and porosity over time, impacts how well the pile can be aerated, both actively and passively. The structure of your pile is the result of how the pile was constructed, the recipe and in particular the particle size and density. Poor structure causes overly dense compost, slumping piles, and can lead to anaerobic conditions.

Field Tools

- **Hands**
- **Eyes**
- **Pile Monitoring Log**

How To Measure

When monitoring and working on the site:

- Observe the compost pile's overall shape. Windrows that are slumping or unable to maintain a vertical conformation (parabolic or triangular) indicate poor structure.
- While performing the moisture content squeeze test, observe the compost's density, diversity of particle sizes, looking for a range of visible particles from 1" and down within the mix. Woody particles in particular provide excellent structure.
- Observe crusting on pile surfaces, which will reduce air exchange in the pile.
- More involved field and lab tests are usually not needed unless there is a consistent problem. Field tests for bulk density and porosity can be found on-line and lab analysis of porosity, particle size and bulk density are also available.

Record descriptions of pile structure in a monitoring log and keep monitoring logs on file (see Monitoring Log documents, which are part of this resource package).

General Responses

Poor pile structure is an indicator that the compost recipe needs adjustment or that there was not adequate homogenization of materials during blending. If a pile is too dense or slumping it will result in increased pile density at the core of the pile, thereby diminishing the availability of oxygen to that part of the pile. Slumping piles should have more bulking material (wood chips or bark 5-10% of mix by volume) incorporated into them and should be reformed.

Additionally, if the piles were large to begin with (8+ feet tall) then the operator should consider





reducing the pile size. All compost piles will reduce in size. This is not an indication of pile slumping but rather volume reduction. Also, if surface crusting is observed on the pile, turn the pile to re-blend the crusted materials and reopen the surface to air flow. Finally, efforts should be made when constructing and turning piles to limit compaction.

Pile Odor

Function

Being aware of odor occurring in the pile will provide the operator with indicators of the internal dynamics of the pile and may direct management choices. Odors from compost piles and composting feedstocks are commonly associated with the release volatile organic acids (VOAs) and other chemical compounds such as ammonia and sulfur dioxide. Smell is a natural byproduct of microbial decomposition, however, particularly when composting food scraps, there is a high nuisance potential and bad smells are an indication that the compost needs attention.

Field Tools

- **Nose**
- **Pile Monitoring Log**

How To Measure

Take note of the smell of both the site and individual piles by consciously breathing in through your nose while working around the piles, including during monitoring and turning. You may observe a particular character to an odor or isolate the odor to a certain location, pile, or portion of a pile. Record descriptions of pile odors in a monitoring log and keep

monitoring logs on site (see companion Monitoring Log documents). Be aware that you will become accustomed to the smells on the site after time. Careful monitoring means being able to identify an objectionable odor, even when you may not find it off-putting yourself.

Vermont Solid Waste Rules

Permitted food scrap composters in Vermont are required to operate in a manner that does not create “objectionable odors” or other “nuisance conditions”. Continuous odor issues could result in fines and eventual closure.

General Responses

The general character, intensity, and objectionability of odors are all indicators of whether a particular smell is a problem. Subtle odors from the pile may indicate potential problems or areas in which to improve upon in the next batch of compost, but may not be of specific concern. Additionally, some odors may be noticeable when raw feedstocks are combined, as well as when fresh compost piles are first turned. While these unsubstantial odors may not require an operator’s response, they should also not be ignored. When odors are distinct, strong, and/or present when the pile has not been agitated they are commonly an indicator of a problem in the compost pile and should be responded to. Common odors from compost piles include ammonia and sulfides (“rotting garbage” smell).

Most odors are indicative of one of three things: the pile is low in carbon, the pile is low in oxygen/high in moisture, or the pile is too dense. Often it’s all three, as these conditions are usually related. Adequate carbon prevents excessive nitrogen volatilization, which is associated with most odors, and creates binding sites where odorous compounds can be captured and metabolized before they are released to the sur-



rounding environment. Carbonaceous materials basically act as a biological scrubber for odors where they can be metabolized by microbes. If the pile is low in carbon, steps should be taken to incorporate additional carbon material into the mix. Often, addressing deficiencies in Carbon will also address low oxygen and high moisture conditions. For additional suggestions to reduce pile moisture see the "General Responses" recommendations in the "Moisture Content" section of this guide.

If the pile is too dense, the best response is to incorporate a bulking material, something with a large enough particle size to allow more airflow in the pile such as wood chips or bark (5-10% by volume). This can be done in a similar manner to adding carbon or dry matter. If such a material is not immediately available, several successive turnings may suffice to elevate pile oxygen sufficiently.

Companion Resources:

Weed Seed Testing
Temp Probe Recalibration
Recipe Development
Recipe Calculator
Feedstock Sampling
Food Scraps and Feedstock Acceptance

Photos

- Srise
- Highfields Center For Composting

Acknowledgements

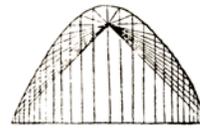
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