Highfields CENTER FOR COMPOSTING

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Monitoring Compost Piles; Why and How

Introduction

Monitoring compost piles is done for several reasons. Primarily, monitoring is done to provide the composter with insight as to what is happening in the compost pile during composting, such as the microbial activity and other pile conditions that will impact microbial activity. This information can in turn impact the management choices you make in your composting operation, regarding the specific piles you are monitoring and/ or how you make and manage compost in general. 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, monitoring also provides some information and documentation regarding the finished product and how it can be used. For compost used within 90 days of the planting of Certified Organic edible crops, documentation is required that demonstrates the compost reached specified time/ temperature requirements. These regulations are designed to ensure pathogen-free compost to protect consumer health. Meeting these criteria may be of interest to Certified Organic farmers wishing to apply compost within 90 days of planting edible crops or composters who sell to such growers. Either way, monitoring is a simple process that provides the composter with practical information that will help to improve and/ or maintain a high quality of composting.

When to monitor

Monitoring is something that should be done to some extent one extent or another every time you walk by your compost piles. 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. In fact, good compost will require a little more than attention, but attention will be a primary factor of ensuring good quality composting, as it will help you correct small issues before they become big problems, as well as helping you learn from your piles and refine your practices. Monitoring your piles, for specific feedback such as temperature, or informally by taking notice of them and being aware of changes, is a good management practice. Monitoring is most important during the first two to three months of pile activity and should be done on farms at least weekly. Since monitoring should inform your management decisions, more regular monitoring is useful if it can be integrated into your farm system.

How to monitor your compost

In building and managing compost, you are primarily trying to ensure that you have created suitable habitat for the decomposer organisms that you want to decompose your feedstocks. Likewise, your pile monitoring is designed to assess the health of the pile habitat. There are four primary monitoring practices that you should employ to one degree or another. These are: pile temperature, pile moisture content, pile odor, and a visual inspection of the site and piles. These monitoring techniques are listed below with a short description as to why the specific monitoring practice is performed, the tools required, how the monitoring is performed, and general recommendations for the operator response. 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. While not discussed here, monitoring pile oxygen is also a useful practice to consider.

Pile Temperature:

1. **Function** – The pile temperature is primarily a product of the microbial body heat being generated in the pile from microbial activity. Pile temperatures can also be affected by the physical characteristics of an individual material (more versus less insulating) and the pile, as well as chemical reactions 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 at least two turnings.

2. **Field Tools** – Compost temperature probe. We recommend using a 3' probe with a 5/16" stem. In colder climates or on large sites, temperature probes with quick response stems can be useful.

3. **How to measure** – Pile temperatures should be taken roughly every 5 – 25 feet along the pile, depending on the total pile length. 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.

4. **General Responses** – Temperature will impact your decision to turn or not turn a pile, as well as if 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 determined through moisture monitoring can be addressed generally by addressing 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. 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. Additionally, if your pile is heating very well and your temperatures have gone above 150 degrees, you should consider turning your pile to cool it down and leverage the microbial activity most efficiently to prevent excessive loss of nitrogen and, potentially, spontaneous combustion if the mix is dry and high in carbon.

Pile Moisture:

1. **Function** – Moisture in the pile is a critical factor regarding the pile conditions for microbial activity. If you have too much or too little moisture, microbes cannot survive or function effectively. You are targeting a moisture content of roughly 60%. Pile moistures of 50-65% are okay, however moisture levels beyond these two parameters should be addressed. Moisture surrounding the pile can also adversely affect the composting process as it will inhibit the oxygen intake of the pile through its sides. Standing water around the piles will result in the saturation of the pile base, creating undesirable, anaerobic conditions. Anaerobic conditions, in general, can cause odors, losses of nitrogen and carbon, develop phytotoxins, and reduce product quality (especially for seedling and transplant applications).

2. **Field Tools** – Hand, eyes.

3. **How to measure** – Take a handful of compost in one hand, remove excessively large particles and squeeze the material. Watch for water dripping freely from your hand and 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 palm up so that the contents remain on the palm. If the contents remain in a ball, depending on how tightly they remain in their form (as well as the pile ingredients and the age of the pile), 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.

4. **General Responses** – If your moisture content (M.C.) is high (above 65%) you need to dry out your mix. If the mix is not significantly greater than 65%, 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 and in dry climates operators may mix to a higher than optimum moisture content to offset the drying effects of the air in the feedstock mixing and pile formation process. One further step along these lines that can be taken is to simply open the top of the pile up with the tractor bucket and allow the air to dry it for a couple of days before reforming it (this basically creates more surface area from which the air and wind can wick away moisture from your mix). If the mix is significantly moister than 65%, the addition of dry matter is required (in some cases multiple turnings over several dry days may be sufficient if the weather is dry). 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 for 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 M.C. down, the use of neutral C:N ingredients (those around 25-30:1) with low M.C. 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 M.C. 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.

Site moisture resulting from the pile, leachate, is indicative of *excessive* pile moisture and 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 on the site after working on the site, will reduce low spots where moisture will accumulate.

Pile Odor:

1. **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 of nutrients or carbon in their gaseous form, Volatile Organic Acids (VOAs), or other chemical compounds. VOAs are a natural byproduct of microbial decomposition, however they have a high odor potential and can accumulate in excess (becoming phytotoxic) under air-limited and/ or low pH pile conditions.

2. **Field Tools** – Nose

3. **How to Measure** – Take note of the smell of the site and individual piles by consciously breathing in through your nose while working around the piles, including during monitoring and turning. You may be able to isolate the odor to a certain portion of a pile.

4. **General Responses** – A compost pile should generally smell earthy. 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, methane and sulfides ("rotting garbage" smell).

   Most odors are indicative of one of two things – either the pile is low in carbon (microorganisms therefore do not have enough carbon to consume in proper proportions with the available nitrogen, and nitrogen is released as a gas – nitrous oxide) or the pile is low in available oxygen/ high in moisture. If the pile is low in carbon, steps should be taken to incorporate additional carbon material into the mix. If the pile is low in oxygen it may be the result of one of two things, excessive moisture or a high bulk density/ pile compaction. For suggestions to reduce pile moisture see the "General Responses" recommendations in the "Moisture Content" section of this primer.

   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. 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.

General Pile Conformation:

1. **Function** – The conformation of your pile is the result of how the pile was constructed, the ingredients, and what is occurring within it. Pile conformation impacts how well the pile will be able to passively aerate. Additionally, the size of the pile will determine if the operator is able to combine piles to consolidate materials and free up additional site space.

2. **Field Tools** – Eyes

3. **How to Measure** – there is no measurement for assessing pile conformation. Simply observing piles visually will give the operator an indication of the pile shape, size and overall appearance. The operator should also look for surface crusting on the piles.

4. **General Responses** – If a pile is 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 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 through moisture loss. Small piles of similar age can be combined to consolidate biomass and pile management tasks, as well as make space available on the pad for new materials.

   Crusting on pile surfaces will reduce air exchange in the pile. Efforts should be made when constructing and turning piles with a bucket to limit compaction. Additionally, if high moisture materials are being added to the pile, they should not be "dumped" onto the pile and left. This excessive surface moisture will cause surface crusting. High moisture feedstocks, such as dairy manure, need to be thoroughly mixed with other ingredients to prevent these issues.

Responses to any problems encountered during monitoring can often be determined by crosschecking the indicators from the various 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 excessive pile moisture because their squeeze test showed similar results. While individual monitoring measurements can provide the operator with valuable information, the results of the combined monitoring techniques collectively portray the internal pile conditions and should be assessed in this way.