Understanding & Troubleshooting Mortality Composting

Developed by Dr. Tom Glanville and Dr. Jay Harmon, Department of Agricultural & Biosystems Engineering, Iowa State University, for ISU outreach program on Poultry & Livestock Disposal in Iowa, sponsored by Iowa Department of Natural Resources.
Learning Objectives

- Understand objectives of on-farm mortality composting
- Learn about layered composting systems and the natural mechanisms that allow them to work
- Five fundamental factors and how they affect composting performance
- Strategies for avoiding leachate release, odor release, slow carcass decomposition
Objectives for on-farm mortality composting are:
- Low capital & operating costs
- Simplicity & reliability... no need for special equipment or materials
- Biosecurity and environmental protection
- Easy to construct or expand in emergencies
Layered or envelope composting systems have proven effective for on-farm mortality composting:

- Carcasses enveloped in a low-cost organic material
- Piles turned infrequently ... sometimes not at all!
- Oxygen, moisture content, temperature, and C:N ratio are NOT uniform throughout the layered pile
- Decomposition rates NOT optimal ... but ARE adequate for on-farm purposes

How On-Farm Mortality Composting Systems Work
Reliance on Natural Mechanisms

Natural ventilation ... of water vapor & decomposition gases

Odorous decay gases adsorbed and broken down

Zone of bacterial activity & heat production

Moisture & nutrients wicked outward

Base layer absorbs leachate

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Key to Mortality Composting Success

Type & Thickness of Envelope Materials

- IF envelope materials are sufficiently:
  - absorptive & thick ... carcass liquids & precipitation are temporarily absorbed
  - gas permeable.... $O_2$ diffuses into pile, and excess moisture evaporates
  - thick ... heat and odorous gases are retained
What is Composting?

- Natural environment contains microorganisms, primarily bacteria, that break down organic matter to produce a soil-like end product.

- Composting employs practices that improve the microbial “working environment” so that
  - Decomposition occurs more rapidly
  - Quality of the end products is more consistent and desirable
How Composting Works

- Works best when decomposition is carried out by bacteria that are:
  - Thermophilic (heat-loving)
  - Aerobic (oxygen-using)
Why thermophilic bacteria?
- This type of bacteria thrives at high temperatures (110–150°F)
- Decomposition at high temperature is desirable
  - Generally occurs more rapidly than at cooler temperatures; and
  - High temps kill pathogens and weed seeds, producing a safer & more desirable product
How Composting Works

○ Why aerobic bacteria?
  ● Aerobic decay is more complete and produces more heat than anaerobic decay
  ● Gaseous by-products of aerobic decomposition are less odorous than for anaerobic decay
Five Key Factors Affecting Composting Success

- Moisture Content
- Oxygen
- Nutrients
  - Carbon-to-Nitrogen ratio
- Temperature
- Shelter from stressful conditions
  - Ultraviolet light (sunlight)
  - Drying
Moisture Content

- **THE** most important factor in mortality composting
  - Below 40% ... too dry
    - Insufficient water to carry nutrients into bacterial cells .... bacteria starve
  - Above 65% ... too wet
    - Pore spaces in compost fill with water
      - Oxygen can’t get in .... toxic gases can’t get out .... aerobic bacteria “drown”
      - Can lead to anaerobic conditions resulting in release of foul **odors**
Oxygen

- Desirable $O_2$ concentration for aerobic bacteria
  - At least 5%
  - Above 10% is preferable to maintain decay that is mainly aerobic
  - NOTE: normal "air" contains 21% $O_2$
Temperature

- Most desirable temp range for thermophilic bacteria 113-140 °F
  - Above 131 °F kills human & animal pathogens
  - Above 145 °F kills weed seeds
  - Exceeding 160°F can cause composting microorganisms to die
  - Below 100 °F can result in slow carcass decay
Carbon:Nitrogen Ratio

- 25:1 C:N generally recommended for composting
  - C:N below 10:1 can result in ammonia emissions
  - C:N above 50:1 can result in slow decomposition

- NOTE: Because mortality composting operations are not uniformly mixed, it is impractical to measure C:N ratios
  - Can use practical field observations to evaluate C:N
    - If excess ammonia odor is noted C:N is low, use more cover material (source of C) around the carcasses
    - If decomposition is very slow (and moisture around carcasses seems adequate) C:N may be too high, try reducing amount of cover material used with carcasses
Shelter from Stressful Conditions

- Bacterial growth can be inhibited by
  - Too much sunlight
    - Ultraviolet radiation in sunlight kills bacteria
  - Excessive drying of the compost
    - Leads to low moisture content and inability of bacteria to obtain food
Troubleshooting Mortality Composting Problems

- **Most Common Problems**
  - Leachate
  - Poor odor retention
  - Slow carcass decay
Troubleshooting - Leachate

- **Cause #1**: Excessive precipitation exposure during wet seasons
- **Solution**: Reduce exposure
  - Roofed bin system; or
  - Install tarp over piles
Troubleshooting - Leachate

- **Cause #2: Insufficient liquid absorption capacity**
  - **Solution:** Use thicker envelope of absorptive material under and around carcasses
  - **For uncovered emergency or temporary operations**
    - 18-24 inches of envelope material *over top* of carcasses
    - 12 inches (poultry) – 24 inches (cattle and large swine) inches of absorptive material *beneath* carcasses
Troubleshooting - Leachate

- **Cause #3**: Overloading ... too many carcasses and too little cover material
  - Remember.... every 1000 lbs of carcasses contains 650 lbs WATER!

- **Solution**:
  - Avoid (stacking) of large carcasses (greater than 500 lbs)... too much water in one place
  - Use plenty of absorbent material around carcasses
    - At least 12 inches of absorptive material between large carcasses
    - At least 6 inches between small carcasses
Troubleshooting - Leachate

- **Cause #4:** Use of envelope material that is too wet

- **Solution:**
  - Check initial moisture content with “squeeze” test
    - Materials with 40-65% moisture feel moist … but yield only a few drops of water when squeezed
    - Store envelope material in dry location to avoid excessive moisture

Note numerous water droplets on concrete … this material too wet
Troubleshooting – Poor Odor Retention

- **Cause # 1:** Envelope over carcasses is too thin or too coarse
- **Solution:**
  - IF envelope is thick enough ... odorous compounds are absorbed & decomposed before escaping into the atmosphere
  - Use 12-24 inches of envelope material over carcasses (thickness varies with coarseness of material)
  - Avoid use of extremely coarse envelope materials
    - Use tub grinder on long fibrous materials such as cornstalks or straw
Troubleshooting – Poor Odor Retention

○ Cause # 2: Compost turned prematurely

○ Solution:

  ● Don’t turn carcass compost too soon
    ○ “Too soon” varies with carcass size
      ● Experience is the best teacher ... turn small portions to see if odors are likely to be a problem before turning whole pile
    ○ Be prepared to cap pile with more envelope material if necessary to suppress odor release
Troubleshooting – Poor Odor Retention

- **Cause # 3: Compost too wet**
  - High moisture reduces oxygen penetration, leading to **anaerobic** decomposition & excessive odor
  - May be accompanied by leachate release

- **Solutions: Similar to those for leachate**
  - Reduce exposure to excessive rainfall
  - Avoid overloading pile with too many carcasses and too little absorptive material
  - Turn pile to encourage evaporation
  - Try mixing wet compost with coarser and drier cover materials
Troubleshooting – Slow Decay

- **Cause # 1: Inadequate O₂ penetration caused by fine textured cover material**

- **Solution: Use coarser cover material**
  - Particles with 1/8th inch **minimum** dimension ... obvious pore spaces between particles (below right)
  - Avoid “soil-like” materials comprised of small particles with tiny pore spaces (below left)

Poor texture | Better texture
Troubleshooting – Slow Decay

- **Cause # 2:** Inadequate O\(_2\) penetration caused by excessive moisture (often accompanied by leachate)

- **Solution:** Similar to those for leachate
  - Reduce exposure to excessive rainfall
  - Avoid overloading pile with too many carcasses and too little absorptive material
  - Turn pile to encourage evaporation
  - Try mixing wet compost with coarser and drier cover materials
    - time consuming, may not work if compost is too sticky to mix
Troubleshooting – Slow Decay

- **Causes # 3: Inadequate moisture**
  - Not very common in Iowa for 2 reasons
    - Iowa a humid state, so excessive drying likely only during extreme dry weather
    - Every 1,000 lbs of carcasses contains 600 lbs water
  - **Solution:**
    - Add water *sparingly* and turn (to mix)
    - May need to repeat several time
    - Proceed slowly, *very* easy to over wet small sections resulting in odor and leachate
Troubleshooting – Slow Decay

- Causes # 4: Low temperature caused by inadequate heat production and/or retention

- Solution:
  - If material near carcasses is not dry (available moisture is OK), try increasing thickness of envelope material to improve heat retention
  - Note: do not put frozen carcasses into a cold composting system... takes extremely long time for carcasses to thaw and begin producing heat
Troubleshooting – Slow Decay

Causes # 5: Inadequate nitrogen

- Least likely cause for slow carcass decay
  - Every 1,000 lbs of carcasses contains 22 lbs of N that is ultimately released into biologically active zone surrounding carcasses

Solution:

- If the 4 previous causes have been ruled out, try mixing small amount of manure into pile to improve N content

Carcass moisture & N move into surrounding material
Composting works best when decomposition is carried out by bacteria that are:

- ____________________________ and
- ____________________________
Summary Quiz

- Composting works best when decomposition is carried out by bacteria that are:
  - Thermophilic (heat-loving)
  - Aerobic (oxygen-using)
Summary Quiz

○ Name some key factors affecting composting success

1. M__ __ __ __ __
2. O__ __ __ 
3. T __ __ __ __ __ __
4. C:_ __ __ _ __
5. S __ __ __ __
Summary Quiz

○ Name some key factors affecting composting success

1. Moisture (40-60%)
2. Oxygen (5% or greater)
3. Temperature (100 – 140 °F)
4. C:N ratio (25:1)
5. Shelter (from UV light, drying)
Summary Quiz

- Typical causes of leachate release?
Summary Quiz

○ Typical causes of leachate release?
  1. Excessive exposure to precipitation
  2. Insufficient use of absorptive envelope materials over and beneath carcasses
  3. Use of cover material that is too wet
  4. Overloading ... too many carcasses with too little cover material
Summary Quiz

- Typical causes of poor odor retention?
Summary Quiz

- Typical causes of poor odor retention?
  1. Cover over carcasses is too thin or too coarse
  2. Premature turning of compost
  3. Excessive moisture
Summary Quiz

- Typical causes of slow decay?
Summary Quiz

- Typical causes of slow decay?
  1. Low oxygen ..., cover material too tight (fine textured)
  2. Low oxygen caused by saturated cover material (accompanied by leachate)
  3. Low temperature (accompanied by low moisture) .... too little cover material to retain heat and moisture.
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