“How-To’s” at Large Scale Composting Facilities

Compost Matters in Manitoba
Brandon, Manitoba
June 28, 2011

Workshop Goals

- Overview of the composting process and basic composting science
- Composting methods/technologies and equipment
- Effective use of monitoring tools
- Process Management
- Odour prevention and control
- Specific health and safety issues
- Fire prevention
- Product sampling and testing
Compost Process Overview and Basic Principles

What is Composting?

A managed process through which solid heterogeneous organic substrates are biodegraded in an aerobic and thermophilic environment.
Composting Process Model

Compost Biochemistry

- Composting is a controlled process. The goal is to maintain conditions that encourage a healthy community of microbes.

- This is done by monitoring and manipulating six main process parameters.

  Oxygen
  Nutrients
  Temperature
  Particle Size, Porosity and Structure
  Moisture
  pH
Microbial Succession

• During composting, there is a succession of microbial species; the environment created by, or the byproducts of, one species invites the activity of another species.
• Bacteria break down easily degraded organic matter, fungi and actinomycetes work on more complex organics.
• As a result, no single species persists though the entire range of conditions encountered during the compost process.

Oxygen Control

• Aeration is provided by passive aeration (chimney effect), forced aeration (fans) or mechanical agitation (windrow turner).
• Oxygen levels in the range of 16% to 18% are typical.
• Action should be taken when oxygen falls below 5%.
Passive Aeration – “Chimney Effect”

Nutrients

- Phosphorous and potassium are usually available in sufficient amounts.
- Carbon or Nitrogen is typically the limiting factor.
- Biological organisms generally require about 25 or 30 times more carbon than nitrogen. C:N Ratio is commonly used to express this relationship.
- Feedstocks with high C:N ratios (not enough nitrogen) degrade slowly.
- Feedstocks with low C:N ratios degrades quickly, but can quickly consume oxygen leading to anaerobic conditions, and can give off excess nitrogen as ammonia.
- C:N ratio is controlled by mixing various feedstocks and bulking agents together to get the desired end result.
- Target range of C:N ratio is between 25:1 and 30:1.
Temperature Control

• Heat is a byproduct of biological activity.
• High temperatures required for pathogen reduction (i.e. PFRP).
• Temperature is controlled through forced aeration, mechanical agitation, or passive aeration.
• 10 to 15 times more air flow is required for temperature control than for meeting oxygen demand.
• Commonly believed that optimal decomposition occurs between 45°C and 60°C. (Gore system?)

Temperature Characteristic Curve

<table>
<thead>
<tr>
<th>°F</th>
<th>Psychrophilic</th>
<th>Mesophilic</th>
<th>Thermophilic</th>
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<td>131</td>
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Active curing
Particle Size, Porosity & Structure

- Particle size affects the rate of decomposition; smaller particles have a greater surface area relative to their volume, and thus more material is exposed to microbial action.

- Porosity is a measure of the free air space within the composting mass, and determines the resistance to airflow.

- "Structure" refers to the strength and rigidity of particles and their resistance to compaction and degradation.

These three factors are inter-related.

- They are adjusted primarily during the initial feedstock mixing step, and are enhanced by adding "bulking agents".

- Porosity and structure requirements are technology dependent.

- A material with poor structure (e.g. cardboard) will lead to reduced porosity after a few weeks of active composting.
**Moisture**

- Water provides a medium for chemical reactions & transports substances within the composting mass.
- Microbes also produce water as a byproduct of decomposition.
- Below 40%, microbial activity slows.
- Makeup water is easily added to the process with hoses, sprinklers, etc.
- Excess water is removed by aeration or evaporative cooling, or as leachate.

**pH**

- Bacteria prefer neutral conditions (pH between 6 and 7.5).
- Fungi can thrive in a wider range: from pH 5.5 to 8.
- When the pH is in excess of 9, nitrogen is converted to ammonia and is unavailable, thus slowing the process.
- When the pH is below 5.5, microbes can not survive and the process slows.
- In low pH conditions, some heavy metals become “mobile” and affect chemical quality of the final compost product.
- If necessary, pH is adjusted by mixing feedstocks and bulking agents at the outset of the process.
- Target range of the initial mixture is between 6.5 and 7.5.
Biochemistry Summary

- Process parameters are interconnected; changes in one can initiate changes to another parameter.
- Ideal conditions seldom exist. Managing the composting process involves juggling the various parameters and making compromises.
- The composting process is slow to react to changes.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>16% +</td>
</tr>
<tr>
<td>Moisture</td>
<td>40 to 60%</td>
</tr>
<tr>
<td>Particle Size</td>
<td>1/8” to 2”</td>
</tr>
<tr>
<td>Porosity</td>
<td>50% to 60%</td>
</tr>
<tr>
<td>C:N Ratio</td>
<td>25:1 to 30:1</td>
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<tr>
<td>pH</td>
<td>6.5 to 7.5</td>
</tr>
<tr>
<td>Temperature</td>
<td>45 °C to 60 °C</td>
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Common Monitoring Tools and Practices
Complexity of Monitoring Methods

- Monitoring tools/methods vary based on the size of operation, type of technology, end product goals, and regulatory requirements.
- What you are using the process measurement for will determine the QA/QC requirements (e.g., water addition).

Testing/Sampling Frequency

- There are no process-specific formulas that dictate sampling frequency.
- Varies depending upon size of your operation, feedstocks, type of technology, product specifications, and quality certification programs.
- Frequencies of specific tests may also be contained in your operating approval.
Common Monitoring Parameters

- Moisture
- Temperature
- Oxygen
- Bulk Density
- Particle Size
- C:N Ratio
- pH
- Stability & Maturity

Moisture Monitoring

- Hand squeeze test.
- Microwave method and Koster Crop Testers are quick and dirty, and inexpensive. (Remember that compost burns.)
- Oven method is the most reliable but takes 24 hours. Run ovens at 75°C to avoid burning off volatile fraction of samples.
- Moisture balances are less expensive than ovens and more reliable than microwaves. Results in 20 minutes.
Microwave Method

• Record the weight of a paper plate (or other microwave safe container).
• Place a ~50 mL sample of material onto the plate. Spread the sample evenly, and remove any metal fragments. Record the weight of the sample and plate, and calculate the sample weight (mass_{total}).
• Dry the material in the microwave at the highest setting for 3-4 minutes.
• Remove the sample and record its weight. Then gently stir the sample and place it back in the microwave for 1-2 minutes at a medium setting.
• Continue to dry the sample in 1-2 minute intervals on medium until the weight of the plate/sample does not change from the previous reading.
• Record the weight of the dried sample and plate. Calculate the weight of the dried sample (mass_{dw}).
• Calculate the moisture content.
• MC = (mass_{total} - mass_{dw}) / mass_{total}

Temperature Monitoring

• Bimetal thermometers are the industry standard. They are inexpensive and reliable, but can take 1 to 2 minutes to stabilize.
• “Pull back” reflex.
• Thermocouples and RTD’s are more expensive, but give faster readings. Thermocouples and RTD’s are normally using in in-vessel systems, but hand probes are available.
• Wireless temperature probes are available.
• Remember to calibrate temperature probes regularly.
• If you have a large site and/or take many readings, consider using thermocouple probes with a datalogger.

Buy 48” probes and always use a probe guard.
Measuring Temperatures

- Insert your thermometer into the side of the pile at a downward angle to reach the core. (You can also insert the probe straight down from the top.)
- Probe several locations along the length of the windrow/pile. Look for consistent temperatures.
- Avoid the tapered ends of the windrows (the larger surface area might affect temperatures).
- The amount of force needed to push the probe in will give an indication of density/porosity.

Oxygen Monitoring

- Oxygen monitoring is normally done in mid to large size operations.
- Requires specialized probes.
- Sensors have a limited self life.
- Demista Instruments is the most common manufacturer.
- Use the oxygen probe in the same manner as the temperature probe.
- Calibrate by measuring oxygen in ambient air. Should be 21%.
**Bulk Density & Porosity**

- Bulk density is used as a surrogate measure for porosity.
- The sample size needs to be large enough to account for non-uniformity of the material.
- Specific Gravity (SG) is the ratio of the density of a material relative to water (1,000 kg/m³).
  - SG > 1 means heavier than water
  - SG < 1 means lighter than water

**Quick “Bucket Test” for Bulk Density**

- Weigh an empty 5 gallon pail. Measure the exact volume (V) by filling pail to the brim with water.
- Fill the empty pail one-third full with your material. Drop the pail 10 times from a height of six inches onto a firm flat surface to compact the material.
- Add more material until the pail is two-thirds full. Drop the pail 10 more times from a height of six inches.
- Fill the pail to the top. Drop the pail 10 times from a height of six inches.
- Fill the pail to the brim (do not heap or over fill the pail). Do not drop the pail to compact the material.
- Weight the pail and sample. Subtract the weight of the pail to calculate the weight of material (m).
- Calculate the bulk density of the sample.
- Bulk density (D) = m ÷ V
Quick “Bucket Test” for Porosity

- Complete the “bucket test” for bulk density.
- Fill the pail to the brim with water.
- Record the weight of the pail, sample and water (mass_total).
- Determine the weight of the water added to the pail (mass_{H2O} = mass_{total} - mass_{pail} - mass_{sample}).
- Calculate the volume of water added to the pail by assuming density of water is 1 kg/L.
- Calculate porosity (n) of the sample:
  \[ n = \frac{\text{volume}_{water}}{\text{volume}_{total}} \times 100\% \]

Particle Size

- Particle size measurement can be useful to ensure you are producing a product that meets your client’s specifications.
- Can be used to ensure your amendment supplier is providing the material you need.
- Standard soil sieves ranging from ¼” up to 2” are used.

Sieve shaker units are loud.
C:N Ratio

- C:N ratio is a measure of the relative amounts of carbon and nitrogen in the material. It is expressed on a dry weight basis.
- Samples are normally set to a laboratory of analysis.
- C:N ratio = total organic carbon/total nitrogen
- Total organic carbon = carbon fraction of the organic matter
- Total nitrogen = organic nitrogen + inorganic nitrogen (ammonia nitrogen + nitrate nitrogen).
- Total Kjeldahl Nitrogen (TKN) provides an approximation of total nitrogen. (TKN = organic nitrogen + ammonia nitrogen)

pH

- pH is a measure of the acidity or alkalinity of a solution.
- Standard methods for measuring pH in soils do not work for compost.
- TMECC method should always be used.
**Slurry Method for pH**

- Oven dry a sample at 75°C for 24 hours (or using the microwave method) to determine the moisture content.
- Transfer the equivalent of 40 g dry weight of sample into a jar with a screw-top lid.
- Add 200 mL of deionized water to the sample. Let stand for 20 minutes, mixing vigorously on a periodic basis.
- Measure pH of slurry using electronic meters.

**Stability & Maturity Tests**

- Stability measures biological activity. Maturity measures whether the compost has any phytotoxic effects.
- Respirometry and germination tests are typically outsourced to a 3rd party lab.
- Solivita or Dewar Flasks can be used at the facility as a screening tool before sending samples off for more expensive lab testing.
- Moisture must be in the proper range before stability tests are done, otherwise you will get a false-positive result.
Managing the Composting Process

Composting Process Model

1. Feedstock Recovery
2. Feedstock Preparation
3. Composting
4. Odor Treatment
5. Compost Curing
6. Compost Screening and Raking
7. Compost Storing and Packaging

Finished Product
Feedstock Recovery

- Feedstock Recovery is the process of physically separating non-compostable and hazardous materials from the composting feedstock
- Generally, contaminants should be removed as soon as is practically possible
- Requirements and methods vary from site-to-site depending on feedstocks, collection program, and tolerances of composting technology and markets
- Load inspection or “screening” should be completed upon receipt
- Non-compostables can be removed manually or mechanically (e.g. screening, magnets, air classifiers)
- You cannot remove “invisible” contaminants such as inorganic metals
- “Garbage in, garbage out”

Feedstock Preparation

- Goal is to prepare feedstocks for the high-rate composting process
- Reduce Particle Size
  - reducing the particle size increases the surface area available for microbial decomposition and results in faster decomposition
  - particle size reduction achieved through grinding, shredding, or mixing process
  - particle size does not need to be reduced for all feedstocks (food waste, biosolids, grass and other high moisture wastes do not typically require size reduction)
- Adjust C:N Ratio
  - target C:N ratio of 25:1
  - it’s possible to combine multiple amendments
- Add Innoculants
  - not always necessary
  - recycle compost for your process
Feedstock Preparation

• Adjust Porosity
  – add bulking agents to adjust porosity of overall mixture
  – choose bulking agents that will provide structure through the process

• Amend Moisture
  – add water or leachate and distribute it evenly
  – 55% to 60%
  – too little water slows the process
  – too much water fills pore spaces and can lead to anaerobic conditions
  – sometimes, high-moisture feedstocks can be used as a moisture source (e.g. milk)

• Adjust pH
  – typically not required for most feedstocks
  – lime or gypsum

Active Composting

• Most active phase of the composting process
• High oxygen demand and heat generation
• Control Temperature
  – Maintain in the 55 to 60°C range to achieve PFRP, then drop to 45 to 55°C range
  – Do not allow temperature to rise to high above 65°C
  – Temperature monitoring frequency ranges from continuous in some in-vessel systems, to daily or weekly.
  – Sometimes continuous temperature monitoring needs to be augmented with manual measurements
  – Reduce temperature through aeration (turning, fan settings), but remember that aeration also reduces moisture
  – A drop in temperature may indicate moisture and/or oxygen levels are too low
  – Dropping moisture is one means of retarding a “run-away” process
Active Composting

- Monitor and Amend Moisture
  - target range is 55% to 60%
  - too little water slows the process
  - too much water fills pore spaces and can lead to anaerobic conditions
  - water is lost through convective heat loss and aeration
  - add water and distribute it evenly is necessary
  - do not add leachate after PFRP has been achieved
  - adding water (especially cold water) can temporarily slow process
  - adding water to reduce temperatures is generally not effective
  - remove water by turning or increasing aeration

Active Composting

- Monitor and Control Oxygen
  - Maintain oxygen levels above 15%
  - Oxygen demand decreases as the process progress, and so to do aeration requirements
  - Increase oxygen levels through aeration, but remember that aeration also reduces moisture
  - Aeration in ASP systems controlled on timers, temperature feedback or oxygen feedback
  - Aeration in static piles and windrows is provided by turning and convection
  - Windrow turning frequency depends on feedstock, porosity and management style (ranges from every two to three days at the outset, to weekly or biweekly during the later stages)
  - Turn based on monitoring data - Don’t turn when it’s not required
Curing (Maturation)

• Lower oxygen demand and heat generation than the active composting phase.
• Most available nutrients have been utilized by the microbes.
• Curing can be accomplished before or after screening.
• Monitor and Amend Moisture:
  – Target range is 40% to 50%
  – Adding water during turning is the preferred method
  – Turn after water to mix and distribute it evenly is necessary
  – Reduce moisture to 40% prior to screening

Curing (Maturation)

• Control Temperature
  – Maintain in the 45°C range
  – A drop in temperature may indicate moisture and/or oxygen levels are too low, but may also mean process is completed
• Monitor Oxygen
  – Maintain oxygen levels above 15%
  – Turning frequency ranges from every two to four weeks
  – Turn based on monitoring data - don’t turn when it’s not required
Screening and Refining

- Screening removes oversized material from the compost including large pieces if wood, stones, bones, leather, glass shards, metal fragments, hard plastic bits, and film plastic.
- The objective of screening and refining is to protect public health and improve the marketability of the compost.
- Equipment can include screens, cyclone separators (light fraction), ballistic separation (heavy fraction), eddy current (metal and sharps), destoners.
- Compost that is too wet will blind off screens,
- Compost that is too dry will lead to dust problems.

Storage and Packaging

- Prevent weed seeds from taking root in product piles. Pick weeds regularly.
- Manage moisture content to prevent spontaneous combustion.
- Prevent pathogen reintroduction.
Odour Management

Typical Odour Sources

- Feedstock receiving
- Mixing areas
- Active composting
- Curing
- Product storage
- Run-off ponds
- Leachate treatment/storage
Measuring Odours

• It is possible to measure specific compounds, but this approach can be costly if the compounds are not known in advance.

• The following parameters have been developed to quantify odours.
  – odour threshold
  – odour intensity
  – persistence
  – character
  – hedonic tone

Odour Psychology

• People often report physical irritation at concentrations much lower than the “irritation threshold”.

• A person may associate an odour with a negative experience from their past.

• A “negative” response to an odour may cause a person to alter their breathing patterns, feel stressed or nauseous.
FIDO Assessment

- Frequency
- Intensity
- Duration
- Offensiveness
Siting and Layout

- Appropriate site selection
- Appropriate buffer zones
- Layout of operations within the site based on predominant wind directions/speeds, locations of neighbours, etc.

Design Features

- Enclosures with negative pressure.
- Doors that rapidly open and close, and which have air curtains.
- Source capture exhaust systems.
- Negative aeration.
- Odour treatment.
Treatment Technologies

- Thermal Treatment
- Activated Carbon
- Scrubbers
  - Packed Towers
  - Atomized Mist
- Biofilters

Operational Controls

Implementing best management practices can solve many odour problems and eliminate the need for redesign.
Educate Your Staff

• Make sure site personnel understand the basics of odour science and psychology.
• Train all staff on “compost 101”.
• Encourage a “culture” where odour prevention is taken seriously, rather than viewed as an obstacle.

Invest In The Right Tools

• Acquire and use the right tools:
  – weather stations or wind socks
  – thermometers and oxygen probes
  – digital camera
• Set up routine odour survey program.
• Set up a system for receiving and responding to odour complaints.
• Give your staff time to learn and use the tools.
Process Feedstocks Quickly

- Process it quickly! Don’t let raw feedstocks sit around.
- Control your receiving hours. Don’t take materials 10 minutes before your staff go home.
- Have contingency plans in place for equipment breakdowns, foul weather, etc.

Maintain Proper Pile Heights

- Increasing the height of piles is easy and lets you increase production, so why not?
- Passive aeration only works when pile height, pile porosity, and energy of the mixture are balanced.
- Aeration systems are may not be designed to provide the necessary cooling capacity for larger piles.
- The process can slow down, and ultimately you lose capacity.
Monitor the Process and Adapt

- Establish and monitor Key Performance Indicators (KPI's).
- Select a bulking agent that will give you good structure and free air space.
- Too high a moisture content leads to saturated pore space, anaerobic conditions and excess leachate.
- A “hot” mix can outstrip your ability to keep up with the process.
- Touch it, smell it.....
- If you don’t get it right... fix it!

Adapt Operating Schedules

- Activities that are likely to create odours (e.g. windrow turning, pile tear-downs) should be planned around neighbor’s schedules.
- Be ready to adapt your schedule to changing weather conditions.
Practice Good Housekeeping

- Make it a habit to clean up after yourself.
- Scrape and sweep alleys daily to reduce “compost tea” generation.
- Wash down receiving areas periodically.

Understand Your Odour Control System

- Take the time to understand your system and how it is supposed to be operated.
- Monitor the performance of odour control systems regularly.
- Remember that biofilters need to be fed and watered.
- Periodically check scrubbers for clogging.
- Keep the Facility’s doors closed.
Maintain Your Equipment

- Repair holes in process air ducting and blower housings.
- Monitor aeration fan vibration.
- Schedule rolling stock maintenance around operating schedules. If necessary, bring in rental equipment.
- Undertake an odour risk assessment. Use this to identify critical spare components that you need to keep onsite.
- Fix doors immediately.

Manage Surface Water & Leachate

- Ponding water is a source of odour. Fix ruts and depressions.
- Re-establish site grading periodically.
- Keep ditches and swales clear of debris that will impede flow.
- Treat or dispose of surplus leachate.
Counteractants: Last Line of Defense

- Two categories:
  - masking agents (perfumes)
  - reactants
- Chemistry is not well defined.
- Can be surface applied.
- More often spray atomized around or above the odour source.
- Partial solution to temporary odour problems.

Know When To Get Help

- Chances are someone’s already made the same mistake. Learn from the experiences of others.
- Attend workshops and conferences.
- Visit other facilities.
- Recognize when you’re in over your head.
- Realize that it’s okay to ask for help.
Health and Safety Concerns at Composting Facilities

Unique Hazards at Compost Sites

- Spontaneous combustion and fires
- Vehicles and Mobile Equipment
- Grinders and shredders
- Moving Equipment (i.e. belts, conveyors, fans)
- Noise
Hazards at Enclosed Compost Sites

- Electrical Equipment
- Process gases (e.g. NH₃, H₂S, CO, CO₂)
- Confined spaces
- Fine particulates (PM10)
- Pathogens
- Bioaerosols
- Moulds

Fire Prevention and Control at Composting Facilities
Fire Triangle and Composting

Ignition sources:
- engine manifolds and exhausts
- welding, cutting and grinding
- cigarettes
- arson (an unhappy neighbour?)
- lightning
- electrical arcs and short circuits
- wildfires

Since composting is supposed to be an aerobic process, we intentionally supply oxygen.

Fuels at composting facilities:
- amendment stockpiles (wood chip, straw, paper)
- dry compost particularly compost amended with wood chip.
- fine compost that accumulates around screening operations
- dust accumulation
- methane pockets from anaerobic conditions
- fuel, hydraulic fluid and oil leaks from equipment

Spontaneous Combustion

- Spontaneous combustion is defined as combustion of material in the absence of “forced ignition” (i.e. a spark or flame).
- Spontaneous combustion results from the a series of heat-generating processes; each process sequentially sets the next process off.
- Reaction rates double with each 10°C rise in temperature.
- Typical composting materials ignite at temperatures in the 150 to 200°C range. Woody material ignites in the 120 to 145°C range.
- Dry materials (20 to 40% moisture), large piles that are self insulating, or piles with poor porosity create ideal conditions for spontaneous combustion.
- Smoldering fires can persist for long periods of time (months?). Opening a pile or otherwise introducing air can allow a smoldering fire to quickly turn into open flame.
Fire Prevention

- Invite the local fire department to your site and work through procedures in advance.
- Set up a “response box” for first responders at the facility’s entrance.
- Maintain fire breaks between the facility and adjacent lands.
- Implement housekeeping practices to reduce dust accumulations.
- Regularly blow down engines and exhaust systems with compressed air.
- Prohibit smoking except in designated areas.
- Set up hot work permit systems and fire watches.

Fire Control

- Maintain aisles between piles to allow for equipment and firefighter access.
- Use fire detection systems in buildings. Make sure they are designed for the environment they are installed in.
- Train staff how to use fire extinguishers and hoses and how to respond to a fire.
- Monitor stockpiles for fissures of steam or wet spots on the surface that might indicate a subsurface hotspot. Check temperatures in these areas.
- Make sure there is an adequate water supply and distribution system if the site does not have hydrants.
**Extinguishing Fires in Compost Piles**

- Internal or smolder fires are more difficult to extinguish since it's hard to know exactly how large they are and where they are.
  - Call the fire department.
  - Do not walk on smoldering piles!
  - Form a plan of attack. Make sure everyone understands their role. Make sure enough space exists for laying out the material.
  - Internal fires generally require the stockpile be broken down with mobile equipment, and the hot material spread out and allowed to cool or be wetted.
  - Remove cool materials from around the exterior of the pile rather than digging straight into the heart of the pile.
  - Use spotters who are in radio communication with the Equipment Operator.
  - Have hoses standing by to wet down any open flames that develop.

- Always remember that a pile of compost or a piece of equipment is not worth a life.

**Product Sampling and Testing**
Finished Product Testing

Reasons for finished product testing:

- Shows that products conform to regulatory criteria (e.g. CCME, CFIA).
- Provides assurances to customers that the products meet their needs.
- Verifies that process control steps are working.
- Required for product labeling.

Testing Frequency

- CCME and CFIA do not dictate sampling frequency (i.e. size of individual batches).
- Batch size may vary depending upon size of your operation, variety of feedstocks, end use and market specifications, and quality certification programs.
- Sampling frequencies may also be written into your provincial operating approval.
- CQA’s recommended testing frequency:

<table>
<thead>
<tr>
<th>Annual Compost Production</th>
<th># of Samples</th>
</tr>
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<tbody>
<tr>
<td>≤ 5,000 tonnes</td>
<td>4</td>
</tr>
<tr>
<td>5,000 to 15,000 tonnes</td>
<td>6</td>
</tr>
<tr>
<td>&gt;15,000 tonnes</td>
<td>12</td>
</tr>
</tbody>
</table>
Sampling Methods

- use standardized and consistent sampling procedures to obtain representative samples.
- Use composite samples to avoid “sampler bias”.
- Use the proper sampling containers and handling techniques.
- Be conscious of sample contamination.
- Consider field blanks to quantify sampling errors.

CFIA Composite Sampling Guidelines

- Randomly select the locations from which to draw sub-samples, taking care to ensure that all levels of the pile (top, middle, bottom) are sampled from.
- The number of sub-sample locations is dependent upon the size of the compost pile:

<table>
<thead>
<tr>
<th>Volume of Pile of Batch</th>
<th># of Subsamples</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 5,000 m³</td>
<td>10</td>
</tr>
<tr>
<td>5,000 to 10,000 m³</td>
<td>20</td>
</tr>
<tr>
<td>&gt; 10,000 m³</td>
<td>40</td>
</tr>
</tbody>
</table>

- To avoid microbial surface contamination, the top 3 inches of material must be removed from the surface of the pile prior to sampling. The “cleaned” area should be roughly circular and about 18 inches in diameter.
- The sub-samples are to be drawn at a depth between 30 and 60 cm (12-24 inches) from the surface of the pile.
- The sub-sample from each sampling location should be the same size and be a minimum of 250 mL.
- All sub-samples are to be combined in the same sterile container and mixed to obtain a relatively homogenous sample.
- The composite sample should be at least 5 L in size.
Analytical Methods

• Use standardized and consistent analytical methods that are well documented.
• Test Methods for the Examination of Composting and Compost (TMECC).
• “TMECC provides detailed protocols for the composting industry to verify the physical, chemical, and biological condition of composting feedstocks, material in process and compost products”.

Typical Analytical Package

• Trace elements (ICP & cold hydride)
• Pathogens (f.coliform and salmonella)
• Foreign matter and sharp foreign matter
• Maturity and stability (O₂ respiration, CO₂ evolution or Dewar PLUS cucumber germination and growth)
• pH, EC, SAR
• Major nutrients (N-P-K)
• Organic matter
• Bulk density
• Moisture content
• C:N ratio