Compost – Basics of On-Farm Composting

Introduction

This factsheet looks at pertinent information, methods and recommendations for New Brunswick farmers who are interested in on-farm composting.

Figure 1: Tractor pulled windrow turner

When compost is applied to farmland, it increases the organic matter, enhances physical and chemical properties of the soil, and thereby improves the tilth, nutrient level and pH.

Compost can also be an excellent component in greenhouse mixes as it holds moisture and nutrients.

What is Compost and How is it Made

Composting is the biological decomposition of organic materials by microorganisms to a relatively stable humus-like material that can be used as a soil amendment or as a component in a greenhouse mix.

Figure 2: A typical compost windrow

Organic materials such as hay, straw, manure, leaves, bark, sawdust, potato waste and seafood waste can be used as feedstock to make compost. They are mixed together in a pile/row in the proper proportions that will provide the optimal carbon to nitrogen ratio (C:N). Following the feedstock mixing, moisture is added if required. With the proper moisture, the microorganisms within the feedstock become active and cause the pile to heat. When the pile/row heats to an optimal temperature, it is turned. This turning action incorporates oxygen into the feedstock, which in turn cools the pile down. Following the turning the microbial breakdown of the feedstock starts heating the pile/row again and turning continues until the original feedstock has been sufficiently digested by the microbes and the temperature of the pile stabilizes.

The process where compost is turned frequently, during the composting stage, allows for good air circulation and penetration into the pile and is known as aerobic composting. Microbial degradation is more efficient and the feedstock breaks down faster into a compost with aerobic composting.

The process where compost is produced in large windrows and infrequently turned is referred to as anaerobic composting as little air is able to penetrate the pile. As a result the microbial breakdown process is much slower. Each type has its own characteristics and use.

Key Requirements in Making Compost

Some very basic conditions are required for the necessary biological activities to occur. They include:

1. Food Supply (carbon and nitrogen)
2. Moisture
3. Oxygen
4. Heat

1. Food Supply

The food supply for the microbes consists of a blend of both carbon (C) and nitrogen (N) sources. Typically, the C:N ratio at the start of the composting process should be in the range of 20:1 to 40:1 with the optimal ratio between 25:1 to 30:1. Ratios below 25:1 result in the increasing loss of N and if above 35:1, can take longer to produce a mature compost product.

In order to determine the right blend of carbon and nitrogen sources in a balanced compost recipe, it is helpful to have the compost feedstock tested for its carbon and nitrogen content.

Composting Tip: *The addition of a small amount of soil as part of the compost recipe at the start of the composting process is beneficial as the soil helps bind ammonium (NH4+N), thus reducing its loss.*

Listed below are some of the more common materials being composted in New Brunswick and their C:N ratios.

Material	C:N Ratios	
	Range	*Average*
Softwood bark, sawmill yard waste	131 – 1285	496
Hardwood bark, sawmill yard waste	116 – 436	223
Sawdust	200 – 750	442
Softwood shavings, chips	212 – 1313	641
Hardwood shavings, chips	451 – 819	560
Hay	15 – 32$_1$	n/a
Straw	48 – 150$_1$	60$_1$
Fresh green chop	9 – 25$_1$	17$_1$
Silage	n/a	Est 30$_1$
Cattle manure	11 – 30	19$_2$

Horse manure	22 – 50	30_2
Chicken manure	3 – 10	6_2
Sheep manure	13 – 20	16_2
Hog manure	9 – 19	14_2
Cull potatoes	n/a	18
Potato waste	n/a	28
Crab & Lobster waste	4 – 5.4	4.9
Seaweed	n/a	17
Fish waste	2.6 – 5	3.6
Yard and leaf waste	40 – 80	54

Source: Adapted from the On-Farm Composting Handbook, Natural Resource, Agriculture and Engineering Service

1. *Nitrogen content will vary due to maturity of crop at time of harvest.*
2. *C:N ratios will vary due to percentage and type of bedding used.*

2. Moisture

The generally accepted moisture range for producing compost is between 40 and 65% with an optimal range of 50 to 60%. Moisture may have to be added depending upon the feedstock used and during the active or thermophilic stages, if composting is done during the hot months. In hot summer conditions, respiration from the composting process will tend to lower moisture below ideal levels.

Excess moisture must be kept out of the compost during the curing or mesophilic stages and the wet and cold months. Fleece covers protect compost from undesirable conditions. The fleece covers also effectively shed water, while still allowing the compost underneath to breath.

If the moisture levels in the pile exceed 65%, the composting process tends to become anaerobic, creating problems such as foul odours. It can also negatively affect the oxygen levels and slow down the composting process.

Composting Tip: *The squeeze moisture test is a good way to quickly determine the moisture level of the compost pile. A handful of material should feel damp, not dripping wet. If you pick up a handful of material and it drips without being squeezed, it is too wet. For sampling, grab from the interior of the pile in an area that is well mixed, not from the outer shell. If the material appears dry and crumbles after squeezing, it is too dry. If the material retains its clumped shape after squeezing without releasing excess water and your hand is damp, then it is just right for composting. (On-Farm Composting Handbook)*

3. Oxygen

Oxygen is supplied in various ways. Common methods include the act of turning compost windrows or piles, the use of aeration vents or pipes inside the windrow/pile, and the natural air movement between feedstock particles. Experts suggest that a minimum of 5% oxygen should be present in the material with 10% being ideal. However, an instrument that measures oxygen levels would have to be used to determine these levels. As the compost completes its decomposition process, oxygen levels will increase.

Oxygen levels and the resulting quality of the compost are influenced by:

- Material density due to particle size being very small may cause compaction of material, especially if the materials are high in moisture. This results in the material being unable to breath.
- High moisture in the pile (above 65%).
- Windrow size (larger means less air to the center of the pile).
- Frequency of turning during the active composting stage.
- Compost produced aerobically (with plenty of oxygen) will contain more beneficial bacteria and fungi.
- Anaerobically produced compost will also contain bacteria and fungi, but not all are beneficial. Generally, in anaerobic conditions, the compost is not broken down as well and if used in greenhouse mixes, may compete with plants for nitrogen if C:N is high (eg. if C:N is greater than 15:1). Anaerobic compost may still have a good moisture holding capacity and if supplemented properly with nitrogen can be used successfully in these mixes.

4. Heat

When the C:N ratio, moisture and oxygen are within proper ranges, heat generation will occur from microbial activity.

It is important to keep temperatures within the optimal thermophilic range in order to preserve the quality of the compost and to destroy most pathogens and weed seeds which may be present in the feedstock. A proper temperature range for the thermophilic stage (active stage) of composting is between 55˚C and 70˚C, although some literature indicate that between 40˚C and 60˚C is an optimal range. Temperatures below 45˚C, during the first two to three weeks of composting, can point to problems with one of the three basic requirements: oxygen, moisture or the C:N ratio. Temperatures above 70˚C are not good for the survival of beneficial bacteria and fungi and may kill some of them.

The University of Maine Compost School recommends that compost piles or windrows be turned: (1) at approximately 150˚F (66˚C), (2) if the temperature drops without cause, or (3) if the difference between the one foot and three foot temperature readings is greater than 20˚F (7˚C). *(On-Farm Composting Handbook)*

Temperature should be checked on a regular basis. This can be done by using a compost thermometer which can reach two to three feet into the pile.

After the pile has reach the thermophilic temperatures for two to three weeks, the compost should progressively start cooling down. This is called the curing stage. When the temperatures no longer rise above 10 C˚ of the ambient temperature, the pile is considered cured or mature.

Composting Tip: *If the inside of the pile is cool and the outside is hot, it means that the pile is either too wet or lacking oxygen and should be turned. If the outside feels cool and the inside is hot, the pile is on the dry side. Moisture should be added and the pile should be turned.*

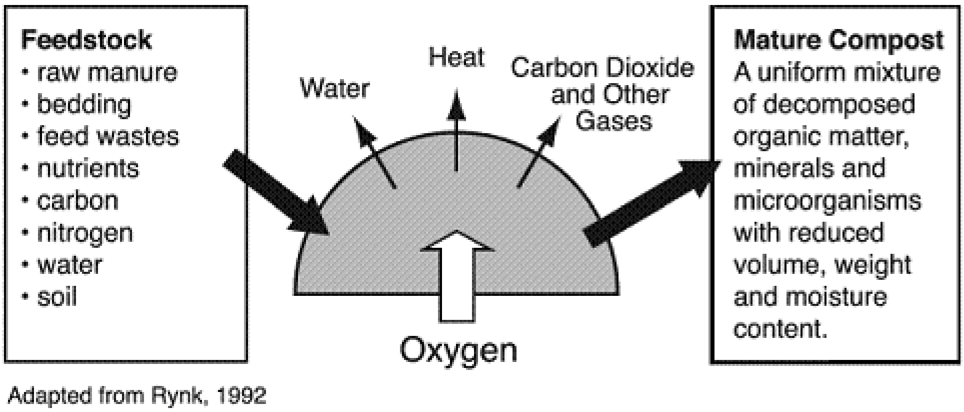

Figure 3: Schematic of the composting process courtesy of the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).

The Composting Phases

There are three phases of the composting process: *(Courtesy OMAFRA)*

- **Active or Thermophilic phase -** This is the phase when the most rapid breakdown of materials occurs. After the materials are mixed and the pile is created, temperatures rise (above 45ºC) and decomposition is done by aerobic, thermophilic, organisms including bacteria, actinomycetes, fungi and protozoa.

  The microorganisms use oxygen to consume the feedstock materials and respire carbon dioxide. Temperature (40-60ºC)[1] and moisture (50-60%) beyond the optimum ranges, or low oxygen levels will reduce biological activity. High moisture levels reduce oxygen. Low moisture levels can result in temperatures rising too high.

  The time required for the active phase will depend on the materials, ambient air temperatures, and the composting method. In-vessel systems with turning and aeration can offer the shortest times. A composting windrow with frequent turning may have an active stage as short as 1-4 months, or up to 4-8 months with less frequent turning and 6-24 months for passive composting with no turning and no active aeration.

- **Curing or Mesophilic stage -** after the main thermophilic phase most materials have broken down and are not recognizable from their original form. Temperatures are more stable (usually less than 40ºC) even after the pile is turned. In this stage there is a shift in the organism populations to those that prefer lower temperatures. Turning is not needed but compost should remain aerobic. In the curing phase, compost is not yet mature. Immature compost may have higher levels of organic acids, high C:N ratios, extreme pH values or high salt contents all of which can damage or kill plants. The time to cure may vary up to a year but is generally less than 3 months.

- **Maturing -** compost needs time in storage to mature. Maturity is an indication of the degree of humification or the conversion of organic compounds to humic substances that are resistant to microbial breakdown. There are various tests for compost maturity. Lab tests can be used or germination tests using lettuce or cress seeds can be used. Immature compost may injure the germinating seeds and plants will not survive. During the maturing phase pile size is less critical than during the active or curing phases. Material can move from storage to utilization when convenient but should be utilized as soon as possible.

  For the complete article by OMAFRA on composting see the following link: http://www.omafra.gov.on.ca/english/engineer/facts/05-023.htm

  - *Note 1: Other sources list 55˚C to 70˚C as the ideal heat range. See above section titled Heat.*

> ***Composting Tip:*** *Regardless of the method used to make compost, it is helpful to preserve its quality by covering the finished product.*

Equipment & Methods Commonly Used to Produce Compost

In New Brunswick most on-farm composting is still performed using either an excavator or a loader to turn the piles. Only a few operations use either the In-vessel system or a straddle turner.

Method	Typical size of row (width x height in meters)[1]	Typical time to make mature compost	Aerobic or Anaerobic[2]
Excavator	7.3 x 3.0	2 years	Anaerobic
Loader	6.7 x 2.4	2 years	Anaerobic
In-Vessel	1.8 x 1.2	6 – 8 weeks	Aerobic
Straddle turner	2.4 x 1.2	8 – 12 weeks	Aerobic
Manure spreader	2.1 x 1.1	10 – 14 weeks	Aerobic
By hand	1.8 x 1.0	8 – 10 weeks	Aerobic

1. Dimensions of windrows vary depending on equipment size and operator's preference.
2. Anaerobic: When turned, the pile does receive oxygen making it aerobic for a short period. Once the oxygen has been consumed, the pile is too large to remain aerobic and becomes anaerobic again.

Figure 4 – Straddle Compost Turner

Figure 5: In-Vessel Composter

Pro's and Con's of each method

Method	Pro's	Con's
Excavator/ loader	• Piles can be larger and composted outdoors as moisture will only penetrate the outside two to three feet of the pile or windrow.	• Due to size of piles and because they are generally not turned as frequently, composting is done more anaerobically. • Takes much longer to compost
In-Vessel	• One of the fastest methods of aerobic composting. • Does a very good job of mixing feedstock. • An excellent method where a regular, steady volume of material is added daily. • Moisture management easily done.	• Generally requires a building to house the unit. • In-vessel machines are dedicated to compost production only. • Expensive infrastructure.
Straddle turner	• A versatile method of producing an aerobic compost. • Mixes components very well, allowing each particle to get maximum air which helps microbes break down substrates.	• May require rows be covered to control moisture either by using fleeces or composting under a roof. • Due to smaller sized piles, it is difficult to compost in cold & snowy conditions even if fleeces are used. • The turner is a dedicated piece of equipment which can only be used in composting. • If a tractor powered turner is employed a tractor with a hydrostatic drive or a creeper gear may be required.
Manure spreader	• Very similar process and benefits as straddle turner. • Utilizes an existing piece of farm equipment.	• Much slower process. • Required spreader bar on the manure spreader has to be changed between field use and compost use.
By Hand (Pitch fork)	• Can make small quantities of high quality compost inexpensively.	• Manual labour. • Small scale production only.

Evaluating the Finished Product

There are several criteria that are important to consider when evaluating a mature compost product.

- The pH should be in the range of 6.5 to 8.0.
- The soluble salts$_1$ levels or Electrical conductivity (EC) should be 1.3 – 2.5 mS/cm, using the 2:1 Water to Media (compost) method.
- The C:N ratio of the finished compost should be between 15:1 and 25:1.
- The moisture content should be between 40 and 65%.

- The bulk density should be in the range of 475 to 700 kg/m³ *(800 to 1200 lbs/yd³).*

- The compost should have a good earthy smell.

- The original feedstock (e.g. straw, hay) should not be recognizable.

- The finished compost should reheat no more than 10˚C (if very mature) or between 10 - 20˚C (if moderately mature) with or without being turned or receiving more moisture.

- The compost should feel soft and slightly damp. – *When squeezed tightly in a fist, a tiny bit of moisture may appear between knuckles. The lump in your hand should hold together when the squeeze is released, but easily fall apart when bounced in the hand.*

- The heavy metal levels must meet the Canadian Council of the Ministers of the Environment (CCME) guidelines. http://www.ccme.ca/files/Resources/waste/compostgdlns_1340_e.pdf

- The volume of the finished compost is 50% or less than the volume of the original feedstock.

Factors to Consider when using Compost

For Greenhouse Use

- Use compost with an EC level under 2.5 mS/cm. The final EC in the transplanting mix should not be too high (eg. less than 1.5). It is best to avoid using chicken manure based compost in a greenhouse mix as it is generally too rich in nitrogen and the ammonia levels may be toxic to greenhouse plants.

- Keep the percentage of compost in a transplanting mix between 10 and 30%. If it is aged bark, do not use more than 10% and preferably not more than 5% in the mix.

- It is best not to use compost in a germinating mix, and it is strongly recommended NOT to try growing plants in straight compost.

For Agricultural Land Use

- Use compost wisely. Just because a little is good, does not mean that a lot is better for the land. A good rule of thumb would be to keep compost applications between 38 – 76 m³/ha *(20 and 40 yd³/ac).* However, it would be best to obtain a lab analysis of both the compost and the soil, so that a Professional Agrologist can recommend appropriate application rates.

- Composts are considered soil amendments because they provide organic matter and beneficial organisms to the soil, but often they do not contain enough available nitrogen for the needs of the crop. Some composts, however, are rich in nutrients and have low C:N ratios (eg. composted chicken manure) and may also be considered fertilizer, as they may provide a significant amount of available nitrogen.

Resources

On-Farm Composting Handbook – Natural Resource, Agriculture and Engineering Service – Cooperative Extension, Ithaca, New York (1992)

Field Guide to On-Farm Composting - Natural Resource, Agriculture and Engineering Service – Cooperative Extension, Ithaca, New York (1999)

BC Agricultural Composting Handbook, Soils and Engineering Branch, BC Ministry of Agriculture, Fisheries and Food

Agriculture Composting Basics, Ontario Ministry of Agriculture, Food and Rural Affairs
http://www.omafra.gov.on.ca/english/engineer/facts/05-023.htm

Maine Compost School
Cooperators:
University of Maine, Cooperative Extension
Maine Department of Agriculture, Food and Rural Resources
Maine Department of Environment
Maine State Planning Office