Dr. Elaine's™ Soil Food Web Foundation Courses

Course Manual

Foundation Course 2: BioComplete^{TM} Compost

Congratulations!

Having completed Course 1: Introduction to the Soil Food Web, you should now have an understanding of the basics of Soil Food Web science, and, more importantly, you should have an appreciation of the inspiring successes that have been accomplished in real world applications of this knowledge. We hope that both this knowledge and your appreciation of the substantial benefits for growers will motivate your continued endeavours through the next section of the Dr. Elaine's™ Soil Food Web Foundation Course.

Throughout the lectures in Course 1 you heard Dr. Elaine Ingham refer to "BioComplete™ Compost". In FC 2 you will learn all about how to produce this material.

We wish you all the best as you continue on with Course 2!

Dr. Elaine's™ Soil Food Web Team

HOW TO USE THIS MANUAL

Used in conjunction with the series of online lectures, Dr. Elaine's ™ Soil Food Web Foundation Course Manual provides the following:

- Overview of the lecture
- Lecture Contents containing Key Points that clarify and/or support information delivered in each lecture. *Please make sure you read these before watching each lecture!*
- Glossary of key words, terms and abbreviations used in each lecture, and
- References and Further Reading

On-screen prompts: During the online video lectures you will occasionally see information popups. These on-screen prompts will refer you to:

- Other sections of this course
- Key Points that are found in this Course Manual

Time references: These appear in this Course Manual:

- After ***Key Points***, for example, "***Key Points:*** **[34:18]"** - this indicates the time in the online video at which Dr Ingham mentions a particular topic or concept. The information in the Key Points sections of the Course Manual will help you to better understand these topics and concepts.

BEFORE WATCHING EACH LECTURE YOU WILL NEED TO DO THE FOLLOWING:

- Read through the section of the Course Manual for that lecture.
- Review the Course Glossary for the terms that are listed in the lecture.
- Review the relevant Appendices for the lecture.

Table of Contents

LECTURE 1

Lecture 1: THE HISTORY OF COMPOST [27:06]

1.0 OVERVIEW
Lecture 1 covers the following:
i) The history of Compost and compost production
ii) The definition of BioComplete^{TM} Compost and the purpose of this term.

1.1 LECTURE CONTENTS
1.1.1 Brief Definition of BioComplete^{TM} Compost

Key Points [1:29] *BioComplete^{TM} Trademark Defined*
BioComplete^{TM} – This is a trademark term that we use to describe Soil Amendments that meet the minimum biological requirements as defined by Dr Ingham (See table 2 and 3 below). You will hear Dr Ingham referring to the terms in the table below frequently throughout the lectures:

Table 1

BioComplete^{TM} Compost	Organic matter that has been aerobically composted, and that meets the minimum biological requirements defined by Dr Ingham.
BioComplete^{TM} Extract	A liquid extraction made using *BioComplete^{TM} Compost,* that meets the minimum biological requirements defined by Dr Ingham.
BioComplete^{TM} Tea	*BioComplete^{TM} Extract* that has been through the brewing process, and meets the minimum biological requirements defined by Dr Ingham.
BioComplete^{TM} Vermicompost	Organic matter that has been aerobically composted using vermiculture, and that meets the minimum biological requirements defined by Dr Ingham.
BioComplete^{TM} Amendments	This is a collective term, used to refer to BioComplete^{TM} Composts, Extracts & Teas that meet the minimum biological requirements defined by Dr Ingham.
BioComplete^{TM} Liquids	This is a collective term, used to refer to BioComplete^{TM} Extracts & Teas, that meet the minimum biological requirements defined by Dr Ingham.

Table 2 - *Minimum Biological requirements for BioComplete™ Compost*

Bacterial Biomass	300 µg/g compost
Fungal biomass	300 µg/g compost
F:B ratio	Equal to or greater than 0.3:1
Protozoa	10,000/g compost
Beneficial Nematodes	100/g compost
Ciliates must be less than	5/drop at 1:5 dilution

Table 3 - *Minimum Biological requirements for BioComplete™ Liquids*

Bacterial Biomass	300 µg/ml liquid
Fungal biomass	300 µg/ml liquid
F:B ratio (*BioComplete™ Tea, lower for extract)*	Equal to or greater than 0.3:1
Protozoa	10,000/ml liquid
Beneficial Nematodes	100/ml liquid
Ciliates must be less than	5/drop at 1:5 dilution

1.1.2 The Beginnings of Composting

1.1.3 Focusing on Problem Organisms - "Killing the Pathogens"

Key Points [13:24] Temperatures at which Problem Organisms are Killed

Problems organisms in a compost pile will be killed if temperatures are:

- Above 131F for 3 days (72 hours) or more
- Above 150F for 2 days (48 hours) or more
- Above 165F for 1 day (24 hours) or more

1.1.4 Definition of the "Aerobic decomposition of a mix of organic materials".

1.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*

The following glossary terms are used in this lecture: **Animalcule; Antibiotics; Hammurabi's Code; Indigenous; Pasteurization.**

1.3 REFERENCES & FURTHER READING

Cato the Critic's (300 BCE *approx.*) "De Agriculturia" *translated into English as* "How to do Agriculture": *soilandhealth.org/wp-content/uploads/01aglibrary/010121cato/catofarmtext.htm*

Howard, Sir Albert, *An Agricultural Testament*, London: Oxford University Press, 1940, Print

LECTURE 2

Lecture 2: WHAT DEFINES BIOCOMPLETE™ COMPOST [35:46]

2.0 OVERVIEW

Lecture 2 draws a sharp distinction between "putrefied organic matter" and actual compost. Most people's experience of organic material labelled as "compost" is really "putrefied organic matter" and this has distorted the general understanding of the term "compost". Continuing on from Lecture 1, the necessary parameters for a material labelled "compost" to really be considered "BioComplete™ Compost" are fully defined.

2.1 LECTURE CONTENTS

2.1.1 Thermal Compost, Landfills, and Waste Reduction Regulations

2.1.2 Negative Effects of Anaerobic Waste Reduction

2.1.3 Greenhouse Gasses Released by Aerobic Microorganisms vs Anaerobic Microorganisms

2.1.4 Parameters for producing Aerobic Compost

2.1.5 Temperatures Generated by Microorganisms in BioComplete™ Compost piles

2.1.6 In Aerobic Composting nutrients are concentrated in the biomass of Bacteria and Fungi

2.1.7 Complete definition of "BioComplete™ Compost"

2.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*

The following glossary terms are used in this lecture: **Campylobacter; Landfill; Norwalk Virus; Obligate.**

2.3 REFERENCES & FURTHER READING

NCAT - ATTRA Sustainable Agriculture
Tipsheet - Compost: *https://attra.ncat.org/attra-pub/download.php?id=522*

National Organic Standards Board (NOSB) to the National Organic Program (NOP)
NOSB Recommendation for Guidance: Use of Compost, Vermicompost, Processed Manure and Compost Tea.
https://www.ams.usda.gov/sites/default/files/media/NOP%20Final%20Rec%20Guidance%20use%20of%20Compost.pdf

LECTURE 3

Lecture 3: THERMOPHILIC COMPOSTING (PART 1) [55:42]

3.0 OVERVIEW

Lecture 3 explains the theory of making BioComplete™ Compost using the "Thermophilic" process. This lecture covers starting materials, temperature and moisture levels.

3.1 LECTURE CONTENTS

3.1.1 Brief Description of Different Types of Composting Methods

Type of Starting Material	Main Functions in the Composting Process
High Nitrogen	- Rapidly increases temperature but does not maintain temperature for a sustained period as it is consumed very quickly.
Green	- Maintains temperature for extended periods of time as it is consumed relatively slowly. - Bacterial food.
Brown/Woody	- Provides structure facilitating diffusion of oxygen into the pile. - Fungal food, consumed very slowly.

3.1.2 Conditions required to produce BioComplete™ Compost

Key Points [5:14] Calibrating a Compost Thermometer

1. Insert thermometer tip into ice water. The temperature on the dial should reach 32° F or 0° C within a minute or so. If it doesn't, then you will need to calibrate, using the screw on the back of the dial. Please refer to the manufacturer's instructions on how to do this.
2. Repeat step 1 following calibration.
3. Insert thermometer tip into boiling water, preferably while water is actively boiling. The Thermometer should read 212° F or 100° C.
   a. If the scale on the thermometer does not reach this point, then the needle should "peg-out" at the end of the scale.
   b. If the thermometer does not give a hot enough reading (either 212° F, 100° C, or "pegged-out") while inserted into the boiling water, then the thermometer must be calibrated (ref point 1 above).

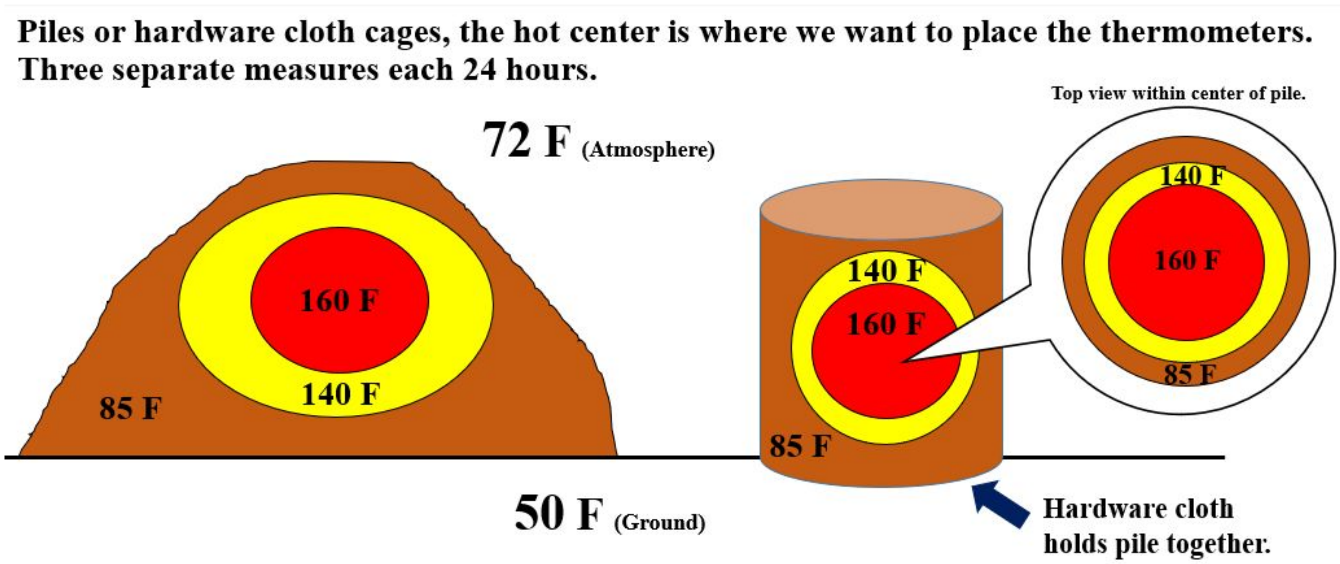
   Repeat steps 1 & 3 following calibration.
4. If the thermometer gives the appropriate readings for freezing and boiling temps, then the thermometer is calibrated accurately.
5. Calibrate Compost Thermometers often (every few months) to ensure accuracy.

3.1.3 How to correctly turn a compost pile

3.1.4 BioComplete™ Compost pile temperatures

Key Points [12:47] *Example of temperature variations within a pile*

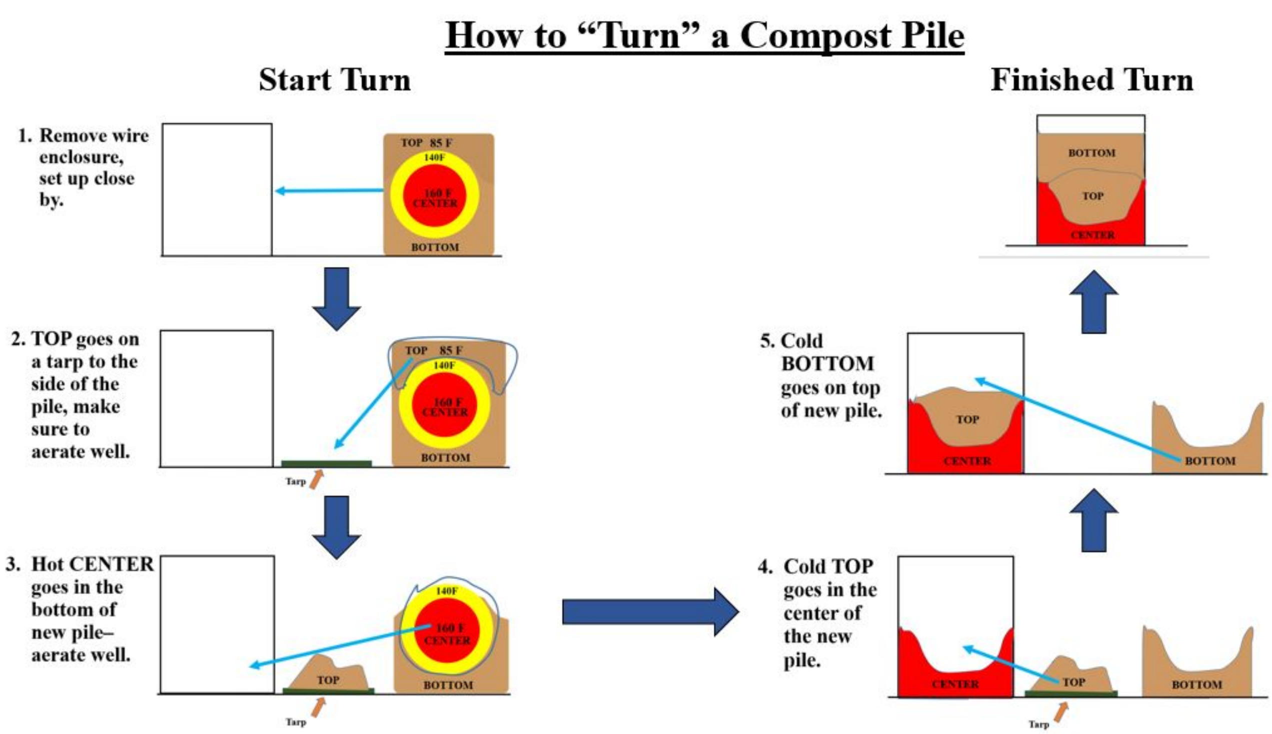
Figure 1



3.1.5 Example of turning a BioComplete™ Compost pile by hand

Key Points [21:47] *Diagram of "How to "Turn" a Compost Pile" by hand*

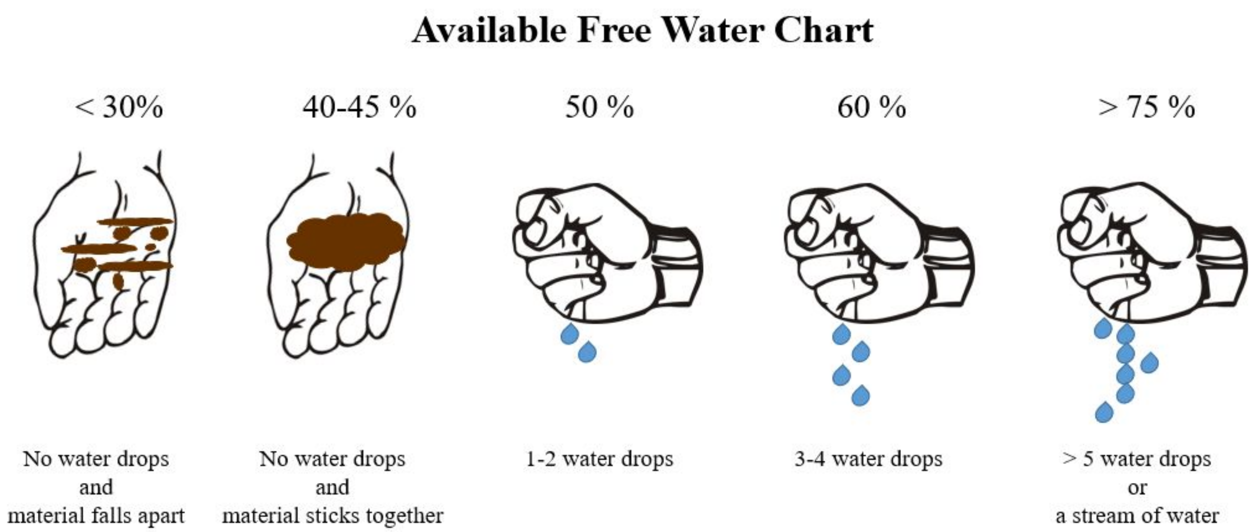
Figure 2



3.1.6 BioComplete™ Compost Pile Temperature Ranges and Steps to Achieve Success

Key Points [40:18] Measuring percentages of Available Free Water in organic material

Figure 3



3.1.7 BioComplete™ Compost Starting Materials Defined

Key Points [51:58] List of C:N ratios of common compost starting materials - *See Appendix 1*

3.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*
The following glossary terms are used in this lecture: **Fecal Coliform; Gravimetric Moisture; Road Apple.**

3.3 REFERENCES & FURTHER READING

LECTURE 4

Lecture 4: THERMOPHILIC COMPOSTING (PART 2) [1:02:57]

4.0 OVERVIEW

Lecture 4 explores the different types of starting materials, their ratios in a recipe for making BioComplete™ Compost, and the various adjustments you may need to make to your recipe, based on the different climatic conditions in your part of the world. This lecture informs you how to develop your recipe, through your own iterative learning process, to make the best possible BioComplete™ Compost in your specific conditions.

4.1 LECTURE CONTENTS

4.1.1 Gathering and storing Starting Materials

4.1.2 Making BioComplete™ Compost in different seasons and locations

4.1.3 Developing the recipe for a BioComplete™ Compost pile

4.1.4 Maintaining correct moisture levels in your starting materials

4.1.5 Mixing starting materials and when to turn the Compost pile

4.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*

The following glossary terms are used in this lecture: **Aliquot; Gemish; Iterative/Iteration.**

LECTURE 5

Lecture 5: THERMOPHILIC COMPOSTING (PART 3) [57:47]

5.0 OVERVIEW
Lecture 5 explores large/commercial scale production of BioComplete™ Compost.

5.1 LECTURE CONTENTS

5.1.1 Large scale commercial BioComplete™ Compost production

5.1.2 Example of how material is mixed by a commercial compost turner

Key Points [4:48] *Example of how material flows when using a compost turner*

Figure 4

5.1.3 Example of a Commercial Composting Facility in South Africa that was producing anaerobic compost.

5.1.4 Examples of different styles of compost turners.

5.1.5 Comparison of different BioComplete™ Compost recipes, tracking temperatures, and turns.

5.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*
The following glossary terms are used in this lecture: **Hydraulic Lift; Sinusoidal; Windrow.**

LECTURE 6

Lecture 6: BIOCOMPLETE™ VERMICOMPOST [58:19]

6.0 OVERVIEW

Lecture 6 covers the theory and process of making BioComplete™ Vermicompost, also known as worm compost or vermiculture. The worm's digestive process is explained, showing how worms successfully and efficiently turn organic matter into BioComplete™ Compost.

6.1 LECTURE CONTENTS

6.1.1 Explanation of how to make BioComplete™ Vermicompost

6.1.2 Earthworm anatomy and digestion

6.1.3 Worms and pathogens

6.1.4 Vermiculture feeding schedule and temperatures

6.1.5 Examples of different styles of worm bins

6.1.6 Examining vermicompost and the additional benefits of this method

6.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*

The following glossary terms are used in this lecture: **Burrow; Centrifuge; Comminute/Comminutor; Eisenia foetida; Peristaltic Waves.**

6.3 REFERENCES - FURTHER READING

Ground Up Soil
https://groundupsoil.com/

LECTURE 7

Lecture 7: STATIC COMPOSTING [50:29]

7.0 OVERVIEW

Lecture 7 covers the theory behind Static Composting. The processes of building and using a household waste static compost pile are explained.

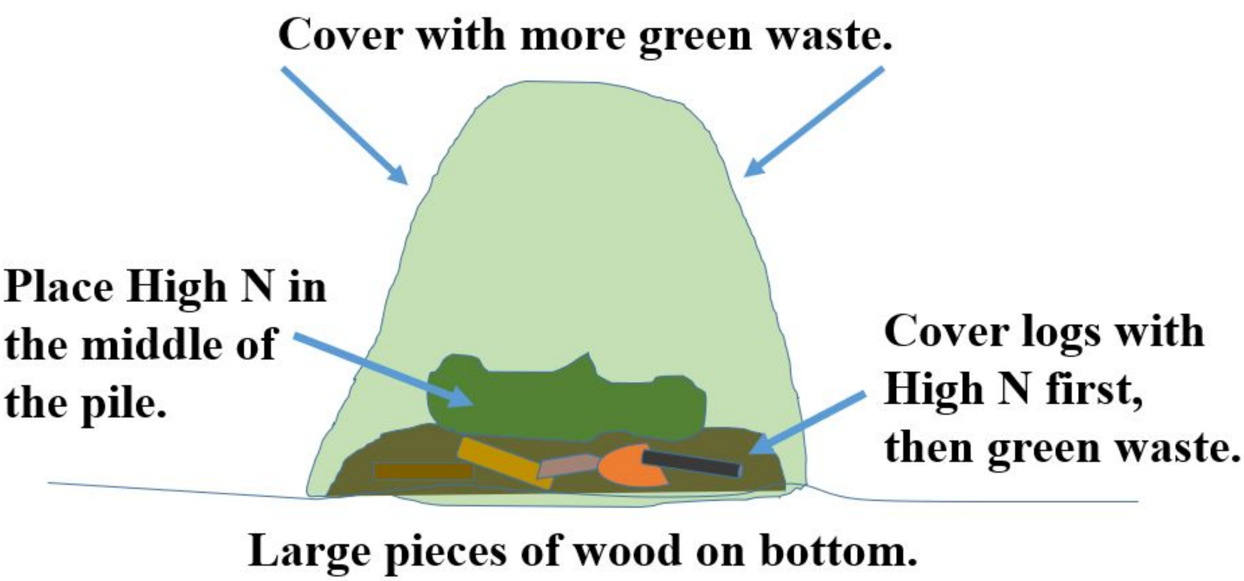
7.1 LECTURE CONTENTS

7.1.1 Introduction to static composting

7.1.2 Example of a "Classic" static compost pile

Key Points [10:30] "Classic" or "Pedestal" Static Compost Pile

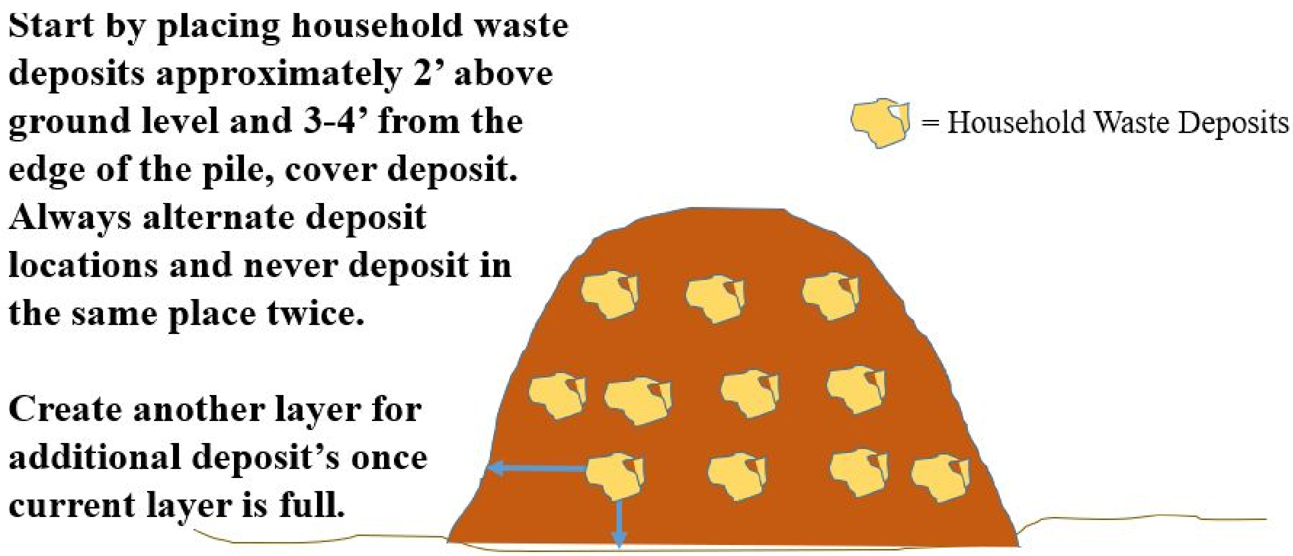
Figure 5



7.1.3 Example of a 'layered household waste static pile'

Key Points [18:40] *Layered Household Waste Static Compost Pile*

Figure 6



7.1.4 Is BioComplete™ Compost a fertilizer?

7.1.5 Review of the criteria for BioComplete™ Compost

7.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*
The following glossary terms are used in this lecture: **Depauperate; Keratin; Primordium; Riparian.**

7.3 REFERENCES & FURTHER READING
Southern Cross University - Environmental Analysis Lab (NSW)
https://www.scu.edu.au/environmental-analysis-laboratory---eal/

LECTURE 8

Lecture 8: MAKING BIOCOMPLETE™ COMPOST (PART 1) [43:08]

8.0 OVERVIEW

Lecture 8 comprises the first of a series of demonstration lectures. Demonstration 1 begins with a review of compost starting materials, and the percentages of each of these used in making BioComplete™ Compost. The process of mixing the starting materials and how to test moisture levels are demonstrated.

8.1 LECTURE CONTENTS

8.1.1 BioComplete™ Compost Recipe and Adjusting Materials according to the Time of Year

8.1.2 How to pack and measure the starting materials for a BioComplete™ Compost pile.

Key Points [6:36] Silage can be defined as "grass or other green fodder (livestock feed) compacted and stored in airtight conditions, without first being dried, and used as animal feed in the winter". When stored under airtight conditions the silage is preserved.

Important Note: In the video Dr Ingham explains that as conditions start to go anaerobic, bacteria - lactobacilli - produce acetic acid. (Correction: Dr Ingham misspoke saying "lactic acid" instead of acetic acid). Acetic acid is a preservative, i.e. it shuts down microbial growth, effectively preventing green material from decomposing. This means that the preserved silage (even though brown in color) will still contain the sugars, carbohydrates and proteins required to feed aerobic bacteria during the thermophilic phase of the composting process, and so this silage can be used as a green starting material.

Before silage can be introduced into a compost pile it must be thoroughly aerated to ensure that the anaerobic microorganisms become dormant. Failing to do this may result in a pile going anaerobic. The silage can be dried using various methods e.g. by spreading it out on a tarp in dry conditions and turning regularly.

8.1.3 BioComplete™ Compost Starting Materials - moisture levels

8.1.4 BioComplete™ Compost Starting Materials - mixing process

8.1.5 Correct Placement of the Thermometer into a BioComplete™ Compost Pile and covering the pile

8.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*

The following glossary terms are used in this lecture: **Pomace.**

LECTURE 9

Lecture 9: MAKING BIOCOMPLETE™ COMPOST (PART 2) [43:11]

9.0 OVERVIEW

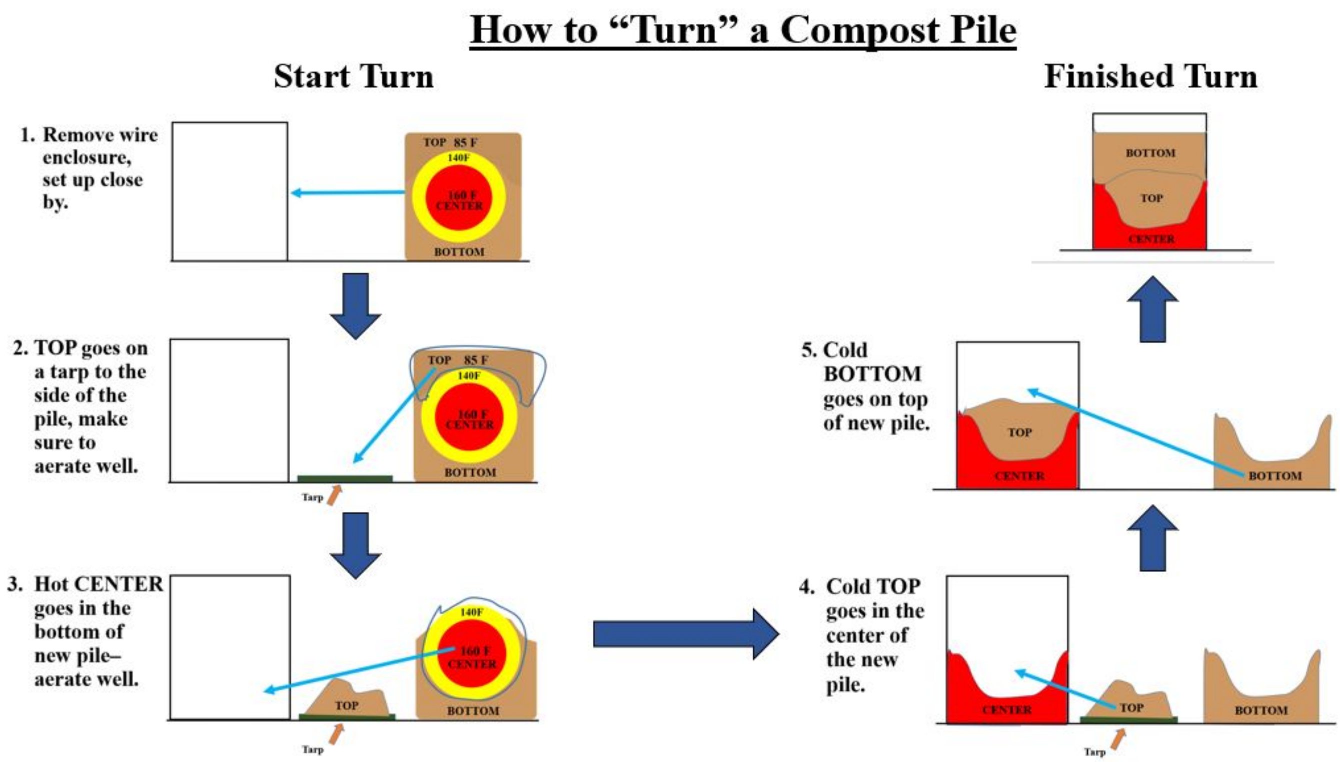
Demonstration 2 shows precisely how to turn a BioComplete™ Compost pile; what to pay attention to when turning; and why the process of turning is conducted in this way.

9.1 LECTURE CONTENTS

9.1.1 Theory and Demonstration of Turning a BioComplete™ Compost Pile

Key Points [9:30] *Diagram of "How to "Turn" a Compost Pile" by hand*

Figure 7



9.1.2 Comparison of Organic Composting Regulations with methods used to make BioComplete™ Compost

9.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*

The following glossary terms are used in this lecture: **Ramify.**

LECTURE 10

Lecture 10: ASSESSING THE QUALITY OF BIOCOMPLETE™ COMPOST [19:12]

10.0 OVERVIEW

Demonstration 3 covers the methods used to inoculate a compost that does not meet the minimum biological requirements, in order to transform it into BioComplete™ Compost.

10.1 LECTURE CONTENTS

10.1.1 Outline on protecting a BioComplete™ Compost pile from excessive/inadequate moisture levels

10.1.2 Adding inoculations to compost to increase biology levels and thereby convert it into BioComplete™ Compost

10.1.3 Adding Fungal Spawn to a compost pile to increase fungal biomass

> ***Key Points [6:30]*** Caution must be taken when adding materials to a compost pile after the thermophilic phase is completed. If you suspect that the material being added may contain any pathogens and/or anaerobic microorganisms, then it should be aerated or composted prior to being added. In the case of fungal spawn, it is important that it was produced under sterile conditions, so be sure to buy spawn from reputable sources.
>
> In order to satisfy EPA (or equivalent) regulations, you must ensure that you are only adding a minimal quantity of materials to the pile after the thermophilic phase. You will need to research the relevant regulations in your state or country regarding permissible quantities of additions to finished compost piles.

10.1.4 Assessing compost quality by sight and smell

10.2 GLOSSARY TERMS *(Please refer to the glossary on page 19)*

The following glossary terms are used in this lecture: **Fungal Spawn; King Stropharia; Sporulating.**

COURSE GLOSSARY

Aliquot - a portion of a larger whole, especially a sample taken for analysis or other treatment.
Animalcule - (*Archaic*) a microscopic animal.
Antibiotics - compounds which inhibit the growth or reproduction of microorganisms such as bacteria and fungi; literal meaning is "against biology"
Burrow - (*of an animal/insect/worm*) make a hole or tunnel, typically for use as a dwelling.
Campylobacter - a genus of motile Gram-negative bacteria, typically appears comma-, s-shaped, or spirally curved; sometimes causes abortion in animals and food poisoning in humans.
Centrifuge - a machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities (e.g. cream from milk) or liquids from solids (e.g. clothes washing machine).
Comminute/Comminutor - break into smaller pieces; reduce to minute particles, to pulverize / the entity which is breaking the material down, reducing the material to smaller size.
Depauperate - (*Biology*) (of a flora, fauna, or ecosystem) lacking in numbers or variety of species.
Eisenia foetida - (or more recently *Eisenia fetida*) a species of epigean earthworm adapted to decaying organic material and rarely found in soil, i.e. rotting vegetation, compost, and manure. Known under various common names such as redworm, brandling worm, panfish worm, trout worm, tiger worm, red wiggler worm, red Californian earthworm, etc.
Fecal Coliform - a large group of facultatively anaerobic, rod-shaped, gram-negative, non-sporulating bacterial species which generally occur in the intestines of warm-blooded animals.
Fungal Spawn - includes both the mycelium and spores of a fungus, especially a cultivated mushroom in a sterile medium used to inoculate larger amounts of material.
Gemish - a mixture of various things, a mélange.
Gravimetric Moisture - the weight of water in a sample of solid material. Usually measured by determining the initial weight of a sample, drying that sample to remove all water, and re-weighing that sample once dry. This does not allow determination of the free water (available for plants or microbes to take up), or of water held tightly by organic matter, sand, silt, clay or other mineral particles (not-available for plants or microbes to obtain).
Hammurabi's Code - is a well-preserved Babylonian code of law of ancient Mesopotamia, dated back to about 1754 BC.
Hydraulic Lift - is the process by which deep-rooted plants take in water from lower soil layers and release that water into upper, drier soil layers. Hydraulic lift is beneficial to the plant transporting the water, and may be an important water source for neighboring plants.
Indigenous - originating or occurring naturally in a particular place; native.
Iterative/Iteration - the act of repeating a process with the aim of approaching a desired goal, target or result.
Keratin - a fibrous protein forming the main structural constituent of hair, feathers, hooves, claws, horns, etc.
King *Stropharia* - *Stropharia rugosoannulata*, a type of mushroom commonly known for its ability to decompose organic matter, build soil structure and remediate undesirable wastes in soil; an agaric of the family Strophariaceae found in Europe and North America, and introduced to Australia and New Zealand.
Landfill - a place to dispose of refuse and other waste material by burying it and covering it over with soil.

Norwalk Virus - a virus that can cause epidemics of severe gastroenteritis. It has been subsumed under the genus Norovirus.
Obligate - (*Biology*) restricted to a particular function or mode of life; specific conditions must exist for the organism to flourish.
Pasteurization - partial sterilization of substances, such as milk or potting soil, at a temperature and for a period of exposure that destroys objectionable organisms without major chemical alteration of the substance.
Peristaltic Waves - involuntary movements of the longitudinal and circular muscles, primarily in the digestive tract but occasionally in other hollow tubes of the body, that occur in progressive wavelike contractions, as for example occurring in earthworms, or the human esophagus, stomach, and intestines.
Pomace - the dry or pulpy residue of material (such as fruit, seeds, or fish) from which a liquid (ie., juice or oil) has been pressed or extracted; e.g., grape pomace.
Primordium - (*Biology*) an organ, structure, or tissue initiating a stage of development; e.g. the initial stage of mushroom formation..
Ramify - to form branches or offshoots; spread or branch out.
Riparian - (*Ecology*) relating to wetlands adjacent to rivers and streams.
Road Apple - (*Slang*) a piece of horse manure on or at the side of a road.
Sinusoidal - shaped like, or varying according to a sine curve or sine wave; e.g., snake-like movement.
Sporulating - producing or forming a spore or spores.
Windrow - a long line of material heaped up by wind or waves (e.g., sand on a beach) or by a machine.

REFERENCES FURTHER READING & LINKS

Cato the Critic's,(300 BCE *approx.*) "De Agriculturia" *translated into english as* "How to do Agriculture"
soilandhealth.org/wp-content/uploads/01aglibrary/010121cato/catofarmtext.htm

Howard, Sir Albert, *An Agricultural Testament*, London: Oxford University Press, 1940, Print

NCAT - ATTRA Sustainable Agriculture
Tipsheet - Compost: *https://attra.ncat.org/attra-pub/download.php?id=522*

National Organic Standards Board (NOSB) to the National Organic Program (NOP)
NOSB Recommendation for Guidance: Use of Compost, Vermicompost, Processed Manure and Compost Tea.
https://www.ams.usda.gov/sites/default/files/media/NOP%20Final%20Rec%20Guidance%20use%20of%20Compost.pdf

Ground Up Soil
https://groundupsoil.com/

Southern Cross University - Environmental Analysis Lab (NSW)
https://www.scu.edu.au/environmental-analysis-laboratory---eal/

APPENDIX 1

C:N ratios for organic materials:

Ranked generally from highest N (narrow C:N) to lowest N materials (wide C:N).

Material	C:N	Description
High Nitrogen **"Party Food"** **C:N 5:1 to 10:1 range**	**Rapid microbial growth expected**	**Many factors influence the concentrations of C and N in any given material. This column points to major factors: other factors will need to be added as fine-tuning occurs.**
Meat / Meat Broth **Blood Meal**	3 – 10:1	High in amino acids and proteins. Note: too much of such high N material causes organisms to grow *very rapidly,* very quickly using up the oxygen, and cause the pile to become anaerobic. Organisms reproducing very fast are generating lots of heat, which can cause spontaneous combustion. DON'T OVERFEED!!!!!
Bone Meal	5 – 30:1	Depends on the amount of marrow (high N) left in the bones when the bones were ground up. Again, DO NOT OVERFEED as danger of anaerobic conditions and consequences occuring.
Fish Hydrolysate / Emulsion	Emulsion: 3 - 5:1 Hydrolysate 5 – 10:1	Different species of fish contain differing amounts of fats and oils. The higher the fat and oil content, the wider the C:N. Fish oils are best for growing fungi. Hydrolysate is usually ground up whole fish, except for the fillets. Emulsion has had the oils removed, leaving the ground up scales, bones, organ meat, skin, etc.

Chicken Manure Composted Chicken Manure Chicken Bedding (manure mixed straw, chips, brown leaves, etc)	3 - 10:1 20 – 100:1 Calculate C:N by estimating how much 10:1 manure and how much 100:1 bedding.	If the chickens are fed grains and food wastes, including meat, the manure will be very high in N. If the chickens eat mostly insects / grubs with wide C:N, the manure will contain less N. If the manure remains wet, anaerobic conditions will prevail, and ammonia gas will be released, dropping N to very low levels.
Cow Manure Cow bedding (cow manure mixed with dry, woody materials)	10 - 20:1 Calculate C:N by estimating how much 10:1 manure and how much 100:1 bedding.	Depends on how much high N versus high C food the cows are being fed. How long is the manure pile wet, and/or anaerobic, losing ammonia gas?
Pig Manure Pig bedding (pig manure mixed with dry, woody materials)	3 - 20:1 Calculate C:N by estimating how much 10:1 manure and how much 100:1 bedding.	Depends on how much high N versus high C food the pigs are being fed. How long is the manure pile wet, and/or anaerobic, losing ammonia gas?
Horse Manure Goat, sheep, rabbit manure	10 – 20:1 20:1 – 30:1	Avoid any manure from animals that have been fed fed dewormers. Pay attention to what the horses are being fed. Poor quality pasture means poor quality manure; grain fed animals means high N.
Manure mixed with bedding	10 - 60:1	Bedding absorbs moisture, preventing anaerobic conditions and thus odors, for a limited time. When smells begin to occur, it is time to replace the old bedding / manure mix. C:N of the bedding is a balance of the amount of manure (high N) and bedding (woody).

Green Legumes (alfalfa, clover, peas, beans, trefoils, etc) ● With nodules/red inside ● No nodules, or some other color than red inside ● Standing dead; dry brown: all nutrients transferred to the roots or seeds	10:1 – 30:1 10:1, perhaps even 5:1 30 – 60:1 60:1 or higher	Legumes need nitrogen-fixing bacteria, i.e., Rhizobium to obtain the N they need in most cases (unless inorganic soluble N is added as fertilizer). To be certain N is being fixed, marble size nodules on the root system should be present. Make certain the nodule is pink to red inside, preferably looking like a bright red drop of blood. Only then will the legume be fixing N and reach C:N of 10.
Grains / Seeds Just the germ (seed coat removed) Germ plus Seed Coat Just seed coat (e.g., rice hulls) Hard Shells	8 - 10:1 25 – 30:1 80 – 150:1 30 – 150:1	The germ, or the viable part of the seed, is high in amino acids and proteins, and that is party food for microbes. Fermentation of grains often removes the seed coat so the germ becomes much easier to get to. Otherwise, energy expended to get to the germ may be about equal to the energy gained from decomposing the germ. Nuts, like walnuts, pecans, peanuts, are protected by very recalcitrant, hard-to-decompose shells whose C:N is often upwards of 150:1. The inner layers of the nut are typically high N, stored on the inside of the shell.
Hair/Fur ● Cleaning hair or fur may strip natural oils, while hairspray may be very detrimental to microbes that would decompose this material	10 - 30:1 But may be very slow to decompose because of the way the filaments align, restricting the organisms that can decompose this material.	Complex chains of amino acids (one or more will be a disulfide amino acid). The amino acid sequence will align with other keratins to make filaments, making decomposition difficult unless the correct sets of microbes are present. Oils and organic matter mixed in the hair will alter C:N.

Green Materials	Food for bacteria; Maintain temperatures	Bacterial Foods, relatively simple structures, easy-to-use so bacterial win.
Food Scraps What is the mix of foods?	Any C:N is possible, from 10:1 to 500:1. Normal range of 30:1 Eyeball the mix and give it your best guess.	Food scraps can be a mix of: - Meat - Green plant materials - Woody materials Monitor how fast the pile starts to heat once the pile is mixed and has adequate moisture.
Compost ● Finished thermal compost ● Spent mushroom waste has not been composted and does not contain the soil or compost organisms desired ● Worm or vermicompost ● Soil	20 – 50:1 20 -30:1 40 – 100:1 20 – 40:1 15 – 20:1	Depends on the ratio of the three groups of starting materials. The more fungal foods added, the wider C:N; the more high N, the narrower the C:N. “Finished” means the compost has returned to ambient temperature after temperatures were high enough for long enough to deal with diseases, pests, parasites and weed seeds. Spent mushroom waste contains ONE species of fungus. The blocks the mushrooms were grown on are far from depleted, and are good food sources for fungi in compost piles. Compost does not contain “party food” even though the C:N is narrow. Thus, C:N is not the end-all and be-all of trying to figure out a recipe. Soil has a C:N of 20:1, but addition of soil to a compost pile does not result in rapid microbial growth. The N has already been used by the microbes and are in stable forms in the compost.
Vegetables Green with sap still inside Green but with no sap inside Standing dead; dry brown, all nutrients transferred into the roots or seeds Roots Seeds	25 – 30:1 30 - 60:1 60 – 200:1 30:1 – 100:1 10:1 – 30:1	The parts eaten by humans / animals are usually 30:1 as the sap or flesh contains amino acids, proteins, and sugars. The plant will move nutrients from the stalks and leaves in order to contain the nutrient content in the flowers and seeds. Once the crop is harvested, the stalks and leaves will have any remaining nutrients translocated into the roots. Values for annual root systems is usually very wide, while perennial roots can be narrow, but these nutrients are protected by terpene noxious flavors.

Green Plants (including weeds) First flush of growth after dormant period (winter, or dry season) Green with sap inside Green but no or little sap Standing dead material (all nutrients pulled back into the crown and roots) Brown leaves, stalks, cobs (all nutrients pulled into the roots)	On average, 30:1 10 - 15:1 25 - 30:1 30 – 60:1 60 – 200:1 60 – 200:1	Plants that humans do not normally grow for food are typically 30:1, except that the nutrients coming from the seed or perennial roots are mobilized all at once, so the first flush of growth is high N, which is rapidly diluted as the plant begins to photosynthesize sugars. Any nutrient deficiency in flowers or seeds will result in the plant taking nutrients away from the stems and leaves to feed the flowers and seeds, causing the green stems and leaves to look more and more yellow. As seeds disperse, the plant takes any remaining nutrients in the aboveground plant material and stores it in the roots.
Seaweed / Kelp	25:1 – 50:1	If cut when rapidly growing, C:N will be narrower (25:1) than when the plant is older, or close to death (50:1). In most cases added as bacterial food, slight boost to fungi.
Coffee Grounds Coffee Parchment	15 - 45:1 10:1	Oils and other soluble elements are removed during the brewing process. Pre-brewing grounds have a wider C:N (30 – 45:1) than used coffee grounds (15 – 30:1).
Humus the dark brown color of compost	30 - 50:1 With the right set of microbes and high disturbance, may decompose rapidly.	Humus is made in the O horizon of soil, and is a mix of very complex, highly condensed organic compounds (e.g., humic and fulvic acids), mixed with less decomposed materials as well as fresh, uncomposed organic matter.

Woody / Brown Materials	Foods for fungi; wide C:N ratios	Fungal foods consist of complex structures that only fungi have the enzymes to decompose and consume.
Humic Acids (HA) **Fulvic Acids** (FA) • complex, highly condensed, carbon compounds with half lives of 500 years or more if disturbance in minimized • can be destroyed in less than 20 years if soil is over-tilled	250 - 500:1	Most HA/FA are extracted from soft brown coal (Leonardite) and are chemically denatured. Water-extracted HA/FA are not chemically altered and are more likely to grow beneficial fungi, if the correct organisms are present.
Wood Ash • Be careful of additives used to get the wood to burn.	50 – 300:1 Nutrients may be concentrated when the carbon is blown off as CO2.	N, P, S and other volatile compounds will be lost when wood is burned. Inorganic forms of K, Na, and Cl can be formed, and reach high concentrations, killing beneficials.
Wood • bark • deciduous wood • conifer / evergreen Nitrogen-fixing trees • Leaves • Twigs • Trunk	250 – 1000:1 100 – 2000:1 200 - 600:1 300 – 1000:1 10 – 20:1 15 – 30:1 50 – 100:1	Different types of trees make different types and combinations of terpenes and tannins to prevent microbial attack. Terpenes and tannins are structurally very complex and high in carbon materials that suppress microbial growth. Nitrogen-fixing trees depend on symbiotic bacteria in their root system, but quite often, these bacteria do not produce nodules. Thus the only way to know if the plant materials are high N is to monitor temperature in the first 24 to 48 hours of the pile.
Peat Moss • Pay close attention to the mix of material in the ”peat moss”	20 – 150:1	Peat moss varies all over the board, based on what is exactly in the mix. Material with mostly stems of plants that were growing on the moss will have a C:N like plant stalks. Peat moss that is mostly sphagnum will have a narrow C:N if the moss was actually fixing N. So, another situation where testing is required

Brown Leaves / Needles ● Break up mats, get air into all parts of the pile. Chop into smaller sizes. ● Addition of fungi able to decompose more difficult materials may be necessary	60 – 300:1	After removal of nutrients into the root system, mostly just carbon is left, which selects for fungi and against bacteria. Aromatic compounds can slow and at times kill beneficial and disease-causing organisms. Turn, fluff, and aerate the pile to speed volatilization.
Paper ● e.g., paper plates, toilet paper, paper towels, newspaper Ink used to print words on paper is soy-based and thus is significantly higher in N. The more ink, the closer to the 70:1 ratio. Lead-based inks are no longer allowed, but several bright colors still are heavy-metal (not lead) based. Avoid using paper materials with those colors.	70 - 200:1	Some paper products (e.g., glossy paper) use tackifiers to hold the paper fibers together before being pressed and dried. Some of these tackifiers appear to be quite harmful to some types of beneficial bacteria and fungi.
Cardboard ● Inks used on boxes are usually soy-based. Again, bright colors may contain some heavy-metals	300 - 600:1	The glues used to glue the layers of cardboard together are very good fungal foods and will often result in a massive growth of one or two species of fungi.

Wood chips • More surface area once chipped, increases surfaces for the fungi to do their job	150 - 1000:1	Aromatic compounds left in the wood or bark can slow and at times kill beneficial and disease-causing organisms. Turn, fluff, and aerate the pile to speed volatilization.
Sawdust • Can cause difficulties because particle size is too small, resulting in dense piles with no air passageways and the potential for anaerobic conditions.	300 - 700:1	High surface area: If structure is imposed by mixing with char, twigs, green plants material, for example, the wood can decompose rapidly. If airways are not maintained, spontaneous combustion could occur.