# Frequently asked questions

1. **Question:** Discuss the factors influencing the composting process

   **Answer:** The major factors that affect the rate of decomposition of the organic matter during composting are oxygen, moisture, temperature and C:N ratio, microbial activity and available inorganic nutrients and Ppresence of toxic substances

   **Oxygen and Aeration**

   Composting is an aerobic process and therefore requires oxygen. Oxygen is provided through aeration. The provision of oxygen depends on the aeration process, which is a function of the system. Windrow composting provides oxygen through the turning process and by convection. Aerated static pile (ASP), agitated bed, and other systems provide oxygen through blowers. For oxygen to reach the microbial population there needs to be sufficient porosity through the matrix. The porosity is dependent on the feedstock, its moisture content, and particle size.

   Biosolids and food waste are dense and have high moisture content. Therefore, bulking agents are usually used. These can either be natural materials, such as wood chips, sawdust, and yard waste, or artificial material, such as shredded rubber tires. Oxygen levels above 10% are usually provided. When the oxygen level is below 5%, it can become limiting to the aerobic microorganisms. At this level anaerobic gases such as methane are generated.

   **Moisture**

   Moisture can be a limiting factor in the composting process. Generally, the rate of microbial activity decreases when the moisture level in compost is below 40%. At 20%, microbial activity is essentially ceased. When moisture content in the compost exceeds 60%, the pore space can be filled with water; then oxygen can become limiting and overall microbial activity decreases. Generally, bacteria are more sensitive to soil moisture than actinomycetes and fungi. Both actinomycetes and fungi tend to predominate in dry soils since they form resisting structures. Since the composting process is a drying process, as water is lost due to the increased temperature, moisture control is essential. The optimal moisture level during the composting process appears to be near 50%. However, the control of moisture is also important from a processing point of view. Many facilities prefer to screen the compost and recover the bulking agent immediately after composting and before curing. Most screens are effective at moisture contents below 45%. Therefore maximum composting is carried out at moisture contents between 50 and 55%.

**Temperature**

Changes in temperature are the result of microbial activity. Temperatures rise from ambient to mesophilic and then to thermophilic. During these temperature variations, the microbial population also subjected to change. These changes are very important as they enable the different microorganisms to metabolize the various components of the feed stocks. Temperature is also important to control pathogens as well as to destroy weed seeds. As the process progresses and the available nutrients for the microorganisms are consumed or metabolized, temperatures will drop and at some point return close to ambient. The rate of heat production is proportional to the available organic material for microbial consumption. The decline of temperature to near ambient is an indication that the process is near completion and that the material, probably, is stable and mature.

**Carbon and Nitrogen (C:N)**

**Carbon**

The two most important nutrients for microbial activity and growth that affect the composting process are nitrogen and carbon. A high carbon-to-nitrogen ratio will slow the composting process. A high nitrogen-to-carbon ratio will release ammonia. Although the ideal carbon-to-nitrogen ratio is approximately 27 to 30:1, the composting process is effective within carbon-to-nitrogen ratios of 22 to 40. It can proceed at lower C:N ratios. However, there will be a release of ammonia. At higher C:N ratios, the process slows down.

The carbon provided to the microorganisms on the feedstock is utilized for cellular growth. During microbial metabolism, carbon dioxide is evolved and released to the atmosphere. As the process progresses, the rate of microbial activity decreases and carbon dioxide evolution decreases. It is the relationship between the volatile solids content of a feedstock and carbon dioxide evolution: the higher the volatile solvents content of organic matter, the greater the production of carbon dioxide. Starches, sugars, and fats decompose or mineralize much faster than proteins or cellulose, whereas lignin is very resistant to mineralization.

Along with these factors since composting involves the interactions of several microorganisms, the rate of decomposition or process limitation is a function of microbial activity. Several conditions can limit or reduce microbial activity, and these in turn influence temperature and the rate of decomposition. These include:

• Low moisture

• Low oxygen content

• Lack of free pore space

• Lack of available carbon or degradable organics

Along with these, other conditions that may affect the decomposition process but are much less significant are:

• Available inorganic nutrients

• Presence of toxic substances

**2. What are the major steps in composting process?**

The major steps in the composting process are as follows

Preprocessing

1. Feedstock delivery and handling
2. Feedstock preparation

Composting

1. Composting phase or active composting
2. Curing phase

Postprocessing

1. Refining
2. Product preparation

**3. Discuss the major feed stocks employed in composting.**

The type of feedstock and its physical properties affect the delivery process, storage, and handling of the feedstock prior to the composting process. The primary feedstock characteristics affecting the delivery process are:

- • Moisture content or its solids content
- • Putrescibility

• Physical properties

Numerous feedstocks have been composted. These include:

• Sewage sludge, biosolids, septage, and night soil

• Municipal solid waste, biowaste (source-separated organics)

• Yard waste

• Food waste—grocery, institutional, industrial etc.,

• Animal waste, fish waste

• Animal mortalities

• Industrial wastes—pharmaceutical, pulp and paper, food processing

Food wastes are generally putrescible, but their odors must be contained or treated, otherwise it will attract vectors such as flies. In addition to being a health issue since vectors can carry and transmit pathogens, they are also a nuisance source. One large biosolids/yard waste facility in California was shut down because of the nuisance source of flies and odors. In Michigan, several facilities handling large volumes of grass were shut down due to odors. In both these cases, proper delivery, storage, and handling as well as an understanding of the basic concepts of composting could have avoided many of the problems.

**4. Write a note on types of composting process**

Haug (1993) classified composting systems according to reactor type. The classification which is simplified is as follows

A. Static systems

a. Passively aerated windrows

b. Forced aeration—static pile

c. Bin/container/bag/tunnel

d. Silo/vertical reactors

B. Turned or agitated systems

a. Windrow

b. Drum/kiln

c. Agitated bed

**5. Explain the phases of composting.**

Composting is essentially a four-phase process that may be summarized as follows.

**Mesophilic Phase (25–40 °C)**

In this first phase (also called starting phase), energy-rich, easily degradable compounds like sugars and proteins which are abundant are subjected to degradation by primary decomposers such as fungi, actinobacteria, and bacteria along with worms, mites, millipedes, and other mesofauna. Depending on the composting method, the contribution of these animals is either negligible or, as in the special case of vermicomposting, it is considerable. It has been demonstrated that the number of mesophilic organisms in the original substrate is three orders of magnitude higher than the number of thermophilic organisms, but the activity of primary decomposers induces a temperature rise.

**Thermophilic Phase (35–65 °C)**

Organisms adapted to higher temperatures gradually replace the entire mesophilic flora. Mesophilic organisms die off and are eventually degraded by the succeeding thermophilic organisms, along with the remaining, easily degradable substrates. The decomposition continues to be fast, and accelerates until a temperature of about 62 °C is reached. Thermophilic fungi do have growth maxima between 35 and 55 °C, while higher temperature usually inhibits fungal growth. Thermotolerant and thermophilic bacteria and actinobacteria are known to remain active even at higher temperatures.

Despite the destruction of most microorganisms beyond 65°C, the temperature may rise further and may exceed 80°C. It is probable that this final temperature rise is not due to microbial activity, but rather is the effect of abiotic exothermic reactions in which temperature-stable enzymes of actinobacteria might be involved.

The thermophilic phase is important for hygienization. Human and plant pathogens are destroyed; weed seeds and insect larvae are killed. Not only the temperature during the thermophilic phase, but also the presence of a very specific flora dominated by actinobacteria, are important for hygienization through the production of antibiotics. The disadvantage of temperatures exceeding 70 °C is that most mesophiles are killed, and thus the recovery is retarded after the temperature peak. This may, however, be avoided by appropriate measures for recolonization.

The same temperatures are not reached in all zones of a compost pile; thus, it is important that, through regular turning, every part of the substrate is moved to the central, hottest part of the pile. From a microbiological point of view, four major zones may be identified within a pile (as shown in figure below).

- The outer zone is the coolest, and well supplied with oxygen
- The inner zone is poorly supplied with oxygen
- The lower zone is hot, and well supplied with oxygen
- While the upper zone is the hottest zone, and usually fairly well supplied with oxygen.

**Cooling Phase (Second Mesophilic Phase)**

Temperature starts decreasing when the activity of the thermophilic organisms ceases due to exhaustion of substrates. Mesophilic organisms recolonize the substrate, either originating from surviving spores, through spread from protected microniches, or from external inoculation. While in the starting phase organisms with the ability to degrade sugars, oligosaccharides and proteins dominate, the second mesophilic phase is characterized by an increasing number of organisms that degrade starch or cellulose. Among them are both bacteria and fungi.

**Maturation Phase**

During the maturation phase, the quality of the substrate declines, and in several successive steps the composition of the microbial community is entirely altered. Usually, the proportion of fungi increases, while bacterial numbers decline. Compounds that are not further degradable, such as lignin–humus complexes, are formed and become predominant.

Overall important characteristics during pre and main composting and postcomposting, mature phase can be summarized as follows

During pre and main composting **(1-6 weeks)**

- Degradation of easily degradable compounds such as sugar, starch, pectin, protein etc.,
- Inactivation of pathogenic microorganisms and weed seeds
- High oxygen demand
- Emissions of odor and drainage water

During postcomposting, mature phase **(3 weeks to 1 year)**

• Degradation of difficult-to-decay degradable compounds such as hemicelluloses, wax, fat, oil, cellulose and lignin

• Composition of high molecular weight compounds (humus)

• Low oxygen demand

• Low emissions

**6. List out microorganisms involved in composting process?**

Wide range of microorganisms play important role in decomposing the organic waste in the compost during different stages. For example, cellulolytic, ligninolytic, coprophagous, wood decaying fungus such as *Aspergillus fumigates*, *Humicola insolens*, *Thermomyces lanuginosus*, *Thermomyces lanuginosus*, *Paecilomyces* sp. *Scopulariopsis brevicaulis*, *Mortierella turficola*, *Mucor miehei*, *M. pusillus*, *Rhizomucor pusillus*, *Rhizomucor* sp. *Chaetomium elatum*, *Chaetomium thermophilum*, *Dactylomyces crustaceus*, *Aporothielavia leptoderma*, *Thermoascus aurantiacus*, *Thielavia thermophilia*, *Armillaria mellea*, *Clitopilus insitus*, *Pleurotus ostreatus*, *Lentinus lepideus*, *Fomes* sp., *Coprinus* sp., *C. cinereus*, *Lenzites* sp., *L. trabea* are found during composting processes.