Lecture 5: Composting (part 1)

Definitions

- Composting = aerobic biological decomposition of the biodegradable organic fraction of MSW under controlled conditions to a state sufficiently stable for nuisance-free storage and handling and for safe use in land applications
- Composting is a natural process that can be enhanced with technical methods
- Composting can reduce
  - The amount of waste in landfills
  - The nutrient and CH_4 emissions from landfills
- Composting can produce
  - Organic part of soil for land applications
  - Heat and gaseous products (mainly CO_2)
- Composting is operated
  - Municipally
  - In a household or housing company

The four phases of decomposition = composting

1) Latent phase (ambient temperature – 22°C, a few days)

- Micro-organism (bacteria, fungi, and other microbes) responsible for composting acclimatize, infiltrate and colonize in the waste
- Start breaking down the soluble (readily degradable) organic material Produce heat

2) Growth phase, mesophilic (22 - 40°C, 2-12 days)

- Micro-organisms grow and reproduce
- High respiration
- Elevation of temperature mesophilic temperatures

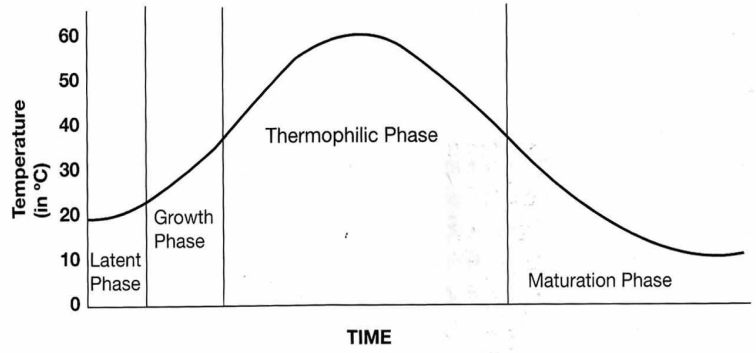
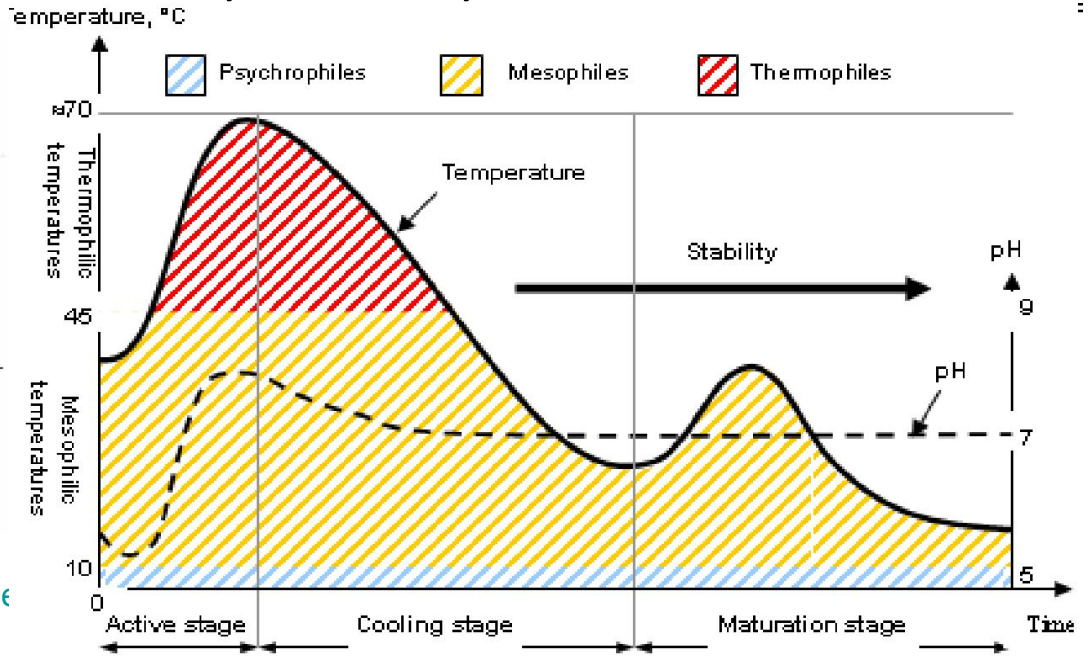


Figure 5.1. Temperature and the phases of composting



The five phases of decomposition = composting

3) **Thermophilic phase** (40 – 60°C, days or months)
   - High temperature → pathogens sterilized
   - Decomposes eg.proteins and fats, cellulosa, hemicellulosa
   - At the end temperature drops to ~ 40°C

4) **Cooling period**

5) **Maturation (curing) phase** (40°C – ambient,several months)
   - Slow process
   - Temperature drops slowly to ambient
   - Organic chemicals → humic compounds
   - Residual ammonia → nitrite (NO_2^-) → nitrate (NO_3^-)

Factors affecting the decomposition in the compost

Temperature

- Depends on the microbial activity in the compost
- High temperature (>40°C)
  - Enhanced breakdown of proteins, fats and even complex carbohydrates like cellulose and hemicellulose
  - Reduction of pathogenes if 40°C for 5 days and 55°C min 4hrs
  - If 60-65°C micro-organisms will dye
    - Aeration will cool down the compost

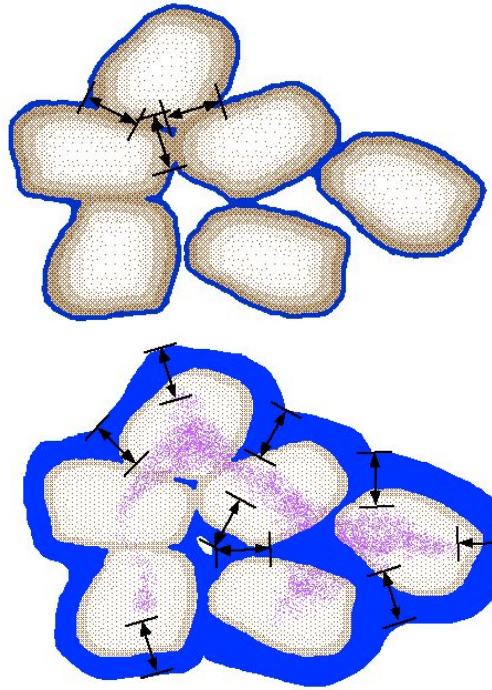
- If cooling down too early
  - Mixing will bring a new temperature peak

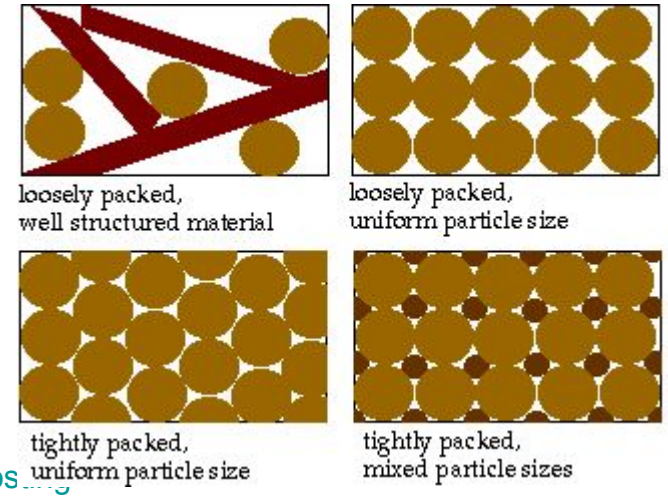
Factors affecting the decomposition in the compost

- **Particle size**
  - Small particles: large surface microbial activity increases
  - Too small particles: too compact
    - Air circulation is prevented
    - Decreases microbial activity
  - Large wood chips are used as bulking agent (air circulation easier)
    - Less available carbon in large chips
- **Aeration**
  - Oxygen necessary for microbes
    - Metabolism and respiration
  - Oxygen oxidizes organic molecules in the waste
  - Biological activity
    - Oxygen is used up
    - If < 5% oxygen anaerobic processes odor
  - Aeration with pipes, forced air flow, mixing

Factors affecting the decomposition in the compost

- Moisture optimum 50-60%
  - Microbial activity in thin films of water around organic particles
  - Low (<30%)
    - Bacteria becomes inactive
  - High (>65%)
    - Nutrient starts leaching
    - Anaerobic pockets between particles
      - fermentation
      - odor
  - Heat and air flow evaporate water significantly
- Porosity
  - Loosely packed material contains oxygen for the reactions





Factors affecting the decomposition in the compost

Composition of the mixture

- C : N ratio optimum 25:1 - 30:1
  - Reduced during the process as C CO_2 into the air
  - If C:N ratio much higher (less nitrogen)
    - microbial population remain small
    - nitrification not complete
    - disturbs proper maturation of the compost
- Too easily available nitrogen (eg if fertilizers added)
  - Microbes cannot use it
    - ammonia emissions (odor)
    - nitrate in the leachate
- C:N ratio depends on the feedstock
  - Mixing different feedstock good C:N ratio
  - Nitrogen addition: manure, sludge
  - Carbon addition: eg. woody material, finely ground

Materials and elements in composting

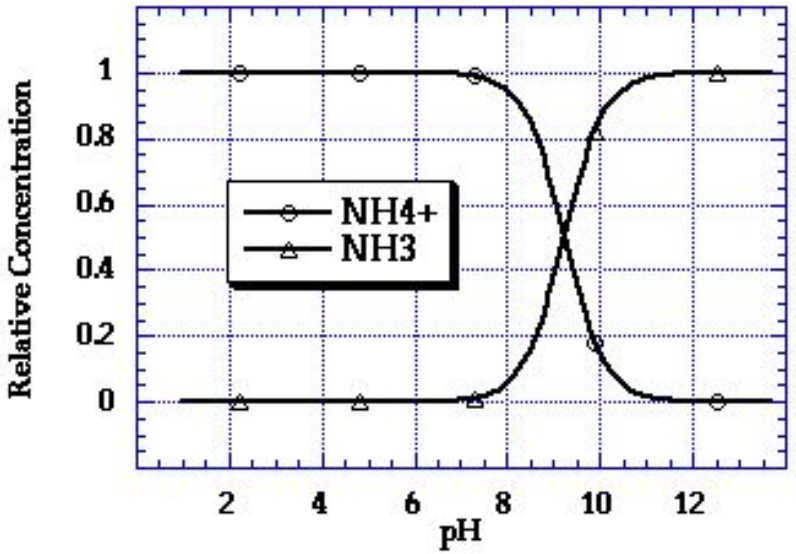
Material	Moisture
Peaches	80%
Lettuce	87%
Dry dog food	10%
Newspaper	5%

Often
Dry = high carbon content
Wet = High nitrogen content

Material	C : N	
Wood and sawdust	500:1	High carbon materials
Paper	170:1	
Bark	120:1	
Leaves and the foliage	60:1	
Horse manure	25:1	High Nitrogen materials
Cow manure	20:1	
Grass clippings	19:1	
Sewage sludge (digested)	16:1	
Food wastes	15:1	

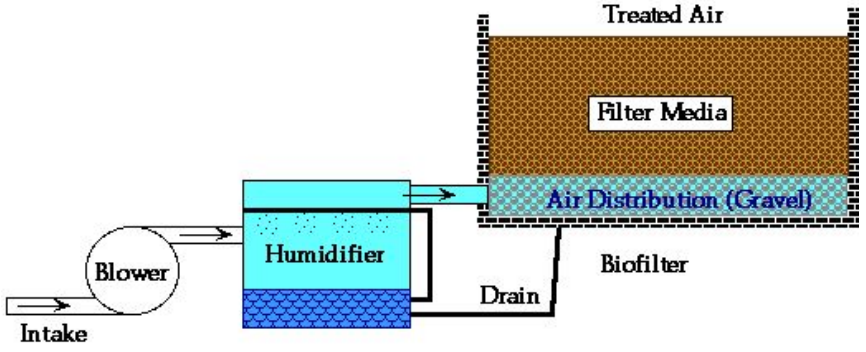
Factors affecting the decomposition in the compost

- pH
  - The equilibrium $NH_4^+ \rightleftharpoons NH_3 + H^+$ depends on pH
    - At pH = 9 □ equilibrium
    - If pH is higher □ ammonia released
    - Too high variation in pH – ki
- pH of certain stages or pro
  - Feedstock appr. pH 5,5
  - Rotary drum pH 5
  - Tunnel compost pH 5,5-6,5



Factors affecting the decomposition in the compost

- Odors are caused if
  - Feedstock is stored anaerobically previous to the composting
  - In compost: low oxygen or anaerobic conditions cause odorouos compounds
    - Reduced sulfur compounds (eg. H_2S)
    - Volatile fatty acids
    - Aromatic compounds and amines
  - High pH ammonia
- Odor prevention/treatment
  - More oxygen into compost
  - Biofiltration in the outer compost
  - Biofiltration of outgoing air
    - Moist organic material
      - Compost, soil, bark, peat…
    - Adsorb and degrade molecules biologically



Properties affecting composting

Property	Unit	Optimum	Other information
Nutrient balance	C/N-ratio N/P-ratio C/P-ratio	20-35 5-20 75-150	-can be high if carbon source doesn´t decompose easily - High P content is not necessray, but is in favour of the nitrogen binding bacteria
Organic matter content and quality			-enough energy has to be released -suggested ratio between decomposable matter and water 1:10
pH		5- 10	-at the limits the composting process starts slower -high pH at the beginning nitrogen vaporizes as ammonia⇒ nitrogen loss
Humidity	p-%	50 – 60	-can be high if porosity is high and turning and mixing of compost is efficient
Porosity			-difficult to maintain oxygen content high enough in a dense and easily densified waste
Medium grain size	mm ⌀	10 – 75	- Big enough to maintain aerobic conditions - Higher in a windrew compost than in a reactor
Poisonous components			- Seldom prevent composting but eg organic components may slow down composting