Composting Your Bedded Pack: Making your manure a soil-building resource while protecting water quality

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Spreading Raw Pack or Compost

- Spreading raw pack manure can be less processing time/space required – if applied and incorporated to crop land with tillage
- Uncomposted manure and bedding can lead to matting/uneven regrowth of hay or pasture
- Raw manure can lead to pasture rejection
- Carbon in bedding may not be broken down and lead to Nitrogen (N) deficiency in plants when applied to soil

Composting Defined

“The return of organic wastes to a rich, stable, humus-like material, through a managed oxidative decomposition process that is mediated by microbe metabolism”

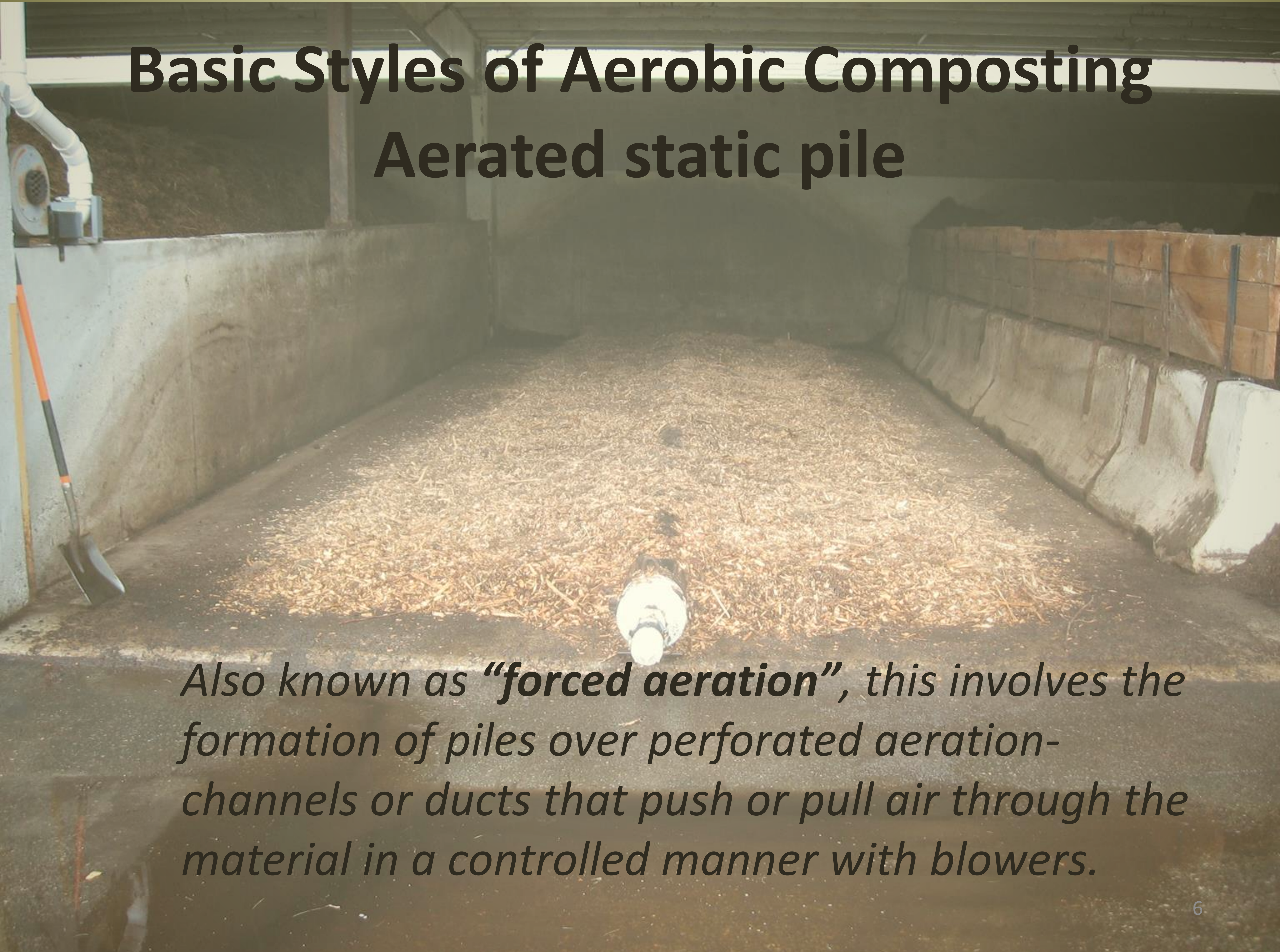
Compost – What and Why?

- Compost is the end product of managed decomposition of manure, bedding, leaves, food scraps and/or similar biodegradable materials – the recycling of organic matter
- Composting stabilizes the volatile substances in raw materials (Nitrogen, odors, physical characteristics)
- Composting reduces pathogens (E. Coli, Salmonella, Cryptosporidium, Johnes, etc.) found in manure

Basic Styles of Aerobic Composting

Turned windrow

Involves the formation of composting windrows and the periodic turning of the windrows with a **bucket loader, windrow turner, or excavator**



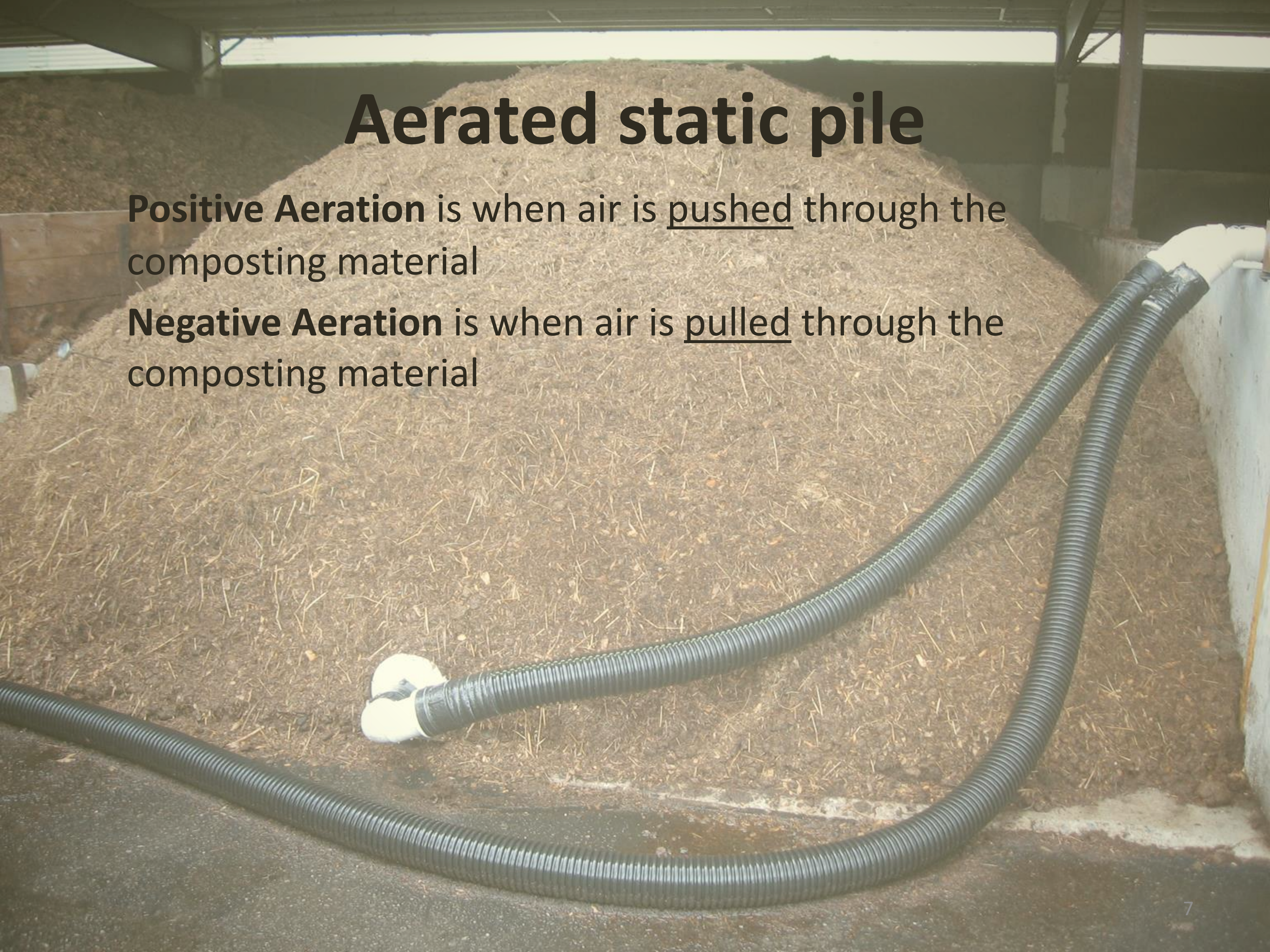
Basic Styles of Aerobic Composting
Aerated static pile

*Also known as **“forced aeration”**, this involves the formation of piles over perforated aeration-channels or ducts that push or pull air through the material in a controlled manner with blowers.*

Aerated static pile

Positive Aeration is when air is pushed through the composting material

Negative Aeration is when air is pulled through the composting material



Characteristics of a Proper Thermophilic Compost Pile Blend

All Parameters are critical to an effective recipe

- **C:N Ratio of 20-40:1 with most ideal being 25-30:1**
- **Moisture Content of 50-65% with the most ideal being 55-60%**
- **Bulk Density Below 1200 lbs/yd^3 with ideal being 700-1000 lbs/yd^3**
- **pH between 6-8**
- **>40% Volatile Solids (or Organic Matter)**
- **Pore Space (30-33%) and Material Structure**
- **Stackability – does matter compress/compact?**

Managed Compost

The presence of oxygen *and oxygen loving organisms promotes:*

- **Fast and complete decomposition**
- **Wider ranges of microbiological diversity**
- **Higher Temperatures** *needed to kill pathogens and weed seeds*
- **Minimal odors** *which are primarily caused by anaerobic organisms*

Managed Compost - Oxygen

Aerobic 5-15% Oxygen

Semi-Aerobic 2.5-5% Oxygen

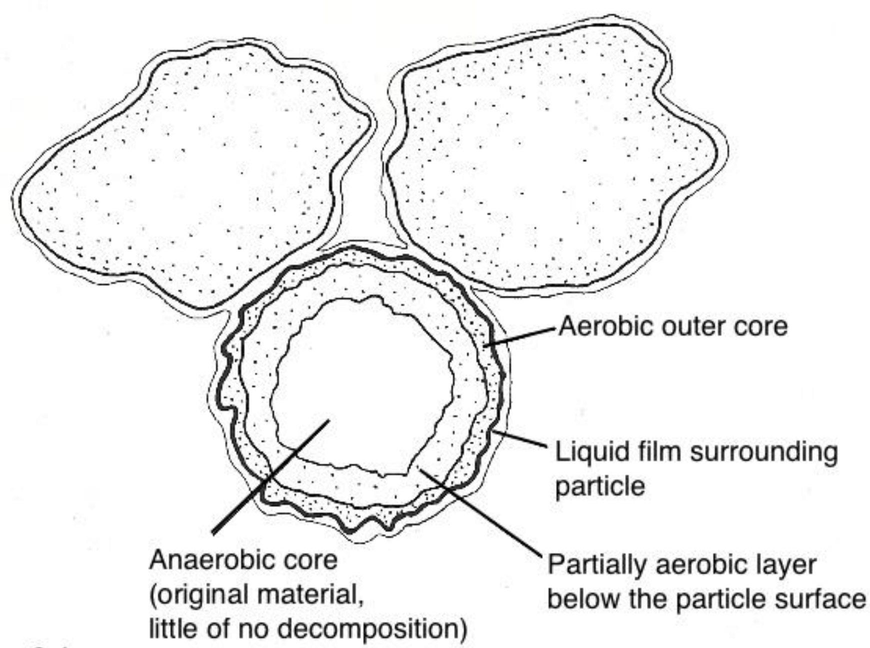


Figure 2.4
Decomposition of solid particles.

The Carbon to Nitrogen Ratio Throughout the Composting Process

- **Support microbial processes effectively**
  - *Carbon Provides Energy*
  - *Nitrogen Builds Proteins*
- **Ideal starting C : N ratio *is 25 to 30:1*** *dry weight*
- **Carbon Dioxide (CO_2) is released through respiration**
- **C : N ratio reduces** *(12:1-15 : 1 ideally)*

Managed Compost

Hot or Thermophilic

(All material reaches 131 F for a minimum of 3 days)

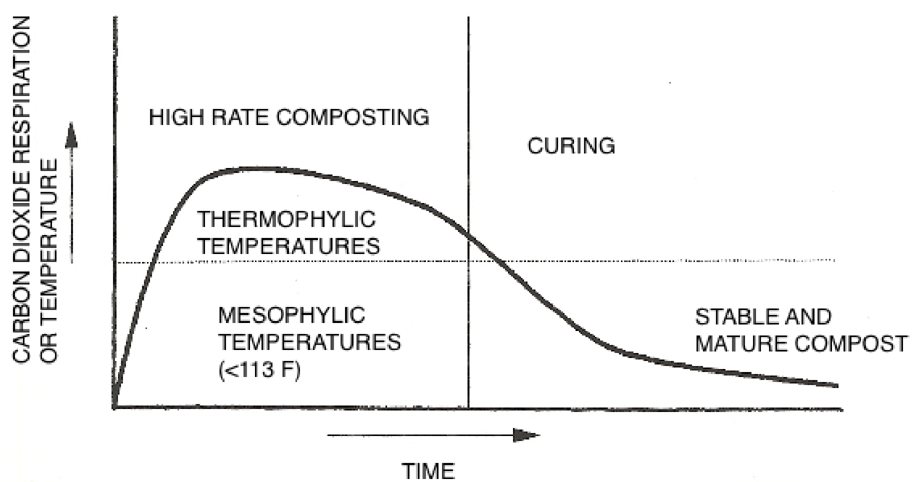


FIGURE 2.2. Phases during Composting as related to carbon dioxide respiration and ɿd temperature.

Managed Compost - Moisture

- Starting moisture should be 55-60% for outdoor windrow composting
- 60-65% moisture ideal for aerated composting
- Above 70% leads to leaching (runoff and loss of nutrients) and reduces porosity for oxygen
- Below 50% moisture is insufficient for good biological activity
- Squeeze test should feel like damp sponge

Feedstock Overview

Every Feedstock has unique chemical, physical, and biological attributes:

Carbon : Nitrogen Ratio

Moisture/Solids Content

Bulk Density

Structural Integrity

Porosity/Particle Size

pH

Conductivity

Physical changes during composting

Finished Compost bears little resemblance to the raw parent material being composted.

- **Color** *brown to black*
- **Particles Reduce** *in size*
- **"Humus-like"** *material, because the humification process will likely not be fully complete until the compost has been applied and has matured in the soil*

Humus is the final and most stable form of decomposed organic matter.

Pile Formation

Turned Windrow Size at Formation

- **Pile height** *is ideally 6-8 ft*
  - *Piles can be built up to 10 ft high with adequate attention to pile structure*
- **Pile width** *is ideally 10-14 ft*
- **Parabolic shape** *to windrow (bread loaf shape)*
- **Dense materials –** compensate with shorter/narrower piles
- **Fluffy materials –** including woodchips that give piles more air spaces (porosity) can be built taller/wider

Pile Turning Overview

Turn Piles Based on:

- **Monitoring**
- **Meeting PFRP**
- **Site Movement**
- **Homogenize Compost Mix**
- **Adjust Recipe or Pile Moisture Content**

Monitoring Pile Activity

Pile Temperature Monitoring

- **Seek temperature trends** *upward or downward Or*
- **Temperature differential** *between* **1' and 3' readings** *greater than 20 Degrees F*

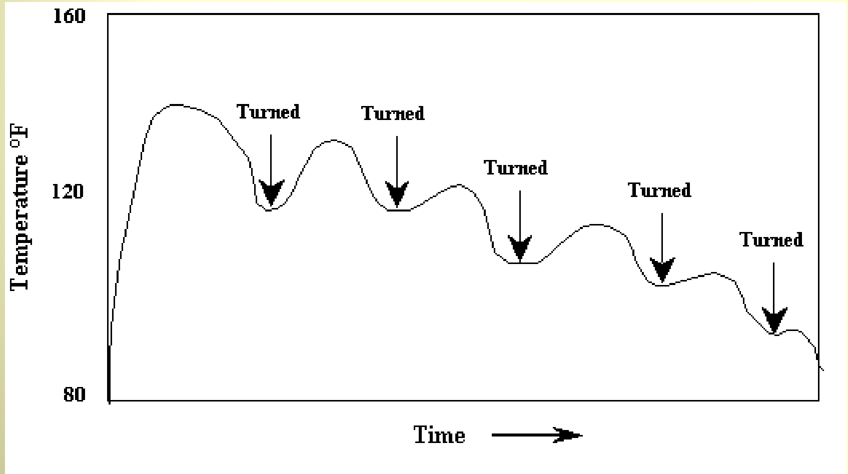
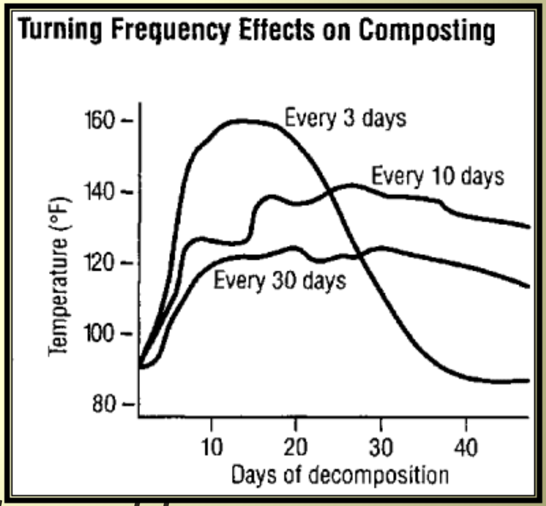


Figure 2. Typical temperature pattern in a turned compost pile.



- **Respond** *to downward temp trends and large differentials by aerating the pile*

Management of organic materials

Improved compost pads

Material	Cost	Effectiveness	Notes
Soil	Low to high	Type dependent	Only if good drainage
Gravel	Low	Moderate	Needs to pack, ruts, blends w/ OM; combines firmness with percolation
Sure Pak	Moderate	Good/ Excellent	Firm working surface; increased storm water runoff
Concrete	High to Very High	Excellent	Access and ease of operation during high moisture; increases storm water; Restricts biological reservoir
Lime-Hardened Clay	Low	Good	Only works with high clay soils
Asphalt	Moderate to High	Poor/ Good	May leach; subject to cracking; offers moderate percolation
Sand	Low	Poor	Does not pack adequately; limited drainage

Management of Site

Windrow organization

- Facilitate easy handling

Maintain adequate working/ turning space

Keep perimeter of pads open – 10’ lane

Don’t pile at edge of field with no room to access windrows

Storm Water Management

Manage moisture and runoff:

- Divert clean water
- Minimize contact between storm water on pad and compost
  - Clean alleys
  - Pile orientation
  - Covers
- Slope pad (2-4% is ideal); Keep pad level to slope
- Capture and treat dirty water
- Plan for snow removal and stock piling; *where will snow melt from stockpiles go?*
- Coordinate windrow site with NRCS/technical support staff to avoid runoff and nutrient loss to surface and ground water

Runoff/Leachate Management

Move "dirty" water, runoff or leachate away from pad to treatment area

- *Planned storm water movement*
  - *Swales*
  - *"hump" culverts*
- *Reduce volume*
- *Reduce flow*
- *Maximize opportunities for infiltration and plant uptake*
- *Decentralize management approach, prevent concentration unless necessary*
- *Settling areas and strategies*

Runoff Treatment Methods

Vegetative Treatment Areas

- **Size adequately**
- **Consider seasonal limitations**
- **Distribute water** *over largest area possible*
- **Integrate diverse cool and warm season species**
- **Use biologically active berms** *(compost, woodchips) – can be recycled into next batch*
- **Utilize swales for vegetative treatment**
- **Identify and plan for overflow – prevent erosion**

Finishing and Cured Compost

General Characteristics:

- **Stable temperature** *of finishing compost is between 90-100 F (Mesophilic)*
- **Cured compost** *is finished compost that has maintained stable temperatures below 90 F for 1-3 months*
- **Smell** *of finished and cured compost is earthy, similar to forest Humus (smell of Actinomycetes)*
- **Turning** *does not yield a large or sustained increase in temperature (microbial activity)*
- **No identifiable materials** *are present*

Finishing and Cured Compost

Finishing and Cured Compost

Handling curing compost:

- **Keep out of stream of stormwater and leachate from active piles**
  - *Prevent reintroduction pathogens*
  - *Promote drying*
- **Mow around curing area before seed sets**
  - *Prevent reintroduction of weed seeds*
- **Piles can be built larger to cure**

  -Still need to passively aerate

Increase in Living Organisms

Microorganisms *can make up to 50% of the weight of finished compost*

- *Up to* **1 Billion bacteria per teaspoon** *of cured compost*
- **400-900 feet of fungal hyphae per Teaspoon** *of cured compost compared to several yards of fungal hyphae per teaspoon of good garden soil*
- ***10,000-50,000 protozoa per teaspoon*** *finished compost*
- ***30-300 Nemetodes (beneficial types) per teaspoon*** *finished compost*

(Lowenfels, J. & Lewis, W. Teaming with Microbes.)

Organisms present throughout the process

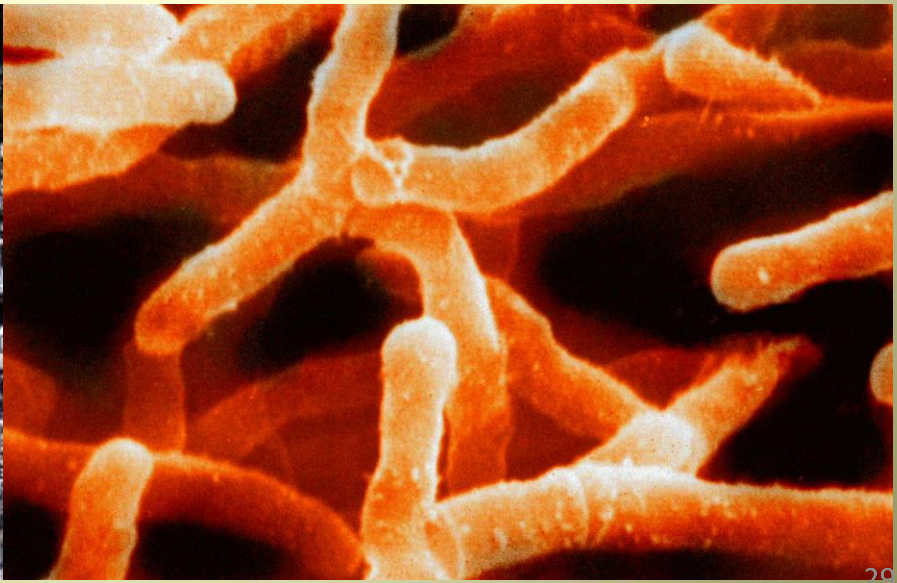
Bacteria are *dominant and do the heavy lifting during the most active stages of composting and when the most accessible forms of Carbon are abundant.*

Bacillus megatherium

Organisms present throughout the process

Actinomycetes *are a group of bacteria that break down plant cellulose and chitin*

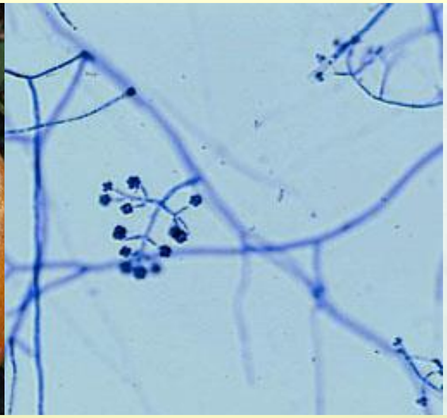
- *Form long visible chains similar to fungal Hyphae*
- *Produce "fresh-earthy aroma" associated with great soil and compost*

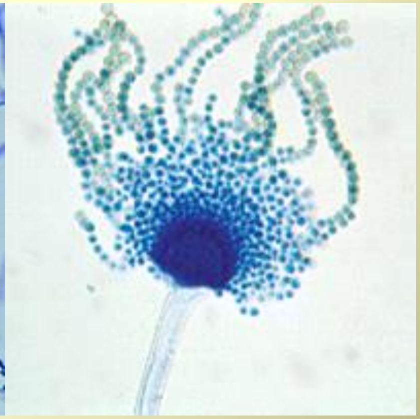
Organisms present throughout the process

Fungi *are dominant and do the heavy lifting during the curing stages of composting when organisms are left with the most complex forms of Carbon for energy.*

Penicillium digitatum



Trichoderma kinongii



Aspergillis tamarii

Organisms present throughout the process

Limited Fungal species are active at thermophilic composting temperatures, however, these species begin to break down woody material at this stage

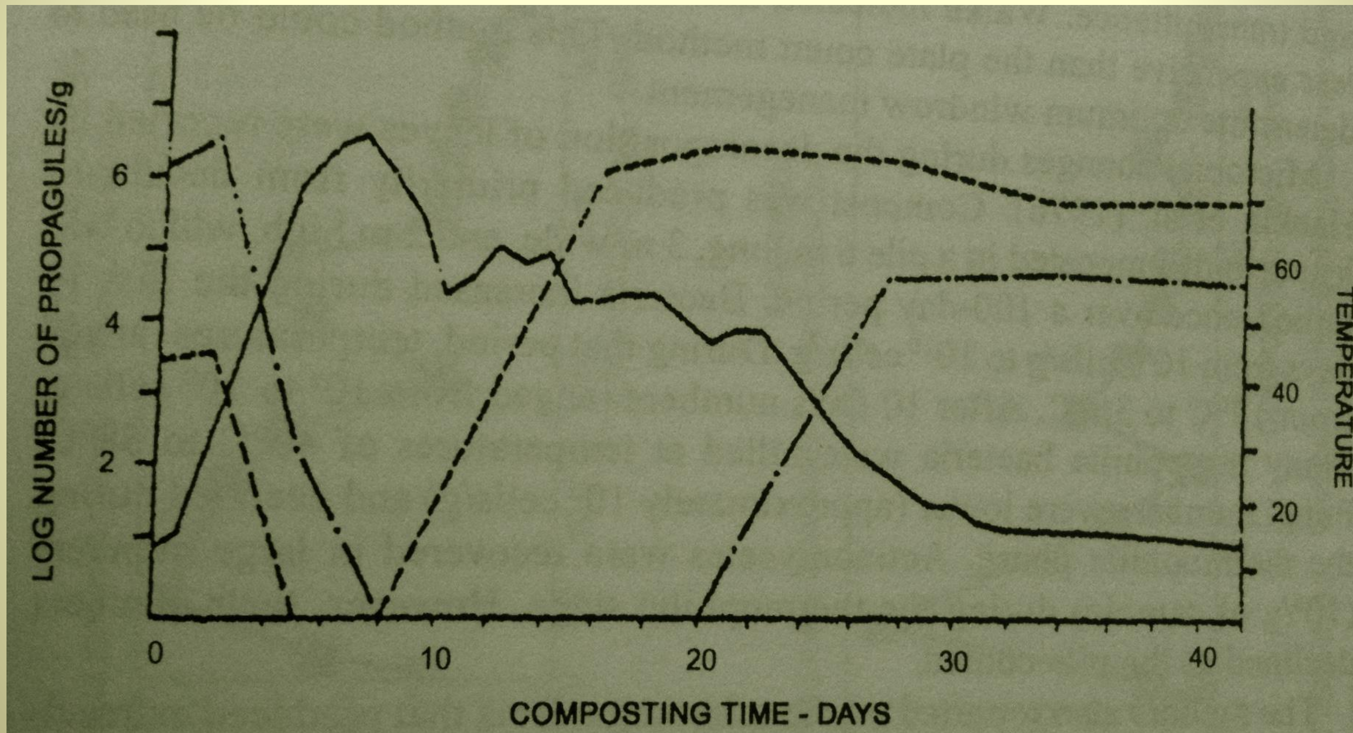


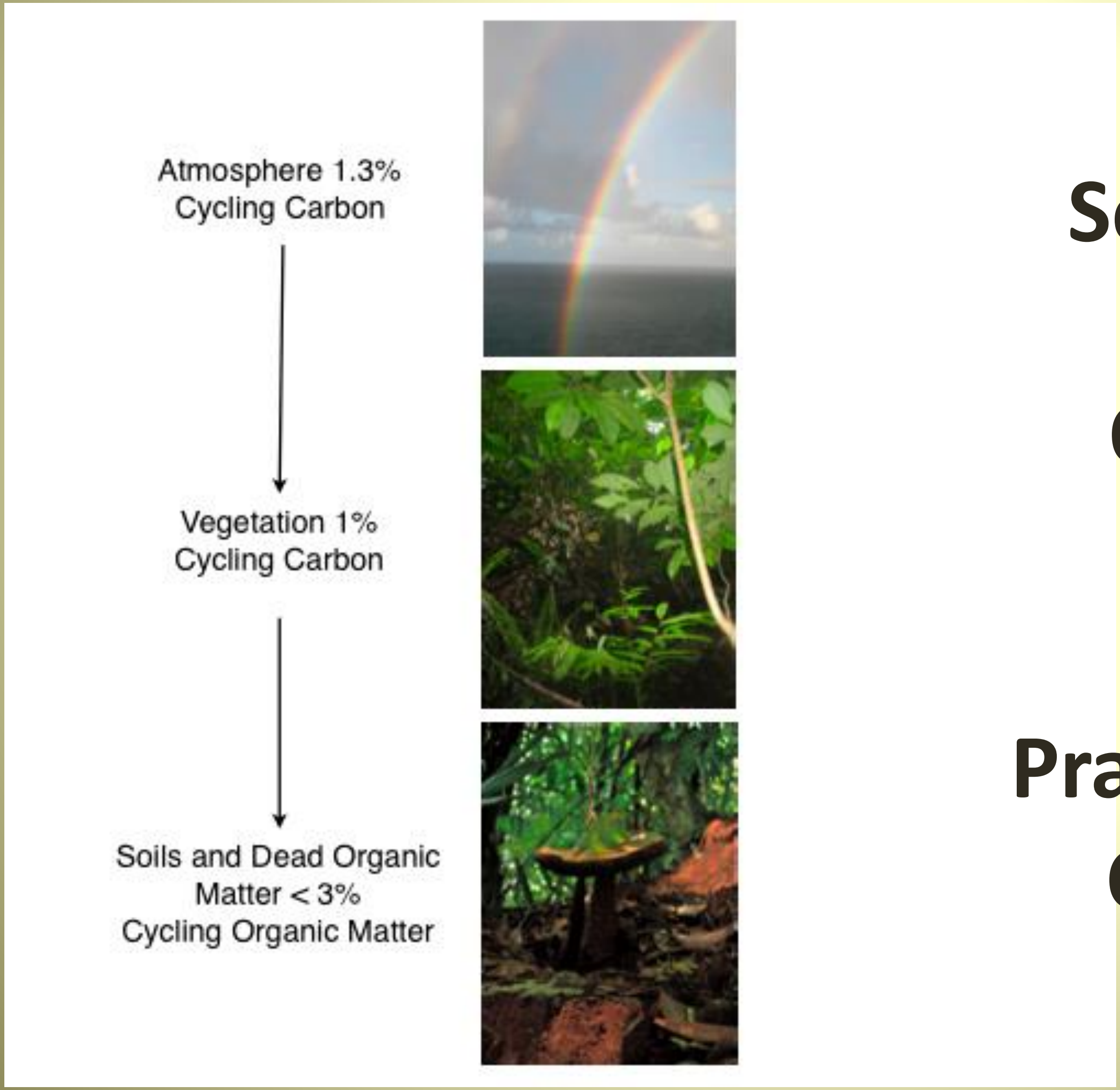
FIGURE 3.2. Changes in fungal populations during the composting of wheat straw. (Data from Chang and Hudson, 1967.)

(Epstein, The Science of Composting 1997)

The Earth's Carbon Cycle

- **100 million Gt of carbon on Earth** *(Gigatons or Billion Metric Tons), most of which is buried in sedimentary rock.*
- **Earth's cycling carbon pools** *include 55,000 Gt of which:*
  - *Oceans 69% of cycling carbon*
  - *Recoverable fossil fuels 18% of cycling carbon*
  - *Soils and dead organic matter <3% of cycling carbon*
  - *Atmosphere 1.3% of cycling carbon*
  - *Vegetation 1% of cycling carbon*

The Earth's Carbon Cycle



Carbon Sequestration In Soil is Outcome of Renewable Agriculture Practices Such as Composting

Carbon Sequestration

Agricultural Soils have the potential to soak up 13% of the carbon that is in the atmosphere today (equivalent to Total Carbon Dioxide released since 1980)

(Olson 2011: See Binder)

The Attributes of Healthy, Carbon-Rich Soil

- **Improved soil structure**, *permeability, and resistance to erosion*
- *Greater* **nutrient retention capacity** *and resistance to nutrient leaching*
- *Increased* **moisture retention** *of soil and drought resistance plants*
- *Higher* **biodiversity of soil organisms**, *microbial activity, and organically mediated nutrient cycling processes*
- **Healthy soils grow healthy plants**, *which are more resistant to diseases, and crop failures*

What is Soil?

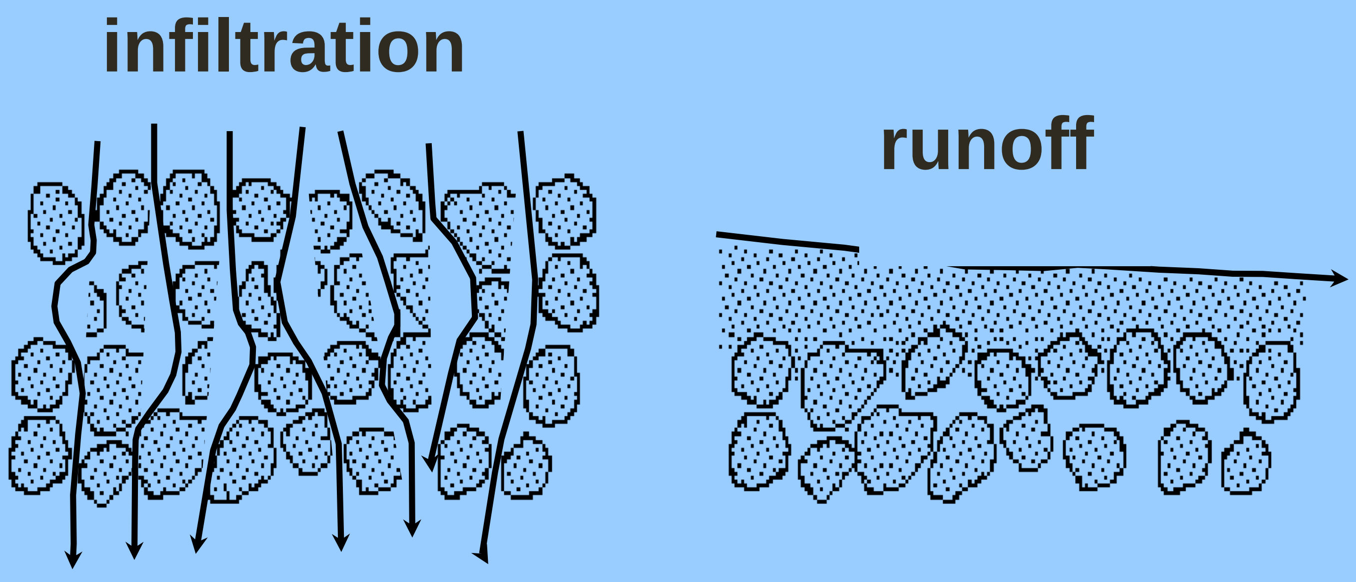
- Mineral solids – particles of sand, silt and/or clay from weathered rocks
- Organic matter – plant fiber, animal residue and microorganisms (OM fractions ranging from easily degradable to highly resistant carbon (C))
- Water and Air
- Physical, chemical and biological properties
- “The living skin of the earth”

What is a Healthy Soil?

- Soil Quality used interchangeably with Soil Health
- Drains well, does not crust, takes in water rapidly (good infiltration), resists diseases, erosion and does not make clods.
- Soils with good tilth are crumbly and break apart easily when worked.
- Tilth depends on aggregation, the process whereby individual soil particles are joined into clusters or aggregates through the activity of soil organisms.

Compacted soil vs. well-aggregated soil

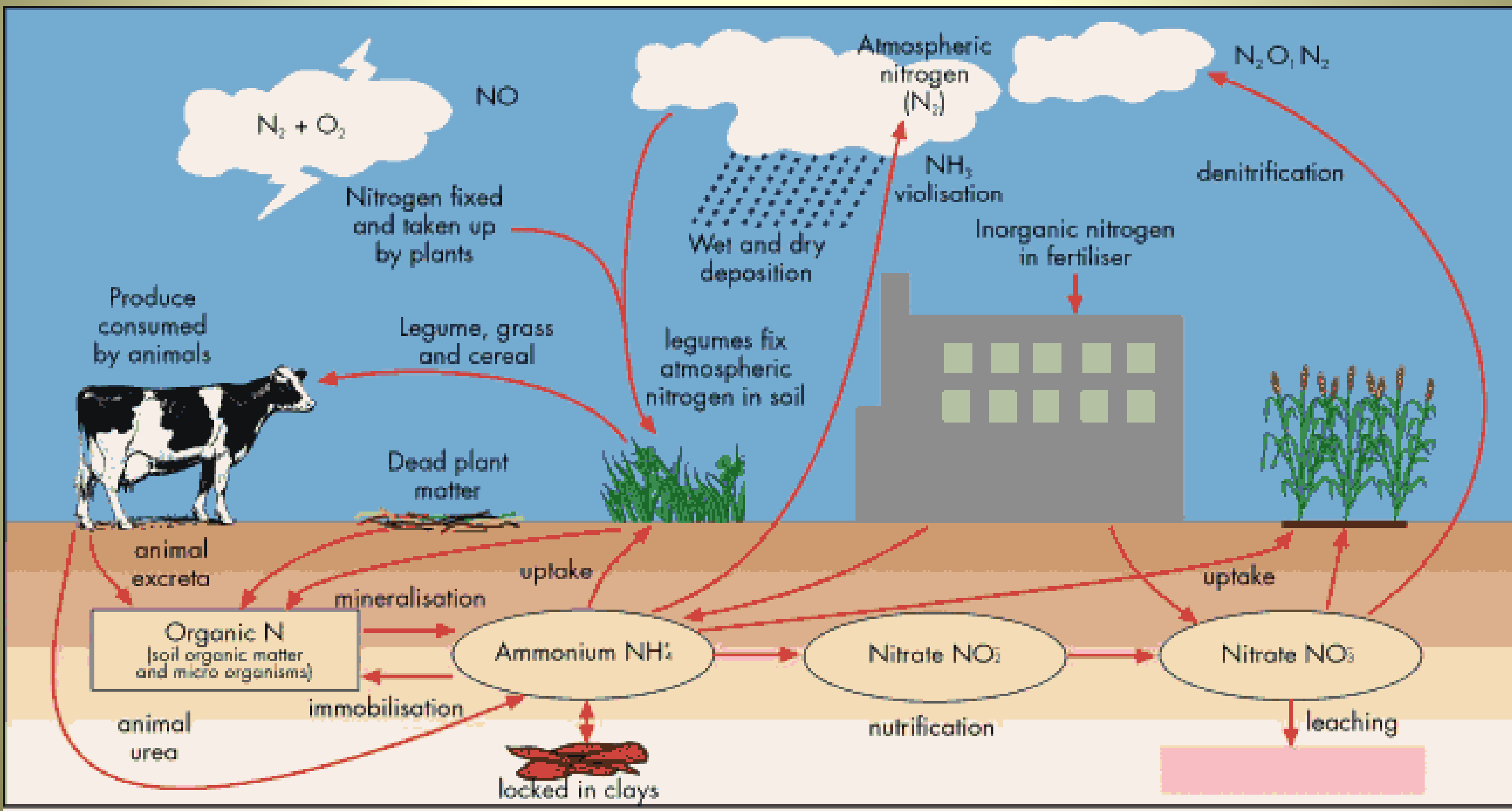
Runoff over crusted soil leads to erosion



a) aggregated soil

b) soil crusts after aggregates break down

The Earth's Nitrogen Cycle



The Soil and Composting Nitrogen Cycle

Goal of composting *is to utilize the natural N cycle to sequester N as protein in the microbial system, where it is non-volatile and becomes available to plants through the soils natural food chain*