How to prepare and use compost for sustainable agriculture + Topics on Green Manure

Part 2: How compost is prepared?

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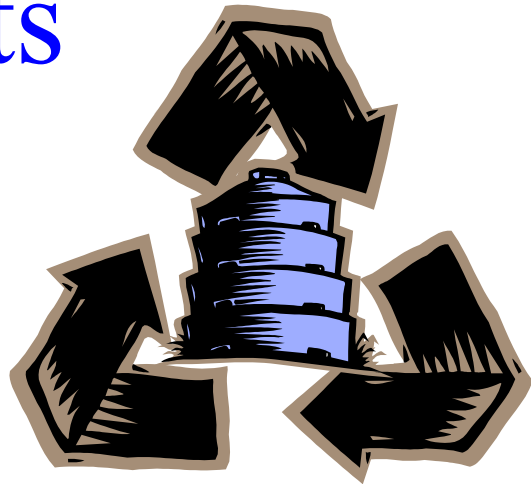
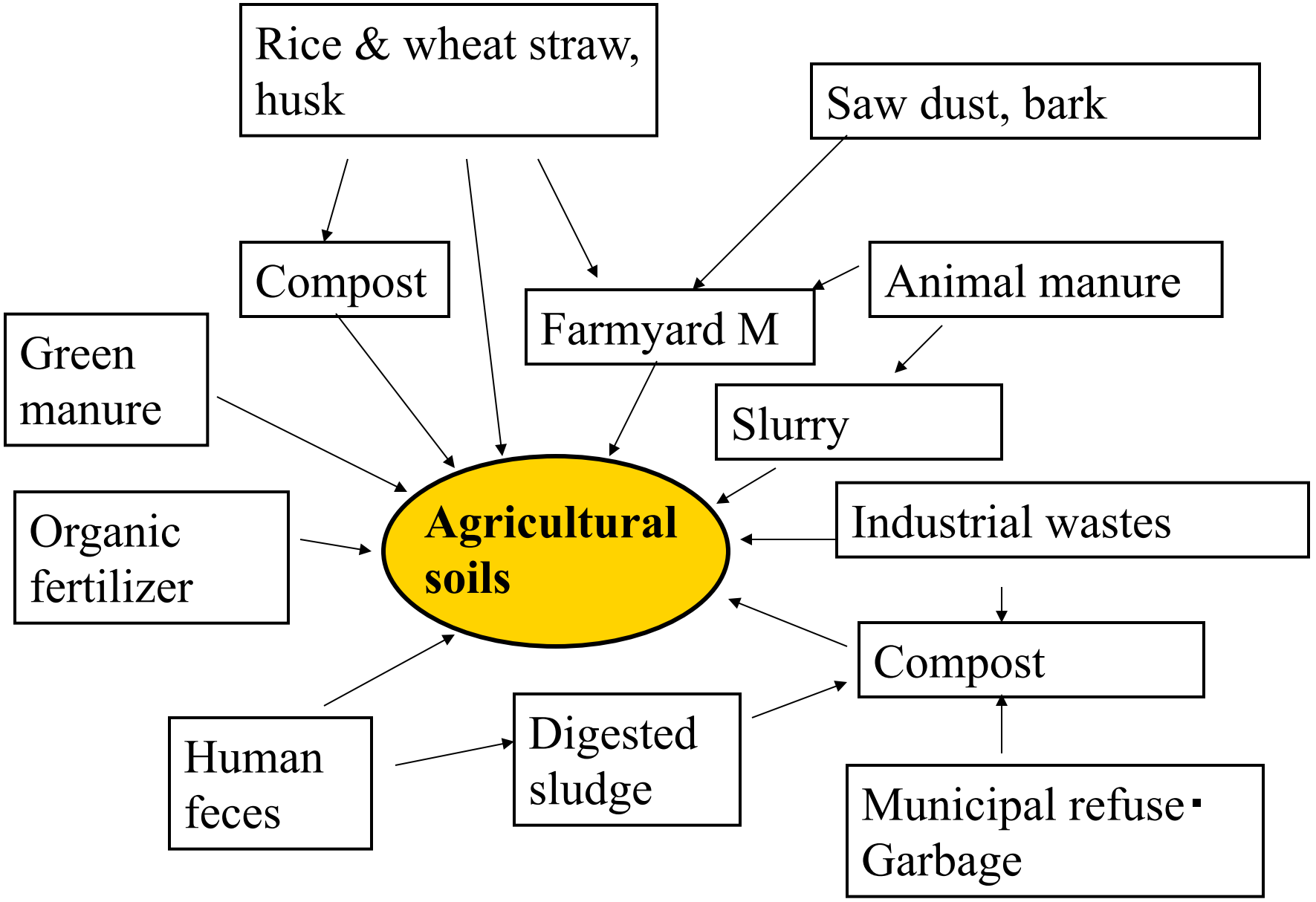
Compost and Farmyard Manure

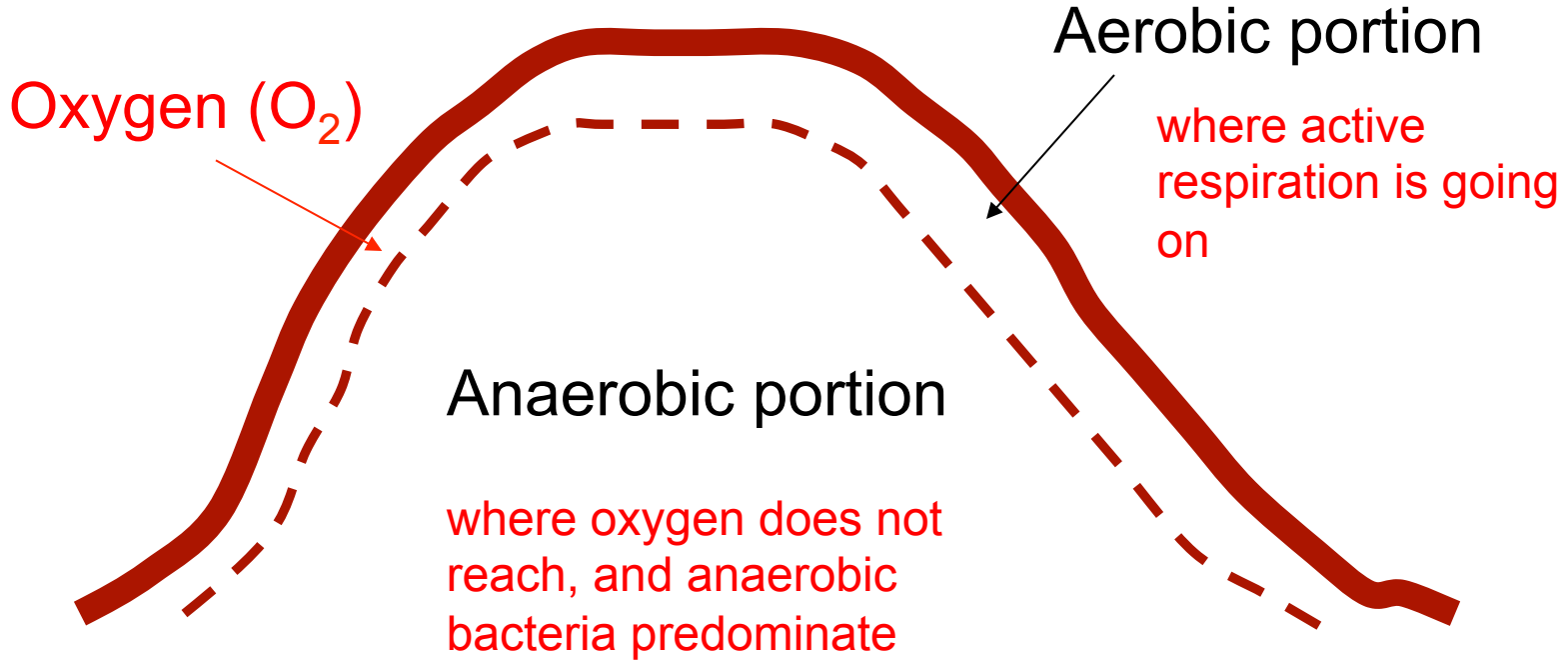
Preparation methods, Characteristics, Effects





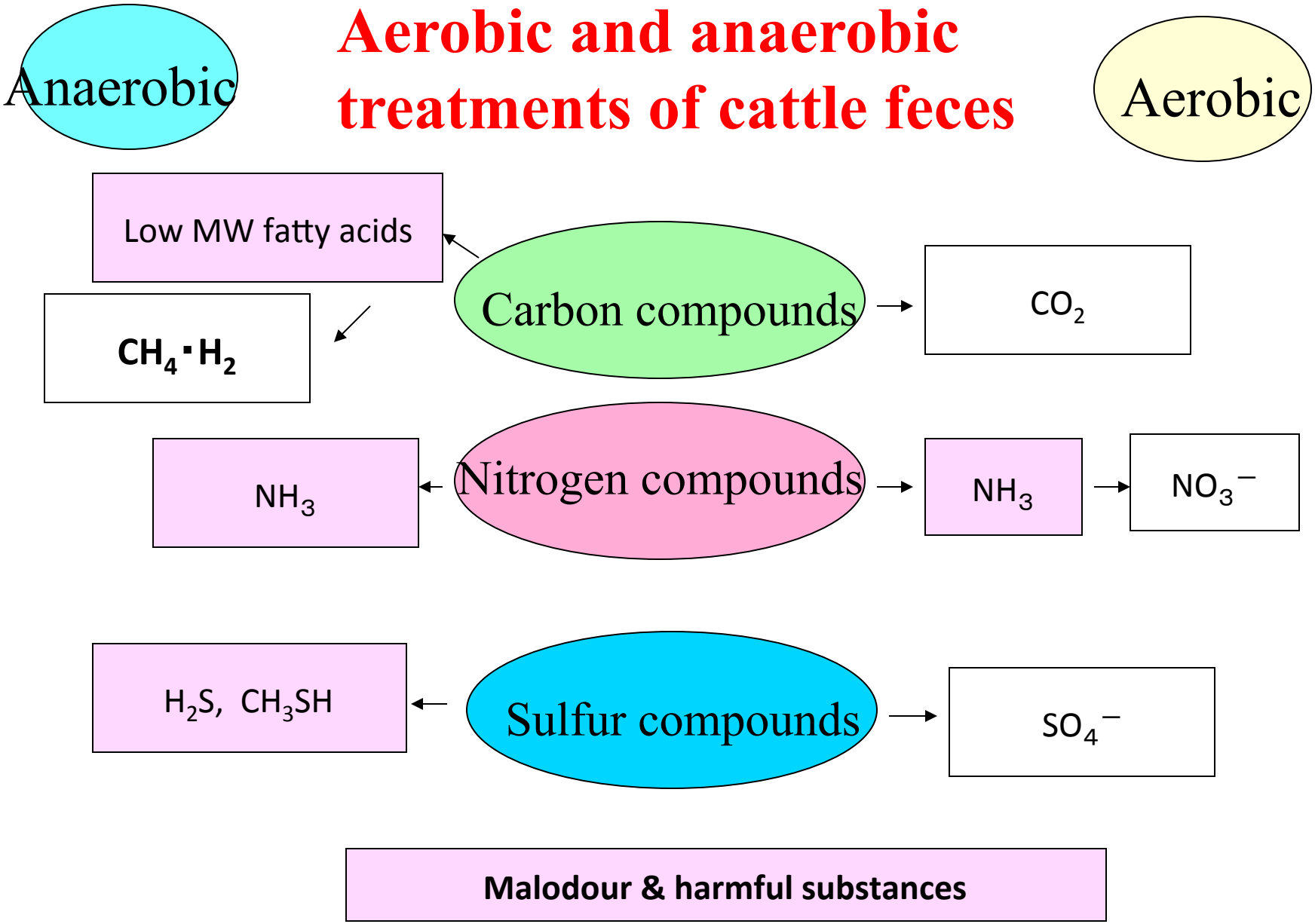
Organic matter Input in Agriculture

Aerobic and anaerobic portions in a compost pile



In the case of compost without forced aeration

Aerobic and anaerobic treatments of cattle feces



Characteristic of aerobic fermentation

- **Large amount of heat is emerged**
- **Organic matter is decomposed more completely**
- **Products are easily (comfortably) handled**
- **Use of emerged heat energy is the subject to be solved**

Characteristics of anaerobic fermentation

- **Little heat is emerged**
- **Reaction stops at intermediate products: like alcohols, aldehydes, organic acids**
- **Bad odor is emerged**
- **Effective with respect to initial decomposition, but not complete. (Microbes need more organic matter for obtaining energy)**

Terminology for “Fermentation” : 1

- Broad and popular meaning =

  Microbial reaction producing beneficial products

Antonym = Rotting

Microbial reaction producing undesired & unpleasant products

Terminology for “Fermentation” : 2

- Narrow and scientific meaning =

  Microbial reaction converting carbohydrates to low molecular weight organic substances under the absence of oxygen

Antonym = Respiration

What is compost ?

R1. Raw materials:

A) **Feces of domestic animals, municipal wastes, and sewage sludges** are main raw materials, while

B) **Straws, rice husks, saw dusts, grasses and recycled papers** are often used as feedstocks.

What is compost ?

2. Mixture of raw material and feedstock is piled and decomposed mainly by the action of arerobic bacteria through high temperature stage (preferably > 70 ^{0}C).

What is compost ?

3. The completed compost is easy to handle and store, ready to be applied to soil without causing any harmful effects to environments.

What is compost ?

4. Compost is a solid mature product resulting from **composting**, which is a managed process of bio-oxidation of a solid heterogeneous organic substrate including a thermophilic phase.

Purpose of composting… 1

1 To make manure easy for handling and transporting, by reducing dirty feeling, malodor, and stickiness.

2. To prevent soil reduction and emission of harmful gasses and the resulting inhibition in crop growth which is assumed to occur when raw material is applied to soil.

Purpose of composting...2

3. To kill pathogens and parasites for human, animals, and plants.
4. To kill the weed seeds which are mixed in feces, hays and feedstocks.
5. To decompose phenolic compounds in feedstocks such as straw and sawdust and low molecular weight organic acids in feces which are assumed to cause growth inhibition of plants.

Table 1.. Change in numbers of *Escherichia Coli.* during the culture of cow compost at different temperatures.
(Shintoku Experiment Station of Animal Husbandry, 1998

Days cultured	Cultivation temperature 4 ℃	20 ℃	30 ℃	40 ℃	50 ℃	60 ℃
	log CFU g^{-1}					
0	7.9	6.8	7.9	7.9	5.4	6.8
1	5.6	8.6	9	8.4	※	※
3	6.4	7.7	8	6.2	※	※
7	5.9	8.1	7	5.8	※	※
10	6.1	7.9	6.8	6.6	※	※

※ below the detection limit

Germination rate of weed seeds in compost (%)

	< 50℃	2 days at 60℃	Japanese name
Digitaria ciliaria Koeler	96	0	メヒシバ
Echinochloa spp.	72	0	ノビエ
Cyperus spp.	56	0	カヤツリグサ
Chenopodiium album Linn.	26	0	シロザ
Percicara lapathiolia Linn.	8	0	オオイヌタデ
Portulaca olelacea Linn.	85	0	スベリヒユ
Amaranthus lividus Linn.	68	0	イヌビユ
Acalypha australis Linn.	7	0	エノキグサ
Fatoua villosa Nakai	26	0	クワクサ

Digitaria ciliaria

メヒシバ

Cyperus spp.

カヤツリグサ

Chenopodium album Linn.

シロザ

Percicara lapacifolia Linn.

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Portulaca oleracea Linn.

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Acalipha australis Linn.

エノキグサ

Fatoua villosa Nakai

クワクサ

Echinochloa spp. in a paddy field

写真 4: 成熟期の水田で出穂するタイヌビエ

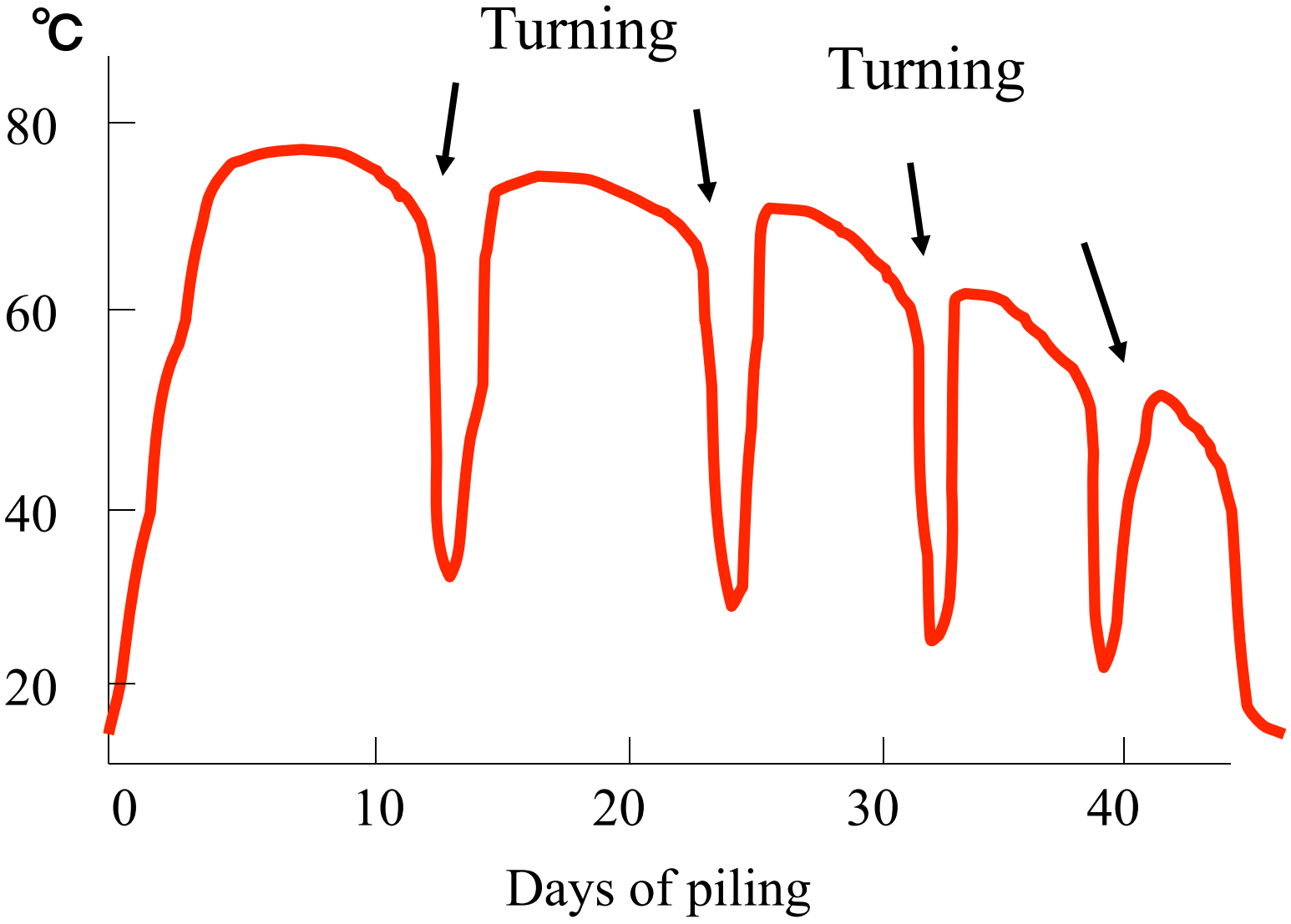
Factors which affect composting

- **Moisture** : recommended to fall between 65 – 70 %.
- **Aeration**: Ratio of volume to weight should be larger than 1.5. Pile of compost should be turned, when its temperature decreases.
- **Initial pH** > 6. When pH < 6, composting will be retarded. During composting, pH will be automatically raised to around 8 or higher.
- **Initial C/N** should fall between 25 and 30.

Temperature

- The temperature of compost pile depends on the balance of generation and loss of heat. The heat is generated by the activity of microorganisms and lost by moisture evaporation and aeration. Under appropriate moisture condition, the temperature of the pile reaches nearly 80 degree C or higher. Temperature higher than 70 ^{0}C, however, deactivates even most of the thermophilic bacteria.

Temperature change during composting



Moisture

- The most important factor for composting is moisture content. Too high (> 70 %) moisture prevents the activity of aerobic bacteria, and too low moisture stops the process of composting before it reaches maturity (Fig. 1).
- To decrease the high moisture content of cow feces (>85 %), large amounts of feedstocks (straw, saw dusts, etc) are required. When feedstock is not available, “feed-back compost” technique may be applied.

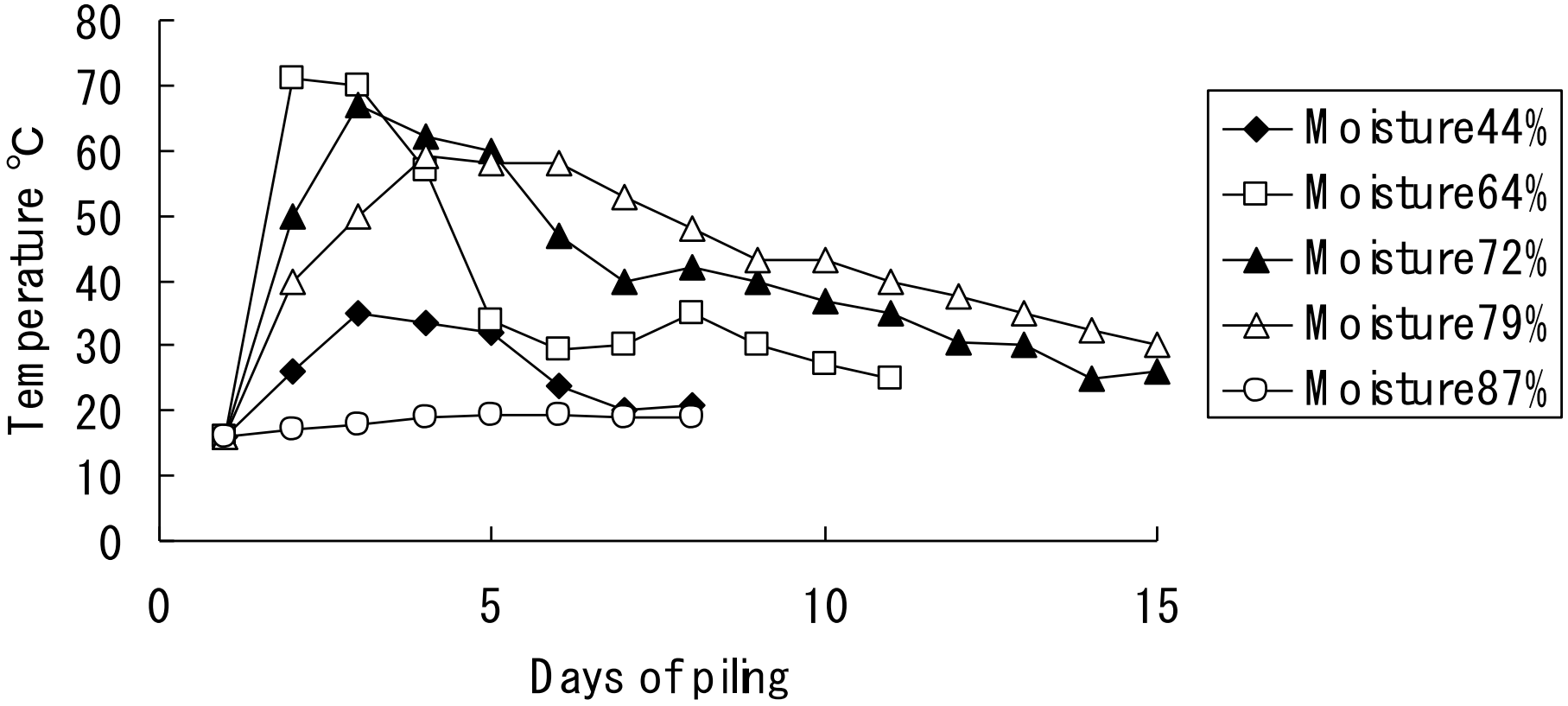


Fig. 1. Fermentation temperature of cow manure depending on different moisture contents

(Shintoku Experiment Station of Animal Husbandry, 1998)

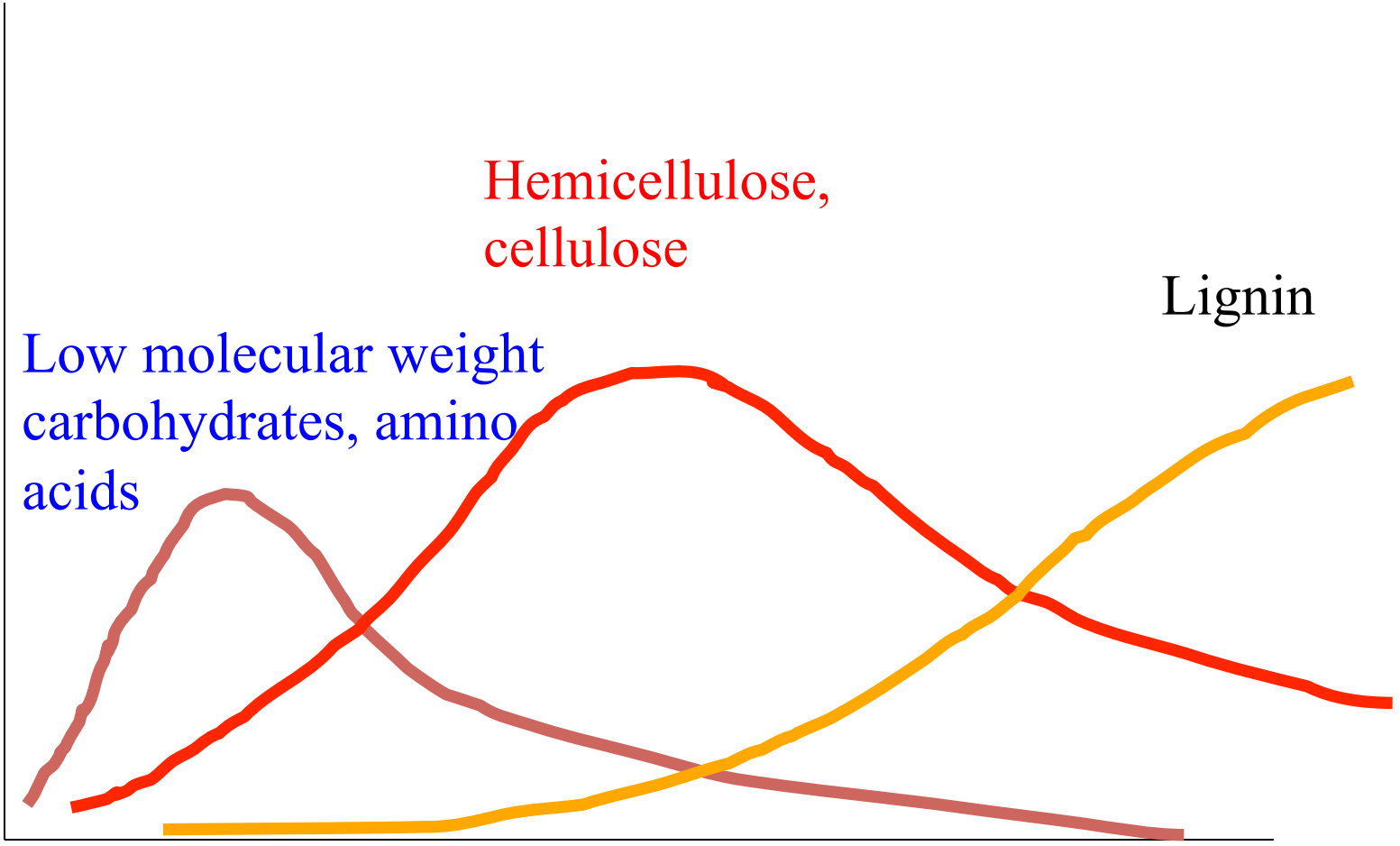
Aeration

- Forced aeration is effective to accelerate the composting process. When aeration is not applied, frequency in turning of compost determines the speed of composting. Turning of compost piles is effective for homogeneous fermentation, because aerobic microbes hardly enter the large clods of feces. However, too frequent turning is not recommended, because it lowers the compost temperature.

Change in constituents during composting

- **First stage** (Saccharide decomposition stage): Mainly easily decomposable organic materials (monosaccharides, starch, amino acids, proteins) are decomposed.
- **Second stage** (Cellulose decomposition stage): Mainly cellulose is decomposed by thermophilic bacteria.
- **Third stage** (Lignin decomposition stage): Mainly lignin is decomposed by Basidiomycota (mushrooms).

Degradation rate of each component



First stage (Saccharide decomposition stage) -1

- Mesophilic bacteria and fungi (aerobic fast growers) mainly act in this stage and easily decomposable organic matter is decomposed which accompanies considerable heat generation. With increase in temperature (>40 degree C), microbial fauna will change to thermophilic members of bacteria, actinomycetes, and fungi.

First stage (Saccharide decomposition stage) -2

- Under a favorable condition for composting, ammonia is formed by the decomposition of protein constituents, which also causes the increase in pH. Due to evaporation of ammonia, pH does not reach too high level. On the other hand, under the deficiency of oxygen, organic acids are formed and the pH is decreased. With decrease in pH, the composting process is delayed.

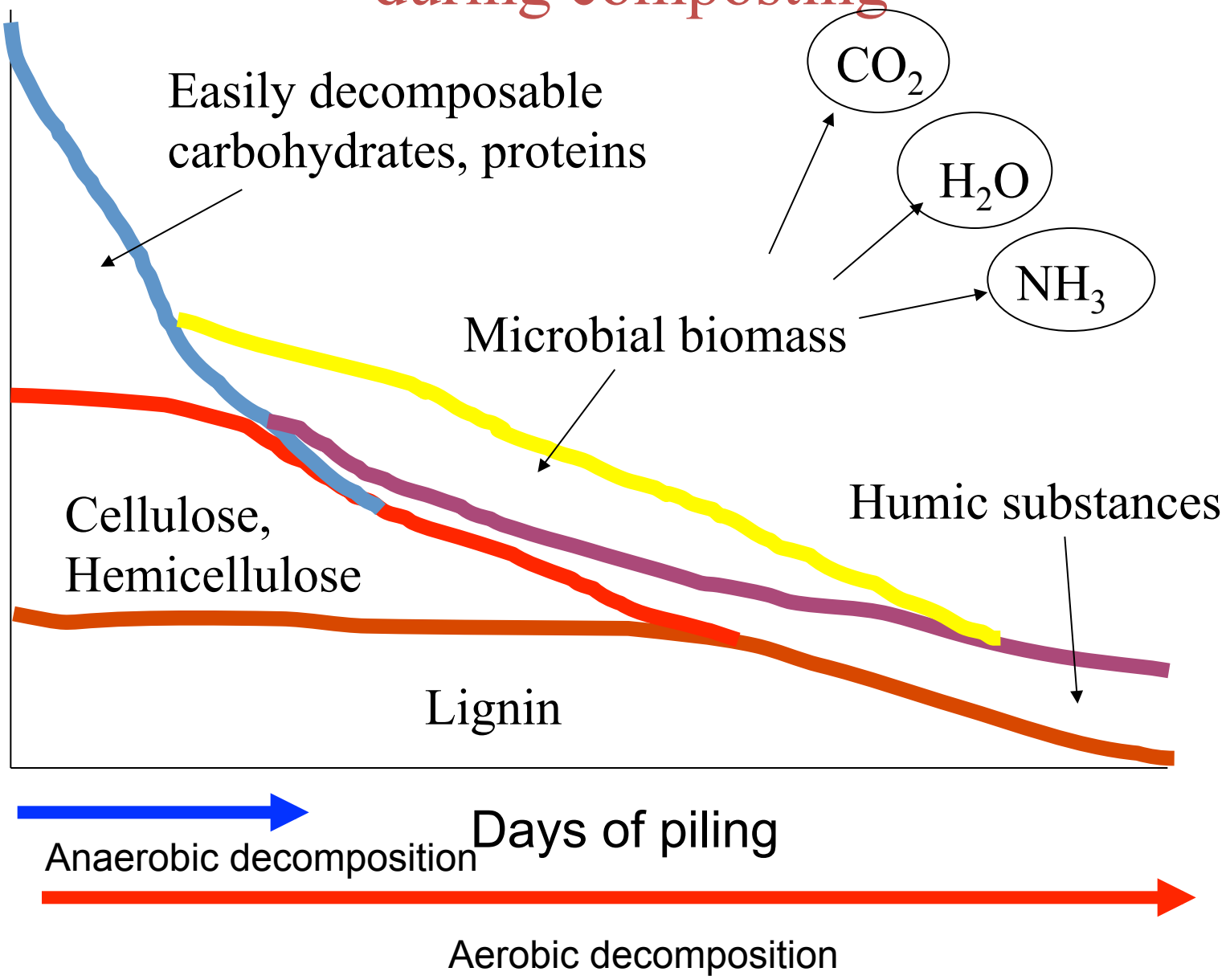
Second stage (Cellulose decomposition stage)

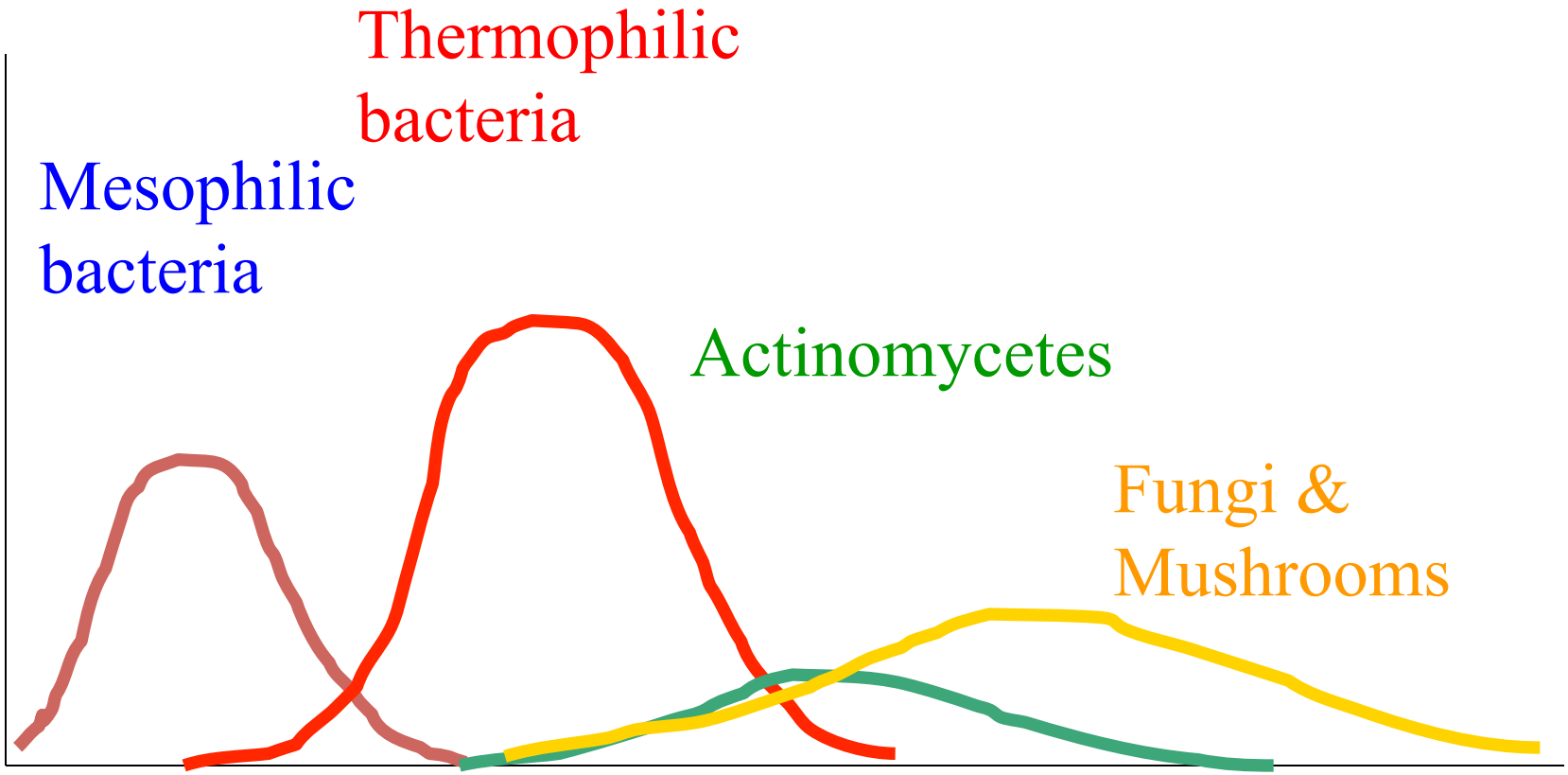
- This is a thermophilic stage and the temperature of compost often reaches 60 – 80 degree C.
- Firstly, aerobic and thermophilic actinomycetes decomposes hemicellulose and exposes cellulose to surface, while creating an anaerobic environment.
- Following this, anaerobic cellulolytic bacteria (*Clostridium*) decomposes cellulose.

Third stage (Lignin decomposition stage)

- Hardly decomposing organic matter, such as lignin, are decomposed by Basidiomycota (mushrooms). Intermediate decomposition products of cellulose and hardly decomposing materials will also be decomposed by various kinds of microbes, as the temperature is not high any more. Then, microbes eat each other, and the dead body of microbes will occupy considerable part of the compost. The color of compost turns to brown-black in this stage.

Change in organic matter composition during composting





Succession of microbes during composting.

Preventing the malodor

- Feces should be quickly composted.
- Ammonia volatilization can be reduced by adjusting the pH of compost to around 7 (by adding calcium perphosphate).

  Aerobic condition of compost should be kept by appropriate turning.

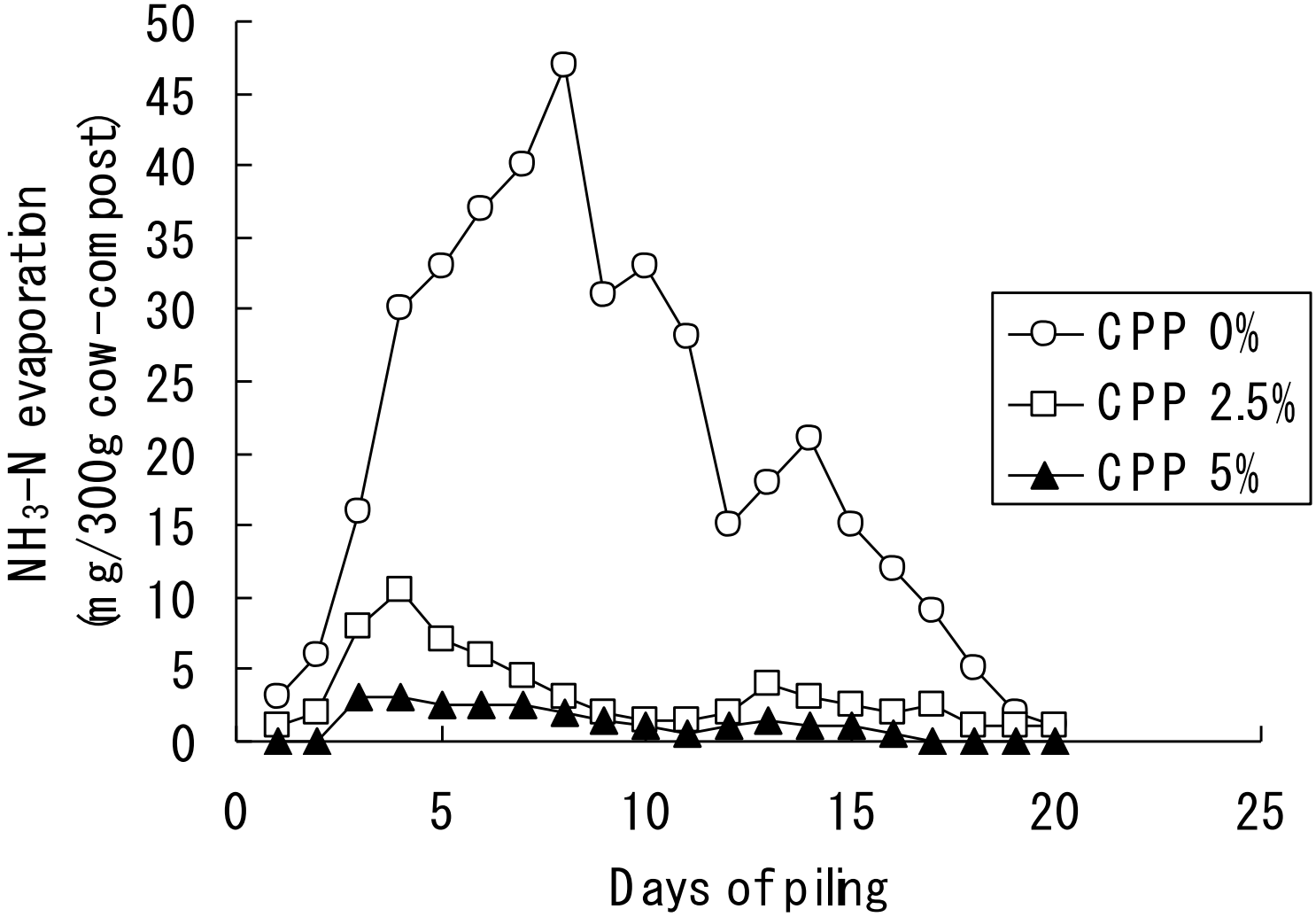


Fig. 2. Suppression of the evaporation of Ammonia N from cow manure by mixing calcium perphosphate (CPP)

(Shintoku Experiment Station of Animal Husbandry, 1998).

Characteristics of feedstock material

- Feedstock material is used to 1) prevent the soiling of animal body, 2) prevent the elution of liquid material from feces and urine in the animal stable, 3) to adjust the moisture to an appropriate level for composting. High water holding capacity is required for feedstock material.

Table 2. Water absorbing capacity of barleys and pasture crops.

Crop materials	Water absorbing capacity (%)
Oats	354 - 423
Barley	494
Wheat	264
Rye	312
Rye wheat	290
Timothy	254 - 256
Tallfesc	268
Reedcanarygrass	324
Saw-dust	236

Water absorbing capacity = absorbed amount of water after 24 hours / initial weight of the sample x 100. (Shintoku Experiment Station of Animal Husbandry 1996)

Table 3. Water holding capacity of alternative feedstock material

Material	Water holding capacity (%)
Recycled news paper	238
Recycled carton paper	167
Rice husk	50
Bagasse (Residue of sugar cane)	110
Saw dust	435

Water holding capacity = water content after 24 hours / initial dry weight of the sample x 100. (Shintoku Experiment Station of Animal Husbandry 1996)