Netherlands East African Dairy Partnership

Improving manure management

Module 4.
Manure composting

Learning objectives of Module 4

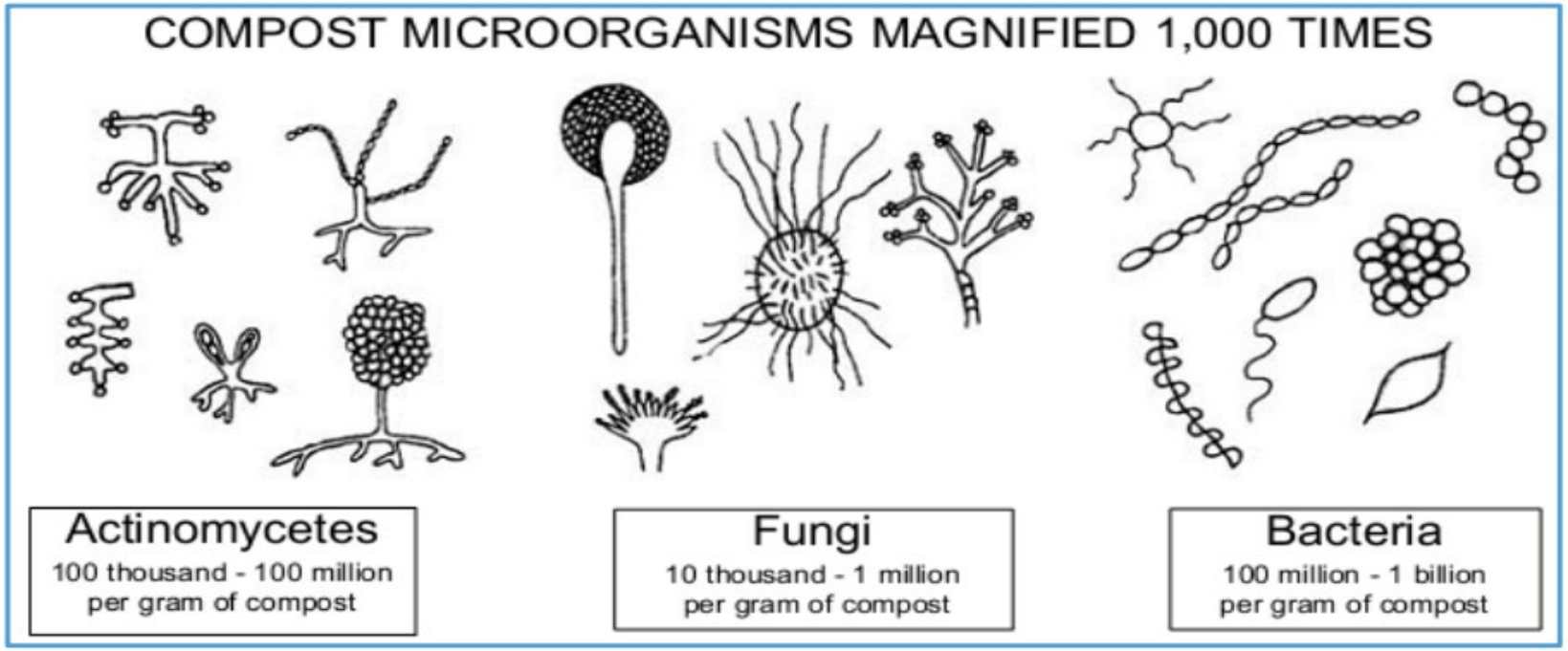
Netherlands East African Dairy Partnership

1. Describe basic composting principles:
   - Methods
   - Ideal requirements and conditions
   - Common troubleshooting issues and solutions
   - Composting in practice

What is composting?

Netherlands East African Dairy Partnership

- Composting is a natural process where organic materials decompose through the actions of bacteria and other micro-organisms
- The result is a stable product (compost) that can be used to improve soil fertility and to fertilize crops



Netherlands East African Dairy Partnership

Methods of composting

Methods of composting (1): Aerobic composting

Netherlands East African Dairy Partnership

- Most common method of composting
- Organic materials are converted by aerobic micro-organisms
- Process needs oxygen (regular turning, ventilation)
- Loss of moisture, carbon (carbon dioxide) and nitrogen (ammonia)
- Critical success factors: oxygen supply, moisture content and C/N ratio of raw materials

Methods of composting (2): Anaerobic composting

Netherlands East African Dairy Partnership

- Process without oxygen: anaerobic conditions
- Organic material is converted by anaerobic micro-organisms
- Emissions of methane and nitrous oxide (GHGs) during the process
- Slow process
- Process can also occur under semi-anaerobic conditions: e.g. less frequent turning of compost pile

Methods of composting (3): Vermicomposting

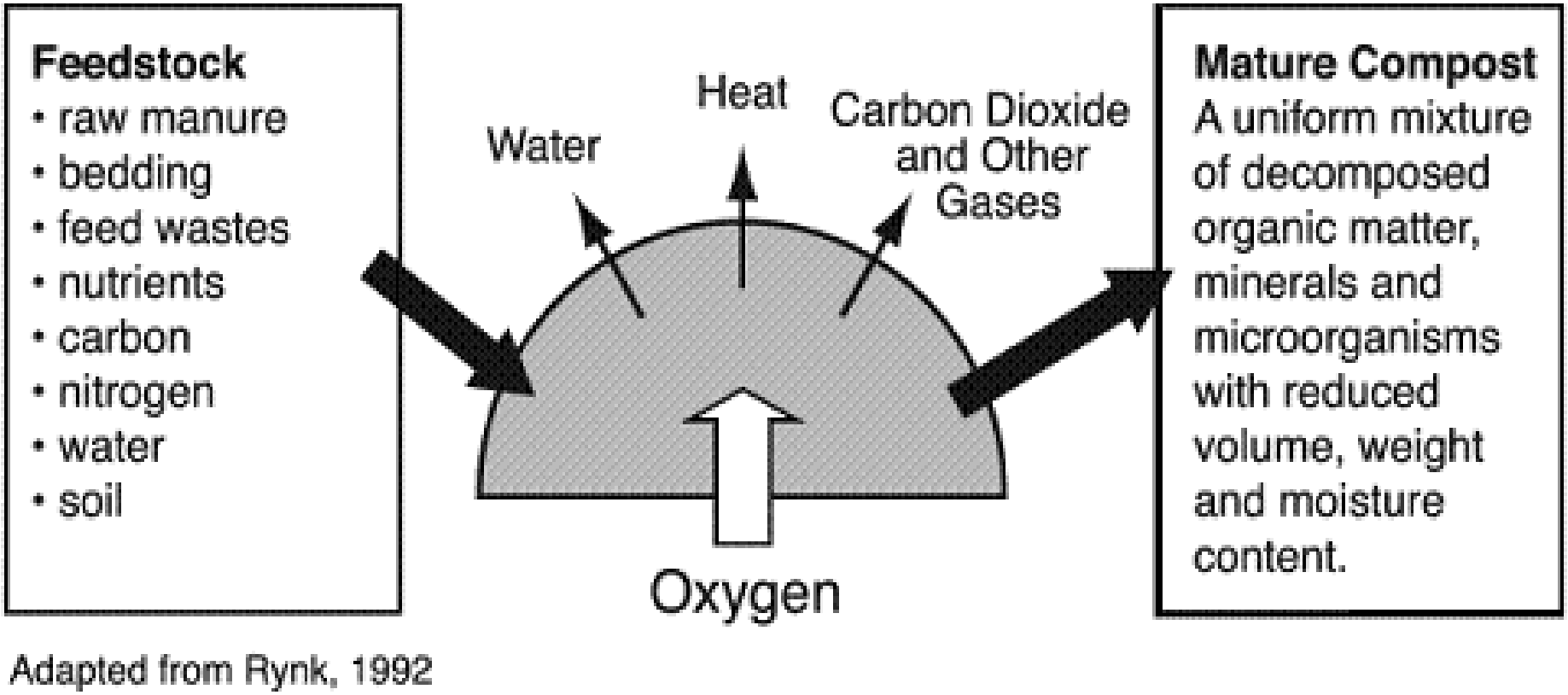
Netherlands East African Dairy Partnership

- Aerobic composting with the assistance of earthworms
- Compost consists mainly of the excreta of the worms
- Compost is very fine

Aerobic composting

Netherlands East African Dairy Partnership

Process of aerobic composting



Adapted from Rynk, 1992

Benefits of aerobic composting of manure

Netherlands East African Dairy Partnership

- More vegetative (dry) material can be added: more nutrients in compost
- Pathogens and most weed seeds are killed: final compost is a safe and hygienic product
- The volume of most materials is reduced (most water is evaporated): better handling and easier application of final product
- Final compost is stable (nutrients) and does not smell bad
- Final compost is easy to store in bags and to transport
- Process is relatively fast (2 months or less)

Limitations of aerobic composting of manure

Netherlands East African Dairy Partnership

- The process of aerobic composting is rather labour intensive: people are needed to monitor (temperature), turn and aerate the compost pile regularly
- Considerable losses of N and organic matter (C) can occur during the process
- Critical factors like moisture content of the pile, C/N ratio and aeration (turning process) slow down the process if not optimal

Process of aerobic composting

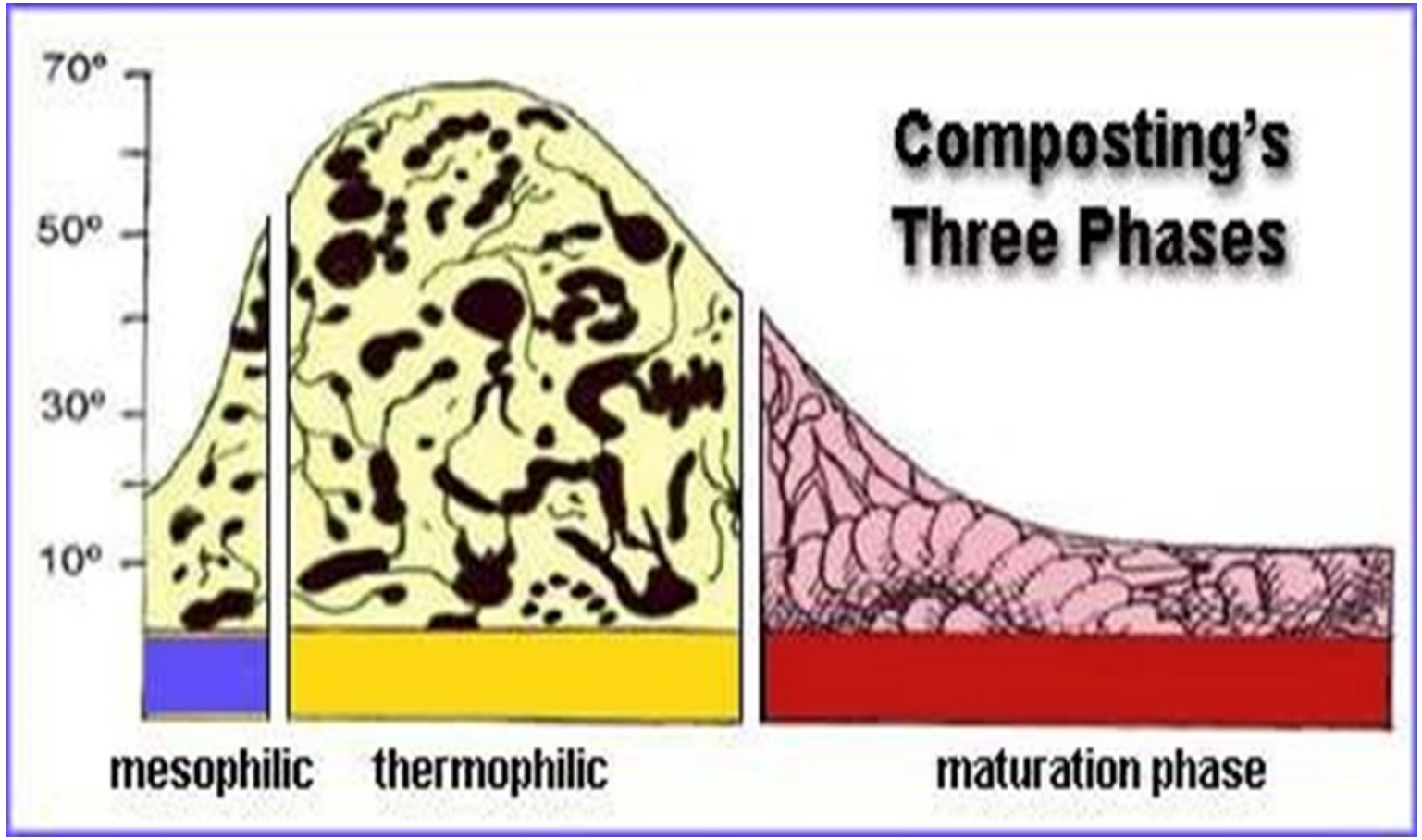
Netherlands East African Dairy Partnership

Composting phases:

1. Mesophilic
2. Thermophilic
3. Maturation

Duration of process:

depends on critical parameters:
normally 1–2 months



Temperature during composting

Netherlands East African Dairy Partnership

Temperature is a good indicator of composting progress: it varies according to the phase of composting

- Starts at ambient temperature
- Temperate rises during mesophilic phase to 65–70ºC (thermophilic phase): killing most of pathogens and weed seeds
- Temperature drops again to ambient temperature at maturation phase
- Temperature should not drop too fast to achieve a higher decomposition rate and hygienization of material (killing of pathogens and weed seeds)

NEADAP
Netherlands East African Dairy Partnership

Ideal requirements and conditions

Critical factors aerobic composting process (1)

Netherlands East African Dairy Partnership

1. Oxygen (ideal content 5–15% in the heap or pile):

- Needed for growth of aerobic micro-organisms
- Sufficient oxygen supply achieved by:
  - controlling the particle size, moisture content, pile size and ventilation
  - frequent turning and mixing of the pile to aerate the material

Oxygen	Problems	Indication	Solutions
< 5% (low aeration)	• Low water evaporation • Anaerobic environment	Odours and acidity	• Regular aeration, turning • Ventilation
> 15% (excessive aeration)	• Low temperature (drop) • High loss of moisture • Decomposition process stops	Low temperature	• Adding water or fresh materials • Chopping of the materials

Critical factors aerobic composting process (2)

Netherlands East African Dairy Partnership

2. Moisture content (ideal 40–65% in the pile)

- Moisture supports metabolic activity of the micro-organisms
- If the pile is too dry (moisture content <40%):
  - composting slows down or temperature becomes very high (risk of fire) → add water
- If the pile is too wet (moisture content >65%):
  - anaerobic spots (emission of methane and possibly nitric acid)
  - temperature remains low, composting process slows down → add dry vegetative materials
- Moisture content of good finished compost product: about 30%

Moisture indication: squeeze test

Too wet

Too dry

OK

Critical factors aerobic composting process (3)

Netherlands East African Dairy Partnership

3. Carbon(C)/Nitrogen (N) ratio

- The **C: N** ratio in the pile depends on the type of materials used
- Optimum C/N ratio **at the start is 25:1 to 35:1** and reduces during the composting process
- If **C/N ratio is higher than 35 (low N in pile)** at the start, composting process will be slow due to lack of nitrogen (N)
- If **C/N ratio is lower than 25**, (high N in pile),composting process could be fast, **losses of N (ammonia) can be high**
  Final product C/N quotient will have a C/N ratio **ranging from 10:1 to 15:1**

C/N ratio of different materials for composting

Netherlands East African Dairy Partnership

C:N Ratio of some materials used in composting

High nitrogen level 1:1 – 24:1		Balanced C:N 25:1 – 40:1		High carbon level 41:1 – 1000:1	
Material	C:N	Material	C:N	Material	C:N
Fresh liquid manure	5	Cattle dung manure	25:1	Recently mown grass	43:1
Poultry litter	7:1	Kidney bean leaves	27:1	Tree leaves	47:1
Pig manure	10:1	Crotalaria	27:1	Sugar cane straw	49:1
Kitchen waste	14:1	Coffee pulp	29:1	Fresh urban garbage	61:1
Poultry litter with pen bedding	18:1	Cow dung	32:1	Rice husk	66:1
		Banana leaves	32:1	Rice straw	77:1
		Vegetable wastes	37:1	Dry grass (grasses)	81:1
		Coffee leaves	38:1	Bagasse	104:1
		Pruning	44:1	Corn cob	117:1
				Corn straw	312:1
				Sawdust	638:1

Source: Adapted from UNDP-INFAT (2002)

Parameters different phases of aerobic composting

Netherlands East African Dairy Partnership

Compost parameters

Parameter	Ideal range at the beginning (2-5 days)	Ideal range of thermophilic phase II (2-5 weeks)	Ideal range of mature compost (3-6 months)
C:N	25:1 – 35:1	15/20	10:1 – 15:1
Moisture	50% - 60%	45%-55%	30% - 40%
Oxygen concentration	~10%	~10%	~10%
Particle size	<25 cm	~15 cm	<1,6 cm
pH	6,5 – 8,0	6,0-8,5	6,5 – 8,5
Temperature	45 – 60°C	45°C- Ambient temperature	Ambient temperature
Density	250-400 kg/m^3	<700 kg/m^3	<700 kg/m^3
Organic matter (Dry base)	50%-70%	>20%	>20%
Total Nitrogen (Dry base)	2,5-3%	1-2%	~1%

Anaerobic composting

Netherlands East African Dairy Partnership

Process:

- Occurs in absence or limited supply of oxygen
- Anaerobic micro-organisms dominate
- Little work involved (no turning required)
- Loss of nutrients relatively low

Limitations:

- Emissions of methane and nitrous oxide (strong GHGs), organic acids, etc.
- Production of organic acids: some with strong odours (butyric acid) and some are phytotoxic
- It is a low-temperature process, which leaves weed seeds and pathogens intact
- The process usually takes a long time (up to 8 months)

NEADAP
Netherlands East African Dairy Partnership

Composting in practice

Composting methods (1)

Netherlands East African Dairy Partnership

1. Heap or pile composting: aerobic composting process

- Suitable for areas with higher rainfall
- Ventilation (oxygen supply) by regular turning of the pile: inside out and outside in
- Temperature is a good indicator for progress of the process
- Permeable cover is needed to protect from rain (control of moisture content)

Types of inputs used for composting (1)

Netherlands East African Dairy Partnership

Organic materials commonly used for compost making are:

- Manure, bioslurry (effluent)
- Young twigs (branches of trees), cut into small pieces
- High carbon materials: dry vegetative materials such as crop residues (stovers), seed husks, stems of Napier grass, dead leaves, dry grass, feed residues
- High nitrogen-rich material – includes green vegetative materials: green weeds, young grass, legumes, hedge cuttings (e.g. tithonia [*Tithonia diversifolia*]), kitchen waste (food leftovers), fruit and vegetable peelings, etc.

Types of inputs used for composting (2)

Netherlands East African Dairy Partnership

Other materials that can be added:

- **Top soil or soil from forest:** adds useful micro-organisms
- **Ash:** provides minerals such as potash, phosphorous, calcium and magnesium. It also reduces the pH.
- N.B.: Effect of **commercial additives/starters** (micro-organisms) is doubtful

Tasks to be performed during composting

Netherlands East African Dairy Partnership

- Selection and levelling of the area for the compost piles:
  - At a safe distance from water sources (over 50 metres) to avoid contamination
  - Protected against strong winds
  - With a slight gradient (to prevent run-off and erosion)
- Collection, chopping and piling of (dry) vegetative materials: small pieces
- Regular turning of the pile (to start after one week: inside out and outside in)
- Monitoring of composting process (temperature, moisture content)

Heap or pile composting: points of attention

Netherlands East African Dairy Partnership

C/N quotient of materials used:

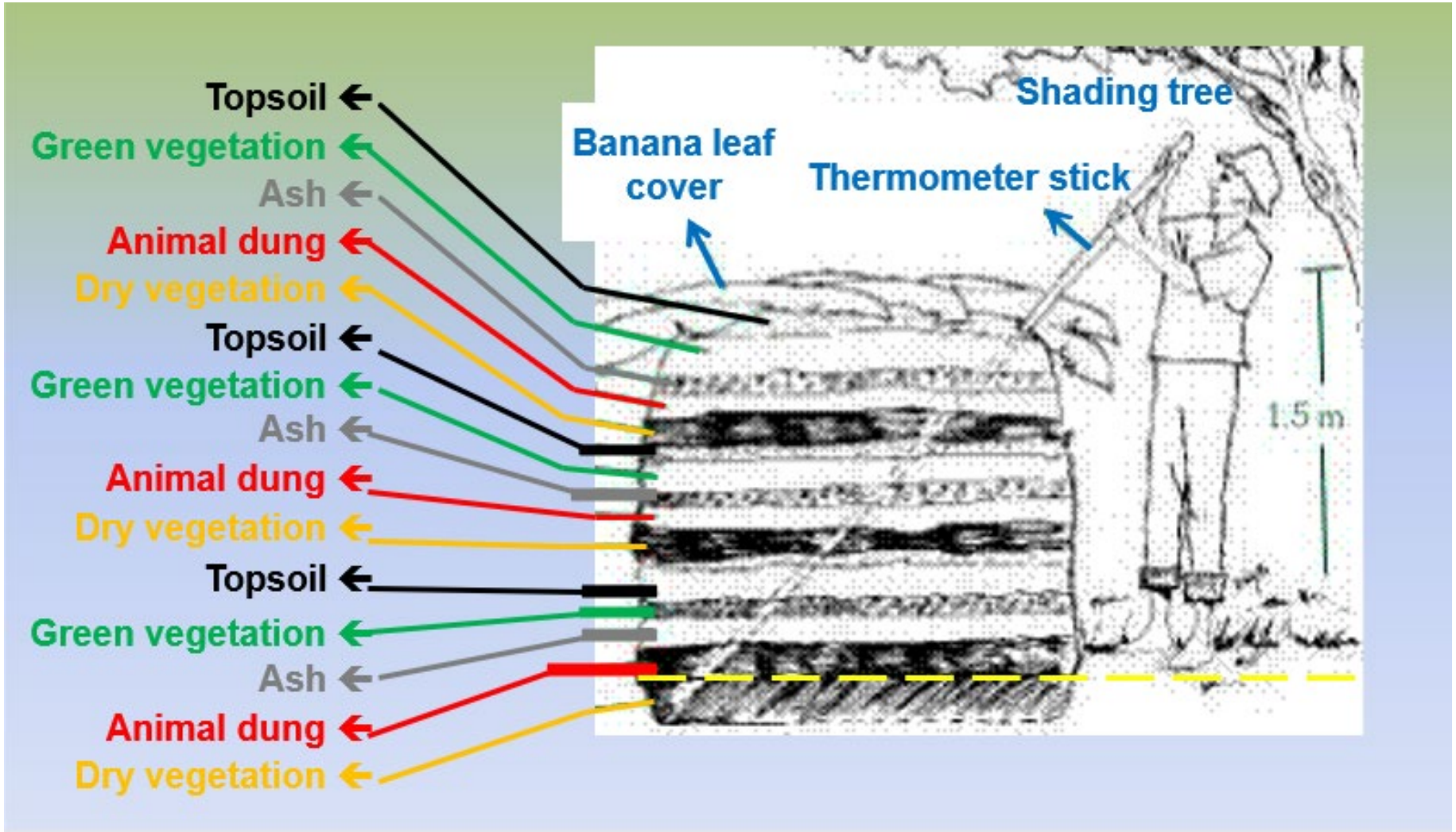
- Pile at the start C/N quotient between 25:1 and 35:1)
  - Cattle slurry or dung: cattle slurry: lower C/N ratio than (dried) cattle dung
  - Dry dead vegetative materials and crop: high C/N ratio
  - Legumes, young grass, tree leaves: low C/N ratio

- **Moisture content of the pile: not less than 55% at the start**

- **Aeration of the heap:** vegetative materials to be chopped but not too fine

Heap or pile method: preparing the pile

Netherlands East African Dairy Partnership



Composting methods (2)

Netherlands East African Dairy Partnership

Pit method: mainly semi-anaerobic composting process

- Very suitable for composting of bioslurry (bioslurry flows into the pit)
- Layers of manure and other (organic) materials put into a pit
- Not suitable for wet areas as the compost may become waterlogged
- Turning/ventilation of the pile is more difficult and results in longer process time
- Emissions of methane and nitrous oxide (GHG) can be high

Bioslurry pit compost making

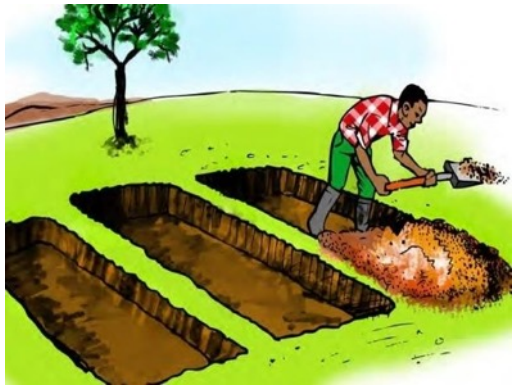
Netherlands East African Dairy Partnership

- Dig at least 3 pits (depth about 1 m; length and width depend on amount of bioslurry)
- Prepare the pits at a location where bioslurry can flow directly into pit 1
- Collect small amount of composting material every day (bio slurry to flow into pit 1 and dry materials added regularly (thick layer at the bottom of the pit)
- Once pit 1 is full: cover and let it stayfor one month to decompose; pit 2 to be filled in the meantime
- Empty pit 1 at the end of the second month and put in pit 3 to decompose for another month; this process should be repeated in pit 4 if compost is not ready; pit 1 can be filled again, etc.

Pit method (sandwich or lasagna method)

Netherlands East African Dairy Partnership

1



1.2 m (4 feet) wide
and 0.6 m (2 feet) deep

2

Collect organic materials

3

Cut plants to finger size

- Group composting materials into three categories:
  a. Mixed dry and green matter – grass, straw, leaves, etc.
  b. Wet starter – fresh dung, bioslurry, water, urine, etc.
  c. Ash, top soil, etc.
- Fill the pit by layering repeatedly →
  a (thick layer at the bottom) → b → c → a → b → c → etc.

Illustrations: source ILRI

Composting of bioslurry: pit method

Netherlands East African Dairy Partnership

NEADAP
Netherlands East African Dairy Partnership

Summary: Practical aspects of composting

- Check availability of recommended tools:
  - pitchfork, shovel/spade
  - watering can
  - wheelbarrow
  - sharp, pointed stick 2–3 m long (thermometer):
    to check heat development and water requirements
- Climatic conditions of the area
- Availability of organic materials
- Area for the compost piles/pits