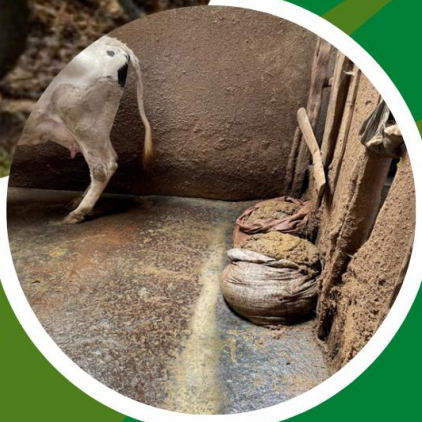
Theme 1: Climate-smart agricultural practices

MANURE MANAGEMENT



A publication sponsored by the ICSIAPL project

What the farmer will learn?

- What is manure?
- What manure consists of?
- Factors affecting manure quality
- Methods of storing manure
  - Aerobic decomposition - Compost making
  - Anaerobic fermentation- Biogas/biodigester
- Manure and its contribution to greenhouse gas emission.

What is manure?

Manure is produced by livestock and can be used and recycled in many ways.

Manure is composed of animal dung (solid part) and urine (liquid part). It may also contain bedding material, water or feed waste.

Animals utilize minerals like nitrogen, phosphorus and potassium from feeds in different ways and these minerals, if not utilized by the animal will end up in manure.

The nitrogen, phosphorus and potassium nutrients found in manure can, fertilize soils, be a source of nutrients for plants but in excess are potential pollutants of water and soil.

Mineral content of manure

Cow manure contains approximately:

- 12.7% Dry matter
- NPK* as % of dry matter
  - ✓ 3.9% N
  - ✓ 0.7% P
  - ✓ 2.6% K

* *N=Nitrogen; P=Phosphorus; K=Potassium*

Manure use

It can be used as organic fertilizer.

Manure is an energy source (biogas (CH4) or direct fuel).

It is used as a construction material.

Manure production

The amount and consistency of manure varies with animal type, climate, feed ration, age, health and other factors.

Manure production and its characteristics change over time. Because animals when they grow, get larger and produce more manure.

Manure produced by livestock categories

Bulls – 42 kgs/day

Beef animals – 37 kg/day

Steers – 26 kg/day

Heifers – 24 kg/day

Calves – 12 kgs/day

Dairy cows – 50-62 kg/day (10% of the average weight of cows)

SOURCE: Statistics Canada, 2006, A Geographical Profile Production in Canada, 2002, Catalogue no. 21-601-M, (accesses October 19,2008).

Factors affecting manure quality

Bedding:

Depending on material used as bedding nutrient content and availability can be better or worse, for example crop-based beddings have nutrients too and can soak in urine**.**

Handling

Timing related to manure handling and storage, that is how often (hourly, daily or weekly) is manure collected relates to how exposed manure is to the environment.

Storage:

Dilution by rain water especially where cows are not kept in a roofed barn.

Manure that is left on bare ground will leach nutrients into the soil when it rains.

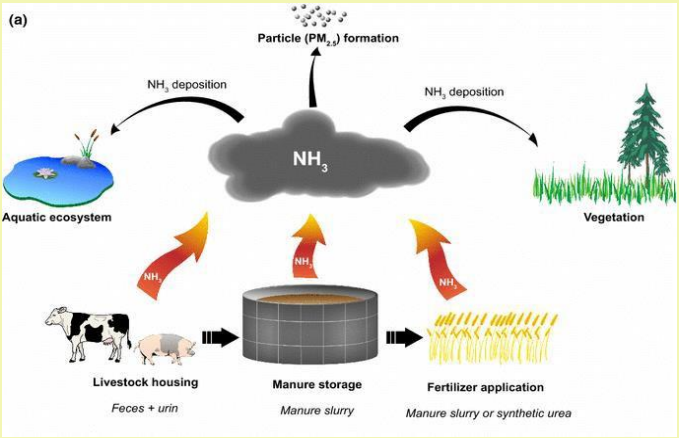
Covering:

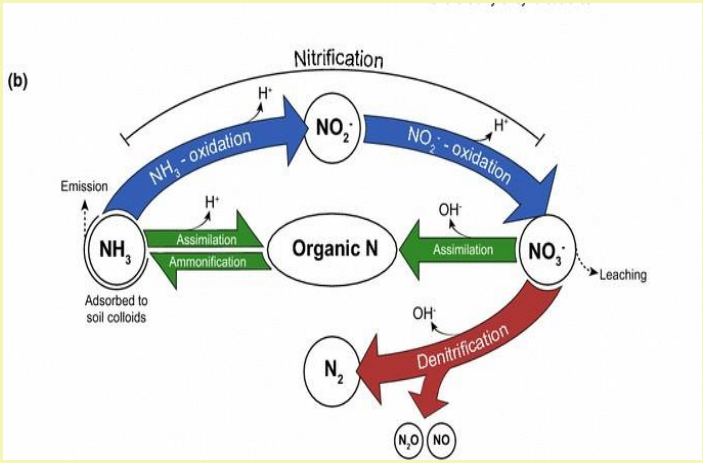
Whether manure is covered or exposed to rain and wind, affects the nutrient content because uncovered manure will allow nitrogen in the form of ammonia to get lost to the atmosphere.

Field application method:

Broadcasting manure without incorporating in the soil leads to a higher nitrogen loss in the form of ammonia.

For small quantities of manure farmers can collect and apply manure every two days or store for longer period if it is not needed or can not be applied in the field. Storage may also be needed due to high production, more animals in comparison to the land available to apply it on. Storage will reduce loss of nitrogen (See image on the right)





Note: NH3 = Ammonia

Weather:

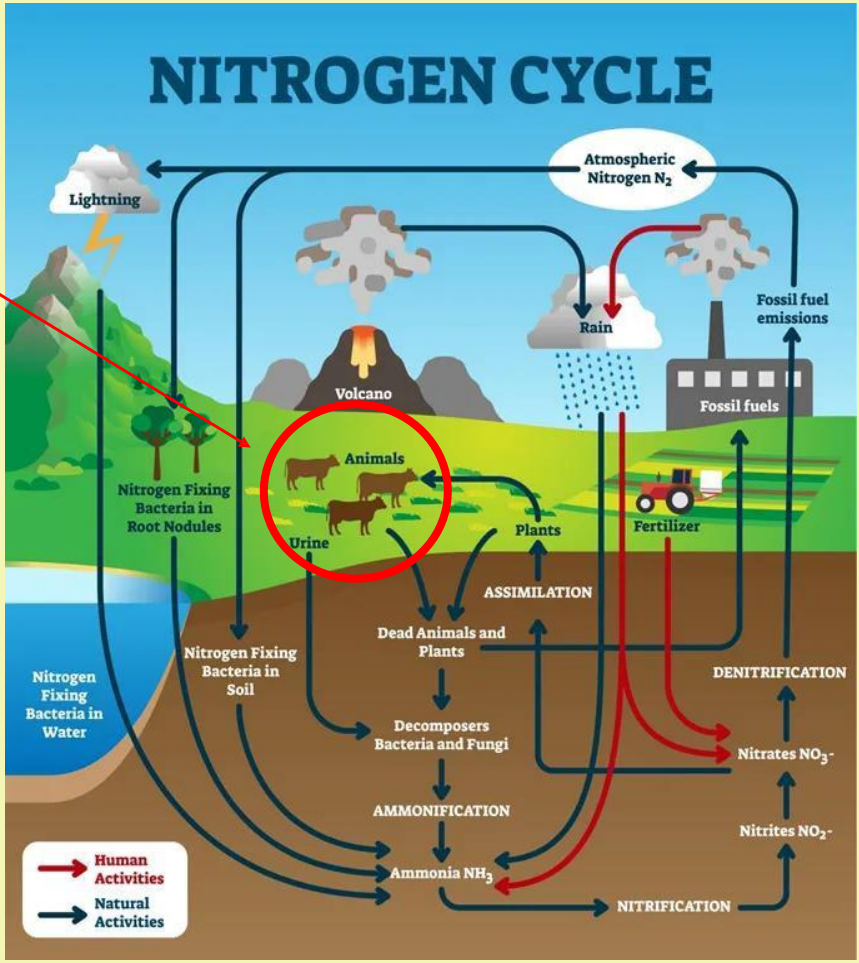
cool temperatures slow down the mineralization (see image on the right) process.

Soil condition:

Too moist or too dry ization process. soils also slow down the mineral

Manure, in the "larger" nitrogen cycle

In the image on the right, in the red circle the role livestock plays in the nitrogen cycle is depicted.



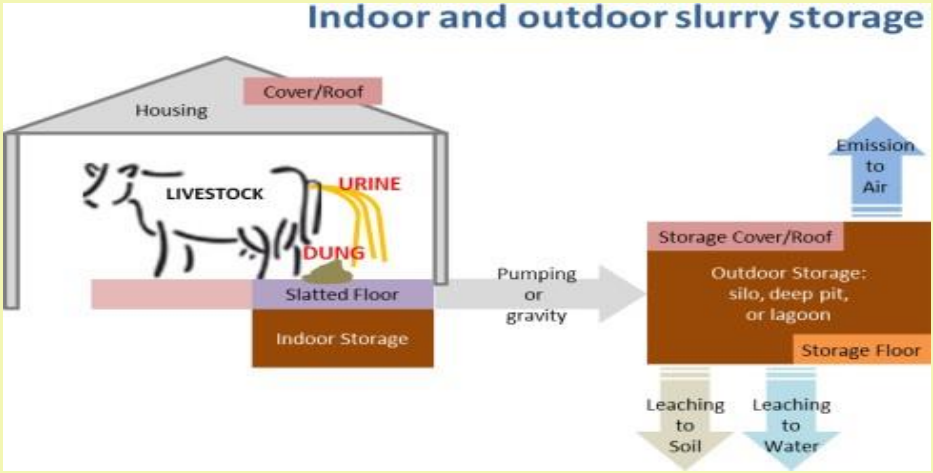
Manure, soil & water pollution

Common causes of water & soil pollution include:

- Careless manure disposal
- Poor & unregulated excessive manure/fertilizer application.
- Poor farming practices.

Polluting water and soil have a counteractive effect on farming practices as we depend on them for production activities.

Water & soil pollution puts at risk your food and health safetyas well as disrupting farming related activities.



Source: https://edepot.wur.nl/362491

Manure storage in farms

Farming system influence manure management method. These systems can either be extensive, semi-intensive and intensive systems.

Farmers can either decide to spread/apply manure on daily basis, store it or alternate between the methods.

Proper storage of manure ensures that manure is protected against influence from;

- sunlight
- wind
- water/rain
- leaching into the underground soil/water

How to store manure in the farm?

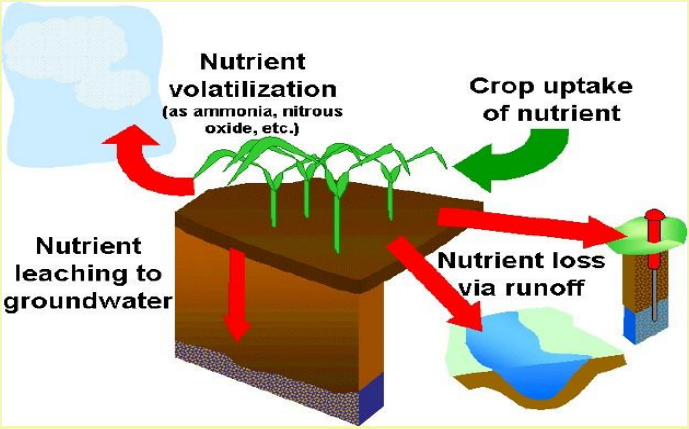
Collect manure and store it in the shade.

Ensure the surface where manure is heaped on is a cemented underground or the ground is covered with a polythene.

This is done to ensure urine is not lost into the ground.

To ensure urine is not lost in the livestock resting area place dry bedding material such as; straw, sawdust or dried manure on the ground to absorb the urine.

If manure is stored in the open cover the manure with banana leaves or a polythene sheet to protect against the sun, rain and wind.



Importance of good manure storage

Proper storage preserves nutrients valuable for the crop until time of application.

Roofed storage prevents volatilization and runoff of nutrients to soil and water due to rainfall (See image on the right)

Cemented flooring further prevents leaching of nutrients into the underground and ground water.

Covering manure in an air-tight storage tank prevents nutrients from volatilization to the air or leaching in the environment.

Manure management in extensive farming systems

Farms with few animals and large land size as well as farmers in pastoral or ranching systems in the arid and semi-arid grazing zones like Taita Taveta, Machakos, Makueni, Kitui, Baringo and Elgeyo Marakwet counties practice extensive grazing.

Livestock is left to graze throughout the day and kept in a boma at night where they are most likely to drop and spread the manure.

Manure management in intensive/confined systems 'zero-grazing'

Livestock in confined (zero grazing) systems compared to other systems deposit more manure in a given area necessitating a proper manure management style.

The dung and urine collection is easy since cows are kept in a particular area which necessitates frequent cleaning and cemented flooring helps when collecting the manure.

However, intensive/confined systems drastically increase labor required for manure collection and application.

Intensive/confined systems requires investment in storage capacity for manure.

On the other hand, manure can easily be directed to an anaerobic biodigesters which can provide clean energy for the farm.

Dung and urine separation and separately stored reduces greenhouse gas emissions of manure storage by around 35%.

Manure management in semi-intensive systems 'semi-zero-grazing'

In farms where semi-zero grazing systems is practised, we may find manure in a confined area e.g. feedlot or in an open space e.g. night boma.

The manure management systems as described in sheet 7 and 8 can be found on farms with semi-zero grazing systems all depending on scale and size of the farms.

A semi-intensive farm can;

1. Evenly spread manure dropped by livestock in pastures.
2. Collect manure in a cow barn.
3. Store manure before spreading on cropland.
4. Store manure in a biodigester.
5. Sale manure.

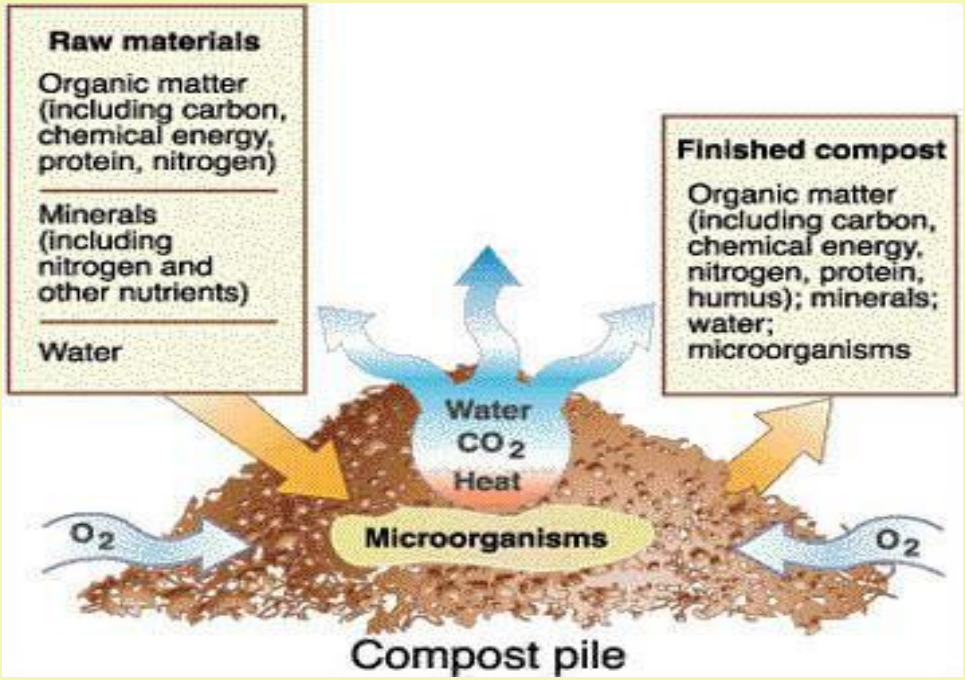
Methods of decomposing manure in farms

The main objectives of treating manure (decomposing);

- reduce the volume of manure.
- increase the value of organic fertilizer.
- improve ease of application.

Decomposition methods are for example:
Aerobic decomposition of manure. This is a natural method that involves storing manure in the open air e.g. compost making

Anaerobic decomposition of manure. This is a method of storing manure in an anaerobic environment (place with no air) e.g. a biodigester.



Aerobic decomposition "composting"

Aerobic processes are most common in nature.

Manure exposed to the air is exposed to aerobic microorganisms that breakdown organic matter because microorganisms are everywhere in the air around us.

The products obtained from aerobic decomposition are; carbon dioxide, ammonia, water, heat and humus.

There is no accompanying bad smell when there is adequate oxygen present during decomposition.

During aerobic decomposition carbon is converted to carbon dioxide and the process produces heat which increases the temperature of the compost pile.

Benefits of aerobic manure management

Reduced odour/smell around the farm.

Final output of aerobically decomposed manure, when mixed with soil, is readily available for the plants. Nitrogen from this process is stable compared to the slurry in anaerobically decomposed manure which is unstable and prone to leaching.

Reduces greenhouse gas emission especially methane compared to anaerobic decomposition.

Oxidation of ammonia to nitrate through nitrification leads to reduced ammonia emissions.

Separated manure solids encourages aerobic environments, eliminating anaerobic conditions necessary for methane production.

Ingredients for compost making

Animal waste **-** i.e. cow dung and dropping of other farm animals (rich in nitrogen).

Planting materials - all plant materials including weeds and grasses can be used.

- Dry (brown) plant material e.g. crop residues, sawdust or dried herbage. This material is high in carbon.
- Wet (green) plant material e.g. kitchen wastes, vegetable leftovers-, grass clippings. This material is high in nitrogen

Water- this is needed to keep the compost pile moist. Urine can also be a source of moisture. The moisture helps to keep decomposition process going without causing anaerobic conditions.

Air- the oxygen in air is needed to oxidize (burn) the carbon.

Source: https://hdl.handle.net/10568/113673

Making compost manure

Select site for the pit and clear the ground around, best if near the farm.

Area should have good drainage to avoid water logging.

Dig a pit I meter deep, height should not be to high to avoid materials being compressed by its weight.

Place organic material in layers with most fibrous plants at the bottom to facilitate drainage.

Compost pits for large farms

Designing an open compost windrow

Mostly used for production in large volumes by medium or large scale farms.

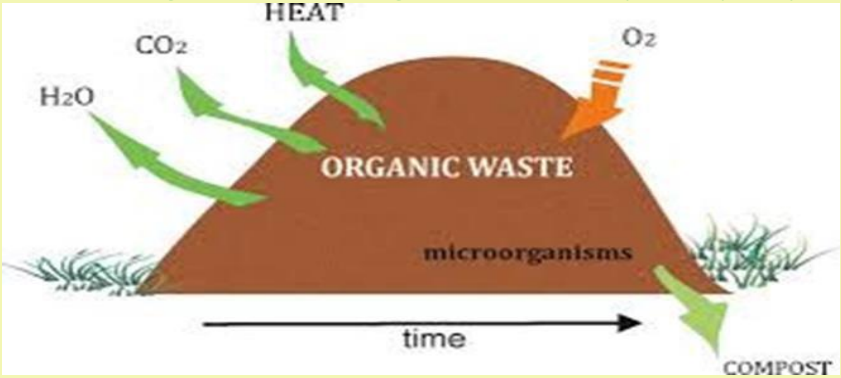
The raw materials needs to be shredded to a similar average size.

Mix all raw materials and manure on the ground.

Pile and mix the organic raw material and biodegradable waste (manure and animal droppings) in rows.

Windrows are turned regularly for air distribution within the compost pile.

Handling and storage of a compost pit/pile



Aerobic compost piles should be loosely stacked to allow space for flow of air.

Note that in compost pits free flow of air is often limited.

Avoid making the pile too low as heat will be lost fast affecting decomposition.

Small piles loose moisture excessively.

Size of the pile/windrow can be adjusted to fit climatic conditions of the region:

- Cold weather- size can be increased to offer higher internal temperatures of the pile.
- Hot weather- size can be reduced to reduce internal temperature of the pile being too high.

Balancing factors inside the pit

Excess water: causes bad smell as a result of materials rotting in the pit.
Correction: Turn to loosen and aerate it and add dry material as you turn

Excess air and limited water: material in the pit dries up and does not decompose to be compost/humus.
Correction**:** Add water to the pit (see image top right)

Excess water and inadequate air: Nitrogen is converted into ammonia making the pit to smell.

Correction: Add dry plant material and turn materials in the pit

Balanced moisture: Rate of decomposition in the pit is best facilitated.
No correction required

Continue to turn materials in the pit for aeration purposes and use a long stick to monitor temperature (see image of a thermometer on the right)

Carbon, Nitrogen ratio (C:N) in the compost pile

Table 2. Average Carbon: Nitrogen Ratios		
Food scraps	15:1	Green
Grass clippings	19:1	
Coffee grounds	20:1	
Rotted manure	25:1	
	30:1	Ideal
Corn stalks	60:1	Brown
Leaves	40-80:1	
Straw	80:1	
Paper	170:1	
Sawdust, wood chips	500:1	
Actual content may vary.		

The C/N ratio needs to be balanced such that more carbon than Nitrogen is required for the decomposition process.

It is desirable to keep the C/N ratio at 30 (30:1) when composting animal waste (dung, urine and animal droppings).

Decomposition of organic matter is facilitated by living organisms (microorganisms, worms, insects) that use carbon as source of energy and Nitrogen for building their cell structure.

Excess carbon: (C:N ratio far above 30:1) causes decomposition to slow down when the available nitrogen is used, and the amount of nitrogen reduces with the result that some organisms die.

Excess nitrogen: (C:N ration below 15:1) causes overheating and nitrogen is converted to ammonia resulting in the release of a bad smell from the pile.

Phases of composting process

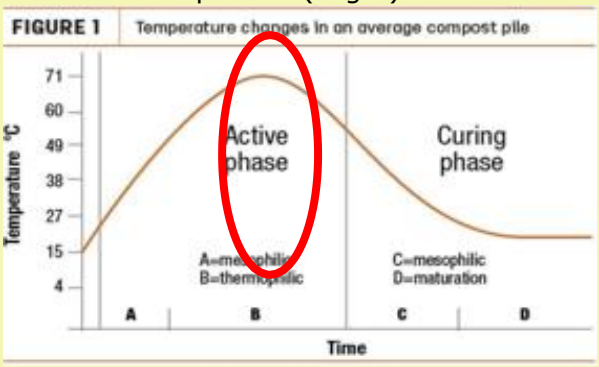
A. Mesophilic phase

Process lasts for 2-8 days.

Temperature rises above 40°C due to metabolic activities.

Mesophilic microorganisms break down the readily available solid compounds to utilize the N and C in the organic matter

Ph drops to around 4.3 due to decomposition of soluble compounds (sugar).



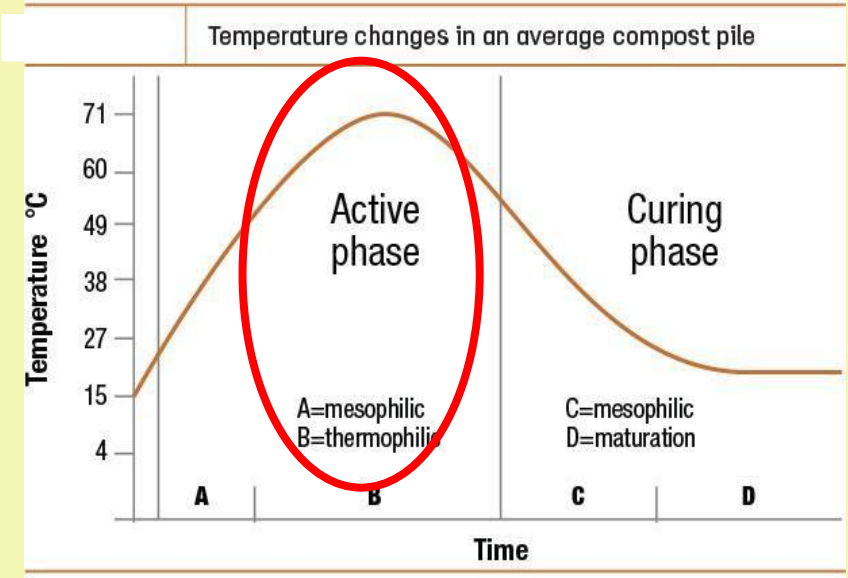
B. Thermophilic phase

Temperature rise above 45°C and introduces thermophilic microorganisms.

Complex organic matter (cellulose & lignin) carbohydrates, fats and proteins are also broken down by the microorganisms.

High temperature above 55°C facilitates destruction of plant and human pathogens i.e. weed seeds are destroyed here and any form of disease causing pathogens.

Ph rises as a result of nitrogen conversion to ammonia.



Phases of composting process

C. Mesophilic phase II (Cooling)

Takes some few weeks before the last stage of maturation depending on type of heap, material used and climate.

Temperature drop to about 40-45°C introduces mesophilic organisms that proceed with their activities under this favourable conditions.

This microorganism convert organic components into humus.

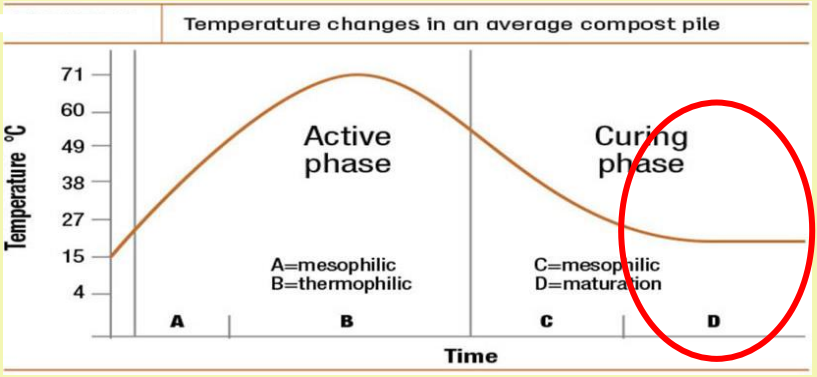
Ph slightly drops

D. Maturation phase

Temperature drops to below 30 °C.

Compost is ready after this last stage for use.

This stage can easily be confused by the Mesophilic phase II



Benefits of compost manure

Source of nutrients to plants (see image on the right).

Improves the soil organic matter.

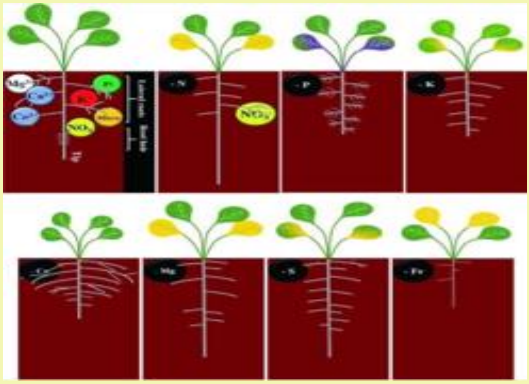
Improves the soil structure when used.

Humus improves moisture holding capacity of soil.

Reduces the effect of soil erosion.

Improves conditions for microbial life in the soil.

Controls spread of pest & diseases as well as weeds, due to high temperatures in the pile.



Signs of compost manure ready for application

Volume of the manure has reduced.

Manure feels lighter in weight and crumbly when felt between fingers.

Moisture content of manure is lower, not damp or wet.

Change in smell from rotting smell to an earthy-like smell.

Dark in colour.

Commonly used compost making methods

Ring – hole method

Commonly used by farmers growing perennial crops like banana plantations and involves creating holes that are ring-like around banana plants.

Nutrient rich waste and livestock manure are dumped in the hole.

Soil is added on top of the waste/manure and left there as compost to restore nutrients and moisture of soil at site damped.

In-Situ method

Mulching is a form of in-situ composting method.
Involves placing nutrient rich waste (food waste, livestock manure) are left on the surface to decompose in open air.
This restores soil nutrients and soil moisture.

Pit composting method (tumbukiza)

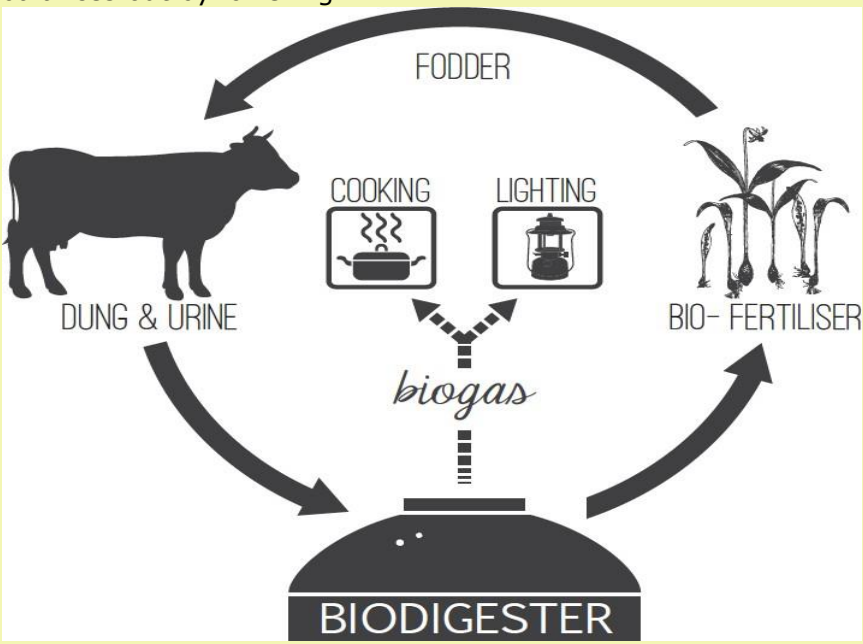
Common method known by farmers that involves collecting waste/manure in pits.
This pits contain nutrient-rich materials used bymicrobes and worms.
Improves soil nutrients availability at site/area placed after maturity.

Anaerobic decomposition: Biodigester

Biodigester makes use of organic waste ' manure' to produce biogas (energy source) and bio-slurry, the leftover product which can be used as a fertilizer.

Manure is directed into the biodigester where microorganisms in the manure are ingested and methane is produced and rises to the top of the tank leaving the (digestate) bio-slurry at the bottom.

Methane gas produced is directed to a piped system, as gas gets produced the pressure inside the digester pushes the manure slurry out through the outlet and as the gas gets used the slurry level balances out by lowering.



The biodigester has to be fed with fresh manure every day.

Biogas is directly burned for heating application or captured and combusted to generate electricity in dairy farms.

The effluent leaving the digestor (digestate) has a modified chemical content and has less degradable biomass than the original substrate (manure slurry).

The gas produced in biogas digestors has to be used (burned) otherwise if released to the environment it still posses the same threat as the original manure by releasing the greenhouse gas methane (CH_4) to the environment.

Types of Biodigesters in Kenya

The three common biodigesters are;

1. Fixed dome
2. Floating drum
3. Balloon-type

Fixed dome

The fixed dome design of biogas is common to Kenyan households.
Requires skilled artisans during construction .

Relatively expensive

Floating drum

ThKenyan farms
Requires skilled artisans during construction.
Relatively expensive
e floating drum design as seen in some

Balloon type

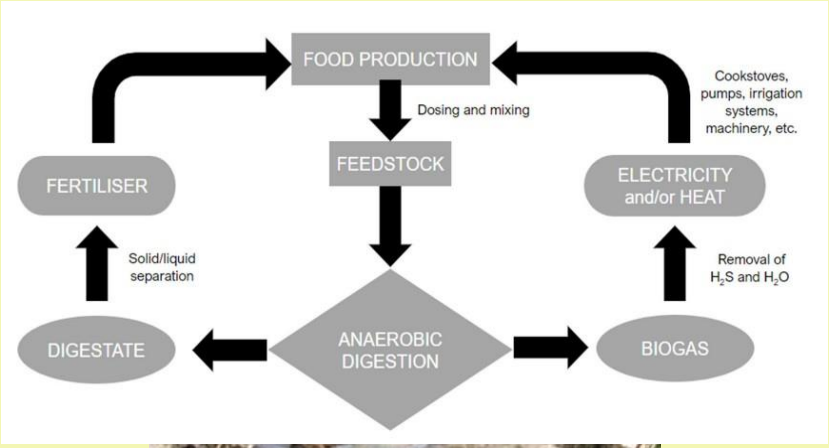
Fairly simple to install.
Relatively inexpensive

Benefits & disadvantage of biogas (anaerobic decomposition)

During the anaerobic decomposition of organic matter methane is released while ammonia is produced through manure organic decomposition or urea hydrolysis.

Final product (digestate/residue slurry) is high in ammonium due to the fermentation process that transforms organic Nitrogen to ammonium.

Ammonium remains high in the residue slurry/digestate due to the depressed nitrification.



Anaerobic composting requires less work but this is debated because the biogas slurry has to be applied to the crops in the field while on the other side the biogas digester requires regular maintenance.

The process however, produces more usable humus per volume of original composting ingredient compared to aerobic decomposition method.

Advantage of manure/waste re-cycling

Cheap source of nutrients to plants.

Reduced accumulation of manure/waste

Utilization of different resources in combination with manure through recycling to create a more stable form of the organic fertilizer as a product.

Improves soil fertility when it is mixed with or decomposed in soil.

Offers alternative and clean source of energy e.g. biogas next to the digestate which can still be used as an organic fertilizer..

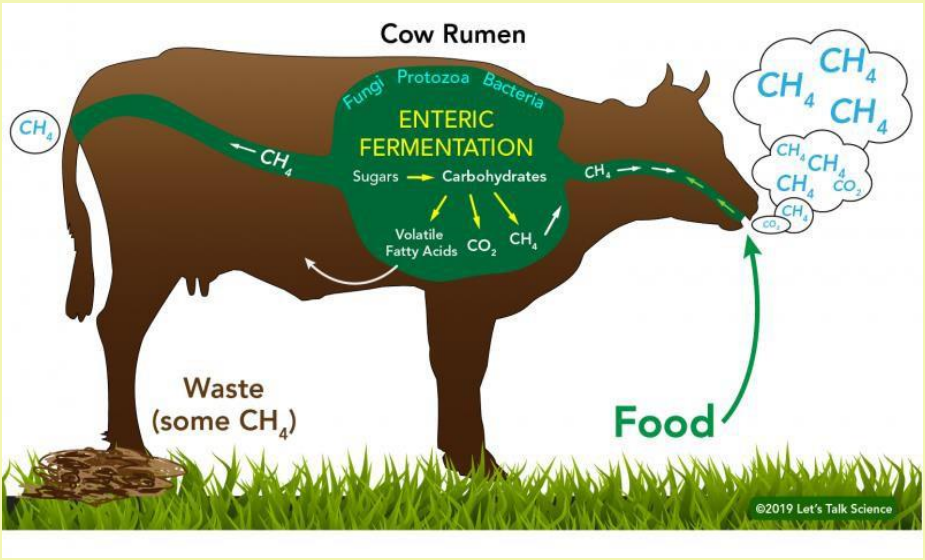
Methane emitted by the cow

Enteric methane production

Enteric fermentation is part of the digestive process in ruminants (cows).
It is where microbes in the digestive tract or rumen decompose and ferment food.
In this process to release pressure caused when methane is produced as a by-product, the animal burps it out.

Methane from manure

However about 5% of methane also comes out of the other end (below the tail).



5% 95%

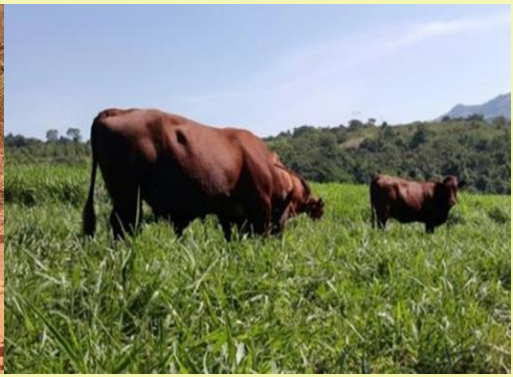
Manure management practices in relation to global warming

Global warming is caused by human activities burning up fossils' fuels

This leads to rise of global temperatures due to increase in the concentration of greenhouse gases (CO_2 and other air pollutants) in the atmosphere.

Products of fermentation greatly contributes to CO_2 emissions. Methane expulsion by livestock as a result of fermentation in the gut contribute to the total greenhouse gases.

Beef animals produce more CO_2 as compared to dairy animals due to the quality of the ration they are fed on.



Reduction of greenhouse gas emmision through improved management practices

Better feeding & feed production.
Feed cows based on nutritional requirement to avoid wastage and improve usage.

Feed cows with quality feed, as it improves feed efficiency while reducing enteric methane emission intensity.

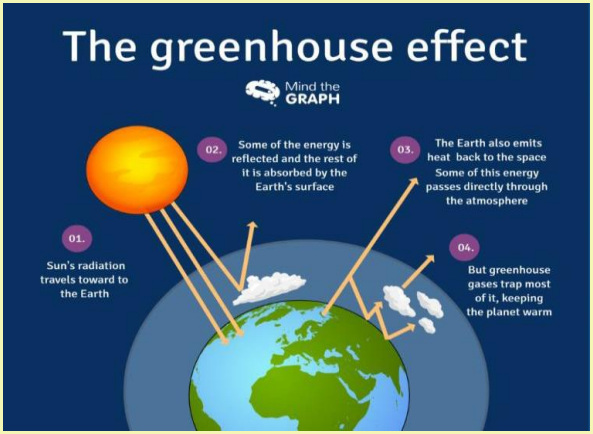
Include additives (e.g. tannins in leaf meal of agroforestry tress) in the ration to supress enteric methane production in the rumen.

Source: https://extension.psu.edu/urea-in-beef-cattle-rations

Greenhouse gases

Greenhouse gas refers to any gas that has the ability to absorb/trap infrared radiation (net heat energy) produced from Earth's surface and reradiating it back to Earth's surface (See image to the right). Thereby, contributing to the greenhouse gas effect.

Greenhouse gases that are important in agricultural production are: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O).



Improved breeding, Increase production by keeping the herd healthy and breeding practices. When cows are high producing the amount of methane per litre is reduced.

Manure & housing management are able to manage manure produced in the farm e.g.

- Compost making
- Implement covered manure storage covers and/or anaerobic digesters (biogas).

Include additives in manure to suppress unwanted biological activity.

Ministry of Foreign Affairs of the Netherlands

About the ICSIAPL Project

The Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes in Kenya's Arid and Semi-arid Lands is (ICSIAPL) is athree-year (2021 –2023) project funded by the European Union (EU) and the Ministry of Foreign Affairs of the Kingdom of the Netherlands (DGIS). It is managed through a delegated cooperation with the Embassy of the Kingdom of the Netherlands (EKN) in Nairobi.

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KALRO
Kenya Agricultural & Livestock Research Organization

SNV