INTEGRATED CROP-LIVESTOCK-GOBAR GAS PRODUCTION

LPM-610 (Unit-II)

LECTURE-3

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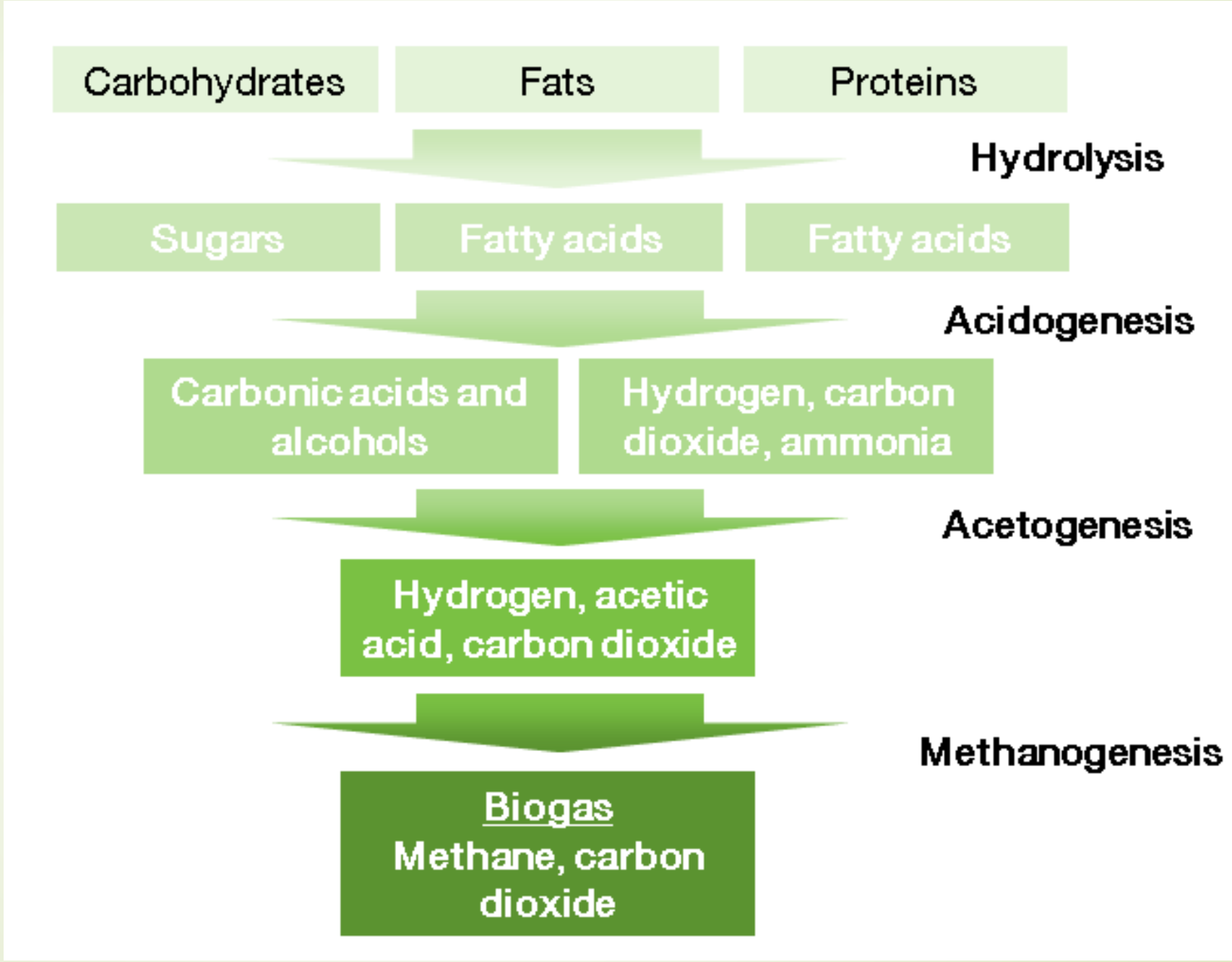
PROCESS of Biogas Production

- Biogas is a renewable gas produced by anaerobic microorganisms which feed on organic materials and producing biogas as metabolic waste products.
- Biogas creation is also called **Biomethanation**.
- Biologically derived gases are produced as metabolic products of two groups of microorganisms called bacteria and *Archaea*.
- These microorganisms feed on carbohydrates, fats and proteins, and producing biogas consisting mainly of methane and carbon dioxide through a series of reactions including hydrolysis, acetogenesis, acidogenesis and methanogenesis.


Carbohydrates
Fats
Proteins
Hydrolysis
Sugars
Fatty acids
Fatty acids
Acidogenesis
Carbonic acids and alcohols
Hydrogen, carbon dioxide, ammonia
Acetogenesis
Hydrogen, acetic acid, carbon dioxide
Methanogenesis
Biogas
Methane, carbon dioxide

- Anaerobic digestion occurs at mesophilic (35-45˚C) or thermophilic temperatures (50-60˚C).
- Both types of digestion typically require supplementary sources of heat to reach their optimal temperature.
- Biogas plants treat wastes originating from animal material, will also require the material to be treated at high temperature to eliminate any disease-causing bacteria in the slurry.
- These systems pasteurise the slurry, typically at 90°C for one hour, to destroy pathogens, and result in the provision of clean, high quality fertiliser.
- Biologically derived gases may include contaminants or impurities including water, hydrogen sulphide and siloxanes.

Parameters for biogas process optimization:

- Substrate temperature
- Available nutrients
- Retention time (flow through time)
- PH level
- Nitrogen inhibition and C/N ratio
- Substrate solid content and agitation
- Inhibitory factors

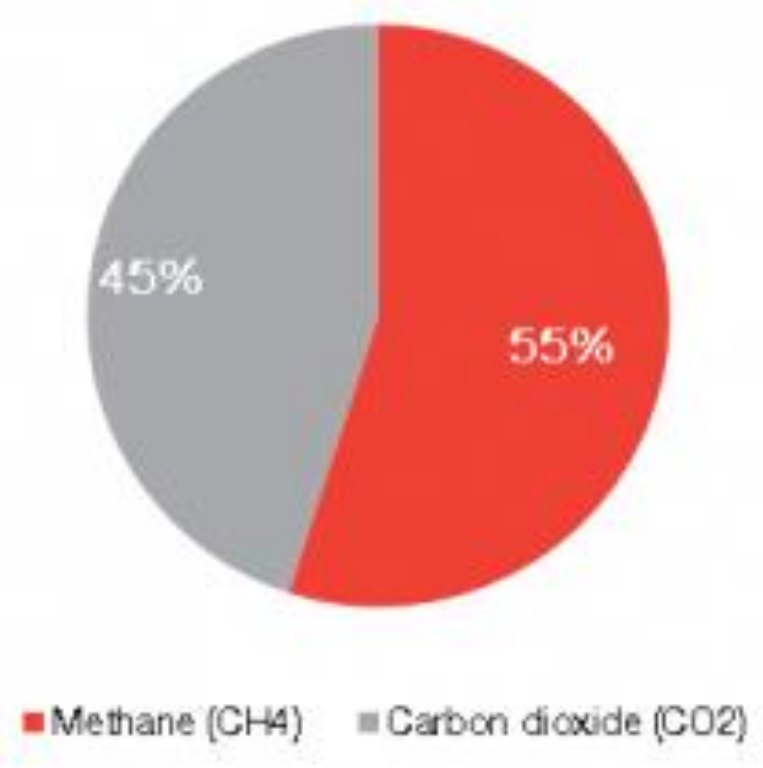
Substrate Temperature

Temperature range of anaerobic fermentation:

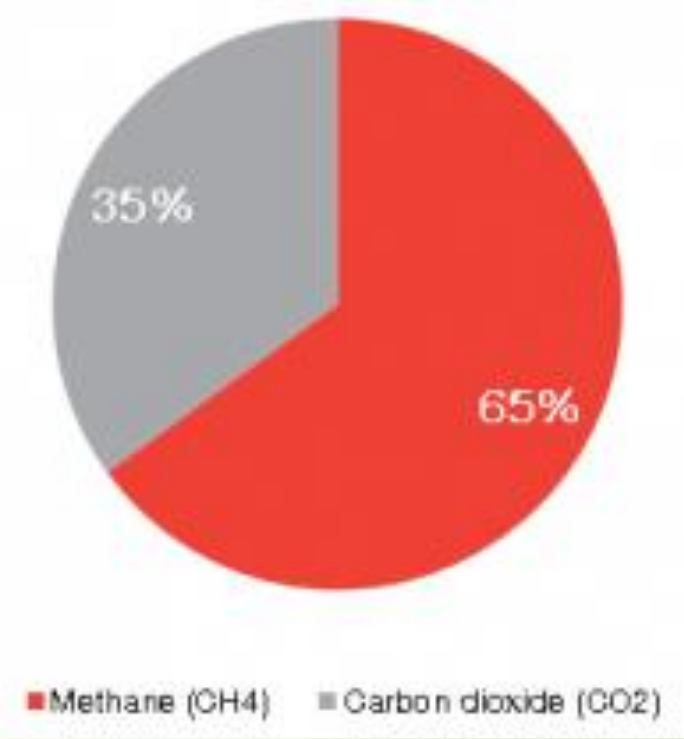
- Anaerobic fermentation is in principle possible between 3°C and approximately 70°C. Differentiation is generally made between three temperature ranges:
  - The *psychrophilic temperature range* lies below 20°C
  - The *mesophilic temperature range* between 20°C and 40°C
  - The *thermophilic temperature range between*40°C and 55 °C
- Ideal temparature20 °C –28°C.
- If the temperature of the bio-mass is below 15°C, gas production will be so low that the biogas plant is no longer economically feasible.

Available Nutrients

- In order to grow, bacteria need more than just a supply of organic substances as a source of carbon and energy.
- Requires an adequate supply of *nitrogen, sulfur, phosphorous, potassium, calcium, magnesium* and a number of trace elements such as *iron, manganese, molybdenum, zinc, cobalt, selenium, tungsten, nickel* etc.
- Normal substrates such as agricultural residues or municipal sewage usually contain adequate amounts of the mentioned elements.
- Higher concentration of any individual substance usually has an inhibitory effect, so that analyses are recommended on a case-to-case basis to determine which amount of which nutrients, if any, still needs to be added.



Agricultural waste digestion



Food waste digestion

Retention Time

- Can only be accurately defined in batch-type facilities.
- For continuous systems, the mean retention time is approximated by dividing the digester volume by the daily influent rate.
- Depending on the vessel geometry, the means of mixing etc., the effective retention time may vary widely for the individual substrate constituents.
- Selection of a suitable retention time thus depends not only on the process temperature, but also on the type of substrate used.

Substrate

- For liquid manure undergoing fermentation in the mesophilic temperature range, the following approximate values apply:
  - Liquid cow manure: 20-30 days
  - Liquid pig manure: 15-25 days
  - Liquid chicken manure: 20-40 days
  - Animal manure mixed with plant material: 50-80 days

pH Value

- The methane-producing bacteria live best under neutral to slightly alkaline conditions.
- Once the process of fermentation has stabilized under anaerobic conditions, the pH will normally take on a value of between 7.0 and 8.5.
- If the pH value drops below 6.2, the medium will have a toxic effect on the methanogenic bacteria.

Nitrogen-content and C/N-ratio of organic substrates

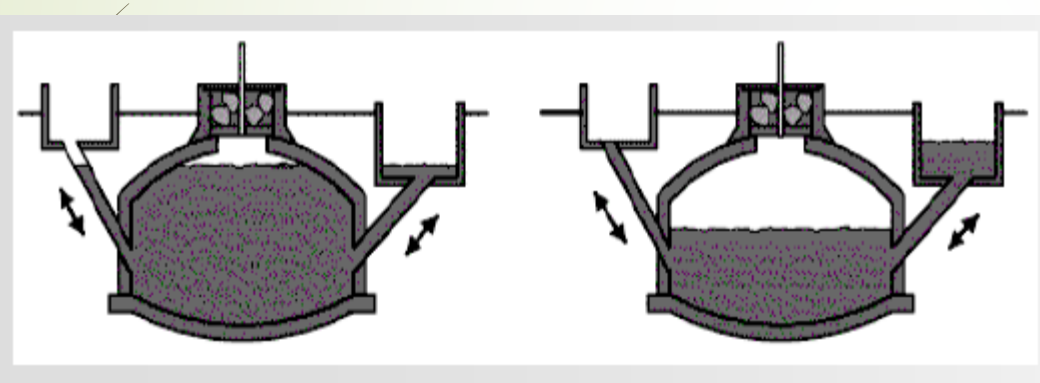
Biodegradable material	N (%)	C/N
Night Soil	6.0	5.9-10
Cow manure	1.7	16.6-25
Pig manure	3.8	6.2-12.5
Chicken dropings	6.3	5-7.1
Hay	4.0	12.5-25
Water hyacinth	2.9	11.4
Kitchen waste	1.9	28.60
Rice straw	0.6	67
Bagasse	0.3	150
Fallen leaves	1.0	50
Sea weed	1.9	79
Sawdust	0.1	200 - 500

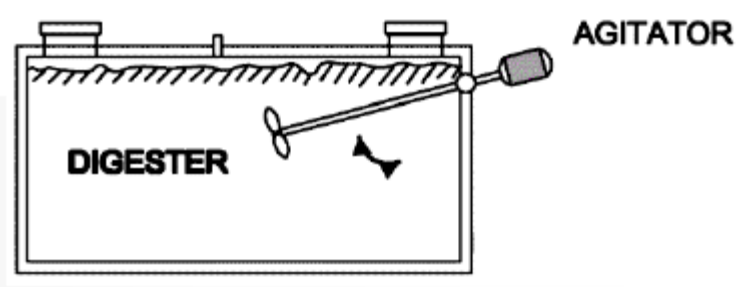
- Metabolic activity of methanogenic bacteria can be optimized at a C/N ratio of approximately 8-20, whereby the optimum point varies from case to case, depending on the nature of the substrate.

- Substrate can be mixed to get the optimum C/N ratio.

Substrate Agitation

- Different ways of homogenizing the substrate or mixing it with water and co-substrate.
- Mixing and homogenizing the substrate in the mixing chamber.
- Agitation inside the digester.
- Poking through the in-and outlet pipes (small scale plants)





Solid Contents

Dry solid matter:

- Substrate after the withdrawal of water.
- For anaerobic digestion, suitable solid waste range : 10-40%

Organic dry solid matter content:

- Organic share of the dry matter exceed 50% in anaerobic digestion.

Structure material:

- Substrate with high content of lignin:
  - Low content : advantageous for AD
  - High : Composting

Toxic substances:

- Hinder digestion process.
- Should be kept low.

Protein content:

- Should not exceed 50%.

Inhibitory Factors

- The presence of heavy metals, antibiotics and detergents used in livestock husbandry can have an inhibitory effect on the process of bio-methanation.

Limit concentrations (mg/l) for various inhibitors

Substance	[mg/l]
Copper	10-250
Calcium	8000
Sodium	8000
Magnesium	3000
Nickel	100-1000
Zinc	350-1000
Chromium	200-2000
Sulfide (as Sulfur)	200
Cyanide	2


THANKS