INTEGRATED CROP-LIVESTOCK-GOBAR GAS PRODUCTION
LPM-610 (Unit-II)

LECTURE-2

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Economic and environmental considerations of integrated biogas production system:

Technology

- Low construction costs
- Simple to operate
- Suitable for climatic conditions
- Low energy demand/ costs for operation/maintenance
- Minimisation of greenhouse gas (GHG) emissions
- High degradation rate
- Low land use
- Low use of chemicals
- Low emissions from digestate

By-products

- Digestate: Use as a low-cost fertilizer to substitute chemical fertilizers
- CHP: Waste heat utilisation
- CO_2: Used in greenhouses

Feedstock

- Use of low cost organic wastes with high energy content
- Low degree of contamination (plastics, chemicals, heavy metals)
- Reliable feed source and available locally
- Avoid GHG emissions (manures, landfill)
- Does not compete with other uses (food/animal feed)

Biogas Utilisation

- Efficient substitution of fossil fuels (firewood, charcoal, coal, diesel)
- CHP: High efficiency and utilisation of waste heat
- Upgrading: Low energy demand and low methane slip

Environmental and Socio-economic Impacts

- Economic viability without financial support
- Community owned (municipality, private initiatives)
- Job creation and security
- Reduction of environmental pollution (odour, GHG emissions and water quality)
- Reduce drudgery (time used to collect firewood in developing countries)
- Improved living conditions particularly in developing countries

Feedstocks:

- Biogas can be produced from most wet biomass and organic waste materials regardless of their composition.

- Feedstocks influence both economic and environmental sustainability of a biogas project depending on the costs for provision of feedstock and the carbon balance of the system including fugitive GHG emissions at the biogas facility.

- Feedstocks like food wastes, may create additional benefits in the form of gate entry fees, disposal costs and avoided methane emissions.

- Feedstocks like energy crops can be costly to produce.

- Use of feedstocks depend on mono-digestion, co-digestion or in centralised or decentralised situations for best economic return, particularly in countries receiving little financial support.

- When considering the overall carbon intensity of the produced biogas, manure have a negative GHG footprint due to the avoidance of fugitive methane emissions in open slurry tanks.

- while cultivation of energy crops cause GHG emissions due to the use of chemical fertilizers and fossil fuels needed for their production.

- Slurry digestion systems have negative carbon intensity and energy crops can benefit greatly in terms of overall carbon sustainability in co-digestion systems.

The most prevalent feedstocks for anaerobic digestion can be categorised into five broad categories:

1. Organic fraction of municipal solid waste
2. Sewage sludge
3. Manure and slurry
4. Energy crops (Maize, cereals, sweet sorghum and sugar beet)
5. Agro-industrial waste streams

Choice of Technology:

- The key requirement is that the technology does not have to be complex and difficult to operate.

The most common technologies fall into two broad categories:

1. Engineered (concrete or steel), heated and continuous stirred tank reactors.
2. Ambient temperature, unmixed covered earthen anaerobic lagoons.

Engineered Continuous Stirred Tank Reactor

Covered Anaerobic Lagoon

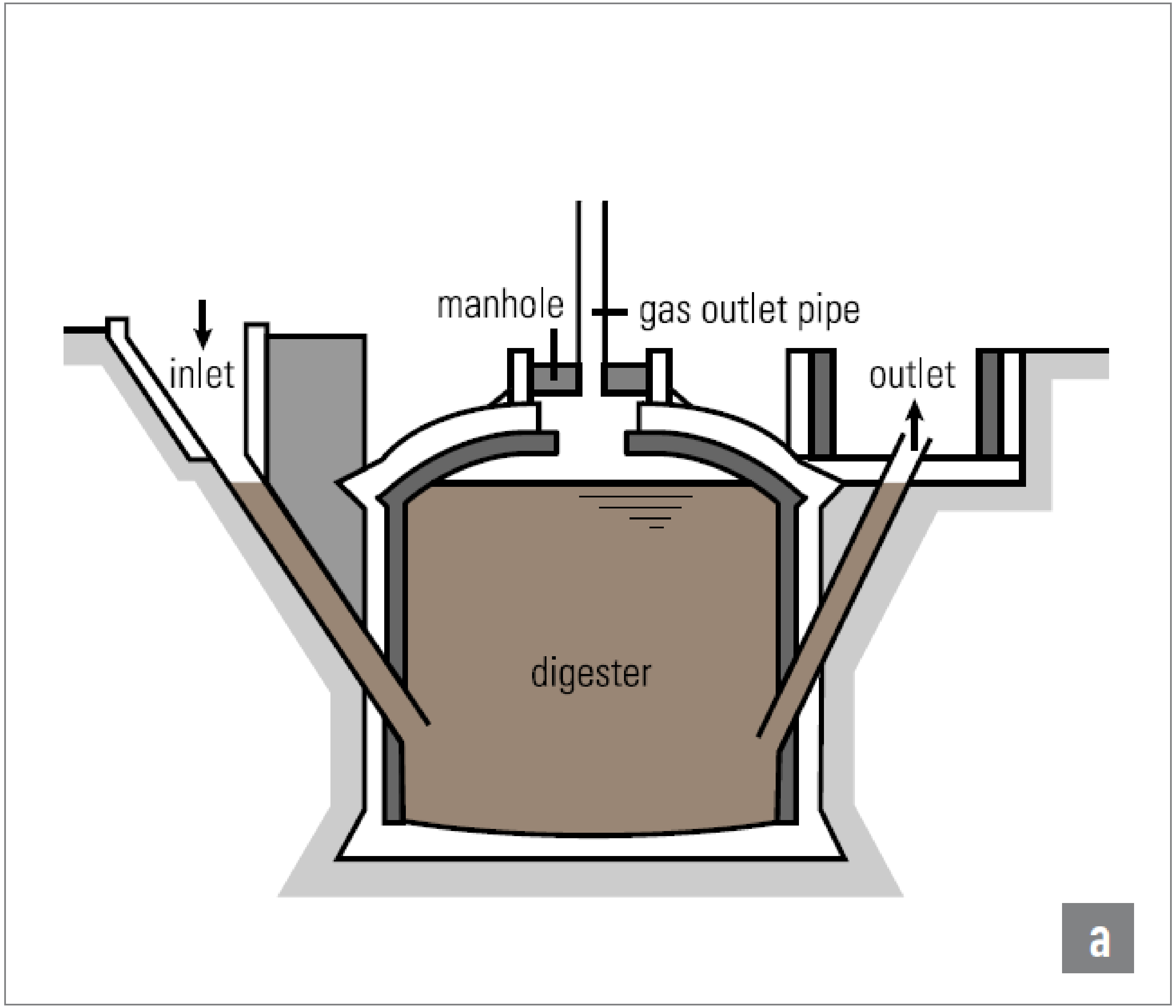
Comparison of continuous stirred tank reactors and covered anaerobic lagoons:

	Continuous stirred tank reactors	Covered anaerobic lagoons
Construction	Concrete or steel tank with insulation, heating, mixing and plastic membrane roof	Earthen lagoon with plastic cover (and plastic liner where required)
Substrate dry matter (DM) concentration	>4%	<5%
Operating temperature	Heated: 35 – 39°C (mesophilic) or 55°C (thermophilic)	Varies with ambient temperature (15 – 35°C)
Advantages	Applicable to a wide range of materials, shorter treatment time, small size, standard designs, applicable for use in all climates.	Lower construction cost using local resources, lower operation and maintenance requirement, no heat demand, tolerant of shock loads, cover also provides biogas storage.
Disadvantages	Higher construction and operation costs including heat demand, requires skilled operation.	Large size, suitable only for liquid organic materials and temperate to warm climates.

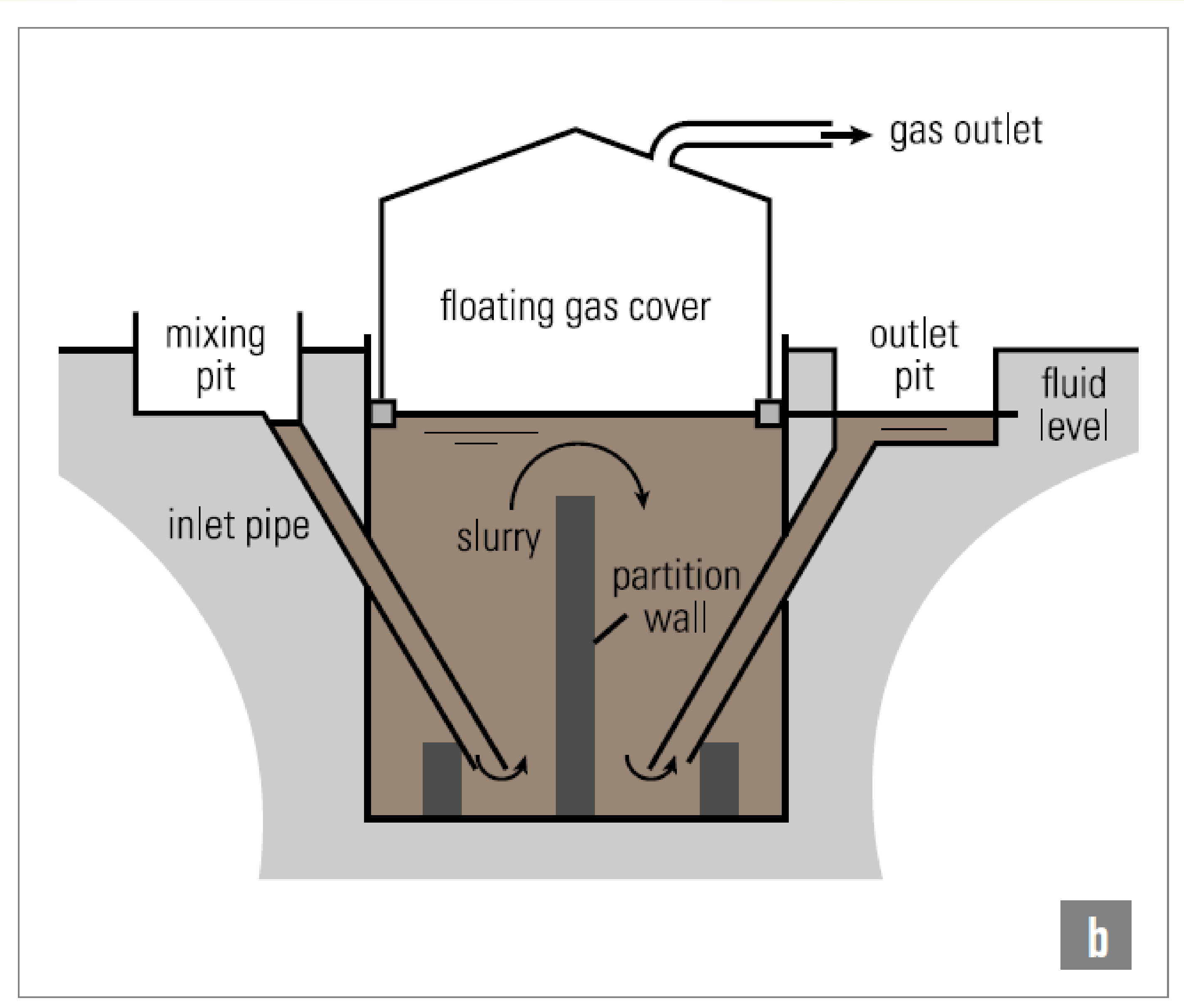
- Covered anaerobic lagoons technology is well suited to the abundant land space available.
- They are low-capital investments which affect a large degree of organic degradation and methane generation.
- Generally, designs used in developing countries for digestion of livestock waste are classified as low-rate digesters, being simpler than those in more temperate regions and lacking heating and stirring capability.
- This is also related to climate, since unheated plants and those without insulation do not work below 15°C.

Three major types of digesters used in developing countries for livestock waste:

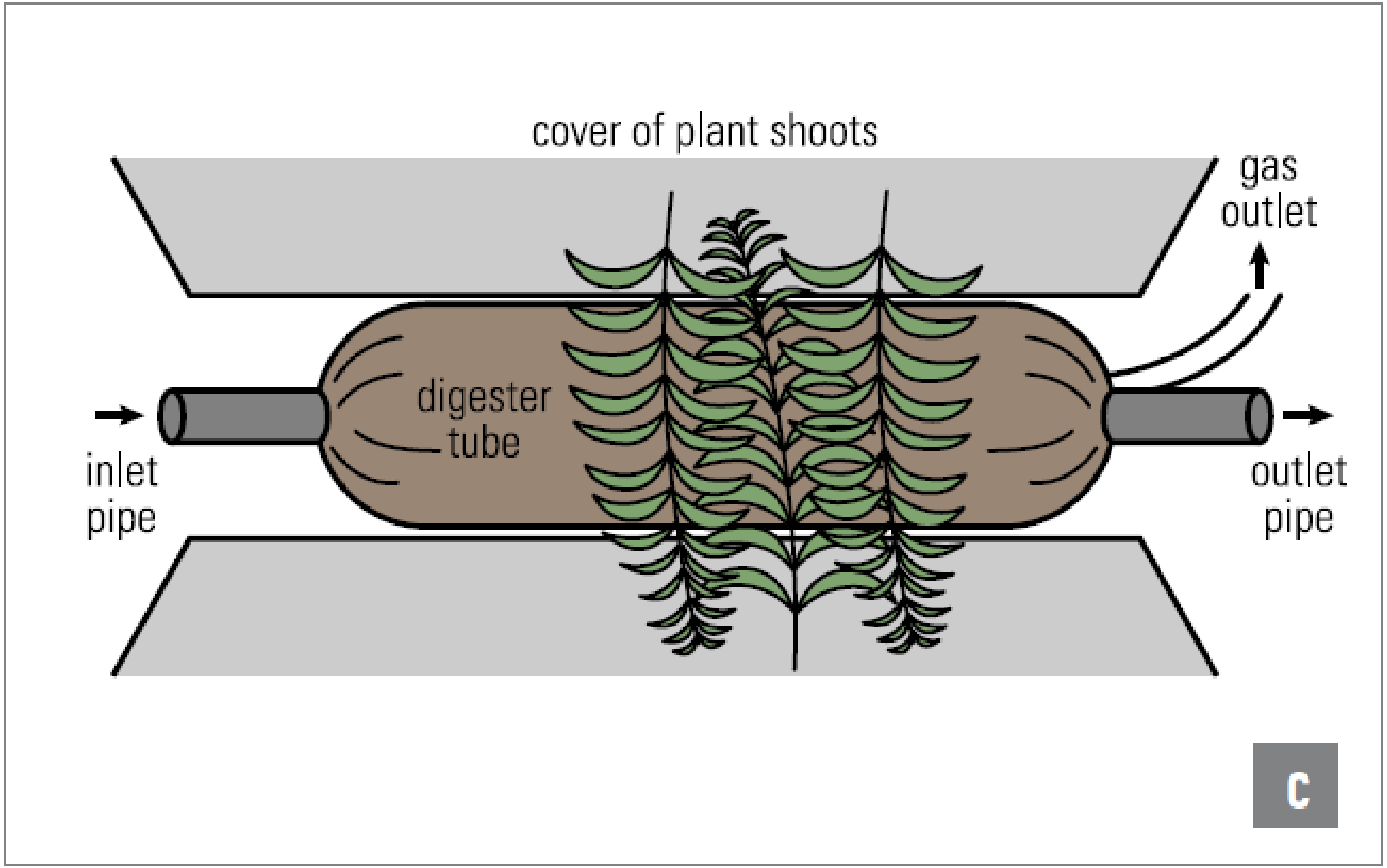
1. Chinese fixed dome digesters.
2. Indian floating drum digesters.
3. Balloon (or tube) digesters.



Chinese Type Fixed Dome Digester



Indian Type Floating Cover Digester



Balloon or Tube Digester

- Floating drum digesters are normally made from concrete and steel.
- Fixed dome digesters are constructed with various available materials such as bricks.
- Balloon (or tube) digesters are fabricated from folded polyethylene foils, with porcelain pipes for inlet and outlet.
- Prefabricated biogas digesters continue to be developed, tested, and extensively applied in developing countries to compensate for the disadvantages of traditional domestic digester models.
- Prefabricated biogas digester prototypes are derived from the three major types of domestic biogas models named above.
- Two main streams of Prefabricated biogas digesters are represented by composite material digesters and bag digesters.

Composition of Biogas

Substance	Symbol	Percentage
Methane	CH_4	50 - 70
Cabon Dioxide	CO_2	30 - 40
Hydrogen	H_2	5 - 10
Nitrogen	N_2	1 - 2
Water vapour	H_2O	0,3
Hydrogen Sulphide	H2S	Traces

Guidelines on Biogas

Suitabl digesting temperature	20 – 35°
Retention time	40-100 days
Biogas energy content	6 kWh/m³ = 0.6 l diesel fuel
1 cow yields	9-15 kg dung/d = 0.4m³ gas/d
1 pig yields	2-3 kg dung/d = 0.15 m³ gas/d
gas requirement for cooking	0.1-0.3 m³ /person
1 lamp	0.5 m³ /d (about 0.13-0.15m³/h)
1 kWh electricity	1 m³ gas

The maximum of biogas production from a given amount of raw material depends on the type of substrate

Guideline Data on Biogas

1 Kg firewood	=> 0.2 m^3 biogas
1 Kg dried cow dung	=> 0.1 m^3 biogas
1 Kg Charcoal	=> 0.5 m^3 biogas
1 Litre Kerosine	=> 2.0 m^3 biogas

- 8–10 m³ biogas plant produces1.5-2.0 m³ gas and 100 litres digested slurry per day using dung from 3-5 cattle or 8-12 pigs.

- With that much biogas, a 6-8 person family can:
  - Cook 2-3 meals
  - Operate one refrigerator all day
  - Burn two lamps for 3 hours
  - Operate a 3 KW motor generator for 1 hour.

Floating Drum Digester:

- Experiment on biogas technology in India began in 1937.
- In 1956,Jashu Bhai J Patel developed a design of floating drum biogas plant popularly known as Gobar Gas plant.
- In 1962, Patel's design was approved by the Khadi and Village Industries Commission (KVIC) of India and this design soon became popular in India and the world.
- In this design, the digester chamber is made of brick masonry in cement mortar.

- A mild steel drum is placed on top of the digester to collect the biogas produced from the digester.
- There are two separate structures for gas production and collection.
- With the introduction of fixed dome Chinese model plant, the floating drum plants became obsolete because of comparatively high investment and maintenance cost along with other design weaknesses.

THANKS