Bio-fractionation assisted CBG technology

Marching towards sustainability through by-product valorisation

EUBCE Biomethane Tripartite Roundtable Table discussions- Marseille

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Energizing through Innovation

Presentation outline

Compressed biogas (CBG): Sustainable biofuel

Bio-fractionation Process

Lignin valorisation

Dry anaerobic digestion

Summary

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Compressed biogas (CBG): Sustainable biofuel

Environmental Challenge

Sustainable Biofuel

- ❑ Utilise waste material
- ❑ Low Environmental Impact
- ❑ Offers rural jobs and business opportunity
- ❑ Additional income to farmers
- ❑ Contributes towards rural energy independence
- ❑ Provides products for energy application

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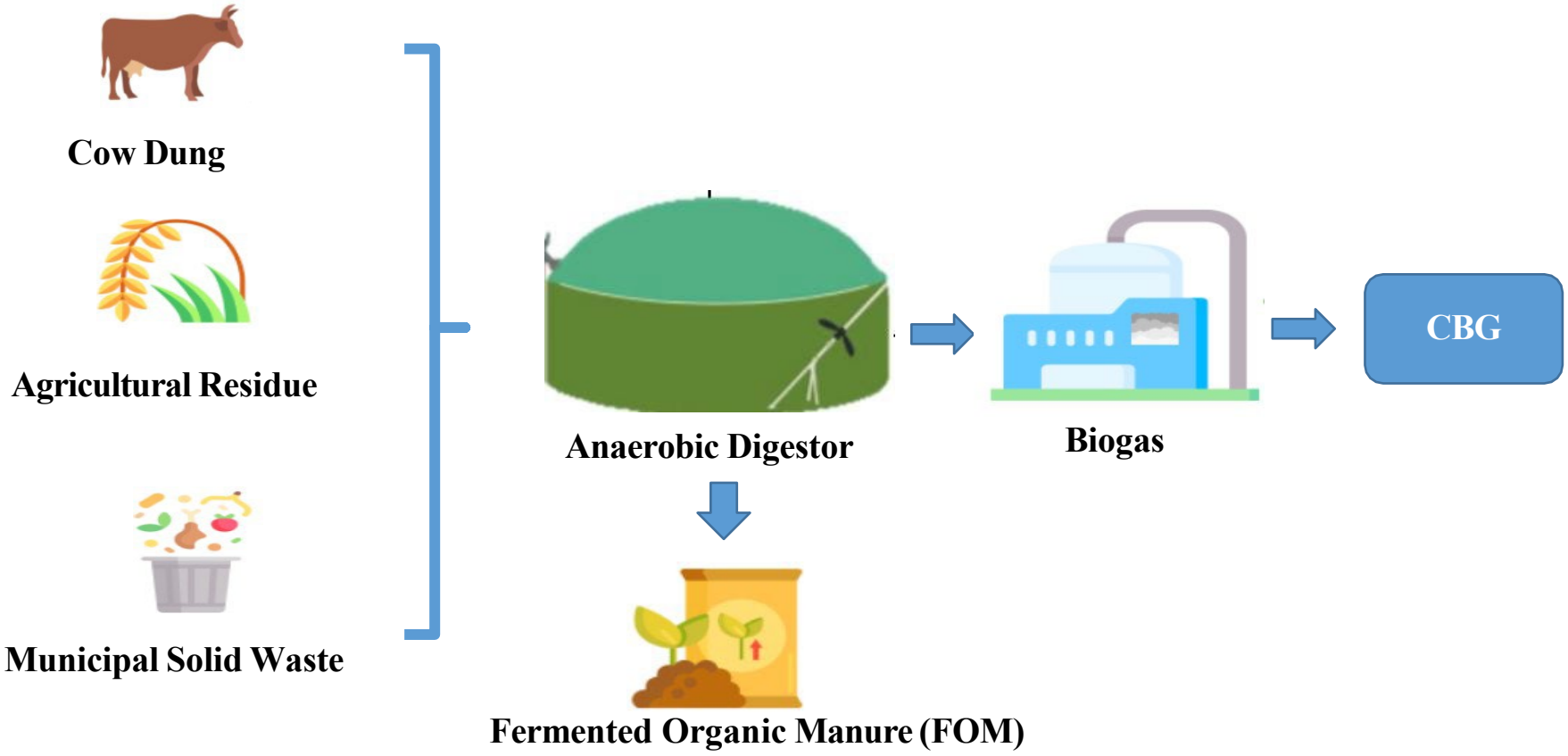
Compressed biogas (CBG): Sustainable biofuel



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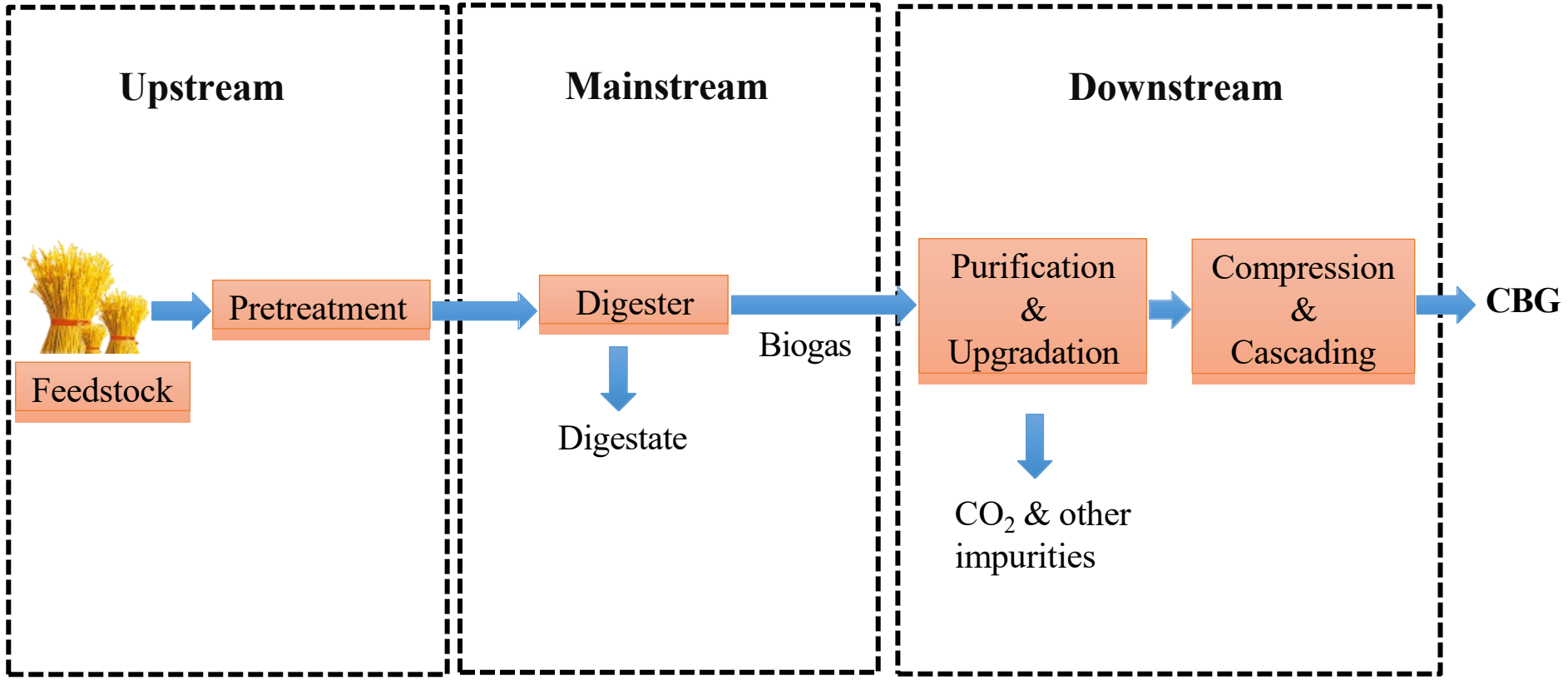
Agricultural residue to CBG Production Process



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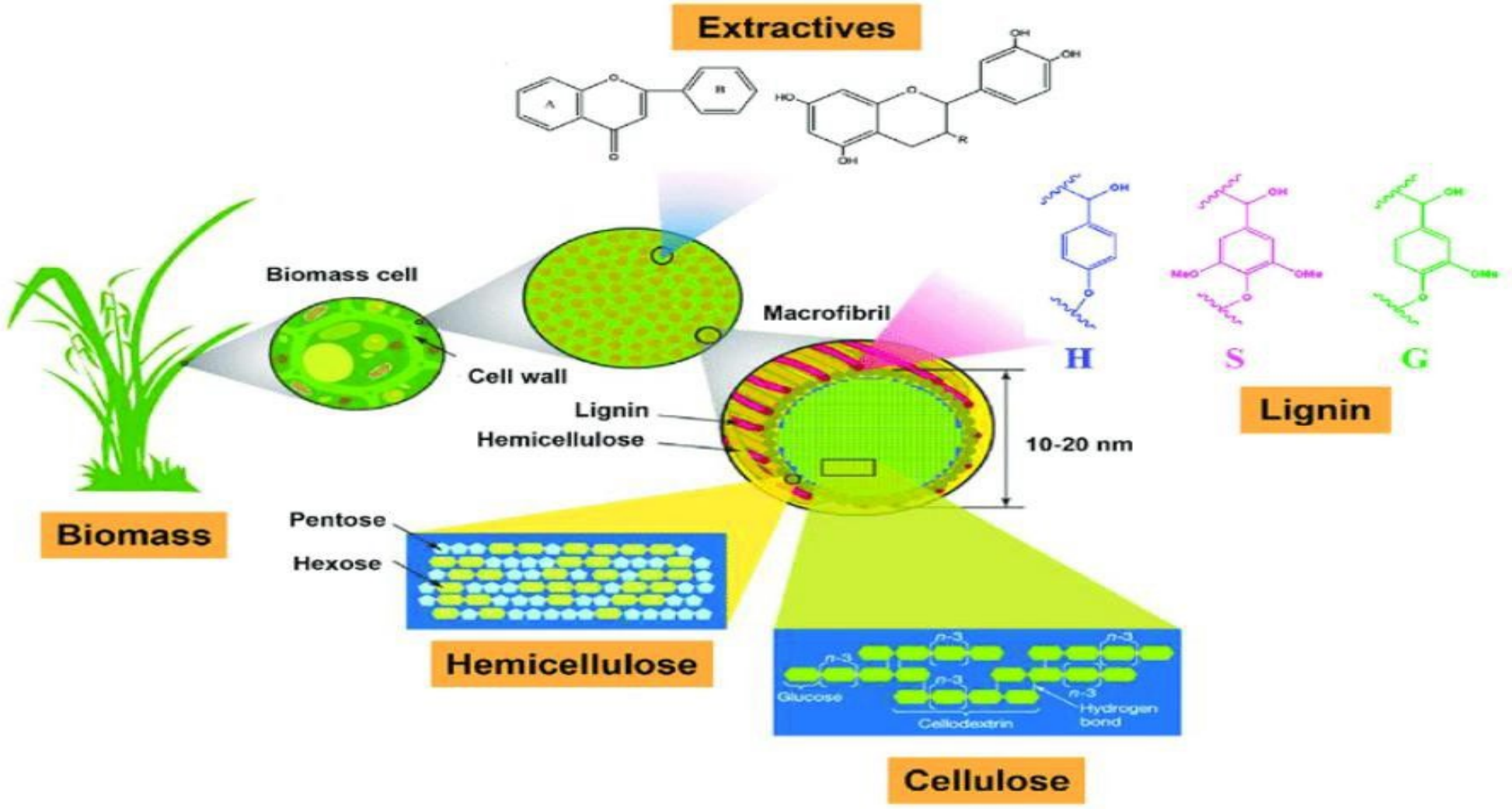
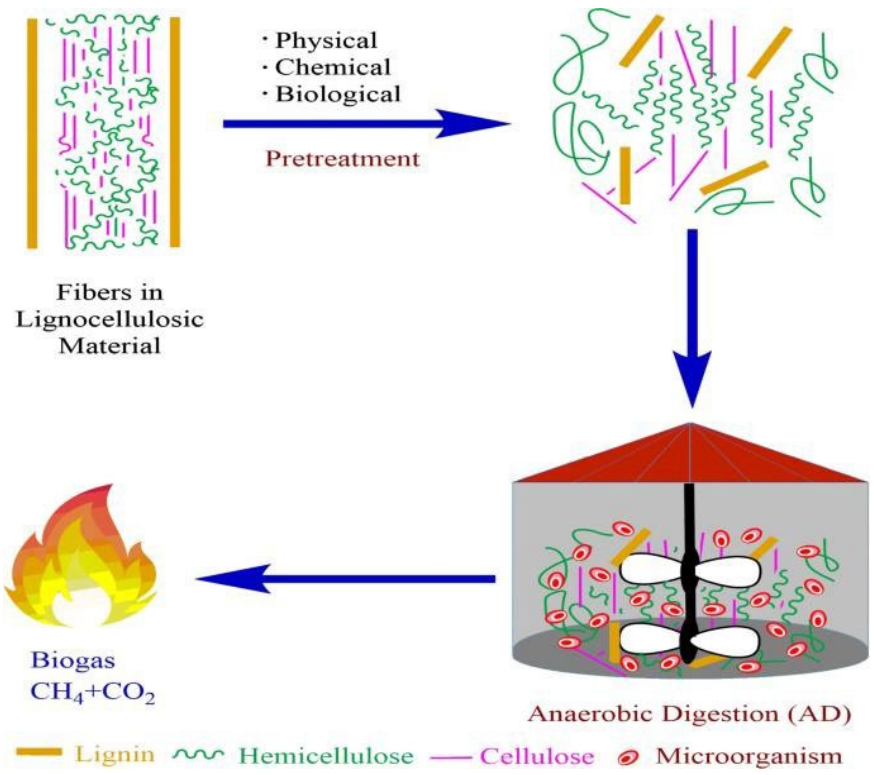
Upstream | Biomass components



Ref: Caoxing Huang 2022

Pretreatment



Physical	Biological
Milling, Extrusion, Ultrasonic cavitation	Microbes, Enzyme

Chemical
Acid, Alkali, Organoslov, Metal salt, Sulfite

Ref: Amin *et al* 2017

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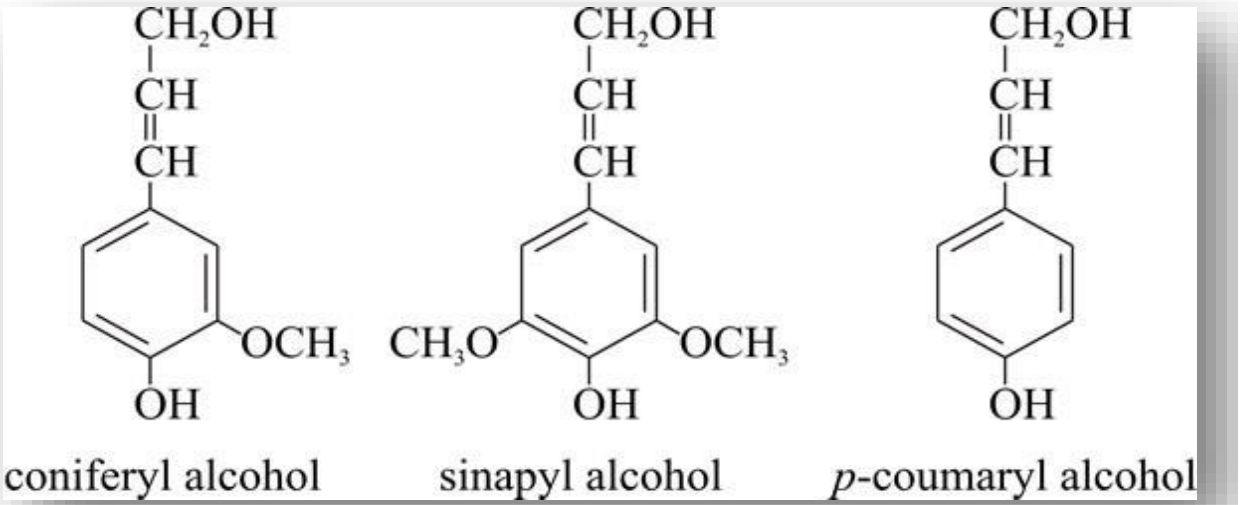
Effect of lignin on anaerobic digestion

- The cross-linked structure formed by lignin protects microbial degradation of cellulose and hemicellulose.
- Lignin depolymerization generate phenolic compounds which impede the growth of microorganisms.
- Phenolics interact strongly with essential amino acids & inhibit synthesis of proteins.
- Inhibition leads to an increase in the lag phase and a decrease in the biomethane production.



Lignin

Ref: Deng *et al* 2023

Bio-fractionation Process

Cellulose + Hemicellulose → 

Anerobic Digestion

Lignin → 

- Carbon Black
- Lignosulphonate
- Green adhesive

- Effective Utilisation of all biomass components
- Lignin valorisation

- ❑ High CBG yield
- ❑ Enriched biomanure
- ❑ Lower HRT

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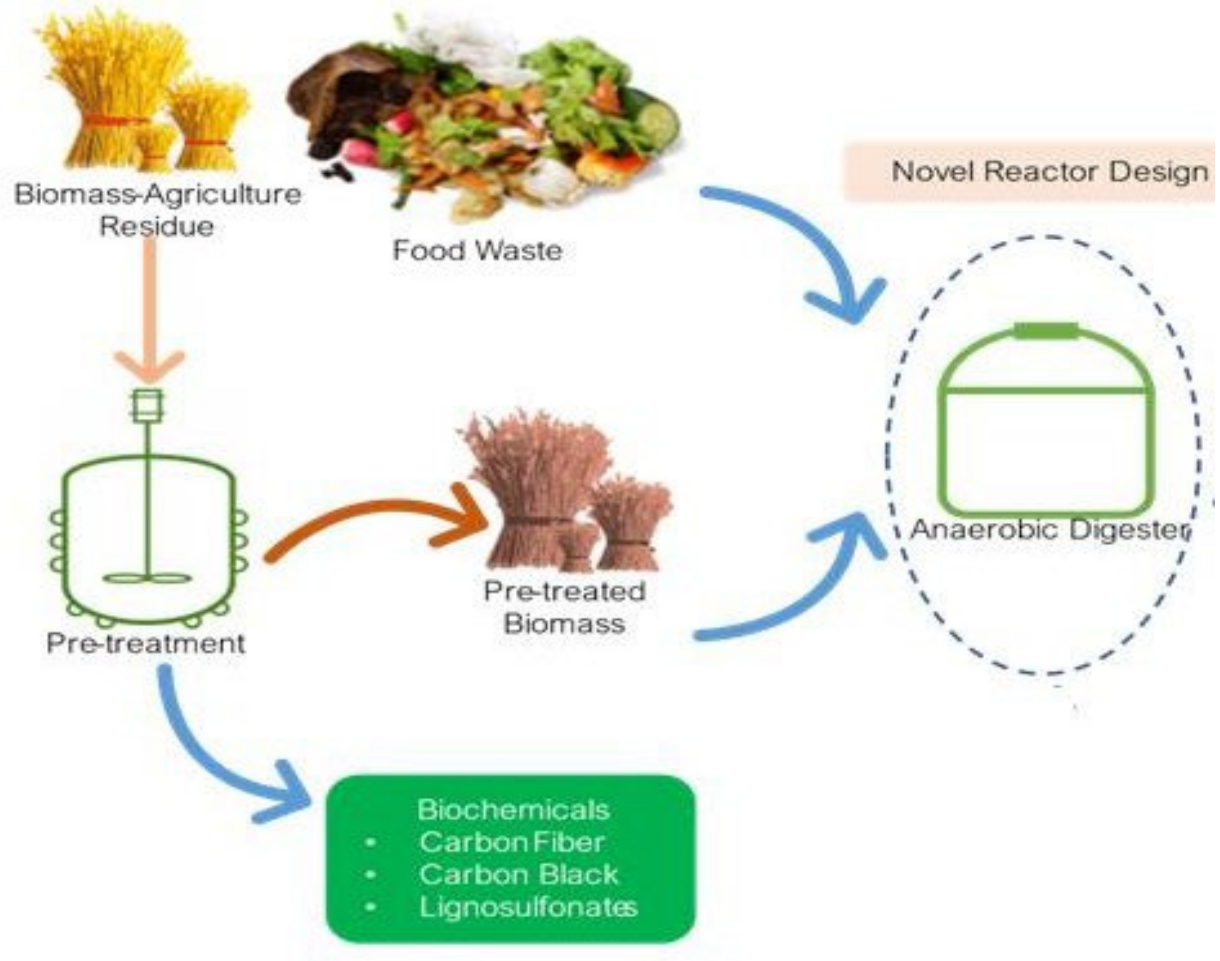
Bio fractionation based CBG production



Anaerobic digestion:

- Reactor design
- Solid loading
- Hydraulic Retention Time (HRT)
- Water requirement
- Energy requirement

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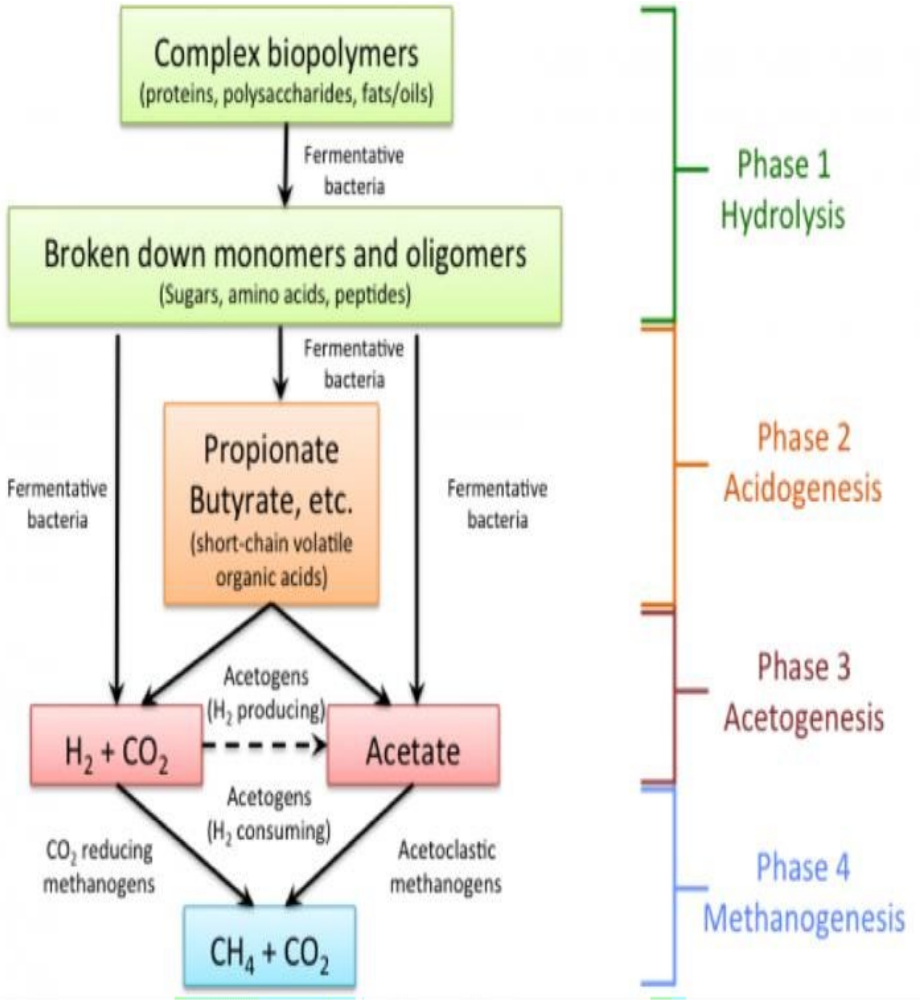
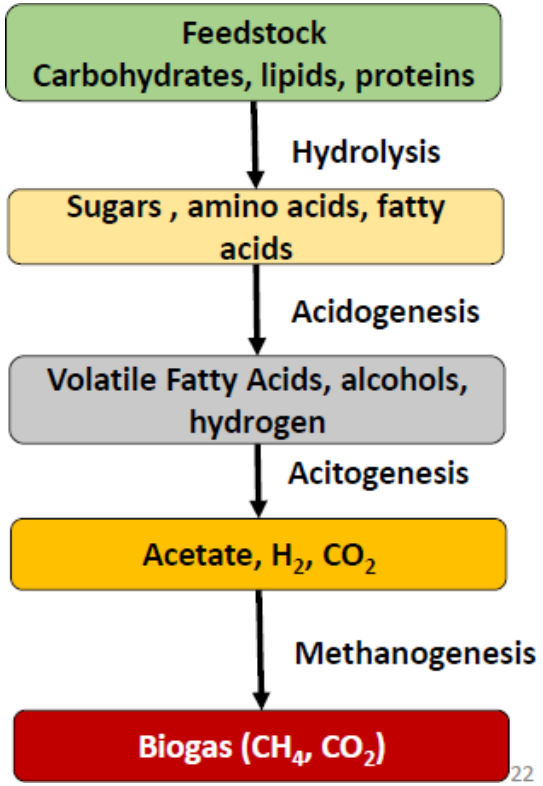
Anaerobic Digestion





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Factor Affecting digester performance

Temperature

- Mesophilic: 30 to 40°C
- Thermophilic: 50 to 60°C

pH and volatile fatty acids (VFA)

- Optimal pH range: 6-8.5
- Change in pH due to accumulation of organic acid, increase ammonia, or VFA accumulation
- VFAs: Indicators of status of digester performance

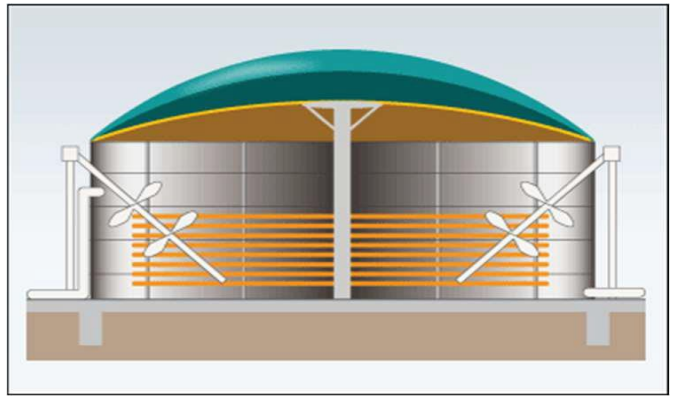
Inhibitors: Toxic substances or intermediate metabolites

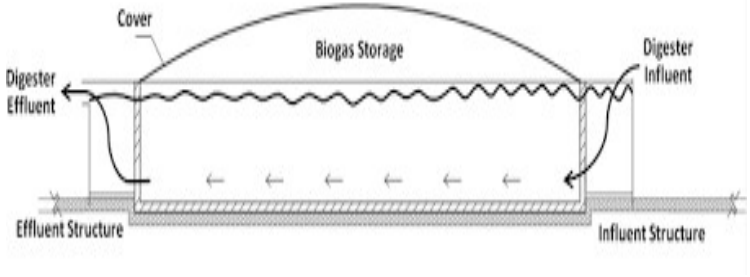
- Increased ammonia concentration (free ammonia, NH_3)
- Long chain fatty acids (LCFA)
- Foaming: Caused by biosurfactants or operations problems like poor mixing

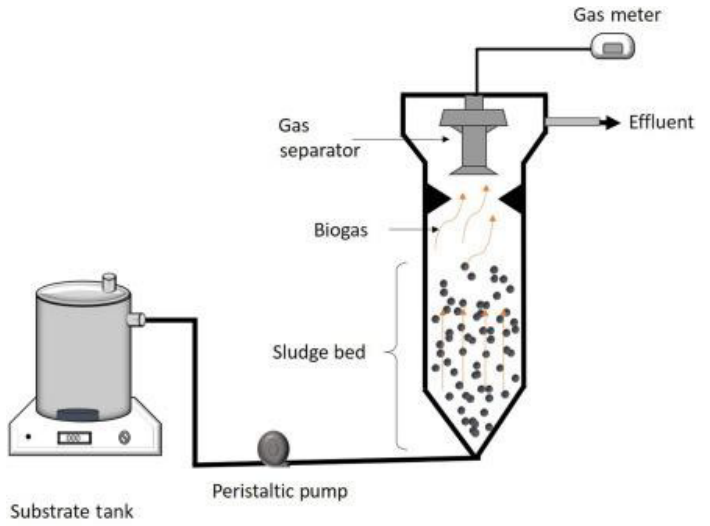
Reactor design

Wet Digestion (TS < 10%)

- ❑ CSTR
- ❑ Plug-flow
- ❑ Up-flow Anaerobic Sludge Blanket







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Biomass Composition

Paddy Straw

Components	Percentage (%)
Cellulose	34 ± 5
Hemicellulose	23 ± 4
Lignin	18 ± 4
Ash	10 ± 3
Extractives & other components	15 ± 5

Wheat Straw

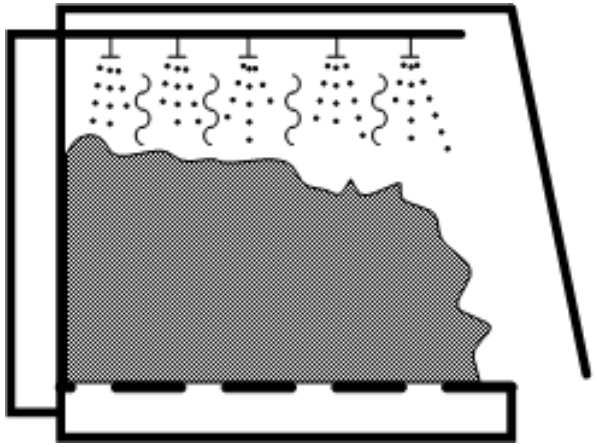
Components	Percentage (%)
Cellulose	35 ± 5
Hemicellulose	26 ± 4
Lignin	15 ± 4
Ash	4 ± 2
Extractives & other components	20 ± 5

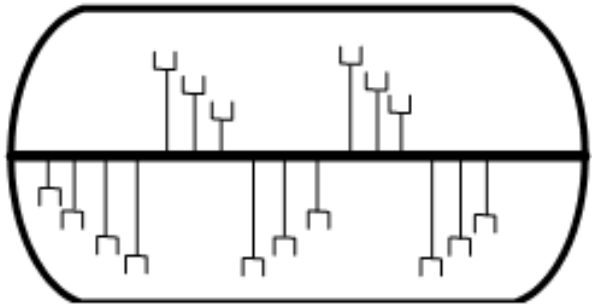
Structural complexity & compositional heterogeneity of biomass hinder their full degradation in anaerobic digestion and result in sub-optimal biogas yields.

Dry Digestion

Dry Digestion/ Solid state anaerobic digestion

- Smaller reactor sizes
- Less energy requirement
- Higher solid processing
- Low water consumption





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Dry Anaerobic Digestor (BPCL-IICT)

Volume: 1 L

Volume: 32 L

Volume: 167 L

Volume: 4000 L

Volume: 4500 L

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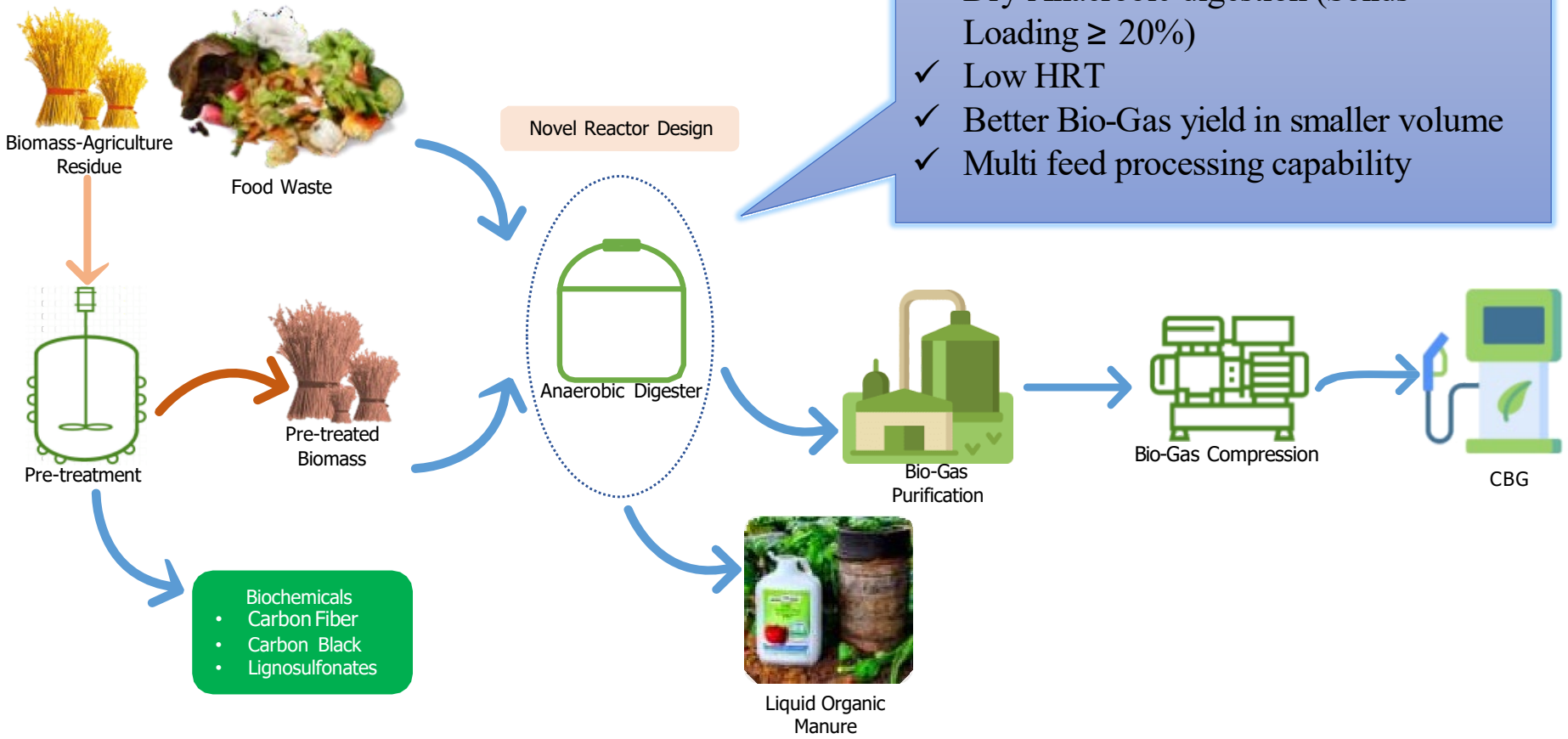
Bio fractionation & Dry Anaerobic Digestion



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Summary

Bio fractionation:

- Bio fractionation process offers effective utilisation of biomass components.
- Lignin is recalcitrant which reduces **microbes efficiency**
- **Lignin removal** increases the efficiency of microbial activity and reduce HRT
- Valorization of lignin offers better economic feasibility to CBG plants.

Dry Anaerobic digestion:

- Lower reaction size
- Higher solid loading
- Reduced water requirement

Thank You

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Lignin application

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