GAS ANALYSIS

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- Anaerobic sludge digestion

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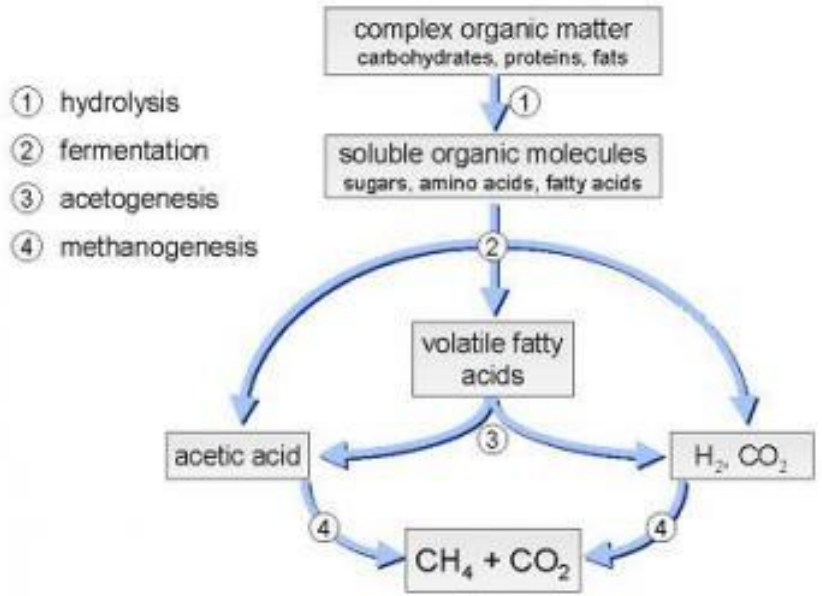
- Anaerobic treatment of high BOD containing wastes (~1500mg/L)



Biogas Formation

Typical composition of biogas

Compound	Formula	%
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulphide	H_2S	0–3
Oxygen	O_2	0–0

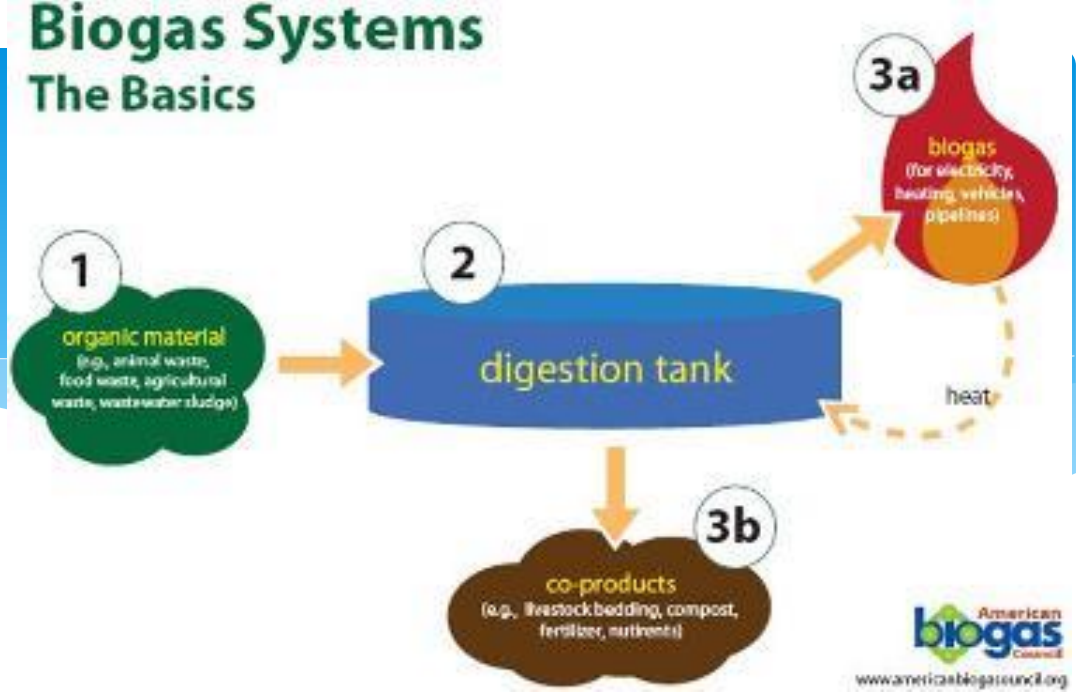
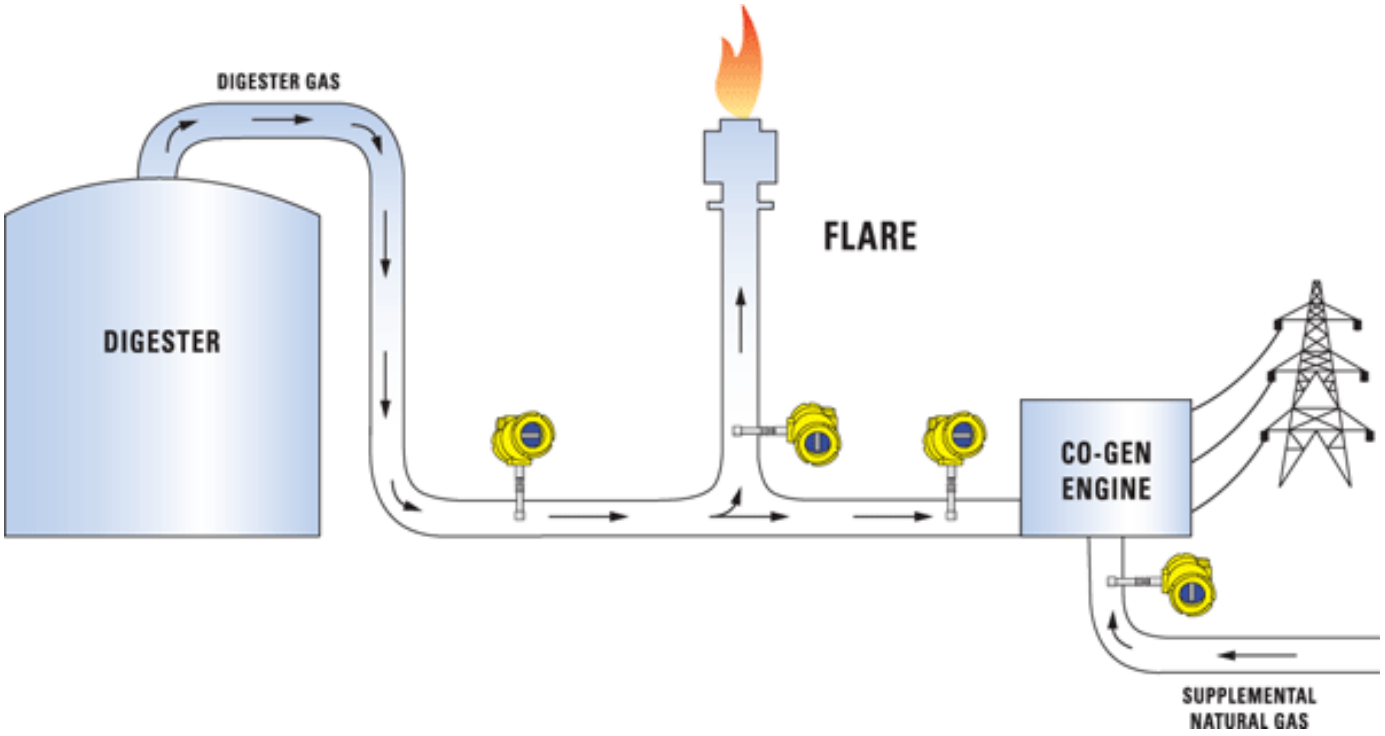


Table 6.4 : Calorific Values of Different Fuels

Fuel	Calorific Value (kJ/kg)
Cow dung cake	6000-8000
Wood	17000-22000
Coal	25000-33000
Petrol	45000
Kerosene	45000
Diesel	45000
Methane	50000
CNG	50000
LPG	55000
Biogas	35000-40000
Hydrogen	150000

Heating value: around 22,000 kj/m^3 (5330 kcal/m^3)

- Anaerobic digester can be heated with this energy.


DIGESTER GAS
DIGESTER
FLARE
CO-GEN
ENGINE
SUPPLEMENTAL
NATURAL GAS

* Heating value depends on the waste strength.
* Composition of the gas is related with conditions in the reactor.

CO_2 / CH_4 ratio →Character of the substrate

Analyze the gases produced

*Determine fuel value

* Monitor treatment

* CO_2 content increases→ indicates trouble in anaerobic treatment
* H concentration should be low,

high H→Digester upset

Methods of Analysis

Volumetric Procedure : (Simple Method)

Orsat Apparatus is used

O_2 , CH_4, H_2, CO_2, N_2

Gas Chromatography:

Advantage : speed

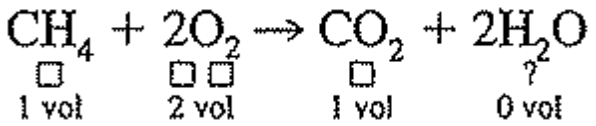
CH_4 ,CO_2 , air (N_2 + O_2)

Gas Chromatography

* Previously calibrated for each gas
* Suitable for routine work, frequent analysis
* TCD (Thermo Conductivity Detector) is used in GC for gas analysis

Volumetric Analysis

* In the past:
  1. Separate measurement of CO_2 and O_2
  2. Combustion of hydrogen and methane → measure amount of CO_2 produced during combustion
  3. Employing a knowledge of Guy-Lussac's Law of combining volumes to determine CH_4 and H_2
* If hydrogen and methane burned together→ Possibility of explosion



Volumetric Analysis

Separate oxidation of H_2 and CH_4

* Hydrogen oxidized by passing the gas through a heated unit charged with cupric oxide

* Methane is oxidized by bringing it and O_2 with a catalyst at a lower temperature.

Carbondioxide Measurement

* Take 100 mL sample, contact with a solution of KOH

$$CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$$

Potassium Carbonate

CO_2 disappears from the gaseous phase

Volume reduction = V_{CO2}

$$\underset{1\ \text{vol.}}{CO_2} + 2KOH \rightarrow \underset{0\ \text{vol.}}{K_2CO_3} + H_2O$$

Hydrogen Sulfide

Volume of H_2S is too small, can be ignored

Oxygen

* Very little possibility of O_2 existence in anaerobic digester gas.

Can enter during sampling.

* If more than 0.1-0.2 % → Poor sampling

Oxygen

* Measured by using alkaline pyrogallol

Under alkaline condition pyrogallol

(1,2,3-trihydroxy-benzene) is oxidized by oxygen

End products: CO2 and organic acids → held as potassium salts in the absorbing solution

* Measure CO_2 . Volume reduction = V_{O2}

↓

(CO_2 present should be removed previously)

Hydrogen

* Pass the gas mixture over cupric oxide @ 290-300 ^{o} C

* H_2 is oxidized to water (methane is not)

Water vapor formed condenses at lower temperature

Cool the sample to room temperature

Measure volume loss after contact with heated cupric oxide

Methane

* After removal of hydrogen

oxidize methane by slow combustion or catalytic oxidation

* Stoichiometry is important to calculate required amount of O_2 for combustion

$$\underset{1\ \text{vol.}}{CH_4} + \underset{2\ \text{vol.}}{2O_2} \rightarrow \underset{1\ \text{vol.}}{CO_2} + \underset{0\ \text{vol.}}{2H_2O}$$

Nitrogen

Inert gas

$$V_{N2} = V_T - (V_{CO2} + V_{O2} + V_{H2} + V_{CH4})$$

Collection - Storage

*Glass / metal tubes

*Gum – rubber balloons

(Pervious to H_2 and CH_4 !!)

Use displacing fluid to transfer the gas sample the apparatus

Collection - Storage

Temperature changes affect the analysis.

If combustion is applied, measure gas volume after the temperature returns to original value.

Collection- Storage

Confining liquid:

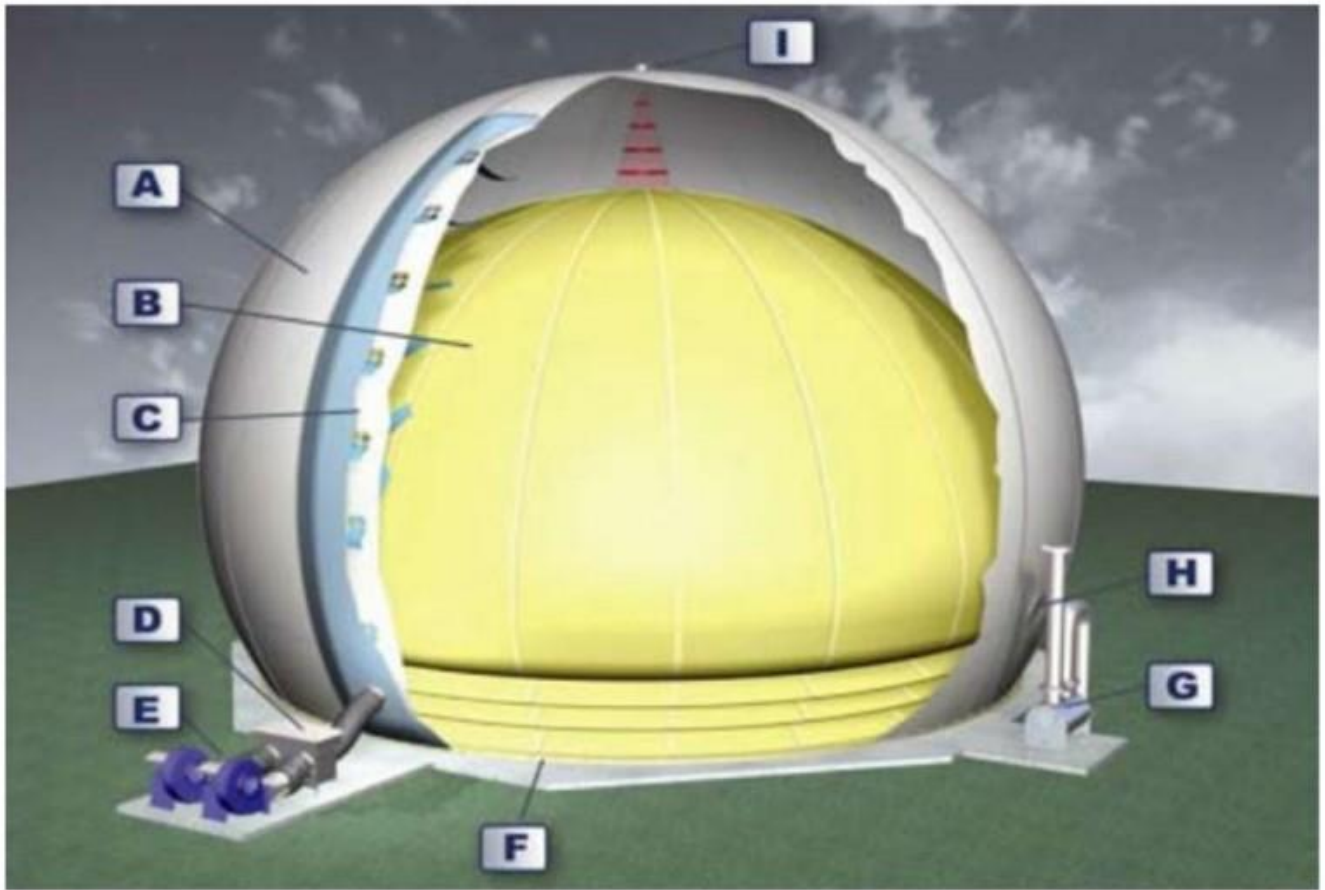
- Hg (ideal, but have health hazards, used in precise inst)

Water ⟶ Solvent power

Aqueous solution 20% Sodium sulfate, 5% H_2SO_4 decreases solvent power of water

Gas Storage

Biogas Storage



A	Outer Membrane
B	Inner Membrane
C	Air Flow System
D	Non Return Valve
E	Radial Ventilator
F	Anchor Ring
G	Safety Valve
H	Inspection Window
I	Ultrasonic Sensor

Hydrogen Sulfide

$H_2S \longrightarrow$ corrosive

- If gas will be used as a fuel, should contain < 1.14 mg/L

$H_2S + I_2 \longrightarrow 2HI + S$

- Excess iodine is indicated with starch indicator.