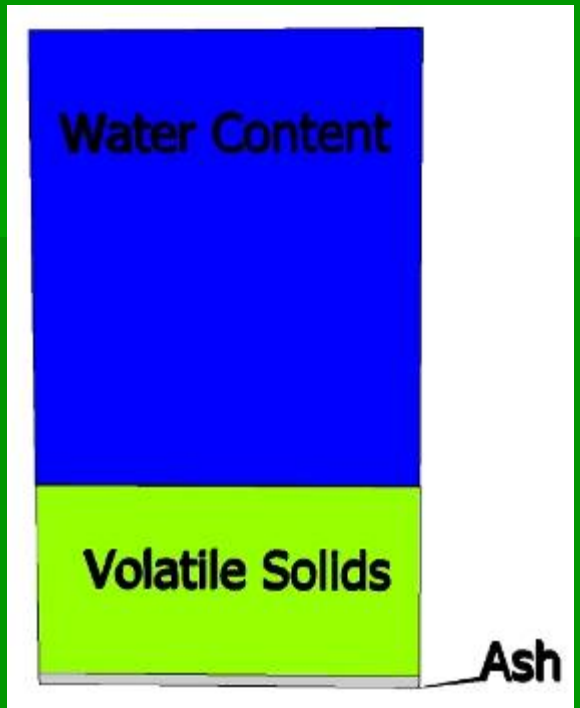
Anaerobic Digestion and Biogas

Terminology and designs

Total Solids, Volatile Solids

- Total Solids (TS)= Dry weight of substrate
- Volatile Solids (VS)= Combustible proportion of TS, organic matter
- Non-volatile Solids (Ash) = Minerals etc. left over from combustion



Total Solids, Volatile Solids

Total Solids

Ash

COD/BOD

- Chemical/Biochemical Oxygen Demand
  - Measures amount of oxygen required to degrade a substrate
  - Used widely in aerobic water treatment
  - Characterizes wastewaters and organic feedstocks
  - Estimates energy content of substrate

BMP

- Biochemical Methane Potential Assay
  - Developed as correlative test of BOD in anaerobic systems
  - Realistic measure of total methane potential of a feestock
  - Can determine non-biodegradable materials in feedstock

Organic loading rate

- Rate at which feedstock is fed to the digester (i.e. g VS / L reactor)
- Varies by feedstock, reactor type, temperature, etc.
- Too low= too large of reactor
- Too high= overload reactor, acidification

Hydraulic Retention Time

- How long substrate remains in active volume (i.e. turnover rate)
- Optimized for higher biogas/ reactor volume ratio
- Too high= Unnecessarily large reactor
- Too low= Reduced biogas output, washout microbes

Temperature

- Anaerobic metabolism much more sensitive to temperature than aerobic
- Methanogens more affected than acidogens
  - Leads to unbalanced pH at low temps.
  - Loading rate reduced at low temps.

Mesophilic vs. Thermophilic

- Temperature classes for microbes in digester
- Mesophilic (30-40°C), Thermophilic (50-60°C)
- Different microbial communities operate at each temp. class
- Most digesters operate at mesophilic

pH

- Very important parameter
- Optimum 7.0, acceptable 6.0-8.0
- Methanogens cannot function at low pH.
- Ammonia toxicity above 8.0
- Slow recovery after sustained drop in pH.

Different digester types

- Batch vs. Continuous
- Two phase
- CSTR
- UASB
- Fixed-film

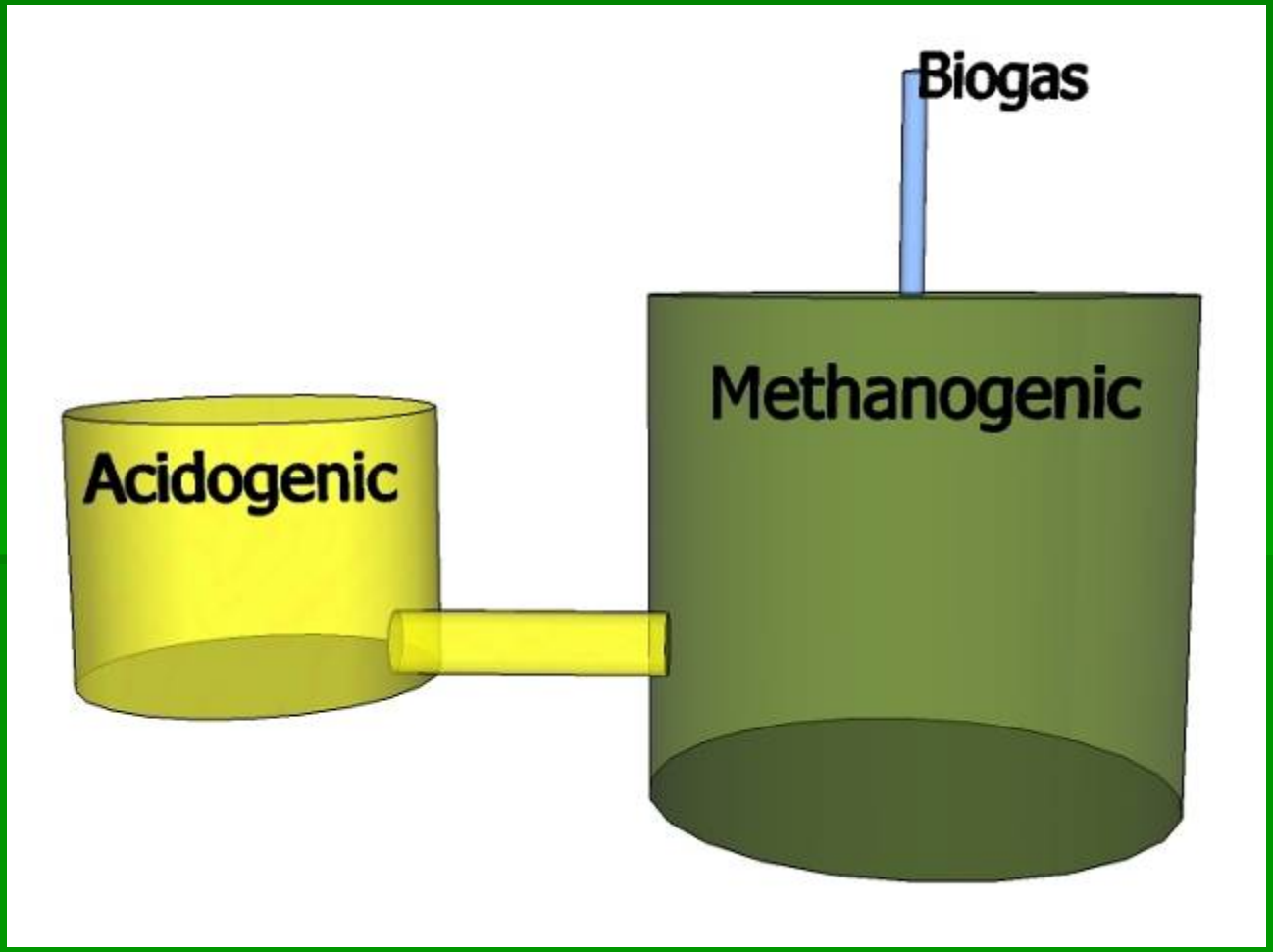
Batch vs. continuously fed

- Batch – Digester loaded once, emptied once fully degraded
- Continuously fed – Digester regularly loaded (usually daily), effluent produced at each loading

Two phase digestion

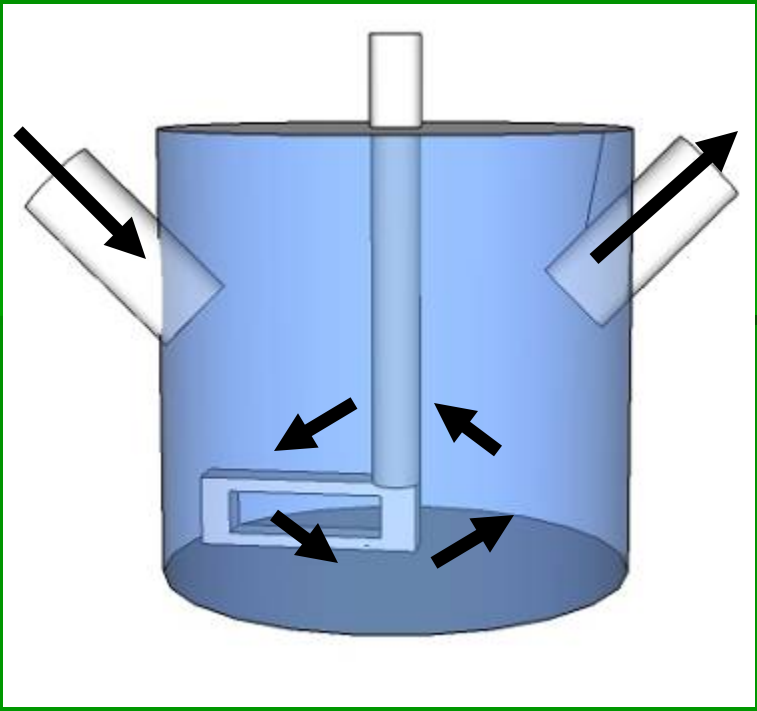
- Single phase- all in one reactor
- Two phase- acidogenesis and methanogenesis separated
- Benefits
  - Increased over-all efficiency (short HRT of acidogenic reactor)
  - More pH control of methanogenic reactor

Two phase digestion



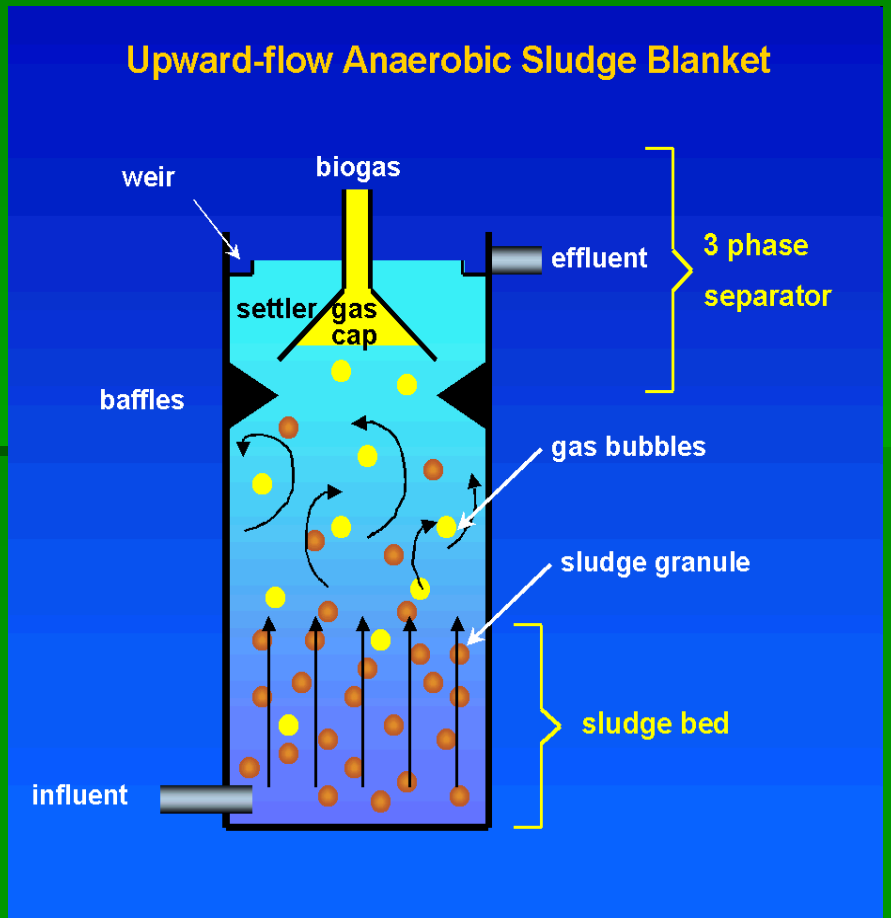
CSTR

- Continuously-Stirred Tank Reactor
- Simple but effective design



UASB

- Up-flow Anaerobic Sludge Blanket
- Frequently used for sewage wastewater



Fixed Film Reactor

- Increased substrate-bacteria contact
- Utilizes biofilms
- Short HRT
- Decreased size
- Used as DRU

Digesters in developing nations

“Bag digester”, Costa Rica

Small scale digester, rural India

Digesters in agriculture

Covered Lagoon, Tulare, CA

Corn sillage digester, Neumunster, Germany

Digesters in industrial settings

Lübek mechanical biological treatment plant, Germany

Mechanical biological treatment plant, Tel Aviv, Israel

Digesters as architectural features?

Reading Sewage Treatment Works, Reading, United Kingdom

Appleton Wastewater Treatment Plant, Appleton, Wisconsin

Questions?