Aerobic Digesters

Anaerobic Digesters

Doug Hill
www.dhillenvironmental.com

Purpose of Digestion
Stabilize Solids
Minimize Odors
Volume Reduction
Improve Dewaterability
Meet Part 503 Land Application Requirements
Vector Attraction Reduction
Pathogens Reduction

Aerobic Digesters
Cell Residence Time

Growth Rate of Organisms

Lag Growth
Log Growth
Declining Growth
Endogenous Growth

Conventional Treatment
Extended Air

Sludge Production

Cell Residence Time

Growth Rate of Organisms

Lag Growth
Log Growth
Declining Growth
Endogenous Growth

Conventional Treatment
Extended Air

Sludge Production

Cell Residence Time

Growth Rate of Organisms

Lag Growth
Log Growth
Declining Growth
Endogenous Growth

Conventional Treatment
Extended Air

Sludge Production

Cell Residence Time

Growth Rate of Organisms

Lag Growth
Log Growth
Declining Growth
Endogenous Growth

Conventional Treatment
Extended Air

Sludge Production

Cell Residence Time

Growth Rate of Organisms

Lag Growth
Log Growth
Declining Growth
Endogenous Growth

Conventional Treatment
Extended Air

Sludge Production

Cell Residence Time
Endogenous Respiration
– Cell Death

Bacterial Cell

Stored Food Used
Cell Components Used
Cell Dies and Splits Open
(Aerobic Digestion)

Aerobic Digestion
Endogenous Stabilization

High CRT allows for the microbes to feed off of the cell contents of other dying/decaying microbes under digestion.

Not all solids can be digested
20 to 25% by weight inert solids
Fine inorganic solids, organic solids, and cell components that are not degradable

Aerobic Digestion
ADVANTAGES

The process is easy to control, easy start-up
Low ammonia and BOD in return stream
Few odors are experienced if properly designed and operated
Explosive gases (methane) are not produced
Aerobic Digestion

DISADVANTAGES
Aerobic digestion does NOT produce energy
Aerobic digestion process is energy intensive
Not usually used for primary sludge due to high O₂ demand and additional biomass produced
Temperature variability throughout the year causes variability in the operating performance
Stabilized sludge may be difficult to dewater

OPERATION
Batch Operation:
Add sludge
Digest – mix, aerate
Turn off the aeration system
Allow the solids to settle
Decant the clear liquid

Control:
D.O. (At least 1 mg/L)
Mixing
Organic loading

OPERATION
Solids loading is typically in the range of 0.02 to 0.15 lb VSS/ft³/day
DT required depends on temperature & objectives (Part 503)

| Class B Pathogen Reduction |
| Vector Attraction Reduction Requirements |
| Min 38% VS Reduction |
| Max SOUR 1.5 mg/h/G |

40 days at 20°C (68°F)
60 days at 15°C (59°F)
Aerobic Digestion

**OPERATION**

VS reductions over 40% possible depending on source of solids, D.O., temperature, detention time

Expect lower values if digesting only waste activated sludge

Expect lower values if digesting waste activated sludge from extended aeration process

Expect lower values as temperature decreases

---

Aerobic Digestion

May have to contend with foaming

- Low dissolved oxygen concentrations
- Improper organic loading rate
- High oil and grease
- Growth of Nocardia or Microthrix Parvicella

Other filamentous populations may develop in the aerobic digester

---

**Autothermal Thermophilic Aerobic Digestion (ATAD)**

Heat released by organic decomposition during digestion typically sustains the thermophilic operating temperatures

122 to 158°F

Higher loading – septage, primary, secondary sludge

More rapid digestion process when compared to conventional aerobic digestion

Solids retention time (12 to 14 days)
**Autothermal Thermophilic Aerobic Digestion (ATAD)**

Typically destroys 50 to 70% of the VSS

Reduces the total solids by nearly 50%

Dewaters well

Pasteurized (Class A) biosolids

---

City of Three Rivers, 2002 2.75 mgd WWTP

![Solids Handling Processes](image)

---

**Anaerobic Digestion**

![Anaerobic Digestion Image](image)
Anaerobic Digestion

The first anaerobic digester was built by a leper colony in Bombay, India, in 1859.

Series of processes in which microorganisms break down biodegradable material in the absence of oxygen.

Anaerobic Digestion

Methane-forming bacteria

About 50 species of methane-forming bacteria

Archaebacteria - extremophiles

Oxygen-sensitive

Extreme Obligate Anaerobic

Killed rapidly by relatively short time exposures to air

Generation times

3 days at 95 °F
50 days at 50 °F

Anaerobic Digestion

Methane-forming bacteria are mesophiles or thermophiles

Mesophiles are those organisms that grow best within the temperature range of 86 - 95 °F

Thermophiles are those organisms that grow best within the temperature range of 122 - 140 °F
Covered anaerobic lagoon digester: Sealed with flexible cover, with methane recovered and piped to the combustion device.

Plug flow digester: Long, narrow concrete tank with a rigid or flexible cover. Plug flow digesters are used on farming operations to treat manure. High solids, mixed or not mixed.

Complete mix digester: Enclosed, heated tank with a mechanical, hydraulic, or gas mixing system.
Anaerobic Digestion

**ADVANTAGES**

- Renewable Energy
  - Produces 12-15 ft³ methane per lb VS digested
  - 65% methane yields
  - 650 Btu per cubic foot
- Destroys Pathogenic Organisms
- Reduces volatile content of sludge
- Produces much less biomass than aerobic processes
- Sludge is more easily dewatered
Anaerobic Digestion

DISADVANTAGES

- Slow start-up
- Requires proper start-up, close monitoring
- May go SOUR if started improperly, overloaded, improper temp range, toxicity
- High BOD & P in supernatant
- Sealed tanks – cleaning, maintenance more difficult
- Heating, mixing, gas collection equipment & plumbing adds cost, complexity
- Extreme confined space hazard
- Production of explosive gas

North Lewiston, ID
Jan 21, 2008

“A biogas plant is not ‘plug and go’: you feed it carefully, you nurse it when it is not well and, most importantly, you must know what to do when something goes wrong.”

Safety issues include risk of explosion, confined space asphyxiation, and hydrogen sulfide poisoning.

Capt. Tom Hatley of the Lewiston Fire Department said crews were dispatched Sunday at 7:45 a.m., minutes after what he said sounded like a sonic boom from the city’s north end. “It pretty much rocked our world,” he told the Lewiston Tribune.

“An explosion at a wastewater treatment plant caused $3 million to $5 million in damages, but no one was injured and the plant is still able to operate, authorities said.”
Operation (Mesophilic)

- Adequate Mixing
- Temperature (85 – 100°F)
- Organic Loading: 40 to 80 lbs VSS/day/1000 ft³
- Hydraulic Loading
  - Detention time
  - < 0.5 VA/ALK Ratio
- Gas Production: 30 – 35% CO₂

Anaerobic Digestion

Class B Pathogen Reduction
Mean cell residence time and temperature shall be between 15 days at 35 to 55°C (95 to 131°F) and 60 days at 20°C (68°F).

Vector Attraction Reduction
Volatile Solids must be reduced by a minimum of 38%.

Anaerobic Digestion Concerns
Any amount of dissolved oxygen in an anaerobic digester raises the ORP of the sludge and discourages anaerobic activity.

- Sludges and wastewaters fed to an anaerobic digester should have no molecular oxygen.
- WAS will slow anaerobic digestion due to high ORP.
### Anaerobic Digestion

- Foaming
- Excessive Mixing
- Rapid breakdown of volatile acids
- Inconsistent loading
- Temperature fluctuations
- Overload
- Toxicity
- Filamentous Bacterial Growth
- Nocardia
- Microthrix Parvicella

### Aerobic Digestion

- Simple Start-up
- Simple Operation
- Best for Secondary Sludge
- Energy Consumer

### Anaerobic Digestion

- Energy Production
- Sludge is more easily dewatered
- Best for Primary Sludge
- More Sensitive, Some Danger