MIXED DIGESTERS

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Mixed Digesters

- Completely Stirred Tank Reactor (CSTR)
  - Continuous flow/stir process

- Sequencing Batch Reactor (SBR)
  - Batch reactor
    - Feed
    - Stir
    - Settle
    - Decant
Stirred Ag Reactors in the U.S.

- 15 mixed digesters*
  - 10 dairy
  - 3 swine
  - 1 caged layers
  - 1 ducks

*Per Agstar database Oct. 2002
Mixed Digesters

- **CSTR...HRT = SRT**
  - Generally design for long detention times
    - 20-30 days
    - Means relatively large volume required...more $$
    - Theoretically fresh manure is discharged if mixing is thorough

- **SBR...HRT>SRT**
  - HRT may be very short...days or even hours
  - SRT is very long...provides more thorough digestion
Mixed Digesters

- Must have some type of mechanical system for agitating the manure
  - **Mechanical propellers**
    - Submerged motors
    - Exposed motors with shafts extending into the manure
  - **Pumps**
    - Recirculate liquid
    - Recirculate gas
Manure Thickness

- Mixed reactors are good for manures too thin for plug flow and too thick for lagoons
  - Plug flow: 10 - 13% TS (dairy)
  - Lagoons: 0.1 – 2% TS (flush sys)
  - Mixed: 2 – 5% TS (swine)
Manure Thickness

- **Swine manure**
  - Farrowing/gestation: 3.0-5.0% TS
  - Finishing houses: 4.0-9.0% TS
    - May have to be diluted if too thick

- **Dairy manure**
  - Typically 10-13% undiluted
    - Bedding may thicken it
    - Works best undiluted in plug flow digester
    - Sand and digesters don’t go together
Construction

- Mixed digesters may be either “hard top” or “soft top”
- Shape can be rectangular or circular
  - Round designs may be easier to mix
  - Rectangular don’t need special length/width ratio like plug flows
- Concrete or steel
  - Must be insulated in cold climates
Mixing

- Ideally mixing would be continuous
  - Keeps microbes into contact with nutrients
  - Requires a lot of energy

- Periodic mixing
  - Digesters respond quickly after mixing or feeding
  - Over-designed mixers provide safety factor against solids settling
Primary Concerns

- Additional mechanical equipment required for mixing
  - More $$ to construct
  - More maintenance/management requirements
- Solids accumulation if mixing or discharge designa are inadequate
- Struvite accumulations
  - Foul pumps & pipes
Heating

- Uniform heat is necessary throughout digester volume
  - Preheat not necessary or advantageous as it is for plug flow
  - Mixing while feeding is good management practice to rapidly warm incoming manure
Iowa Mixed Digester

- Reception & pump pit
- Stored digested manure
Iowa Mixed Digester

- Iowa swine digester
  - Mixed morning and night for ~ 1 hour each time
  - Fed in the morning during the mixing cycle
  - Manually activated pumps to provide feed
Performance

- Loading rate
  - Gal manure fed = 540,000 gal/mo.
    - 18,000 gal/day
    - 3.6 gal/sow-day
    - 1.5 kg VS/M$^3$-day
      - 90 lb VS/1000 ft$^3$ (~10X lagoon loading rate)
**Performance**

- **Energy production**
  - Biogas generated = 588,000 cu ft/mo.
    - 19,600 cu ft/day (70% methane)
    - 3.9 cu ft/sow-day
  - Electricity = 24,500 Kwh/mo.
    - 816 kwh/day
    - 163 watt-hr/sow-day
    - 6.8 watts/sow
  - Generator run time 80% first 6 months
Average COD reduction for Iowa CSTR = 60%
Performance – N Change

Nitrogen Change

TKN and NH3-N, Ib/Kga

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<thead>
<tr>
<th></th>
<th>TKN</th>
<th>NH3</th>
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<tbody>
<tr>
<td>Raw</td>
<td>75%</td>
<td>20</td>
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<tr>
<td>Digested</td>
<td>86%</td>
<td>25</td>
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Performance – Odor Reduction

- Odors reduced ~ 90%

### Anaerobic Digester Odors

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<tr>
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<th>Liquid</th>
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<tbody>
<tr>
<td>Concentration (ppb) or ratio</td>
<td>H2S</td>
<td>Odor H2S</td>
<td>Odor Threshold</td>
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Legend:
- **undigested**
- **digested**
Summary – Mixed Digesters

- Useful for moderately thick manure
  - Use if manure’s not thick enough for plug flow

- Additional mechanical requirements
  - Maintenance and good management very critical
  - Iowa unit has been challenging to maintain

- Good COD & VS reductions
- Odor concentrations are reduced
- Manure is still not “releasable” quality