MAKING SENSE OF MANURE TREATMENT TECHNOLOGY OPTIONS FOR LIVESTOCK FARMS

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Nutrient Recovery Categories
- Coarse solid separation
- Fine solids separation
- Membrane separation
- Energy generation
- Fiber drying & bedding recovery
- Other technologies

Technology Selection Factors
- Manure characteristics
  - Moisture content
  - Nutrient content
  - Ash content / fixed solids
  - Grit / contamination
- Bedding
- Handling
  - Collection
  - Conveyance
- Target products

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Manure Characteristics, excreted

<table>
<thead>
<tr>
<th>Source</th>
<th>TS, % wb</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWPS – 18, Section 1, Manure Characteristics</td>
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</tr>
<tr>
<td>Beef Feedlot</td>
<td></td>
</tr>
<tr>
<td>High forage</td>
<td>46.7</td>
</tr>
<tr>
<td>High energy</td>
<td>47.9</td>
</tr>
<tr>
<td>Dairy</td>
<td></td>
</tr>
<tr>
<td>As excreted</td>
<td>14.3</td>
</tr>
<tr>
<td>Dry lot, daily scrape</td>
<td>21.9</td>
</tr>
<tr>
<td>Dry lot, weekly scrape</td>
<td>58.8</td>
</tr>
<tr>
<td>Freestall flush</td>
<td>1-3</td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
</tr>
<tr>
<td>Broiler litter</td>
<td>78.5</td>
</tr>
<tr>
<td>Broiler cake</td>
<td>60.0</td>
</tr>
<tr>
<td>Turkey litter</td>
<td>73.5</td>
</tr>
<tr>
<td>Turkey cake</td>
<td>55.0</td>
</tr>
<tr>
<td>Swine</td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>9.2</td>
</tr>
<tr>
<td>Manure from building</td>
<td>2.0</td>
</tr>
<tr>
<td>Lagoon surface</td>
<td>0.37</td>
</tr>
<tr>
<td>Lagoon sludge</td>
<td>10.0</td>
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Manure Characteristics, as managed

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Manure Treatment >> Nutrient Recovery

- Solid-Liquid Separation
- Anaerobic Digestion
- Dissolved Air Flotation
Potential Value of Dairy Manure

Dairies over 500 cows or 2,647 dairies nationwide


Legend:
- Manure
- Concentrate
- Filtrate
- · Recycle (Qo)

Nutrient Recovery System

Carbon Footprint of Milk

17.6 lb CO₂e/gal

51.5% at the farm

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Nutrient Recovery System

Solid-Liquid Separation (Coarse)

- Why
  - Pipe clogging
  - Sludge accumulation
  - Storage crushing
  - Easier application
- Solids use
  - Bedding
  - Soil amendment
  - Compost

Coarse Solid Separation

Images provided by Newtrient, LLC
Coarse Solid-Liquid Separation Approaches in the U.S.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Performance</th>
<th>OPEX ($)</th>
<th>CAPEX ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary &amp; Secondary</td>
<td>15 – 30%</td>
<td>0.68 – 0.82</td>
<td>4.4 – 5</td>
</tr>
<tr>
<td>Mechanical Screens</td>
<td>15 – 25%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Nutrient Recovery System

Coarse Solid-Liquid Separation

Fine Solid-Liquid Separation

- Why
  - Phosphorus limited
  - Reduced truck traffic or cost
  - Field distance
  - Desire to irrigate
  - Nutrient market opportunity

Solids use
- Soil amendment & fertilizer
- Compost
## Fine Solids Separation / Dewatering

Images provided by Newtrient, LLC

Moving Disc Press
- Arrangement makes up of many vertically aligned plates that move linearly forward for an auger to force the material through a series of slots, being dewatered in the process. Material on the dewatering disks may or may not be removed by polymers or coagulants also used for dewatering following other fine solids separation systems.

Plate Presses
- Fine systems utilized to assist in dewatering.
- Dewatering of fine solids already precipitated by polymers or coagulants also used for dewatering following other fine solids separation systems.

Belt Filter Press
- A press in the form of a belt with filtration and dewatering of fine solids already precipitated by polymers or coagulants also used for dewatering following other fine solids separation systems.

### Fine Solids Separation / Dewatering

Images provided by Newtrient, LLC

Centrifuges
- Performed dewatering of fine particulates, centrifugal force may or may not be assisted by polymers or coagulants also used for dewatering following other fine solids separation systems.

Dissolved Air Flotation (DAF)
- A process involving the flotation of fine solids that are either small or hydrophobic in nature by an air bubble and may or may not be dewatered by polymers or coagulants also used for dewatering following other fine solids separation systems.

In-line Screen
- Similar to screen presses, but has a fibrous mesh, usually used with polymers or coagulants.

Struvite Crystallization
- A process involving mixing soluble forms of nitrogen, phosphorus, and potassium into a solution, slowly introcucing a calcium source which precipitates as a struvite crystal, a process used primarily in livestock systems.

## Advance Treatment of Dairy Manure

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Chemical &amp; Belt Press</th>
<th>UF Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Input (mg/L)</td>
<td>Effluent (mg/L)</td>
</tr>
<tr>
<td>Total Solids</td>
<td>4.2%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>1,740</td>
<td>634</td>
</tr>
<tr>
<td>Ammonia (NH₃-N)</td>
<td>864</td>
<td>552</td>
</tr>
<tr>
<td>Phosphorus (P₂O₅)</td>
<td>684</td>
<td>2</td>
</tr>
<tr>
<td>Potassium (K₂O)</td>
<td>1,356</td>
<td>924</td>
</tr>
</tbody>
</table>

Images provided by Newtrient, LLC

### Advance Treatment of Dairy Manure

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**Fine Solids Products**

![Phosphorus Cake]

**Fine Solid-Liquid Separation Approaches in the U.S.**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Performance</th>
<th>OPEX ($/1000gal)</th>
<th>CAPEX ($/1000gal/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequential Screening + Advance Non-Chemical</td>
<td>24 – 30%</td>
<td>50 – 65%</td>
<td>$3.4 – 6.8</td>
</tr>
<tr>
<td>Sequential Screening + Advance Chemical</td>
<td>45 – 55%</td>
<td>75 – 90%</td>
<td>$3.4 – 10.3</td>
</tr>
<tr>
<td>Struvite Crystallization</td>
<td>30%</td>
<td>75%</td>
<td>$12.3 – 15.1</td>
</tr>
</tbody>
</table>


**Nutrient Recovery System**

![Diagram of Nutrient Recovery System]

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Nitrogen Recovery

- Why
  - Application restrictions
  - Desire to irrigate
  - Nutrient market opportunity
- Technology
  - Air stripping
    - Temp, pH & ammonia concentration sensitive
  - Biological conversion
- Product use
  - Nitrogen gas or fertilizer
  - Low nutrient water

---

Nitrogen Recovery Approach in the U.S.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Performance</th>
<th>OPEX ($/1000gal)</th>
<th>CAPEX ($/1000gal/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia Stripping</td>
<td>65 – 85%</td>
<td>$14 – 26</td>
<td>$60 – 90</td>
</tr>
</tbody>
</table>


Based on data from various sources, assume 7,300 gal/cow/yr.
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Clean Water Approach in the U.S.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Performance</th>
<th>OPEX ($/100gal)</th>
<th>CAPEX ($/1000gal/yr)</th>
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</thead>
<tbody>
<tr>
<td>Salt Recovery</td>
<td>85 – 95%</td>
<td>$68–137</td>
<td>$200–250</td>
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</table>


Energy Generation / Thermal Conversion

Pyrolysis
Use of moderate temperatures (approximately 400°C or higher) in the absence of air to convert biomass solids into various energy-dense forms, providing combustible gases, liquids that can be further refined to liquid fuels and solid biochar.

Torrefaction
A form of partial or incomplete thermal conversion of biomass feedstock, resulting in the removal of volatile compounds and producing a fuel with a higher energy density than the original biomass.

Energy Generation / Anaerobic Digesters

Plug Flow
Complete Mix
Covered Lagoon

Images provided by Newtrient, LLC.
Fiber Drying & Bedding Recovery

Drum Dryers: A slightly inclined drum fed on high end well solids and cool, warm air flow of warm air sparging on the lower end. With drum rotating, water vapor is carried off and solids are moved to the end for evaporation and drying of solids.

Belt Dryers: A series of perforated metal plates which act as heat exchangers. Evaporation takes place across a horizontal flow of heated air. Indicating a reduction of moisture and drying of solids.

Composting Drums: Decaying biomass & reactor separated from solids rotating against hot-an air stream powered by a biological gas producer. Resulting in anaerobic compost product over 13 day reaction time.

Other Technologies

Vermifiltration: A series of perforated metal plates which act as heat exchangers. Indicating a reduction of moisture and drying of solids. Evaporative Systems: Beyond evaporation, as discussed above regarding moisture levels, moisture accumulation can be partially or completely removed by evaporating the liquid through a series of flash evaporation systems. Energy heat and/or power can be efficiently and effectively recovered. Recovery of useful products in the evaporated liquid is also required.

Products & Markets
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Where do we stand today

- Manure application costs inexpensive
- Social pressure extremely high
- Nutrient recovery technologies
  - Commercially viable technologies available
  - Capital and operational costs are high
  - Nutrients do not go away, still require management
- Manure storage practices
  - Planning for nutrient recovery products
  - Storage design standards may not apply to some products
- Resources and opportunities exist

Questions?

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