Utilizing Biosolids
As
Packaging or Building Material

Methods and equipment necessary to produce value added products from biosolids for packaging and building material applications.

John F. Hunt, P.E.
Research Mechanical Engineer
USDA Forest Products Laboratory, Madison, WI

Midwest Manure Summit, February 16, 2011
Presentation Overview

- Post-processing options
- Manure vs. Wood Fiber Comparison
- Packaging products
- Building materials
- Possible processing methods
- Considerations
- Summary
Post-Processing Options

“So in the case of a biogas plant treating energy crops, substrates high in lignin, cellulose and hemi-cellulose, hydrolysis becomes the speed determining process. Therefore for these plants, implementing a hydrolysing unit makes a lot of sense. In the case of a biogas plant treating wastes such as fats, oils, grease, vegetable or meat processing wastes or mixed food wastes acetogenesis and methanogenesis are the speed determining processes. Therefore a plant utilizing primarily food waste will not benefit from hydrolysing feedstocks prior to digestion.

As you can see the composition of the substrates (feedstock) that you are planning to use for your biogas plant determines the rate of anaerobic digestion from the decomposition rates of each substrate.”

Biogas-ology September 2010 Edition
Post-Processing Options

So ….. The output of the digestate is also important where fiber characteristics impact performance. You will need to pay attention to what you feed and the duration in the digester to get the type of fiber out that you want.

If you plan to make consistent products, then you also need to think about the output from the digestate which begins with the input.
As the Manure Passes through Digester

- % Lignin increases
- % Crude protein increases
- % Starch decreases

The fiber characteristics change and you need to understand what you have at the end.
Classification by weight percent vs. particle size for digested bovine manure and wood particles from a commercial particleboard operation.
Wood vs. Manure Comparison

<table>
<thead>
<tr>
<th>16 Mesh</th>
<th>20 Mesh</th>
<th>40 Mesh</th>
<th>&lt;40 Mesh - Fines</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB Wood</td>
<td>Manure</td>
<td>Fiber</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hwd ~ 1/16”</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Swd ~ 1/8”</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>~</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>?% Fines</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>~</td>
<td></td>
</tr>
</tbody>
</table>
Wood, Paper, vs. Manure Fiber

- Paper fiber is very different than particleboard or manure. Chemical digestion makes paper fiber flexible.
- Paper fiber’s surface energy level is very high for virgin and high for recycled paper fiber. Hence fiber-to-fiber bonding is higher.
- Paper fiber bonds well with other cellulosic fibers.
- Digested fiber has a lower surface energy.
- Digested fiber has a natural bonding protein on the surface of the fiber and in the liquid fraction.
- Digestate fiber is very stiff.
- Digestate has other “roughage” that needs to be reduced in size.
Post-Processing Options

**Wet-forming Refiner:**

A refiner is necessary to break up larger particles, seed hulls, and fiber bundles into a more homogeneous mixture of cellulosic material.

Material flows into the middle and passes between spinning disks that have an adjustable gap. The gap sets the particle size.
Simple Pulp Molding Line

Add digestate here

Add refiner here
Packaging Products

Three pulp molding machines making egg trays

Midwest Manure Summit, February 16, 2011
CowPots Specifications

Cowpots are available in all typical popular seed starter pot sizes. To purchase wholesale quantities of CowPots, contact us via email at info@cowpots.net. For smaller orders, consider purchasing from one of our many retail partners.

3” Round
275 ml
16 cu in

3 1/4”
(82mm)

3 3/8”
(86mm)

2 1/4”
(57mm)

3” Square
200 ml
12 cu in

3”
(76mm)

2 7/8”
(73mm)

1 7/8”
(48mm)

4” Square
450 ml
27 cu in

3 3/4”
(95mm)

4”
(101mm)

2 1/2”
(64mm)
Packaging Products

Manure, recycled paper

Ag Prod. Digestate 80% recycled paper 20%

Pulp molding patents with manure or digestate.
Increasing density or increasing fiber-to-fiber contact has a significant impact on strength of a fiber product.

\[ y = 1.037 \times 10^{-5} x^{2.247} \]

\[ y = 3.7497 \times 10^{-6} x^{2.315} \]
Packaging Products

Low-Density (Usually made from paper fiber)
• Egg Cartons – ~2oz./per
• Agricultural plant pots
• Paper
• Absorbent Items

Mid-to-High-Density
• Pallets
• Misc. material distribution containers
• Spacers
• Paper
• ?

Fiber Filled Plastic Composites
• Non-food contact applications
Building Materials

**Low- Medium Density < 45lb/ft\(^3\)**
- Insulation panels
- Shear panels
- Concrete slab spacers
- Core material (between laminates)

**High-Density > 45 lb/ft\(^3\)**
- Particleboard like ( 3/8 to 3/4 inch)
- Hardboard like (1/10 to 3/16 inch)
- Sheathing
- Specialty (3D shapes)

**Digestate-Fiber Filled Plastic Composites**
- Decking
Figure 11–3. Classification of wood composite panels by particle size, density, and process (Suchsland and Woodson 1986). Note that insulation board is now known as cellulosic fiberboard. (Wood Handbook: 2010)
Figure 11–9. Examples of grade stamps for particleboard. (Courtesy of TECO, Sun Prairie, Wisconsin, and Composite Panel Association, Leesburg, Virginia. Used by permission.) (Wood Handbook: 2010)
Building Material Standards

Return to Resources

CPA Publications
(The following items are available for purchase. Items that are available electronically are noted and will be emailed separately)

Category: Standards

ANSI 208.1-2009 Particleboard Standard

Industry standard for particleboard

* This item is not available electronically.

Your Price $50.00

Order
# Building Materials

## Annex B
(Informative)

<table>
<thead>
<tr>
<th>General use and grades</th>
<th>Grade</th>
<th>Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>M-1, M-S</td>
<td>A</td>
</tr>
<tr>
<td>Industrial</td>
<td>M-2, M-3</td>
<td>A</td>
</tr>
<tr>
<td>High density industrial</td>
<td>H-1, H-2, H-3</td>
<td>A</td>
</tr>
<tr>
<td>Door core</td>
<td>LD-1, LD-2</td>
<td>A</td>
</tr>
<tr>
<td>Interior Stair Tread†</td>
<td>M-3</td>
<td>A</td>
</tr>
<tr>
<td>Exterior construction</td>
<td>M-1-Exterior glue, M-S-Exterior glue, M-2-Exterior glue, M-3-Exterior glue</td>
<td>A</td>
</tr>
<tr>
<td>Exterior industrial</td>
<td>M-1-Exterior glue, M-S-Exterior glue, M-2-Exterior glue, M-3-Exterior glue</td>
<td>A</td>
</tr>
<tr>
<td>High density exterior industrial</td>
<td>H-1-Exterior glue, H-2-Exterior glue, H-3-Exterior glue</td>
<td>A</td>
</tr>
<tr>
<td>Underlayment</td>
<td>PBU</td>
<td>B</td>
</tr>
<tr>
<td>Manufactured Home Decking</td>
<td>D-2, D-3</td>
<td>B</td>
</tr>
</tbody>
</table>

Figure 11–9. Examples of grade stamps for particleboard. (Courtesy of TECO, Sun Prairie, Wisconsin, and Composite Panel Association, Leesburg, Virginia. Used by permission.) (Wood Handbook, 2010)
Building Materials

Panel Processing Options

• Air-Dried Fiber Forming – will need adhesive

• Semi-dry Forming

• Wet-Forming Direct Digestate

• [Wet-Forming](#) with Wood Particles or Paper Fiber

• Air-Dried Fiber/Plastic Composites

• ?
The Product Defines the Process

Output of the digestate is important where fiber characteristics impact performance. You need to pay attention to what you feed and duration in the digester to get out what you want.

If you plan to make consistent products, then you also need to think about the output from the digestate which begins with the input.
Considerations

**Sell Fiber as a Raw Material**
- Fiber processing (fiber fractionation, refining, material handling)
- Minimal additional effort

**Develop On-site or Coop Products:**
- Fiber processing (fiber fractionation, refining, material handling)
- Pumps
- Water management
- Forming Equipment
- Hydropulper
- Cold press
- Hot Press (Including hot-oil or steam boiler from heat exchanger)
- Hydraulics
- Dedicated personnel
Considerations

**On-site Farmer Benefits:**
- Energy (Heating, electricity, waste energy)
- Water
- Biological control through the digestater.
- Source of fiber (24/7 – 365)
- Land (Buildings)

**Considerations:**
- Focus on value added products not commodity products for better return on investment.
- Partner with someone in the business for niche market(s) that have existing market distribution channels.
Summary

- Digested Manure Fiber – Similar but different than wood. Higher crystalline cellulose, lower hemicellulose which is more hydrophobic.
- Digested Manure Fiber – stiffer, less flexible than paper fiber
- Size distribution impacts packing, flow, and bonding. Consider fiber fractionation to separate into various fiber uses.
- Refining is necessary for homogeneity (reduce seed hulls and long fiber bundles).
- Digesters provide valuable resource: energy, fiber, water.
- Consider developing a coop to pool resources.
- Consider partnership with a company to provide expertise in fiber forming and distribution channels.