Breaking it Down: Cotton’s Biodegradability in Various Environments
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Breaking it Down: Cotton’s Biodegradability in Various Environments
Biodegradability of Cotton and Polyester in Soil
Disposing of old clothes...

What’s the problem?

- The average American discards about 70 pounds of clothing per year\(^1\)
- Of that only about 10 pounds are donated
- The remaining 60 pounds end up in landfills
  - 327 million people in the US
  - 20 billion pounds of textile waste goes to US landfills each year

Recycling Options

- Donation
  - Charities
  - Retailers
- Municipal recycling programs
  - Sort through the waste
  - Creates different streams
  - Convenience
What happens to fabrics in a compost pile?

- Today’s landfills are good at preserving things.
- Little air, water, sunlight and bacteria available.
- How well would natural soil break down garments?
- Could back-yard composters convert their fabrics to soil?
Three biodegradation methods have been explored...

- ASTM D5988-03
- Composting in winrows at Cornell University
- ASTM D6400 Compostable Product Test
  - Controlled temperature, moisture level, carbon:nitrogen ratio
  - Compost bin was used
Design of Trials One and Two

ASTM D5988-03 and Composting

- Fabrics Evaluated
  - 100% cotton jersey, scoured and bleached, no finish
  - 100% cotton jersey, scoured and bleached, softener only
  - 100% cotton jersey, scoured and bleached, resin plus softener
  - 100% polyester shirt

- Fabrics were laundered 30 times before testing
  - D5988-03 measures the generation of CO$_2$
  - In composting, weight loss is measured
  - Fabrics were exposed for 90 days
Results of ASTM D5988-03

% converted to CO2

- Cotton NF
- Cotton S
- Cotton R
- Polyester
Degradation of Fibers in Compost

Cornell University composting facility

% weight loss

Cotton NF  |  Cotton S  |  Cotton R  |  Polyester

%weight loss
Degradation in Soil

0 Days

90 Days

Cotton, NF

Cotton, Softener

Cotton, Resin

Polyester
Design of Trial Three

ASTM D6400 (Biodegradability Testing in Compost)

- Fabrics Evaluated
  - 100% cotton jersey, scoured and bleached, softener only
  - 100% cotton jersey, scoured and dyed black, plus softener
  - 100% recycled polyester shirt

- Fabrics were laundered 30 times before testing
- Carbon-to-nitrogen ratio of 30:1
- Moisture content 45–50%
- Fabrics were exposed for 12 weeks (84 days)
Recycled Polyester T-Shirt

Cotton Jersey, Bleached, Softened

Cotton Jersey, Dyed Black, Softened

Week 0 Compost Bin
Recycled Polyester T-Shirt

Cotton Jersey, Bleached, Softened

Cotton Jersey, Dyed Black, Softened

Week 6 Compost Bin

Week 6
Recycled Polyester T-Shirt

Cotton Jersey, Bleached, Softened

Cotton Jersey, Dyed Black, Softened

Week 12 Compost Bin

Week 12
Biodegradability of Wet Wipes
Cotton Nonwoven Degradation in Soil
Methodology

- ASTM D-6400
  - Standard Specification for Labeling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities
- Materials tested
  - Spunlaced nonwovens
    - 100% virgin cotton
    - 100% virgin cleaned cotton
    - 100% purified cotton
    - 55% purified cotton/45% PP
Methodology

- Samples were prepared, weighed, and placed into an active compost vessel.
- Every 2 weeks, samples were removed from the compost vessel, dried, weighed, and photographed.
- Average percent biodegradability was calculated for each sample.
- Biodegradability was accomplished at 90+% mass loss.
- 100% cotton nonwovens biodegraded 90+% within 4 weeks.
Nonwoven Results
100% Virgin Cotton Composting (ASTM D6400)

Week 0

Week 2

Week 4

Sample #4

% BIODEGRADATION

TIME IN WEEKS

0 10 20 30 40 50 60 70 80 90 100

2 4

100

28

92
100% Virgin Cleaned Cotton Composting (ASTM D6400)

Sample #3
100% Purified Cotton Composting (ASTM D6400)

Week 0

Week 2

Week 4

Sample #9

% BIODEGRADATION

TIME IN WEEKS

0 10 20 30 40 50 60 70 80 90 100

Week 0

Week 2

Week 4

Sample #9

Composting (ASTM D6400)
55% Purified Cotton/45% PP
Composting (ASTM D6400)

Week 0 | Week 2 | Week 4 | Week 6

% Biodegradation

<table>
<thead>
<tr>
<th>TIME IN WEEKS</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
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<tbody>
<tr>
<td>Sample #1</td>
<td>14</td>
<td>42</td>
<td>50</td>
<td></td>
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</table>
Conclusions

- Cotton wipes biodegrade quickly in a composting container
- 100% cotton: 92 – 95% in four weeks
- Blend: Cotton biodegraded; Polypropylene did not
Biodegradability of Wet Wipes

Flushability
Methodology

- Followed Guidelines for Assessing the Flushability of Nonwoven Disposable Products
  - INDA/EDANA
  - Developed as standards for the industry to produce wet wipes that can be marketed as flushable to consumers
- 2 Test Methods:
  - Aerobic Biodisintegration (FG 505)
  - Anaerobic Biodisintegration (FG 506)
- Materials Tested
  - 60 gsm nonwovens measured at approximately 2 grams per sample
Results
Virgin Cotton
Aerobic Biodisintegration (Sewer System)

<table>
<thead>
<tr>
<th>Sample #1</th>
<th>Sample #2</th>
<th>Sample #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Weight (g)</td>
<td>Final Weight (g)</td>
<td>Mass Loss</td>
</tr>
<tr>
<td>97%</td>
<td>100%</td>
<td>97%</td>
</tr>
<tr>
<td>97%</td>
<td>100%</td>
<td>97%</td>
</tr>
</tbody>
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Minimum Required Mass Loss: 95%
Average Mass Loss: 98%

28 Day Test
Purified Cotton
Aerobic Biodisintegration (Sewer System)

28 Day Test
Minimum required mass loss: 95%
Average mass loss: 100%
Virgin Cotton
Anaerobic Biodisintegration (Septic System)

Minimum required mass loss: **95%**
Average mass loss: **74%**

28 Day Test

<table>
<thead>
<tr>
<th>Sample</th>
<th>Initial Weight (g)</th>
<th>Final Weight (g) After 28 Days</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>2.0</td>
<td>0.8</td>
</tr>
<tr>
<td>#2</td>
<td>2.0</td>
<td>0.6</td>
</tr>
<tr>
<td>#3</td>
<td>2.0</td>
<td>1.2</td>
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</tbody>
</table>

**70% Mass Loss**

**85% Mass Loss**

**68% Mass Loss**
# Purified Cotton

## Anaerobic Biodisintegration (Septic System)

<table>
<thead>
<tr>
<th>Sample #1</th>
<th>Sample #2</th>
<th>Sample #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Weight (g)</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Final Weight (g)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### 28 Day Test

- Minimum required mass loss: **95%**
- Average mass loss: **100%**

![Graph showing mass loss over 28 days](image.png)
Conclusions

- Similar results to the composting test
- Purified cotton biodegraded faster than the virgin cotton
- Cotton – An example of the cycle of nature
Thank You
Breaking it Down: Cotton’s Biodegradability in Various Environments
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