Designing with Nature: LID & Stormwater Quality Treatment with Compost BMPs

Dr. Britt Faucette, PhD, CPESC, LEED AP
Director of Research/Technical Services, Filtrexx International
Outline

• Stormwater: Gray to Green Infrastructure (LID)
• Compost & Stormwater Volume and Quality
• Compost Applications (BMPs)
• Research, Performance, & Design
• Case Study
• Q/A
Stormwater Impact

- 850 - US cities with outdated & under-designed SWM infrastructure
- 75% of Americans live near polluted waters
- 48,800 TMDL listed (impaired) water bodies
- $44,000,000,000 – annual total cost to society
Grey Infrastructure is...

- Centralize Collection, Conveyance & Treatment
- Land Intensive
- Infrastructure Intensive
- Pollution Intensive
- Energy Intensive
Land Use = Hydrology = Pollutant Load = Water Impairment

Source: Sego Jackson, 2001

*water that travels just below the surface
75% of Us Live Near a Polluted Water

- Coliform bacteria (10,900 streams)
- Metals – Cu, Cd, Cr, Ni, Pb, Zn (8600 streams)
- Nutrients – N & P (5300 streams)
- Turbidity/TSS - Clay & Fine Silt Sediment (5100 streams)
- Petroleum Hydrocarbons - Motor Oil, Diesel Fuel, Gasoline (polycyclic aromatic hydrocarbons)
Storm Water Pollution Areas

- Parking Lots, Highways/Streets, Rooftops
- Golf Courses, Lawns, Pet Parks
- NPDES Stormwater Permits:
  - MS4s, Industrial, Construction
  - CAFOs, CSOs

Who

- Trout/Salmon bearing
- Endangered species
- Eutrophic water bodies
- Beaches/Recreational
- TMDL designated streams

Sources

Priority Areas
Low Impact Development (LID) =

hydrology mimics natural site, distributed, decentralized

- Runoff Volume ↓
- Runoff Rate ↓
- Pollutant Loading ↓
- Flooding ↓
- CSOs ↓

✓ Water Quality ↑
✓ Wildlife Habitat/Biodiversity ↑
✓ Aesthetics/Land Value ↑

Green Infrastructure = green stormwater management; site preservation/restoration; integrated design & practices; reuse
Low Impact Development (LID) =
restore natural site hydrology; decentralize
Compost Tools

Filter Media
- Designed for Optimum Filtration & Hydraulic-flow

Growing Media
- Designed for Optimum Water Absorption & Plant Growth
# Stormwater BMPs

## Erosion & Sediment Control

1. Perimeter Control
2. Inlet Protection
3. Ditch Check
4. Filter Ring/Concrete washout
5. Slope Interruption
6. Runoff Diversion
7. Vegetated Cover
8. Erosion Control Blanket
9. Vegetated Sediment Trap
10. Pond Riser Pipe Filter

## Low Impact Development

11. Runoff Control Blanket
12. Vegetated Filter Strip
13. Engineered Soil
14. Channel Liner
15. Streambank Stabilization
16. Biofiltration System
17. Bioretention System
18. Green Roof System
19. Living Wall
20. Green Retaining Wall
21. Vegetated Rip Rap
22. Level Spreader
23. Green Gabion
24. Bioswale
Natural Stormwater Management

50% evapotranspiration

35% surface water detained/infiltrated

15% surface water runoff

Organic Matter
Topsoil

Subsoil

Groundwater

Bedrock
Designed to: 1) dissipate energy of rain impact; 2) hold, infiltrate & evaporate water; 3) slow down/disperse energy of sheet flow; 4) provide for optimum vegetation growth
LID: Rainfall Absorption

(4”/hr 1-hr; 100 yr return)

- Bare Soil: %
- Straw Mulch: %
- Compost Blanket: 84%
# Runoff Volume Reduction

<table>
<thead>
<tr>
<th>Reduction</th>
<th>Influencing Factors</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>49%</td>
<td>Sandy clay loam, 10% slope, 1.5” blanket, 3.2 in/hr – 1 hr rain</td>
<td>Faucette et al, 2005</td>
</tr>
<tr>
<td>60%</td>
<td>Sandy clay loam, 10% slope, 1.5” blanket, 4.0 in/hr – 1 hr rain</td>
<td>Faucette et al, 2007</td>
</tr>
<tr>
<td>76%</td>
<td>Silty sand, 2:1 slope, 3” blanket, 1.8 in/hr - 2.4 hr rain</td>
<td>Demars et al, 2000</td>
</tr>
<tr>
<td>90%</td>
<td>Loamy sand, 3:1 slope, 2” blanket, 4.0 in/hr – 2 hr rain</td>
<td>Persyn et al, 2004</td>
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</tbody>
</table>
# Peak Flow Rate Reduction

<table>
<thead>
<tr>
<th>Reduction</th>
<th>Influencing Factors</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>36%</strong></td>
<td>Sandy clay loam, 10% slope, 1.5” blanket, 3.2 in/hr – 1 hr rain</td>
<td>Faucette et al, 2005</td>
</tr>
<tr>
<td><strong>42%</strong></td>
<td>Sandy clay loam, 10% slope, 1.5” blanket, 4.0 in/hr – 1 hr rain</td>
<td>Faucette et al, 2007</td>
</tr>
<tr>
<td><strong>79%</strong></td>
<td>Loamy sand, 3:1 slope, 2” blanket, 4.0 in/hr – 2 hr rain</td>
<td>Persyn et al, 2004</td>
</tr>
<tr>
<td>Study</td>
<td>Methodology</td>
<td>Total N</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Mukhtar et al, 2004</td>
<td>(seed+fertilizer)</td>
<td>88%</td>
</tr>
<tr>
<td>Faucette et al, 2007</td>
<td>(seed+fertilizer)</td>
<td>92%</td>
</tr>
<tr>
<td>Faucette et al, 2005</td>
<td>(hydromulch)</td>
<td>58%</td>
</tr>
<tr>
<td>Persyn et al 2004</td>
<td>(seed+topsoil)</td>
<td>99%</td>
</tr>
</tbody>
</table>
## Peak Flow Rate Reduction

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<td>Faucette et al, 2005</td>
</tr>
<tr>
<td><strong>42%</strong></td>
<td>Sandy clay loam, 10% slope, 1.5” blanket, 4.0 in/hr – 1 hr rain</td>
<td>Faucette et al, 2007</td>
</tr>
<tr>
<td>(30% relative to straw)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>79%</strong></td>
<td>Loamy sand, 3:1 slope, 2” blanket, 4.0 in/hr – 2 hr rain</td>
<td>Persyn et al, 2004</td>
</tr>
</tbody>
</table>
## Runoff Curve Numbers

<table>
<thead>
<tr>
<th>Watershed Surface</th>
<th>Curve Number*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking lot, driveway, roof</td>
<td>98</td>
</tr>
<tr>
<td>Commercial district</td>
<td>92</td>
</tr>
<tr>
<td>Dirt road</td>
<td>82</td>
</tr>
<tr>
<td>Residential lot: ¼ ac, ½ ac, 1 ac</td>
<td>75, 70, 68</td>
</tr>
<tr>
<td>Cropland</td>
<td>71-81</td>
</tr>
<tr>
<td>Pasture</td>
<td>61-79</td>
</tr>
<tr>
<td>Public green space</td>
<td>61-69</td>
</tr>
<tr>
<td>Woodland and forests</td>
<td>55-66</td>
</tr>
<tr>
<td>Brush &gt;75% cover</td>
<td>48</td>
</tr>
<tr>
<td>Vegetated Compost Blanket</td>
<td>55</td>
</tr>
</tbody>
</table>

*Based Hydrologic Soil Group B

Reference: USDA SCS, 1986
Ecosystem Services: Economics of Grey vs Green SWM

- Compost Blanket vs Impervious Surface
- Area = 10 acres
- Design Storm = 3 in/24 hr

✓ Stormwater Volume = 54,300 vs 752,100 gallons (1400% increase!)

- **Option 1: Containment/Pond:**
  - Real Estate Value = $50,000/acre
  - SW Pond Design/Construction = $1/gal

✓ Stormwater Pond (4 ft deep) = 0.5 acre
  - -$25,000 (lost usable real estate)
✓ Stormwater Pond Cost = $697,800 (design/construction)
  - TOTAL = $722,800
Ecosystem Services:
Economics of Grey vs Green SWM

• Compost Blanket vs Impervious Surface
• Area = 10 acres
• Design Storm = 3 in/24 hr

✓ Stormwater Volume = 54,300 vs 752,100 gallons (1400% increase!)

• Option 2: Off-Site Discharge (Grid):
• Water Conveyance Cost = $0.26/gal
• Water Treatment Energy Cost = 2 kWh/1000 gal
• Energy Cost = $0.13/kWh
• Carbon Emission = 2 lbs CO2/kWh

✓ Water Conveyance = $181,428/yr
✓ Energy Cost = $91/year
✓ Carbon Emission = 1,396 lbs/CO2/yr
Compost Tools

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• Designed for Optimum Filtration & Hydraulic-flow

Growing Media
• Designed for Optimum Water Absorption & Plant Growth
# Stormwater BMPs

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22. Level Spreader
23. Green Gabion
24. Bioswale
Sediment Control/
Stormwater BMPs

- Silt Fence
- Straw Bale
- Mulch Berm
- Fiber Rolls
- Straw Wattles
- Filtration
- Chemical Treatment
- Stormwater Ponds
Compost Sock

3-Way Biofiltration

• Physical
  – Traps sediment in matrix of varying pore spaces and sizes

• Chemical
  – Binds and adsorbs pollutants in storm runoff

• Biological
  – Degrades various compounds with bacteria and fungi
Particle Size Specifications

**Filter Media Specifications and Their Performance**

- **Flow Through Rate**
- **Filtration Ability**
- **Optimum Performance Zone**

```
Flow Through Rate gpm/ft²

Flow Through Rate

Filtration Ability

Optimum Performance Zone

Particle Size
```

```
.25  .5  .75  1  2

.375

Sediment Removal Percentage

100  90  80  70  60  50  40  30  20  10
```
(Bio)Filtration Devices use Filter Media
## TS Reduction of Sediment Barriers

<table>
<thead>
<tr>
<th></th>
<th>Runoff Exposure</th>
<th>Sediment Exposure</th>
<th>Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filter Sock</strong></td>
<td>• 260 gal</td>
<td>• 850 lbs</td>
<td>77%</td>
</tr>
<tr>
<td></td>
<td>• 1.7 g/ft²</td>
<td>• 150 lbs/ft²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 2.75 ac-in</td>
<td>• 125 t/a</td>
<td></td>
</tr>
<tr>
<td><strong>Silt Fence</strong></td>
<td>• 260 gal</td>
<td>• 850 lbs</td>
<td>72%</td>
</tr>
<tr>
<td></td>
<td>• 1.7 g/ft²</td>
<td>• 150 lbs/ft²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 2.75 ac-in</td>
<td>• 125 t/a</td>
<td></td>
</tr>
<tr>
<td><strong>Straw Wattle</strong></td>
<td>• 260 gal</td>
<td>• 850 lbs</td>
<td>59%</td>
</tr>
<tr>
<td></td>
<td>• 1.7 g/ft²</td>
<td>• 150 lbs/ft²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 2.75 ac-in</td>
<td>• 125 t/a</td>
<td></td>
</tr>
</tbody>
</table>

ASTM 6459 for RECPs
% TSS Reduction of Sediment Barrier

- 8" Compost Filter Sock
- 12" Compost Filter Sock
- Mulch Filter Berm
- Straw Bale

Runoff Volume:
- 315 gal
- 42 ft³
- 6.5 gal/ft²
- 10.4 ac-in

Sediment:
- 15 lbs
- 6000 mg/L
# Sediment Summary

## % Reduction of TSS & Turbidity

<table>
<thead>
<tr>
<th>Treatment</th>
<th>TSS</th>
<th>Turbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt Fence</td>
<td>67</td>
<td>52</td>
</tr>
<tr>
<td>Filter Sock</td>
<td>78</td>
<td>63</td>
</tr>
</tbody>
</table>

* Based on rainfall of 3.0 in/hr for 30 min; runoff sediment concentration (sandy clay loam) of 70,000 mg/L.
## Stormwater Pollutant Removal

<table>
<thead>
<tr>
<th></th>
<th>TSS</th>
<th>Turbidity</th>
<th>Total N</th>
<th>NH$_4$-N</th>
<th>NO$_3$-N</th>
<th>Total P</th>
<th>Sol. P</th>
<th>Total coli.</th>
<th>E. coli.</th>
<th>Metals</th>
<th>Oil</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Sock</td>
<td>80%</td>
<td>63%</td>
<td>35%</td>
<td>35%</td>
<td>25%</td>
<td>60%</td>
<td>92%</td>
<td>98%</td>
<td>98%</td>
<td>37-78%</td>
<td>99%</td>
<td>99%</td>
</tr>
</tbody>
</table>

Sources:
- USDA
- JEQ
- Filtrexx
Stormwater Pollutant Removal w/ Filter Socks

• Britt Faucette¹, Fatima Cardoso¹&², Eton Codling², Carrie Green², Dan Shelton², Yakov Pachepsky², Gregory McCarty², Andrey Guber²

1. Filtrexx International, Atlanta, GA;
2. USDA-ARS, Beltsville, MD
Compost + Additives

• To target specific runoff pollutant
  – Fine Sediment
  – Nutrients (N & P)
  – Bacteria
  – Metals
  – Petroleum Hydrocarbons
Fine Sediment Removal

FilterSoxx Fine Sediment Removal over 30 min Runoff Event

- Silt
- Clay

Sediment Removal Efficiency (%)

Class 1: 0.01 um - 5.754 um
Class 2: 5.754 um - 19.953 um
Soluble P

-92%

-27%
Nitrogen Removal

N Removal Efficiency

FilterSoxx + NitroLoxx

FilterSoxx

+ Additive

Filter Sock
Bacteria Removal

**Bacteria (MPN) Exposure**
- Total coliform – 200 million/100 mL
- E. coli – 170 million/100 mL
- *Typical* – 50,000/100 mL
# Metals Removal

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Parameters (mg)</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Surface</td>
<td></td>
<td>0.004</td>
<td>0.019</td>
<td>6.491</td>
<td>0.144</td>
<td>0.154</td>
<td>2.028</td>
</tr>
<tr>
<td>Transported to Soxx</td>
<td></td>
<td>0.812</td>
<td>0.490</td>
<td>1.640</td>
<td>1.056</td>
<td>0.937</td>
<td>1.669</td>
</tr>
<tr>
<td>Runoff Water</td>
<td></td>
<td>0.210</td>
<td>0.221</td>
<td>0.383</td>
<td>0.301</td>
<td>0.144</td>
<td>0.621</td>
</tr>
<tr>
<td>Removal Efficiency*</td>
<td></td>
<td>72</td>
<td>29</td>
<td>70</td>
<td>69</td>
<td>79</td>
<td>57</td>
</tr>
<tr>
<td>Runoff Sediment</td>
<td></td>
<td>0.014</td>
<td>0.039</td>
<td>0.122</td>
<td>0.029</td>
<td>0.105</td>
<td>0.161</td>
</tr>
<tr>
<td>Removal Efficiency*</td>
<td></td>
<td>77</td>
<td>78</td>
<td>45</td>
<td>63</td>
<td>61</td>
<td>47</td>
</tr>
<tr>
<td>Total Runoff</td>
<td></td>
<td>0.224</td>
<td>0.260</td>
<td>0.505</td>
<td>0.330</td>
<td>0.249</td>
<td>0.782</td>
</tr>
<tr>
<td>Removal Efficiency (%)</td>
<td></td>
<td>73</td>
<td>47</td>
<td>70</td>
<td>69</td>
<td>73</td>
<td>53</td>
</tr>
</tbody>
</table>

*Relative to Bare Soil w/out Treatment
Petroleum Hydrocarbons

- Runoff Concentrations = 1,400 mg/L (motor oil), 5,400 mg/L (diesel), and 74 mg/L (gasoline)
- Runoff Loads = 20,820 mg (motor oil), 77,440 mg (diesel), and 1,070 mg (gasoline)
## City of Chattanooga

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>1600 mg/L</td>
<td>259 mg/L</td>
<td>255 mg/L</td>
<td>125 mg/L</td>
<td>125 mg/L</td>
<td>405 mg/L</td>
<td>214 mg/L</td>
<td>75-93</td>
</tr>
<tr>
<td>TSS</td>
<td>1370 mg/L</td>
<td>208 mg/L</td>
<td>38 mg/L</td>
<td>18 mg/L</td>
<td>24 mg/L</td>
<td>249 mg/L</td>
<td>177 mg/L</td>
<td>82-99</td>
</tr>
<tr>
<td>Oil/Grease</td>
<td>107 mg/L</td>
<td>27 mg/L</td>
<td>N/A</td>
<td>N/A</td>
<td>5 mg/L</td>
<td>18 mg/L</td>
<td>37 mg/L</td>
<td>65-95</td>
</tr>
</tbody>
</table>
"...an essential tool for engineers, designers, architects, regulators, planners, managers, contractors, consultants, policymakers, builders, and water resource managers." – Forester Press
Contact Me

• Britt Faucette, Ph.D., CPESC, LEED AP Director of Research/Technical Services

• Ph: 678 592 7094
  brittf@filtrexx.com

• www.filtrexx.com