Enhancing Markets for Recovered C&D Derived Products: Opportunities with C&D Fines and Wood-Derived Biochar

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Major C&D Recovered Commodities

- Aggregate
- Wood
- Fines
- Metal
- Cardboard
- Gypsum Drywall
- Asphalt Shingles
- RDF
C&D Wood

• Dimensional lumber
• Pallets
• Land clearing wood
• Engineered wood
  • Plywood
  • MDF
  • OSB
• Treated wood
C&D Fines

- Materials screened from the mixed CDD
  - Soil  \(\text{Major}\)
  - Aggregate  \(\text{Major}\)
  - Wood  \(\text{Minor}\)
  - Gypsum  \(\text{Minor}\)
  - Shingles
- Depends on waste stream, materials removed, degree of processing
- Size depends on screen size
- Management options:
  - Reuse as alternative daily cover at landfills
  - Reuse outside of landfills
CDRA Fines Characterization Study

Asphalt
- 15.2%
- 10.9%
- 16.5%

Gypsum
- 5.02%
- 10.1%
- 5.87%

Concrete
- 42.9%
- 49.6%
- 49.6%

Paper
- 5.01%
- 5.87%
- 16.5%

Wood
- 20.1%
- 16.5%
- 16.5%

Glass
- 11.5%
- 3.65%
- 3.65%

Cotton
- 0.03%
- 0.02%
- 0.02%

Plastics
- 0.10%
- 1.11%
- 1.11%

Steel
- 0.14%
- 2.38%
- 2.38%

> 25 mm

19 mm – 25 mm
Potential Fines Markets and Issues

- Landfill Cover
  - Will it suppress fires?
  - Will it cause odor?
  - Meet fill needs?
  - Will it pose environmental risk?
  - Will it meet amendment needs?
  - Will it pose environmental risk?

- Fill material

- Soil/agricultural amendment
In some cases, beneficial use risk levels may already be provided for C&D fines.

<table>
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<th>CAS No.</th>
<th>Analyte</th>
<th>Residential SL (mg/kg)</th>
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<td>83-32-9</td>
<td>Acenaphthene</td>
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<td>30560-19-1</td>
<td>Acephate</td>
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Guidelines for the Beneficial Use of Recovered Screen Material

Division of Materials and Waste Management
Construction & Demolition Debris Recycling Program
November 2015
Most trace components were not found to be a concern.
  • Asbestos, PCBs, most metals

Four components emerge as levels of possible concern:
  • Arsenic
  • Lead
  • Benzo-a-pyrene (BAP)
  • Sulfate

Exposure concern

Landfill odor concern
Distribution of Lead by Particle Size

Pb concentrations in different cumulative size fractions (mg/kg)

- 0-19mm
- 0.30-19mm
- 0.84-19mm
- 4.76-19mm

Residential SCTL/ RSL

C

G
Washing Results for Sample A

Aggregate without washing (above) and aggregate after washing (below)

- Floatables: 22%
- Fines: 39%
- Aggregate: 39%
Washing Results for Sample B

Aggregate without washing (above) and aggregate after washing (below)

- Floatables: 6%
- Aggregate: 13%
- Fines: 81%
Transitioning from Managing By-Products to Developing Products

• Limitations often exist to the reuse of C&D fines

• Opportunities to reduce pollutant concentrations:
  • Be more selective on the waste processed
  • Target specific size fractions
  • Washing
  • Blending

• What about the gypsum drywall problem when the desired market is landfill daily cover?
The Challenge of Gypsum Drywall in Landfills

• Issues with Hydrogen Sulfide (H$_2$S)
  • Odor
  • Health and safety

Gypsum (CaSO$_4$$\cdot$2H$_2$O) → Water → Sulfate (SO$_4^{2-}$) → sulfide (H$_2$S)
Creating a Better Landfill Cover Product
Biochar

• Produced by pyrolysis of biomass under oxygen-limited conditions
• Fine-grained and porous substances
• Activated carbon and biochar is known to absorb $\text{H}_2\text{S}$
Proof of Concept Study

- **Objective**: Explore whether addition of biochar could attenuate \( \text{H}_2\text{S} \) emissions from landfilled C&D fines
- **Approach**: Mix biochar and C&D fines in simulated landfill reactors and measure \( \text{H}_2\text{S} \) generation
Materials

• Two C&D fines
• Two biochar samples
Preliminary experiment

100ml 25ppm H₂S

250ml bottle

30g size reduced biochar 2

30g size reduced biochar 2

250ml bottle

60g size reduced biochar 2

60g size reduced biochar 2

250ml bottle

90g size reduced biochar 2

90g size reduced biochar 2

250ml bottle

Store in dark for 3 days

Measure H₂S

H₂S (ppm)

No biochar  30g biochar  60g biochar  90g biochar
Experimental flask

- Sampling / nitrogen flushing valves
- Twist seal cap with two valve slots
- C&D fines, biochar and water
H2S measurement

- Use a glass syringe to take H$_2$S out of flask
- Inject the gas into a tedlar bag (dilute if necessary)
- Measure the H$_2$S in the bag using a Jerome 631-X H$_2$S analyzer

- The Jerome meter has a detection range of 0.003-50ppm
- The H$_2$S was diluted using the lab air if higher than 50ppm
- The Jerome meter was checked using a 25ppm H$_2$S standard gas before measurement
Results
Results

Week 2

C&D Facility 2
Biochar 1

H$_2$S (ppm)

Control  120g biochar 1  240g biochar 1  360g biochar 1

Control
120g biochar 1
240g biochar 1
360g biochar 1
Results
Results

![Graph showing results of Week 4 with comparison of Control, 120g biochar 1, 240g biochar 1, and 360g biochar 1 for C&D Facility 2 Biochar 1. The graph plots H$_2$S (ppm) on the y-axis against treatments on the x-axis. The control has significantly higher H$_2$S levels compared to the biochar treatments.]
Results

C&D fines 2

Cumulative $\text{H}_2\text{S}$ concentration (ppm)

Week 1  Week 2  Week 3  Week 4  Week 5  Week 6  Week 7  Week 8

- Control
- 120g Biochar 1
- 240g Biochar 1
- 360g Biochar 1
- 120g Biochar 2
- 240g Biochar 2
- 360g Biochar 2
Focused Research Effort for End Market Development

- Determine the optimum approach or recipe for blending C&D fines and biochar in the laboratory
- Validate with pilot and field studies
Phase I

• Using laboratory landfill simulations, examine multiple properties and develop a blending strategy or recipe.
Phase I

• C&D fines
  • Gypsum content
  • Organic matter content
  • pH

• Biochar properties
  • Particle size
  • Surface sorption properties
  • pH
  • Wood source
Phase II

• Using laboratory lysimeters to examine the performance of the recipe under more realistic landfill conditions
Phase III

• Validate the approach at a landfill site
Excavate a 40 ft by 60 ft artificial hole
A 40 ft by 60 ft by 1.5 ft artificial hole
Crush drywall
1 inch crushed drywall at the bottom of test area
Place 1st geonet and install air pipe
Load cover soil
Load other cover materials into different cells
Sampling tubing
Install sampling tubing
Summary

• CDRA research has targeted market development for C&D materials; there is a need to develop products, not just manage residuals.

• Past research focused on how to produce better fines.

• Current research is examining the creation of products made from C&D fines and C&D-wood derived biochar.
What About Benefits of C&D Biochar?

- In addition to removing and sequestering H2S, biochar is known to sorb other contaminants.
  - Heavy metals
  - PAH
  - PFAS
- PFAS = perfluoroalkyl and polyfluoroalkyl substances
Experiment mixing C&D Fines and Biochar in Lab Leaching Tests

![Bar chart showing concentration of PFOA and PFOS in C&D Fines and C&D Fines + Biochar samples.](chart.png)
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