Coal Ash-Composites

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Acknowledgements:
NCDEQ (Cynthia Moseley)

Mt. Olive Missionary Baptist Church
704 Old #1, Moncure, NC
October 1, 2016
US Coal Ash Production and Utilization

Unused Coal Ash: 45 mT/Yr
(1/2 of yearly Production)

Source: American Coal Ash Association
North Carolina Ash Ponds

High Hazard Coal Combustion Waste Site

Asheville (2)
Riverbend (2)
Buck (3)
Allen
Marshall
Belews Creek
Dan River (2)

Created June 30, 2009
Data Sources: EPA, USGS, ESRI

South Carolina Environmental Law Center
Coal Ash Utilization and Products

- Aggregates
- Green Bricks
- Plastic Roads
- Cement Concrete
- Metal Matrix Composites
- Fillers
- Ash-Composites NC A&T SU

Thanks to:
- Sen. Trudy Wade (District 27)
- Sen. Andrew Brock (District 34)
- Sen. Bill Cook (District 1)

- Lighter weight
- Fire resistant
- Large ash consumption
- Building products – Resistant to Insects & Pests
- Value >> concrete
Coal Fired Steam Plant and Residuals

Coal is a naturally formed material!

Chemical Composition of Fly Ash
- Silica 55% - 65%
- Alumina 25% - 35%
- CaO 25%-35%
- $\text{F}_2\text{O}_3$ (Iron Oxide 1% - 5%)

North Carolina Agricultural and Technical State University
Air and Ground Water Pollution

Air-Open Pits

Ash Ponds

Road Base

Courtesy: China

Courtesy: EPA
Emission Controls
Hg, NOx, SO₂ & Particulate Matter

SCR - Selective catalytic reduction
ESP – electrostatic precipitator
FF – Fabric Filter
FGD – Flue Gas Desulfurization

Hg°, Hg²⁺ or Hg⁰ – 370 °C

COAL SUPPLY
SUPERHEATER
BOILER
Hg° >1400 °C

AMMONIA INJECTION
SORBENT INJECTION
ASH + SORBENT REMOVAL

FGD GYPSUM OR SCRUBBER SLUDGE REMOVAL
WET FLUE GAS DESULFURIZATION (FGD) SCRUBBER
<table>
<thead>
<tr>
<th></th>
<th>Hg</th>
<th>As</th>
<th>Se</th>
<th>Sb</th>
<th>Ba</th>
<th>B</th>
<th>Cd</th>
<th>Cr</th>
<th>Co</th>
<th>Pb</th>
<th>Mo</th>
<th>Tl</th>
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</thead>
<tbody>
<tr>
<td>Total in Material</td>
<td>0.04-0.6</td>
<td>70-90</td>
<td>2-30</td>
<td>3-15</td>
<td>600-1,500</td>
<td>NA</td>
<td>0.7-1.5</td>
<td>100-200</td>
<td>20-50</td>
<td>40-90</td>
<td>10-20</td>
<td>3-13</td>
</tr>
<tr>
<td>(mg/kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Leach results</td>
<td>&lt;0.01-0.4</td>
<td>7-300</td>
<td>7-400</td>
<td>&lt;0.3-200</td>
<td>90-4,000</td>
<td>200-300,000</td>
<td>&lt;0.2-30</td>
<td>1-4,000</td>
<td>&lt;0.3-200</td>
<td>&lt;0.2-2</td>
<td>100-40,000</td>
<td>&lt;0.3-300</td>
</tr>
<tr>
<td>(µg/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>MCL¹ (µg/L)</td>
<td>2</td>
<td>10</td>
<td>50</td>
<td>6</td>
<td>2,000</td>
<td>7,000 DWE L2</td>
<td>5</td>
<td>100</td>
<td>-</td>
<td>15</td>
<td>200 DWE L</td>
<td>2</td>
</tr>
<tr>
<td>TC² (µg/L)</td>
<td>200</td>
<td>5,000</td>
<td>1,000</td>
<td>-</td>
<td>100,000</td>
<td>-</td>
<td>1,000</td>
<td>5,000</td>
<td>-</td>
<td>5,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Variability relative to pH⁴</td>
<td>Low to High</td>
<td>Low to Med</td>
<td>Low to Med</td>
<td>Med to High</td>
<td>Low</td>
<td>Med to High</td>
<td>High</td>
<td>Low to Med</td>
<td>High</td>
<td>Med</td>
<td>Low to Med</td>
<td>Med</td>
</tr>
</tbody>
</table>

¹MCL is the maximum concentration limit for drinking water.
²DWEL is the drinking water equivalent level.
³TC is the toxicity characteristic and is a threshold for hazardous waste determinations.
⁴Variability defined as low is <1 order of magnitude difference; moderate is 1 to 2 orders of magnitude difference; and high is >2 orders of magnitude difference.
Reversal Process

Coal → Fly Ash → Boiler Slag → Bottom Ash → Block
Coal Ash-Composite

Mix: Ash + Polyurethane

Mold

Panel

Concept

Resin
Ash

Mixer & Extruder
Cutting & Loading

Typical Continuous Process (Plan)

North Carolina
Agricultural and Technical State University
Ash-Composite Panels & Blocks

BC Steam Station Ash

STAR Processed Ash

Reusable Ash-Composite Blocks

Ash Weight: 75% Composite; Potential to make >80%
Examples of Building Products

Base Board

Decorative Mold

Chair Rail

North Carolina
Agricultural and Technical State University
Leach Test: Ash and Composite & Block

Schematic

PE Container
PP Coarse Grid
PP Fine Grid
Ash

River flow model

Fly-Ash
Ash-Composite
Ash-Composite Block

EPA M1313
## Leachate from Ash
As per EPA M1313 (LEAF)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>EPA MCL</th>
<th>PQL</th>
<th>AC3717</th>
<th>AC3714</th>
<th>AC3718</th>
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<tr>
<td>Antimony by ICP</td>
<td>6</td>
<td>10.0</td>
<td>35</td>
<td>19</td>
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<td>As by ICPMS</td>
<td>10</td>
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<td>54</td>
<td>29</td>
<td>330</td>
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<tr>
<td>B by ICP</td>
<td>7,000</td>
<td>50.0</td>
<td>4,400</td>
<td>3,800</td>
<td>3,800</td>
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<tr>
<td>Ba by ICP</td>
<td>2,000</td>
<td>10.0</td>
<td>160</td>
<td>160</td>
<td>400</td>
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<tr>
<td>Be by ICP</td>
<td>4</td>
<td>5.0</td>
<td>5.0 U</td>
<td>12</td>
<td>5.8</td>
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<td>0.5</td>
<td>6</td>
<td>16</td>
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<td>Cr by ICPMS</td>
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<td>28</td>
<td>34</td>
<td>220</td>
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<tr>
<td>Cu by ICPMS</td>
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<td>2.0</td>
<td>65</td>
<td>680</td>
<td>170</td>
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<td>Mn by ICPMS</td>
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<td>82</td>
<td>180</td>
<td>83</td>
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<td>Pb by ICPMS</td>
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<td>16</td>
<td>140</td>
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<td>240</td>
<td>52</td>
<td>350</td>
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<td>8.4</td>
<td>24</td>
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<td>160</td>
<td>69</td>
<td>550</td>
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<td>Zn by ICPMS</td>
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<td>10.0</td>
<td>260</td>
<td>760</td>
<td>380</td>
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Leachate from Ash Block
Circulating Water

<table>
<thead>
<tr>
<th>Mineral</th>
<th>EPA MCL</th>
<th>PQL</th>
<th>Distilled Water</th>
<th>Block_7_37_S</th>
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<td>10 U</td>
<td>10 U</td>
</tr>
<tr>
<td>As by ICPMS</td>
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<td>2.0 U</td>
<td>2.0 U</td>
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<tr>
<td>B by ICP</td>
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<td>100</td>
<td>460</td>
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<tr>
<td>Ba by ICP</td>
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<td>10 U</td>
<td>10 U</td>
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<tr>
<td>Be by ICP</td>
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<td>0.5 U</td>
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<tr>
<td>Cr by ICPMS</td>
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<td>5.0 U</td>
<td>5.0 U</td>
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<td>2.0 U</td>
<td>9.2</td>
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<td>Mn by ICPMS</td>
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<td>10 U</td>
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<td>Pb by ICPMS</td>
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<td>2.0</td>
<td>2.0 U</td>
<td>2.3</td>
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<td>1.0 U</td>
<td>1.0</td>
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<tr>
<td>Thallium (Tl) ICPMS</td>
<td>2</td>
<td>2.0</td>
<td>2.0 U</td>
<td>2.0 U</td>
</tr>
<tr>
<td>V by ICP</td>
<td>200</td>
<td>10.0</td>
<td>10 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Zn by ICPMS</td>
<td>5,000</td>
<td>10.0</td>
<td>10 U</td>
<td>690</td>
</tr>
</tbody>
</table>

Content in micogram/Liter

Leachate from Ash Block

Thanks to: Dr. Roy Byrd, NCDEQ
Ash Storage

Unlined

Lined

Block Filled Unlined Storage
Blocks are Reusable

Aggregates

Grounded to Powder for Building Products
Summary

- **Coal Ash is not a Waste/Toxic; It is a Valuable Mineral!**
- **Ash-Composite is a Solution to the Coal Ash Problem**
  - Offers Short & Long Term solutions: Composite Blocks, Building & Infrastructure Products
  - Blocks are reusable
  - Minimizes landfill
  - Non-radioactive
  - No heavy metal leachate
- **Ash-Composite Technology is:**
  a. Safe; Reduces Natural Resource Consumption (Green Technology)
  b. Minimizes Air & Ground Water Pollution
  c. Uses High ash loading (≥80%)
  d. Requires little or no energy and water
  e. Suitable for In-situ manufacturing and storing in closing ash ponds
  f. All materials used are Commercial Available