Innovative Treatment of Combined Sewer Overflow and perspective of Hydrochar reuse for pollutants adsorption

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Combined Sewer Overflows: pressure and impacts

- ORGANIC MATTER
- SOLID MATTERS SUCH AS MACRO AND MICRO PARTICLES
- CHEMICALS (N, P, HEAVY METALS…)
- PATHOGENS

- Bathing and Recreational water use
- Water and food consumption
- Water uses for agricultural activities
- Eutrophication
- Biodiversity
- Morphology

20% of surface water is at serious risk from pollution (EU Water Framework Directive, WFD)

Land → Urban area → Change of quality of the receiving water body

Runoff → Combined Sewer System → 650,000 CSOs stations in Europe (EurEau)
Typical CSOs treatment

PRELIMINARY DEGRITTING FOR SOLIDS REMOVAL
The INTCATCH Project

Dynamic rotating filtration to remove solids

Granular activated carbon adsorption to remove solids and contaminants

UV disinfection to remove pathogens
Advanced treatment: Granular Activated Carbon (GAC) Filtration

- The most applied adsorption technique for the treatment of wastewater
- No real information about CSO water treatment
- Used to absorb natural organic compounds and chemicals by both chemical and physical absorption
- From organic materials with high carbon contents (wood, lignite, coal)
- Diameter ranging between 0.5-1.5 mm
Hydrochar: production and uses

400 g digested-dewatered sludge + 350 g digested sludge

HYDROCHAR:
- Fuel
- Soil amendment
- Absorbent for activated carbon production

T=190°, 250°
P=140 bar
<table>
<thead>
<tr>
<th>NAME</th>
<th>ST 300</th>
<th>ST 300</th>
<th>STW 400</th>
<th>STW 400</th>
<th>ST 100</th>
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</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>Mineral GAC</td>
<td>Mineral GAC</td>
<td>Mineral GAC</td>
<td>Mineral GAC</td>
<td>Mineral GAC</td>
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<tr>
<td>SIZE</td>
<td>8x30</td>
<td>12x40</td>
<td>8x30</td>
<td>12x40</td>
<td>8x30</td>
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<tr>
<td>DISTRIBUTION [U.S. mesh]</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>DENSITY [g/L]</td>
<td>500±20</td>
<td>500±20</td>
<td>500±20</td>
<td>500±20</td>
<td>520±20</td>
</tr>
<tr>
<td>UMIDITY [%]</td>
<td>&lt;2</td>
<td>&lt;2</td>
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<tr>
<td>IODINE NUMBER [mg/L]</td>
<td>&gt;950</td>
<td>&gt;950</td>
<td>&gt;1000</td>
<td>&gt;1000</td>
<td>&gt;750</td>
</tr>
<tr>
<td>METHYLENE BLUE INDEX [mg/L]</td>
<td>&gt;180</td>
<td>&gt;180</td>
<td>&gt;190</td>
<td>&gt;190</td>
<td>&gt;150</td>
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<tr>
<td>ABRASION NUMBER [%]</td>
<td>&gt; 80</td>
<td>&gt; 80</td>
<td>&gt; 80</td>
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<td>&gt; 80</td>
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<tr>
<td>HARDNESS [%]</td>
<td>&gt; 90</td>
<td>&gt; 90</td>
<td>&gt; 90</td>
<td>&gt; 90</td>
<td>&gt; 90</td>
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<tr>
<td>ASH LEVEL [%]</td>
<td>&lt; 15</td>
<td>&lt; 15</td>
<td>&lt; 15</td>
<td>&lt; 15</td>
<td>&lt; 15</td>
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<tr>
<td>SURFACE AREA [m²/g]</td>
<td>&gt; 950</td>
<td>&gt; 950</td>
<td>&gt; 1000</td>
<td>&gt; 1000</td>
<td>&gt; 800</td>
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</table>

Characteristics of GAC tested
Granulometric and spectroscopy analysis

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<thead>
<tr>
<th>GAC type</th>
<th>$C_u$</th>
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<tbody>
<tr>
<td>ST100 8X30</td>
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<tr>
<td>ST300 8X30</td>
<td>1.5</td>
</tr>
<tr>
<td>ST300 12X40</td>
<td>1.6</td>
</tr>
<tr>
<td>STW400 8X30</td>
<td>1.5</td>
</tr>
<tr>
<td>STW400 12X40</td>
<td>1.7</td>
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</table>

1-2 mm in diameter

Scanning Electron Microscope
Results: GAC performance

**Test GAC**
- Wastewater (30 mg sCOD/L)
- Absorbent: commercial GAC
- Quantity: 2, 5, 10, 20 g/L

**ST100 8x30**
Best performance in sCOD removal

**ST300 8x30**
Best performance observed in the removal of Mn and Cd (80%) and Cr (40%)

**ST100 8x30, ST300 8x30**
used in CSOs Pilot Plant in real environment
# Hydrochar Analysis

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<tr>
<th></th>
<th>Zn</th>
<th>Mn</th>
<th>Na</th>
<th>Al</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>K</th>
<th>Ca</th>
<th>Fe</th>
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<tbody>
<tr>
<td><strong>Raw HC190°</strong></td>
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<td></td>
<td>1.2</td>
<td>0.9</td>
<td>3.7</td>
<td>7.5</td>
<td>6.6</td>
<td>18.1</td>
<td>8.2</td>
<td>1.1</td>
<td>17.6</td>
<td>31.4</td>
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<tr>
<td><strong>Raw HC250°</strong></td>
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<td>8.6</td>
<td>7.4</td>
<td>20.7</td>
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<td>0.9</td>
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<td><strong>Washed HC190°</strong></td>
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<td>9.6</td>
<td>8.8</td>
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<td>7.1</td>
<td>0.9</td>
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<tr>
<td><strong>Washed HC250°</strong></td>
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<td>10.2</td>
<td>8.7</td>
<td>23.5</td>
<td>8.2</td>
<td>0.8</td>
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</table>

**EDS Microanalysis (wt%)**

- **190°**: 0.85 g HC/g feedstock
- **250°**: 0.67 g HC/g feedstock

**50-500 micron in diameter**
Test 0_A_HC
- Distilled water
- Absorbent: raw HC
- Quantity: 5 and 0.5 g/L
- Analysis: sCOD profile

Test 0_B_HC
- Distilled water
- Absorbent: washed HC
- Quantity: 5 and 0.5 g/L
- Analysis: sCOD profile
**sCOD removal efficiency of washed HC**

**Test 1_HC**
- Wastewater (200 mg sCOD/L)
- Absorbent: washed HC
- Quantity: 5 and 0.5 g/L

**Test 2_HC**
- CSO water (30 mg sCOD/L)
- Absorbent: washed HC
- Quantity: 5 and 0.5 g/L

NO LEVEL OF ABSORPTION IN TERMS OF sCOD
Metals profile with washed HC

Test 3_HC
- Distilled water
- Absorvent: washed HC
- Quantity: 0.5 g/L
- Metal added: Mn 2 and 15 mg/L
Conclusion and future outlook

- Higher sCOD removal efficiency observed at lower concentration of HC (0.5 g/L) and higher concentration of sCOD/metals
- Optimal washing ratio of 0.5 g of absorbent for each L of washing water
- Slight removal of Mn detected

- Further experiments are needed to investigate more in detail the activated and non-activated HC
Innovative Treatment of Combined Sewer Overflow and perspective of Hydrochar reuse for pollutants adsorption

Thank you
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