An environmental comparison between powdered activated carbon and biochar for tertiary wastewater treatment

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Organic micropollutants from wastewater are a pervasive threat to the aquatic environment.

Triclosan

Estrone

Nonylphenol

Meador et al. *Environmental Pollution*, 2016, 213 (C).
Powdered activated carbon (PAC) is a relatively sustainable treatment method for organic micropollutants.

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Biochar can have a net environmental benefit due to renewable energy production and carbon sequestration.
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Sulfamethoxazole (SMX) is one of the most challenging organic micropollutants to remove by adsorption.

This first step of life cycle goal definition and scoping is to express environmental impacts in 10 midpoint categories.

Life Cycle Inventory
- raw materials
- energy

Life Cycle Stages
- goal definition & scoping
- inventory
- unit process #1
- unit process #2
- unit process #3
- unit process #4
- unit process #5

Life Cycle Impacts
- air emissions
- water emissions
- soil emissions

Life Cycle Impact Assessment categories
- respiratory effects (kg PM2.5 eq)
- global warming (kg CO2 eq)
- smog (kg O3 eq)
- ozone depletion (kg CFC-11 eq)
- acidification (kg SO2 eq)
- carcinogens (CTUh)
- non-carcinogenics (CTUh)
- ecotoxicity (CTUe)
- eutrophication (kg N eq)
- fossil fuel depletion (MJ surplus)

75% Removal of SMX from 12.5 MGD of wastewater

classify & characterize

TRACI: Tool for the Reduction and Assessment Of Chemical and Other Environmental Impacts
# Three adsorbents: PAC, wood biochar, biosolids biochar

<table>
<thead>
<tr>
<th>Key</th>
<th>Out of Scope (raw material creation)</th>
<th>System Boundary</th>
<th>Out of Scope (impacts at destination)</th>
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</thead>
<tbody>
<tr>
<td>PAC Use</td>
<td>coal (unmined)</td>
<td>PAC generation</td>
<td>hauling</td>
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<td>2° effluent</td>
<td>adsorbent dosing and removal</td>
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<td>biosolids</td>
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<tr>
<th>Wood Biochar Use</th>
<th>trees (forest)</th>
<th>wood chip generation</th>
<th>wood chip drying &amp; pyrolysis</th>
<th>hauling</th>
<th>storage</th>
<th>150 mg/L</th>
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</tbody>
</table>

| Biosolids Biochar Use | coal or trees | PAC or wood biochar generation | hauling | | 150 mg/L |
|-----------------------|---------------|-------------------------------|---------|---|
| | biosolids | biosolids drying & pyrolysis | storage |
| | 2° effluent | adsorbent dosing and removal | hauling |
| | | | receiving water |
| | | | landfill |
| | | | land application site |

Wood biochar has lower environmental impacts than PAC in 8/10 categories.
Biosolids biochar is worse than wood biochar in all environmental impact categories.
Wood biochar had higher impacts from adsorbent storage and adsorbent disposal.
Wood biochar had less impact from delivery and an environmental benefit from pyrolysis energy.
Biosolids biochar had more impact than wood biochar because its generation is energy consuming.
The relative sustainability of wood biochar depends on its adsorption capacity.
Wood biochar usage is sufficient to offset the global warming impact of an entire wastewater treatment plant.

Conclusions

Wood biochar has lower environmental impacts than PAC or biosolids biochar.

The environmental benefit of wood biochar is largely due energy production during pyrolysis.

Relative sustainability of wood biochar depends on adsorption capacity.