Laboratory Measurements of Hydraulic Properties of Granular Activated Carbon (GAC)

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Introduction

- Granular activated carbon (GAC) (Figure 1, Figure 2) is used in water and wastewater treatment plants because of its adsorption properties.
- GAC reduces undesirable taste, odor, and color in drinking water and removes organic contaminants, heavy metals, pesticides, along with other contaminants.
- Spent GAC can either be regenerated and reused or sent to a landfill.

Objectives

- To measure the hydraulic conductivity and matric potential of exhausted GAC from Upper Valley Water Treatment Plant (UV-WTP).
- To improve our understanding of exhausted GAC from UV-WTP and its potential to be used as a soil amendment for growing riparian vegetation.

Methodology

- Air dried ten samples of GAC and labeled as GAC-1 through GAC-10

Hydraulic conductivity

- Followed ASTM standards for the constant head method (Figure 3)
- Used a measured head of about 101.5 cm
- Collected water out of spigot for 5 seconds (Figure 4)
- Measured volume of water in graduated cylinder
- Repeated three trials for each sample of GAC
- Corrected for viscosity of water at 20°C

Matric Potential—Water Content Relationship

- Measured volumetric water content (VWC) (m\(^3\)/m\(^3\)) using a reflectometer model CS655 by Campbell Scientific Inc. (Figure 5)
- Measured matric potential (MPa) of GAC at specific VWC using WP4C Dewpoint Potentiometer by Meter Environment (Figure 6)
- Repeated measurements for predetermined VWCs
## Results

### Saturated Hydraulic Conductivity (Ks)

- Average: 0.019 cm/s; Standard deviation: 0.004 cm/s (n=10 samples). See Table 1.
- Comparable to that of fine sand (0.001 – 0.1 cm/s).

### Matric Potential-Water Content Relationship

- Moisture characteristic curve (Figure 7) indicates how much water is potentially available to plants and at what VWCs.
- The amount of available water for plants is determined based on a soils’ permanent wilting point (PWP) and field capacity (FC).
- For the UV-WTP GAC, PWP occurs at a VWC of about 15%, while FC ranged from about 25% to 40% (Figure 7).

## Conclusions

- The Ks values of exhausted GAC from UV-WTP are comparable to that of fine, graded, sand.
- A GAC moisture characteristic curve was developed:
  - demonstrated low matric potentials at VWCs ranging from 20% to 40% which are suitable for plant growth
  - These hydraulic properties indicate:
    - good soil drainage

## Future Work

- Measuring capillarity of GAC to evaluate its use as a wicking material
- Chemical testing to better understand the macro and micronutrients adsorbed to the GAC
- Chemical testing to better understand harmful substances adsorbed to the GAC
- Ensuring the safe use of GAC as a soil amendment

### Table 1. Measured Hydraulic Conductivity of Granular Activated Carbon (GAC)

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Hydraulic Conductivity (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAC-1</td>
<td>0.016</td>
</tr>
<tr>
<td>GAC-2</td>
<td>0.023</td>
</tr>
<tr>
<td>GAC-3</td>
<td>0.019</td>
</tr>
<tr>
<td>GAC-4</td>
<td>0.016</td>
</tr>
<tr>
<td>GAC-5</td>
<td>0.015</td>
</tr>
<tr>
<td>GAC-6</td>
<td>0.014</td>
</tr>
<tr>
<td>GAC-7</td>
<td>0.018</td>
</tr>
<tr>
<td>GAC-8</td>
<td>0.025</td>
</tr>
<tr>
<td>GAC-9</td>
<td>0.021</td>
</tr>
<tr>
<td>GAC-10</td>
<td>0.024</td>
</tr>
<tr>
<td>Mean</td>
<td>0.019</td>
</tr>
<tr>
<td>Stdev.</td>
<td>0.004</td>
</tr>
</tbody>
</table>