# Performance Enhancing Devices for Stormwater BMPs

# Biochar

December 2018

Prepared By:

Hirschman Water & Environment, LLC

Center for Watershed Protection, Inc.

For:

*Roadside Ditch Management & PEDs*

Center for Watershed Protection, Inc.

Chesapeake Stormwater Network

Funded By:

Chesapeake Bay Trust

# Biochar

**1. Definition & Applications**

Biochar is produced by the pyrolysis (i.e., combustion at extreme heat with no oxygen) of biomass such as wood chips, poultry litter, switchgrass, and waste wood products (Law et al., 2014). In most applications, biochar is used as a soil amendment to boost soil water and nutrient retention. Other researchers have investigated whether biochar can sequester nutrients and metals since it produces a large porous surface area for pollutant adsorption and microbial processing. Depending on its parent feedstock, biochar is not expected to have the same nutrient leaching potential as other, more raw forms of carbon, such as peat or compost (Hirschman et al., 2017).

The use of biochar as a stormwater soil media amendment may not target specific pollutants. Most of the research on biochar for stormwater has been via laboratory studies, and documented pollutant removal has included ammonia, nitrate/nitrite, total phosphorus, and metals. The results are not consistent, and field applications are not widespread (Hodgins & Seipp, 2018). However, biochar does appear to enhance water retention and can provide a carbon source for denitrification (in systems designed to include that process), and thus is suitable for stormwater applications. Biochar can replace, in part or whole, the organic matter component in soil media, which has been shown to be a concern for nutrient leaching when used at high rates (e.g., greater than 5% of the media mix).

As with other PEDs, biochar can be considered for retrofits where the soil media will be replaced, improved, or amended. One example is from Carroll County, MD, where dry pond retrofits included sand filters amended with biochar. Another application used biochar to amend roadway vegetated filter strips, leading to reductions in runoff volumes and peak flows (Imhoff & Nakhli, 2017).

The salient question about biochar in stormwater applications is whether that material offers significant benefits compared to the material it is replacing in the stormwater system (e.g., compost, other carbon source), and whether those incremental benefits are worth the effort and cost to procure and transport the product. Some of that question revolves around the availability of sources (see section below), procurement, and transportation for biochar compared to what is likely to be a local source for other materials, such as compost. There will be more certainty about these questions as more applications are conducted in the Chesapeake Bay Watershed. Also, there is ongoing work to develop more localized sources, and that would change the calculus on the cost/benefit issue.

See **Section 7** for a list of qualifying conditions in order for a biochar amendment to qualify for enhanced nutrient removal as a performance enhancing device (PED).

**2. Source Selection & Procurement**

Sourcing an appropriate biochar material is an evolving process. Biochar production as an industry is growing into new applications, and there are many different feedstocks and processes. The following list from the U.S. Biochar Initiative may be a start, and additional research may also reveal other sources in closer proximity.

http://biochar-us.org/manufacturers-retailers

There are several general recommendations for stormwater applications (see **Table BCH-1)**:

- Use wood-based biochar products (preferably derived from hardwood). Other sources, such as from poultry litter, have the potential to leach nutrients.
- When using woody feedstocks, recommended production temperatures are 500 to 600 degrees Celsius.
- Pyrolysis times should be at least 3 hours to reduce accumulation of toxins, such as PAHs.
- Particle size is a significant variable, and will affect the drainage rate, reactive surface area, and binding sites. Recommended particle sizes are 0.5 to 3 mm. This approximately equates to 0% passing a number 36 standard mesh sieve and 100% passing a number 6 standard mesh sieve. Note that rinsing the biochar before incorporation will likely change the particle sizes, breaking up some of the larger particles. Therefore, biochar particle sizes can change over time due to environmental conditions (Imhoff & Nakhli, 2017). It is advisable that particle size analysis be done before and after rinsing, and professional judgement used for particles that fall outside the recommended ranges.

**Table BCH-1. General Specifications for Biochar in Stormwater Applications**

<table>
<tr><td rowspan="5">Biochar</td><td rowspan="5">Woody derived material</td><td>Sieve</td><td>Size</td><td>% Passing</td></tr>
<tr><td>No. 6</td><td>3 mm</td><td>100%</td></tr>
<tr><td>No. 36</td><td>0.5 mm</td><td>0%</td></tr>
<tr><td colspan="3">Production temperatures between 500 and 600 °C</td></tr>
<tr><td colspan="3">Pyrolysis time at least 3 hours</td></tr>
</table>

### 3. Material Testing

Testing should be conducted on representative samples to ensure that the biochar will not leach undesirable elements. Testing procedures should be adjusted to the biochar source (e.g., type of wood or other material). While there are not standard testing protocols, the following should be considered as part of a testing procedure:

- Polycyclic Aromatic Hydrocarbons (PAHs)
- Pathogenic bacteria, bacterial spores, viruses, protozoa
- Antimicrobial residues
- Nutrients
- Heavy metals
- pH, alkalinity

## 4. Mixing The Material

Biochar should constitute 5% to no more than 10% of the soil media by volume. Ideally, mixing will be done by a soil media vendor using appropriate mixing equipment to ensure that the overall soil media meets the applicable specifications. Some applications may want to mix the biochar into the soil or sand media at the site. However, lessons from sites that have attempted this indicate that it is difficult to achieve a consistent blend when amending in-place; only the top few inches to about a foot of media can be amended effectively.

Also, it may be necessary to confer ahead of time with the appropriate stormwater authority because applications that use biochar will have to adapt the specifications for organic matter and perhaps cation exchange capacity.

Some sources indicate that rinsing the biochar before mixing may help remove the hydrophobic coating on some biochars and reduce leaching of soluble compounds after incorporation. Laboratory studies have used deionized water (three rinsings at 1 part biochar to 50 parts DI water). The rinsed biochar was then oven-dried at 105 degree Celsius (Imhoff & Nakhli, 2017). It is not clear at this point whether this type of treatment is advisable for broader field applications and how it would be adapted to make it more feasible. In any case, some regimen of rinsing and drying prior to incorporation into the soil media is likely a good idea.

## 5. Risks

With proper testing, the risks of using biochar should be minimal. The most important risk is using biochar derived from feedstocks that will leach nutrients or biochar pyrolysis times that will lead to accumulation and possible leaching of toxins, such as PAHs. Biochar appears to bind up heavy metals for long periods of time, but metals leaching may be a potential risk in some cases. As stormwater applications that integrate biochar are relatively new, it is recommended that some monitoring take place to further evaluate these risks.

## 6. O&M Considerations

At this point, there are not enough field applications to indicate that vegetation plans or O&M procedures would change due to the addition of biochar. Again, this may change as applications spread throughout the Bay Watershed. With regard to vegetation, one factor to be aware of is if and how the biochar amendment may alter the pH of the soil media, perhaps increasing the alkalinity. If this is the case, the selection of plant species may have to consider the higher pH environment (or adding other amendments to adjust the pH to more optimal levels for vegetation).

One possible O&M issue is "recharging" the biochar as practices age and vegetation is removed and replaced. Based on the research, biochar sorption lifespans may be as long as the practice itself, but sorption capacities can possibly decrease over time.

For a practice that is undergoing major repairs, it would be worth considering removing the top layer of soil and replacing with a clean mix that contains new biochar. Also, BMPs in the Bay Watershed must undergo a verification process to ensure the BMP is still present and performing as designed (CSN, 2014). This verification is intended to take place every two permit cycles for MS4s, or every 9-10 years. For practices with biochar, this would be an ideal time to retest the soil media to determine if and how the biochar has sequestered certain pollutants and how particle sizes and other characteristics may have changed as the mixture endures a range of environmental conditions. Since there is not a long track record of biochar use for stormwater, this procedure would generate valuable data on the longevity of biochar in a blended media.

**7. Qualifying Conditions for Biochar as a PED**

The following conditions summarize the use of biochar to qualify for the PEDs pollutant removal credit:

- Sourced from qualified vendor as per the specifications in Section 2 of this fact sheet.
- Material tested as per Section 3.
- 5 to 10% of the soil or sand media by volume.
- Mixed consistently throughout media using appropriate mixing equipment.
- O&M plan that addresses adaptive management of vegetation and possible “recharging” of biochar, as per Section 6.

**References**

Chesapeake Stormwater Network. (2014). Urban Stormwater Verification Guidance. https://chesapeakestormwater.net/events/webcast-ms4-implementers-and-the-bay-tmdl-urban-bmp-verification/.

Hirschman, D.J., Seipp, B., Schueler, T. (2017). Performance Enhancing Devices for Stormwater Best Management Practices. Urban Stormwater Work Group. Center for Watershed Protection.

Hodgins, B. and Seipp, B. (2018). Bioretention System Design Specifications and “Performance Enhancing Devices” (Issue Paper). Center for Watershed Protection, Inc., Ellicott City, MD.

Imhoff, P.T. and Nakhli, S.A.A. (2017). Reducing Stormwater Runoff and Pollutant Loading with Biochar Addition to Highway Greenways. Final Report for NCHRP IDEA Project 182. Transportation Research Board, The National Academies.

Law, N., Christianson, R., Hoffman, G., and Wong, C. (2014). A literature review to evaluate the effect of particulate sorbing media on pollutant removal efficiency of best management practices. Center for Watershed Protection. Ellicott City, MD.

**Photos**

*Figure BCH-1: Pure Biochar*

*Figure BCH-2: Pure Biochar delivery via "Super Sacks"*

*Figure BCH-3: Integrating biochar into existing SWM sand filter.*