FILTER POLLUTANTS WITH BIOCHAR

Cleaner water at less cost

Rain and snowmelt that flow over impervious surfaces are not absorbed into the ground. Referred to as stormwater runoff, it picks up pollutants like chemicals, oils, metals and dirt/sediment that can pollute rivers, streams, lakes, and coastal waters. Stormwater best management practices (BMPs) are used to protect these resources. Incorporating biochar into these practices can enhance their effectiveness and reduce costs.[1]

Engineered and in situ biofilters are increasingly used in urban environments to provide green space, alleviate flooding, and improve stormwater quality. These typically contain sand, soil, mulch or compost. In a meta-analysis of 84 studies, the addition of biochar was a low-cost option to remove various pollutants: heavy metals, microbial pollutants (like *E. coli* bacteria), and trace organics.[2]

Department of Transportation agencies that operate roadways must meet increasingly stringent regulations for stormwater runoff. Biochar

Research shows that adding biochar to stormwater media mixes can generate these benefits[4]:

- **Increases soil water holding capacity**
- **Improves soil aggregation in fine textured soils improving water infiltration**
- **Improves soil fertility in nutrient-poor soils improving nutrient availability for plants**
- **Filters metals**
- **Prevents the movement of bacteria into waterways, e.g. *E. coli***

Stormwater vault. *Photo by Sarah Burch*

Photo by Sarah Burch

Stand alone filter system to filter metals from industrial sites. *Photo by Ryan Holmann, Stormwater Biochar; filters by BioLogical Carbon*

can also be effectively used in stormwater vaults, gabons, or stand alone filter systems.

Biochar offers a cost-effective option to existing carbon-based medias, such as activated carbon, that are used in stormwater filtration. Bulk biochar costs 20 – 100% less than activated carbon, which costs between $1,000 and $5,000 per ton. By comparison, bulk biochar costs can range from about $800 to $2,500 per ton.[3] Before using biochar, verify specifications: % carbon, surface area, particle size, and other characteristics.

How to use biochar in stormwater applications

Biochar effectiveness will vary by several factors including particle size, the surface area, pH, and the percentage of carbon in the material. The type of feedstock, as well as biochar production temperature, will influence media effectiveness.

Given all these variables, interested users of biochar can check with your local biochar producer to ensure the right biochar is selected for a specific project and application.

In general, biochar specifications vary by stormwater application type:

BMP Types	Objective	Specifications
Grass Swales **Vegetated Filter Strips** **Infiltration Basins**	Support healthy plants and increase soil infiltration	High quality biochar from wood or crop residues. Medium particle size: #20 - #60 sieve.
Bioretention	Support healthy plants and filter pollutants	High quality biochar from wood or crop residues. Medium particle size: #20 - #60 sieve.
Media Filtration	Filter pollutants at high flow rates	Wood-derived biochar. Coarse particle size: #8 - #20 sieve.

Environmental engineering firms can realize the following benefits from using biochar

- **Treat greater volumes of water with a smaller treatment footprint**[5]
- **Remove organic pollutants and bacteria**[5]
- **Filter dissolved metals not just metals in particulate form**[6]
- **Improve growing conditions for bioswale plants (particularly in urban environments)**[7]
- **Improve carbon footprint through use of a natural material**[8]

CASE HISTORY: BIOLOGICAL CARBON

CHALLENGE/OPPORTUNITY: John Miedema, founder of BioLogical Carbon, began working with biochar in 2008 after building his own pilot biochar machine. John makes customized biochar blends for his customers, particularly engineering firms installing stormwater vaults and other water treatment systems. He also constructs his own stormwater upflow and downflow systems for industrial customers.

His data sets demonstrate biochar's ability to remove metals and various other pollutants (including nutrients). BioLogical Carbon sees the opportunities and market applications for biochar are growing every year.

In 2021, BioLogical Carbon was contacted by one of his environmental engineering clients to supply a large volume of biochar for a major industrial company in Washington state. The company was building a large stormwater treatment system to manage and treat water for heavy metals produced during the construction of airplanes.

SOLUTION/APPROACH: John worked with Rexius company to sift and process nearly 1,500 yards of biochar into the appropriate particle and size class and arranged for delivery to the stormwater install location.

RESULTS: The biochar material was installed in the summer of 2021. The engineering company reports the material is working very well and is filtering copper and zinc at the required levels.

CASE HISTORY: CHESAPEAKE BAY

CHALLENGE/OPPORTUNITY: State highway agencies must meet increasingly stringent regulations for stormwater runoff. They are looking for low-cost options to avoid more expensive investments in infrastructure to handle rain events. In the Chesapeake Bay, a watershed collaborative between the University of Delaware, DelDOT, MDTA transportation agencies and Chuck Hegberg[9] tested biochar amendments for water infiltration and retention.[10]

SOLUTION/APPROACH: The group used laboratory column studies of soils collected by DOT's in California, Delaware, Maryland, and North Carolina. Lab tests assessed if adding 4% biochar (by mass) could increase rates of water infiltration and also remove nitrates.

RESULTS: For soils with poor water infilitration, the biochar amendment attenuated peak flow by 77% and runoff volumes by 53%.

As a result, researchers estimated that highway greenways could infiltrate 50% more water and remove 83% of sediment and nutrients. The biochar amended buffer could save $215,000 over standard treatments. That's because the biochar amended buffer needed only 0.12 acres compared to 3.7 acres required for standard treatments.

Economics

Save on material costs: Research and practical experience in the stormwater industry show that biochar can do as well or better than more expensive filter medias. Biochar can be made to a similar specification as activated carbon for 25% to 50% less (in some cases). Biochar also has a better carbon footprint than fossil-fuel based activated carbon.

Access to more markets: Biochar is superior to other filter medias because it can remove dissolved forms of heavy metals, which makes it unique among medias. Particulate-sized forms of metals can be removed with regular low-cost sand filters and activated carbon. Biochar can also remove dissolved forms of metals in water solution, allowing an expanded filtration media offering. It's a viable new tool for stormwater treatment.

Metal	Initial concentration ug/L	Post biochar filter ug/L	% removed
Total Copper	54.2	7.88	71.1%
Total Zinc	1,018	39.0	92.6%

Results from Biochar stormwater up flow filter tests to remove copper and zinc (biochar+ peat) in Washington State. *Data courtesy of Myles Gray, Geosyntec*

Non-economic benefits

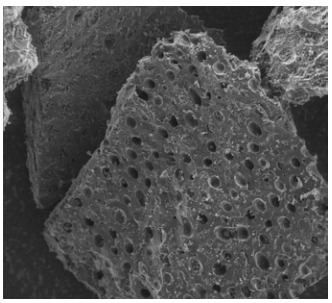
Biochar is made from a variety of biogenic biomass sources (leaves, wood chips, agricultural residues, orchard prunings, vineyard cuttings, and many others), which makes them natural and renewable.

Many locations across the United States have excess biomass with little or no market value. These materials are often either burned or sent to a landfill. Biochar applications, like stormwater management, provide a valuable mechanism to divert large-scale waste biomass resources and convert them into a product that can help clean up polluted stormwater and reduce runoff.

Right biochar for the right stormwater application

In most stormwater applications, biochar must be properly sized to ensure good complete contact with the water while not being too small as to clog up the filter or greenway. Biochar that is low in ash content (less than 5% ash is preferred) is typically needed for most metal filtration applications.

It is also usually helpful to conduct some initial lab tests of biochar's properties before using it in a field application.



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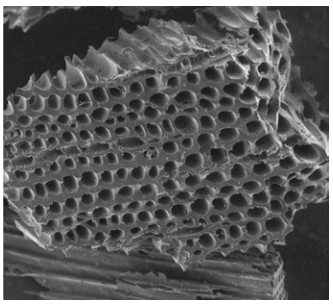

Douglas-Fir

Electron microscope scans of biochar made from different feedstocks. *Photo courtesy of Myles Gray, Geosyntec*

CASE HISTORY: STORMWATER BIOCHAR

CHALLENGE/OPPORTUNITY: Ryan Holman is the CEO of Portland, Ore.-based Stormwater Biochar, which sells filtration systems to municipalities and private companies. Ryan specializes in navigating the permitting process to make sure customers meet water pollution controls required under the National Pollutant Discharge Elimination System (NPDES). He was particularly interested in biochar's ability to remove dissolved forms of metals and the materials low-cost compared to other media like peat and activated carbon.

SOLUTION/APPROACH: To explore biochar as a potential media for capturing metals, Ryan worked with John Miedema (BioLogical Carbon) and Myles Gray (Geosyntec) to conduct tests of the biochar performance in a laboratory over two years, Stormwater Biochar deployed filter systems with biochar media in 2017.

RESULTS: Stormwater Biochar reports solid performance of the systems in real world settings.[11] The filter systems consistently removed over 90% of dissolved copper and zinc, in addition to other problematic metals such as lead. In 2021, Stormwater Biochar installed a filter system at an Auto Parts Company near Los Angeles. Holman said biochar's main benefit is the lower cost and superior performance, particularly at removing dissolved forms of metals from stormwater. The biochar also performs consistently throughout the year in all seasons.

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Published by: USBI in partnership with Nebraska Forest Service.
Thanks to the US Forest Service for funding support.