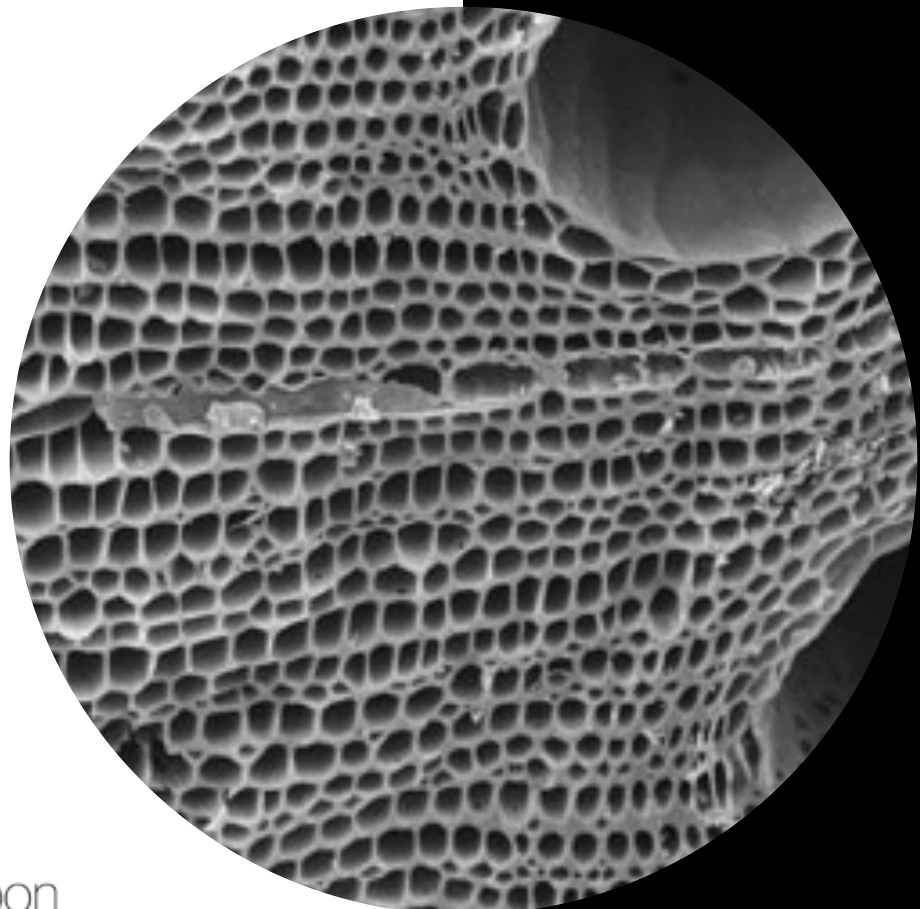
DOT Biochar Design Manual

New standards for using micro-based solutions to manage macro environments.

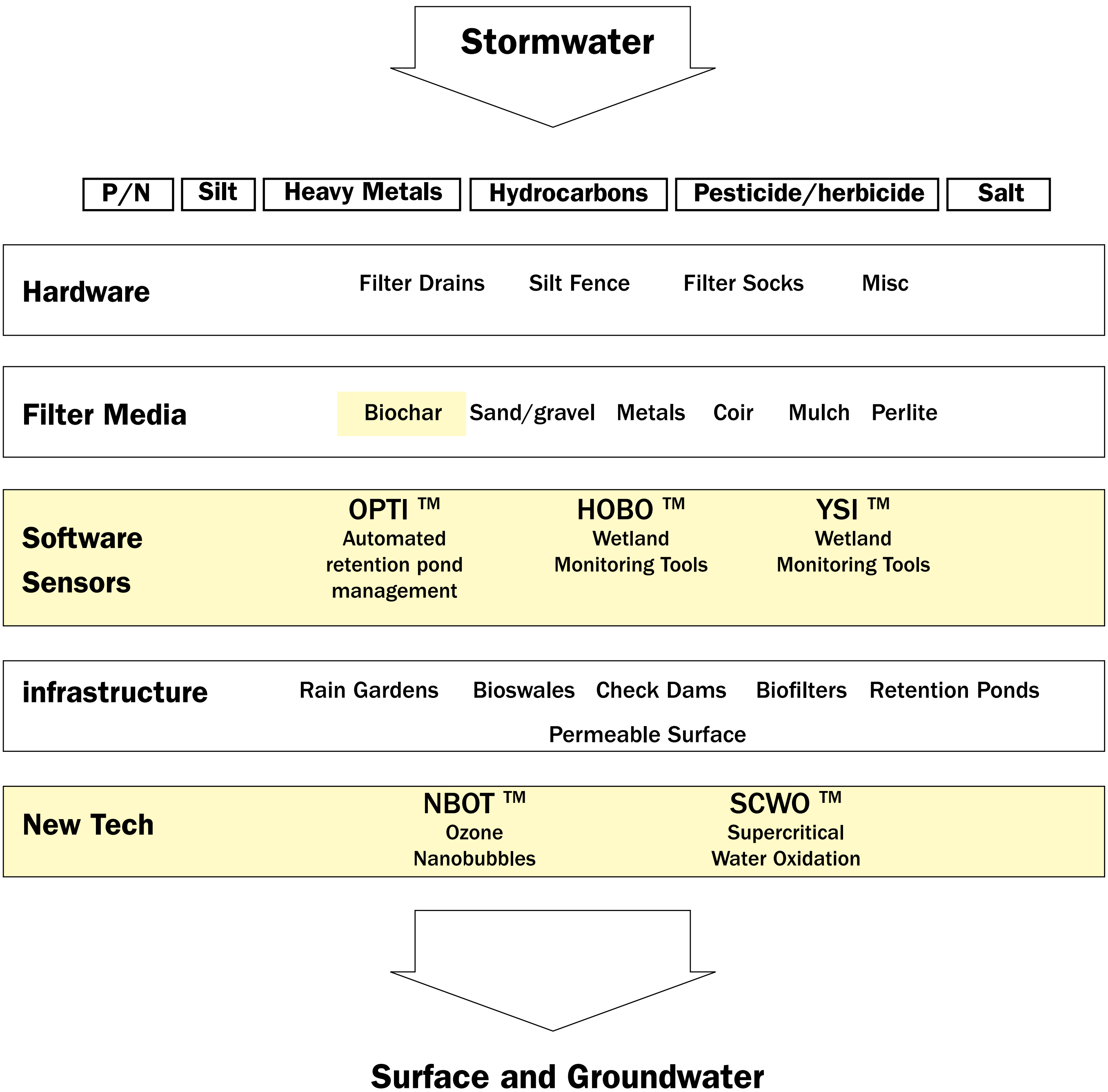
2026



Carbon Intel llc

1.2 Integrated solutions

Biochar can fit into the mix of stormwater solutions that have been in development for decades. Added to that are new technology solutions.



2.1 Carbon forms

These three forms of charcoal vary by production method and end application. Biochar's value is continuing to grow, based on its unique potential for environment and economy.

	Biochar	Activated Carbon	Charcoal
Feedstock	Wood (preferred), biosolids, organic material	Wood	Hardwood
Production	Pyrolysis	Steam or chemical activation	
Temperature	< 700° C	800° C to 1000° C	
Cost	Low to Moderate	High	NA
Applications	Soil amendment, carbon sequestration, industrial innovations. INNOVATIONS 1. We advance the storm and wastewater industry using patented **biochar structural composites**, with improved performance compared to activated carbon. 2. We add fungi and pyrolysis as two options to destroy the contaminants in filter units, increasing their functional life cycle. 3. Structural biochar composites open a new pathway for insulated building materirals.	Industrial contaminant filter systems.	Cooking/ heating fuel

Summary

Activated carbon is the standard industry filtration medium. It has a higher surface area than biochar, due to high-temperature activation, but is expensive and energy-intensive.

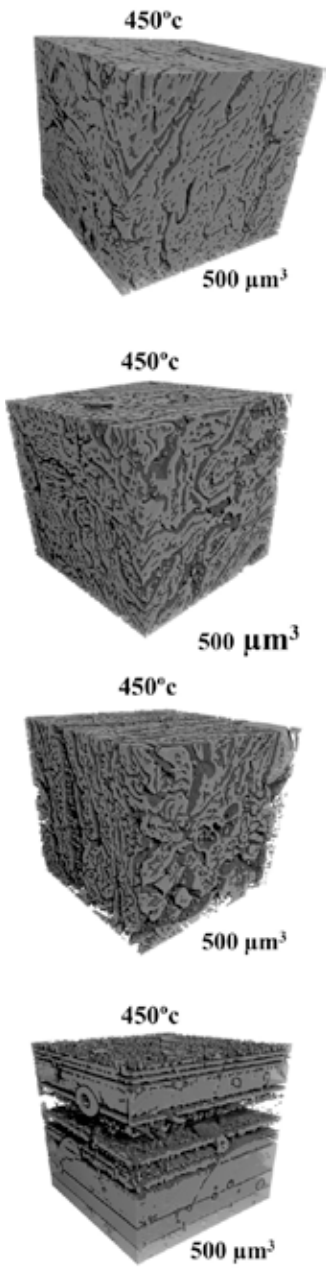
Biochar advantages over AC: More abundant surface functional groups; Produced at lower temperatures, lower energy footprint; Reduced cost; Increased physical and chemical adsorption value. Structural composites for filtration and thermal insulation.

Charcoal's primary purpose is for cooking and it can contain original wood chemistry or with starch, limestone, sawdust, and borax, (to help form briquettes). It contains varying amounts of ash, volatile substances, and moisture.

DEPARTMENT OF TRANSPORTATION

MN DOT has set a new standard for biochar as an engineering tool.

Development of Biochar Specification Criteria as Soil Amendment for Slopes, Conveyances and Stormwater Treatment Systems (Phase 1)



4D Structural Changes And Pore Network Model Of Biomass During Pyrolysis

Nature.com

While most organic waste materials can be pyrolyzed into biochar, it's important to note that there is tremendous difference in the end product, based on which materials are used and how it's processed. Pilot studies will continue to fine tune effectiveness for stormwater filtration. The state of Minnesota is the first to establish standards for biochar feedstock and porosity.

FEEDSTOCK CRITERIA

Strategies for biochar application must take into account the following criteria, for maximum effect.

1. Use available wood waste from forest or pulp industry

From an economic standpoint, this is important as the wood / pulp industry is transitioning toward new industrial applications, with the closing of paper mills and excess wood from storm damage.

2. Effective adsorption

Porosity and chemical/physical composition affect how contaminants are adsorbed. Hydrocarbons, heavy metals and phosphorous are the primary focus for stormwater.

The good news is that hard wood and soft wood biochars are most effective and in great abundance. Minnesota has large amounts of black ash that must be processed due to damage from the emerald ash borer, so the conditions for expansion of biochar to solve both environmental and economic problems are in place.

CONTROLLING POROSITY & STRUCTURE

1. Pyrolysis temperature and time determines the values of the end product biochar, for different purposes.

2. Moisture levels are important from an energy cost, as green mulch must be pre-dried, which is feasible, but slows down throughput and increases cost. Using air dried mulch is the first priority.

Pyrolysis production creates syngas as an energy by-product, which can be applied to the pre-drying process, to achieve feedstock moisture content below 30%.

2.6 DOT pilot process

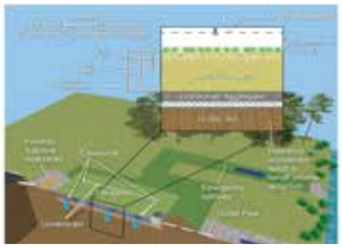
Feedstock	DOT supply black ash mulch.
Pellet Production	Extruded from available ash or equivalent hardwood via qualified third party. Delivered for analysis to meet DOT specs.
Apply to Soil	Apply various methods, including trenching; Bore holes of varying depth; Broadcast and cover with clean soil, gravel or matt.
Filter Socks	Use test pellet batch to fill available socks in various mixtures. This would be applied to field conditions as a basis for pilot project. Testing would determine best option.
Analysis	Determine rates of remediation per unit based on pilot performance, with a goal of keeping within expected budgets. Compare to existing filter socks for comparing stormwater reduction.
Structural Composites	Extruded or compressed forms with various binders, prototyping and pilot testing.
New Forms	Board barriers and cylinders or tubing that can be tested for various site opportunities. As depicted above, can be applied in horizontal or vertical array to fit conditions.
Slurry Solutions	Borrow from existing methods, to fine tune specific mixtures and conditions, working with NRRI and soil science.
Bulk VS Pellets	Pilot comparison of pellets to bulk in sock and soil amendment applications. Determining ideal pellet size and sock fill density for flow through variation.
Production Assessment	Evaluate cost/benefit of producing biochar and pelletizing onsite. For level 3B stormwater filter testing for Sulfur;O/Corg Ratio; Bulk Density; Particle Size Distribution; Porosity; Water Holding Capacity
End Purpose Testing	Combine test results from above, over a 6 month period, with recommendations.
Reporting	Standard reporting process, with options for online public dashboard.

2.9 DOT filtration examples

SOURCE: GA DOT

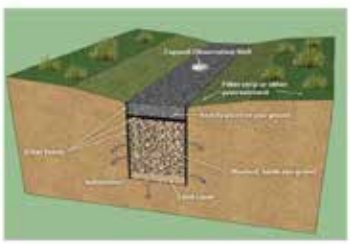
Biochar materials and engineered products can fit existing models of stormater engineering.

Sand Filter



Forebay

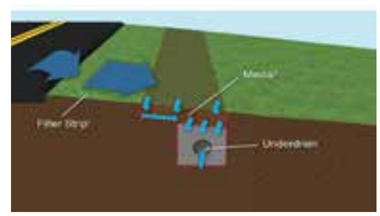
Infiltration Trench



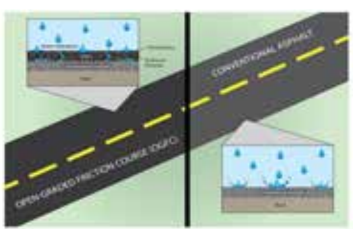
Grass Channel

Bridge Drains

Bioslope

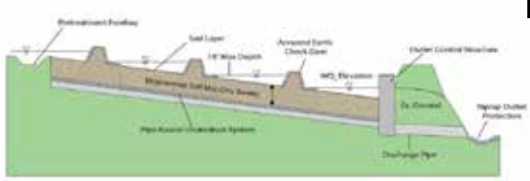


Open-Graded Friction Course

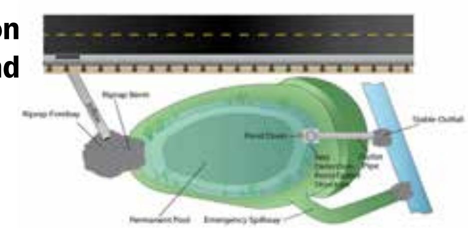


Stormwater Wetland

Swales & Check Dams



Detention Pond



3.5 Sand bed maintenance

Improved stormwater practices will require new maintenance strategies.

Current environmental challenges will require re-thinking the engineering and operations of biochar and how it is applied and managed over time. Field studies that prove their value over 1-3 years will have to incorporate more hands-on maintenance practices.

Workforce development is a key value point to increase community engagement and public-participation in environmental issues. This is especially important for the forest products industry that is very strong supporter of a biochar industry, and to make effective use of community programs.

Excerpts from:

EPA Stormwater Best Management Practice, Sand and Organic Filters

Table 1. Typical maintenance activities for sand filters.

Activity	Timeframe
Remove trash and debris, including clippings from regular landscaping activities	After storm events or as needed, at least semi-annually
Inspect for structural damage and leaks	Annually
Inspect for evidence of erosion	After storm events or as needed, at least annually
Inspect to ensure stormwater is not bypassing the unit	After storm events or as needed, at least annually
Repair or replace damaged parts	As necessary
Clear sediment from sediment chamber	If sediment accumulates to half the chamber volume
Replace filter media	As necessary, as indicated by prolonged periods of pooling water over the filter bed during dry weather

Sand filters are a good option to achieve water quality goals in retrofit studies where space is limited, because they take up very little surface space and have few physical site restrictions.

A sand filter consists of a settling chamber and a filter bed with sand or other filtering media. As stormwater flows into the settling chamber, large particles settle out, and the filtering media then remove finer particles and other pollutants. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter and various organic media filters. Design engineers have modified the traditional surface sand filter to fit more challenging sites or to improve pollutant removal.

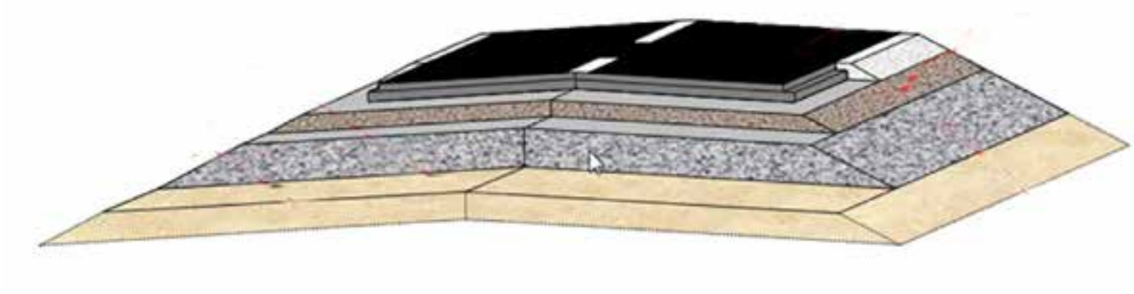
Stormwater hot spots are areas where land use or activities generate highly contaminated stormwater discharge, with pollutant concentrations exceeding those typically found in stormwater. Examples include gas stations, vehicle repair areas and waste storage areas.

A stormwater retrofit is a stormwater management practice (usually structural) put into place after development or construction of a stormwater control to improve water quality, protect downstream channels, reduce flooding or meet other specific objectives that did not exist at the time of original construction.

Pretreatment plays an important role in stormwater treatment. Pretreatment structures, installed immediately upgradient to a stormwater control, reduce flow rates and remove sediment and debris before stormwater enters a stormwater control. This helps to improve the stormwater control's pollutant removal efficiency and reduces maintenance requirements.

Sand filters that incorporate liners or sit on poorly infiltrating soils are often a good option to treat discharge from stormwater hot spots due to the treatment they provide and their limited potential to contaminate groundwater. Organic media [i.e. biochar] are an effective adsorbent of many hotspot pollutants, such as metals and hydrocarbons.

3.6 Road amendments



Carbon-negative and permeable roadbeds with biochar are feasible. Having onsite control over biochar production will be a huge asset to bring costs down.

DESIGN CRITERIA

Carbon sequestration, with carbon credit values.

No compromise on life cycle or durability.

Temperature stability proven for application and life span.

Control over biochar specs and capacity to modify as needed.

Heavy metal sequestration.

Increased percolation.

Reduced worker risk from solvents.

Cold mix, to reduce energy usage.

Asphalt additive.

Biochar slurry, with customized amendments, depending on conditions.

3.8 Phosphorous media

Biochar is a relatively new addition to the stormwater filter media industry. Washington state's Technology Assessment Protocol (TAPE) provides a standard for assesment of a several commercially available media, to cover seven categories:

1. All
2. Pretreatment
3. Oil
4. Phosphorous
5. Metals
6. Basic
7. Construction

The City of Bellingham WA established in 2022 its own open-sourced media called POST which combines many of the features of these engineered media, which allows for end users to develop blends that are more cost-effective than commercial blends.

Phosphorous Optimized Stormwater Treatment (POST)

POST is a three-stage vertical filtration media bed with underdrain, typically housed in a precast concrete vault but may be constructed in lined earthen excavations with or without structural walls. Typical configured vertically stacked or unstacked with 3 filtration stages arranged in series:

Stage 1: Mmulch prefilter removes gross solids, debris, oils, and larger particulate matter.

Stage 2: Primary media bed optimized for the physical filtration of total suspended solids (TSS), dissolved pollutant sorption, and (optional) plant growth.

Stage 3: A polishing media bed specifically formulated for dissolved phosphorus and metals removal. This is where biochar mixtures with aluminum oxide can operate most effectively to adsorb phosphorous with minimal particle or silt infiltration.

The frequency and type of required maintenance depends on the site selected and the size and character of the drainage / filtration method.

In summary, the POST system provides a structure to develop specific mixtures to fit field conditions, especially for phosphorous.

3.10 Problem areas

EV Fires & Hazmat

Electric vehicle (EV) technology has become commonplace, but there is very little response guidance for emergency responders. The nature of battery technology and EV manufacturing presents big challenges in effectively managing EV fires. There are substantial gaps in the science available to inform safe and effective approaches for identifying, confining and extinguishing these fires.

EMS responders must continue to adapt, as lithium and other heavy metals can have great impact on the surrounding ecosystem.

Biochar filtration products will be far more effective and should be easily accessible to first responders.

An ample supply of biochar can be stored and managed similar to road salt. While spill barriers can catch some of the toxic runoff, there is always some residual spill onto shoulders and ditches. This where a truckload of raw biochar, available within 50 miles, can be highly effective for emergency situations.

Fire agencies are included in our hazmat programming package so that they can be collaborators in emergency spills.

Road salt

Another critical concern is road salt, an unavoidable contaminant. This has been a major conundrum for science and governments to solve, with little effect.

All research points to the potential value of biochar in addressing the chloride issue in the following manner:

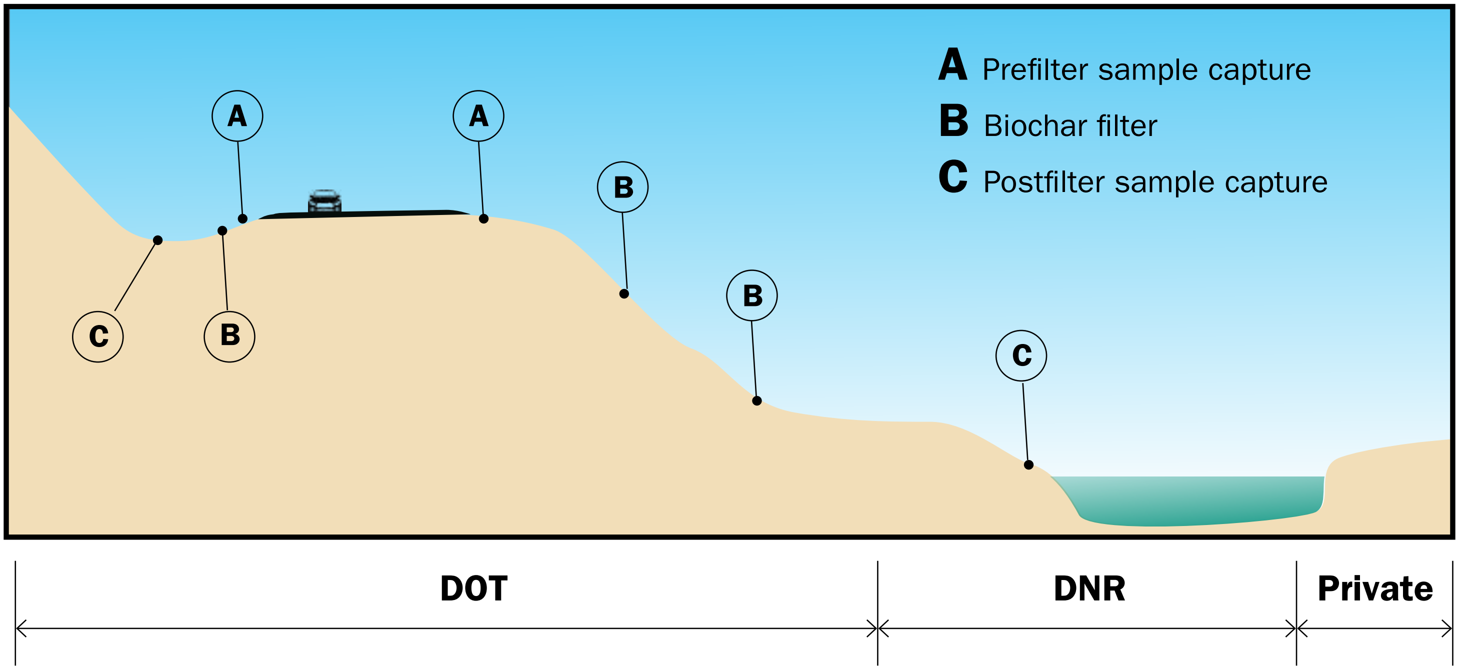
1. Salt amendment products.

2. Roadside soil engineering to buffer and filter the runoff at critical points.

3. Soil desalination at critical runoff points.

4. Increasing salt tolerance of plants.

The science of road salt mitigation will benefit from DOT rollout of biochar. Our program includes engagement with chloride mitigation groups in local government to prove these lab scale solutions.



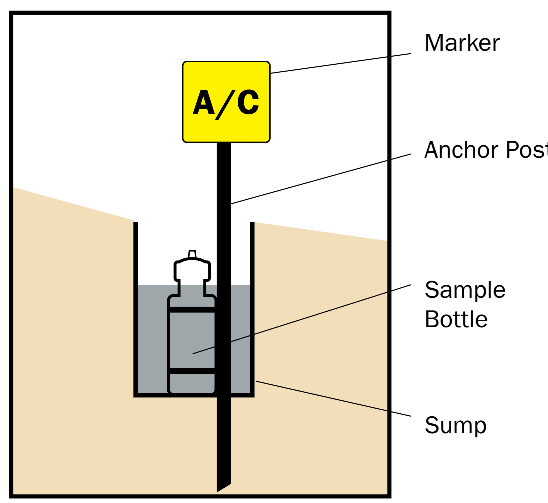
Increased Monitoring & Testing

Scaling up biochar filtration for stormwater requires an enhanced monitoring and testing protocol. Available sampling systems will be applied to keep track of progress, measured with each rain event.

Crossing property lines from DOT to DNR or to private property requires a collaborative effort to manage the process.

The goal is to increase the frequency and quality of collection / testing / reporting while keeping within budget.

Mobile laboratories will add value to minimize time and cost for higher volume ot samples.



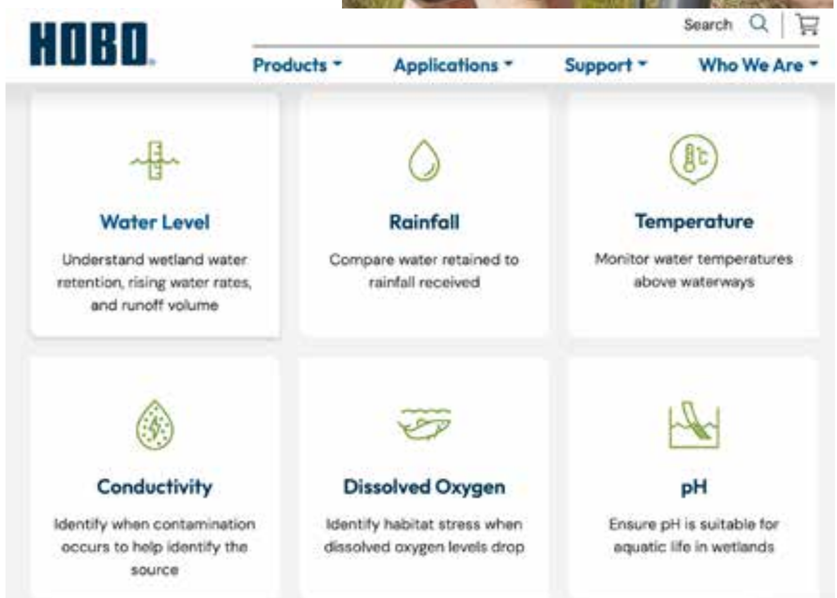
Mobile testing lab

3.12 Smart infrastructure

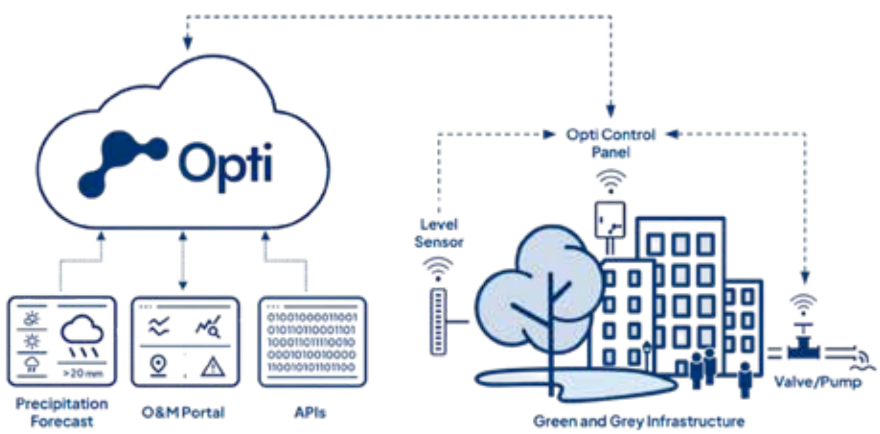
Smart sensors and controls are effectively improving ecosystems, while increasing public engagement.

The HOBO product line provides a wide array of sensors and turnkey off-grid systems to track key stormwater conditions, with options to develop an online dashboard, a critical component to increase public engagement.

Water level loggers are a useful, low-cost monitoring tool for evaluating the performance of stormwater control measures.



Opti is a cloud-based, real-time adaptive control for stormwater infrastructure, typically reducing capital and operating costs by 50% to 90% compared to traditional grey infrastructure. Opti uses weather forecasts to proactively manage water levels, to achieve compliance at a lower cost, reducing water quality credit costs from $150,000 to approximately $40,000 per acre in an urban setting.



Case Study: Albany NY

The Opti system has enabled the capital of NY to reduce storm overflow to 10%, down from 90%. This helps to put all types of technology, including biochar, into a new era of pollution control.

3.13 Hot spots

Pilot projects can focus on specific locations that affect a wide area.

1, Identify high risk locations.

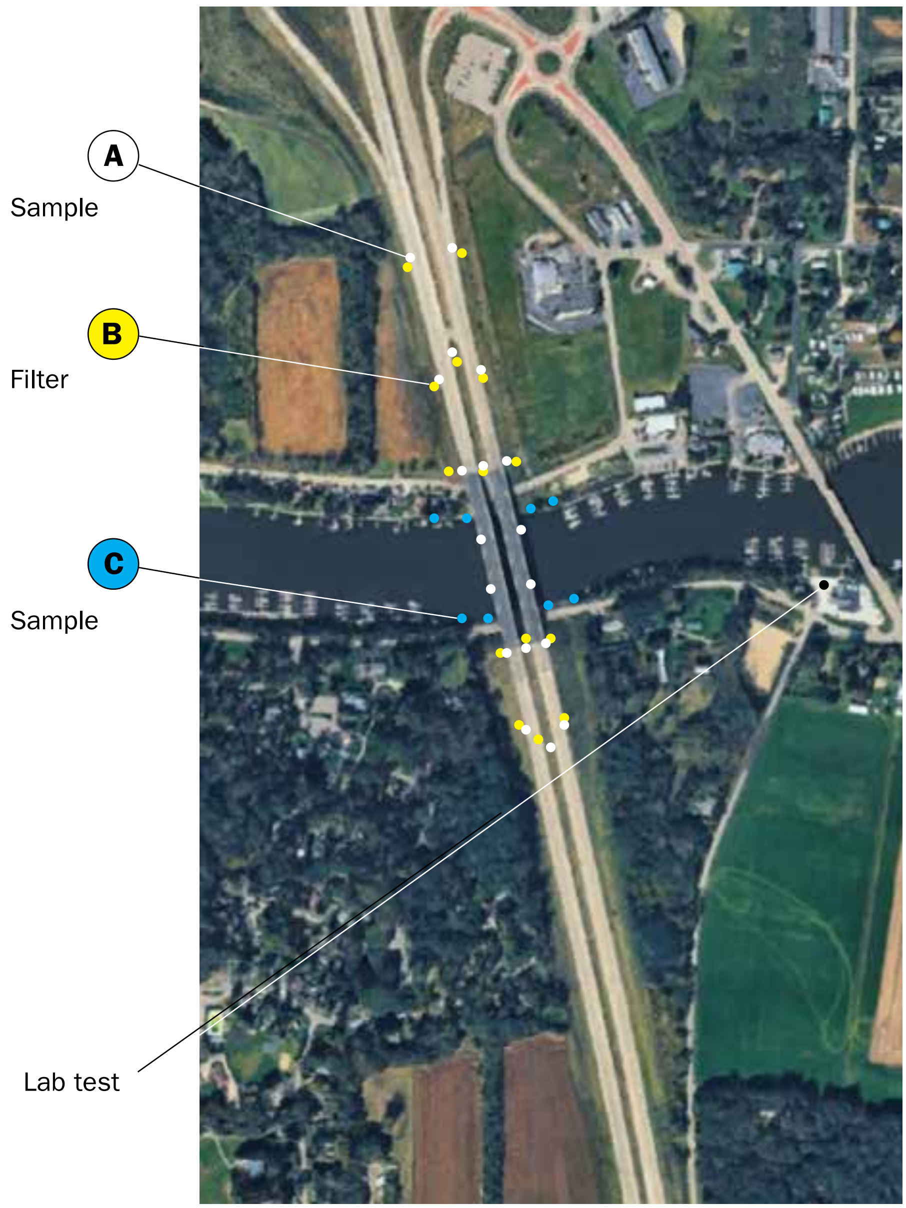
2. Develop channeling strategy using less expensive methods and filters.

3. Apply a comprehensive biochar method, starting with filter socks and extending to check, dams, swales, slopes, etc.

4. Maintain consistent and focused monitoring over time, working with community partners.

5. Establish next-day lab testing and reporting where possible for crucial contaminants.

Typical Location, I-90 Overpass, Rock River, Rock County, Wi



4.0 Field study examples

Key takeaways from **Development of a New Green Infrastructure by Using Biochar Amended Topsoil for On-Site Stormwater Runoff Treatment**

Ga Southern University, 2024

• Unique field scale biochar amended topsoil filtration system.

• 2x 250 sq feet comparirng top soil control cell with biochar test cell.

• 1-year continual Field Test Site monitoring, sampling and testing the water samples.

• Test Cell with the addition of biochar (5% by wt) into the topsoil significantly increased its moisture content and infiltration rate.

• Test cell high carbon content (average 75-80%), significant heterogeneity, along with a high level of microporosity and macro-porosity

• Test Cell had much higher biofilm quantity than Control Cell that affected nitrogen removal efficiency over time.

• Test Cell showed higher pollutant removal efficiencies than Control Cell and Test Cell is a better best management practice for stormwater runoff treatment

• Removal efficiencies of all pollutants by Test Cell are much higher than those by Control Cell..

• infiltration rate increased 78% over time in the Test Cell than Control Cell and the TSS and nutrients removal efficiencies also increased.

• ATP density/biofilm/biomass quantity increased over time in the Test Cell. 58% higher biofilm/biomass quantity was observed in the Test Cell than Control Cell. (Adenosine triphosphate (ATP) is the primary molecule for storing and transferring energy in cells.)

• The addition of biochar to topsoil improves its carbon (C) content and moisture content, which in turn improves the growth of soil microbes.

• Heavy metals,oil-grease and TSS (total suspended solids) removal efficiencies were also increased by biofilm/biomass attachment of biochar amended topsoil.

• Biochar had a great effect on every pollutant removal efficiency.

•Benefits, improved stormwater treatment, soil health, and urban aesthetics.

•Biochar amended topsoil for on-site stormwater runoff treatment is cost-effective and sustainable

Key takeaways from **Critical Field Evaluations of Biochar-Amended Stormwater Biofilters for PFAs and Other Organic Micropollutant Removals**

Luleå University of Technology, Sweden

•Biochar biofilters were effective at removing PAHs from stormwater. (Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 persistent, toxic chemicals formed by incomplete burning of organic materials like coal, oil, gas, and garbage).

• The most common OMPs (Organic Micropollutant) detected in the filter materials were particle-bound hydrophobic, heavier PAHs, PCBs, PHCs, and phthalate (DEHP)

• A noticeable improvement in DOC removal (Dissolved Organic Carbonrepresents the fraction of organic matter in water that passes through a filter, originating from decaying matter or human activity.)

• Biochar improves OMP adsorption through different mechanisms (i.e. electrostatic, and hydrophobic interactions).

• Increasing performance with low levels of competing agents and co-contaminants in stormwater, replacing saturated filters, higher biochar content, small particle size, and high contact time.

• Specific designs that could mitigate factors hindering the performance of biochar in stormwater biofilters.

• Biochar content (%) and particle size, as well as influent stormwater quality, should be optimized (with silt filters) to maximize the effectiveness.

• There is increased effectiveness from modifying biochar surface (e.g., with metal-ions, nano metal oxides/hydroxides, organic polymers, acids, and vapor/CO2 activation), increasing surface area mixing different types of biochar

• Regulating saturation and flow rate to enhance contact time.

• Altering filter media amendment configurations (e.g., placing biochar as a separate layer at a deeper layer rather than inter-mixing it with sand material) to improve the biochar effectiveness.

SUMMMARY

Specific site and environmental conditions should be considered carefully when applying biochar. Increasing control options for pre-filtering silt and reducing co-contaminants will yield better results.

Pilot studies focused on limited or known contaminants will yield better results.

Speciaized additives, such as metals, will increase effectiveness for some pollutants, such as phosphorous.

Biochar has many control factors that we can include in developing solutions for storm water.

4.1 Typical contaminants

Adapting biochar to fit variable conditions.

Matching the chemical/physical properties to work with specific contaminants is required. A series of filters may be deployed, containing specific blends and consistencies, which can be determined in the trial process.

Summary of research by contaminant.

Heavy Metals

USDA's biochar composite material is our standard for next-level filtration of heavy metals.

Removal of heavy metals using biochar composite material.

Time	Concentration of Metal Ions (ppm)			
	Pb^{2+}	Cr^{3+}	Cd^{2+}	Ni^{2+}
0 hr	71.49	72.32	84.0	72.99
5 hr	35.91	42.79	80.90	69.6
24 hr	0.88	6.35	74.95	66.01
48 hr	0.2	0.27	67.33	61.28
3 day	0.07	0	68.30	65.08
4 day	0.03	0	62.29	59.99
Adsorption Efficiency after 4 days	99.9%	100%	26%	18%

Our goal for pilot projects is to achieve similar results in the field, starting on a small scale and gradually increasing volume and scope of contaminants.

Achieving 99% efficiency will require a filtration scheme using filters, bioslopes and ponds.

USDA FPL

Phosphorous

Biochar can be effective with phosphorous adsorption if impregnated with cations (e.g. magnesium) during production at relatively low temperatures. Integrating it into bioretention systems can potentially achieve high phosphorus removal rates, with some systems demonstrating up to 97% efficiency. This will be a focus of field research.

Biochar's ability to adsorb or desorb phosphorous, as a nutrient, will vary according to a number of factors.

Specific biochars can be used to treat surface or waste water with high phosphorous levels, with the potential for capturing and selling the material, a circular economic model that is feasible.

University of MN /MN DOT

Hydrocarbons

Biochar is effective for the bioremediation of soil polluted with total petroleum hydrocarbons (TPHs). Biochar acts as a medium for petroleum-degrading bacteria to immobilize and degrade TPH compounds. After 60 days of remediation, the strategy involving immobilized bacteria on biochar was more effective than other treatments in reducing the contents of TPHs, with the highest biodegradation efficiency. The biochar treatment improved not only the soil fertilizer and carbon storage, but the immobilization greatly affected both the physicochemical properties of soil and bacterial activities. Moreover, the bacterial population diversity and bioavailability of hydrocarbons were promoted by the inputs of

Bioremediation Of Petroleum Hydrocarbon-Contaminated Soil By Petroleum-Degrading Bacteria Immobilized On Biochar

College of Chemical Engineering,
China University of Petroleum

4.3 Tire particles & 6PPDQ

Tire particles and dust represent an important threat to fish and human health. Biochar shows very promising results.

Biochar Mix Remedies Coho Salmon Mortality from Tire Dust in King County, WA

King County's Water and Land Resources Division March 2025

King County scientists have identified a potential breakthrough in the longstanding problem of coho salmon dying from exposure to polluted stormwater before they can spawn with a new soil mixture that has is highly effective at treating a toxic chemical found in tire dust.

Scientists are now building on laboratory success to better understand and address the toxic chemical, known as 6PPDQ, that is killing coho salmon before they reach their spawning grounds. The recently discovered 6PPDQ is found in all tire dust. Rain washes the toxic chemical from roadways into waterways, where it kills adult salmon preparing to spawn.

Before 6PPDQ was discovered, a collaborative group partnered to develop a new soil mixture to optimize the treatment of stormwater. The study showed that while nearly 100% of coho placed in unfiltered stormwater died, there was a 100% survival rate for the coho placed in stormwater that had been filtered through the new soil mixture. The soil mixture includes prescribed amounts of sand, coconut fiber, and biochar that stormwater runoff slowly filters through, removing pollutants and excess nutrients as it percolates into the ground.

Effects Of Biochar On Tire Wear Particle-Derived 6PPD, 6PPD-Q, and Antimony Levels and Microbial Community In Soil

Laboratory for Ecological Security of Regions and Cities, Chinese Academy of Sciences

The addition of biochar to tire wear particle (TWP)-contaminated soils effectively decreased 6PPD, 6PPD-Q, and antimony (Sb) levels, with biochar pyrolyzed at 600°C exhibiting the most pronounced remediation effects under varying moisture conditions. Also, there is significant reduction in Sb mobility and bioavailability in TWP-contaminated soils, with biochar treatments demonstrating up to 80 % reduction in Sb(V) and Sb(III) levels under varying moisture conditions.

- Biochar reduced 6PPD in flooded soils over 60 days.

- BC reduced Sb(V) and Sb(III) bioavailability, especially in flooded conditions over 60 days.

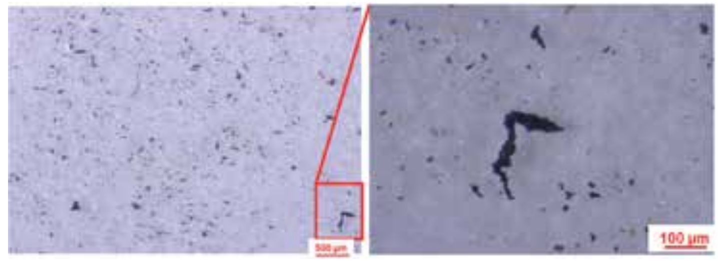
- BC influenced microbial composition, increasing Firmicutes in flooded and Proteobacteria in dry soils.

6PPD and 6PPD-Q exposure altered bacterial composition, with Desulfobacterota and Planctomycetota thriving in flooded conditions, while Gemmamonadota and Verrucomicrobiota declined in 50 % water holding capacity (WHC). Key results indicated a strong reduction in alpha diversity under 50 % WHC, while treatments with 400° biochar maintain higher biodiversity, and higher species richness. Higher-temperature BC effectively reduced 6PPD, 6PPD-Q, and Sb bioavailability while mitigating TWP contamination by enhancing microbial diversity.

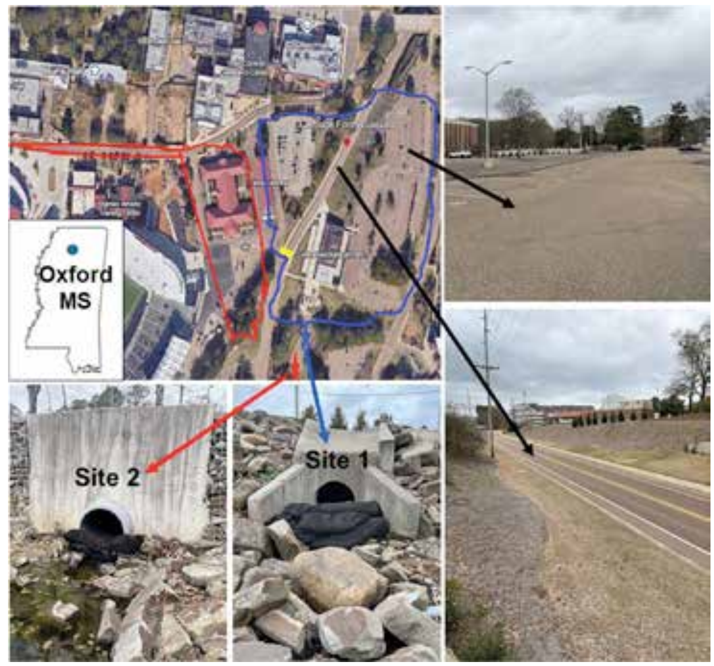
4.4 Tire particles field study

Field Evaluation of Rice Husk Biochar and Pine Tree Woodchips for Removal of Tire Wear Particles from Urban Stormwater Runoff in Oxford, Mississippi (USA)

University of MS



Contact us for more details.

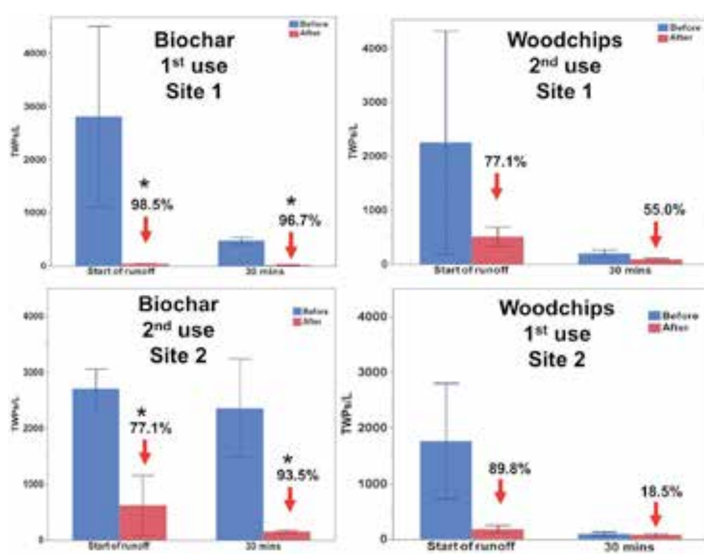


Abstract

We investigated the effectiveness of stormwater filter socks filled with rice husk biochar or pine tree woodchips in reducing TWP pollution in urban runoff in Oxford, Mississippi. Triplicate runoff samples were collected upstream and downstream of the biofilters at two sites during two storm events at peak flow within minutes of the start of the storm and after 30 min.

Biochar was more effective than woodchips ($p < 0.05$) at removing TWPs, reducing concentrations by an average of 97.6% (first use) and 85.3% (second use) compared to 66.2% and 54.2% for woodchips, respectively. Biochar was particularly effective at removing smaller TWPs (<100 µm).

Both materials became less effective with use, suggesting fewer available trapping sites and the need for removal and replacement of the material with time. Overall, this study suggests that biochar and woodchips, alone or in combination, deserve further scrutiny as a potential cost-effective and sustainable method to mitigate the transfer of TWPs to aquatic ecosystems and associated biota.



4.7 Other field studies

Key takeaways from **Field Evaluation Of the Contaminant-Retention Performance For A Biochar-Amended Stormwater Filtration System**

U of Minnesota 2020 - 2023

• The contaminant-retention performance for a stormwater filtration testbed containing three filter cells with different media was monitored over the first two years of operation in the field.

• Biochars that facilitate enhanced retention of certain contaminants may be less effective for retention of others, representing the importance of the biochar production process as well as the resulting surface properties.

• Wood-based biochars produced at higher temperatures are more effective for removal of aromatic organic substances and E. coli, while biochars produced at lower temperatures are more effective for removal of metals.

• Quality assurance criteria based on readily biochar properties, rather than the production process, will be critical to biochar specifications for treatment applications.

• There is a need for standardized practices for performance certification.

• Batch tests are substantially simpler than column tests, require less space, and can be used to distinguish between materials based on sorption capacities for a variety of contaminants.

Key takeaways **from Development of Biochar Specification Criteria as Soil Amendment for Slopes, Conveyances and Stormwater Treatment Systems**

U of Minnesota 2025

Recommended production methods for optimal biochar performace:

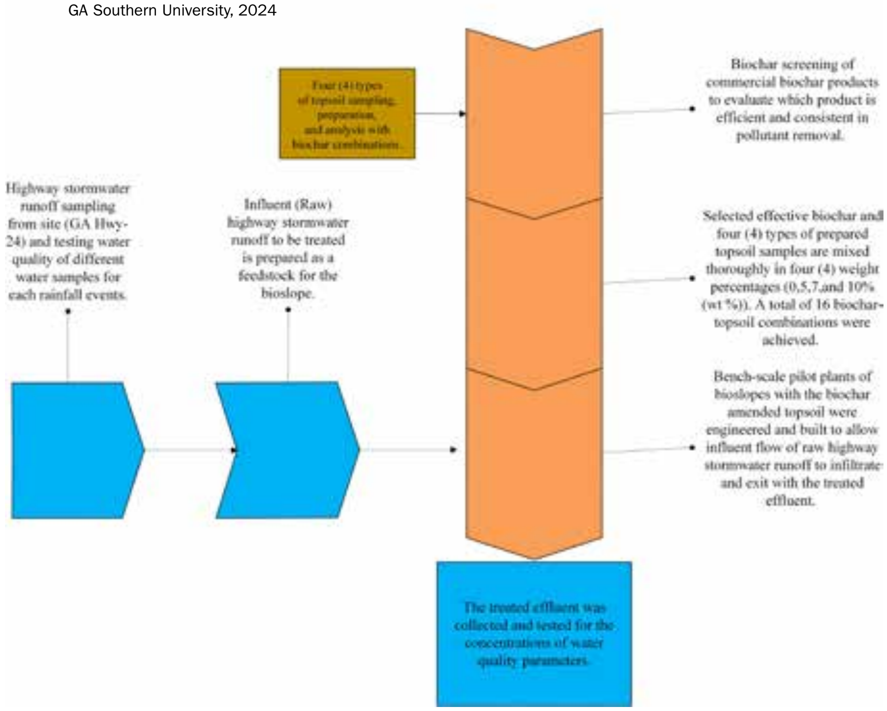
• EXTRACTIVES CONTENT...A 50/50 benzene/ethanol solvent mixture is used to extract deposited volatile organics via Soxhlet extraction. Total extractives weight is reported as a 5 of the sample mass.

• ≥ 675 °C... Production temperature is optimal.

• VASCULAR POROSITY... Control and measurement of porosity is required to achieve optimal results. Careful choice of feedstock is appropriate.

Experimental Process Flow for Biochar-Amended Topsoil Bioslope For Highway Stormwater Runoff Treatment

GA Southern University, 2024



Summary of **Biochar-Amended Topsoil For Highway Runoff Treatment: Unintended Consequences Of Heavy Metal Release Amid Success In Solids And Oil & Grease Removal**

GA Southern University, 2024

Biochar-amended topsoils, with • biochar achieved over 60% removal efficiencies for physical pollutants, including total suspended solids, total dissolved solids, and total solids from real sampled highway stormwater runoff. Organic pollutants such as chemical oxygen demand and oil & grease exhibited removal efficiencies exceeding 80% and 20%, respectively.

However, the study also revealed the inherent difficulties in treating heavy metals such as lead, zinc, and copper, where the removal efficiency was highly variable due to biochar saturation and competitive ion exchange, particularly for the dissolved metals.

5.0 Community jurisdictions

“We all live downstream.”

Problem: A patchwork of overlapping jurisdictions, public agencies, research groups and property owners can rarely find consensus.

Solution: Public programs and access to information will enable citizens and community groups to get more involved as stakeholders, with job and education opportunities. Public policy will follow increased community engagement.

Urban Runoff	Parking lots and rooftops take the lead as producers of non-point source runoff. The DOT, DNR and EPA seek to manage these overlapping boundaries with zoning laws and research but far more can be done. Many developers and property owners are keen to do more. The public can add a lot if they have access to information and can see the direct benefit. .
Airports	Airports contribute a lot to PFAs situation, as opposed to roadways. The FAA is in charge of airport’s environmental impact, under NEPA, the National Environmental Policy Act of 1969 that requires analysis of potential impacts to the environment and when there are, considering alternatives and mitigation before approving federal actions
Rail lines	The Federal Railroad Administration (FRA) manages environmental compliance under NEPA when considering approval of proposed transportation projects. They engage with appropriate federal, state, and local authorities as well as with the public at the earliest practical time in the project planning process.
Farms	Farm runoff is another major contributor of chemicals that the DOT and DNR has to deal with. This can include raw manure, ammonia, phosphorous, glyphosate and any number of pesticides or herbicides that are oversprayed onto public roadways. Programs are in place to get voluntary compliance and investment by farmers in practices that reduce runoff. Farmers however, are shielded from regulatory compliance by “Right to Farm” laws which protect the profits more of large operations such as CAFOs, while doing little to protect smaller family operations. Continuing to advocate for small farmers, while making it easy for them to adopt best practices is the best political solution.
Industry	Industrial sites can be major sources of toxic runoff. Similar to farmers, businesses are seeking to increase compliance while reducing liability and maintaining the bottom line. Biochar and micro-solutions represent a new era of opporunity for industry to acheive these goals.

5.1 Community engagement

A New Era of Public Responsibility

Immense value can be gained by partnering with community groups seeking to engage volunteers, with options to learn skills that can be applied as a career.

Considering that roads intersect all of our lives, we can work with DOT to civic groups who are already involved with Support a Highway programs, water activist groups and existing programs at schools, connecting K-12 and research universities.

One example is the Billion Oyster Project in NYC is successfully restoring marine habitats with support of hundreds of volunteers.

Increased participation is required among community members to improve conditions. Landscape companies, homeowners, industry groups and famers can be persuaded with a carefully-planned promotional campaign, which may require funding.

New York City is a leader in developing collaborations with community members to resolve major environmental issues.

The Billion Oyster Project, a volunteer program producing excellent results at restoring marine habitats, with oysters providing a foundation environment that starts with thousands of tons of processed shells donated by restaurants. Like biochar, the shells provide abundant microbial surface area.

Across the US, Riverkeeper groups are among the most committed and effective partners that can help monitor bridges and culvert locations, reducing costs and improving outcomes.

NYC Clean Soil Bank is a municipal clean soil exchange that recovers clean, native soil from deep excavations at construction sites and redirects it to where it's needed.

5.4 Collaborative industrial design

Carbon Intel, LLC is a national leader in developing innovative environmental remediation strategies. We integrate engineering rigor with economically viable, nature-based solutions. Our work focuses on advancing fungal, microbial, biochar and ozone technologies that address complex contaminant issues including PFAS and heavy metals at cost and scale superior to incumbent technologies. Through the combined application of biochar, fungal remediation systems, and emerging technologies developed by agencies such as the NOAA and the USDA, we are advancing approaches that both capture and destroy persistent pollutants while improving the health of the land.

Our methodology reflects a broader shift toward working with natural systems to restore ecological balance while creating measurable economic value. These approaches align with longstanding environmental stewardship traditions found across many Indigenous cultures, reinforcing solutions that support both environmental restoration and community resilience.

Headquartered in Madison, Wisconsin, Carbon Intel collaborates with partners across several states, including leaders in forestry management, stormwater infrastructure, industrial filtration, and regional economic development.

The need for scalable, effective remediation technologies is increasingly urgent as communities across the United States confront the environmental and public health impacts of persistent industrial contaminants. Carbon Intel is committed to advancing practical solutions that help communities regain control over these legacy pollutants.