Biochar in Urban Landscapes (Stormwater)

State of the Science

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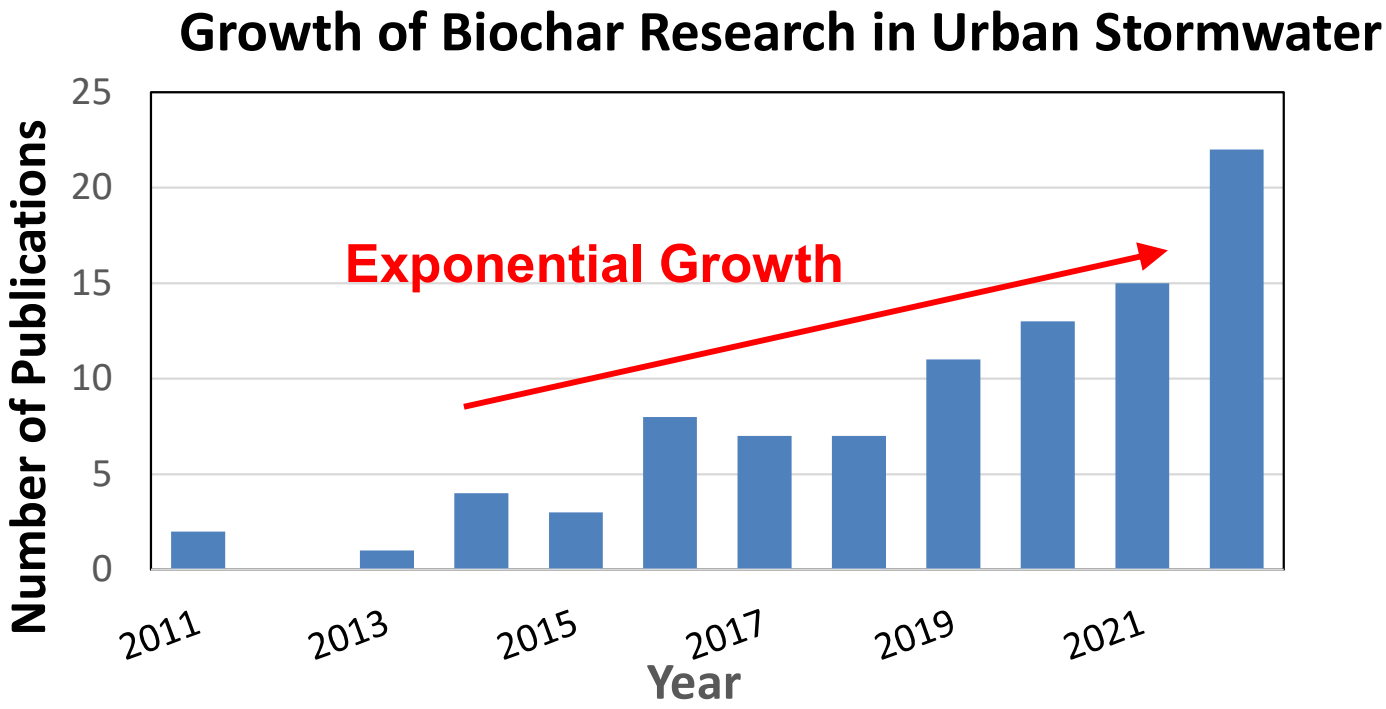
Historical Perspective



- **Exponential growth in research**

Modified from Biswal, et al. (2022) Biochar-based bioretention systems for removal of chemical and microbial pollutants from stormwater: A critical review, *Journal of Hazardous Materials*, doi.org/10.1016/j.jhazmat.2021.126886.

Recommended Urban Stormwater BMPs for Biochar

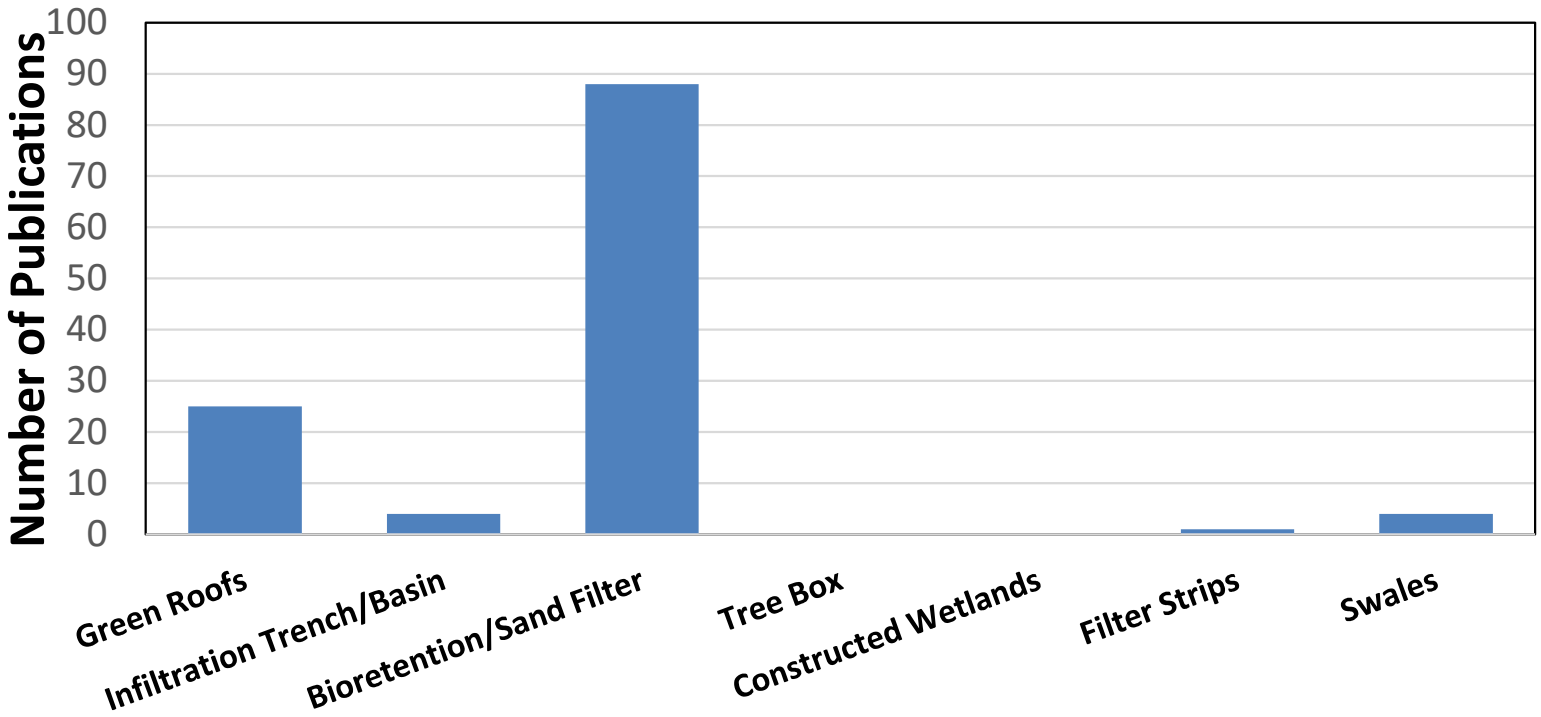
Stormwater BMPs
Green Roof
Infiltration Trench/Basin
Bioretention/Sand Filter
Constructed Wetland
Filter Strip
Swale

- **All involve amending existing engineered media (or soil) with biochar.**

Sanjay et al. (2018) Plenty of room for carbon on the ground: Potential applications of biochar for stormwater treatment, *Science of the Total Environment*, doi.org/10.1016/j.scitotenv.2018.01.037

What Have We Learned?

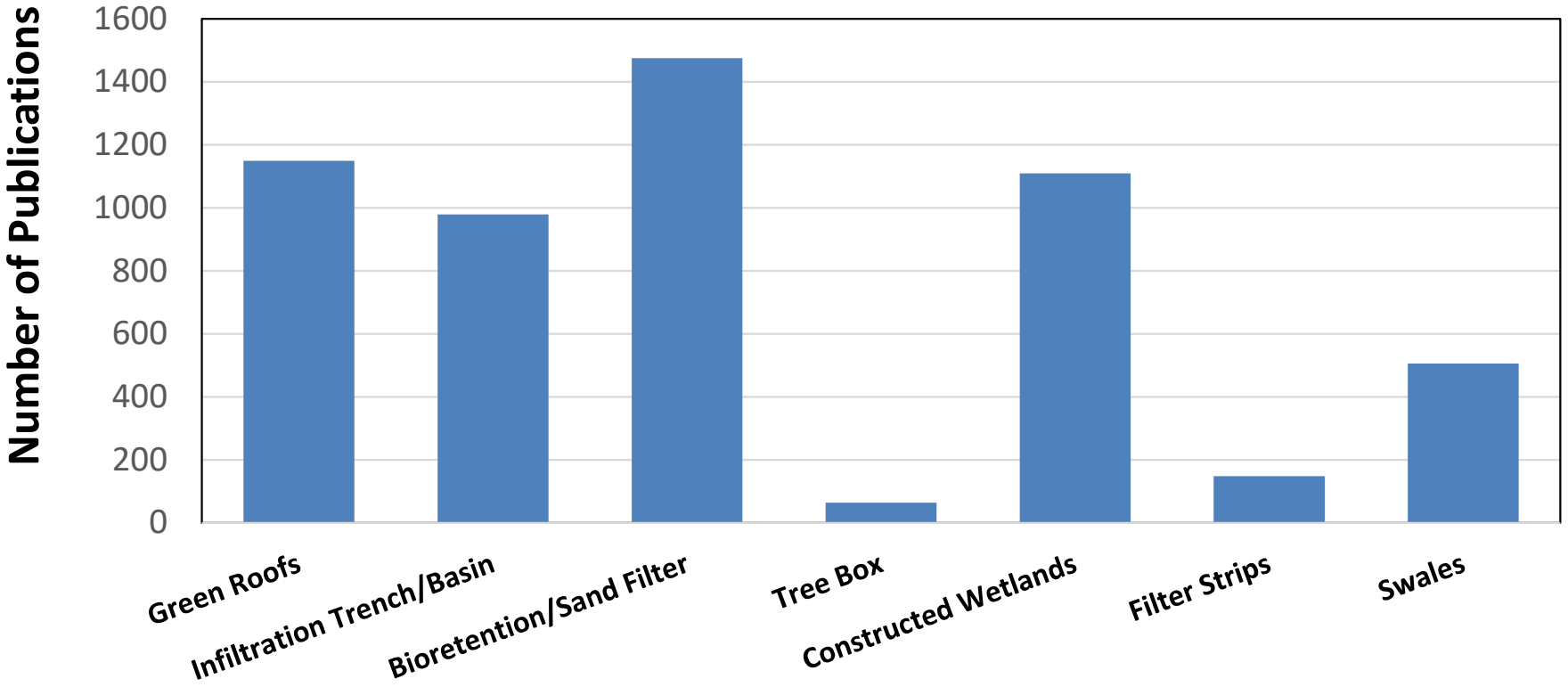
Publications for Biochar Stormwater Application (All Years)



- **Bioretention/sand filter – most studied.**

But … Not Unexpected

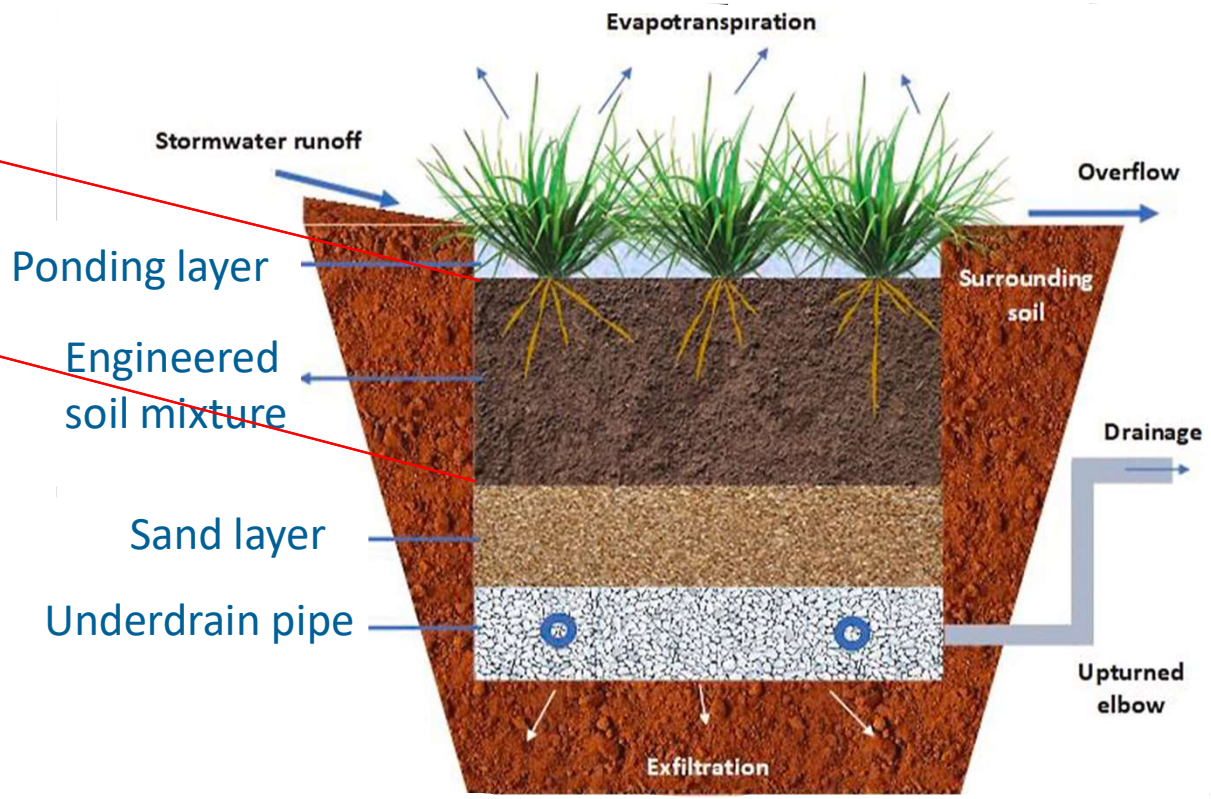
Publications for Stormwater BMPs (All Years)



- **Bioretention/sand filter – most studied among all BMPs.**

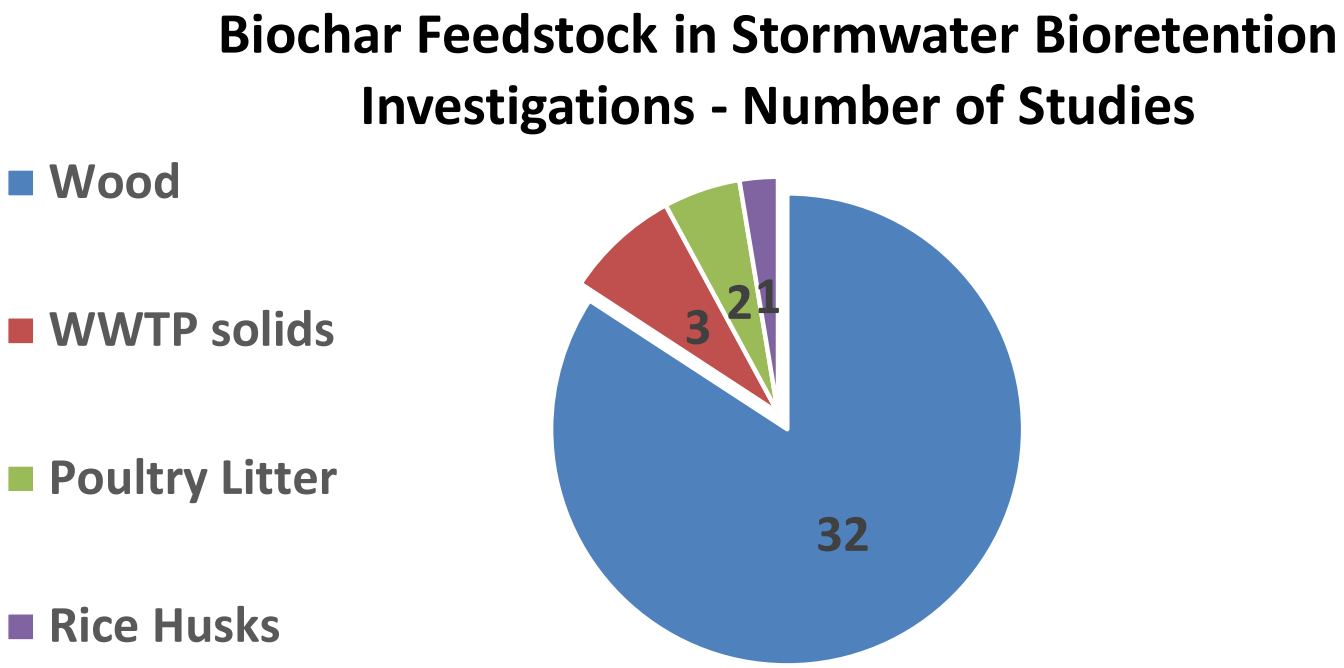
Biochar in Bioretention Media

BSM: Bioretention Soil Media



- **Bioretention/sand filter – most studied.**

What Have We Learned?

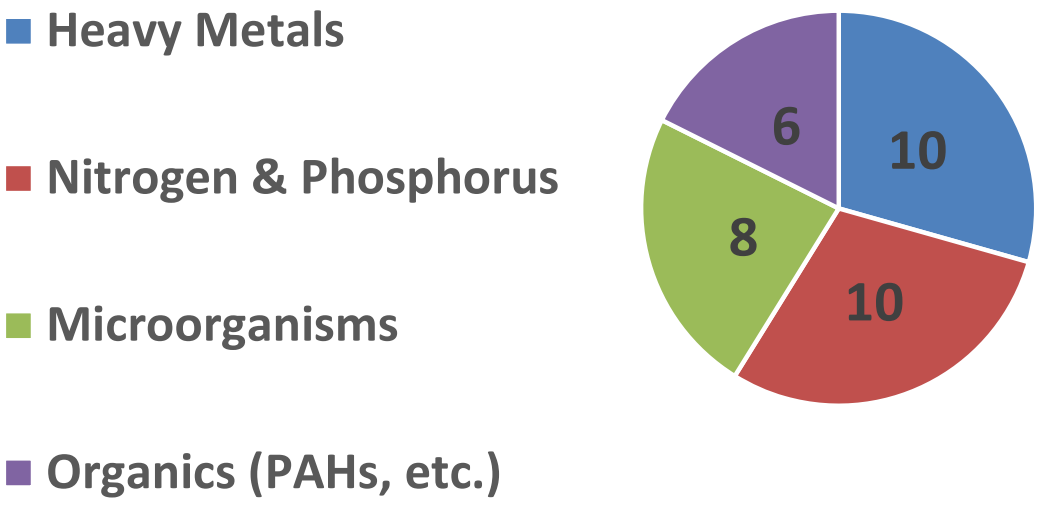


- **Wood biochars – most promising properties. Manures <u>may</u> leach pollutants.**

Modified from Biswal, et al. (2022) Biochar-based bioretention systems for removal of chemical and microbial pollutants from stormwater: A critical review, *Journal of Hazardous Materials*, doi.org/10.1016/j.jhazmat.2021.126886.

What Have We Learned?

Stormwater Pollutants with Biochar (Bioretention) - Number of Studies

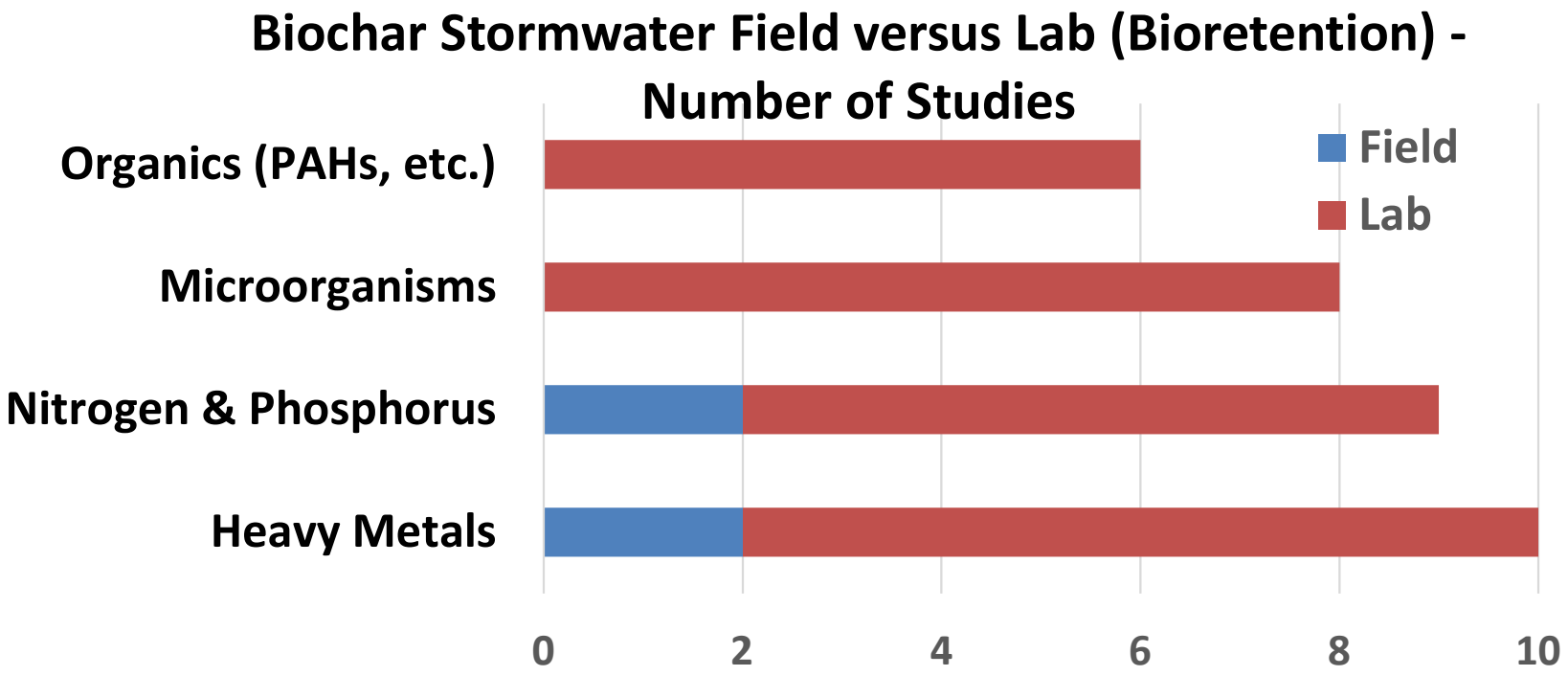


Pollutant	Reduction Range with Biochar
Heavy Metals	27 – 100%
Total Nitrogen & Phosphorus	32 – 94%
Microorganisms	Log10 = 0.78 – 4.23
Organics (PAHs, etc.)	54 – 100%

- **Biochars effective for <u>most</u> pollutants investigated.**

Modified from Biswal, et al. (2022) Biochar-based bioretention systems for removal of chemical and microbial pollutants from stormwater: A critical review, *Journal of Hazardous Materials*, doi.org/10.1016/j.jhazmat.2021.126886.

What Have We Learned?

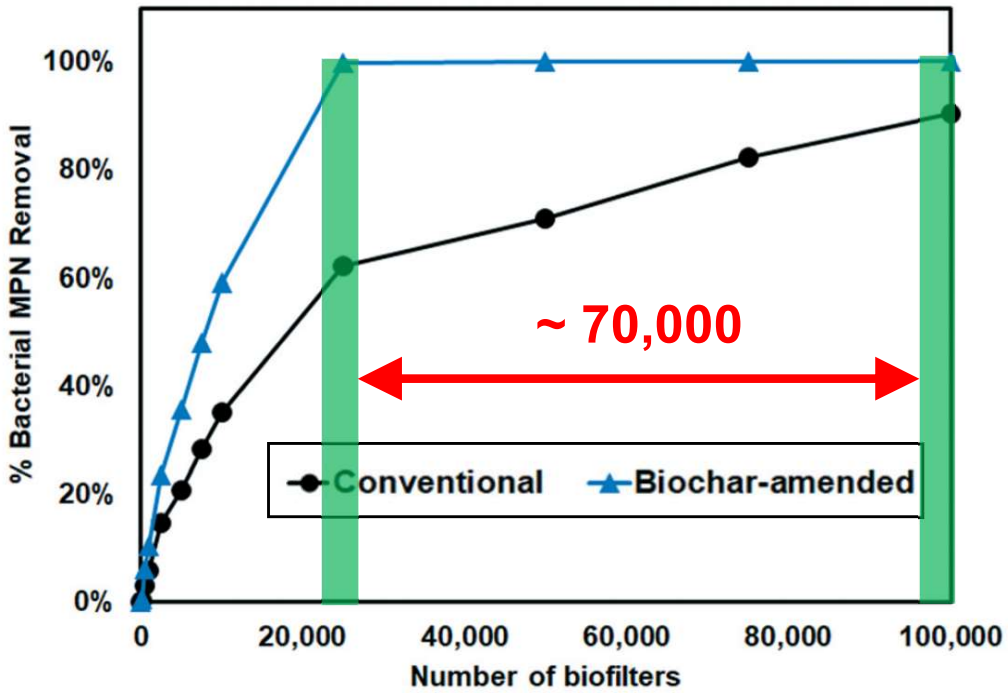


- **Most studies in the laboratory**.

Modified from Biswal, et al. (2022) Biochar-based bioretention systems for removal of chemical and microbial pollutants from stormwater: A critical review, *Journal of Hazardous Materials*, doi.org/10.1016/j.jhazmat.2021.126886.

Potential Impact of Large-Scale Applications - Bioretention

- **Case study – Ballona Creek Watershed (Los Angeles, CA)**
- **Focus on bacterial removal**



- **~ 70,000 fewer biofilters with biochar-amended media.**

Boehm et al. (2020) Biochar-augmented biofilters to improve pollutant removal from stormwater – can they improve receiving water quality?, *Environmental Science Water Research & Technology*, DOI: 10.1039/d0ew00027b

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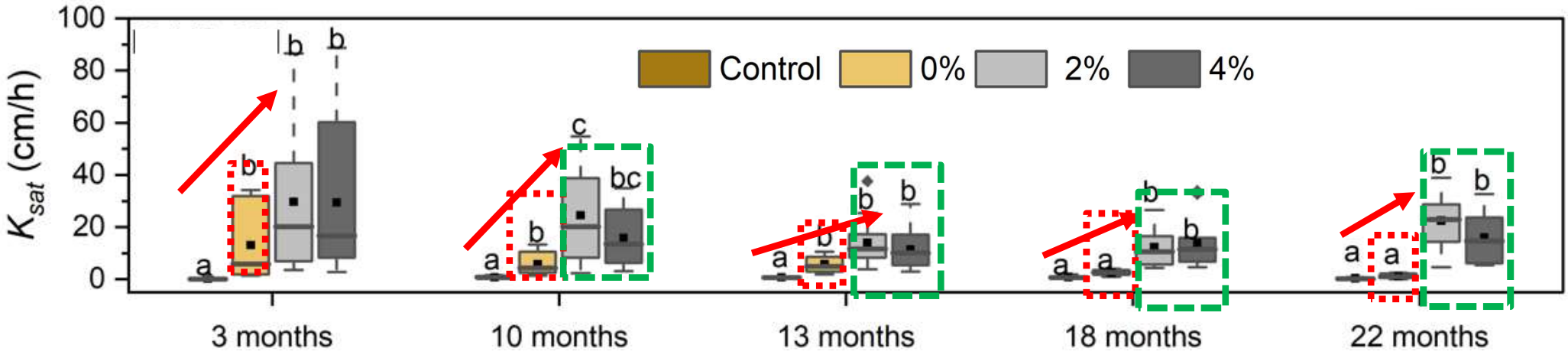
Potential Impact of Large-Scale Applications – Filter Strip

- Grass seeding

Straw blanket

Potential Impact of Large-Scale Applications – Filter Strip

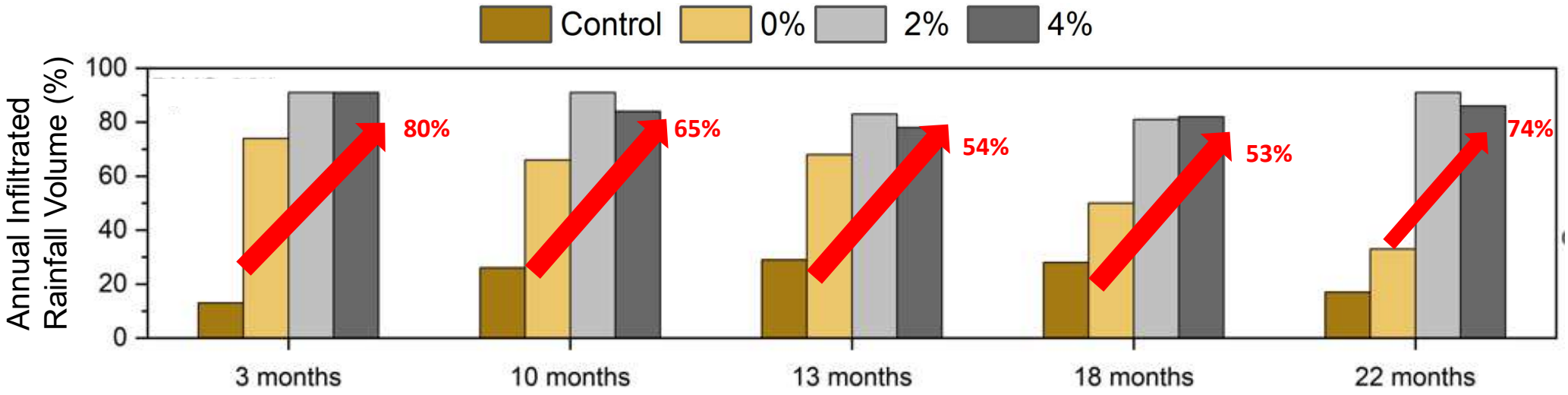
- **Case study – US 301 Roadside Vegetated Filter Strip in Delaware**



- **While 0% treatment compacted with time, compaction much less with biochar.**
- **Saturated hydraulic conductivity ~ 10 times larger with biochar after 2 years.**

Akpinar D. (2023) Assessment of Biochar Addition to Natural and Engineered Soil Mixtures: Effects on Soil Structure, Plant Growth, and Hydrology, PhD Dissertation, University of Delaware.

Potential Impact of Large-Scale Applications – Filter Strip

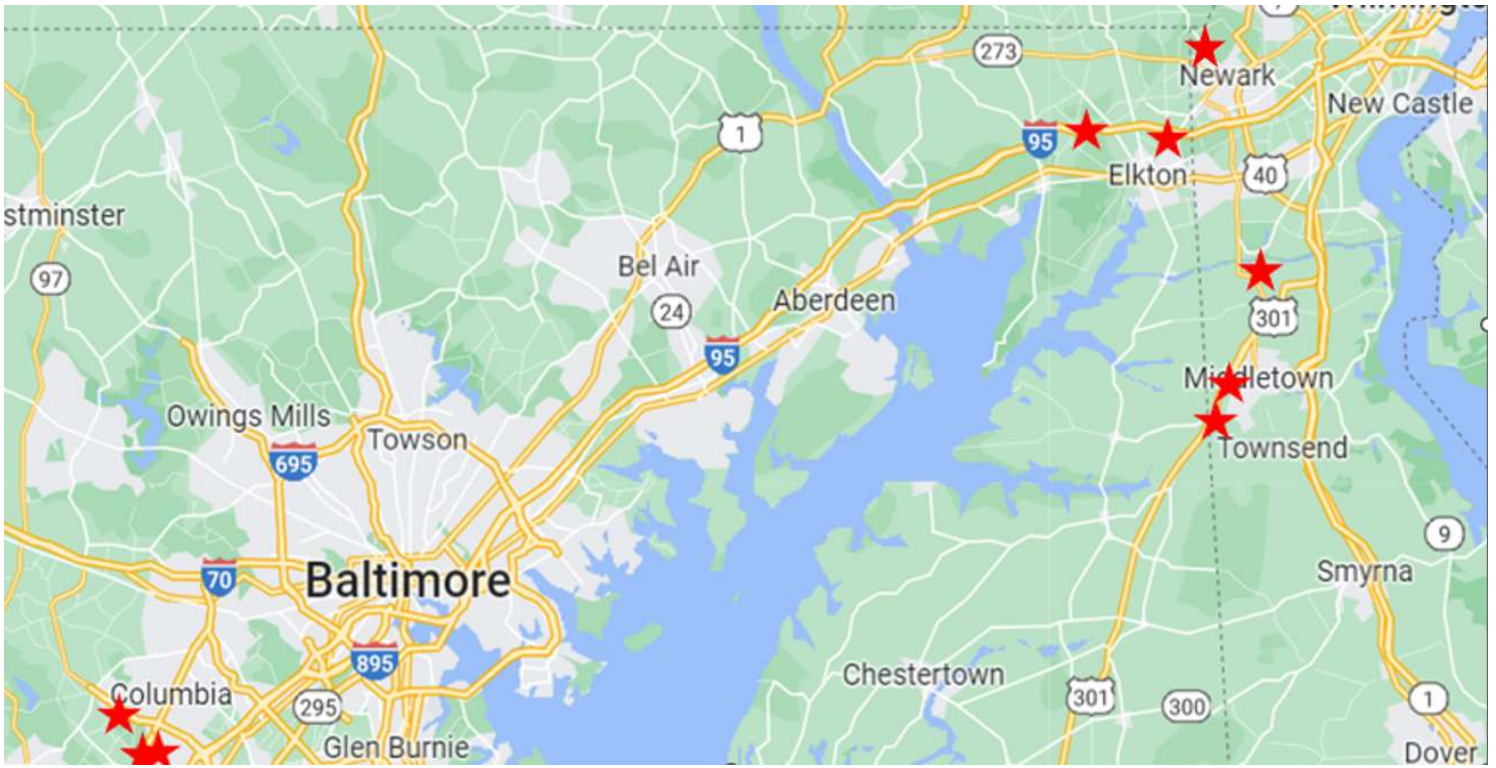


- **Amendment with 2% (w/w) biochar increased annual infiltration 53 – 80%**

Akpinar D. (2023) Assessment of Biochar Addition to Natural and Engineered Soil Mixtures: Effects on Soil Structure, Plant Growth, and Hydrology, PhD Dissertation, University of Delaware.

Potential Impact of Large-Scale Applications – Filter Strip

- 8 filter strips
  - 4 wood biochars
  - Sandy loam and loam



- **Biochar increased hydraulic conductivity in <u>all</u>**

Summary

- **What we know:**
  - Wood-derived biochar preferred (generally)
  - Biochar amendments improve removal of most pollutants
  - Biochar influence on water retention and infiltration challenging to predict, but models improving (filter strips)

- **What we don't know:**
  - Time-dependent effects on performance – especially in field
  - Impacts of watershed-scale application
  - Are promising improvements from biochar addition to urban soils replicated for a wider range of soil textures and mineralogy (filter strips)

Acknowledgements

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