Evaluation of Biochar as a potential filter media for the roadside Stormwater Runoff

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Background

- In urban areas, highways can account for 5-8% of impervious surface coverage. And stormwater runoff is largely due to increased overland flow over surfaces that precipitation can not infiltrate[1].
- Roadway construction can result in reduced soil porosity, reduced soil infiltration rate and increased water runoff[1].
- Current North Carolina stormwater regulations, including filtration rules, do not optimize contaminant removal (Heavy metals, nutrients and indicator bacteria).
- Studies have shown successful contaminants removal via adsorption from complex formation between contaminants and oxygenated functional groups on biochar surface[2].
- Biochar is organic material which is derived through thermal processing of biomass in the limited amount of oxygen.
- Biochar properties generally depends on biochar feedstock
  - Crop residues
  - Forestry waste
  - Animal manure
  - Sewage sludge
  - And waste from from different sources
- Biochar can improve
  - Erosion control
  - Flood mitigation
  - Increased saturated hydraulic conductivity for clay soil
  - Heavy metal removal
  - Nutrients removal
  - Indicator bacteria removal
  - improved soil structure[3].

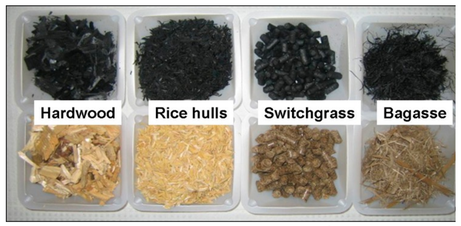


Figure 1. Biochar types[4]

Research Objective

- The overall goal of this research is to evaluate the cost-effective use of biochar for maximal stormwater infiltration and runoff quality in amended soils and assess its ability to provide social and ecological co-benefits resulting from healthy landscapes.
- To perform batch testing to assess biochar application rates on contaminant removal.

Figure 2. Biochar benefits[4]

References
1 - NCDOT: Stormwater Management Program. (n.d.). NCDOT.
2 - Haile, T., & Fuerhacker, M. (2018). Simultaneous Adsorption of Heavy Metals from Roadway Stormwater Runoff Using Different Filter Media in Column Studies. Water, 10(9), 1160– 1178. doi: 10.3390/w10091160
3 - Mohanty, S. K., & Boehm, A. B. (2014) Env. & Tech. doi: 10.1021/es5033162
4 – "Biochar feedstocks" 2022.
5 - "biochar-benefits" 2021.

Materials and Methods

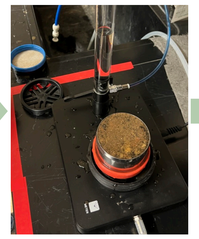
STEP 1: Biochar Physiochemical characterization

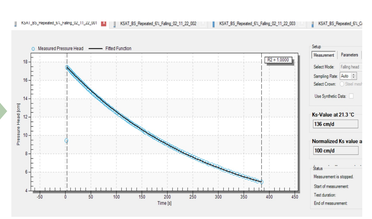
10 different Biochar + Clay loam soil → Sieve analysis → Hydrometer analysis → Dry bulk density → Pycnometer density → Methylene Blue adsorption capacity

*All lab tests were done by following ASTM standards.

STEP 2 : Saturated Hydraulic conductivity (Ksat)

Samples are packed in circular ring and saturated for overnight



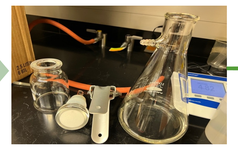


Important technical terms
Dry bulk density – Dry mass of the particle divided by its volume.
Pycnometer density - mass of a unit volume of a soil solids to the mass of the same volume of gas-free distilled water at 20°C.
Porosity – fraction of volume of voids over the total volume.

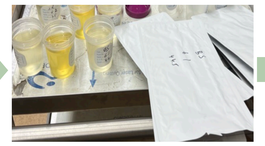
STEP 3: Batch testing

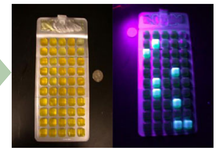
Collected stormwater has been used for four week seeding to generate the biofilm before doing the batch testing. All the tests were done in duplicates

100:1 of stormwater to soil biochar mixture



Heavy metal
Indicator Bacteria
Nutrients





Results

Table 1. Indicator bacteria removal percent, Ksat percent improvement and porosity

Biochar mixed with soil	Biochar percentage	Total cliform MPN read (per 100ml)	Percent removal	Ksat (in/hr)	Percent improvement	Porosity
Wake field (WF)	3%	4.2	46%	3.1	18%	0.59
	6%	4.7	52%	3.71	42%	0.63
Aries green (AG)	3%	----	----	5.1	95%	0.64
	6%	2.0	22%	5.53	111%	0.68
Blue sky (BS)	3%	3.6	40%	2.21	-16%	0.66
	6%	----	----	2.28	-13%	0.7
Soil reef (SR)	3%	<1	>90%	3.89	48%	0.7
	6%	<1	>90%	5.23	100%	0.74
Naked char (NC)	3%	<1	>90%	3.59	37%	0.66
	6%	<1	>90%	2.74	5%	0.67
The anderson (TA)	3%	----	----	4.71	80%	0.63
	6%	----	----	5.1	95%	0.64
Char bliss (CB)	3%	4.2	46%	**	**	0.71
	6%	4.3	47%	**	**	0.76
Biochar now chip (BNC)	3%	6.3	70%	5.56	112%	0.52
	6%	2.1	23%	5.99	129%	0.55
Biochar now medium (BNM)	3%	5.2	58%	6.3	140%	0.66
	6%	2.1	23%	**	**	0.69
Biochar now small (BNS)	3%	5.2	58%	**	**	0.66
	6%	3.6	40%	**	**	0.69
Control (soil only)	0%	9.0	**	2.62	**	**

Methylene Blue adsorption capacity - At the lower concentration of MB, higher adsorption efficiency has been found. As more and adsorption surface would be available for adsorbate to be adsorbed and up to 100% removal efficiency had been achieved.

- The available result shows that some biochars are efficient in removing indicator bacteria and more than 90% of removal efficiency could be achieved. However no significant difference between 3% and 6% biochar has been found.
- Result shows that application of biochar improves the saturated hydraulic conductivity of the soil

Future works

- Determine heavy metals and nutrients removal through batch testing to select the most efficient biochars.
- Bench scale (column study) will be done on selected biochar.
- Over the time the properties of amended soil changes which may lead to the change in the performance of aged biochar. The column will be examined over the years to to determine in the performance matrix.
- The collected effluent will be further analyzed for heavy metals, nutrients, and indicator bacteria removal.

Acknowledgement

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