

Research Stage 1 Problem Statement

PROPOSED TITLE: Field Testing Biochar Amended Soils for Low-Cost Water Quality Improvement

1. Concisely describe the transportation issue (including problems, improvements, or untested solutions) that Oregon needs to research.

The Problem

Maintaining winter road safety is critical and applying chloride deicers is part of the current state of practice. While currently considered necessary, the practice comes with high costs. The United States Environmental Protection Agency estimates that the damage caused by chloride deicers costs approximately \$5 billion dollars per year in repairs for cars, trucks, roads, culverts and bridges nationwide. Environmental concerns are growing due to the effects of deicers on soil, groundwater, surface water, aquatic species and infrastructure. Chlorides are elemental, meaning there are no permanent natural processes that break down, metabolize or take them up (e.g., vegetation up-take). As a result, consistent application of chloride deicers accumulates over time and can contribute to toxic chloride concentrations in soil, groundwater, and surface water systems. Stores of chloride in soil and groundwater increase over time, contributing to pulses and consistent releases into surface water bodies throughout the year (not just during winter application). This poses the risk of harming or killing wildlife and permanently contaminating drinking water and irrigation sources, and points to the need for longer term filtration and mitigation BMPs. What's more, several heavy metals are mobilized and made more toxic by the presence of chlorides.¹ This includes common pollutants like cadmium, copper, zinc and lead present in runoff, soil, groundwater, surface water bodies and water pipes. Heavy metals are of particular interest in stormwater runoff due to their toxicity, ubiquitousness, and the fact that metals cannot be chemically transformed or destroyed.

Untested Solution

Biochar amended roadside soil filtration of deicer is one low-cost method to help reduce contamination and damages to infrastructure, vehicles and the environment. The efficacy of biochar to filter metals from stormwater runoff is well established and attributed to its high pH, porosity and surface area, and ionic absorption capabilities.^{2 3 4} The use of roadside biochar soil amendments for chloride filtration has more recently been developed and represents a low-cost and low-tech approach to soil and water quality improvement that reduces chloride inputs into soil and waterways, while also reducing heavy metal concentrations and metal mobilization from chloride inputs.⁵ Other state DOTs, including [North Carolina](#),

¹ Schuler, M.S. and Relyea, R.A., 2018. A review of the combined threats of road salts and heavy metals to freshwater systems. *BioScience*, 68(5), pp.327-335.

² Wang, H., Garg, A., Ping, Y., Sreedeeep, S. and Chen, R., 2023. Effects of Biochar Derived from Coconut Shell on Soil Hydraulic Properties under Salt Stress in Roadside Bioretention. *Waste and Biomass Valorization*, 14(3), pp.1005-1022.

³ Kang, D.H., Al Tameemi, R., Lopez, S. and Qian, X., 2022. Evaluation of Deicing Salt Immobilization in Biochar Applied BMPs. In *World Environmental and Water Resources Congress* (pp. 87-94).

⁴ Quedraogo, A.S., Yuzhu Fu, G. and Yunus, A.I., 2023. Treatment of Highway Stormwater Runoff Using Sustainable Biochar: A Review. *Journal of Environmental Engineering*, 149(2), p.03122005.

⁵ King, A., 2022. Mitigating Roadway Deicing Salt Runoff: Utilizing Environmental Containment Socks to Sequester Na⁺ and Cl⁻. (2022). <https://vtechworks.lib.vt.edu/handle/10919/113087>

[Delaware](#), Maryland and California have already tested biochar amended soils for stormwater filtration and report improvements.

The academic research on chloride filtration is also growing. Biochar has long been recognized for its cation and anion adsorption properties and is a proven candidate for chloride and heavy metal filtration alike. Research is needed to define an optimal biochar medium and soil amendment design, and to develop operating parameters in Oregon. Specifically, testing the longevity of road-side biochar-amended filter strips and determining associated maintenance costs.

There are three strong reasons to support this work:

- 1) **We can leverage previous field study.** In partnership with the USGS, ODOT has supported two previous studies of deicer impact on stormwater runoff and roadside soils at Siskiyou Pass. Both studies indicate that deicers are impacting receiving [waters](#) and nearby [soils](#), in some cases significantly. Improved monitoring is necessary but costly.
- 2) **We can demonstrate agency action to address environmental impact on lands and waters.** Oregon's Executive Order 25-26 (October 2025) directs ODOT and other state agencies to "take urgent action to promote the resilience of our communities and natural and working lands and waters." ODOT is required to provide metrics and monitor them over time. Exact metrics are not yet known and may not be determined by ODOT. Developing low-cost highway runoff filtration options that sustain standard road safety practices, while cost effectively reducing the pace or risk of environmental damage, may be necessary under increased scrutiny on the environmental impact of ODOT's practices related to lands and waters.
- 3) **Costs associated with water quality improvements and borne by ODOT are very important considerations.** The NCHRP has funded two previous [IDEA Program studies](#) to further DOT knowledge and practice of the costs and benefits derived from adding biochar to roadway soils. The study concluded that biochar is less expensive than 21 other BMPs – up to 10 times less.

2. What final product or information needs to be produced to enable this research to be implemented?

Proposed Research

We propose a hybrid lab and field test at Oregon's Siskiyou Pass to examine at least one of ODOT's two biofiltration soil mixtures that are current used to improve stormwater quality at some stormwater facilities. The biochar amended mix is currently part of a lab-based study at Oregon State University to examine the efficacy of 6-PPD Quinone filtration under SPR 304-791. Results from this work can be leveraged to understand co-benefits and other protocols for additional stormwater quality improvement uses. The Siskiyou Pass location was previously selected for chloride deicer exposure testing under SPR 812, which identified the significant impact of ODOT's chloride deicer application on soils and groundwater. These results indicate the prudence of a follow-up study to identify a chloride contamination mitigation strategy. The proposed work would leverage ongoing ODOT research and build upon recent discoveries at a critical location.

- 1) Conduct laboratory column tests to determine optimal biochar material and concentration.
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Adsorption and desorption activity will be determined for each sample. Considerations: examine biochar with ODOT's two approved soil amendment mixtures. Alternatively, test biochar with unamended roadside soil samples. Biochar types tested must be locally available in large quantities. Lab methods will ultimately be informed by current DOT BMPs and academic literature.

2) Field test of most promising biochar amended mixture, including a paired control test strip. This includes water quality testing of each test trip (including control) for at least one to two consecutive winter storm seasons.

3) Produce a guidance document for ODOT's maintenance and stormwater management groups that outlines the purpose, estimated maintenance costs and lifecycle, proven water quality benefits and field implementation protocols.

The final product will be a low-cost chloride mitigation option that retains current road safety practices while reducing the negative impacts of deicer application and potential hazards.

3. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

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Jennie Morgan	Stormwater Program Manager	Jennie.MORGAN@odot.oregon.gov	
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Patti Caswell	Environmental Program Manager	Patti.CASWELL@odot.oregon.gov	

4. Other comments:

Citations:

Implementation of biochar amended soils for water quality improvement/chloride removal

[**Evaluating Biochar as a Multi-Beneficial and Cost-Effective Soil Amendment Option for Maximal Stormwater Infiltration**](#)

[**Case Study: Delaware Highway Greenway Pilot**](#)

[**NCHRP IDEA: Reducing Stormwater Runoff with Biochar Addition to Roadway Soils**](#)

[**Soil Amendment Guidance for Infiltration and Stormwater Treatment**](#)

Academic Citations:

Clark, O. Grant, William H. Hendershot, and Shiv O. Prasher. "Adsorption of trace metals and deicing salt in soil amended with compost or biochar." *2014 Montreal, Quebec Canada July 13–July 16, 2014. American Society of Agricultural and Biological Engineers, 2014.*

Egamberdieva, Dilduza, et al. "Biochar for improving soil biological properties and mitigating salt stress in plants on salt-affected soils." *Communications in Soil Science and Plant Analysis* 53.2 (2022): 140-152.

Kang, Dong Hee, et al. "Evaluation of Deicing Salt Immobilization in Biochar Applied BMPs." *World Environmental and Water Resources Congress 2022.*

Lin, Yuchen, et al. "Biochar modification methods and mechanisms for salt-affected soil and saline-alkali soil improvement: A review." *Soil Use and Management* 40.1 (2024): e12992.

Liu, Qiang, et al. "Biochar application in remediating salt-affected soil to achieve carbon neutrality and abate climate change." *Biochar* 5.1 (2023): 45.

Ouedraogo, Angelika S., George Yuzhu Fu, and Ahmed I. Yunus. "Treatment of highway stormwater runoff using sustainable biochar: A review." *Journal of Environmental Engineering* 149.2 (2023): 03122005.

Wang, Xiao, et al. "Biochar addition reduces salinity in salt-affected soils with no impact on soil pH: A meta-analysis." *Geoderma* 443 (2024): 116845.

Yuan, Yanfei, et al. "Biochar as a sustainable tool for improving the health of salt-affected soils." *Soil & Environmental Health* 1.3 (2023): 100033.

Zaib, Muhammad, et al. "Remediation of saline soils by application of biochar: a review." *J. Environ. Agric. Sci* 24 (2022): 29-36.

5. State of Oregon Decision Making Lenses

5a. Will addressing the transportation issue identified as a need in Question 1 develop, or **validate methods for the estimation, measurement, or monitoring** of transportation generated greenhouse gases (GHG)?

☐Yes

☒No

☐Unsure

5b. If climate or GHG is not the focus of this **transportation issue** identified in this problem statement, will the research apply a GHG analysis to transportation infrastructure, planning, operations, maintenance, or materials?

☐Yes

☒No

☐Unsure

5c. Will addressing the **transportation issue** include development or testing of construction practices, methods, or materials to establish potential reductions in greenhouse gas emissions?

☐Yes

☒No

☐Unsure

5d. Will solving the **transportation issue** in question 1 study or support the reduction of vehicle miles traveled and single occupancy vehicle travel or support transition to electric vehicles (or other types of zero emission vehicles) or low-carbon alternative fuels?

☐Yes

☒No

☐Unsure

5e. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, or monitor, transportation system resilience in response to expected climate events, effects, or natural disasters in general?

☒Yes

☐No

☐Unsure

5f. Will solving the **transportation issue** in question 1 lead to work that may result in better environmental conditions for wildlife and native vegetation?

☒Yes

☐No

☐Unsure

5g. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

Climate change is increasing the risk of drought, wildfire and ecosystem sensitivity at the Siskiyou Pass and across Oregon. This study will reduce risk to roadside vegetation health and related wildfire risk at a very high risk location, and it will reduce the risk of damage to water quality and aquatic habitat. The increased risk of severe winter storms and intense rainfall events due to climate change requires improve resilience to chloride contamination of soils and receiving waters. Previous study at the proposed location indicates that large precipitation events lead to pulses of chloride mobilizing from soil to nearby streams in large pulses. The proposed work measures the potential benefits of a BMP that will improve system resilience to the negative impacts of chloride deicer use.

Equity

5h. Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐Yes

☒No

☐Unsure

5i. If the **transportation issue** is not focused on transportation equity, will the primary topic be assessed for equity benefits or impacts within the research project?

☐Yes

☒No

☐Unsure

5j. Is the implementation of potential findings from this research likely to directly involve participation from an identified group that would benefit from an equitable process or outcome?

☐Yes

☒No

☐Unsure

5k. Is the intended final product or information expected to support ODOT's equity efforts (Including but not limited to supporting one of the equity related objectives of the [ODOT's Strategic Action Plan](#) or [Oregon Transportation Plan](#)) ?

☐Yes

☒No

☐Unsure

5l. If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

This work does not focus on equity but it aligns with equity by mitigating impacts to water sources, cultural practices, fisheries and ecotourism that are highly valued by Tribes and surrounding rural communities. The segment of 1-5 proposed for study runs through an area experiencing “low-medium” levels of social disparity, according to ODOT's [social disparity index](#).

Safety

5m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐Yes

☒No

☐Unsure

5n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☒Yes

☐No

☐Unsure

5o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☒Yes

☐No

☐Unsure

5p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐Yes

☒No

☐Unsure

5q. Will solving the **transportation issue** support improving safety through **investing strategically**? 5r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

The use of deicer is currently a standard winter safety practice but it has significant drawbacks that may face increased scrutiny as climate stressors mount, and as ODOT contributions to land and water protections are called for state leadership and other state agencies (EO 25-26). By testing a low cost, high potential mitigation strategy for chloride contamination damage, ODOT is investing in reducing infrastructure, truck and environmental impacts, while retaining road safety practice.

6. Corresponding Submitter's Contact Information:

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