



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-053

Proposal Title: Protecting Minnesota's Waters Using Sustainable Waste Materials

Project Manager Information

Name: Bridget Ulrich

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: We will develop new approaches to remove nutrients and emerging contaminants from runoff using filter media derived from Minnesota-sourced waste materials, enabling statewide efforts to prevent surface and groundwater contamination.

Funds Requested: \$497,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Water Resources (B)

Project Location

What is the best scale for describing where your work will take place?

Region(s): NE

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Minnesota's fresh water resources are a part of our state's cultural identity, and statewide efforts to protect these resources are essential to ensure public safety and maintain recreational opportunities. Runoff poses a threat to Minnesota's water resources because it carries contaminants such as pesticides and nutrients to receiving waters, contaminating surface waters and groundwater. For example, contamination of surface waters with nutrients can cause harmful algal blooms (HABs), leading to conditions that are not safe for recreation and harmful to aquatic organisms. Further, evidence is emerging that urban runoff is an overlooked pathway of extensive surface and groundwater contamination, carrying organic contaminants such as pesticides and household chemicals. Finally, PFASs, or "forever chemicals" have emerged as a major public health concern, and we are only beginning to understand their occurrence in runoff. Treatment of runoff to remove harmful contaminants could have profound environmental benefits; including reduced water contamination, prevention of harmful algal blooms, and reduced impacts to human health and aquatic species. Filtration in systems such as rain gardens is one approach to runoff treatment, however removal of nutrients and pesticides in these systems is highly variable. Removal of these contaminants can be improved by adding engineered filtration media.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

Innovative solutions to this problem will require a holistic approach, and Minnesota must protect its freshwater resources in a way that prevents greenhouse gas emissions, reduces waste, and benefits local economies. Development of sustainable filtration media derived from Minnesota-sourced waste materials could provide opportunities for small businesses across the state. Biochar, a charcoal-like material produced from renewable biomass that can be used to treat water, has the added benefit of preventing CO₂ emissions by locking carbon from waste biomass into a solid form. Mixtures of biochar and iron-rich wastes such as taconite byproduct could be used to filter nutrients (nitrates, phosphates) and emerging contaminants (such as pesticides and PFASs, or "forever chemicals") from runoff. We therefore seek to develop guidelines for production of filtration media containing locally sourced biochar and iron-rich materials to remove nutrients and emerging contaminants from runoff. Contaminants to be evaluated include nitrates, phosphates, pesticides, and PFASs. Waste and low-cost materials to be assessed include beetle-kill wood from ash trees, papermill byproducts, sawdust, iron-rich bog deposits, and taconite byproduct. This will be accomplished in a two phase process to (1) screen a wide variety of materials for their effectiveness, and (2) verify performance in vegetated column experiments.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

Our project benefits numerous key issues for Minnesotans, including protection of water resources, reduction of waste, prevention of greenhouse gas emissions, and providing opportunities for small local businesses. We will provide recommendations for the application of sustainable filtration media, informing the efforts of practitioners to implement sustainable runoff treatment approaches across the state. This will lead to sustainable management of nutrient and emerging contaminant pollution, contributing to HAB prevention and protection of human health and aquatic species. The broader outcome of this project will be the preservation of surface and groundwater resources statewide.

Activities and Milestones

Activity 1: Screening Minnesota-sourced waste materials for contaminant removal performance

Activity Budget: \$173,474

Activity Description:

The objective of this activity is to select the most promising Minnesota-sourced filtration materials for further application development. This activity will consist of two experimental tasks: (1) material collection, processing, and characterization, and (2) laboratory batch experiments to assess contaminant removal performance.

Task 1: Promising waste materials will be collected from facilities in Minnesota. Waste biomass materials, including beetle-kill wood from ash trees, papermill byproducts, and sawdust, will be converted to biochar at NRRI's biomass conversion laboratory in Coleraine, MN. Low-cost iron materials, including iron-rich bog deposits, and taconite byproduct, will be used with minimal processing. All materials to be tested will be characterized for the physical and chemical properties to inform material selection decisions.

Task 2: Materials will be screened for their contaminant removal performance in laboratory batch experiments. Contaminants to be analyzed will include nutrients (Total Nitrogen, Total Phosphorus, nitrate/nitrite, Dissolved Organic Carbon), metals (lead, copper), PFASs, and pesticides. Researchers will also examine the differences between materials before and after performing the batch tests, to assess the mechanism of contaminant removal. This data will allow researchers to identify the most promising materials and combinations thereof to further evaluate in vegetated column experiments.

Activity Milestones:

Description	Completion Date
Evaluate up to 24 materials for their contaminant removal performance in laboratory batch tests	2021-11-30
Process and characterize up to 24 different filtration materials	2022-06-30

Activity 2: Evaluate the contaminant removal performance of combinations of biochar and iron materials in vegetated column experiments

Activity Budget: \$323,526

Activity Description:

The objective of this activity will be to assess the effectiveness of different combinations of biochar and iron materials for contaminant removal performance under realistic conditions. Experiments will be conducted in the NRRI greenhouse to enable evaluation of vegetated systems. The activity will consist of two tasks: (1) preparation and conditioning of vegetated columns containing material combinations, and (2) evaluation of contaminant removal performance in challenge tests using natural water.

Task 1: Grasses will be grown from seed in natural soil while the column apparatus (1 ft tall by 1 ft diameter PVC columns with controlled drainage and sampling ports) are being assembled. Assembled columns will be filled with combinations of filtration media (as layers or mixtures), such that up to 12 configurations can be tested. Grasses will be planted in the top layers of the columns (containing compost) and allowed to condition under irrigation.

Task 2: Natural water will be collected weekly, augmented with contaminants as necessary, and used to water the columns. Contaminant concentrations will be measured in the water at the inlet and outlet of the vegetated columns to

assess removal. Contaminant removal will be monitored over 6 months, and performance among media combinations will be compared.

Activity Milestones:

Description	Completion Date
Assemble experimental apparatus and grow grasses	2022-08-31
Evaluate contaminant removal performance over 7 months	2023-03-31
Final report completed	2023-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Donald Fosnacht	Natural Resources Research Institute	Dr. Donald Fosnacht, NRRI Initiative Director for Renewable Energy, will be a project partner and provide technical guidance regarding biochar production technology development. He is a seasoned technical manager with 38 years of experience in managing and directing research and technology development programs.	Yes
Tim Hagen	Natural Resources Research Institute	Tim Hagen will join the project as a partner and will provide technical guidance for material development and application. He specializes in the development of novel and innovative solutions for transforming wood, lignite, recycled plastics, tear-off shingles and cotton lintens into useful green-based products for re-use.	Yes
Meijun Cai	Natural Resources Research Institute	Dr. Meijun Cai will join the project as a collaborator and provide technical guidance regarding the application of low cost materials for runoff treatment. She specializes in the study of the effects of environmental stressors to aquatic biological communities and highway stormwater treatment.	Yes
Christopher Filstrup	Natural Resources Research Institute	Dr. Christopher Filstrup will join the project as co-PI, and specializes in aquatic ecosystem health and management, biogeochemical nutrient cycling, and nutrient reduction strategies. His role will be to provide technical guidance and oversight regarding the development of nutrient reduction approaches.	Yes
Sara Post	Natural Resources Research Institute	Sara Post, who specializes in by-product reuse, especially taconite materials, will serve as the Project Coordinator. In addition to providing technical guidance regarding the selection and characterization of iron materials, she will also coordinate the day-to-day project activities, under the guidance of Lead PI Ulrich.	Yes
Joe Magner	University of Minnesota College of Food, Agriculture, and Natural Resources Science (CFANS)	Dr. Joe Magner, who has worked in water quality management for over 40 years, will also serve as Co-PI. Dr. Magner will provide technical guidance regarding the integration of filter media into runoff treatment system, and also serve as a liaison for stakeholders and practitioners in the Twin Cities area.	Yes
Jim Doten	Minneapolis Health Department	Jim Doten, Supervisor for Environmental Services at the Minneapolis Health Department, will also be a partner on the project. His role will be to provide guidance regarding urban runoff treatment needs and available waste materials in the Twin Cities area.	No

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

Results will be implemented through dissemination of a publicly available report describing our findings and recommendations for media application. Findings and recommendations will be disseminated during the project duration by presenting results at statewide conferences such as the Minnesota Water Resources Conference, such that to practitioners across the state can learn from our findings. Ongoing work to be completed prior to the project start date is focused on evaluating biochar for E. Coli removal, and is funded by a MnDRIVE seed grant for which Dr. Magner is Lead PI and Dr. Ulrich is Co-PI.

Project Manager and Organization Qualifications

Project Manager Name: Bridget Ulrich

Job Title: Aqueous Geochemist

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Bridget Ulrich's research expertise is the application of low-cost materials for water treatment, and she specializes in removal of organic contaminants (such as pesticides and PFASs, or "forever chemicals") from water. She has over a decade of experience with research related to environmental chemistry and contaminant fate and transport. Her past research has included projects focused on the removal of pesticides from stormwater, as well as the removal of PFASs from groundwater. Dr. Ulrich grew up on the Iron Range in Virginia, MN and obtained her Bachelor's degrees in chemistry and chemical engineering from the University of Minnesota Twin Cities, instilling in her a strong passion for protecting Minnesota's waters. She went on to obtain her Master's degree in Chemical and Bioengineering at the Swiss Federal Institute of Technology in Zurich and her PhD in Environmental Engineering at the Colorado School of Mines. She has since returned to Northern Minnesota, where she is now an Aqueous Geochemist and Research Program Leader at the Natural Resources Research Institute in Duluth, MN.

Organization: U of MN - Duluth - NRRRI

Organization Description:

The Natural Resources Research Institute (NRRRI) is a U.S. based research institute established by the Minnesota state legislature within the University of Minnesota Duluth. NRRRI is an applied research organization that works to develop and deliver the understanding and tools needed to utilize our mineral, forest, energy and water resources in a balanced and environmentally responsible manner. NRRRI is a unique, multidisciplinary, applied research institute focused on Minnesota's many natural resources. Associated with the University of Minnesota Duluth with research facilities in Duluth and Coleraine, NRRRI is a leading research arm of the greater University of Minnesota community. The Institute was created to be an economic development engine for the state. NRRRI delivers solutions to allow responsible use of Minnesota's resources, provides information and tools for sound environmental decisions and assists existing and entrepreneurial business and industry evolve and prosper. Ultimately, NRRRI is here to collaborate broadly in creating resilient, vital Minnesota communities.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Bridget Ulrich, Lead Principal Investigator		Oversee technical staff and ensure all milestones met on schedule			26.7%	0.24		\$30,776
Christopher Filstrup, Co-PI		Lead efforts to assess nutrient removal			26.7%	0.16		\$16,834
Sara Post, Collaborator		Lead efforts to evaluate iron materials, coordinate day-to-day project tasks			24.1%	0.7		\$40,975
Joe Magner, Co-PI		Provide technical assistance regarding treatment system design, act as liaison with practitioners in the Twin Cities.			26.7%	0.02		\$3,518
Donald Fosnacht, Collaborator		Provide technical guidance regarding biochar production technology development			26.7%	0.02		\$5,133
Meijun Cai, Collaborator		Provide technical assistance regarding runoff treatment applications.			26.7%	0.02		\$2,014
Tim Hagen, Collaborator		Provide technical guidance regarding filtration material development			26.7%	0.02		\$2,713
Matt Young, Biochar Production Coordinator		Oversee kiln operation to produce biochar materials			24.1%	0.16		\$13,336
Greenhouse Coordinator		Coordinate hourly staff running experiments in the greenhouse			26.7%	0.15		\$15,660
Analytical Chemistry Researcher		Coordinate batch screening experiments and sample analysis for all activities			24.1%	0.4		\$25,450
Hourly temporary assistant		Assist staff in project duties for batch experiments and vegetated column experiments			7.3%	0.2		\$6,772
Hourly Undergraduate Research Assistant		Assist staff in conducting vegetated column experiments			0%	0.3		\$8,182
							Sub Total	\$171,363

5/15/2020

Contracts and Services								
Nutrient analyses	Internal services or fees (uncommon)	Costs to measure nutrient concentrations at NRRI central analytical lab. Costs include supplies and technician time for 288 samples for Activity 1 and 900 samples Activity 2. Total nitrogen and total phosphorus are \$28/sample, and nitrate/nitrite is \$36/sample. Many samples are required to test many materials.				0		\$76,100
Materials characterization costs	Professional or Technical Service Contract	Costs to characterize materials, external contracts for surface area analysis, elemental analysis, cation exchange capacity for up to 24 materials. If a Research Infrastructure Investment Program grant is awarded to NRRI by the University of Minnesota costs may be changed from external to internal. Decision pending in June 2020.				0		\$50,000
Trace metals analyses	Professional or Technical Service Contract	Trace metals analyses to evaluate removal of metals by materials. Costs for for 288 samples from Activity 1 and 900 samples from Activity 2. Estimated cost is \$30/sample.				0		\$35,640
							Sub Total	\$161,740
Equipment, Tools, and Supplies								
	Tools and Supplies	Supplies for batch experiments	Supplies required to conduct 96 batch experiments Activity 1, including chemicals and reagents for synthetic runoff solutions, batch vessels, and general lab supplies such as pipette tips and centrifuge tubes.					\$9,698
	Tools and Supplies	Supplies for vegetated column experiments	Supplies required to conduct 60 vegetated column experiments for Activity 2, including materials to build mesocosm vessels, tanks to hold and transport water (including transfer pumps), soils and sands for base media, and materials required to grow grasses.					\$15,000
	Tools and Supplies	Supplies for pesticide and PFAS analyses	Supplies for pesticide and PFAS analyses for Activity 1 (288 samples)					\$95,000

			and Activity 2 (900 samples), including costs associated with instrument operation (gases, depreciation), sample analysis (analytical standards, solvents), and sample preparation (pipette tips, gloves, solid phase extraction consumables).					
	Tools and Supplies	Supplies for total organic carbon analyses	Supplies for dissolved organic carbon analyses for Activity 1 (288 samples) and Activity 2 (900 samples)					\$17,800
	Tools and Supplies	Costs to produce biochar in kiln at NRRI Coleraine facility.	Biochar is needed to be tested in column experiments, which requires materials and energy to be produced.					\$15,000
							Sub Total	\$152,498
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Includes 2 trips per year for 2 PIs for 3 days at a time (2 nights in a hotel with 2 rooms and meals at GSA rates). Mileage costs \$0.575 per mile for 320 mile round trip, \$10/day vehicle rental fee. Also include registration for 2 project personnel to the MN Water Resources Conference each year.	Travel between Duluth and Twin Cities to meet with project collaborators and attend conferences					\$4,696
	Miles/ Meals/ Lodging	Considers six single day 163 mile round trips per year at \$0.575 per mile and \$10 per day vehicle fee.	Day travel for project staff between Duluth and Coleraine required to manage biochar production.					\$1,248
	Miles/ Meals/ Lodging	Considers a 20 mile round trip with a \$6.00 half day vehicle fee. There will be 26 trips per year, considering that mesocosm experiments will be 6 months in duration and require weekly water collection.	Weekly travel to water collection location to collect water for mesocosm experiments.					\$455

							Sub Total	\$6,399
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	Costs to make two peer-reviewed publications open source.	Open source publication ensures findings are publicly available.					\$4,000
							Sub Total	\$4,000
Other Expenses								
		Shipping of materials to NRRRI	Large volumes of materials will need to be shipped to NRRRI in Coleraine for processing, and to Duluth for testing.					\$1,000
							Sub Total	\$1,000
							Grand Total	\$497,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	\$273,350
			Non State Sub Total	\$273,350
			Funds Total	\$273,350

Attachments

Required Attachments

Visual Component

File: [3769223c-e3d.pdf](#)

Alternate Text for Visual Component

The graphic says:

"Protecting Minnesota's Waters using Sustainable Waste Materials: Filtration material removes pesticides, PFASs, nutrients, and metals from runoff" and depicts a rain garden containing biochar and iron materials treating runoff. It also lists the following outcomes:

"Protect surface and groundwater, Prevent greenhouse gas emissions, Promote renewable energy."

Optional Attachments

Support Letter or Other

Title	File
Minneapolis Health Department Letter of Support	5fd81c05-6ac.pdf
Sponsored Projects Authorization Letter	7701a6e6-09a.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

Yes,

- Patent, Copyright, or Royalty Potential
- Potential revenue generated or net income from the sale of products or assets developed or acquired with ENRTF funding

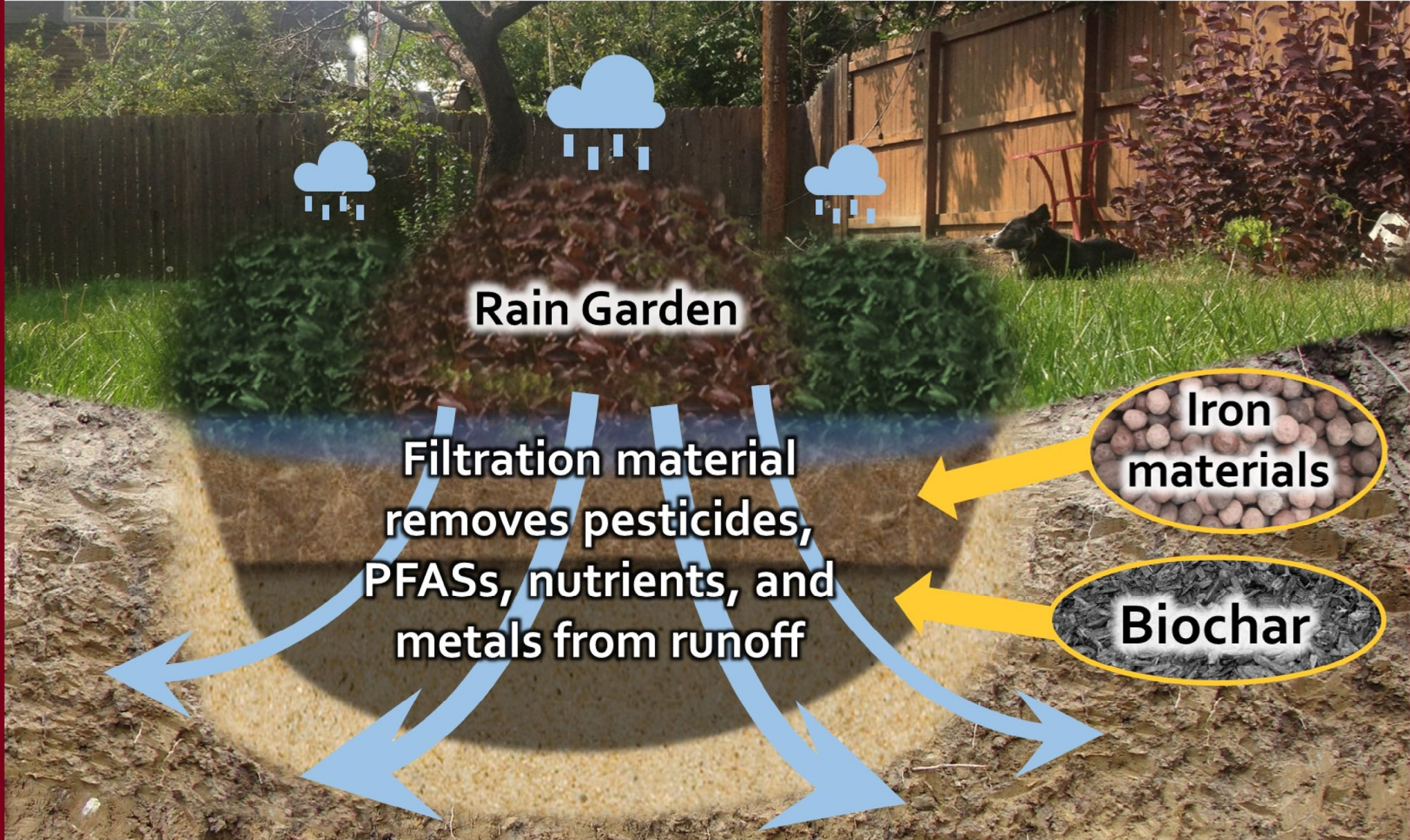
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Protecting Minnesota's Waters using Sustainable Waste Materials



✓ Protect surface & groundwater

✓ Prevent greenhouse gas emissions

✓ Promote renewable energy