# Environment and Natural Resources Trust Fund

2025 Request for Proposal

## General Information

**Proposal ID:** 2025-272

**Proposal Title:** Occurrence of Nanoplastics in Minnesota's Drinking Water

## Project Manager Information

**Name:** Boya Xiong

**Organization:** U of MN - College of Science and Engineering

**Office Telephone:** (814) 954-2509

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## Project Basic Information

**Project Summary:** We will determine the extent of nanoplastic pollution in public water supplies, groundwater private wells, and bottled waters in Minnesota, identify their likely sources, and develop mitigation solutions.

**ENRTF Funds Requested:** $649,000

**Proposed Project Completion:** June 30, 2028

**LCCMR Funding Category:** Water Resources (B)

## Project Location

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

Statewide

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

Statewide

**When will the work impact occur?**

During the Project and In the Future

## Narrative

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

Nanoplastics are fragments of large plastic, with a size even smaller than microplastics (1 nm to 1 µm). Nanoplastics are also speculated to be more toxic than microplastics. When ingested by the human body from contaminated drinking water, food, and air, these small particles can enter and penetrate cell membranes, tissues, and organs and even cross the blood-brain barrier, some of which are not possible for larger microplastics. Nanoplastics are persistent and can accumulate in the human body, where they could slowly leach thousands of unknown toxic additives and environmental contaminants (e.g., heavy metals). Despite the serious health concerns, we have no data on the extent of nanoplastic pollution in waters for human consumption in Minnesota. This is because detecting small nanoplastics in water samples is highly challenging. However, current estimates indicate there are a lot more nanoplastics in drinking water than microplastics. Indeed, a study published in early 2024 found that 90% of plastic particles in bottled water are nanoplastics, with a concentration as high as approximately 100,000 nanoplastics per liter. Furthermore, it is even more challenging but also important to simultaneously determine the concentration, type, and morphology of nanoplastics, as they dictate the toxicity of nanoplastics.

**What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.**

We will develop novel tools to quantify nanoplastics in various drinking water samples so that the risks posed to human health can be evaluated. We will survey three major water sources for human consumption in Minnesota: water from public water supplies, private wells, and bottled water. We will evaluate how our current public utility can better remove nanoplastics. We will develop methods that determine both the concentration and type, as well as the size and shape of nanoplastics. We will use pyrolysis gas chromatography-mass spectrometry (py-GCMS) to determine the mass concentrations and types of nanoplastics, which have been successful in quantifying microplastics. To determine the size and shape of nanoplastics, we use a novel tool atomic force microscopy-infrared spectroscopy (AFM-IR). This AFM-IR technique is similar to micro-FTIR which is widely for microplastic detection in environmental samples but can uniquely nanometer resolution to detect nanoplastics. In addition, we will develop filtration methods to specifically concentrate nanoplastics from water samples for analysis. We will also identify microplastic in the same water samples to explore the potential correlation between microplastic and nanoplastic occurrence, so that in the future, we may use the easier-to-generate microplastic data to approximate nanoplastic occurrence in drinking water.

**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?**

Recent studies proved our concerns that there could be more nanoplastic than microplastics in drinking water. Nanoplastics can be more toxic than microplastics, as they can more easily penetrate tissues but also be as persistent in the human body. For the first time, we will reveal the extent of nanoplastic pollution in the major drinking water sources in Minnesota. We will know whether nanoplastics are abundant, and if so, where they can come from, and how we can better remove them. A better understanding will lead to improved protection of our water resources and benefits to human health in Minnesota.

## Activities and Milestones

### Activity 1: Develop sample processing, identification, and quantification methods for nanoplastic standard particles.

**Activity Budget:** $177,326

**Activity Description:**
It is important to establish optimized standard operation procedures and reference results because several factors in real water samples would lead to inaccuracy in the identification and quantification of nanoplastics. For example, natural organic matter residuals in drinking water samples, even present in small quantities, could interfere with nanoplastic analysis. Therefore, we will first establish reference spectra of MS and IR for various standard nanoplastics suspended in ultrapure water for confirmation of polymer type in real water samples. We will test commercially available polymer nanoparticles that have limited polymer types and are perfectly spherical. We will also fabricate and test standard nanoplastics with irregular shapes and diverse polymer types that better represent nanoplastics in real samples. These factors could also contribute to errors in analysis. Lastly, other interfering factors are that natural samples typically contain a mixed particle size, and the amounts of nanoplastics present in drinking water are very small. We will test isolation and pre-concentration methods for water samples using sequential and cross-flow filtration. The activity is a critical first step that will enable the sample processing, identification, and quantification of nanoplastics in actual drinking water samples.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Produce nanoplastic standard particles | June 30, 2025 |
| Create py-GCMS methods to quantify nanoplastics | June 30, 2026 |
| Develop AFM-IR methods to identify and quantify nanoplastics | June 30, 2026 |
| Develop a concentration and isolation protocol for nanoplastic using sequential and crossflow filtration | June 30, 2026 |

### Activity 2: Optimize methods for nanoplastics isolated from various drinking water sources.

**Activity Budget:** $254,935

**Activity Description:**
In actual drinking water samples, there are various types and amounts of residue chemicals from natural and biological organic matter. Even if they are likely to present in small quantities, they can interfere with nanoplastic analysis. For example, they can significantly alter the mass spectrometry in py-GCMS analysis, or they could appeal as nanosized particles that share similar IR spectra features with some types of nanoplastics. This interference will be stronger when samples are concentrated for nanoplastics. We will collect representative samples to investigate the extent of background interference in water samples from public water supplies, private wells, and bottled water. We will then add oxidation and additional separation in our sample processing protocol to remove potential interference. Furthermore, we will try other modes of AFM to measure mechanical hardness or melting properties that are unique to plastics. In addition, from this activity, we will also have an initial idea of the amounts of nanoplastics in drinking water samples, which will allow us to determine how much water samples need to be collected to detect nanoplastics in activity 3. This activity is another critical step that allows us to accurately determine the extent of nanoplastics in Minnesota's drinking water.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|

| | |
|---|---|
| Sample processing protocol for actual public utility, groundwater, and bottled water samples | June 30, 2026 |
| Optimize the py-GCMS and AFM-IR analysis methods for actual water samples | December 31, 2026 |
| Publication/dissemination | December 31, 2027 |

## Activity 3: Identify and quantify nanoplastics from drinking water for human consumption in Minnesota and assess potential treatment strategies.

**Activity Budget:** $216,739

**Activity Description:**

Recent studies highlighted that long-term chemical aging of membrane materials and PVC water pipes could be potential sources of nanoplastics in drinking water. This was also true for bottled water that is treated similarly. We will collect samples from public water utilities across the state, including the City of Minneapolis public water utility equipped with membrane treatment. The results could also inform the capability of removing nanoplastics in current drinking water treatment plants. In addition, studies found high levels of nanoplastics made of single-use plastic bags and bottles in bottled water, varied by brand. Groundwater samples from private wells could receive surface water polluted with nanoplastics which may be less removed by groundwater aquifers compared to microplastics. We will also analyze nanoplastics in private wells across the state and different brands of bottled water sold in Minnesota. We will also identify and quantify microplastics in the same drinking samples using established methods. By correlating data on microplastics to nanoplastics, we could potentially utilize less time-consuming measurements for microplastic to identify water sources with nanoplastic pollution. This will be the first investigation of nanoplastic pollution in Minnesota's drinking water and potential mitigation and treatment strategies will be proposed.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Collect water samples from public supplies, groundwaters, and bottled waters | June 30, 2027 |
| Process water samples to isolate and concentrate nanoplastics | December 31, 2027 |
| Analyze nanoplastics in the samples using py-GCMS and AFM-IR | June 30, 2028 |
| Analyze microplastics in the same samples using micro-FTIR and py-GCMS | June 30, 2028 |
| Publication/dissemination | June 30, 2028 |

## Project Partners and Collaborators

| Name | Organization | Role | Receiving Funds |
|---|---|---|---|
| Melissa Maurer-Jones | University of Minnesota Duluth | co-investigator. Dr. Maurer-Jones has extensive experience in sampling and analysis of microplastics in environmental samples. She will consult the nanoplastic sampling efforts and polymer-type identification using IR spectra, and be responsible for microplastic detection and quantification. | Yes |
| Brian Barry | NRRI | co-investigator. Dr. Brian Barry has a PhD in Chemistry and is the Chemistry and Materials Science Program Leader at NRRI. He will be responsible for developing a standard procedure for nanoplastic quantification and detection using the pyrolysis-GCMS instrument at NRRI. | Yes |
| Greg Haugstad | University of Minnesota | co-investigator. Greg Haugstad is a well-known expert in atomic force microscopy for polymer analysis and is the director of the Characterization facility at the UMN Twin Cities campus. He oversees a state-of-the-art AFM facility in the Midwest and will be assisting with AFM-IR method development for nanoplastic identification and quantification. | Yes |
| George Kraynick | City of Minneapolis - Department of Public Works | George Kraynick is the manager of the Water Quality and Laboratory Services from the City of Minneapolis Public Works. He will assist us to collect samples from his plant uniquely equipped with membrane filtration for over 10 years to identify if aging membrane filters could be a source of nanoplastics. | No |
| Kyle Doudrick | University of Notre Dame | Prof. Kyle Doudrick is an expert in the fate and detection of emerging pollutants. He recently invented a novel method that can detect nanoplastics down to 300 nm in various water samples. He will use his method to cross-validate a few selected samples tested positive for nanoplastics using our methods. | 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 work be funded?**

If nanoplastics are found abundant in Minnesota's drinking water, we will pursue funding from the Department of Health to continue to improve sampling and detection protocol and perform a larger scale of sampling in Minnesota. We will also pursue federal funding such as NIH and NSF to better understand the toxicity levels and mechanisms of nanoplastics to cells, tissues, and human body. We will also pursue fundings from Water Research Foundation to develop effective point-of-use filters for nanoplastic removal that can be deployed in Minnesota.

## Project Manager and Organization Qualifications

**Project Manager Name:** Boya Xiong

**Job Title:** Assistant professor

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

Dr. Boya Xiong has nine years of experience in studying the fate and degradation of emerging contaminants derived from polymer chemicals and plastic wastes, and the design of membrane filtration for water and wastewater treatment. She has 23 manuscripts published in peer-reviewed journals on the fate and degradation of polymers and plastics, and membrane materials design and processes for contaminant removal. Her unique combination of expertise in micro- and nano-plastic detection and degradation as well as filtration process design and optimization make her the ideal person to lead the proposed research. Recently her group at the University of Minnesota developed various novel tools using atomic force microscopy (AFM) for understanding the key processes that generate nano- and micro-size plastics from bulk plastic degradation. These methods can be used to quantify nanoplastics in environmental samples. In addition, Dr. Xiong has extensive experience in particle filtration material and process design, for various complex water and

wastewater treatment, including drinking water, energy extraction wastewater, and seawater. This expertise will ensure her successful development of filtration-based sample processing for nanoplastic detection in the environment.

**Organization:** U of MN - College of Science and Engineering

**Organization Description:**
The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States, leading research areas including water quality and material science (http://www1.umn.edu/twincities/01_about.php). The College of Science and Engineering is one of the premier public institutes in the country for graduate and undergraduate education and research. The laboratories of the PI and/or core facilities at the University of Minnesota contain the entire essential fixed and moveable instrumentation needed for the proposed studies. In particular, the characterization facility led by co-PI Greg Haugstad has a Burker NanoIR that uniquely can be used for nanoplastic detection. PI Xiong's lab is also equipped with an AFM for nanoplastic pre-screening detection.

## Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | $ Amount |
|---|---|---|---|---|---|---|---|---|
| **Personnel** | | | | | | | | |
| Boya Xiong | | Principal investigator. Prof. Xiong will oversee the project, develop sample processing methods, and lead the sampling and AFM-IR analysis efforts. | | | 37.1% | 0.12 | | $25,416 |
| Melissa Maurer-Jones | | Co-Principal Investigator. Dr. Maurer-Jones will lead the effort of microplastic analysis in the same samples used for nanoplastics. | | | 37.1% | 0.12 | | $21,611 |
| Greg Haugstad | | Co-investigator. Dr. Greg Haugstad will assist the development of AFM-IR protocol and advise postdoc and graduate students to perform the analysis. | | | 37.1% | 0.03 | | $76,735 |
| Brian Barry | | Co-investigator. Dr. Barry will lead the analysis of nanoplastics using py-GCMS. | | | 37.1% | 0.03 | | $10,089 |
| Oleksiy Kacharov | | Oleksiy Kacharov will work on performing py-GCMS analysis. | | | 37.1% | 0.03 | | $15,878 |
| Graduate student (1.33 student per year) | | Perform AFM-IR analysis, sampling, and processing. | | | 25.1% | 1.5 | | $233,717 |
| Postdoctoral associate | | Perform AFM-IR analysis, lead sampling efforts, and develop sampling procedures. | | | 27.1% | 2 | | $150,107 |
| Undergraduate students | | Assist nanoplastic analysis | | | 0% | 0.12 | | $16,036 |
| | | | | | | | **Sub Total** | **$549,589** |
| **Contracts and Services** | | | | | | | | |
| Characterization facility-use of NanoIR | Internal services or fees (uncommon) | Use NanoIR to perform AFM-IR analysis of nanoplastics | | | | - | | $78,000 |
| | | | | | | | **Sub Total** | **$78,000** |
| **Equipment, Tools, and Supplies** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Tools and Supplies | Microplastic detection supplies. Chemicals, solvents, materials, and labware | Necessary to perform the experiments for microplastic detection | | | | | $5,110 |
| | Tools and Supplies | Crossflow filtration setup, chemicals, lab supplies, external validation of nanoplastic samples. | Water sample processing, nanoplastic isolation and concentration, nanoplastic detection using AFM-IR | | | | | $8,000 |
| | Tools and Supplies | py-GCMS supplies | for py-GCMS analysis | | | | | $301 |
| | | | | | | | **Sub Total** | **$13,411** |
| **Capital Expenditures** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Acquisitions and Stewardship** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel In Minnesota** | | | | | | | | |
| | Miles/ Meals/ Lodging | Car rental, meals, gas milage. | 13 trips to collect water samples around Minnesota | | | | | $2,000 |
| | | | | | | | **Sub Total** | **$2,000** |
| **Travel Outside Minnesota** | | | | | | | | |
| | Conference Registration Miles/ Meals/ Lodging | conference attendance by graduate students (2 conferences for each student) | disseminate results | | | | | $4,000 |
| | | | | | | | **Sub Total** | **$4,000** |
| **Printing and Publication** | | | | | | | | |
| | Publication | Open access journal fees | maximize dissemination of results of the project | | | | | $2,000 |
| | | | | | | | **Sub Total** | **$2,000** |
| **Other Expenses** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Grand Total** | **$649,000** |

## Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or Type | Description | Justification Ineligible Expense or Classified Staff Request |
|---|---|---|---|

## Non ENRTF Funds

| Category | Specific Source | Use | Status | Amount |
|---|---|---|---|---|
| **State** | | | | |
| | | | **State Sub Total** | **-** |
| **Non-State** | | | | |
| | | | **Non State Sub Total** | **-** |
| | | | **Funds Total** | **-** |

**Total Project Cost: $649,000**

**This amount accurately reflects total project cost?**

Yes

## Attachments

### Required Attachments

*Visual Component*

File: d8e21c80-285.pdf

*Alternate Text for Visual Component*

Unraveling a hidden micro-nano world of plastic encircling in our drinking water in Minnesota...

### Supplemental Attachments

*Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other*

| Title | File |
|---|---|
| UMN SPA | d0868fc5-658.pdf |

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

**Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?**

No

**Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?**

N/A

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**

N/A

**Does your project include original, hypothesis-driven research?**

Yes

**Does the organization have a fiscal agent for this project?**

Yes, Sponsored Projects Administration

**Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?**

No

**Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?**

No

**Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:**

Katie Sauer