Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 067-B**

Innovative Technology to Remove Nitrate from Surface Water

Category: B. Water Resources

Total Project Budget: $ 173,847

Proposed Project Time Period for the Funding Requested: 2 years, July 2018 to June 2020

Summary:

To develop an innovative technology to remove nitrate from surface water that is flexible enough to be used in household, large scale public utility system and in farm/livestock industry.

Name: Kannan Sivaprakasam

Sponsoring Organization: St. Cloud State University

Address: 720 Fourth Avenue South
St. Cloud MN 56301

Telephone Number: (320) 308-1692

Email ksivaprakasam@stcloudstate.edu

Web Address www.stcloudstate.edu

Location

Region: Central, Southwest

County Name: Benton, Cottonwood, Jackson, Martin, Stearns

City / Township:

Alternate Text for Visual:

Minnesota map showing pounds per acre per year of Nitrate getting into surface water

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base	
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency	
_____ Capacity Readiness	_____ Leverage		_____ TOTAL	_____%

PROJECT TITLE: Innovative technology to remove nitrate from surface water

I. PROJECT STATEMENT

Goal of the Proposal: In this grant proposal development of an innovative technological process to remove nitrate from surface water is proposed. This technological process is flexible enough to be used in household, large scale public utility system and **most importantly** in farm/livestock industry.

Why removal of nitrate is important and why current methods are ineffective?: Public water utilities of the major metropolitan areas in Minnesota (Duluth, St. Cloud, Twin cities) rely on surface water. Surface water is open to environment and is highly susceptible to contamination. Nitrate is a major contaminant in surface water and it mainly comes from farming and livestock industry. High levels of nitrate in water is a public health risk and is harmful to livestock and marine organisms. On average, 158 million pounds of nitrate leaves Minnesota per year in the Mississippi river. **Hence, there is an urgent unmet need for an affordable technology to remove nitrate from surface water**. Current technology to remove nitrate is expensive and cost $3,300 per household and hundreds of thousands of dollars for a city utility. While both household and city water utilities have been using different nitrate removal processes, farms/livestock industry has not been able to reduce nitrate pollution as there is **no** affordable process. **Unless** the farms/livestock industry remove nitrate from the drainage, current methods will remain ineffective.

What is one of the key technological challenge and how this proposal team is uniquely qualified to address it?: In addition to affordability, removal of nitrate from farms/livestock drainage needs to be done before it reaches underground. Else it would be very expensive and difficult to contain/remove nitrate. Dynamics of nitrate between surface and groundwater depends on the hydrology of soil. Hence, any technological solution to remove nitrate requires **interdisciplinary approach**. One of the **key strength** of this proposal is it brings together experts from chemistry, hydrology and physics to develop a rational approach to the nitrate contaminant problem.

How this proposal is innovative?: The PI has successfully demonstrated the use of different zeolites to remove various contaminant chemicals from solution. Zeolites are a family of charged minerals (modified sand) containing microholes. The key aspects of the innovative technology lie in the ability of zeolites to be **reused after regeneration**: zeolites can be used many times before the efficiency drastically reduces. Unlike the current technology that relies on use-and-throw materials, regeneration and reuse capability makes it **attractive and affordable for all users, especially the farm/livestock industry**.

II. PROJECT ACTIVITIES AND OUTCOMES

The grant proposal can be broadly categorized into **two** phases with clear goals and anticipated outcomes that would allow us to measure the success of the individual steps. Development of a pure zeolite or a mixture of zeolites along with testing the key material characteristics will be undertaken in the first year (activity 1). In the second year (activity 2) efforts will be mainly devoted to the field testing and fine tuning the system based on the results obtained for the targeted end users (household, public utility and farm/livestock industry) and cost analysis.

Budget: $87,810

Activity 1: Develop filter system: pure zeolite or zeolite mixtures for nitrate removal

We will investigate commercially available zeolite materials for their affinity for nitrate. To make this process attractive for users from farms/livestock industry, inexpensive natural and synthetic zeolite materials will be tested. From the field application standpoint, nanoparticles of zeolite will be made using planetary ball mill (crushes large particle to nano powders) and its stability across a range of pH (from acidic to basic) and temperature range of interest will be examined for both pure and mixture of zeolites. In short, activity 1 deals with the demonstration of methods to generate zeolite nanoparticles that remove

nitrate and identify the critical process parameters that affect the stability and performance of the zeolite materials. For the zeolites to be regenerated and reused, it is essential that the affinity for nitrate should be intermediate; strong or weak interaction between zeolite-nitrate is not ideal for repeated use.

Outcome	Completion Date
1. Identify pure zeolite and mixtures that have the optimum affinity for nitrate	12/2018
2. Optimize the particle size, pH, temperature stability of the zeolite materials	03/2019
3. Optimize the weathering, regeneration and reuse conditions	06/2019

Activity 2: Optimize the field application of the filter system **Budget: $86,037**

The zeolite materials from activity 1 will be packed in a column (cartridge) for field test. The following process parameters for field testing will be undertaken: effect of contact time between wastewater and filter, effect of flow/static/mixing conditions and effect of turbidity (both low and high). Since the zeolite material is meant for repeated use, resistance to discoloration (anti-fouling) in contact with wastewater samples is necessary. The most effective form factor of the filter system for the various end users and the hydrological impact of the zeolite filter in various geographical locations across Minnesota will be tested. Based on the above results, cost analysis of the filter system for different end users will be accomplished.

Outcome	Completion Date
1. Optimization of process parameters of the filter system	12/2019
2. Form factor, hydrologic testing and assessment of end user rating	03/2020
3. Cost analysis	06/2020

III. PROJECT STRATEGY

A. Project Team/Partners

The project team comprises of Principal Investigator (PI) Kannan Sivaprakasam (Materials Chemist, St. Cloud State University, (SCSU)) and co-PIs Jeffrey Cheng (Hydrologist, SCSU) and John Sinko (Physicist, SCSU). PI will administer the project and direct the development of pure zeolite and its mixtures that have the optimum nitrate removal function (activity 1). In collaboration with Co-PI, Dr. Sinko, we will focus on the material characterization and process parameter evaluation of zeolites (activity 1 and 2), Dr. Cheng would support field testing of the zeolite filter system under different hydrological conditions. Volunteer homeowners who use groundwater will be approached to test the filter system developed by this grant proposal. The St. Cloud water treatment plant will be contacted to do the pilot testing of the filter system before extending the work to similar public utility treatment statewide. We will also work with farms/livestock industry to test these filter systems.

B. Project Impact and Long-Term Strategy

This project is in alignment with one of the most important mission of SCSU: engage in active and applied learning. Involving students in the interdisciplinary project will allow the students to apply the concepts learned in chemistry, physics and hydrology in projects that addresses the challenges faced by Minnesota. Most importantly, this project team would engage with the important stakeholders, the farm/livestock industry, to reduce nitrate pollution. The results from this study can also be applied to other states (Iowa, Illinois, etc) that face similar challenges.

C. Timeline Requirements

The proposed project will be completed in 2 years. July 2018 to June 2020.

2018 Detailed Project Budget

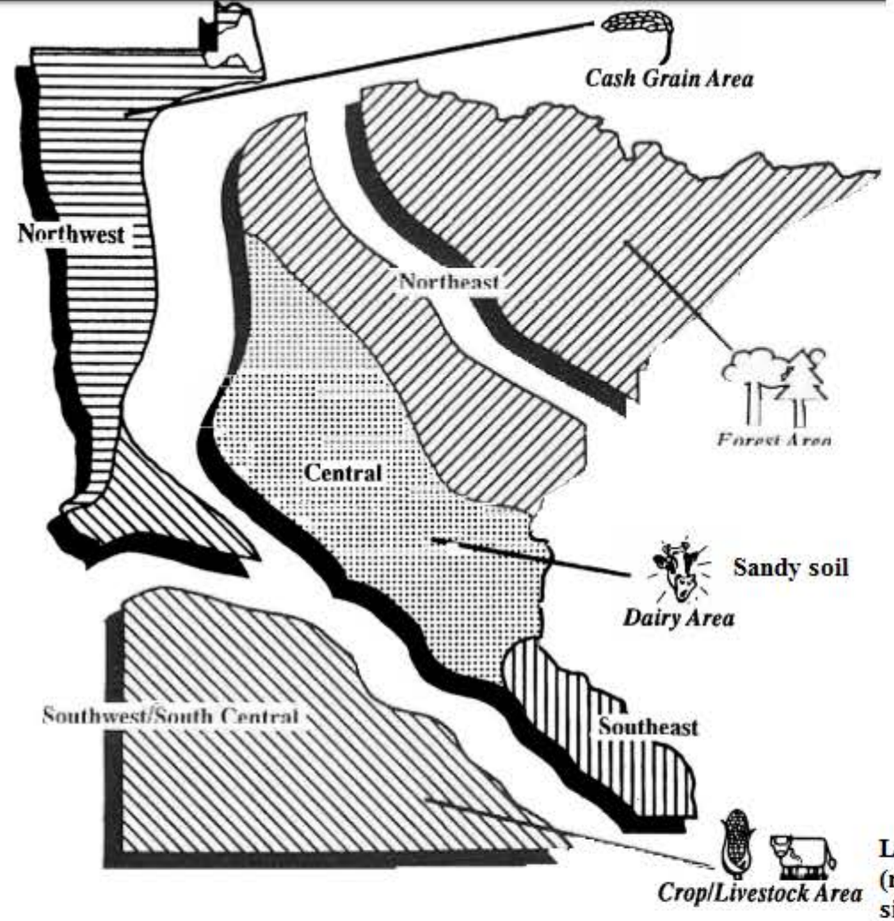
Project Title: Innovative technology to remove nitrate from surface water

IV. TOTAL ENRTF REQUEST BUDGET: 2 years

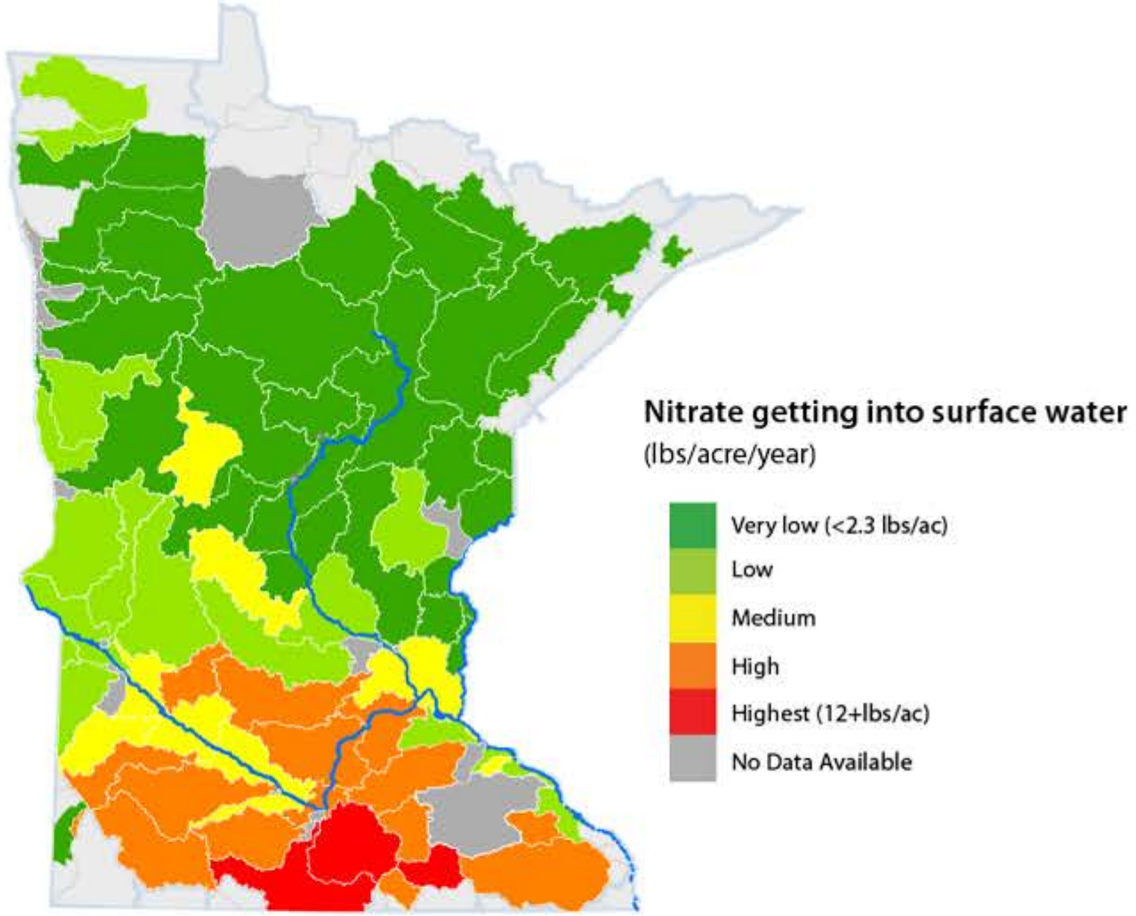
BUDGET ITEM	AMOUNT
Personnel:	
Kannan Sivaprakasam- Project Manager (63% salary, 37% benefits); 25% FTE for each of 2 years (summer salary)	$27,094.00
Jeff Cheng- (63% salary, 37% benefits); 25% FTE for 1 year (summer salary)	$15,228.00
John Sinko (63% salary, 37% benefits); 25% FTE for each of 2 years (summer salary)	$25,198.00
6 Student Research Assistants- (92% salary, 8% benefits); 12.5% FTE for each of 2 years	$64,827.00
Equipment/Tools/Supplies:	
Laboratory supplies: chemicals for material synthesis; characterization techniques needs such as liquid nitrogen for thermal analysis, sample pans, columns and guard columns for making filter columns; consumables such as gloves and solvents ($10,000/yr). Additional funds budgeted requests for equipment repair and maintenance ($3,000), shipping and handling charges ($500).	$18,500.00
Planetory ball mixer	$20,000.00
Travel	$3,000.00
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$173,847

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *Indicate any additional non-state cash dollars secured or applied for to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.*	N/A	*Indicate: Secured or Pending*
Other State $ To Be Applied To Project During Project Period: *Indicate any additional state cash dollars (e.g., bonding, other grants) secured or applied for to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.*	N/A	*Indicate: Secured or Pending*
In-kind Services To Be Applied To Project During Project Period: 12% of total costs for Facilities and Administrative costs not applied to the project budget. Included here as in-kind support.	$20,862.00	Secured
Past and Current ENRTF Appropriation: *Specify dollar amount and year of appropriation from any current ENRTF appropriation for any directly related project of the project manager or organization that remains unspent or not yet legally obligated at the time of proposal submission. Be as specific as possible. Indicate the status of the funds.*	N/A	Indicate: Unspent? Legally Obligated? Other?
Other Funding History: *Indicate funding secured but to be expended prior to July 1, 2018, for activities directly relevant to this specific funding request. State specific source(s) of funds and dollar amount.*	N/A	Indicate: Unspent? Legally Obligated? Other?



Central, Southwest/South Central would be the main focus since the farming/livestock industry is predominant in these regions.



Minnesota map showing pounds per acre per year of Nitrate getting into surface water

Project Manager Qualifications and Organization Description

Project Manager: Dr. Kannan Sivaprakasam
Dr. Sivaprakasam is an expert on materials science and teaches undergraduate and graduate coursework on materials science and chemistry at St. Cloud State University (SCSU). He has mentored masters and undergraduate students research project in materials science. He has access to state-of-art laboratory with 1000 ft^2 space in the SCSU Integrated Science and Engineering Laboratory Facility (ISELF). Dr. Sivaprakasam has published over 25 peer-reviewed publications and has a strong collaboration with industry; He has ongoing Small Business Innovation Research (SBIR) grants (Phase I and Phase II) for over $1.4 million.

Education: Ph.D. Materials Science, Indian Institute of Science (1999)
M.S. Chemistry, University of Madras (1990)
B.S. Chemistry, University of Madras (1988)

Professional Experience: SCSU, Assistant Professor, 2009-2014
SCSU, Associate Professor, 2014-present
SCSU, Graduate Director, Materials Science and Instrumentation, 2014-present

Member Organizations: American Chemical Society, Materials Research Society

Co-PI: John Sinko has a PhD in Physics (SCSU). He is an expert in optics and materials science. His research group will contribute towards understanding the stability of zeolite materials under different processing conditions.

Co-PI: Jeffrey Cheng has a PhD in Hydrology. He is an expert in hydrology of soils. He would contribute towards understanding the influence of soil in the movement of contaminant from surface to ground water and vice versa.

Organization Description:
St. Cloud State University is a regional comprehensive university located on the banks of the Mississippi river in St. Cloud, Minnesota. It is the second largest public university in Minnesota with an annual enrollment of over 15,000 students. SCSU has strong undergraduate programs in science and engineering and it has growing masters program in materials science and instrumentation. In the last 8 years, SCSU has invested over $77 million in STEM education and research.