Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 194-K**

Unique modular filter for keeping Minnesota waters chemical-free

Category: B. Water Resources

Total Project Budget: $ 905,700

Proposed Project Time Period for the Funding Requested: 3 years, july 2017 to june 2020

Summary:

We propose to construct and apply an efficient, cost-effective, durable water technology that degrades major Minnesota drinking water pollutants such as organic contaminants (pesticides) and emerging pollutants (bisphenol A, antibiotics)

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Minnesota waters quality are threatened by know pollutants (e.g. phosphates, nitrates, or pesticides) but also by an increasing number of emerging chemicals of concerns with uncertain consequences on the health of Minnesotans. We propose here to construct an all-in-one, revolutionary modular filtration system that can clean waters from a large number of pollutants and be rapidly adapted to address new chemical threats.

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

PROJECT TITLE: Unique modular filter for keeping Minnesota waters chemical-free

I. PROJECT STATEMENT

Here we propose to construct, demonstrate, apply, and disseminate an efficient, cost-effective, stable, self-sustaining water technology that removes and degrades current major Minnesota water pollutants such as nitrates, phosphates, organic contaminants (pesticides) and will handle emerging pollutants (e.g. bisphenol A, antibiotics). Minnesota's water quality is essential to preserve our environment and the health of Minnesotans. However, the quality of this water is threatened by numerous chemical contaminants, originating from excess use of field chemicals (phosphates, nitrates or insectides), and from products of everyday use. The need for a technology that can remediate and clean water from this diversity of chemicals requires a new approach. A very recent report on Minnesota waters from the U.S Geological Survey, the U.S. Dept. of the Interior, and the MN Pollution Control Agency shows that nitrate, phosphate, and pesticides are exceeding EPA guidelines for human health in southeastern Minnesota while water in the Twin Cities metro area contains contaminants of emerging concern (CEC), such as antibiotics, hormone mimics, and household chemicals. Among pesticides, organophosphorus chemicals found in MN waters have been demonstrated to contribute to the development of various cancers, autism spectrum disorders, and related developmental and neurological disorders. Evidence showing a possible role of neonicotinoids in bee population decline are accumulating. Lastly, this 2014 report notes that the most abundant CECs in Minnesota drinking water wells are antibiotics, herbicides, pesticides, flame retardants, plasticizers, hormones, hormones metabolites, or hormone mimics including bisphenol A. Antibiotics dissemination is known to accelerate spread of resistance, affecting 2 million patients each year in the US, and thousands in Minnesota. The state of Minnesota has a need for new drinking water treatment technologies that can remove these current and emerging pollutants, and can be easily scalable with respect to the volume of water to be treated and cost-effective to allow implementation in existing municipal treatment plants. The current methods for the removal of these contaminants from the drinking water (e.g. Ion exchange, reverse osmosis) are very expensive and not sufficient to remove traces. Some of these chemicals are toxic at very low concentrations, and so traces should also be removed. It is proposed here to make a technology matrix to remove many chemicals at once. Over the past years, our team has studied enzymes that can individually remove phosphate, nitrate, pesticides (organophosphorous compounds, atrazine and derivates), antibiotics, flame retardants, and bisphenol A. We will, for the first time, combine these enzymes to make a filter that can clean water, and remove trace concentrations of pollutants. We note that the comprehensive and modular nature of this filter makes it revolutionary and expandable: new enzymes can be added as new chemicals emerge. This new generation filter will be designed to be (i) versatile, and degrade current and emerging Minnesota drinking water pollutants (ii) low-cost and efficient (iii) modular and rapidly adaptable to new chemical threats as they emerge. In this project, we propose to perform the research that is necessary to characterize the enzymes, put them into a filter, optimize the filter performances, test the durability of the filtration system, disseminate this new technology and test the market potential for the filter so that it can become widely used within the State of Minnesota.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Characterize enzymes and optimize enzymes for remediation **Budget: $310,000**

Our team has identified a range of enzymes that are capable of detoxifying environmental pollutants. We will optimize these enzymes for high efficiency in the filter, and in conditions relevant for field implementation. We will use University facilities at the BioTechnology Institute to efficiently and inexpensively produce the components of the filter. The University provides facilities for producing bio-materials to faculty at well below market cost, as the BioTechnology Institute is supported by fees from Minnesota industry.

Outcome	Completion Date
1. Optimization of pollutant-degrading enzymes for field-like conditions	*March 31st 2018*
2. Production of enzymes for making the biofilter	*September 30th 2018*

Activity 2: Implementation of the enzymes in the biofilter **Budget: $291,900**

The modular filter will be constructed via a low cost, durable immobilization of natural enzymes. The efficiency of the filter in removing pollutants will be determined. Various performance parameters of the filter will be tested, and the enzymes quantities for optimal operation efficiency will be determined.

Outcome	Completion Date
1. Construction of enzymes modular filters, efficiency tests and steady-state operation	*June 30th 2019*
2. Optimization of the matrix, and enzyme quantities for optimal operation	*September 30th 2019*
3. Construction of the modular, versatile biofilter	*November 30th 2019*

Activity 3: Testing, optimization and dissemination of the biofilter **Budget: $303,800**

The filter performance will be tested by monitoring its bioremediation capacity in various condition, relevant to Minnesota water treatment plants. In particular, flow rates (critical for scaling), pollutant concentrations and durability will be tested. The properties of the filter, including its capacities and costs, will be summarized in a marketing brochure and communicated to the State agencies and water treatment plants around the State.

Outcome	Completion Date
1. Test and optimization of the modular biofilter performance to detoxify pollutants	*February 29th 2020*
2. Determination of the critical parameters for field installation and production scale-up	*June 30th 2020*
3. Dissemination of the biofilter data in the hands of the major State and private professional in water treatment.	*June 30th 2020*

III. PROJECT STRATEGY

A. Project Team/Partners

The project will be managed by Dr. Mikael Elias (Biochemistry assistant professor, UMN). Dr. Lawrence Wackett a Fellow of the Institute on the Environment and professor; and Dr. Alptekin Aksan, a Mechanical Engineering professor, will be the project's co-investigators. We have assembled a strong team that possess a unique set of skills that are necessary to perform this conceptually revolutionary project. Collectively, the team covers environmental science, biology, and engineering expertise. The team has a specific and strong background in dealing with environmental chemicals, particularly pesticides, and engineering systems to remove them.

B. Project Impact and Long-Term Strategy

Clean water is essential for life and a fundamental human right. The number of drinking water pollutants has increased with the sharp increase in the number of man-made synthesized chemicals (> 100,000). Minnesota is particularly exposed to the problem: >70% of the population rely on groundwater as drinking water sources. There is a critical need for improved methods to treat water, and in particular for versatile systems as described here. Our results will target professionals of State agencies, water treatment plants, and companies as we disseminate our findings in peer-reviewed journals, as well as in local news, and regional conferences.

C. Timeline Requirements

This project will take 36 months to carry out as described above. Thereafter, it is expected that the products of the project to be handed off to state agencies and the private sector.

2017 Detailed Project Budget

Project Title: *Methods for Removing Problematic Pesticides from Minnesota Waters*

INSTRUCTIONS AND TEMPLATE (1 PAGE LIMIT)

Attach budget, in MS-EXCEL format, to your "2017 LCCMR Proposal Submission Form".

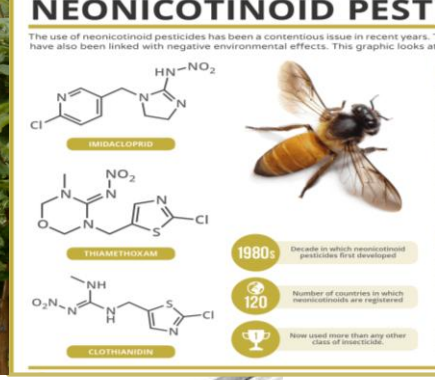
(1-page limit, single-sided, 10 pt. font minimum. Retain bold text and DELETE all instructions typed in italics. ADD OR DELETE ROWS AS NECESSARY. If budget item row is not applicable put "N/A" or delete it. All of "Other Funds" section must be filled out.)

IV. TOTAL ENRTF REQUEST BUDGET *2* **years**

BUDGET ITEM *See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**
Personnel : Mikael Elias, 9-months appointment, project manager, PI: 16% time; 66.3% salary; 33.7% benefits, 2 month/year for 3 years . Prof. Elias is a new assistant professor (started 9/14) at the University of Minnesota. Dr Elias will be in charge of the completion of all project activities.	$ 78,000
Personnel : Al Aksan, co-PI, 9-months appointment: 4% time; 66.3% salary; 33.7% benefits, 2 month/year for 3 years . Prof. Elias is a new assistant professor (started 9/14) at the University of Minnesota. Dr Elias will be in charge of the completion of all project activities.	$ 17,700
Personnel: Postdoc fellow (TBN): (77.6% salary, 22.4% benefits); 100% FTE for 3 years. Funds are requested for 1 year to support a postdoctoral fellow to fulfill activity 1.	$ 168,000
Personnel : Postdoc fellow (TBN): (77.6% salary, 22.4% benefits); 100% FTE for 3 years. Funds are requested for 1 year to support a postdoctoral fellow to fulfill activity 1.	$ 168,000
Personnel : Postdoc fellow (TBN): (77.6% salary, 22.4% benefits); 100% FTE for 3 years. Funds are requested for 1 year to support a postdoctoral fellow to fulfill activity 2.	$ 168,000
Personnel: Postdoc fellow (TBN): (77.6% salary, 22.4% benefits); 100%FTE for 2 years. Funds are requested for 2 years to support a postdoctoral fellow to fulfill activity 2 and 3 .	$ 112,000
Professional/Technical/Service Contracts: Funds are requested for service provided by the University of Minnesota's BioTechnology Institute Pilot Plant to prepare the pesticide-degrading biocatalysts used in this proposed research.	$ 80,000
Equipment/Tools/Supplies: Funds are for producing and optimizing presticide-degrading materials for lab testing, as well as routine lab supplies (chemicals, flasks, pipetters).	$ 114,000
Acquisition (Fee Title or Permanent Easements): *In this column, indicate proposed number of acres and and name of organization or entity who will hold title.*	$ -
Travel: *Be specific. Generally, only in-state travel essential to completing project activities can be included.*	$ -
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	905,700

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

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.*	$ -	*Indicate: Secured or Pending*
Other State $ To Be Applied To Project During Project Period: MnDRIVE Initative project funded by State of Minnesota through the University of Minnesota to Mikael Elias and Lawrence Wackett for bioremediation projects.	$ 40,000	*Secured*
In-kind Services To Be Applied To Project During Project Period: Faculty salary time paid by the University of Minnesota that will be devoted on the project over the rest of summer months and university indirect cost matching (52% mtdc in 2017; 53% in 2018)	$ 182,000	*Secured*
In-kind Services To Be Applied To Project During Project Period: BioTechnology Institute Pilot Plant fee waiver. Since the PIs are members of the BioTechnology Institute, this project will have the entry fee waived for the use of the facilities to prepare pesticides-degrading biocatalysts to be used in this proposal. The project will only be charged for materials used in production and the hourly wages of the staff at the	$ 40,000	*Secured*
Funding History: **$738,000** - *National Science Foundation - (Wackett, co-PI) - Project funded for 3 years through August 31, 2016 to engineer metabolic pathways to biodegrade triazine pesticides.*	$ 738,000	Secured (spent by 2016)
Remaining $ From 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.*	$ -	



1000's of chemicals threaten MN surface and drinking waters

This filter removes them all

Project manager qualifications: Mikael Elias

(i) Education and training

INSTITUTION AND LOCATION	DEGREE	MM/YY	FIELD OF STUDY
Universite de Lorraine, Nancy, (France)	B.S.	06/04	Biochemistry
Universite de Lorraine, Nancy (France)	M.S.	06/06	Biochemistry, Biophysics
University Aix-Marseille (France)	Ph.D.	05/09	Molecular & Structural Biology
Weizmann Institute of Science (Israel)	Postdoctoral	08/14	Molecular Evolution and Engineering

(ii) Position

2014-present Assistant professor, Biochemistry, Molecular Biology & Biophysics Dpt, University of Minnesota

(ii) Production (42 peer-reviewed journal, 4 world patents, 1 biotechnology start-up company (since 2013; 6 employees)

5 most significant

1. "The molecular basis of phosphate discrimination in arsenate rich environments", (2012) Nature, 491(7422):134-7. PMID: 23034649. Mikael Elias#, Alon Wellner, Korina Goldin-Azulay, Eric Chabriere, Julia A. Vorholt, Tobias J. Erb & Dan S. Tawfik#
2. "Directed evolution of sulfotransferases and paraoxonases by ancestral libraries" (2011), Journal of Molecular Biology, 411;837-53. PMID: 21723874. Uria Alcolombri, Dan Tawfik#, Mikael Elias#.
3. "What makes a protein fold amenable to functional innovation? Fold polarity and stability tradeoffs", (2013) Journal of Molecular Biology, 425:2609-21. PMID: 23542341. Eynat Dellus-Gur, Agnes Toth-Petroczy, Dan Tawfik#, Mikael Elias#.
4. "Divergence and Convergence in Enzyme Evolution: The Parallel Evolution of Paraoxonases from Quorum Quenching Lactonases", (2012) Journal of Biological Chemistry, 287:11-20. PMID: 22069329. Mikael Elias & Dan Tawfik
5. "The Universality of Enzymatic Rate-Temperature Dependency" (2014) Trends in Biochemical Sciences, 39;1-7. PMID: 24315123. Mikael Elias#, Grzegorz Wieczorek, Shaked Rosenne, Dan Tawfik#.

(iii) Synergistic activites.

My Lab focuses on biological macromolecules. Indeed, these molecules comprise fantastic objects with nearly unlimited activities and potentialities. Their use in biotechnology has already changed several segments of industry including the detergents, paper industries, the food industry (e.g. sugar), and is expected to revolutionize the every fields of human activities. My Lab aims to understand the molecular basis of their biological functions, and to develop new methods for their engineering, with the aim of developing soft, ecological solutions to current or emerging society issues, including toxic pollutants remediation and water treatment. (lab website: http://www.eliaslab.org/)

Organization: the University of Minnesota is the main research and training institution in Minnesota. The University has several missions: improve lives through research, education, and outreach. The University possess extensive facilities that ensure high research performance, and will be very precious for the success of this project:
• X-ray crystallography facility: houses four complete macromolecular X-ray data collection beam lines with three RigakuMSC Micromax 007 X-ray generators, three R-axis IV++ image plate detectors, and a Saturn 944+ CCD Camera. Crystallization robots and crystal growth monitoring systems are also available.
• Biotechnology Resource Center: (http://www.bti.umn.edu/brc/index.html) A wide variety of bench-scale to pilot scale fermenters is available, up to 500L, and will be used in this project to produce cost-effective biomaterials.