Environment and Natural Resources Trust Fund
2010 Request for Proposals (RFP)

LCCMR ID: 009-A2

Project Title:

Dioxins Derived from Antibacterials in Minnesota Lakes

LCCMR 2010 Funding Priority:

A. Water Resources

Total Project Budget: $ $287,000

Proposed Project Time Period for the Funding Requested: 2 years, 2010 - 2012

Other Non-State Funds: $ $0

Summary:

The antibacterial in liquid soaps (triclosan) represents an unrecognized, substantial source of toxic, carcinogenic, and endocrine disrupting dioxins to Minnesota waters. Sediment cores will be analyzed to quantify the threat.

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Sponsoring Organization: U of MN

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Location:

Region: Statewide

County Name: Statewide

City / Township:

_____ Knowledge Base _____ Broad App. _____ Innovation

_____ Leverage _____ Outcomes

_____ Partnerships _____ Urgency _______ TOTAL

PROJECT TITLE: DIOXINS DERIVED FROM ANTIBACTERIALS IN MINNESOTA LAKES

I. PROJECT STATEMENT

Triclosan is the antibacterial ingredient in soaps, toothpastes, lotions, and deodorants. Our recent work has shown that:

- Triclosan and its chlorinated derivatives are not completely removed by wastewater treatment plants. Thus, *triclosan and its derivatives are released into Minnesota surface waters.*
- In surface waters, **sunlight converts triclosan and its derivatives into dioxins**.

Dioxins are an infamous class of pollutants that have been found at Superfund sites.

- Dioxins are toxic, carcinogenic, and endocrine disrupting. They accumulate in sediments and bioaccumulate in fish.
- Dioxins are linked to birth defects, developmental abnormalities, and other disorders.
- Dioxins pose a risk to the health of aquatic species and their predators (including humans).

Known sources of dioxins are combustion/incineration processes, manufacture of vinyl chloride, chlor alkali (electrolysis) processes, and bleaching in pulp and paper mills. The latter three processes release dioxins into surface waters. Technological improvements have dramatically decreased the loads of dioxins to the environment over the past twenty years. Dioxins, however, are still released to air, water, and land.

We estimate that the wastewater discharge of triclosan (and its derivatives) leads to a loading of dioxins as large as all other currently known dioxin sources to surface water and land combined. Thus, triclosan derived dioxins would be equivalent to 10% of all known dioxin releases to air, land, and water. These dioxins comes from a known precursor that could be controlled through improved wastewater treatment, consumer education (i.e., *that triclosan is not necessary nor particularly effective*), or regulation. First, however, the dioxin load in Minnesota waters attributable to triclosan must be verified to confirm the environmental threat.

The dioxins derived from triclosan are not among those commonly analyzed, and thus the dioxin load to surface waters that can be attributed to triclosan and its derivatives is poorly understood. Dioxins are not particularly soluble and will absorb onto suspended particles in the water. These particles settle out in lakes that either directly receive wastewater effluent or that are fed by rivers that receive wastewater discharge. Thus, lake sediments contain a historical record of triclosan and triclosan-derived dioxin inputs, and these records can be used to determine the trends in inputs of these compounds to Minnesota lakes. These dioxin releases into surface waters have the potential to directly impact aquatic life (potentially more so than dioxin releases into air). While it is now recognized that estrogenic and pharmaceutical pollution are a potential threat to Minnesota waters, this project will explore an additional, generally unrecognized threat posed by the ubiquitous antibacterial triclosan.

The overall goal of the project is to determine the concentration of dioxins in lake sediments attributable to triclosan. With this knowledge, it will be possible to determine if additional steps should be taken to limit triclosan discharges into the environment through wastewater treatment, community education, product regulation, or a combination thereof. Because dioxins are toxic and bioaccumulative, this work will have immediate bearing on food webs and fish consumers (including humans) statewide. We will accomplish our project goal by analyzing lake sediment cores from around the state. We will sample five sites impacted by wastewater discharges – Lake Pepin, Lake St. Croix, Lake Superior near the entrance to the Duluth Harbor, Lake Winona near Alexandria, and Shagawa Lake near Ely – and a control site in the Boundary Waters Canoe Area that is not impacted by wastewater or triclosan. These study sites represent a large range of lake types, sizes, sedimentation rates, and degree of human impact. By dating the sediments and analyzing the concentrations of triclosan and dioxins downward in the core, we will determine recent and historical loads of triclosan, triclosan-derived dioxins, and total dioxins to Minnesota lakes.

II. DESCRIPTION OF PROJECT RESULTS

Result 1: *Core collection and dating* **Budget:** $ _94,000__

Duplicate sediment cores will be taken from five lakes impacted by wastewater effluents (and thus triclosan) and one control site (see above). The control site will allow determination of background dioxin levels. Fresh sediment cores are needed to minimize any losses of the dioxins during storage/handling. The cores will be collected by a piston or box-type corer. Cores will be dated using lead-210 and cesium-137 methods, and the organic matter content will be determined as a function of depth. Sediment deposition rates as a function of time will be calculated.

Deliverable	**Completion Date**
1. Core collection	February 2011
2. Core dating and determination of sediment deposition rates	August 2011

Result 2: *Measurement of triclosan and dioxins in sediment cores* **Budget:** $ 193,000

The collected sediment cores will be sliced into sections (each with a mass of 20-30 grams) as a function of depth. Each sample will be split with one being extracted for triclosan and triclosan derivatives and the other for dioxins. The triclosan and dioxin concentrations and loads (mass and mass per area) will be determined as a function of time. We will also analyze for all di- to octa-chlorinated dioxins in the sediment cores. Analyzing for all dioxins (not just those that are triclosan derived) will provide additional valuable information about the relative sources (e.g., atmospheric deposition versus wastewater) of dioxins to Minnesota waters.

Deliverable	**Completion Date**
1. Determine triclosan concentrations	January 2012
2. Measure triclosan derived and total dioxins in the sediment core	March 2012
3. Calculate current and historical contribution of triclosan to dioxin loads using calculated dates of samples and deposition rates	June 2012
4. Data synthesis, reporting, and recommendations	June 2012

III. PROJECT STRATEGY

A. Project Team/Partners

Dr. William Arnold (University of Minnesota, Department of Civil Engineering) will lead the project and be responsible for coordinating sample collections, extractions, and triclosan and dioxin analyses. Dr. Kristopher McNeill (University of Minnesota, Department of Chemistry) will be responsible for supervising triclosan and dioxin analyses. Dr. Daniel Engstrom (Science Museum of Minnesota & Adjunct Professor of Geology, University of Minnesota) will have responsibility for collecting and dating the sediment cores. Drs. Arnold and McNeill will advise the two graduate students, and Dr. Engstrom will co-advise one of the students. All three will be responsible for reporting results to LCCMR. Charles Sueper (Pace Analytical Laboratories) will assist with dioxin extractions and analyses.

B. Timeline Requirements

The project will require two years to complete. Sediment sampling will occur over the first year of the project. As sediment cores are collected, they will be dated, extracted, and analyzed. This will take 18 months.

C. Long-Term Strategy

Triclosan is of questionable effectiveness and the formation of dioxins is an undesirable outcome of it use. We will provide the data necessary for a voluntary or a regulatory solution.

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET (Two years)

BUDGET ITEM	AMOUNT
Personnel: *Dr. Arnold will provide 10% effort and Dr. McNeill 8% effort in each year. Two graduate students (50% time for 4 semesters and 1 summer per person) will work on the project.*	$ -
William Arnold, PI ($28,986 summer salary, $9,363 fringe, 32.3% fringe rate, total for 2 years). Dr. Arnold is on a 9-month contract.	$ 38,349
Kristopher McNeill, co-PI ($17,366 summer salary, $5,609 fringe, 32.3% fringe rate, total for 2 years). Dr. McNeill is on a 9-month contract.	$ 22,975
Two Graduate Research Assistants ($77,269 salary, $48,584 fringe-includes healthcare and tuition; total for 2 years)	$ 125,676
Contracts: *Science Museum of Minnesota/St. Croix Watershed Experiment Station. Funding for Dr. Engstrom (4% effort per year) and funds for core collection and dating.*	$ -
Daniel Engstrom ($9,375 salary, $2,625 fringe; total for 2 years)	$ 12,000
Core collection and dating, including laboratory supplies and analytical costs	$ 25,000
Equipment: Accelarated solvent extraction system. This is needed to extract triclsoan and its derivatives from sediment core samples. It allows extractions to be done in 2 hours (versus 2-4 days with traditional methods). Given the number of samples to processed for triclosan, this efficiency is needed. In the future the equipment would be used for extraction of a variety of endocrine disrupting compounds and pharmaceuticals from sediments, soils, and slugdes for analysis.	$ 35,000
Travel: In-state travel. Mileage, hotel, and meal charges for trips to collect sediment cores.	$ 3,000
Additional Budget Items: Laboratory supplies and analytical costs. Dioxin analyses cost $115 per sample	$ 25,000
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 287,000

V. OTHER FUNDS

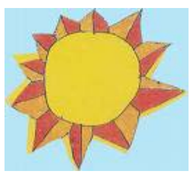
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period:.	$ -	
Other State $ Being Applied to Project During Project Period:	$ -	
In-kind Services During Project Period: Arnold and McNeill 2% unpaid effort per year.	$ 25,433	
Remaining $ from Current Trust Fund Appropriation (if applicable): Arnold is co-PI on two current LCCMR projects that focus on removing pharmaceuticals from wastewater, but these are not directly related to this effort.		
Funding History: National Science Foundation-to determine the mechanism and extent of dioxin formation from triclosan	$ 260,000	ends 12/31/09
Funding History: University of Minnesota Water Resources Center	$ 27,000	ends 2/28/10

Path from triclosan to dioxins in MN waters and fish

Antibacterial soap with triclosan

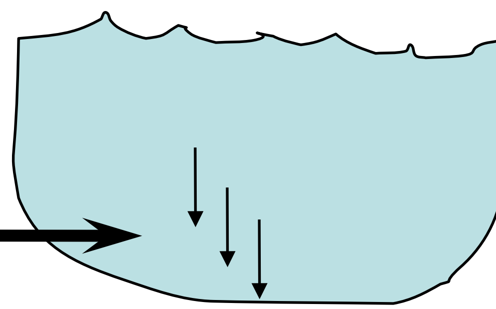
Incomplete triclosan removal in wastewater treatment

Discharge to surface water

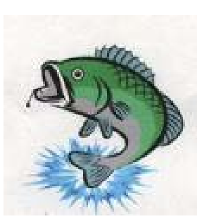


sunlight

Photolysis in Rivers/Lakes
Triclosan → Dioxin



Dioxin deposition in lake sediments



Bioaccumulation in fish

- Toxic (poisonous)
- Carcinogenic (cancer causing)
- Endocrine disrupting (hormone mimic)
- Developmental effects (birth defects)

Human exposure

- Toxic (poisonous)
- Carcinogenic (cancer causing)
- Endocrine disrupting (hormone mimic)
- Developmental effects (birth defects)
- Diabetes

Project Manager Qualifications and Organization Description

William A. Arnold

Associate Professor, Environmental Engineering, Department of Civil Engineering, University of Minnesota

B.S., Chemical Engineering, 1994, Massachusetts Institute of Technology, Cambridge, MA.
M.S., Chemical Engineering, 1995, Yale University, New Haven, CT.
Ph.D., Environmental Engineering, 1999, The Johns Hopkins University, Baltimore, MD.

Dr. William Arnold will be responsible for overall project coordination. He has been studying the fate of pharmaceutical compounds in aquatic environments for ten years. The main focus has been the photolysis rates of pharmaceuticals and personal care products in surface water to determine the persistence of these compounds in the environment. As part of these efforts, reaction products have been identified to determine if photolysis leads to a loss of biological activity of the compounds and/or if reaction products are of additional environmental concern. Recent LCCMR-funded work has focused on harnessing solar photolysis as a polishing step in wastewater treatment. In collaboration with Dr. McNeill, fifteen peer-reviewed papers on pharmaceutical photolysis have been published since 2003. Dr. Arnold is an Associate Fellow of the University of Minnesota Institute on the Environment and a member of the graduate faculty in Water Resources Science. He was the 2003 Minnesota Young Engineer of the Year.

Dr. Kristopher McNeill (Associate Professor, Department of Chemistry, University of Minnesota) studies key chemical processes of current environmental problems including surface water pollution by pharmaceuticals, groundwater pollution by chlorocarbons, and the global carbon cycle. He takes a fundamental chemistry-based approach, with a focus on elucidating reaction mechanisms. Dr. McNeill and Dr. Arnold have been collaborating on pharmaceutical photochemistry for ten years. Dr. McNeill is an Fellow of the University of Minnesota Institute on the Environment and a member of the graduate faculty in Water Resources Science.

Dr. Daniel Engstrom (Science Museum of Minnesota & Adjunct Professor of Geology, University of Minnesota) conducts research that centers on the use of lake sediment records to understand long-term environmental change, particularly the effects of human activities on water quality, atmospheric chemistry, and biogeochemical processes on a global scale. He is particularly interested in approaches that quantify the magnitude and rates of change and establish mechanistic linkages to modern-day systems. His recent efforts have focused on the historical inputs of mercury (and other heavy metals) and phosphorus into Minnesota's lakes.

Organization Description

The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States (http://www1.umn.edu/twincities/01_about.php). The laboratories and offices of the PI and co-PIs contain all of the necessary fixed and moveable equipment and facilities needed for the proposed studies.