Environment and Natural Resources Trust Fund
2011-2012 Request for Proposals (RFP)

LCCMR ID: 047-B

Project Title: Use of Biofilm Reactors for Water Purification

Category: B. Water Resources

Total Project Budget: $ $375,000

Proposed Project Time Period for the Funding Requested: 3 yrs, July 2011 - June 2014

Other Non-State Funds: $ 0

Summary:

Biofilm reactors having strong bioremediation potentials will be developed and tested for purification of persistent organics and removal of inorganic nutrients from dairy farm and wastewater treatment plant effluents.

Name: Fu-Hsian Chang

Sponsoring Organization: Bemidji State University

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Bemidji MN 56601

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Email fchang@bemidjistate.edu

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Location

Region: NW

Ecological Section: No. Minnesota and Ontario Peatlands (212M)

County Name: Beltrami

City / Township: Bemidji

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

2011-2012 MAIN PROPOSAL

PROJECT TITLE: Use of Biofilm Reactor for Water Purification

I. PROJECT STATEMENT

A biofilm reactor is made up of clusters of bacterial cells that attached themselves to a specific surface of a supporting medium that is packed in a reactor. Microbial biofilms are found throughout the environment and have been found to have strong properties in remediation of persistent organics. Biofilm based reactor can be used to treat water contaminated with various organic and inorganic pollutants. Biofilm reactors will be researched and developed for the purification of specific contaminants present in effluent discharged from a dairy farm and a municipal wastewater treatment plant near Bemidji, MN.

Effective, economical, and safe approaches need to be developed for the cleanup of contaminated surface and ground waters throughout Minnesota. Agricultural and domestic sewage contaminants are an ongoing threat to human health as well as wildlife health. In this project, we propose to culture specific species of natural microbial consortium (Pseudomonas sp., Rhodococcus sp., Sphingomonas sp., Alcaligenes sp., etc.) biofilms that demonstrate the ability to degrade and remove contaminants such as nitrates, phosphate as nutrient, and most frequently prescribed pharmaceuticals (antibiotics and hormones) as carbon source. These biofilms will be used in combination with pre-filtering techniques in a specialized fluidized bed reactor to degrade and remove the persistent organic and inorganic contaminants from the effluent of the dairy farm and wastewater treatment plant. Laboratory tests, as well as field tests, will be conducted using the specifically developed biofilms. Analysis of contaminant degradation and removal rates, and biofilm viability will be used to determine success rates in terms of ecological and economic benefits. The ultimate outcome is to have a consortium of bacteria making up the biofilms that are capable of removing the specified contaminates while achieving high ecological and economic benefits. This approach will provide an extremely important water treatment technology for persistent pharmaceuticals and inorganic nitrogen and phosphate removal that will significantly improve water quality and minimize adverse effects on ecosystem and public health.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Preliminary Microbial Biofilm Growth **Budget:** $ 100,000

Bacterial species (Pseudomonas sp., Rhodococcus sp., Sphingomonas sp., and Alcaligenes sp.) will be isolated from dairy farm and wastewater treatment plant effluent according to their specific degradative potentials and contaminant removal capability. Species will then be combined to form a biofilm consortium capable of optimal degradation and removal of a variety of contaminants. Spectrophotometric as well as ion-, gas-, and liquid- chromatography methods will be used in analysis of biofilm reactor functions and degradative/removal capabilities.

Outcome	Completion Date
1. Isolation, identification, and selection of specific microbial consortium that has high potential degradative capability.	Dec. 31, 2011
2. Preliminary screening test on biofilm reactor using contaminated effluent collected from the dairy farm and wastewater treatment plant.	June 30, 2012

Activity 2: Construction and Test of Biofilm Reactors **Budget:** $ 200,000

A specific biofilm reactor will be developed for optimal application of microbial biofilms. Once a reactor is developed, assessment of microbial consortium with respect to purification of persistent organics (pharmaceuticals and hormones) and inorganic pollutants (nitrate and phosphate) will be conducted in the laboratory. During testing procedures, spectrophotometric readings as well as ion, liquid, and gas chromatography will be used in analysis of biofilm strength and degradative/removal properties. A scale-up pilot study in the field (dairy farm and wastewater treatment site) will follow.

Outcome	Completion Date
1. Construction of 2 bench-top scale biofilm reactors and optimization of operating conditions.	June 30, 2013
2. Scale-up pilot study of a 20 liter biofilm reactor and field trial using dairy farm and wastewater treatment plant effluents.	June 30, 2014

Activity 3: Environmental and Economic Benefit Analysis **Budget:** $ 75,000

Data obtained from activity 1 and activity 2, along with literature data, will be used for environmental and economic benefit analysis. Internal cost implication will be assessed to understand the commercial application viability of the developed biofilm reactors. U.S. Environmental Pollution Agency Water Standards will be used to assess environmental benefits. To broaden the environmental and economic perspectives, a benefit-cost analysis will be conducted in order to better understand those benefits associated with purification of effluent produced by the dairy farm and wastewater treatment plant using the newly developed biofilm reactor for water purification technology.

Outcome	Completion Date
1. Environmental benefits analysis	June 30, 2014
3. Economic benefits analysis	June 30, 2014

III. PROJECT STRATEGY

A. Project Team/Partners

Three scientists of the Center for Environmental, Earth and Space Studies, Economics and Sociology of Bemidji State University namely: Dr. Fu-Hsian Chang, Dr. Patrick Welle, and Mr. Peter Lund, a dairy farm owner and operator, will participate in this project.

Project manager Dr. Chang holds a Ph.D. in Environmental Microbiology and Biotechnology, has participated and completed more than 30 research projects and has presented and published more than 100 papers.

Dr. Welle holds a Ph.D. in Economics, has participated and completed more than 25 research and consulting projects, and has published more than 80 papers.

Mr. Lund holds a B.S. in Physics, owns a 200 acre crop and dairy farm, and will provide field space for our scale-up pilot test as well as assisting in the setup of our biofilm reactors.

B. Timeline Requirements

Successful completion of this project will require 36 months of funding. Approximately one year will be required to produce a biofilm consortium capable of degrading/removing pharmaceuticals and several other inorganic pollutants. During the second year, development of a specific biofilm reactor will take place, including bench-top analyses. The third year of project will conclude with a scale-up field demonstration of the biofilm reactor as well as analysis of economic and environmental benefits.

C. Long-Term Strategy and Future Funding Needs

The goal of this project is to develop biofilm reactors using natural bacterial isolates that have great purification potential to cleanup effluents discharged from dairy farms and wastewater treatment plants. Naturally occurring bacteria, such as Pseudomonas sp., Rhodococcus sp., Alcaligenes sp., and Sphingomonas sp., could provide an efficient, economical and environmentally safe approach to water purification.

Many bacteria are known to have the ability to degrade a variety of persistent organic pollutants by utilizing inorganic nutrients (i.e. nitrogen and phosphorus) present in effluent and thus achieve water purification goals. These bacteria can be mixed in various combinations to degrade a specific group of organic pollutants that are present in contaminated waste streams or effluents. This provides a flexible approach to design the appropriate combination of bacterial species, forming biofilm reactors that can effectively cleanup a feedlot effluent contaminated surface water or groundwater plume that have been identified by the Minnesota Department of Natural Resources (MN DNR) and the Minnesota Pollution Control Agency (MPCA).

2011-2012 Detailed Project Budget

IV. TOTAL TRUST FUND REQUEST BUDGET 3 **years**

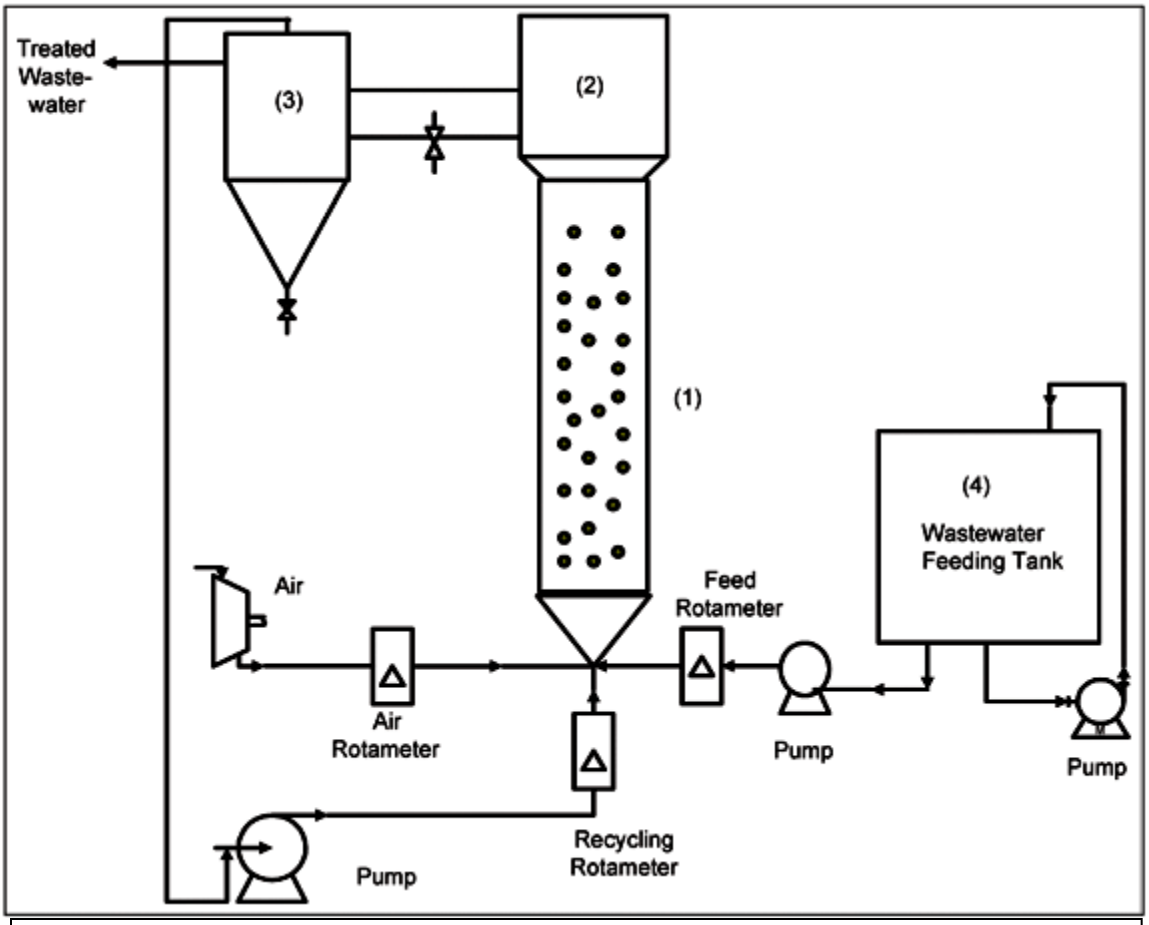
BUDGET ITEM	Activity 1	Activity 2	Activity 3	Project Total	AMOUNT	
A. *Personnel*						
PI: Dr. Chang (28 d/yr)	$15,052	$15,052	$15,052	$45,156		
Dr. Welle (25 d/yr for 2nd and 3rd yr)	$0	$0	$25,500	$25,500		
Graduate Assistant	$18,000	$36,000	$9,000	$63,000		
Undergrad Lab Assistant	$18,000	$18,000	$2,538	$38,538	(45.9%)	$172,194
B. Personnel Benefits						
PI: Dr. Chang (38% salary)	$5,720	$5,720	$5,720	$17,160		
Dr. Welle (38% salary)	$0	$0	$9,690	$9,690		
Graduate Assistant Tuition Waiver	$15,000	$30,000	$7,500	$52,500	(21.2%)	$79,350
Personnel Total (A+B)					67.10%	$251,544
Travel: Travel to scale-up site and project update sessions.					(1.3%)	$5,000
Equipment/Tools/Supplies:	**Activity 1**	**Activity 2**	**Activity 3**	**Project Total**		
Equipment: *Biofilm reactors (2 2-liter, 1 20-liter)*	$8,228	$40,228	$0	$48,456		
Chemical/Supplies: *(growth medium, biofilm reactor* materials, assay chemicals and supplies)	$20,000	$50,000	$0	$70,000	(31.6%)	$118,456
TOTAL ENVIRONMENT & NATURAL RESOURCES TRUST FUND $ REQUEST					(100%)	$375,000

V. OTHER FUNDS	AMOUNT	Status
SOURCE OF FUNDS		
Other Non-State $ Being Applied to Project During Project Period:	N/A	
Other State $ Being Applied to Project During Project Period:	N/A	
In-kind Services During Project Period:		

Budget Item	In-kind Match for Activity 1	Activity 2	Actvity 3	Total
Personnel	$15,052	$15,052	$15,052	$45,156
Fringe Benefits	$5,720	$5,720	$5,720	$17,160
Chemicals and Supplies	$500	$500	$0	$1,000
Travel Outside Minnesota to Attend National Meeting	$1,000	$1,000	$0	$2,000
Total	$22,272	$22,272	$20,772	$65,316

	$ 65,316	
Remaining $ from Current ENRTF Appropriation (if applicable):	N/A	
Funding History:	N/A	

Biofilm Reactor for Water Purification



R. R. Souza; I. T. L. Bresolin; T. L. Bioni; M. L. Gimenes; B. P. Dias-Filho . Brazilian Journal of Chemical Engineering.
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Education:

MBA	Business Administration, Carlson School of Management, University of Minnesota, Minneapolis, MN, 1994
Post-Doctorial	Environmental Microbiology – Cornell University, Ithaca N.Y. 1979-1981
Ph.D.	Environmental Microbiology, University of California, Davis, California, 1979.
M.S.	Biology, (Biochemistry & Biophysics) University of North Texas, Denton, Texas, 1974.
B.S.	Agricultural Chemistry, National Chung-Hsing University, Taichung, Taiwan, 1970.

Professional Experience:

July 1, 2002 -Present	Director and Professor – Center for Environmental, Earth and Space Studies, Bemidji State University, Bemidji, MN
Oct, 1981 -Present	Assistant Professor to Professor – Center for Environmental Studies, Bemidji State University, Bemidji, MN

50/50 teaching and research. Teaching Wastewater Treatment, Environmental Microbiology, Environmental Toxicology, Research Methods in Natural Sciences, Introductory Environmental Sciences and Environmental Chemistry, Grants and Contracts. Research in (1) bioconversion of agricultural biomass into biofuel (ethanol) using a multienzyme system; (2) biodegradation and modeling of Microbial fate of organic pollutant in surface and subsurface environment; (3) microbial technological utilization of solid wastes; (4) treatment and recovery of agricultural wastes; and (5) water and waste treatment technology; (6) bioremediation of hazardous organics in the environment; (7) bioconversion of potato waste into biopolymers and (8) application of biotechnology in eutrophic lake restoration.

Research Grants/Activities: Total of U.S. $2,033,277 research grants was funded during the past 28 years.

Professional Memberships:
WEF (Water Environment Federation)
ACS (American Chemical Society)
ASM (American Society for Microbiology)
APHA (American Public Health Association)
ASA (American Society of Agronomy)
SSSA (Soil Science Society of America)
ASEE (American Society for Environmental Engineering)

Publications and Presentations: More than 100 publications and presentations were published in scientific journals, meetings proceedings and book chapters.