USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Proposal Submitted to US Geological Survey,

Regional Water Resources Competitive Grants Program, North Central Region

17 April 1998

Submitted by the Center for Biofilm Engineering (CBE), Montana State University in collaboration with the Montana Department of Environmental Quality (MDEQ) and Conoco Inc.

Title: Enhancement of Fuel Oxygenate (MTBE) Biodegradation Potential in Groundwater

Focus Categories: GW, TS, TRT

Keywords: Bacteria, Biodegradation, Bioindicators, Contaminant Transport, Groundwater Quality, Natural Attenuation, Petroleum Additives, Solute Transport, Soil Microbiology, Underground Storage Tanks

Duration: September 1998 – September 2001

Federal Funds Requested: $16,738/ year

Non-Federal Matching: $35,760/year (additional $12,000/yr from NSF for student support)

Principal Investigators: Alfred B. Cunningham, Richard Veeh, Paul J. Sturman, MSU/CBE

Jeff Kuhn, MT Dept. of Environmental Quality

Stephen Jester, Conoco Inc.

8. Congressional District: Montana at Large

9. Statement of critical regional or state water problems:

Alkyl ethers such as methyl-*tert*-butyl ether (MTBE), ethyl-*tert*-butyl ether (ETBE), and *tert*-amyl methyl ether (TAME) have been used as oxygenate additives in gasoline to reduce vehicle emissions such as carbon monoxide and other volatile, toxic organic

compounds. MTBE, the most common oxygenate, is currently added at concentrations up to 15% (v/v) to more than 30% of all gasoline sold in the United States. In 1992, more than 1.8 billion gallons of MTBE were used in gasoline, and its use has increased every year since. More than 29 companies now produce MTBE, and it is the second largest organic chemical produced domestically. Due to the widespread use of MTBE in reformulated gasoline, most of which is stored in underground tanks, documented release sites are continually being reported. A recent survey conducted by the USGS identified MTBE as the second most common contaminant of urban aquifers in the nation. Although human health effects are still being evaluated (Leclair, 1997), the EPA has designated MTBE as a probable human carcinogen and issued a draft nonregulatory health advisory of 70 ug/l for nonprimary water sources (Cooney, 1997). Many states have much more stringent maximum contaminant levels for MTBE. The risks to human health posed by MTBE are exacerbated by its high water solubility and mobility in groundwater systems. The relative recalcitrance of MTBE, combined with its high water solubility make it the single largest threat to ground water quality resulting from gasoline releases. Given the widespread use of MTBE and its potential health risk, MTBE and other oxygenate contamination of groundwater is clearly a problem of national scope.

Traditional methods to remove gasoline constituents from groundwater do not work well for MTBE. Air stripping is very difficult because MTBE's low volatility requires large air/water ratios to make the treatment effective. In addition, MTBE's low affinity for organic carbon prevents efficient removal by granular activated carbon. However MTBE is capable of being biodegraded by native soil bacteria, albeit at slower rates than other gasoline constituents. Available research indicates that many naturally occurring microbial populations can biodegrade MTBE as well as tert-butyl alcohol (TBA), an MTBE metabolite of concern, over time. Strategies for enhancing *in situ* biodegradation (i.e. accelerated natural attenuation) of MTBE are urgently needed.

The proposed research project, which involves a 3-way collaboration between MSU's Center for Biofilm Engineering (CBE), the Montana Department of Environmental Quality (MDEQ) and Conoco Inc., will assess the environmental factors which limit MTBE and other oxygenate metabolite degradation for the purpose of developing improved strategies for enhancing MTBE biodegradation in the field. MSU graduate and undergraduate students from multiple disciplines (i.e. engineering, microbiology, geology, and soil science) will be organized into teams and mentored by state regulatory and industrial officials, together with MSU faculty. The project work plan includes review of all pertinent hydrogeological and geochemical data as well as a full characterization of the microbial population present at an existing MTBE release site located in Ronan MT, and will focus on isolation, identification, and enrichment of bacterial strains that can biodegrade MTBE metabolites. Strategies for enhancing MTBE biodegradation *in situ* will be identified and piloted at the Ronan MT study site.

10. Statement of results or benefits

The proposed study will greatly increase our knowledge of the fate and transport of oxygenate gasoline additives in groundwater systems. The project work plan will

determine the physical, chemical and biological processes which limit the rate of MTBE biodegradation. Anticipated results include:

- field and laboratory identification of primary mechanisms of MTBE natural attenuation
- recognition of microbial populations capable of oxygenate degradation
- identification of degradation pathways and metabolite recalcitrance
- optimization of parameters which limit oxygenate biodegradation to maximize degradation rates
- development of biodegradation enhancement strategies and subsequent pilot testing at the Ronan MT field site.

Environmental quality personnel form Montana and many other states have recently begun testing for MTBE at petroleum release sites and are discovering that ground water contamination is far more widespread than originally anticipated. MDEQ is very interested in determining the rate and extent to which MTBE biodegradation can be documented at existing field sites. The results from this study will help states and municipalities decide what level of remediation is necessary to address MTBE concentrations in drinking water supplies and whether specific groundwater remediation efforts can be undertaken to prevent future MTBE impacts (see attached supporting letter from the MDEQ). Development of improved methods for enhancing MTBE biodegration will clearly also be of use to industrial practitioners responsible for developing remediation strategies for subsurface gasoline release sites (see supporting letter from Conoco Inc.).