Reduction of Microbiological Contaminants by Low Pressure Membrane Technologies

Problem: *Cryptosporidium, a* protozoan microbe associated with the disease cryptosporidiosis in man, can be transmitted through ingestion of drinking water, person-to-person contact, or other pathways, and can cause acute diarrhea, abdominal pain, vomiting, fever, and can be fatal in sensitive subpopulations (i.e., infants, immune suppressed patients, and the elderly). In 1993, cryptosporidium in drinking water in Milwaukee, Wisconsin caused the largest waterborne disease outbreak in U.S. history with over 400,000 illnesses and 100 deaths. Reducing the levels of cryptosporidium in finished drinking water will substantially lower rates of endemic cryptosporidiosis.

Description: Sound technologies and performance of treatment systems are critical to protecting human health and the environment. EPA's Environmental Technology Verification (ETV) Program verifies the performance of innovative commercial-ready environmental technologies to accelerate their use in the marketplace. The ETV Program has partnered with NSF International to test and certify three Siemens membrane separation technologies for cryptosporidium control. Three individual studies are being conducted to evaluate the removal of microbial contaminants from drinking water using the Siemens Memcor L10V, L20V and S10V technologies. NSF International is performing the testing activities in their laboratory in Ann Arbor, Michigan.

Impact: The experimental design conforms to the procedures for the product-specific testing as described in the EPA's LT2ESWTR Membrane Filtration Guidance Manual (MFGM) to provide:

- Five membrane modules of each Siemens three types of membranes will be tested
- Performance of the membrane modules challenged with microbials MS-2 coliphage virus, spores of *Bacillus atrophaeus, and live Crytosporidium parvum oocysts.*

Regulatory Driver: The EPA finalized the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) on Jan. 5, 2006.

Technology Status: Preliminary results to date show very good microbial removals but data has not yet been subjected to EPA Quality Assurance review, and is not yet publically available. EPA reports on all three Siemens technologies should be available in late Spring 2009 at www.epa.gov/etv and www.nsf.org/etv.

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The EPA's National Risk Management Research Laboratory and its partners are developing new environmental technologies that provide unique opportunities for green job creation and enhanced protection of human health and the environment.

Biomass Concentrator Reactor (BCR)

Problem: Untreated wastewater, surface water and groundwater pose a significant risk to human health and the environment. Finding new, innovative ways to treat our nation's water and make it safe for human use can be a challenge. Through a unique partnership between EPA's National Risk Management Research Laboratory (NRMRL) and the University of Cincinnati (UC), scientists have developed a simple, yet innovative "green" technology for the biological treatment of wastewater, surface water and industrial wastewater, making it safe and useable.

Description: The NRMRL/UC team successfully field-demonstrated the gravity-flow Biomass Concentrator Reactor (BCR) in treating groundwater contaminated with gasoline and MTBE (methyl tertiary-butyl ether, a fuel additive in gasoline) to non-detectable levels. The BCR was bench tested treating synthetic wastewater to extremely low levels of COD (chemical oxygen demand, a measure of the oxygen required to oxidize all organic and inorganic compounds in water) and nitrogen, resulting in a clear effluent. The team is now looking to collaborate with interested manufacturing companies to scale-up and mass produce the BCR as well as assist in marketing the new technology that has the potential to become highly profitable. A bench-scale model of the BCR design is shown in the photograph below.

Impact: The BCR:

- -Produces and retains high concentrations of biomass without loss through the thick permeable membrane.
- -Achieves highly effective solids/liquid separation with a minimum hydraulic head pressure of only 1-2 inches.
- -Destroys MTBE in fuel-contaminated groundwater to sub-ug/L levels, rendering the water potable again.
- -Achieves the high degree of biological treatment and biomass retention claimed above in one compartment, requiring only one tank for both compartments.

IP Position: Development of patented membrane bioreactor (U.S. patent #6,821,425).

- -License pending with the wastewater treatment equipment company Purestream LLC, located in Walton, Kentucky.
- -Active CRADA with UNECO, an Italian company, for field-treatment of MTBE and BTEX in groundwater.

Technology Status: The technology has been field tested and is ready for implementation.

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Use of Green Methods and Applications to Destroy Toxic Organics and Inorganic Compounds in the Environment

Problem: There are over 500,000 contaminated sites across the United States. Current cleanup technology requires excavation and may even generate toxic by-products. Remediating or destroying various organic and inorganic environmental toxins in the subsurface and in water at or around these sites is a complex challenge.

Description: EPA's world-renown scientists in Cincinnati are trained and educated to develop innovative cleanup strategies that restore contaminated sites to productive use, reduce associated costs, and promote environmental stewardship. Through a Cooperative Research and Development Agreement (CRADA) between EPA's National Risk Management Research Laboratory (NRMRL) and the private company VeruTEK in Bloomfield, Connecticut, EPA green-synthesis technology is being used to further improve VeruTEK's green remediation and treatment technologies used in environmental cleanup. This project combines EPA's expertise in green synthesis of nanoparticles with VeruTEK's expertise with surfactant enhanced in situ chemical oxidation and reduction methods. As a result, new environmentally-friendly applications and methods have been developed. The anticipated benefits from the new green-synthesis methods over conventionally used processes are: only natural materials are used; no hazardous waste is produced; reduced processing is required; materials are more stable, easily stored, and transported; and, materials can be more easily produced around the world.

Impact: The Cooperative Research and Development Agreement between the EPA and VeruTEK will provide:

- -Production of nanoiron using various plant extracts and iron sources
- -Catalytic activation of hydrogen peroxide
- -Destruction of contaminated soils

IP Position: VeruTEK filed a provisional U.S. Patent with co-inventors from the EPA in 2008. The project covers the method of synthesis of metal nanoparticles using plant extracts and their application as catalysts for oxidation reactions, and also as reductants to treat organic and inorganic chemicals.

Technology Status: The CRADA reinforces the collaboration between the EPA and VeruTEK and will greatly enhance how nanoscale technologies are applied for site remediation. It is anticipated that using the new greener synthetic pathways, the cost of nanoscale iron and other nanoscale metals will be reduced, along with the elimination of toxic byproducts often generated in the conventional process. While the green-synthesis process is new, it is expected that it will be used in the field in 2009.

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