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EPA Ground Water Currents

Developments in innovative ground water treatment

HYDROCARBON FILTRATION RECOVERY SYSTEM

By Laurel Staley, EPA Risk Reduction Engineering Laboratory

The InPlant Systems, Inc. SFC Oleofiltration System (SFC System) is a hydrocarbon recovery technology that utilizes an innovative amine-coated ceramic granule to separate suspended and mechanically emulsified hydrocarbons from aqueous solutions. These granules form an oleophilic filtration system (the Oleofilter) that separates some chemical emulsions and reduces concentrations of dissolved hydrocarbons. The Superfund Innovative Technology Evaluation (SITE) Program conducted a demonstration of the SFC 0.5 System at the Petroleum Products Corporation site near Fort Lauderdale, Florida during June 1994. The site is a former oil recycling facility where the ground water has been contaminated with a variety of organic and inorganic constituents. Accidental releases during the operation of the facility deposited approximately 29,000 gallons of used oil on the ground water surface. The SFC System removed at least 90% of the total recoverable petroleum hydrocarbon (TRPH) from the emulsified oil/water feed stream.

The SFC System combines a conventional oil/water separator, a coalescing unit and the innovative Oleofilter into one unit, reportedly capable of treating virtually any oil/water mixture. Units are available in sizes capable of treating 2.2 to 50 gallons per minute (gpm); other systems utilizing stand-alone components are capable of treating up to 600 gpm. All units operate at atmospheric pressure.

The oil/water mixture feeds into the top of the unit through a port, Port A, where free floating oil is removed by the oil/water separator. The emulsified oil then flows downward inside the outer shell of the unit and upward through a middle portion of the unit that contains plates that coalesce the oil. This oil, together with the oil initially captured by the oil/water separator, is discharged from the system through a second port, Port B, at the top of the unit. Final cleansing occurs as the remaining material flows upward through the center of the unit and then drains through the bed of oleophilic granules. The treated water than exits the system through Port C.

For the SITE demonstration, the feed oil was recovered from the site and thinned with lighter petroleum products. The feed stream to the SFC System was generated by emulsifying the feed oil and ground water using an air-powered inline blender. The average TRPH concentrations for the feed streams ranged from 422 to 2,267 milligrams per Liter (mg/L). As stated, the SFC System removed at least 90% of the TRPH from the emulsified oil/water feed stream —with remaining TRPH concentrations in the treated water at 15 mg/L or less. The effectiveness of the oleophilic granules were evaluated by comparing the TRPH concentration in the water before passing through the granules. The granules were responsible for a 95% reduction in TRPH concentration for the runs with similar feed oil.

The oleophilic granules are produced by "grafting" a hydrophobic amine to a ceramic substrate through a series of substitution reactions. The amine's hydrophobic properties attract hydrocarbons present in an emulsion in water. The hydrocarbons remain attached to the amine by weak charges while the treated water exits the system. When the Oleofilter becomes saturated with hydrocarbons and suspended solids, it can regenerate itself by back-flushing, which is built into the SFC System.

EPA is publishing a Technology Capsule and Innovative Technology Evaluation Report this Spring.

For more information about the technology and the report, call Laurel Staley at EPA's Risk Reduction Engineering Laboratory at 513-569-7863.

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BIOREACTOR AND MEMBRANE FOR VOCs

By Daniel Sullivan, EPA Risk Reduction Engineering Laboratory

The ZenoGem™ process is an integrated bioreactor and ultrafiltration (UF) membrane system that is designed to remove biodegradable materials, including most organic contaminants, from ground water and wastewater. The ZenoGem™ technology was evaluated at a Superfund Innovative Technology Evaluation (SITE) Program demonstration at the Nascolite Superfund site in New Jersey. The ground water at this 17.5 acre site had been contaminated from past operations at the facility, which included manufacturing of polymethyl methacrylate plastic sheets, commonly known as plexiglass. Methyl methacrylate (MMA) is the major contaminant at the site, with ground water levels approximating 12,000 milligrams per liter (mg/L). In addition to the other volatile organic compounds at the site, chemical oxygen demand (COD) levels often approximated 20,000 mg/L. The ZenoGem™ SITE demonstration achieved 100% removal of MMA and between 84% and 95% for COD.

Here's how ZenoGem™ works. The wastewater enters the enclosed tank bioreactor where a biomass containing bacterial cultures breaks down the organic contaminants. In order to maintain sufficient aerobic conditions and optimal process temperatures, the contents are constantly mixed by the introduction of air bubbles through a series of manifolds from the tank bottom. Air is recycled, except for the air that is emitted into the atmosphere through a pressure purge vent, but not before it first passes through a carbon adsorption unit.

Feed flow wastewater treated in the bioreactor is continuously fed into the UF membrane system. The membrane system consists of a series of tubes, in ten-foot modules and approximately three inches in diameter, into which the cylindrical membrane filters are inserted. UF is a pressure-driven cross flow filtration process (typically at 60 to 70 pounds per square inch) in which the water to be processed flows tangentially over the surface of the membrane filter that is capable of separating both insoluble materials (bacteria, colloids, suspended solids) and higher molecular weight soluble materials from the treated water. Thus, the treated filtrate from the bioreactor flows through the membrane while the remaining feed, a mixture of sludge solids and unfiltered wastewater, is concentrated and recycled to the bioreactor where it remains in the treatment system for further treatment for several weeks. Because of the long sludge retention time, the bioreactor size is significantly reduced.

The SITE evaluation ran for 89 days. During the evaluation, shock loading tests were performed that demonstrated the flexibility of the process to handle a sudden increase (a four-fold increase) of concentration of contaminants. Overall, the process ran very smoothly and could recover quickly from upsets encountered in Superfund operations such as loss of electricity, quadrupling of feed concentration, free product in feedstock and adverse weather conditions. The system was computer controlled with an alarm that activated a beeper retained by the operator, demonstrating that unattended operation is extremely viable for extended periods.

The resulting treated water product from the process was clear, odorless and free of suspended solids. For this project, the product was sent to the publicly owned treatment works (POTW) which accepted the product for disposal at $22.50 per 6,000-gallon tanker. The bioreactor, which had processed approximately 28,000 gallons of water, contained only 400 gallons of nonhazardous sludge at the end of the 89-day period. The sludge was stabilized and sent to a landfill.

For more information, call Dan Sullivan at EPA's Risk Reduction Engineering Laboratory at 908-321-6677.

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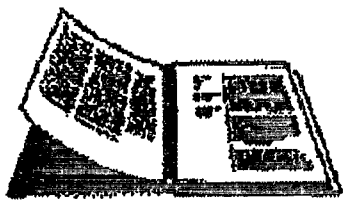

ULTRASOUND EXAMINED FOR IN SITU MONITORING

By William H. Engelmann, EPA Environmental Monitoring Systems Laboratory, Las Vegas

Ultrasound is a new concept for field screening applicable to in situ ground water monitoring. EPA's Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV) has been examining the potential of combining sonication (i.e., ultrasound) with existing measurement technologies for monitoring specific classes of organic pollutants in water. The research to date has addressed using ultrasound processors to decompose aqueous organochlorine compounds into ions as a method to screen organochlorine pollutants in water. The research demonstrated that sonication could produce anions specific to the inorganic components and that changes in ion concentrations before and after sonication could be used to monitor these pollutants. Success to date with compounds such as trichloroethylene (C_2HCl_3), chloroform ($CHCl_3$) and carbon tetrachloride (CCl_4) serve as proof-of-principle and form a rationale for expanding the research to other pollutant classes.

In the research design, the above compounds were tested in the range of 3-40 parts per million. The equipment used was an ultrasonic system with either a cup-horn or a 1/2 inch diameter horn-probe; commercially available probes such as ion selective electrodes (ISEs), conductivity cells and pH electrodes. The following parameters were investigated: sonication times (1-90 minutes); continuous vs. pulsed ultrasonic; sample temperature (constant 30 degrees Celsius); sample volumes (8-15 milliliters); and water sources (deionized, tap, well). The research on sonochemistry of organochlorine compounds in water gave much support for using sonication in combination with changes in chloride ion, conductivity and/or pH.

Common denominator in the aqueous sonochemistry is HCl, as it was the major ionic product. However, the mechanism and rate of the reaction may differ markedly depending on the conditions under which the sonication is performed.

Sufficient chloride ion was formed under the sonication conditions used to allow measurement using a commercially available chloride ISE. It was apparent that 5 minutes sonication with the cup horn at 60% pulse mode or one minute sonication with the 1/2 inch horn probe resulted in close to 3% or higher yields of chloride ion. This was sufficient to achieve detection with the commercial chloride ISE for 37-40 ppm of C_2HCl_3, $CHCl_3$ and CCl_4. Lower concentrations of these compounds should be detectable by increasing the chloride-ion yield.

It is believed that pH may be useful in driving the reaction toward HCl as the final product. Results from the present research confirmed the pH decreases. It also appears from the work that the sonolysis of organochlorine compounds was inhibited at higher pHs. Bicarbonate and carbonate may act as hydroxyl radical scavengers, thus inhibiting the organochlorine compound decomposition. However, more research is needed on real-world samples to better understand the implications of pH for monitoring methods development using ultrasound.

Overall, the potential of combining sonication with commercially available measurement technologies for monitoring specific pollutants in water is judged to be high. The approach in using sonication is applicable to other organic compounds, halides, phosphorus, nitrogen and sulfur.

For more information, call the principal researchers, Edward J. Poziomek (phone: 804-683-5643; FAX: 804-683-4628) and Grazyna E. Orzechowska (phone: 804-683-4105; FAX: 804-683-4628). A report on the research, "Potential Use of Ultrasound in Chemical Monitoring," (Order No. PB94-188190; cost: $17.50, subject to change) can be ordered only from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (telephone: 703-487-4650). The EPA Project Officer is Bill Engelmann at EMSL-LV at 702-798-2664 by phone or 702-798-2107 by FAX.

DNAPL TECHNOLOGIES EVALUATED

The EPA's Robert S. Kerr Environmental Research Laboratory has published a report of a project that reviewed and evaluated in situ technologies for remediation of dense nonaqueous phase liquids (DNAPLs) contamination occuring below the ground water table. The report reviews various in situ technologies and evaluates them on the basis of their theoretical background; field implementation; level of demonstration and performance; waste, technical and site applicability/limitations; and cost and availability. The processes discussed are: biological; electrolytic; containment and ground modification; soil washing; air stripping; and thermal. A summary of the project's conclusions follows.

The report concludes that the remediation of DNAPLs faces challenges posed by the site stratigraphy and

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heterogeneity, the distribution of the contamination and the physical and chemical properties of the DNAPL. A successful technology has to be able to overcome the problems posed by the site complexity and be able to modify the properties of the DNAPL to facilitate recovery, immobilization or degradation. In addition, methodology must be adaptable to different site conditions and must be able to meet the regulatory goals.

Thermally based technologies are regarded as among the most promising, with steam enhanced extraction (SEE) as probably the most promising candidate. The CROW® process relies on similar mechanisms; however, it was not clear whether the injection of hot water and low quality steam offers an advantage over SEE. Radio frequency heating, which relies on in-situ steam generation to be effective, has only been tested in the vadose zone.

The report concluded that the next group of promising technologies are the soil washing technologies because they can manipulate chemical equilibria and reduce capillary forces. A blend of akalis, cosolvents and surfactants [illegible] probably the best combination for a soil washing application, each important for its own reasons. Alkalis can saponify certain DNAPLs and affect wetability and sorption; cosolvents provide viscous stability and enhance solubility and mass transfer between the aqueous phase and the DNAPL; surfactants have the largest impacts on solubilty and interfacial tension reduction. Water flooding is best applied in highly contaminated areas as a precursor to these methods.

The thermal and soil washing technologies are considered as best suited for areas that are highly contaminated with DNAPLs. However, these techniques by themselves still may not be able to achieve the currently mandated regulated cleanup standards. Thus, consideration should be given to using these technologies in combination with the technologies suitable for long-term plume management. The bioremediation techniques and permeable treatment walls hold the best promise.

A special problem is posed by mixed wastes, heavy metals and radionuclides mixed with DNAPLs since recovery at the ground surface may not be desirable in many instances. In such instances, solidification/stabilization (S/S) and vitrification are among the most viable in situ technologies. Excluding radionuclides, in situ S/S is the most promising candidate because of its broadly demonstrated effectiveness, cost and applicability to the saturated zone.

A copy of the report, EVALUATION OF TECHNOLOGIES FOR IN-SITU CLEANUP OF DNAPL CONTAMINATED SITES" (Order No. PB94-195039), can be obtained for $27.00 (subject to change) from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (Telephone: 703-487-4650).

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