AquAeTer
optimizing environmental resources - water | air | earth

The AquAeTerian

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Aqua Aer Terra

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Groundwater Sampling in Adak, Alaska by Cathryn Stewart, P.G.

Emission Testing for Fugitive Sources by Paul Marotta, P.E.

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The President's Corner

Felices Bacteria: Happy Bacteria

We are excited to welcome our newest employee, Dr. Wesley Eckenfelder, to the **AquAeTer** family. In this issue, Wes discusses a new bio-stimulation process that we have developed, which is now patent-pending. This new process has been tested both in the laboratory and in pilot field tests in Pennsylvania, Tennessee, and Texas. The constituents currently being treated at these sites include contaminants from former wood treating facilities, industrial dry cleaners, and equipment manufacturers. Our new process uses substantially less chemical than the other processes currently in use, and so far we have achieved significant degradation of the groundwater contamination in less than one year. As Wes will explain in his article, this process stimulates existing bacteria in order to break down the constituents. We like to refer to them as "Happy Bacteria", which in Latin translates to **Felices Bacteria**. As Wes often says, "When the bugs are happy, everybody's happy."

The development of this new remediation technology has been a team-effort at **AquAeTer,** along with our clients. Luke Patterson and Paul Marotta conducted the original bench-scale tests in our in-house laboratory. Guyton Giannotta and Dr. Pete Zlatev first applied the technology in a pilot study on a chlorinated-solvent plume in Pennsylvania. Wes worked with Steve Wampler, Chrisie Brown, Chris Bolin, Pam Hoover, and John Michael Corn in tweaking the field application techniques to improve the biological degradation rates and developing hydraulic, chemical, and bacterial analyses for field applications. We are excited about this new process and we look forward to assisting our clients in remedial projects that will allow the client to walk away from old contaminated sites.

This issue also includes a short article on using Global Positioning System (GPS) instrumentation with field equipment to record data in real time and in real location in the field. This results in a significant data collection and analysis cost savings. John Michael Corn presents some examples of how our professionals have applied this technology in the field.

We have also added several new employees to the **AquAeTer** family including Patrick Allen, Geologist, in our Hershey office; Julie Brashears, Administrative Assistant; Christopher Green, P.G., Hydrogeology; Trey Lewis, Technician; and Amanda Wilding, Biologist in our Brentwood office.

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Bio-Stimulation for Groundwater Remediation

AquAeTer has developed a proprietary process (patent-pending) for aerobic bio-stimulation of groundwater systems that enhances the aerobic activity of naturally occurring bacteria. The indigenous bacteria population is usually dormant due to the lack of oxygen and essential nutrients. The biological environment can be enhanced by providing a carbon source for energy, an oxygen source, and nutrients. When the oxygen and carbon sources acclimate to the environment, bio-stimulation occurs with consequent degradation of the target organics as shown in Figure 1. The bio-stimulant mixture containing the oxygen, carbon and nutrient source, is injected into the groundwater through a series of injection wells. When treating the saturated zone, a well-point system is preferred to deliver the bio-stimulant to the groundwater. The location of the injection and recovery wells depends upon the mixing patterns and groundwater movement. In the vadose zone, a french-drain type system is a suggested method of delivery, as shown below in Figure 2.

A critical part of every **AquAeTer** bio-stimulation project includes characterization of the hydrogeologic setting. **AquAeTer**'s ability to investigate and understand such natural systems has been a company hallmark from our beginning. As a description of a new and innovative technology, this article does not focus on the hydrogeologic aspects, but we do emphasize that it plays a significant role in the success of any remediation project.

Figure 1. Oxygen Demand and Constituent Degradation

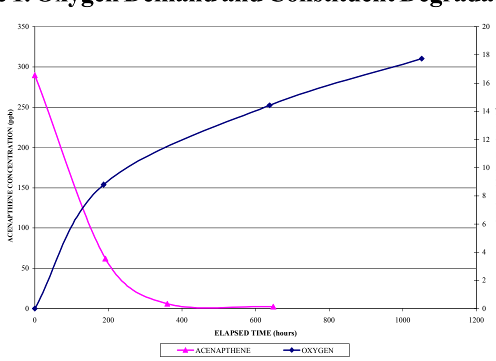
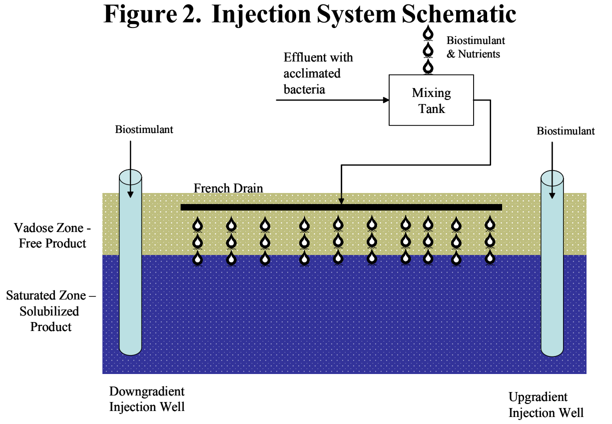


Figure 2. Injection System Schematic

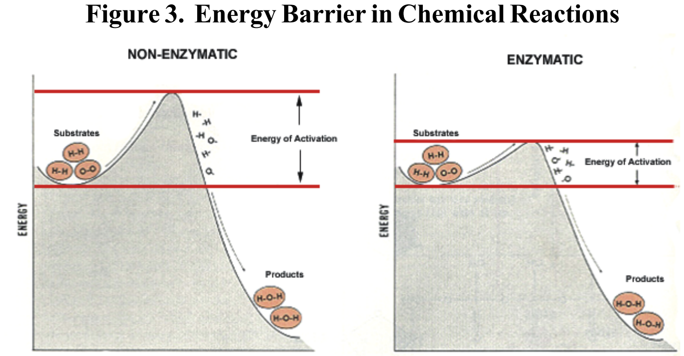


BIO-STIMULATION THEORY

Traditional aerobic degradation involves a metabolic process where bacteria attack the molecule from the outside and eventually degrade the molecule to end products of carbon dioxide and water. Carbon double-bonded molecules, such as, chlorinated solvents, polycyclic aromatic hydrocarbons (PAHs), and volatiles (e.g., benzene), can also be degraded by a shorter, co-metabolic process. **AquAeTer's** aerobic bio-stimulation treatment is designed to enhance the co-metabolic degradation of organic contaminants.

The aerobic bacteria that are stimulated in this co-metabolic process, allowing for this remediation, are naturally occurring in groundwater systems, and are believed to be facultative bacteria. Literature suggests that these bacteria are methanotrophic, (i.e., use methane as their food source), but we believe that a number of resident bacteria can be enhanced to provide increased degradation of groundwater pollutants. The bacteria are enhanced in population from the conversion of the groundwater system into an aerobic environment. During the bacterial growth process, through excretion and respiration, enzymes are produced by the bacteria. "To this day, there are few enzymes for which we understand in more than cursory data, how they achieve their enormous rate accelerations" (VOLPE, Biology and Human Concerns, 3rd Edition, 1983). According to Volpe, these enzymes act as a catalyst that lowers the energy required to break the carbon double bonds of these organic molecules. Once these carbon double bonds are weakened by the catalyst or the enzyme combining with the molecule, as depicted in Figure 3, the free oxygen easily bonds with the molecule to form epoxides. These epoxides rapidly degrade to organic acids which then degrade to carbon dioxide and water.

Figure 3. Energy Barrier in Chemical Reactions



(VOLPE, Biology and Human Concerns, 3rd Edition, 1983)

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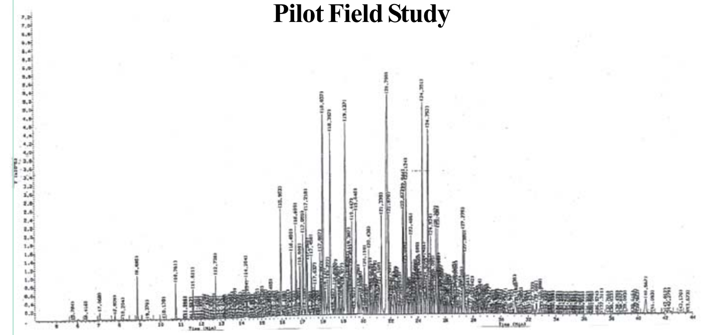
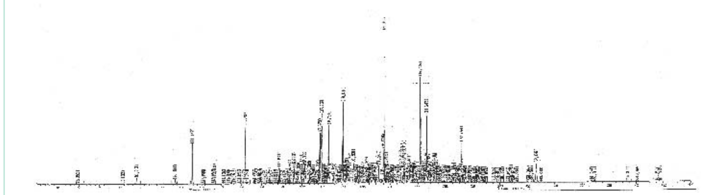
Recognized as one of the world's foremost authorities on industrial water quality management, Dr. Eckenfelder has been responsible for the development of many wastewater treatment processes and design principles used throughout the world. He has initiated and conducted many technical training courses for professional engineers on behalf of professional organizations, industries, and governments including 20 continuing education programs in the United States, Europe, South America, Australia, the Middle East, and Asia. His numerous texts and papers are used as fundamental references in the water environment profession. He has served as editor of journals and books, authored 24 books and over 200 scientific and technical papers. He has served on 33 state, national, and international committees, boards, and advisory committees for the purpose of environmental engineering, water quality, and environmental standards and research. He has served as consultant for over 100 major U.S. corporations. He was awarded D.Sc. Honorary Doctorate from Manhattan College-New York City in 1990. He was recently received the 2004 Pillar of the Profession award from the Water Environment Association in Texas. Currently, he is a Technical Director at **AquAeTer** and provides technical direction and overview of industrial wastewater projects as well as seminars and workshops throughout the nation.

Figure 4-a. Initial Chromatograph
Pilot Field Study



Scale 7:1

Figure 4-b. Final Chromatograph
Pilot Field Study



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BENCH SCALE AND PILOT SCALE STUDY RESULTS

AquAeTer conducted treatability studies of several aerobic and anaerobic processes for enhancing the degradation of chlorinated organics including: 1) perchloroethylene ($Cl_2C:CCl_2$); 2) trichloroethylene ($CHCl:CCl_2$); 3) cis- and trans-1,2-dichloroethylene (ClHC:CHCl); and 4) vinyl chloride ($ClHC:CH_2$). The microcosm tests were run using standard 2L BOD bottles incubated at a constant temperature of 20 °C with groundwater containing as much as several parts per million (ppm or mg/L) of these chlorinated solvents.

Following this successful laboratory test, a pilot test was implemented for chlorinated solvents in groundwater at two sites, and a third site with PAHs. Results from the site containing PAHs are presented in Figures 4-a and 4-b. Figure 5 shows the degradation results at one of the pilot field studies. About 82 % degradation of the PAHs was achieved in a five-month period. The degradation of specific organics shows a first order decay rate. The half-lives achieved were about an order of magnitude quicker than traditional environmental aerobic pathways and about two orders of magnitude quicker than the anaerobic pathway.

At present, the two studies involving chlorinated organics are continuing. Also, two more groundwater treatability studies involving PAH contamination have been started. Several full-scale remediation systems are currently being designed. We anticipate that additional sites will be considered for remediation of PAH impacts in the vadose zone and groundwater beginning later this fall. We are excited about the results achieved so far, as this technology appears to be giving us *the right bug, at the right place, at the right time.*

Figure 5. Degradation of Phenanthrene, Anthracene, and Fluoranthene