Hello, this is Kevin O'Donovan, and I'd like to welcome you to the National Institute of Environmental Health Sciences Superfund Research Program monthly Research Brief podcast.

This month, we're discussing the development of a sustainable remediation system to remove trichloroethylene from groundwater.

The Research Brief, Number 251, was released on November 4, 2015, and was written by SRP contractor Sara Mishamandani in conjunction with SRP-supported researcher Akram Alshawabkeh.

An electrochemical system can effectively remove trichloroethylene (or TCE) from groundwater at high flow rates, as demonstrated by researchers at the Northeastern University Superfund Research Program Center. They optimized the electrode material and configuration to determine the best conditions to dechlorinate TCE at a flow rate of one liter per minute, which exists in karst aquifers.

Karst aquifers are a particular type of groundwater system that supplies drinking water in Puerto Rico, as well as in several U.S. regions and around the world. The karst aquifers contain cave systems that are vulnerable to contamination from toxic chemicals, such as TCE. This is because these contaminants tend to be trapped in the rock formations as non-aqueous phase liquids, and there is little opportunity for their dissolved phase to be filtered by soil or to become bound to bedrock while flowing through the systems.

The research team, led by Dr. Akram Alshawabkeh, is developing novel solar-powered technologies for remediation of contaminated groundwater, particularly in karst systems. Because groundwater is electrochemically conductive and contains a low concentration of chlorinated compounds, applying low direct electric currents can manipulate the chemistry of the water to transform contaminants to non-toxic substances.

Researchers were able to show efficient removal of TCE using a simple, two-electrode system. The two electrodes, or electrical conductors, are referred to as the cathode and anode, which donate and accept electrons, respectively, from the surrounding groundwater. This movement of electrons leads to oxidation of surrounding compounds, or loss of electrons, at the anode and reduction, or gain of electrons, at the cathode, which have both been previously shown to dechlorinate TCE.

The researchers simulated groundwater conditions in the lab to test the system performance by using various electrode materials. From the combinations they tested, they found that the optimized design for removal efficiency involved an iron anode, a mixed metal oxide cathode, and using a palladium catalyst to promote dechlorination of TCE.

The design resulted in 84 to 96 percent removal of TCE depending on the current rate. Higher current rate increased the removal rates, with a 96 percent removal at the highest current rate of 500 milliamps, but this higher rate required higher energy consumption and led to more precipitation, or deposits coming out of solution. The lowest current rate of 62 milliamps limited precipitation, but the removal efficacy reduces to 84 percent, which nevertheless remains significant.

According to the authors, although this system is effective even at the lower current rates, further research is required to address changes in parameters that may occur in the field within aquifers, such as changes in groundwater flow rate as a result of seasonal rainfall.

The researchers continue to develop this system with the ultimate goal of creating a cost-effective and sustainable electrochemical process using a solar panel as a power supply. They have recently reported on their work to optimize the electrode arrangement and the modification of the electrodes to enhance TCE removal. For example, they have shown that having multiple cathodes upstream from an anode and in the presence of a palladium catalyst is an effective method to promote the reduction of TCE in groundwater. They also showed that an increase in the nickel content in the cathode materials, such as stainless steel, improves the TCE removal rate.

Additionally, the team is evaluating potential competing processes that should be addressed before implementing the device in the field. For example, they demonstrated that the presence of humic substances adversely affects TCE removal but that the presence of limestone gravel reduces this negative impact.

If you'd like to learn more about this research, visit the Superfund Research Program website at www.niehs.nih.gov/srp. From there, click on "Who We Fund" and follow the links to the Northeastern University research summary. If you have any questions or comments about this month's podcast or if you have ideas for future podcasts, contact Maureen Avakian at avakian@niehs.nih.gov.

Join us next month as we discuss more exciting research and technology developments from the Superfund Research Program.