Research Brief 356: Pyrite Improves Electrochemical System for Removing a Chemical Mixture

Adding a common mineral, pyrite, to an electrochemical system can simultaneously remove organic and heavy metal contaminants from groundwater, according to a study funded in part by the NIEHS Superfund Research Program, or SRP.

Led by Dr. Akram Alshawabkeh, researchers at the Northeastern University SRP Center found that combining two types of remediation techniques – one that relies on applying an electrical current to destroy contaminants and one that uses minerals to adsorb contaminants – removed pollutants more effectively than either strategy alone. The heavy metals tested and removed by the combined approach were arsenic and chromium. The antibacterial compound sulfanilamide was also tested and removed.

Emerging persistent pollutants, such as those used in the study, can leach into groundwater and are difficult to remove. In particular, the metals are linked to a variety of negative health outcomes, such as liver damage and several cancers.

The research team previously developed and patented an electrochemical process that uses electricity to remove or add electrons to molecules to destroy organic compounds in water. This method also generates hydrogen peroxide and highly reactive hydroxide radicals that degrade organic contaminants, but it does not remove heavy metals. The scientists hypothesized that adding pyrite, a naturally occurring mineral found in rocks and used to adsorb heavy metals, would improve the efficacy of the electrochemical process for removing arsenic and chromium from groundwater.

First, the researchers created an electrochemical reactor by embedding two electrical conductors, or electrodes, inside a plastic tube filled with sand. They created a second reactor the same way, this time adding pyrite between the electrodes. Groundwater with either sulfanilamide, arsenic, or chromium was pumped from the bottom of the tube through each reactor.

For each contaminant, the team conducted separate experiments using the electrochemical reactor, the pyrite reactor with the electrodes turned off, and the pyrite reactor with the electrodes turned on. At regular intervals, the scientists collected samples of water from the top of the reactors for chemical analysis. Finally, they tested if the combined system could remove the antibiotic sulfanilamide, arsenic, and chromium simultaneously.

The researchers found that combining pyrite with the electrochemical process increased the amount of each contaminant removed when compared to either method alone. Additionally, the combined process allowed for simultaneous removal of organic and heavy metal pollutants.

According to the scientists, the electrochemical process interacted with pyrite to release dissolved iron from the mineral. This dissolved iron was transformed by the electrodes into iron (oxy)hydroxide, which can remove both organic and heavy metal pollutants.

Additionally, the dissolved iron combined with naturally occurring chemicals in groundwater to form a mineral called green rust, which adsorbs heavy metals. The green rust can also continue to remove certain contaminates when the electrochemical reactor is turned off.

The electrochemical process and pyrite interacted together to create a very effective combined method that addressed the shortfalls of either method alone without the need for any chemical additives, said the scientists. In the future, other researchers should consider switching from single to combined processes to address multiple contaminants, they added.

If you'd like to learn more about this research, visit the Superfund Research Program website at niehs.nih.gov/srp. From there, click on the Research Brief title under the banner, and refer to the additional information listed under the research brief. If you have any questions or comments about this month's podcast, send an email to srpinfo@niehs.nih.gov.

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