

## **Arsenic Complicates Groundwater Bioremediation**

A common groundwater contaminant, trichloroethene, or TCE, can be broken down by certain bacteria, a process known as bioremediation. But, according to a new NIEHS Superfund Research Program study, this process may stall when arsenic is present. TCE, a widely used industrial solvent, pollutes groundwater from improper handling practices.

Arsenic has been detected at 63% of current TCE-contaminated Superfund sites in the U.S. Degradation of TCE by *Dehalococcoides mccartyi* bacteria in laboratory cultures has been well characterized, but less is known about how these bacteria degrade TCE under various environmental conditions, including in the presence of other contaminants such as arsenic.

In a study led by Lisa Alvarez-Cohen, researchers at the University of California-Berkeley Superfund Research Program Center, assessed whether arsenic affected the TCE-degrading activities of *Dehalococcoides mccartyi* strain 195 (Dhc195), which is known to convert TCE into nontoxic products.

They focused on two common types of arsenic, arsenate and arsenite. Generally, aerated surface waters with higher oxygen levels contain more arsenate. In lower oxygen conditions, including in well water, arsenite is more prevalent. Although both types have been shown to disrupt cell processes, arsenite is generally considered more toxic.

Using laboratory microcosms of TCE-contaminated groundwater, the researchers measured growth and physiology of Dhc195 amended with arsenate or arsenite and identified changes in genes and metabolites in the bacterial community.

Addition of arsenite led to a 50% decrease in Dhc195 cell growth and significant decrease in TCE degradation. When arsenate was added, Dhc195 converted arsenate to arsenite over time. While arsenate exposure did not initially impact TCE degradation, they observed inhibition of TCE degradation after exposure for more than 12 days, corresponding to the conversion of arsenate to arsenite and its subsequent accumulation.

The researchers identified significant genetic changes in the Dhc195 bacterial community in response to arsenite and arsenate. In arsenite-amended cultures, 52 protein-coding genes, or transcripts, were downregulated and 278 transcripts were upregulated. In cultures amended with arsenate, 33 transcripts were downregulated and 332 transcripts were upregulated.

Some of the gene regulation changes were shared between arsenite and arsenate but others were specific to the different types of arsenic. With exposure to both types of arsenic, genes involved in DNA repair, replication, and translation were found at higher levels, which is consistent with promoting DNA mutations in bacteria.

The researchers also observed significant changes in metabolite abundances within the Dhc195 community in response to both types of arsenic. Based on the analysis of metabolites, they identified specific amino acids, or building blocks of proteins, that could increase arsenic tolerance of Dhc195.

Addition of a 20-amino-acid solution increased the growth rate of Dhc195 in arsenic-contaminated cultures, indicating that adding amino acids enhances Dhc195 tolerance to arsenic and may improve TCE degradation.

According to the authors, the study improves understanding of potential inhibitors of Dhc195 metabolism caused by arsenic and can inform the design of bioremediation strategies at co-contaminated sites. Based on these results, engineered bioremediation strategies, such as developing ways to inhibit conversion of arsenate to arsenite or providing the TCE-dechlorinating bacterial community with additional nutrients, could promote TCE degradation at arsenic-contaminated sites.

If you'd like to learn more about this research, visit the Superfund Research Program website at [niehs.nih.gov/srp](https://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](mailto:srpinfo@niehs.nih.gov).

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