A Citizen's Guide to In Situ Chemical Reduction

What Is In Situ Chemical Reduction?

In situ chemical reduction, or "ISCR," uses chemicals called "reducing agents" to help change contaminants into less toxic or less mobile forms. It is described as "in situ" because it is conducted in place, without having to excavate soil or pump groundwater above ground for cleanup. ISCR can clean up several types of contaminants dissolved in groundwater. It can also be used to clean up contaminants known as "dense non-aqueous phase liquids" or "DNAPLs," which do not dissolve easily in groundwater and can be a source of contamination for a long time. ISCR is most often used to clean up the metal chromium and the industrial solvent trichloroethene, or "TCE," which is a DNAPL.

How Does It Work?

When reducing agents are added to contaminated soil and groundwater, a chemical reaction occurs that changes contaminants into other forms. For example, a very toxic form of chromium called "hexavalent chromium," or "chrome 6," can be changed to chrome 3 when reducing agents are injected into contaminated groundwater. Chrome 3 is a much less toxic form of the metal. Chrome 3 is also less mobile because it does not dissolve as easily in water.

Common reducing agents include zero valent metals, which are metals in their pure form. The most common metal used in ISCR is zero valent iron, or "ZVI." ZVI must be ground up into small granules for use in ISCR. In some cases, micro- or nano-scale (extremely small) particles are used. The smaller particle size increases the amount of iron available to react with contaminants. Other common reducing agents include polysulfides, sodium dithionite, ferrous iron, and bimetallic materials, which are made up of two different metals. The most common bimetallic material used in ISCR is iron coated with a thin layer of palladium or silver.

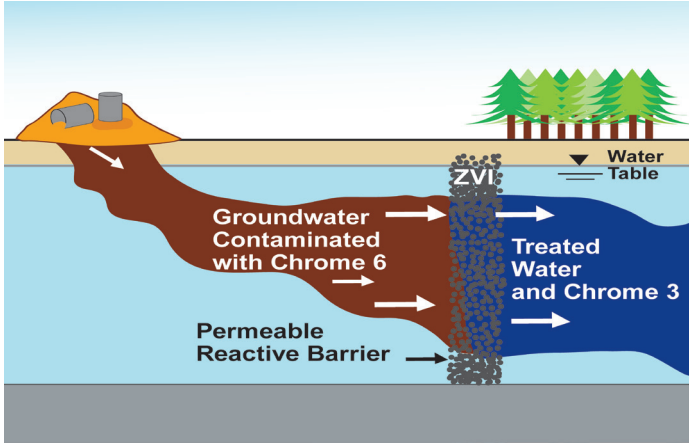

Illustration of the treatment of contaminated water with a PRB made of ZVI.

There are two ways of bringing reducing agents into contact with contaminated soil and groundwater: direct injection and construction of a permeable reactive barrier, or "PRB."

Direct injection involves mixing the reducing agent with water (or sometimes vegetable oil) to create a slurry, which is pumped down holes drilled directly into the contaminated soil and groundwater. This method is often used to treat highly contaminated source areas, including DNAPLs. Nano-scale ZVI is usually used when injecting iron underground, but micro-scale ZVI also is used.

A **PRB** is a wall built below ground, usually by digging a trench and filling it with a reducing agent. Iron filings, which are larger granules of ZVI, are commonly used. Because the wall is permeable, groundwater flows through the PRB allowing contaminants to react with the reducing agent; treated water flows out the other side. A PRB is used to treat contaminants dissolved in groundwater. It will only treat the water that flows through it. (See *A Citizen's Guide to Permeable Reactive Barriers* [EPA 542-12-015].)

How Long Will It Take?

ISCR may take as little as a few months to clean up a source area using direct injection, and PRBs may take several years. The actual cleanup time will depend on several factors that vary from site to site. For example, ISCR will take longer where:

- The source area is large, or contaminants are trapped in hard-to reach areas like fractures or clay.
- The soil or rock does not allow the reducing agent to spread quickly and evenly or reach contaminants easily.
- Groundwater flow is slow.

Is In Situ Chemical Reduction Safe?

The use of ISCR poses little risk to the surrounding community. Workers wear protective clothing while handling reducing agents, and when handled properly, these chemicals are not harmful to the environment or to people. Because contaminated soil and groundwater are cleaned up underground, ISCR does not expose workers or others at the site to contamination. If contaminated soil is encountered when digging the PRB trench, workers will need to wear protective clothing. They also cover any loose contaminated soil to keep dust and contaminants out of the air before disposing of it. Groundwater and soil are tested regularly to make sure ISCR is working.

How Might It Affect Me?

Residents and businesses near the site may see increased truck traffic when drilling rigs, earth-moving equipment, and reducing agents are delivered to the site. Residents also may hear the operation of equipment during injections or installation of PRBs. However, when injections and PRB installations are complete, ISCR requires no noisy equipment. Cleanup workers will occasionally visit the site to collect soil and groundwater samples to make sure ISCR is working.

Why Use In Situ Chemical Reduction?

ISCR can treat some types of contaminants including DNAPLs that are difficult to clean up using other methods. It can destroy most of the contamination in situ without having to pump groundwater for treatment or dig up soil for transport to a landfill or treatment facility. This can save time and money. In addition, no energy is needed to operate a PRB because it relies on the natural flow of groundwater. ISCR is a relatively new method for cleaning up hazardous waste sites, but is seeing increased use at Superfund sites across the country.

Injection of reducing agent into a hole drilled underground.

Example

ISCR was used to treat soil and groundwater contaminated with chrome 6 at the Macalloy Corporation Superfund site in South Carolina. Leaks and disposal of wastes at the former iron-chrome alloy manufacturing plant contaminated the groundwater, which flows into a nearby creek.

In December 2005, five PRBs (and later another four) were constructed to contain and treat groundwater before it could enter the creek. Soil excavated from trenches was mixed with gravel and a blend of ferrous iron and sodium dithionite. The mixture was placed back in the trenches to form the PRBs.

A 2010 review showed that concentrations of chrome 6 and the extent of contamination are decreasing at the site. Cleanup goals are being met in most of the wells sampled. The PRBs are expected to continue to reduce chrome 6 over the next five years.

For More Information

For more information about this and other technologies in the Citizen's Guide Series, visit::

www.cluin.org/remediation
www.cluin.org/products/citguide
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