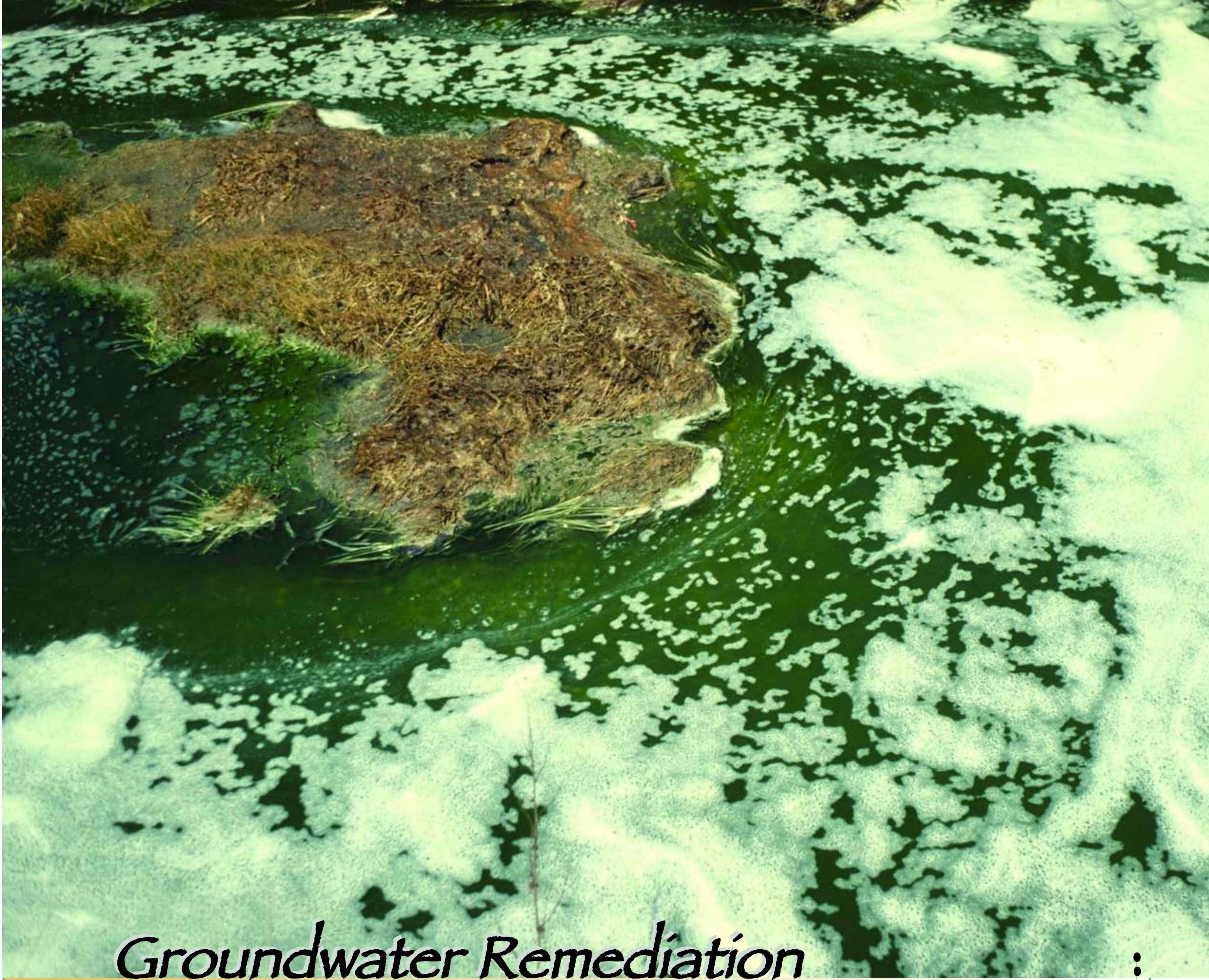

Groundwater Remediation

Saving the Source

No one questions whether surface water sources are contaminated. We wouldn't go down to the local waterway, dip our cups in, and take a big drink—there's no telling what's in there, right? But we will drink water that comes directly from a well. Why is that? Largely because we think that groundwater that has been filtered through the soil has become safe to drink, and we don't give it much more thought than that.

Until recently, this view may have been mostly true. But now groundwater investigators have found contaminants in groundwater supplies, such as industrial and municipal wastes; leaking sewer or septic tank effluent; animal feedlot runoff; and lawn and crop fertilizers, pesticides, and herbicides.

A well can be contaminated easily if it is not properly constructed or if toxic materials are released into the well. Toxic material spilled or dumped near a well can leach into the aquifer and contaminate the groundwater drawn from that well. Contaminated wells used for drinking water are especially dangerous. Wells can be tested to see what chemicals may be in the well and if they are present in dangerous quantities.

By **Kathy Jesperson** • *On Tap* Editor

These are some nasty contaminants that can have some equally nasty health effects. The health effects of microbial contaminants are generally immediate, leading to diarrhea, nausea, and vomiting. But the health effects of some chemical contaminants won't be apparent for a long time and could lead to cancer.

Health Relies on Clean Sources

We depend upon environmental engineers, public health officials, and regulators to figure out how to remove contaminants from groundwater. But removing contaminants from groundwater is a bit trickier than removing them from surface water. Surface water is pumped from the source, such as a river, lake, or stream, to a treatment plant, where it's made safe to drink.

And, yes, we probably could build treatment plants to treat groundwater sources, and many are likely already in place. But this solution only solves part of the problem. It still leaves pollutants in the ground and the groundwater that may compromise the ecosystem.

Using a groundwater remediation system, the U.S. Army Corps of Engineers do some sampling to check the water quality at the Pueblo Depot in Pueblo, Colorado.

Photos by Harry Weddington, U.S. Army Corps of Engineers Digital Visual Library

Remediation Can Improve Quality

Remediation techniques can improve the quality of groundwater, and many approaches already exist or are being developed.

For years, groundwater remediation usually meant the pump and treat method. This approach applies well-established wastewater treatment to groundwater remediation.

Using the pump and treat method, contaminated groundwater is pumped from the ground to a treatment plant on the surface. This method has the advantage of using proven techniques and is easy to control. The treated groundwater can be reinjected into the ground or discharged into rivers or lakes.

The main disadvantages are that it disturbs the routine way that groundwater flows, and it requires steady energy and other inputs. In addition, it doesn't work so well with some slowly secreted contaminants, such as polyaromatic hydrocarbons (PAHs).

In recent years, groundwater remediation techniques have improved. According to the Ground Water Remediation Technologies Analysis Center, a nonprofit organization that evaluates novel remediation technologies, there are a number of innovative ways to rehabilitate your well.

Innovative Methods Can Rehabilitate Wells

Air sparging involves injecting gas (usually air or oxygen) that's under pressure into well(s) installed within the saturated zone to volatilize (break apart) contaminants dissolved in groundwater.

Blast-enhanced fracturing creates "fracture trenches" or highly fractured areas through detonation of explosives in boreholes (shotholes). This technique is used at sites with fractured bedrock formations to improve the recovery rate and predictability of contaminated groundwater.

Directional wells are especially useful when a contaminant plume covers a large area and has linear geometry, or when surface obstructions are present. This technology uses horizontal wells. Trenched or directly drilled wells also are installed to use for groundwater monitoring or remediation.

Groundwater recirculation wells involve creating a groundwater circulation "cell." Injecting air or inert gas into a zone of contaminated groundwater creates an airlift pumping system that causes groundwater to rise and break up volatile contaminants. Groundwater is recirculated through a stripping well until remediation goals are met. This application works best for volatile organic contaminants, but modifying the basic process could make the application acceptable for semi-volatile organic compounds, pesticides, and inorganics.

Hydraulic and pneumatic fracturing techniques create enhanced fracture networks to increase soil permeability to liquids and vapors and accelerate contaminant removal. The techniques are especially useful for vapor extraction, biodegradation, and thermal treatments and work best in unconsolidated sediments or bedrock.

***In Situ* flushing** is also known as injection/recirculation or *in situ* (in place) soil washing. This method requires injecting or infiltrating a remediation solution into contaminated soil/groundwater. The solution is then extracted below the area where the solution was injected. The groundwater may be further treated and possibly reinjected back into the aquifer. This flushing method works best in moderate to high permeability soils. It may be used for a variety of organic contaminants, including nonaqueous phase liquid and inorganic contaminants.

***In Situ* stabilization/solidification** is also known as *in situ* fixation or immobilization. It involves injecting or infiltrating stabilizing agents into contaminated soil or groundwater. The process changes organic or inorganic contaminants to a harmless or immobile state. Contaminants are physically bound or enclosed within a stabilized mass or their mobility is reduced through chemical reaction. This process works best for moderate to high permeability soils and may be used for a variety of organic and inorganic contaminants.

Permeable reactive barriers include passive barriers, passive treatment walls, treatment walls, or trenches. An in-ground trench is backfilled with reactive media to provide passive treatment of contaminated groundwater. The treatment wall is placed at a strategic location to intercept the contaminant plume and backfilled with media, such as zero-valent iron, microorganisms, zeolite, activated carbon, peat, bentonite, limestone, saw dust, or other material. This application can work for a wide range of organic and inorganic contaminants.

Thermal enhancements use steam, heated water, radio frequency, or electrical resistance to alter contaminants' temperature-dependent properties to facilitate their removal. This process may be used for a variety of organic contaminants and nonaqueous phase liquids as well as some inorganic contaminants.

Biological Treatment

Bioslurping uses vacuum-enhanced pumping to recover light, nonaqueous phase liquid. This process promotes biodegradation of organic compounds.

Intrinsic bioremediation is a natural, non-enhanced process that uses microbials to degrade organic constituents. Contaminants are broken down to simpler, often less toxic, compounds through aerobic or anaerobic processes.

Monitored natural attenuation includes intrinsic bioremediation. It relies on a variety of physical, chemical, or biological processes (within the context of a carefully controlled and monitored site cleanup approach) that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater.

Phytoremediation uses plants to remediate environmental media in situ. This technique includes:

- rhizofiltration in which plant roots absorb, concentrate, and precipitate heavy metals,
- phytoextraction in which plant roots and shoots can be harvested and contaminates can be extracted,
- phytotransformation in which plant tissues degrade complex organic molecules to simple molecules,
- phytostimulation or plant-assisted bioremediation in which the release of exudates/enzymes into the root zone stimulates microbial and fungal degradation, and
- phytostabilization in which plants absorb and precipitate contaminants, principally metals.

These processes may or may not involve periodically harvesting plants. These processes may be applied to a wide range of organic and inorganic contaminants, but they are most appropriate for sites where large volumes of groundwater have been contaminated by relatively low concentrations of pollutants but must be remediated to strict standards. They are most effective where groundwater is within ten feet of the ground surface and soil contamination is within three feet of the ground surface.

Electrokinetics

Electrokinetics is an *in situ* process that involves applying low intensity direct electrical current across electrode pairs implanted in the ground on each side of a contaminated area, causing electro-osmosis and ion migration. The process separates and extracts heavy metals, radionuclides, and organic contaminants from saturated or unsaturated soils, sludges, and sediments. Especially unique due to ability to work in low permeablility soils as well as high permeability soils. The process works for a broad range of organic and inorganic contaminants.

For more information about groundwater remediation, contact the Ground-Water Remediation Technologies Analysis Center, Concurrent Technologies Corporation, 28th Floor, Regional Enterprise Tower, 425 Sixth Avenue, Pittsburgh, PA 15219. You may e-mail them at gwrtac@gwrtac.org, *or call (800) 373-1973. Their Web site is located at* www.gwrtac.org.