Groundwater Pollution & Aquifer Restoration: Fundamentals and New Technical Developments in Maintaining and Improving Water Quality

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Groundwater protection from anthropogenic (man-made) pollution and naturally-occurring pollution is vital, given that groundwater use is increasing and currently supplies almost fifty percent of the world's drinking water. Natural pollution is not as prevalent as anthropogenic pollution. An example of natural pollution is the high concentrations of arsenic in Bangladesh groundwater.

Most anthropogenic groundwater pollution can be categorized into either agricultural or industrial pollution. There is widespread agricultural pollution from nitrates and phosphates from fertilizers, animal manure and sewage, and from phosphates in detergents.
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Industrial pollutants can grouped as fuels (gasoline, diesel), solvents (degreasers including trichloroethylene), metals (cars, batteries), semivolatile organic compounds (pesticides, polychlorinated biphenyls [PCBs], and wood treatment compounds); explosives, and per- or polyfluoroalkyl substances (PFAS in Teflon, Gore-Tex, aqueous film forming foam, metal plating baths), which are a widespread emerging class of compounds whose toxicity is still being defined.

The principal method of groundwater remediation of industrial pollutants is extraction via pumping and treatment ("pump and treat") by activated carbon or ion exchange. Groundwater contamination typically takes decades (e.g., 50-100 years) to achieve cleanup levels (CULs), and many times are never achieved and a dilute plume persists.

Frequently, indigenous bacteria can metabolize (eliminate) most industrial contaminants and are being increasingly used as a remediation method. In some cases, bacteria are introduced (bioaugmentation) into groundwater after pilot testing establishes their ability to thrive and break down contaminants in a specific environment. Bacteria are provided a carbon substrate (e.g., fructose), and this biostimulation can enable achievement of CULs within the cone of depression of a pumping well within several years. This can render a restored portion of an aquifer within a contaminant plume, where a pumping well can produce clean water. Case studies are presented from successful pilot tests where portions of contaminated aquifers are restored through biostimulation of indigenous anaerobic bacteria.

PFAS compounds are unusual in that they are generally not amenable to microbial degradation. Some PFAS can be treated with activated carbon, whereas others are amenable to ion exchange. Enormous monetary resources are being devoted internationally to developing PFAS treatment technologies, and to defining the human health and ecological risk posed by PFAS.

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