Leachate isn't always the culprit in groundwater contamination.

Gas attack

Solid waste managers often assume a landfill's greatest threat to groundwater is the migration of liquids that come in contact with waste, otherwise known as leachate.

That's not surprising, given that in 1997 the EPA announced that the "... fundamental objective of monitoring land disposal sites is to serve as a check on potential leachate contamination."

Yet in California, when landfills have investigated the source of groundwater contamination, gas was the culprit in almost every case where volatile organic compounds (VOCs) represented the principal agent of water-quality degradation.

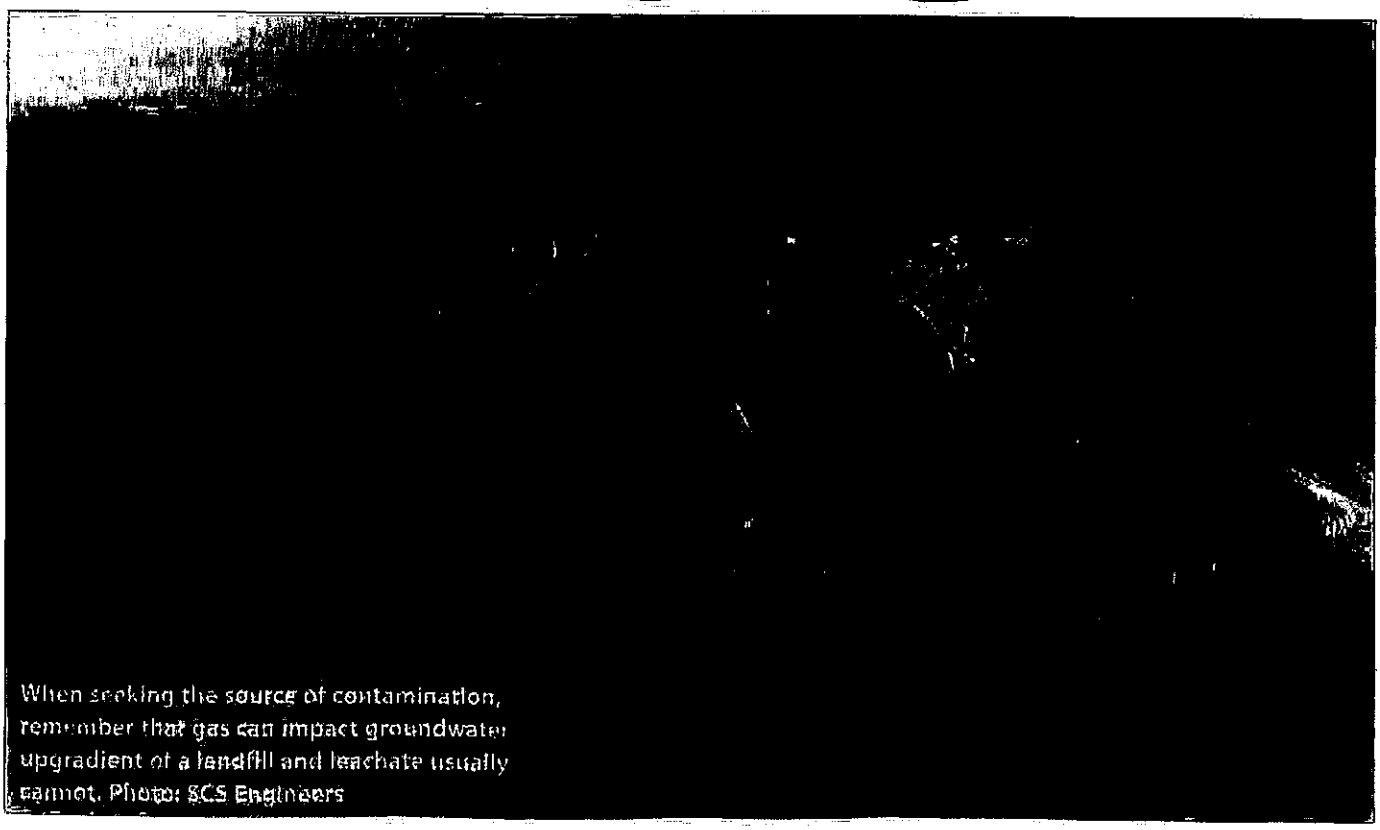
In the past five years, three relatively large, active landfills with fully operational corrective-action groundwater extraction systems found that gas—not leachate—was contaminating groundwater. Moreover, the landfills' extraction systems were not only *not* improving water quality, they were occasionally making it worse. These landfills are now focusing on controlling gas migration instead.

It's clear, then, that groundwater can just as easily be contaminated by gas as by leachate. Landfills in arid and semi-arid regions of the country, where the low volume of leachate and the distance from the landfill to aquifers and other underground water sources hamper the formation and migration of leachate, should pay particular attention to how gas may be affecting water quality.

WHAT TO LOOK FOR

Federal regulations promulgated under the Resource Conservation and Recovery Act, Subtitle D, require nearly all public landfills to monitor groundwater, and most states have developed guidelines for designing monitoring programs.

Unfortunately, these guidelines are very general. They provide little or no advice on how to interpret monitoring data, a skill that's critical to determining



When seeking the source of contamination, remember that gas can impact groundwater upgradient of a landfill and leachate usually cannot. Photo: SCS Engineers

Be careful with covers

Landfill operators often try to limit leachate formation by switching to a less-permeable cover, thus reducing water infiltration. But since this also reduces the amount of gas that migrates out of the landfill through the cover, this tactic can exacerbate gas issues. Therefore, changes in cover characteristics may need to be done in concert with upgrades to the landfill's gas-control system.

whether leachate or gas is contaminating groundwater.

The first indication of contamination is often the presence of relatively low concentrations, perhaps in the parts-per-billion range, of VOCs in samples from perimeter groundwater monitoring wells: vinyl chloride, tetrachloroethene, trichloroethene, 1,1-dichloroethane, dichlorodifluoromethane, benzene, and toluene.

Many of these substances are found in both landfill gas and leachate, so their mere presence won't pinpoint the source. But examining inorganic groundwater monitoring data—particularly how concentrations of major ions (calcium, magnesium, sodium, potassium, chloride, sulfate, carbonate, bicarbonate) and certain metals have changed with time—can.

Landfill gas is made up principally of methane and carbon dioxide. While methane has limited solubility in water, carbon dioxide is easily soluble. So it can dramatically change the geochemical makeup of samples by interacting with host minerals in the aquifer.

Dissolution of carbon dioxide in water usually forms bicarbonate or carbonate ions in groundwater (the dominant ion that forms is pH-dependent). This process also will affect pH and/or the concentration of other ions in solution. Interactions of water affected by dissolved carbon dioxide with minerals containing calcium and magnesium in the host geologic material can increase the dissolved phase concentration of these substances.

This is one clue that gas is the culprit. There are others as well.

If the vadose zone atmosphere under or near the landfill contains a high proportion of gas, the proportion of oxygen will be decreased. The result can decrease an aquifer's oxidation-reduction potential, in turn affecting the solubility of trace metals such as iron and manganese.

Some inorganic effects—such as increases in alkalinity, calcium, and magnesium—are characteristic of gas contamination, but the exact nature of the effects varies considerably depending on the water's initial chemistry.

WHAT TO DO NEXT

If the source of groundwater VOCs can be attributed to the migration of landfill gas:

- Install or upgrade the facility's gas control system to provide an adequate number and spacing of extraction points. Perimeter gas monitoring can provide clues regarding localized problem areas.
- Evaluate the design of the groundwater monitoring system. Monitoring wells may be too close to the landfill to be unaffected by gas under even normal circumstances. Make sure they're directly downgradient of the landfill and that their screens don't extend too far above the top of groundwater and form an avenue for gas migration. **PW**

— Lister is a senior technical manager with SCS Engineers in Long Beach, Calif.