Fracking: how isotope hydrology can support environmental assessments to help protect groundwater

By Miklos Gaspar

Any industrial activity near water reserves could, in principle, cause contamination. Isotope hydrology offers a unique combination of methods to monitor water quality and trace the source of pollution if any is identified. Increasingly, countries are making use of this technology to protect surface and ground water near sites used for oil extraction with a technique known as fracking.

Hydraulic fracturing, or fracking, has opened up previously inaccessible oil and natural gas resources for production. It accounts for about half of the total oil output of the United States, and many developing countries are considering using it for the first time.

Fracking is a well-stimulation technique in which rock is fractured by injecting fluid at high pressure. This fluid consists of water, sand and other chemical additives. Injected through a well, fracking creates cracks in deep-rock formations, through which natural gas and oil can flow more freely. This method allows access to oil and gas that are trapped in tight formations and are not accessible using conventional drill and pump methods.

Surface water may be contaminated through spillage during fracking, or accidental release from the waste pit in which the fracking fluid is recovered after extraction; groundwater can be contaminated if the fluid escapes through, for example, abandoned or leaking wells; and drinking water may also be contaminated if natural gas leaks into shallow aquifers.

In many cases where contamination is suspected, identifying the source and extent of the contamination is difficult due to a lack of baseline data, said Jennifer McIntosh, Professor of Hydrology and Atmospheric Sciences at the University of Arizona in the US. “There is an opportunity for the scientific community to provide guidance on the best analytical methods for evaluating fugitive gas leakage and fracking fluid or water contamination of groundwater,” she said.

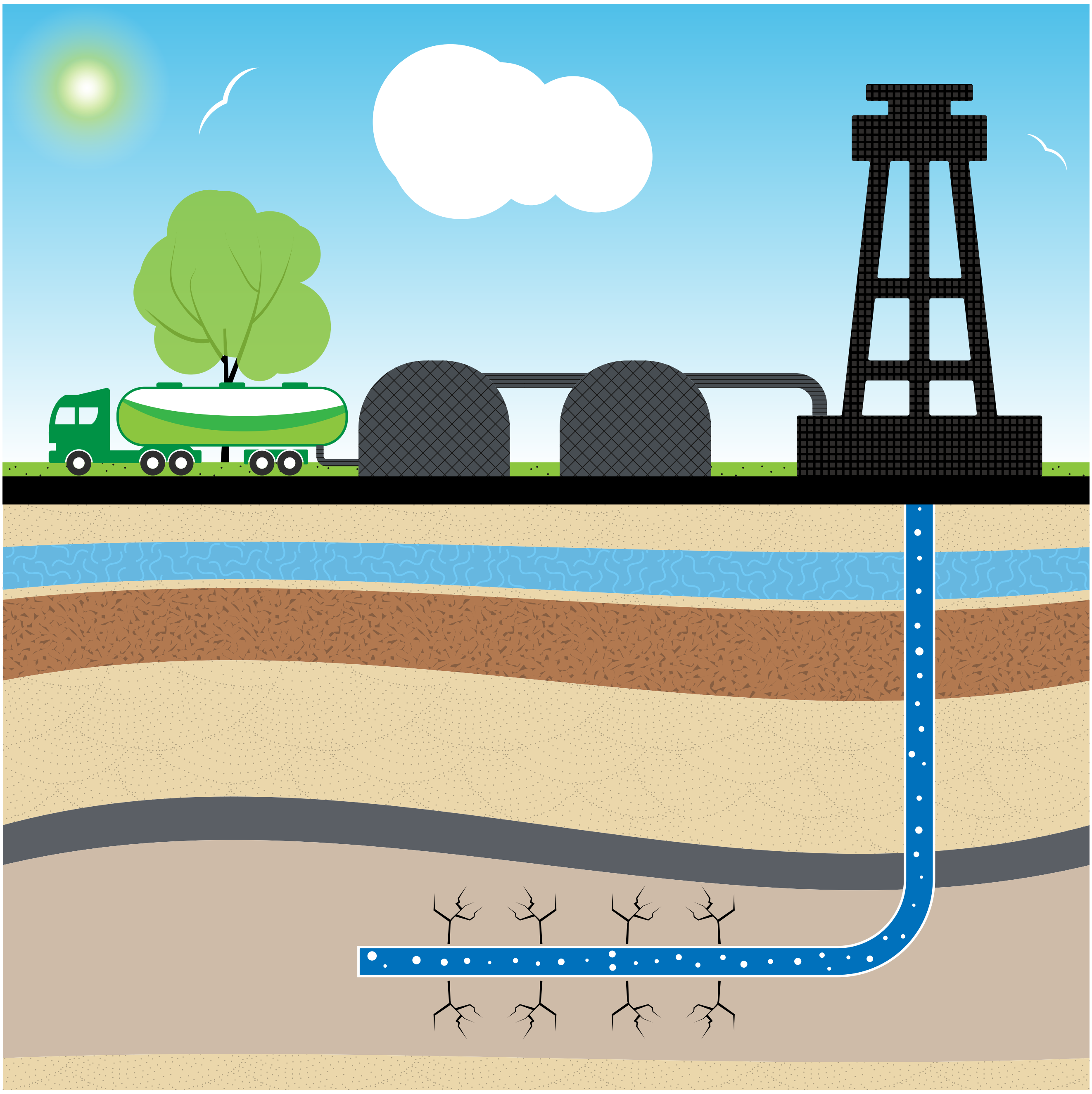
How isotope hydrology can help

A recent paper by McIntosh and 14 other authors from leading universities around the world explained how various isotope hydrology techniques can be used to monitor the impact of fracking on ground and surface water. It also provided recommendations on which method to use under a diverse set of circumstances and environmental conditions. The initial ideas for the paper entitled A Critical Review of State-of-the-Art and Emerging Approaches to Identify Fracking-Derived Gases and Associated Contaminants in Aquifers, which appeared in the journal *Environmental Science and Technology* in December 2018, were developed at an IAEA technical meeting two years earlier.

Recent analytical developments using naturally occurring isotope tracers in hydrocarbons, high-resolution data sets of natural gases and associated fluids from surface to target reservoirs, and the incorporation of noble gas geochemistry and microbiology into more traditional hydrogeological and geochemical approaches offer powerful analytical tools for identifying the sources of contaminated fluid.

Substances such as naturally occurring radioactive materials or salt can occur naturally in groundwater, but their presence can also be the result of pollution. Isotope hydrology can be used to distinguish these sources. A source’s isotopic make-up depends on its origin: measuring minor element concentrations, stable isotopes of water and dissolved components, and radiogenic isotopes of iodine, radon and strontium can provide data on the origins of the water and its dissolved components. This, in addition to traditional chemical analysis of ions, can reveal the water’s origin and whether the substances it contains are the result of fracking, other human activity or are naturally present in the environment.

Ideally before fracking begins, a background isotopic survey of the area’s ground and surface waters should be made to



establish a pre-drilling characterization of the area's waters. Suspicions of pollution due to fracking activities can then be isotopically tested against this baseline, McIntosh explained.

An emerging complex isotopic approach, using 'clumped isotopes' of methane gas, allows scientists to probe the molecular position of hydrogen isotopes in the methane gas relative to its single carbon atom, giving new diagnostic insights into which gas reservoirs the suspected stray gases may have come from, or to distinguish whether the methane is from deep thermogenic sources or was produced naturally in aquifers by soil bacteria, or a mixture of the above. "New groundwater age radiotracers like krypton-81 and argon isotopes can help to determine how long pollutants related to fracking and oil and gas production may reside in drinking water aquifers," McIntosh said.

The final section of the paper provides guidelines for a phased programme to identify contamination. It offers a strategic roadmap that would enable regulatory officials to select the best isotope hydrological method in site-specific cases.

Some of the approaches developed to detect contamination in fracking have broader applications, including for the subsurface storage of carbon dioxide and nuclear waste disposal, McIntosh added.

Hydraulic fracturing, or fracking, is a well-stimulation technique in which rock is fractured by injecting fluid at high pressure to access oil and gas. Isotope hydrologists can monitor water quality and trace the source of pollution, if any.