Jordan's fossil water source has high radiation levels

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Ancient groundwater being tapped by Jordan, one of the 10 most water-deprived nations in the world, has been found to contain twenty times the radiation considered safe for drinking water in a new study by an international team of researchers.

"The combined activities of 228 radium and 226 radium - the two long-lived isotopes of radium - in the groundwater we tested are up to 2000 percent higher than international drinking standards," said Avner Vengosh, associate professor of earth and ocean sciences in the Nicholas School of the Environment at Duke University.

Making the water safe for long-term human consumption is possible, he said, but it will require extra steps to reduce its radioactivity.

Vengosh and his research team, made up of scientists from Jordan, Palestine, Israel and the United States, published their findings Feb. 19 in a paper in the peer-reviewed journal *Environmental Science & Technology*.

Jordan's annual water use exceeds the natural replenishment of its major river, the Yarmouk, and its local aquifers that are becoming salinized as a result of over-pumping.

In 2007, the Jordanian government announced plans for a $600-million project to pump low-saline fossil groundwater from the Disi aquifer, located along the nation's remote southern border with Saudi Arabia, and

pipe it 250 kilometers north to the capital, Amman, a city of 3.1 million people, and other population centers.

Fossil groundwater is a nonrenewable supply of water trapped underground in aquifers. In recent years, policymakers in countries facing chronic water shortages have increasingly viewed low-saline supplies of fossil groundwater as an important potential source of water for human and agricultural use. Libya and Saudi Arabia, for example, have relied extensively on fossil groundwater from Nubian sandstone aquifers similar to the Disi to meet their water needs in recent decades.

Most fossil groundwater resources in North Africa and the Middle East are characterized by high-quality water with low salinity. "The assumption has been that unsafe radioactive levels occur primarily in high-saline groundwater, so low-saline sources, such as water from a Nubian sandstone aquifer, are relatively safe resources just waiting to be tapped," Vengosh said.

To test that hypothesis, Vengosh and his colleagues investigated water from 37 pumping wells in the Disi aquifer's Rum Group, where low-saline groundwater is extracted from Cambro-Ordovician sandstone, and from wells in the Khreim Group, where saltier water is extracted from an aquifer containing larger amounts of clay minerals and oxides. All samples were analyzed for major and trace elements and for four radium isotopes. For comparative purposes, sandstone rocks from the Disi aquifer, along with Nubian sandstone rocks from the nearby Negev Desert in Israel, were also measured for radium.

"We found a lack of correlation between salinity and radioactivity," Vengosh said. "Instead, our findings suggest that an aquifer's geological properties may be a much more significant factor."

Vengosh and his group hypothesize that an aquifer with a higher content

of clay minerals and oxides provides more adsorption sites for radium, and this results in lower radionuclide levels in the water itself. Sandstone aquifers, on the other hand, offer fewer adsorption sites, and, as a result, generate radium-rich groundwater.

"Given that most of the aquifers in the region that contain fossil water are composed of Nubian sandstone and are characterized by low-saline groundwater, similar to that in the Disi aquifer, we suggest that high-radioactive groundwater may also exist in these basins. This could pose health risks for a large population," Vengosh said. Groundwater from the Disi aquifer is already used for drinking water in parts of Jordan and, more extensively, in Saudi Arabia, where it is known as the Saq aquifer.

"Making groundwater from the Disi aquifer and similar sandstone basins in the region safe for long-term human use will require a significant reduction of radionuclide levels," Vengosh said.

Health officials could reduce radioactivity to safe levels by diluting radium-rich water with low-radium water from other sources, he said, or by treating it with ion exchange, reverse osmosis desalination or lime softening. Each of these three treatment technologies does a good job of removing radium, Vengosh noted, but each produces solid and liquid residues that would have to be handled and disposed of as low-level radioactive waste.

The U.S. Environmental Protection Agency (EPA) classifies radium as a Group-A carcinogenic material, which means exposure to it could cause cancer.

More information: The paper is online at http://pubs.acs.org/doi/abs/10.1021/es802969r.

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