High salt levels in Saharan groundwater endanger oases farming

April 8 2013

A date palm surrounded by surface waters diverted for irrigation in Morocco 4549 -- Researchers sampled surface water being diverted to irrigate six oases in Morocco and performed isotopic "fingerprinting" to identify sources of rising salinity. Credit: Nathaniel Warner, Duke University

For more than 40 years, snowmelt and runoff from Morocco's High Atlas Mountains has been dammed and redirected hundreds of kilometers to the south to irrigate oases farms in the arid, sub-Saharan Draa Basin.

But a new study by American and Moroccan scientists finds that far from alleviating water woes for the six farm oases in the basin, the inflow of imported water has exacerbated problems by dramatically increasing the natural saltiness of their groundwater.

Researchers from Duke University in Durham, N.C., and Ibn Zohr University in Agadir, Morocco, measured dissolved salt levels as high as 12,000 milligrams per liter at some locations—far above the 1,000 to 2,000 milligrams per liter most crops can tolerate.

Dissolved salt levels in the groundwater of the three southernmost farm oases are now so high they endanger the long-term sustainability of date palm farming there.

"The flow of imported surface water onto farm fields has caused natural salts in the desert soil and underlying rock strata to dissolve and leach into local groundwater supplies," said Avner Vengosh, professor of geochemistry and water quality at Duke's Nicholas School of the Environment. "Over time, the buildup of dissolved salt levels has become irreversible."

The team of Duke and Ibn Zohr scientists was able to know this by identifying the distinctive geochemical and isotopic signatures of different elements in the water, such as oxygen, strontium and boron. Elements in low-saline water have different stable isotope signatures, or fingerprints, than those in high-saline water.

"Once we get a water sample's fingerprint, we can compare it to the fingerprints of other samples and track the nature of the salinity source," explained Nathaniel Warner, a Ph.D. student at Duke's Nicholas School who led the study. "We can also track the source of low-saline water flowing into a system."

The practice of importing freshwater to irrigate crops is widespread throughout much of the world's arid regions, Vengosh noted. Governments have invested billions of dollars to construct reservoirs, dams, pipelines, canals and other infrastructure to bring the vital resource from areas where it is plentiful to where it is scarce.

This is a short-term solution at best, he said. Future climate change models predict significant reductions in precipitation in the Southern Mediterranean and Northern Africa regions in coming decades. Snowmelt and runoff will diminish. Local groundwater may be the best—perhaps only—source of water remaining for many communities.

"Protecting this vital resource, and helping governments in desert areas worldwide find new, untapped sources of it, is the wiser approach in the long run," Vengosh said. "The forensic tracing technologies we used in this study can help do that."

Warner noted that by using the isotopic fingerprinting technologies, the researchers discovered a previously overlooked low-saline water source that flows naturally into the Draa Basin from the adjacent Anti-Atlas Jabel Saghro Mountains. The natural flow of freshwater from this source dilutes the saltiness of nearby groundwater aquifers and improves prospects for the future of farming at the basin's three northernmost oases.

Dissolved salt levels in these oases' groundwater are between 450 and 4,225 milligrams per liter—a more sustainable level, especially for growing date palms, which are the primary commercial crop in the basin and relatively salt-tolerant.

"Prior to our study, people didn't think this was a major water input into the Draa system," Vengosh said. "We now know it is—and that it deserves to be protected as such."

Vengosh and Warner conducted the study with five Moroccan scientists and graduate students led by Lhoussaine Bouchaou of the Applied Geology and Geo-Environment Laboratory at Ibn Zohr University. They analyzed more than 100 water samples collected in 2009 and 2010 from sites above, below and at the man-made reservoir that stores and releases runoff from the High Atlas Mountains into the Draa Basin. Samples were collected from surface water, hand-dug wells, boreholes and springs.

More information: The new peer-reviewed study appears online in the journal *Applied Geochemistry*: dx.doi.org/10.1016/j.apgeochem.2013.03.005

Provided by Duke University