Intensive Pumping Impacts Arsenic Concentrations in Drinking Water Aquifers in an Inter-montane Basin

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The Independence Basin in Guanajuato, Mexico was initially formed during volcanic eruptions, and uplift and extensional events ~28 – 30 Ma. The basin is comprised of fractured volcanic rocks (rhyolite, ignimbrite and andesite) overlain by sandstones and conglomerates. In the 16th century Spanish settlers irrigated their lands with the shallow water table and perennial streams. The water table began to fall in the 1940's after farmers imported mechanical pumps and rotary drilling rigs to irrigate fruit and vegetables for a growing global market. Today, the streambeds are dry and the water table lies >100 m below surface. And a growing population, concentrated in 7 cities, is increasing pressure on the aquifers. Each year, deeper groundwater is discharging through wells. Arsenic (As), fluoride (F), nitrate (NO_3) and sodium (Na) occur at toxic concentrations. Arsenic concentrations exceed the World Health Organization's maximum drinking water limit of 10 µg/L in 50 % drinking water wells sampled across the basin. Our objective is to evaluate the flow pathways and possible chemical reactions contributing to increasing human exposure As in drinking water. Such hydro-chemical mechanisms include: 1) upwelling of deep, mineralized, geothermal waters possibly traveling along normal faults; 2) release of As from oxidative weathering of As-bearing minerals in the expanding vadose zone (e.g. pyrite); and 3) reductive dissolution of As-bearing iron-oxide minerals caused by infiltration of fertilizers and human fecal waste. Each mechanism is tested against the observed spatial distribution of chemistry, temperature and water isotopes in 150 wells. Furthermore, long-term changes in neighborhood As concentrations are assessed by comparing the spatial distribution of As concentrations to that measured in ~250 wells in 1999. Finally, 22 wells were re-sampled in 2016 to assess chemical changes in specific wells over ~20 years. Over-pumping aquifers in semi-arid regions, such that water tables fall by hundreds of meters, carries the risk of irreversible changes to aquifer chemistry.