

REGIONAL ASSESSMENT OF ARSENIC CONCENTRATIONS IN GROUND WATER IN THE SAN JOAQUIN VALLEY, CALIFORNIA

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Elevated concentrations of arsenic are found in ground water throughout the western United States (Welch and others, 2000). In the San Joaquin Valley, arsenic concentrations commonly exceed the U.S. Environmental Protection Agency maximum contaminant level (MCL) of 10 micrograms per liter. In this study, we analyzed existing data on arsenic concentrations in the San Joaquin Valley regional aquifers to evaluate the utility of these datasets for characterizing the regional distribution of arsenic and to further develop our understanding of the dominant biogeochemical processes that govern its mobilization.

Existing data were compiled from the U.S. Geological Survey (USGS) National Water Information System (NWIS) and the California Department of Health Services databases. The combined dataset contains arsenic analyses for 1,042 domestic, irrigation, observation, and public-supply wells from the NWIS database and for 1,595 public-supply wells from the DHS database (Belitz and others, 2003). Explanatory variables compiled in the database include pH and indicators of reduction/oxidation (redox) conditions. In addition, water chemistry samples were collected and solid-phase analysis of cores from local ground-water flow paths was done for the USGS National Water-Quality Assessment (NAWQA) Program studies in the San Joaquin-Tulare Basins.

Arsenic was widely detected in wells (76 percent) in the San Joaquin Valley. Arsenic concentrations were greater than 10 µg/L in 13 percent of the wells, with a median concentration of 4 µg/L, although different detection limits in the dataset restricts rigorous statistical comparison. The highest concentrations of arsenic (up to 2,600 µg/L) were in shallow observation wells in the Tulare Lakebed area, although these waters are not used as drinking water. Arsenic concentrations in this area are controlled by redox conditions, sorption, and evapoconcentration (Fujii and Swain, 1995). In the alluvial-fan aquifers of the eastern San Joaquin Valley, ground water commonly is used for domestic and public drinking-water supply. Arsenic concentrations exceeded 10 µg/L MCL in the northeastern and southeastern parts of this area, but concentrations rarely exceeded 50 µg/L.

Analysis of the arsenic dataset suggested that the dominant mechanisms resulting in elevated concentrations of arsenic were related to high pH and reducing conditions. Arsenic is commonly associated with iron hydroxides that coat grain surfaces in the sediments under oxidized conditions. Arsenic adsorbed onto iron hydroxides can be released by high-pH conditions or by reductive dissolution. Forty-eight percent of the samples from wells with arsenic concentrations greater than 10 µg/L had a pH of greater than 8. In the context of the regional flow system, areas having high concentrations of arsenic that result from high pH generally were at the distal ends of the alluvial fans adjacent to the floodbasin deposits in the axis of the valley. Thirty-five percent of the samples from wells with arsenic concentrations greater than 10 µg/L were geochemically reduced. The majority of geochemically-reduced wells in the northern part of the valley were public-supply wells located along the edge of the floodbasin deposits; the majority of geochemically-reduced wells in the southern part of the valley were shallow observation wells in the Tulare Lakebed.

Arsenic concentrations in ground water sampled from monitoring wells installed along a local ground-water flow path in the Modesto area ranged from 4 to 16 µg/L. In contrast, arsenic concentrations in ground water sampled from monitoring wells installed along a local ground-water flow path in the Fresno area ranged from 1 to 3 µg/L. All of the arsenic in ground water sampled in the Modesto area flow path has a valence of 5+ and occurs as the oxyanion arsenate, consistent with near neutral pH and oxic redox conditions, indicating that pH and redox did not explain the varied concentrations. Small-scale differences in redox environments or the generally low (<50 µg/L) concentrations may have reduced the ability of the local-scale study to explain arsenic concentrations. A better understanding of processes affecting arsenic concentrations below 50 µg/L is needed to more effectively develop future ground-water supplies.