Chemical Considerations for an Updated National Assessment of Brackish Groundwater Resources

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Photograph by Phil Stoffer, USGS
Working Definition of Brackish Groundwater

- 1,000 to 10,000 mg/L total dissolved solids (TDS)
SECURE Water Act
Section 9507(c) Brackish Groundwater Assessment

“Increase the acquisition and analysis of water resources for irrigation, hydroelectric power, municipal, and environmental uses, and for other purposes” – SECURE Water Act (2009)

Description of each significant brackish aquifer:

- Information available
- Known level of TDS
- Current use
- Data gaps to fully characterize
Major Components of the Study

• Compile readily available information
• Generate national maps of total dissolved solids (TDS) concentrations and other chemical characteristics
• Describe chemical and physical characteristics of brackish aquifers
• Describe current brackish groundwater use
• Identify data gaps
Water-Quality Data

- Site/well information, TDS, field parameters, major ions, most trace elements, nutrients, tritium, radium

- Sources (35 data sets)
  - Federal agencies
  - National Geothermal Data System (Geo-Heat Center)
  - State agencies
  - Selected reports

- Over 1.4 million water-quality samples compiled

- About 380,000 sites met data needs of the study

Photo Source: Siim Sepp (www.sandatlas.org)
Availability of Brackish Groundwater

- Physical factors
  - Volume & depth
  - Porosity & permeability
  - Connectivity with other water-bearing units

- Chemical factors
  - Chemical requirements of proposed use
  - Chemical characteristics of the resource
  - Treatment options to make resource compatible with use
Uses, Sources, and Treatment Options are Linked

Water - use chemical requirements

Chemistry of brackish groundwater

Treatment options

Drinking water, Irrigation, Livestock, Cooling water, Hydraulic fracturing, Etc..

Membrane technologies, Thermal technologies, Hybrid & other technologies

TDS, Arsenic, Barium, Boron, Nitrate, Organics, Etc..
Diverse major-ion chemistry because many processes produce it

Major-ion chemistry largely controls mineral saturation states, a key characteristic for predicting scale formation
Chemistry as it May Relate to Use & Treatment
<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Texas</td>
<td>(drinking water)</td>
</tr>
<tr>
<td>Fresno Co.</td>
<td>(irrigation)</td>
</tr>
<tr>
<td>Williston Basin</td>
<td>(hydraulic fracturing)</td>
</tr>
</tbody>
</table>

### Graph A
- 27% exceedance rate
- $n=225$
- Arsenic (µg/L)
- Dissolved oxygen (mg/L)
- 10 µg/L

### Graph B
- 44% exceedance rate
- $n=191$
- Boron (µg/L)
- Total dissolved solids (mg/L)
- 3,000 µg/L

### Graph C
- 77% of samples $SI > 0$; 53% $SI > 0.3$
- Barite saturation index ($SI$)
- $n=135$
- Well depth (m)
- Total dissolved solids (mg/L)
Simulated mineral precipitation potential in BGW undergoing treatment to remove TDS

South Texas (drinking water)  Fresno Co. (irrigation)  Williston Basin (hydraulic fracturing)

PHREEQC model conditions:
25°C, 20 atm, closed to atmospheric pCO₂
Conclusions

• National assessment that includes chemical characterization could provide a useful framework for understanding the overall availability and limitations of the resource

• Assessment of the most prevalent water-quality problems associated with BGW could help guide research and development efforts related to treatment technologies

• Thorough compilation of existing data could improve understanding of the spatial variability in key geochemical characteristics that are important with respect to use and treatment requirements
Thank you!

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Additional information

Groundwater
Issue Paper/
Chemical Considerations for an Updated National Assessment of Brackish Groundwater Resources