Arsenic Symposium
October 11, 2018
Fresno State University
Presenters:

- **John Borkovich, P.G.** – Section Chief for the State Water Board – Division of Water Quality’s GAMA Program

- **Dr. Eric Miguelino, M.D.** – Research Scientist/Toxicologist for State Water Board – Division of Drinking Water

- **Eugene Leung, P.E.** – Senior Sanitary Engineer for the State Water Board – Division of Drinking Water

- **Darrin Polhemus, P.E.** – Deputy Director for the State Water Board – Division of Drinking Water
Overview:

- Module 1: Data and Statistics on the Presence of As in PWSs in the San Joaquin Valley (John)
- Module 2: Public Heath Risks Associated with As (Eric)
- Module 3: Best Available Technology for As Treatment and Case Study (Eugene)
- Module 4: Key Regulatory Challenges that Remain for As in Drinking Water and Next Steps (Darrin)
- Questions
Arsenic in Groundwater Wells

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Fresno State University
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John Borkovich, State Water Board
Public Water System Wells

Historic statewide sampling, Division of Drinking Water:

- 200,000 sampling events for 16,000 wells
- 6,300 detections of arsenic (40%)
- 1,300 above arsenic MCL (8%)
GAMA
Small Community and Private Domestic Wells

- Data includes:
  - GAMA USGS shallow aquifer statewide sampling, with trends sampling, in progress
  - State Water Board Domestic Well Project sampling

- Over 1,300 wells
- About 800 detections of arsenic (60%)
- About 60 Above Arsenic MCL of 10 µg/L (5%)
USGS GAMA Study: Northern San Joaquin Valley Arsenic

1. Most frequently detected chemical constituent (9%) at high levels
2. Source: eroded volcanics and granitics of the Sierra Nevada
3. High levels found in southwestern part of E. San Joaquin study area
4. High As: dissolution of Fe- or MnOxHs under reducing conditions
GAMA Groundwater Information System

- Water quality data on a Google-based map
- Interactive queries
- Over 83 million analytical results from 286,000 wells
- Provides analytical tools and reporting features
GAMA Online Tools

- GAMA Groundwater Information System
- Salt and Nutrient Management Plan Tool
- USGS GAMA Groundwater Quality Mapping Tool

Coming Soon

- Digitized Well Completion Reports
- Groundwater Susceptibility Tool: using relative groundwater age
- New Nitrate Tool
- New 1,2,3 TCP Tool
- Source Water Protection Information Hub
- Trends Data Tools
Arsenic Fact Sheet

Available on GAMA Webpage

• Summary of General Information
• Regulatory and Water Quality Levels
• Summary of detections in PWS Wells
• Analytical info
• Occurrence
• Remediation and Treatment
• Health Effects
• References

GAMA Website includes eighteen others
Public Health Risks of Arsenic

Eric Miguelino, M.D.
Division of Drinking Water
State Water Resources Control Board (SWRCB)

Arsenic Symposium – Fresno State University
October 11, 2018
Background

* Arsenic is a naturally occurring element that is widely distributed in the Earth’s crust.

* Most inorganic and organic arsenic compounds are white or colorless powders that do not evaporate. They have no smell, and most have no special taste.
What is arsenic used for?

Arsenic has been used in the manufacturing of electronics, glass, lumber, and pesticides.
How are we exposed to arsenic?

- Most people are exposed to some arsenic by eating food, drinking water, or breathing air.

- Food is usually the largest source of arsenic exposure.

- Children may also be exposed to arsenic by eating soil or from hand-to-mouth activities while playing on arsenic treated wood structures.

- Occupational exposures
What are the public health risks of arsenic?

- Ingestion of arsenic over a long period of time may pose a risk for cancer.

- The public health goal (PHG)* of 0.004 μg/L is based on lung and urinary bladder cancer risk from a lifetime of exposure.

- Prolonged ingestion of arsenic can cause skin damage.

- Acute effects from arsenic could cause gastrointestinal distress.

* PHG is established by the Office of Environmental Health Hazard Assessment (OEHHA)
Arsenic poisoning

Skin damage:
- Hyperkeratosis (scaling skin)
- Pigment changes

Increased cancer risk:
- Lung
- Bladder
- Kidney and liver cancers

Nerve damage
Circulatory problems in skin
What are the clinical features of the arsenic poisoning?

<table>
<thead>
<tr>
<th>Dose</th>
<th>Period of Exposure</th>
<th>General Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 mg/day (~2500 μg/L)</td>
<td>acute (one day)</td>
<td>vomiting and diarrhea</td>
</tr>
<tr>
<td>100 -300 mg/day (~50,000 - 150,000 μg/L)</td>
<td>acute (one day)</td>
<td>death</td>
</tr>
<tr>
<td>10 to &gt;50 μg/L in water</td>
<td>chronic (years)</td>
<td>skin changes, nerve damage, organ damage</td>
</tr>
<tr>
<td>10 μg/L in water</td>
<td>chronic (~70 years)</td>
<td>may cause lung or bladder cancers</td>
</tr>
</tbody>
</table>
What are other sources of arsenic exposure?
Arsenic Treatment Techniques and Small Systems Treatment Challenges

Eugene H. Leung, P.E.
Senior Sanitary Engineer
Technical Operations Section
California State Water Resources Control Board, Division of Drinking Water
October 2018
Challenges in Providing Arsenic Treatment in California

• Announced in 2001, Arsenic Maximum Contaminant Level (MCL) was lowered from 50 ppb to 10 ppb in January 2006

• More than 12 years later, many small water systems in California are still struggling with compliance

• Multiple issues: Water quality, high treatment costs, pilot testing, Point-of-Use (POU) limitation in CA, treatment residuals, other system specific issues
Treatment Options

• BATs or “Best Available Technologies” are technologies that have been proven effective for water systems to use. However, source water quality may impact effectiveness of a BAT.

• SSCT or “Small Systems Compliance Technologies” are specified in the Federal Safe Drinking Water Act. SSCTs must be affordable and technically feasible for small systems.

• Key Costs to consider:
  – Capital Costs
  – Operation and Maintenance Costs
    • Certified Treatment Operator, Increased Testing
    • Waste Disposal Costs – Liquid & Solid Treatment Residuals
Treatment Options (2)

• Centralized Treatment – treating all water coming from a well

• Point-of-Entry Treatment – treating only water that enters a building for human consumption (useful for some businesses, schools (NTNC) or community water systems with a lot of outdoor water use)

• Point-of Use Treatment – treating only water that is used for drinking and cooking (useful for small community water systems and NTNC)
Best Available Technologies for Arsenic 40 CFR 141.62 (b) & CA Title 22, Section 64447.2

• Activated Alumina
• Coagulation/Filtration (not BAT for systems < 500 service connections)
• Ion Exchange
• Lime Softening (not BAT for systems < 500 service connections)
• Reverse Osmosis
• Electrodialysis
• Oxidation/Filtration
Arsenic Small Systems Compliance Technologies (SSCT) 40 CFR 141.62 (d)

Note: The range of numbers provided in this table are based on the number of persons served.
Arsenic Treatment Options

Non-Treatment Options
- Well Abandonment or New Well
- Alternative Sources and Source Modifications
- Blending
- Limiting Use (Peak Use Only)

Centralized Treatment Options
- Anion Exchange
- Adsorptive Media
- Oxidation Coagulation Filtration
- Reverse Osmosis
- Electrodialysis
- Modified Lime Softening

Point-of-Use*
- Adsorptive Media
- Reverse Osmosis

Point-of-Entry**
- Adsorptive Media
- Reverse Osmosis (with Blending)

Vending Machines*
- Reverse Osmosis

* Centralized chlorination may be required
** Site specific engineered solutions
Centralized Treatment vs POU

Key POU Considerations

1. High customer acceptance with goal of full participation.

2. Routine water system personnel or contractor access to inside of customer homes for maintenance.

3. Annual monitoring of each treatment unit.

Point-of-Use devices must be installed and maintained by public water system. Routine maintenance may be contracted out.

Source: USEPA Complying with the Revised Drinking Water Standard for Arsenic: Small Entity Compliance Guidance
Arsenic Treatment Options (in California)

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** Site specific engineered solutions
Treatment Issues (Technical)

- Naturally High Raw Water pH (~ 8.0), resulting in low treatment capacity for Activated Alumina and other Adsorptive Media
- Treatment Residuals (liquid and solid)
- Pre-oxidation requirement (adsorptive media and reverse osmosis treatment)
- pH adjustments needed to improve treatment capacity
Managerial and Financial + State Limitation

- General lack of TMF at very small water systems
- Water system may not have a good relationship with community members (general distrust)
- Severely disadvantaged communities (treatment affordability)
- Rental property owners or tenants – who pays for the water bill? Will property owners allow modifications to the rental units?

- State law prohibiting the use of Point-of-Use or Point-of-Entry devices as a permanent solution
Potential Solutions...

- Well Modifications
  - Shallower wells have alleviated arsenic problems
- Point-of-Use at NTNC’s
  - 100% participation not applicable
  - No individual homeowners to deal with
  - Business owner has ultimate control of every unit
- Consolidation and blending of sources
- Split distribution system to separate outdoor (non-treated) and indoor use water
- Coagulation Filtration treatment
Promising Interim Solution...

• Arvin Community Service District
• Centralized treatment scheduled for completion in about 3 years
• Point-of-Use devices and Vending Machines are used to provide children and community with safe drinking water at many locations
• Partnership between water system, environmental justice group, technical assistance provider and State program
Safe Water Station
Estación de Agua Sana

For more information on the Agua4All Project, please visit:

http://www.calendow.org/
http://www.rcac.org/agua4all

Photos courtesy of:
David Wallis and Sarah Buck
Rural Community Assistance Corporation,
Community Water Center and
Arvin Community Service District
Adsorptive Media Treatment
Multiple certified POU devices

Drinking Fountains and Bottle Filling Stations at Schools and other public.

Joint educational program to encourage drinking of water.

Certified POU’s with a separate Performance Indication Device (PID) for each unit.

Multiple units operate in parallel.
Reverse Osmosis Treatment
Bottle Water Vending Machines

Reverse Osmosis based Bottle Water Vending Machines for a low cost (or free) source of drinking water.

Vending machines are jointly regulated by SWRCB DDW and CDPH Food and Drug Branch.

RO reject is discharged into public sewer.
What kind of treatment can I use at home?

• Point-of-Entry Treatment
  – Whole-house adsorptive media

• Point-of-Use Treatment
  – Adsorptive media based Point-of-Use
  – Reverse osmosis based Point-of-Use
Disclaimer:
Photos are shown as examples and should not be considered endorsement of the products / vendors

Examples: Culligan Whole House Arsenic Reduction Filter (www.culligan.com) (left)
Multipure Aquaversa Undersink or Countertop Water Filter (https://www.multipure.com/aquaversa.html) (right)
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Certified Home Treatment Devices

- Devices marketed to consumers in CA must be registered with the Division of Drinking Water’s Residential Water Treatment Devices

https://www.waterboards.ca.gov/drinking_water/certlic/device/watertreatmentdevices.html
California-Registered Water Treatment Devices
for Arsenic Reduction as of August 11, 2017

Arsenic in groundwater has two forms: Arsenic 3 and Arsenic 5. In well water, arsenic is typically found in both forms. However the amount of each form in the well water varies from location to location.

Both forms of Arsenic are of health concern. Arsenic 3 is much more difficult to remove from the water. Most water treatment devices are certified to reduce Arsenic 5 but may provide a minimal reduction of Arsenic 3. For this reason, we have provided two tables below so that you can choose the device that meets your needs.

If you are concerned about the performance of a water treatment device, you should have the water tested periodically for reduction of Arsenic.

Table 1.
The models listed in this table provide devices that are capable of arsenic reduction – Reduces BOTH Arsenic 3 and Arsenic 5

<table>
<thead>
<tr>
<th>Registration Number</th>
<th>Manufacturer</th>
<th>Model Number</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Culligan International</td>
<td>Gold Arsenic 14”</td>
<td>Absorption Media</td>
</tr>
<tr>
<td>1998</td>
<td>Culligan International</td>
<td>Gold Arsenic 12”</td>
<td>Absorption Media</td>
</tr>
</tbody>
</table>

https://www.waterboards.ca.gov/drinking_water/certlic/device/watertreatmentdevices.html
Key Challenges and Next Steps

Darrin Polhemus, P.E. – Deputy Director
Division of Drinking Water
State Water Resources Control Board (SWRCB)
Questions?