HEXAVALENT CHROMIUM AND MANAGED AQUIFER RECHARGE

2017 NGWA SUMMIT
NASHVILLE, TN
DECEMBER 5, 2017

STORMWATER RECHARGE IN CALIFORNIA IMPROVES AQUIFER STORAGE

Stormwater collection and recharge is viewed as an important part of improving storage in groundwater basins.

In Los Angeles alone, plans are to recharge more than 200,000 AF/yr of stormwater.

CR+6 CALIFORNIA DRINKING WATER WELLS

Water quality standards for Cr6+ were set at 10 ppb in 2014, subsequently reversed (2017). New standard being developed.

Cr6+ is found in groundwater basins across California that exceeds 10ppb. Significant research into the cause for the Cr6+. Sediment source rock and recharge is suspected at some locations. Major data gap – no vadose zone samples.

STORMWATER RECHARGE IN CALIFORNIA IMPROVES SURFACE WATER QUALITY

Regulations require that stormwater is captured and infiltrated on-site or treated before discharge.

Beach pollution at third-highest level in 22 years
June 27, 2012, Los Angeles Times

Thousands of individual stormwater capture and recharge facilities are required throughout the Los Angeles Basin, many of these have already been installed.

Are there potential groundwater quality consequences?

COUNCIL FOR WATERSHED HEALTH – WATER AUGMENTATION STUDY (WAS)

• Purpose: Evaluate the potential impacts of infiltrating storm water on underlying groundwater quality.
• Landmark 2008 study
• Monitoring program
• Each location was instrumented
• Fresh review of existing chemistry data considering recent work in hexavalent chromium mobility.

WAS INSTRUMENTATION AND MONITORING

• Stormwater Collection
• Vadose Zone Lysimeters
  – Shallow
  – Deep
• Groundwater Wells
• Broad Analytical Suite
• Monitoring focused on storm events
**RESULTS – HEXAVALENT CHROMIUM (Cr\(^{6+}\))**

Cr\(^{6+}\) Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Cr(^{6+}) concentration (µg/L)</th>
<th>Stormwater</th>
<th>Soil Moisture</th>
<th>Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>ND - 0.49</td>
<td>ND - 0.7</td>
<td>ND - 1.0</td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>ND - 0.95</td>
<td>0.37 - 2.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>ND - 0.61</td>
<td>0.32 - 0.74</td>
<td>ND - 0.02</td>
<td></td>
</tr>
<tr>
<td>Park</td>
<td>ND - 1.4</td>
<td>ND - 1.3</td>
<td>ND - 0.2</td>
<td></td>
</tr>
</tbody>
</table>

- MCL for Cr\(^{6+}\) is 50 µg/L (future between 10 and 50 µg/L)
- Anthropogenic contamination was not suspected
- No known sources of Cr\(^{6+}\) in the area.

**RESULTS – VADOSE ZONE SOILS**

Vadose Zone Soils Analysis

<table>
<thead>
<tr>
<th>Avg. Soil Conc</th>
<th>Arsenic (mg/kg)</th>
<th>Chromium (Total) (mg/kg)</th>
<th>Iron (mg/kg)</th>
<th>Manganese (mg/kg)</th>
<th>Nickel (mg/kg)</th>
<th>Zinc (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>ND</td>
<td>13000</td>
<td>175</td>
<td>4.9</td>
<td>23</td>
<td>113</td>
</tr>
<tr>
<td>Residential</td>
<td>1.6</td>
<td>16400</td>
<td>345</td>
<td>12</td>
<td>97</td>
<td>42</td>
</tr>
<tr>
<td>Commercial</td>
<td>1.3</td>
<td>13000</td>
<td>545</td>
<td>43</td>
<td>91</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CA Soil Background Conc</th>
<th>Arsenic (mg/kg)</th>
<th>Chromium (Total) (mg/kg)</th>
<th>Iron (mg/kg)</th>
<th>Manganese (mg/kg)</th>
<th>Nickel (mg/kg)</th>
<th>Zinc (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>0.06 - 0.11</td>
<td>23 - 1579</td>
<td>1000 - 8700</td>
<td>285 - 1687</td>
<td>8.9 - 508</td>
<td>88 - 1740</td>
</tr>
<tr>
<td>Median</td>
<td>2.7</td>
<td>69</td>
<td>33000</td>
<td>590</td>
<td>27</td>
<td>153</td>
</tr>
</tbody>
</table>

Takeaways from these data:
- Total Cr has a good correlation with nickel (R-Square: 85%) and suggests a mafic source
- Mn oxides are suspected as a source of Cr oxidation to Cr\(^{6+}\) (USGS)
- Metals data are within background ranges for common soils in CA

**COMMERCIAL SITE RESULTS – Cr\(^{6+}\)**

Soil Moisture Cr\(^{6+}\)

Lysimeter 2 was damaged and replaced in early 2004 with Lysimeter 3 in a different location.

**OBSERVATIONS AND CONCLUSIONS**

- Potential mobility of Cr\(^{6+}\) varies by location at the 4 non-industrial sites in the Los Angeles Basin.
- The factors that may contribute to the mobility of Cr\(^{6+}\) likely include:
  - Origin and nature of the sediments and soil chemistry
  - Chemistry of the infiltrating stormwater
  - Recharge in new areas that never have been subject to this quantity and quality of infiltration.

**SOURCE OF SEDIMENTS AT COMMERCIAL SITE**

The soil results suggest that a geogenic source of Cr\(^{6+}\) may be a contributor. Rocks in the nearby Santa Monica Mountains are one source of the sediments to the basin.

These include mafic formations, rocks often naturally rich in Cr minerals.

**OTHER ANALYTES**

Commercial Site Vadose Zone Soil Moisture Analysis

<table>
<thead>
<tr>
<th>Site Moisture</th>
<th>Arsenic (mg/kg)</th>
<th>Chromium (Total) (mg/kg)</th>
<th>Iron (mg/kg)</th>
<th>Manganese (mg/kg)</th>
<th>Nickel (mg/kg)</th>
<th>Zinc (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysimeter 1</td>
<td>1.6</td>
<td>170</td>
<td>1300</td>
<td>50</td>
<td>15</td>
<td>70</td>
</tr>
<tr>
<td>Lysimeter 2</td>
<td>2.3</td>
<td>93</td>
<td>33000</td>
<td>590</td>
<td>27</td>
<td>153</td>
</tr>
</tbody>
</table>

- Variability between lysimeters suggest complicated flowpaths.
- Elevated dissolved inorganic concentrations in the vadose zone.
- Cr\(^{6+}\) and Mn data are consistent with Manning, et al., 2015.
- Dissolved Fe data may present a paradox (Sedlak, 1997).
OBSERVATIONS AND CONCLUSIONS

- Stormwater recharge, particularly with low ionic strength, potentially disturbs the chemical equilibrium of the soils.
- State database suggests that ~25% of the recharged stormwater has TDS < 50 mg/L and 5% < 10 ppm TDS.
- Results are consistent with recent USGS studies in California regarding Cr⁶⁺ mobility (Izbicki, 2012 & 2015; Manning 2015). However, these studies did not have the vadose zone water data.

QUESTIONS?

- The results of the study suggest that careful geochemical screening of the vadose zone at stormwater infiltration facilities is warranted to avoid enhancing the migration of Cr⁶⁺ into regional groundwater supplies.
- Proper instrumentation of the vadose zone for fate and transport analysis can be challenging.
- Stormwater recharge is a critical element of groundwater sustainability plans but...

Water is the universal solvent – it dissolves more substances than any other liquid. (USGS)