HEXAVALENT CHROMIUM AND MANAGED AQUIFER RECHARGE

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GSI ENVIRONMENTAL



Anthony Daus
GSI Environmental
addaus@gsienv.com

4590 MacArthur Blvd., Suite 285 | Newport Beach, CA 92660
949.679.1070 | www.gsi-net.com

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.

The New York Times

U.S.

Storm Water, Long a Nuisance, May Be a Parched California's Salvation

STORMWATER RECHARGE IN CALIFORNIA IMPROVES SURFACE WATER QUALITY

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

Los Angeles Times

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?

CHROMIUM $^{6+}$ CALIFORNIA DRINKING WATER WELLS

Water quality standards for Cr^{6+} were set at 10 ppb in 2014, subsequently reversed (2017). New standard being developed.

Cr^{6+} is found in groundwater basins across California that exceeds 10ppb.

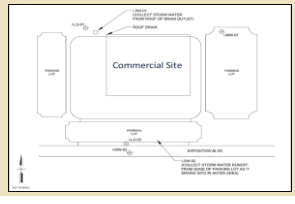
Significant research into the cause for the Cr^{6+}. Sediment source rock and recharge is suspected at some locations. Major data gap – no vadose zone samples.

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

Location	Cr^{6+} concentration (µg/L)		
	Stormwater	Soil Moisture	Groundwater
School	ND - 0.49	ND - 40	ND - 1.7
Residential	ND - 0.95	0.37 - 25	N/A
Commercial	ND - 0.61	0.32 - 74	ND - 24
Park	ND - 1.4	ND - 1.3	ND - 2.9

- 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

Ave. Soil Conc.	Arsenic (mg/kg)	Chromium (Total) (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	*SW TDS* (mg/L)
School	ND	12	13800	175	4.9	23	113
Residential	1.6	17	18400	349	12	97	42
Commercial	13	45	33800	545	43	91	18
Park	2.1	22	20850	213	11	66	177

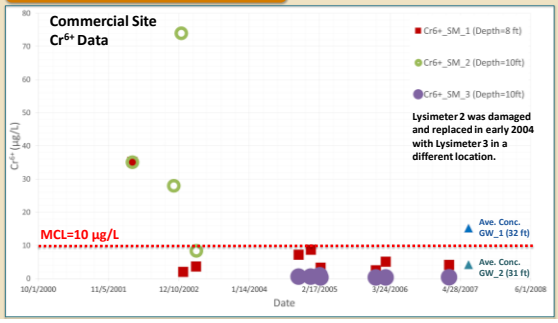
CA Soil Background Conc.	Arsenic (mg/kg)	Chromium (Total) (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
Range	0.6-11	23-1579	1000-87000	253-1687	9-509	88-170
Median	2.7	69	33000	590	27	153

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 $^{6+}$



OTHER ANALYTES

Commercial Site Vadose Zone Soil Moisture Analysis

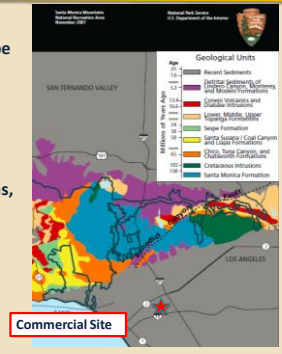
Soil Moisture	Arsenic	Chromium (Total)	Chromium-6	Iron	Manganese	Nickel	Zinc	TDS
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L
Lysimeter 1	2 - 18	2 - 64	2 - 35	132 - 985	1 - 5	6 - 35	63 - 209	710 - 3000
Lysimeter 2	10 - 29	9 - 83	8 - 74	1290	26 -31	1- 32	120 - 7050	130 - 700
Lysimeter 3	1 - 5	1.36 - 1.4	0.32 - 0.57	101 - 224	1 - 5	2 - 4	9 - 47	180 - 750

- 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).

SOURCE OF SEDIMENTS AT COMMERCIAL SITE

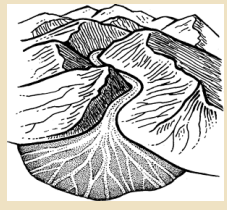
The soil results suggest that a geogenic source of Cr6+ may be a contributor. Rocks in the nearby Santa Monica Mountains are one source of the sediments to the basin.

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



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.



OBSERVATIONS AND CONCLUSIONS

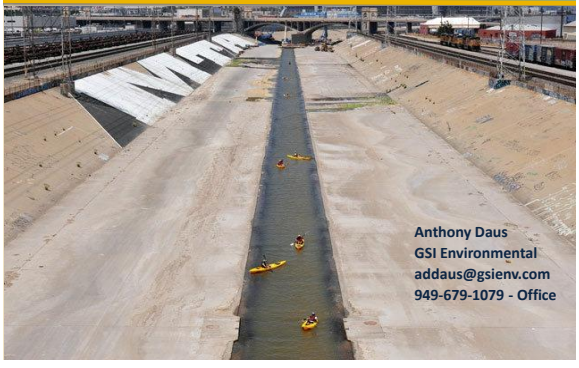
- Stormwater recharge , particularly with low ionic strength, potentially disturbs the chemical equilibrium of the soils.
- State database suggests that ~25% of the recharged stormwater has TDS < 50 mg/L and 5% < 10 ppm TDS.
- Results are consistent with recent USGS studies in California regarding Cr^{6+} mobility (Izbicki, 2012 & 2015; Manning 2015). However, these studies did not have the vadose zone water data.

OBSERVATIONS AND CONCLUSIONS

- 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 Cr^{6+} 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)

QUESTIONS?



Anthony Daus
GSI Environmental
addaus@gsienv.com
949-679-1079 - Office