The Source of Arsenic and Nitrate in Borrego Valley Groundwater Aquifer

M. H. Rezaie-Boroon*, J. Chaney-Seemayer, B. Bower

Geosciences and Environment Department, California State University, Los Angeles, *mrezaie@calstatela.edu

Objectives

The main objective of this study is to
1. find the exact source and the pattern of arsenic and nitrate in BV aquifer for the pumped raw/untreated water.
2. study is to examine the ground-water chemistry in a groundwater basin, which historically containing high arsenic concentrations.
3. identify geochemical patterns that would help explain the occurrence of high arsenic concentrations.

Project Significance

We believe the distribution of arsenic in the Borrego Valley, CA aquifer depends on the partitioning between the aqueous and solid phase. Therefore processes causing changes in the aquifer geochemistry need to be considered since they directly affect the mobility of arsenic.

Methods

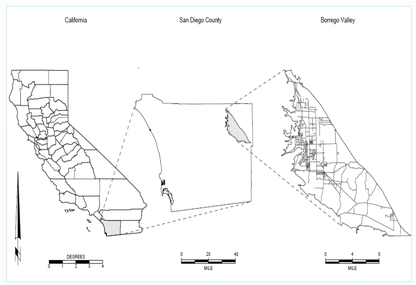
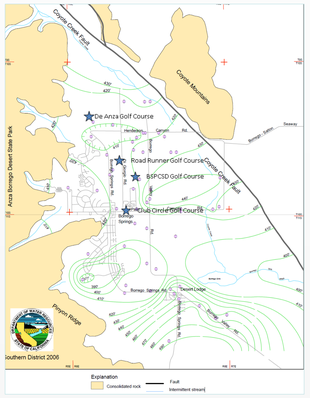


Figure 1. Regional location map of Borrego Valley, CA. (Modified after [2])

Figure 2. Base map modified from USGS 7.5-minute topographic maps. Groundwater contours area generalized representation of the regional static water level interpreted from 35 wells measured in Spring 2005. Water levels are interpreted to represent unconfined conditions [2][16]). (Courtesy of DWR, 2005; Netto, 2001).

Photo 1. The photo shows one of production pumping wells.
In the field, before sampling ground-water wells, each well was pumped continuously to purge at least three casing-volumes of water from the well and also until pH and temperature readings stabilized.



A total of 12 groundwater samples including blank and replicates samples (from six groundwater production well) were collected in the study area.. The production wells were chosen specifically based on the history of contamination records for arsenic and nitrate for each well. The sampling wells include ID1-10, ID1-12, ID 4-10, ID 4-11, ID4-18, and Wilcox, which were located in the western edge of BV.

Results

Well ID	Latitude	Longitude	Land surface elevation (ft)	Well Data								
				Total Depth (ft)	Eh (mV) **	pH **	Completed Depth* (ft)	Water Level* (ft)	Diameter (in)	Well yield GPM	Well yield GPM**	Total Perforated (ft)
ID4-18	33.306749390	-116.384712840	691.06	n/a	-25.27	6.97	570	301.2	12	250	170	n/a
ID4-11	33.267497550	-116.383355020	614.06	800	23.5	6.91	770	216.6	14	900	900	310
ID1-12	33.226028270	-116.348315130	532.24	768	-45.77	7.37	580	143.2	14	900	950	320
ID4-10	33.218318120	-116.392224090	830.29	630	35.3	7.17	630	451	8	100	100	210
ID1-10	33.211789010	-116.346811970	594.74	816	-71.8	7.65	392	236.1	12	350	350	210
Wilcox	n/a	n/a	n/a	n/a	-61.7	7.49	n/a	304.2	n/a	150	170	n/a

***Data was collected on Oct. 2013 by BWD. ** observed on the sampling day**

Table 1. This table shows the sampling well data including the exact coordinate locations land elevation of the well location and well data including total depth, pH etc.

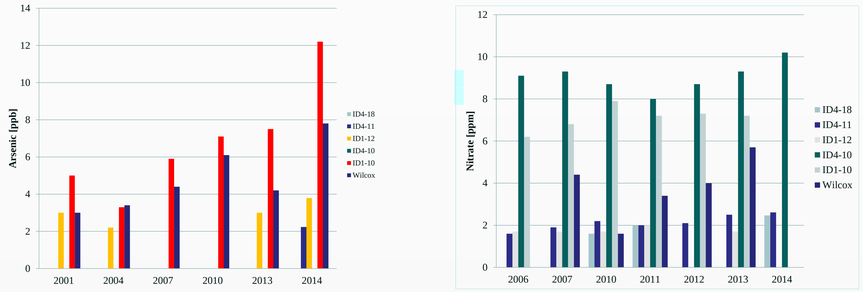
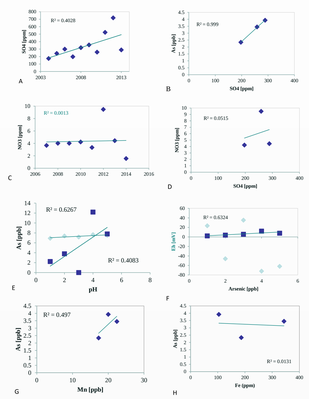


Figure 4. The concentration for arsenic (top) and nitrate (bottom) for different wells samples in June 2014. The values for 2006 to 2013 is the courtesy of BWD.

Nitrate[ppm]										
	ID4-18	ID4-11	ID1-12	ID4-10	ID1-10	Wilcox	mean	SD	min	max
2006	<1.0	1.6	1.7	9.1	6.2	<1.0	4.7	3.7	1.6	9.1
2007	N/A	1.9	1.7	9.3	6.8	4.4	4.8	3.3	1.7	9.3
2010	1.6	2.2	1.7	8.7	7.9	1.6	4.0	3.4	1.6	8.7
2011	2	2	2	8	7.2	3.4	4.1	2.8	2.0	8.0
2012	<2	2.1	<1.7	8.7	7.3	4	5.5	3.0	2.1	8.7
2013	<2	2.5	1.7	9.3	7.2	5.7	5.3	3.2	1.7	9.3
2014	2.47	2.61	N/A	10.2	NA	NA	5.1	4.4	2.5	10.2
Arsenic [ppb]										
2001	N/A	N/A	3	N/A	5	3	3.7	1.2	3.0	5.0
2004	N/A	N/A	2.2	N/A	3.3	3.4	3.0	0.7	2.2	3.4
2007	N/A	N/A	0	N/A	5.9	4.4	3.4	3.1	0.0	5.9
2010	N/A	N/A	0	N/A	7.1	6.1	4.4	3.8	0.0	7.1
2013	N/A	N/A	3	N/A	7.5	4.2	4.9	2.3	3.0	7.5
2014	N/A	2.23	3.79	N/A	12.2	7.8	6.3	3.9	2.2	12.2
Total Dissolved Solid (TDS) [ppm]										
2001	620	390	290	530	460	250	423.3	141.7	250.0	620.0
2004	558	318	246	459	274	200	342.5	137.8	200.0	558.0
2007	590	390	260	490	250	210	365.0	151.8	210.0	590.0
2010	620	370	240	510	240	220	366.7	166.3	220.0	620.0
2013	620	340	270	500	280	230	373.3	153.6	230.0	620.0

Table 2. The arsenic, nitrate, and TDS concentration for different years and from different wells based on authors results (2014) and data from BWD. N/A = Not Available.

Discussion and Conclusion



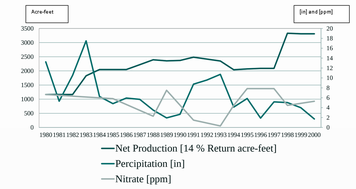


Figure 6. Comparing the precipitation, nitrate concentration from different wells and return flow values from 1980 to 2000. The return flow is the portion of the water pumped from the BV aquifer for irrigation of citrus groves and for golf course grass, which returns to the aquifer via seepage through the vadose zone. There was no data recorded for nitrate from 1981 to 1985.

Figure 5. Clockwise from top-left: A. Historical record for sulfate mean concentration (n=152) from 2004 to 2014 based on GAMA (R^2 = 0.40). B. Correlation of arsenic and sulfate concentration values from mean data record of 2007(SO_4 [n=25], for As [n=14]), 2010 (SO_4 [n=16], As [n=10]); and for 2013 (for SO_4 [n=20] and for As [n=8]). C. Historical record for nitrate concentration from 2007 to 2014 based on mean GAMA data (n=98). The graph shows fluctuation pattern for nitrate. D. There is a weak correlation between nitrate and sulfate. The mean values of NO_3 and SO_4 were used for 3 different years (SO4 [n=25], NO_3 [n=18]), for 2010 (SO4 [n=16], NO_3 [n=12]); and for 2013 (for SO_4 [n=20] and for NO_3 [n=11]). E. Correlation of As with pH (n=6) F. Correlation of As with Eh (n=6). G. Correlation of Mn versus As using mean GAMA data for 2007 (Mn [n=14], As [n=14]), 2010 (Mn [n=10], As [n=10]); and for 2013 (for Mn [n=9] and for As [n=8]) H. Correlation between Fe and As using mean GAMA data for 2007 (Fe [n=14], As [n=14]), for 2010 (Fe [n=12], for As [n=10]); and for 2013 (Fe [n=15] and As [n=8])

The groundwater basin system of BV is comprised of three hydraulically distinct aquifers that will likely provide sufficient supply if properly managed. However, nitrate and arsenic contamination in groundwater may be a concern for the study area. The results of this preliminarily study indicate that nitrate concentrations is not exceeding regulatory limits (MCL = 45 ppm) but shows some sign of increase of arsenic in only one well (around and/or slightly above 10 ppb). This may not be ruled out as an imminent threat but we suggest further monitoring of the nitrate and arsenic levels (e.g. wet season water sampling) is necessary to evaluate the temporal evolution and distribution of nitrate and arsenic concentrations within the aquifers underlying the region. Under these circumstances, future studies using nitrogen, oxygen, and carbon isotopes is also required to better assess the migration pattern of the specific sources and contributions of nitrate to the BV groundwater aquifer.

References

[1] Water Education Foundation (2006) Where does my water come from? Sacramento, Calif., Water Education Foundation, accessed September 13, 2010, at http://www.water-ed.org/watersources/default.asp.
[2] Netto, S. P. (2001) Water Resources of Borrego Valley San Diego County, California, Thesis, Master of Science in Geological Sciences, 159 p. 61 figures, 17 tables, 1 plate.
[16] California Department of Water Resources DWR (2004a), California's groundwater Individual basin descriptions, Lucerne Valley: California Department of Water resources Bulletin 118, accessed December 2, 2010, at http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/7-19.pdf.

Acknowledgements

The authors thank Dr. Tim Ross at Department of Water Resources. This research study would not have been possible without his assistance. We thank also Mr. Jerry Rolwing, General Manager at Borrego Water District for allowing the groundwater well sampling and access to wells, and also working with us tirelessly on sampling day, providing us valuable information for this study regarding groundwater use and information about wells in Borrego Valley area.