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The Human Right to Water: A 20-Year Comparative Analysis of Arsenic in Rural and Carceral Drinking Water Systems in California

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Introduction

Access to safe drinking water is considered a universal human right.[1] In the United States, exposure to arsenic contamination in drinking water disproportionately impacts small, groundwater-reliant communities and communities of color.[2,3] These inequities are driven by a combination of natural, built, and sociopolitical factors.[4] The United Nations calls upon states to especially safeguard the right to safe water for groups that may face difficulties exercising this right, such as incarcerated people.[1] Limited research exists on water quality in prisons; however, prisons in the Southwestern United States have elevated arsenic concentrations compared with other community water systems (CWSs) in the region.[5]

Inorganic arsenic is an odorless, colorless carcinogen, common in California's San Joaquin Valley groundwater.[3,6] In 2001, the U.S. Environmental Protection Agency lowered the maximum contaminant level (MCL) for arsenic from 50 μg/L to a running annual average of <10 μg/L.[7] This stronger standard went into effect in 2006. In 2012, California passed its Human Right to Water bill (Assembly Bill 685) mandating safe, affordable, and accessible water for all.

In this article we present a comparative analysis of 20 y of data (2001–2021) on arsenic concentrations in the CWSs serving Kern Valley State Prison (KVSP) and three neighboring rural communities: Allensworth, Delano, and McFarland. Our objective was to better understand trends in water quality, compliance, and treatment following adoption of the revised arsenic MCL and to elucidate differences, if any, between neighboring incarcerated and nonincarcerated populations.

Methods

We selected KVSP because of its well-documented history of arsenic contamination.[5] The Allensworth Community Services District, City of Delano, and City of McFarland CWSs are located in close proximity to KVSP, rely exclusively on groundwater sources, and serve >500 people each. All three communities have median household incomes of <60% of California's statewide average (Table 1).

We analyzed publicly available drinking water quality monitoring and violation data for 2001–2021, downloaded from California's Drinking Water Watch, which is partly sourced from the U.S. Environmental Protection Agency's Safe Drinking Water Information System.[9] For our case analysis, we compared MCL and monitoring violation occurrence and frequency by CWS, and we calculated and compared running average arsenic concentrations for each water source in each CWS (Figure 1A–D). We further analyzed disaggregated sampling points and the 2001–2021 averages for served water (i.e., water served to CWS customers) (Figure 1E–H; Table 1). To assess arsenic remediation effectiveness, we disaggregated publicly reported monitoring data to calculate the number and percentage of posttreatment and post-blending samples exceeding 10 μg/L (Table 1). We communicated with regional water engineers to confirm our understanding of publicly available water source labeling and arsenic remediation information. Data and R scripts used for our analyses are available in our supporting information files (https://osf.io/7wqvn).

Results

Over the time period analyzed, all four systems served water in exceedance of the revised arsenic MCL in multiple years, and all received violations for exceedances (Figure 1). Mean arsenic levels in served water sources from 2001 to 2021 ranged from 3.4 μg/L [standard deviation (SD) = 6.7 μg/L] in Delano, to 9.3 μg/L (SD = 2.9 μg/L) in Allensworth ($n = 2{,}426$ samples from served water sources across four systems) (Table 1). All four systems also received MCL violations for other contaminants (e.g., nitrate, total coliforms, 1,2,3-trichloropropane) over this 20-y period. Disaggregated sampling results for served water sources (Figure 1E–H) reveal that, following arsenic remediation efforts, multiple samples remained >10 μg/L in every system except Delano (Table 1). Uniquely among the three CWSs with arsenic treatment in place, KVSP had several posttreatment water samples with arsenic levels >20 μg/L (Figure 1G). From 2019 to 2021, Allensworth and McFarland also exhibited short periods during which arsenic remediation efforts were not optimized (Figure 1E,H).

Discussion

Although all four CWSs were in compliance with the arsenic MCL as of the third quarter of 2021, sample levels and daily concentrations fluctuate and can periodically exceed legal limits with no violations recorded (Figure 1). Because compliance with the arsenic MCL is determined using a running annual average by water system sampling point, in communities with arsenic levels

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Table 1. Key socioeconomic and drinking water-related characteristics for the four study sites.

	Allensworth	City of Delano	City of McFarland	Kern Valley State Prison
Demographic and economic indicators				
Population: ACS estimate[a]	575 (±162)[b]	52,886 (±31)[b]	14,823 (±34)[b]	Data unavailable
Population: SDWIS estimate[c]	521	52,658	15,105	5,300
Median household income[a,d]	$33,214 (±$14,921)[b]	$43,641 (±$4,601)[b]	$35,346 (±$3,476)[b]	Data unavailable
Poverty rate (CA mean = 13.11%) (%)[a,e]	47.63	19.32	30.21	Data unavailable
Governance and water supply				
Type of local governance	Community services district	City council	City council	NA
Active public groundwater supply wells (as of 2021, Q3) (n)[c]	2	14	3	2
SDWA violation data: 2001–2021[f]				
Arsenic MCL violations (n)[c,g]	11	27	12	19
Arsenic monitoring or treatment technique violations (n)[c]	3	0	8	0
Most recent MCL violation: arsenic (as of 2021, Q3)[c]	Q2 of 2020	Q4 of 2012	Q1 of 2013	Q4 of 2012
Most recent MCL violation: any (as of 2021, Q3)	2020 arsenic violation	2019 1,2,3-trichloropropane violation[h]	2019 1,2,3-trichloropropane violation[h]	2019 total coliform rule violation
Sampling results from served water sources: 2001–2021[i]	$n = 150$	$n = 1,714$	$n = 136$	$n = 426$
Mean arsenic level ± SD (µg/L)	9.27 ± 2.88	3.41 ± 6.71	8.43 ± 6.68	7.51 ± 8.19
Median arsenic level (IQR) (µg/L)	8.95 (5.00)	0 (4.27)	7.95 (4.43)	5.00 (5.00)
Min. and max. arsenic level (µg/L)	3.7, 23	0, 56	2, 76	0, 50.4
Samples exceeding 10 µg/L arsenic[c]	34% ($n = 51$, max: 23 µg/L)	8% ($n = 141$, max: 56 µg/L)	20% ($n = 27$, max: 76 µg/L)	19% ($n = 81$, max: 50 µg/L)
Posttreatment or post-blending samples exceeding 10 µg/L arsenic[c,j]	18% ($n = 13$, max: 23 µg/L)	0% ($n = 0$ of 1,250)	13% ($n = 9$, max: 18 µg/L)	12% ($n = 47$, max: 50 µg/L)
Arsenic treatment status and funding				
Approximate state funding for arsenic remediation[k]	$496,000 interim solutions; $390,000 planning grant	$20.5 million loan and $818,000 construction grant	$232,000 planning grant, $3.7 million construction grant	$6.2 million planning and construction funding
Arsenic treatment status (as of 2021, Q3)[c]	No, but the water from two wells was blended	Yes, wellhead treatment on four wells	Yes, wellhead treatment on one well	Yes, treatment on blended water

Note: Socioeconomic data and results from our drinking water analyses are presented for four neighboring community water systems in California's southern San Joaquin Valley. Analyses are based on $n = 3,984$ water quality monitoring samples taken across these four systems from 2001 to 2021, of which $n = 2,426$ samples were from served water sources. Samples below the detection limit were included as reported in California's Drinking Water Watch.[9] ACS, American Community Survey; CA, California; IQR, interquartile range; max, maximum; MCL, maximum contaminant level; min, minimum; NA, not applicable; Q, quarter; SD, standard deviation; SDWA, Safe Drinking Water Act; SDWIS, Safe Drinking Water Information System.

[a]Information from 5-y ACS 2019 estimates (most recent year available) for these census-designated geographies.

[b]Margin of error bounds reflect a 90% confidence interval around the estimate.

[c]Information calculated based on data from California's Drinking Water Watch,[9] which is partly sourced from the U.S. Environmental Protection Agency's SDWIS.

[d]Median household income in the past 12 months, in 2019 inflation-adjusted U.S. dollars.

[e]Percentage of the population whose income in the past 12 months was below the federal poverty level.

[f]SDWA violation data.

[g]The MCL is the highest level of a contaminant allowed in drinking water. MCL violations are assigned by the Division of Drinking Water when a public water system exceeds the MCL.

[h]California's state MCL for 1,2,3-trichloropropane is 0.005 µg/L.

[i]Served water sources refers to water sources served to community water system customers, which excludes raw water samples from treated and blended sources.

[j]Water quality samples taken after arsenic treatment (i.e., in Delano, McFarland, and Kern Valley State Prison), or after blending the water from two wells without treatment (i.e., in Allensworth).

[k]Information from the California Department of Corrections and Rehabilitation (2013)[8] and California State Water Resources Control Board (CSWRCB) Department of Financial Assistance (DFA).[9] DFA confirmed funding for Allensworth, Delano, and McFarland from 2014 to 2021 (B. Chase, Supervising Water Resource Control Engineer, CSWRCB, personal communication). "Interim solutions" refers to grant funding for bottled water deliveries and school water filling stations.

near the MCL, the number of MCL violations (Table 1) likely underestimates the risks of chronic exposures to arsenic, and underreports potential violations of the human right to safe water. Disaggregated sampling results (Figure 1E–H) more accurately reflect the health risks from arsenic levels than do the running annual averages used to assess legal compliance. Metrics such as the 95th percentile of sample results, or the number of samples exceeding half of the MCL, are useful additional tools for tracking such exposure risks.[3,10]

In low-income rural settings, persistent and known water-related injustices can reach across carceral boundaries. Unlike the other CWSs in our study, KVSP was built following notification of the new arsenic MCL in 2001. After 2006, KVSP was out of compliance for 7 y. Despite a ∼$6-million state investment for arsenic remediation (Table 1),[8] violations of the human right to water persisted at KVSP with respect to day-to-day water safety and access to alternatives (Figure 1C,G). Bottled water is sold at KVSP, but because incarcerated people can be paid at most $56/month per California regulations (15 California Code of Regulations, Section 3041.2) it is not a viable safe water alternative. By comparison, Allensworth residents still lack a long-term solution for their arsenic exposure, although the state subsidizes bottled water access. Because federal laws situate the responsibility for CWS financing primarily at a local level, small CWSs serving low-income communities often lack the funding needed to adequately mitigate exposures to water contaminants such as arsenic.[4] Repeated individual sampling results for arsenic >10 µg/L in Allensworth, KVSP, and McFarland (Figure 1E,G,H) reveal the limitations of current arsenic remediation efforts.

Our analysis is bounded by reported CWS data and limited by a lack of water quality testing data at the point of use; thus,

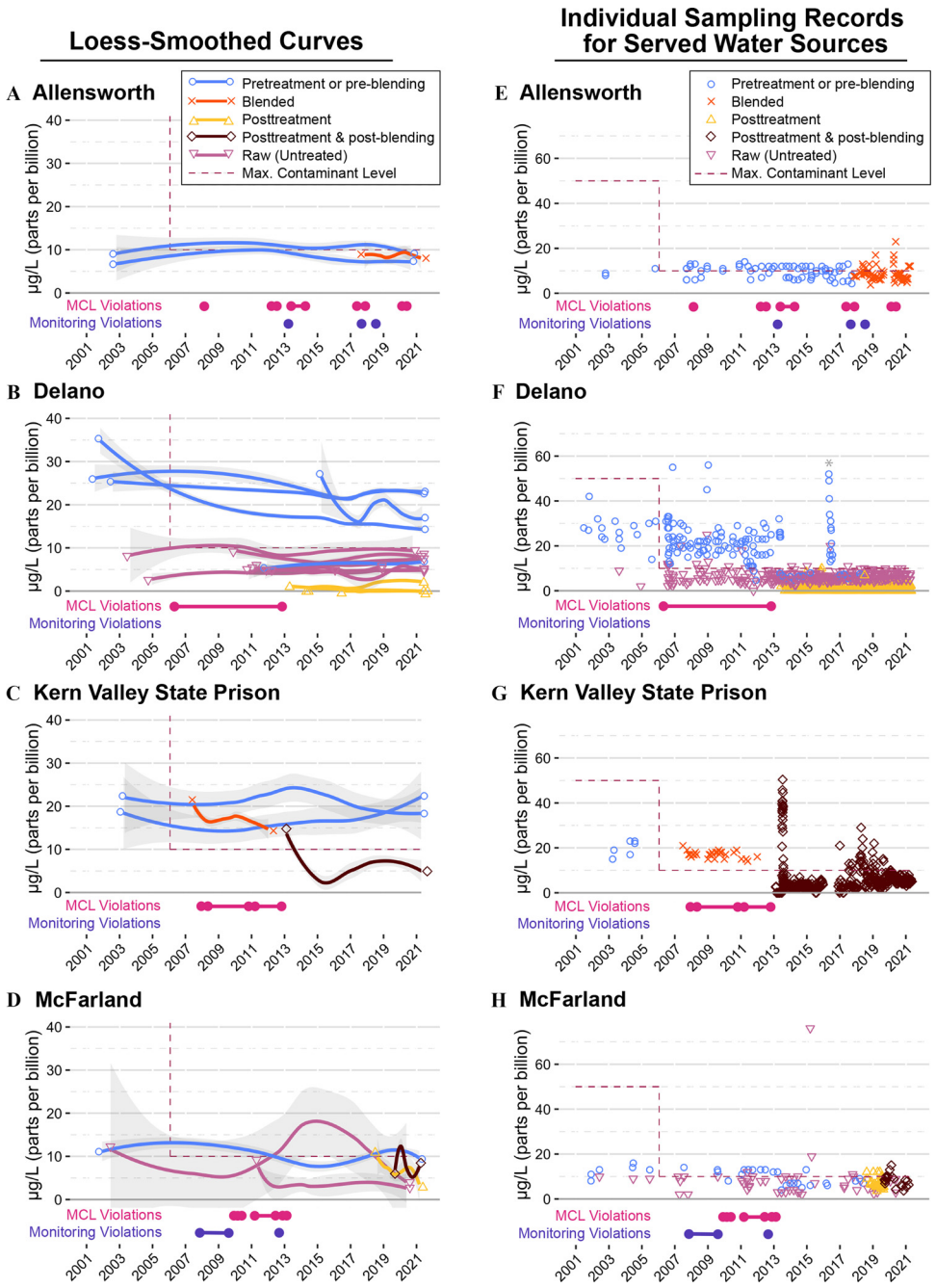

Figure 1. Public water supply arsenic data for the four study sites (Allensworth, Delano, McFarland, Kern Valley State Prison), January 2001–May 2021. All panels depict reported arsenic concentrations. (A–D) depict loess-smoothed water quality data for each water sampling point within each CWS, with shading for 95% confidence intervals around the moving averages. Pre- and post-arsenic-remediation (i.e., blending or treatment) water quality data are included for comparison and assessment of average arsenic remediation effectiveness. Both MCL violation data and monitoring and reporting violation data for arsenic are shown below each panel for year(s) with violations. For comparison with (A–D), (E–H) depict arsenic concentration sampling data for served water sources only (i.e., water sources served to CWS customers, excluding raw water samples from treated sources). Although running annual averages are used to assess MCL compliance, scatter plot figures reveal served samples that exceeded the MCL, enabling pre- and post-arsenic-treatment comparison. The asterisk in (F) indicates that pretreatment water quality monitoring samples taken around that date were likely sampled during the treatment plant commissioning process and, if so, would not have been served to customers (personal communication from a Water Resource Control Engineer at the California State Water Resources Control Board); however, we include these monitoring results here because engineers at the CSWRCB could not definitively confirm that these samples were not served to customers. In all panels, samples below the detection limit were included as reported in California's Drinking Water Watch[9] and dashed lines indicate the 2006 legal limit (i.e., MCL) change to 10 µg/L. Note: CSWRCB, California State Water Resources Control Board; CWS, community water system; loess, locally estimated scatterplot smoothing; max, maximum; MCL, maximum contaminant level.

we cannot properly estimate individual exposures. Generalization of our findings to other carceral and rural communities may be limited by the particulars of KVSP and the other study communities.

Conclusions

Overall, our findings illustrate that *a*) structural challenges to the realization of the human right to safe water occur pre- and post-arsenic treatment and unfold in distinct ways for incarcerated

and nonincarcerated rural communities, *b*) human right to water violations can persist even following state investments for remediation, and *c*) annually averaged water quality data used to track and publicly report violations of the Safe Drinking Water Act provide only a partial guide to whether the human right to water is being realized. Publicly available, disaggregated monitoring data enables a more nuanced comparison of water quality and of progress toward the human right to water.

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URLs for all data sources as well as the R scripts used for data processing and analysis are included in the supporting information files (https://osf.io/7wqvn).

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