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Disparities in Water Quality in Indian Country

*Otakuye Conroy-Ben and Rain Richard

Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ
**Corresponding Author*

Abstract: Tribal Nations in the United States are afflicted by a number of disparities including health, socioeconomics, education, and contaminant exposure to name a few. To understand drinking water quality disparities, we analyzed Safe Drinking Water Act violations in Indian Country found in the Environmental Protection Agency's (EPA's) Enforcement and Compliance History Online (ECHO) and compared them to violations in non-tribal areas of the same state for the time period 2014 – 2017. The violations assessed were total point accumulations per year per 1,000 customers, health-based maximum contaminant limit (MCL), reporting and monitoring, and public notice for each state reporting tribal data. Violation point disparities were evident, as tribal facilities acquired nearly six times the points of the national average. In some states, health-based tribal water quality was better than in non-tribal communities, however Arizona, Iowa, Idaho, Montana, Utah, and Wyoming had MCL violations affecting a greater percentage of tribal populations than non-tribal. Nation-wide, monitoring and reporting violations affected tribal communities at nearly twice the rate of non-tribal customers. Public notice reporting was high and comparable for both tribal and non-tribal facilities. Finally, a comparison of small drinking water facilities, under which ~97% of the surveyed tribal drinking water falls, confirmed state-wide disparities. Solutions for the apparent disparities in Indian Country and on non-tribal lands may be as simple as rectifying monitoring and reporting violations, though this correction will not shift the overall water quality difference. Addressing MCL and treatment violations is the next step to reduce the disparity.

Keywords: *drinking water quality, tribal water quality, EPA ECHO, disparity*

There are 567 federally recognized American Indian and Alaska Native Tribal nations throughout the United States (Department of the Interior 2016). Based on the U.S. Constitution, each tribal nation has a sovereign status, resulting in a unique government-to-government relationship. Several federal agencies work directly with tribal nations (e.g., Bureau of Indian Affairs, Bureau of Indian Education, Indian Health Service, Office of Tribal Justice), while other agencies house tribal divisions within their agency (Department of Interior, Environmental Protection Agency (EPA), Department of Energy). Federal laws apply to sovereign nations, and such is the case regarding environmental regulations through the U.S. EPA. Tribes may, however, adapt stricter or additional regulations to protect their people, land, air, and water.

Established under the 1986 Safe Drinking Water Act (SDWA) Amendments, tribes may develop their own water quality standards (Public Law 99-339 1986). This "primacy" allows tribes to establish and enforce their own standards through an application process, but they must meet the minimum EPA health-based criteria of established standards under the SDWA and follow treatment standards for groundwater and surface water (Diver 2018). The EPA's regional offices are responsible for monitoring, enforcement, and compliance for those tribes that do not have primacy. As of November 2017, the only tribe to receive primacy is the Navajo Nation (EPA 2017c). In Alaska, water facilities that serve Native villages fall under state primacy.

The SDWA applies to public water systems (Calabrese 1989). The EPA's definition of a

public system is one that provides water to at least 25 people or has 15 service connections for a minimum of 60 days per year. The SDWA regulates health-based contaminants that are known or are likely to occur in drinking water, including organic pollutants, inorganics, pathogen indicators, radionuclides, and disinfectants and disinfection by-products. Maximum Contaminant Level Goals (MCLGs) are goals the EPA would like to attain, but they are not enforceable. There are also federally enforceable limits set for these contaminants known as maximum contaminant levels (MCLs). These levels are set near or at the MCLG based on technological and cost feasibility (EPA 2017b).

The original SDWA monitored the 28 chemicals listed in the Public Health Drinking Water Standards and introduced other organic and inorganic chemicals that required monitoring (EPA 1999). Total coliform bacterial levels also required monitoring. As time passed more standards were set, such as monitoring for trihalomethanes and radionuclides. The Act has had two major amendments, one in 1986 and the other in 1996. Currently, the SDWA includes chemical monitoring, pathogen monitoring, and surface water treatment requirements through risk-based assessments. Furthermore, the SDWA believes in the "right to know" as a way to promote public involvement and awareness, thereby improving accountability for the local governments and water treatment plants.

The Interim Enhanced Surface Water Treatment Rule (IESWTR) went into effect December 1998 (EPA 1998). The rule applies to public water systems serving 10,000 or more customers that use surface waters or groundwater under direct influence of surface water as source water for drinking. The rule addresses standards and treatment techniques for *Cryptosporidium*. The MCLG for *Cryptosporidium* has been set to zero by the rule. Public systems that use filtration as part of their treatment train must meet 2-log removal requirements for *Cryptosporidium*. For public systems that do not use filtration, they must set forth a watershed protection program to address *Cryptosporidium*. Other key elements of this rule define requirements for covers on newly completed water reservoirs, mandate state-led sanitary inspections, and require data collection of microbial inactivation levels to determine risk of disinfection byproducts.

The Surface Water Treatment Rule (SWTR) went into effect June 1989 (EPA 1989). The rule requires that surface water and groundwater under direct influence of surface water be filtered and disinfected. The SWTR set MCLs for viruses, bacteria, and *Giardia lamblia* and established treatment techniques for filtered and unfiltered water systems to decrease exposure of microbial pathogens.

Additional regulations that were implemented under the SDWA deal with the water source, and include the groundwater rule and variations of the surface water treatment rule. The Groundwater Rule went into effect November 2006 (EPA 2006), and imparts protection from microbial pathogens in source groundwater used by public systems. The rule is a risk-based approach with four main parts: 1) routine sanitary inspections of specific criteria and identification of major deficiencies; 2) source water monitoring when triggers are violated for total coliform or other state implemented criteria; 3) corrective action for systems with source fecal contamination or other significant shortcomings; 4) compliance monitoring of the water treatment system to confirm 4-log removal or inactivation (99.99%) of viruses has been achieved.

The Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR; EPA 2002) specifies treatment of microbial polluted water, focusing on small facilities (customers < 10,000). The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) went into effect January 2006 (EPA 2007). The rule focuses on microbial protection measures required by higher risk public water systems using surface water as source, mainly addressing *Cryptosporidium*. If systems cannot provide the maximum level of treatment for *Cryptosporidium*, then monitoring of source water is needed to establish proper treatment requirements. The treatment requirements for *Cryptosporidium* depend on whether or not the public system uses filtration in their treatment train. Furthermore, the rule creates treatment techniques for uncovered water reservoirs and endorses the Stage 2 Disinfection Byproduct Rule, which enforces monitoring of haloacetic acids (HAAs) and trihalomethanes (THMs), when a public system

wants to make corrections to their disinfection practice.

The EPA provides public notices regarding actions such as regulation and permitting. The public notice process serves as communication between the public and the EPA. The EPA allows participation from the public during the public notice period in the form of comments or public meetings. At other times the EPA uses the process to inform the public of a final report.

Environmental rules also apply to tribal lands, which may be under the jurisdiction of a tribe or a regional EPA office. Utilities, whether operated privately, by tribes, or by the federal government, are responsible for quarterly testing, reporting, addressing violations, and notifying the public of violations. In this report, we compared SDWA violations in "Indian Country" (tribal lands) and non-tribal lands to gain a better understanding of recent water quality disparities. Important parameters assessed were: violation points accrued; drinking water source; population served; and violations involving public notice, monitoring and reporting, and health (MCL and treatment technology (TT)). Tribal and non-tribal data were aggregated by state to protect identity and to pool numbers from systems serving small tribes.

Methodology

Water quality reports were downloaded from the EPA's ECHO in October 2017, representing data from July 1, 2014 through June 30, 2017 (EPA 2017a). Search criteria entered included drinking water source type, location (Indian Country or not in Indian Country; by state), health-based violations, public notice violations (MCL violations), and monitoring/reporting violations. Individual compliance reports were accessed to differentiate between violations that were health-based versus those not reported or monitored. Non-Indian Country data for the same states were accessed using the same search criteria. In total, 30 states were part of this analysis; the remaining 20 states did not have tribal drinking water facilities within their boundaries.

To protect individual tribal and facility identities, data are presented by state and as total population affected, rather than by number of facilities out of compliance. This is because tribal and non-tribal facilities represent customer numbers spanning orders of magnitude ($n = 25 – 8 \times 10^6$ customers). In addition, the data are not differentiated by tribe, but rather by state.

Results and Discussion

Drinking Water Sources in Indian Country

There are 1001 drinking water utilities in "Indian Country" (all within 30 states) that report water quality data to the EPA. The source water report of each facility includes surface water, groundwater, and groundwater under the influence of surface water (included in groundwater data), some of which is purchased (not shown). Other than Alaska and North Dakota, a majority of tribal water facilities use groundwater as their drinking water source (Figure 1). However, when service population is included, tribal communities in Colorado, Kansas, Montana, North Carolina, New York, Oregon, Texas, and Wyoming shift to predominantly surface water sources (Figure 2). Non-tribal drinking water facilities obtain a majority of their source water from groundwater in all 30 states (Figure 3). The total customer water intake shifts to surface water, with the exception of Florida, Iowa, Idaho, Minnesota, Mississippi, Montana, Nebraska, New Mexico, South Dakota, and Wisconsin, whose water sources are primarily groundwater (Figure 4).

We then determined if tribal populations receive the same water source type as non-tribal customers within their state. To evaluate this, the surface water to groundwater population ratio was determined (data not shown). States that had greater percentage of the population serviced by surface water sources for both tribal and non-tribal communities included Colorado, Kansas, North Carolina, New York, Oregon, Texas, and Wyoming. However, in Alabama, Arizona, California, Massachusetts, Michigan, North Dakota, Nevada, Oklahoma, Rhode Island, Utah, and Washington, the non-tribal water source was primarily surface water, whereas the tribal water source was groundwater, based on customers served. This is an important distinction because certain contaminants are associated with groundwater and others with surface water sources, as discussed later.

Drinking Water Violation Points Accrued

To determine the overall disparity of drinking water violations in Indian Country, we evaluated the violation points accumulated by tribal and non-tribal facilities by state. The EPA tracks total violations (over five years) through a point system where 1 point is assigned for violations of public notice, violations of monitoring/reporting, and for each year a violation is not addressed; 5 points for each MCL or treatment technology violation that is not coliform or nitrate, monitoring/reporting violations of nitrate, and repeat monitoring violations of coliform; and 10 points for acute MCL violations of coliform or nitrate. This weighted point system puts emphasis on MCL violations and less on reporting/monitoring and public notice violations.

Because this is a three-year study and the point system is assessed for the previous five years, we divided the total points by 5 to obtain annual points accrued. Results show that the six worst offending states in Indian Country are AZ > WA > NM > CA > NV > UT on a per year basis (data

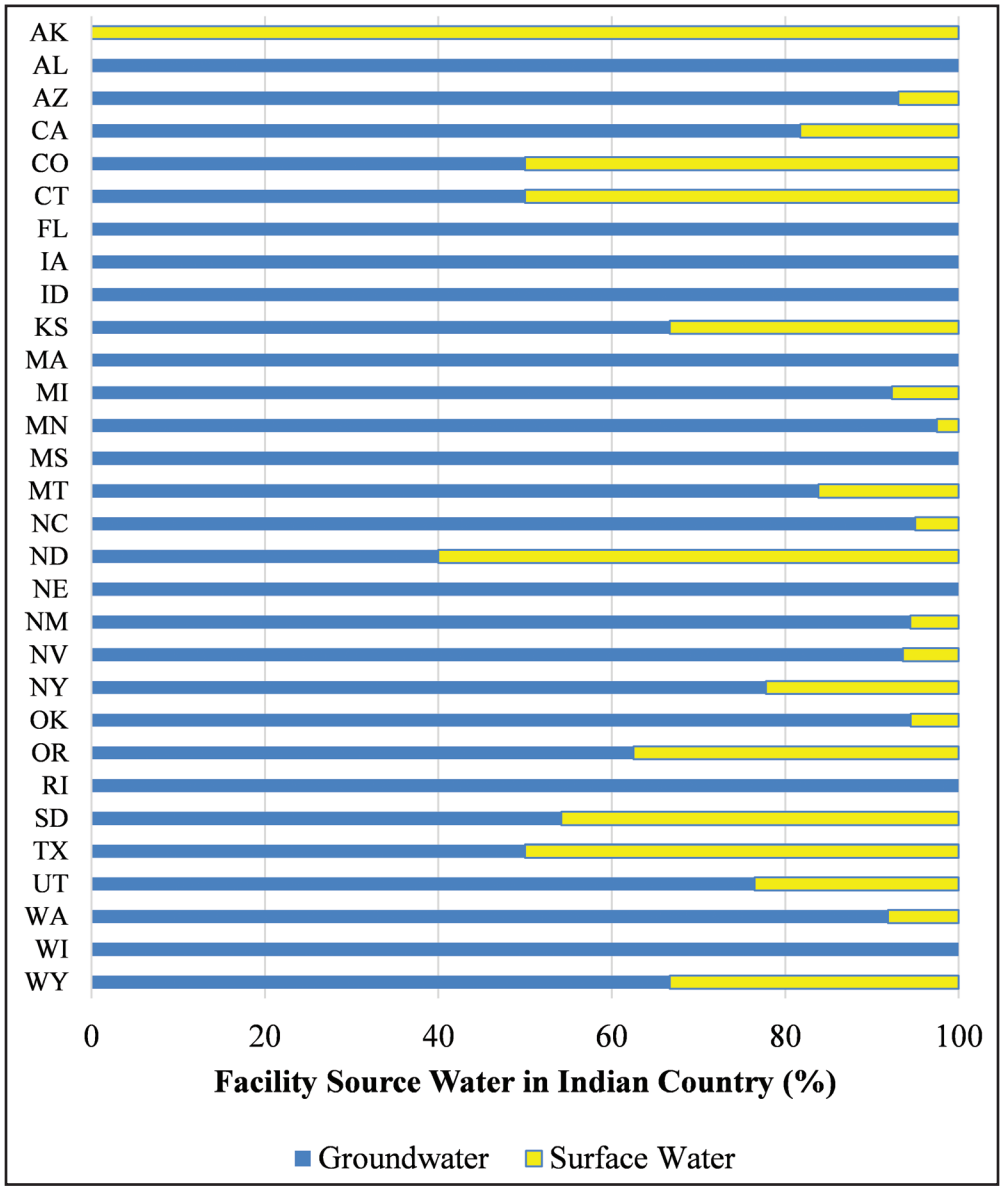

Figure 1. Facility source water percentage in Indian Country, by state.

not shown). The average points over a five-year period for each state do not account for the number of facilities out of compliance, or the number of customers per facility. This may explain why Arizona, Washington, New Mexico, and California have higher accumulated points, as there are more facilities and tribes.

To correct this, we normalized the data on a per 1,000 customer basis by state (Table 1). The data were aggregated (Figure 5), showing a statistical difference between non-tribal and tribal customers with respect to drinking water violation points. The average points accumulated per 1,000 customers per year was 0.86 for non-tribal water, and 5.13 for tribal water. The point disparity is statistically significant ($p < 0.05$), and serves as the basis for this study.

SDWA Compliance

SDWA compliance and violations are reported quarterly by individual water facilities. Those that fail to conduct or report values are out of compliance under monitoring and reporting requirements. If reported values exceed MCLs or

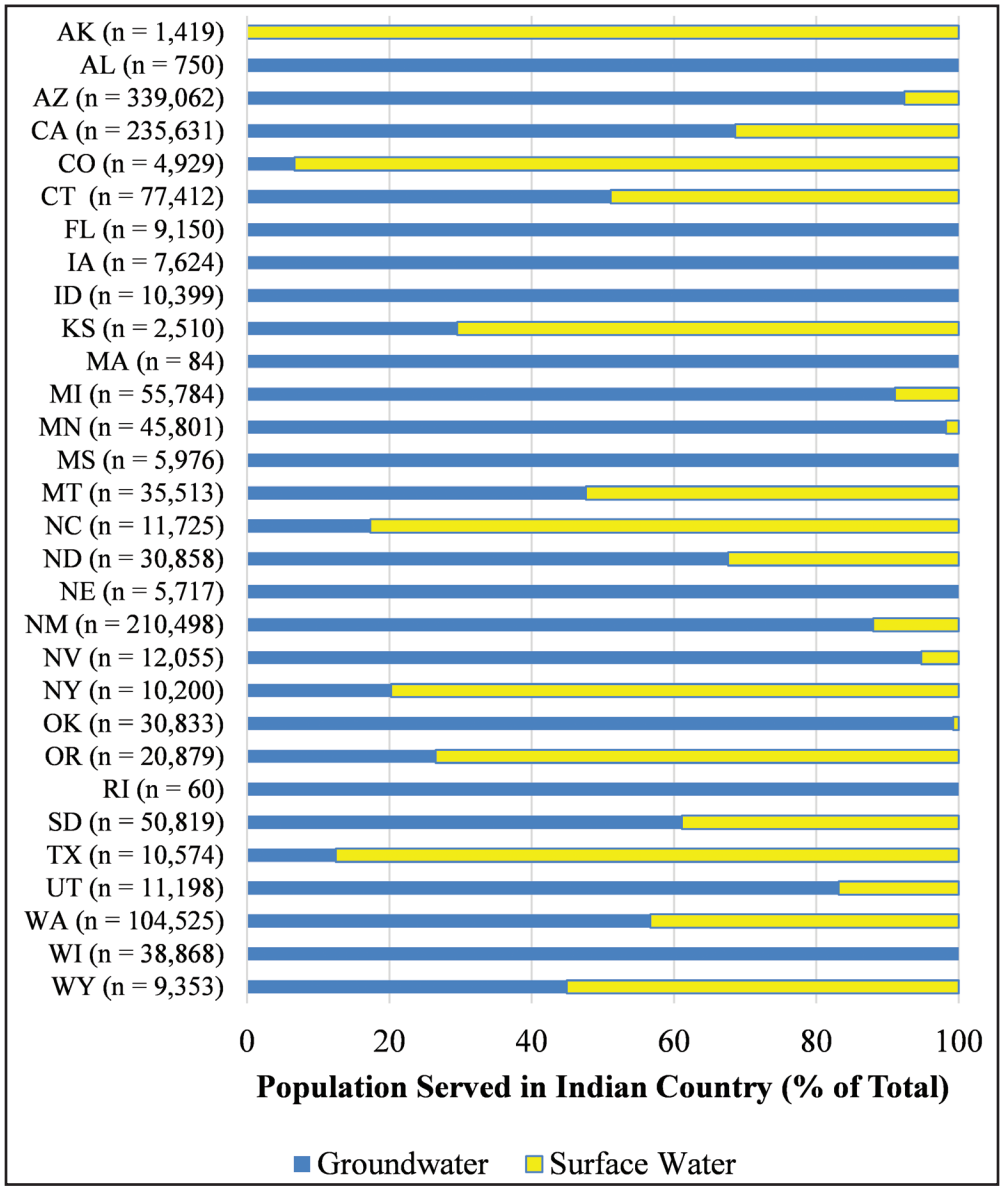

Figure 2. Customer source water in Indian Country, by state.

do not meet TT standards, a health-based violation is noted. For this analysis, we report the state tribal population (as percent) affected by a health-based violation during any quarter of the three-year time period (Figure 6).

Contaminant MCL and TT exceedances varied from state to state in tribal communities. There were no health-based SDWA violations in Alabama, Colorado, Connecticut, Florida, Kansas, Massachusetts, Michigan, Mississippi, North Carolina, North Dakota, Nebraska, Rhode Island, South Dakota, Texas, and Wisconsin during the time period of interest. All other states had MCL violations for at least one quarter of the three-year period. In these states, the most common contaminant-based violations were the coliform and revised coliform rule and arsenic, followed by total HAA and total THM. Less commonly, violations of total radium, nitrate, total carbon, diethyl hexyl phthalate (DEHP), and the lead and copper rule were also reported. Treatment-based violations included the groundwater rule

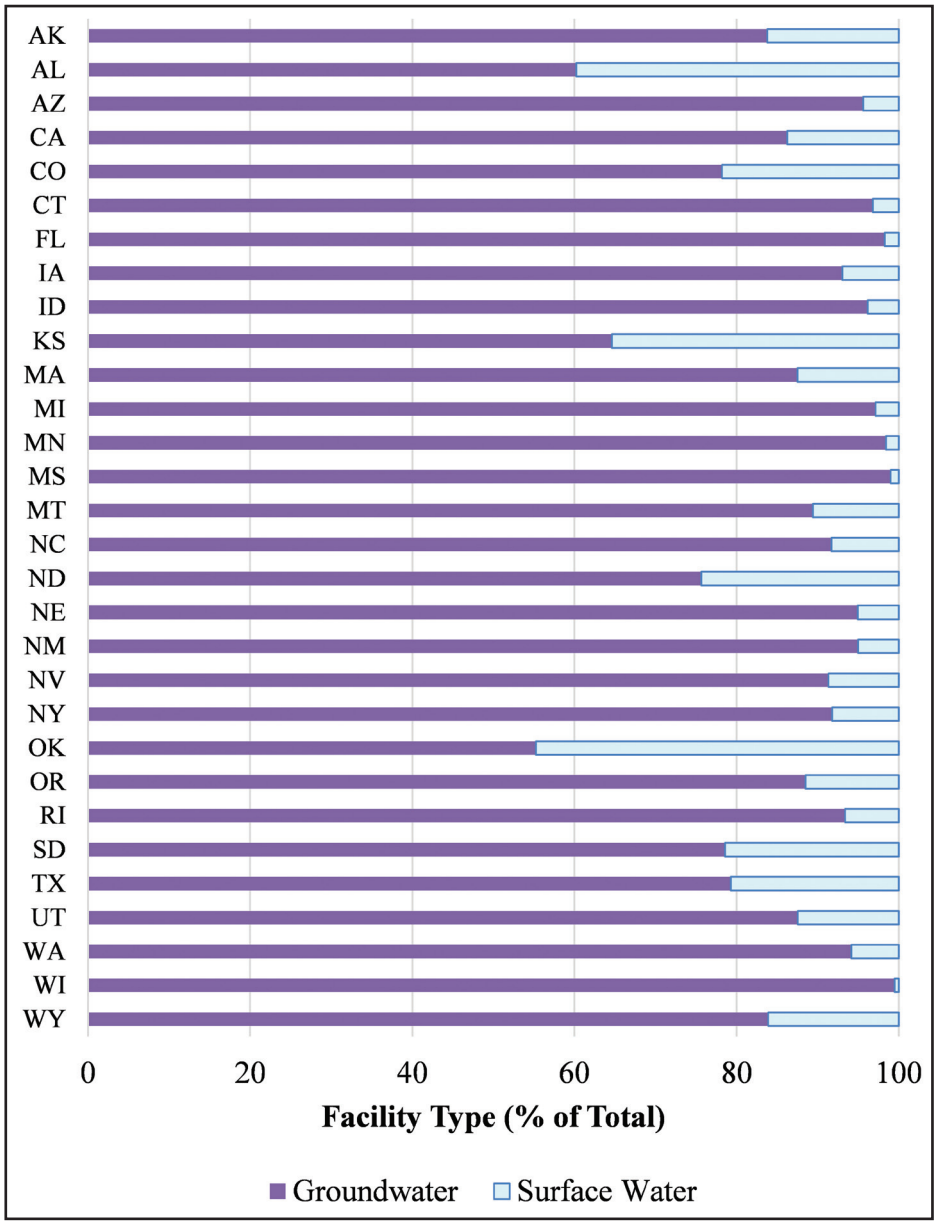

Figure 3. Non-tribal facility source water, by state.

and the SWTR. Analyzing the distribution within individual states, arsenic pollution affected tribal populations in New Mexico, Utah, and Washington to the greatest extent. Violations of the groundwater rule impacted tribes in Iowa, Oklahoma, and Wyoming. Coliform/revised coliform violations were prevalent in tribal communities in Arizona, Iowa, Idaho, Nevada, New York, and Oregon. The water source played a role in contaminant type, with surface water contributing to the elevated incidence of total HAA, total THM, and total carbon (C), indicators of elevated organic carbon in the source water (Figure 7). All other contaminants were primarily found in drinking water arising from groundwater sources, including coliform.

Comparisons between tribal and non-tribal facilities reveal that tribal customers in certain states are disproportionately affected by poor water quality, as measured by health-based MCL or TT violations, while those in other states fare better than non-tribal facilities (Table 2). MCL violations affected tribal customers in Alaska,

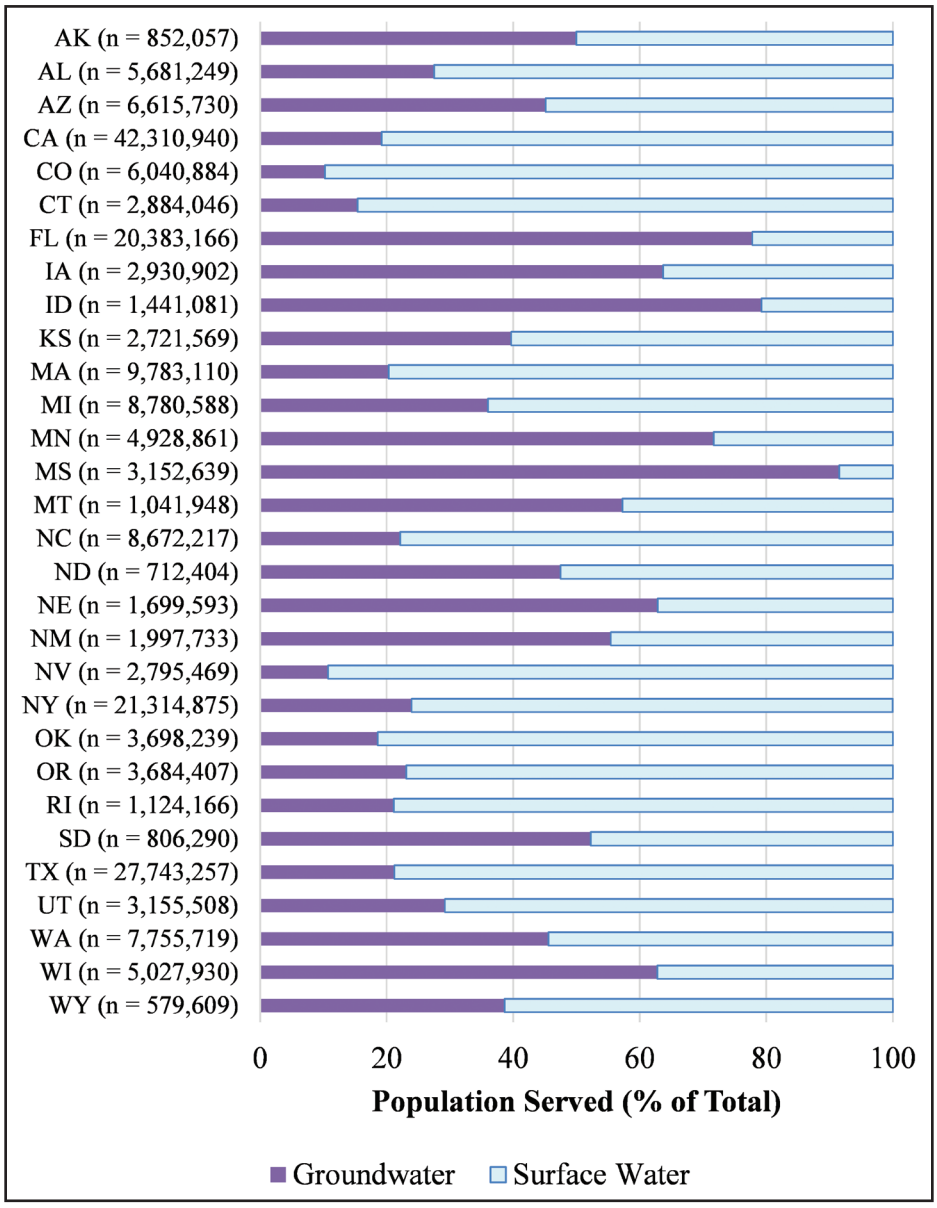

Figure 4. Non-tribal customer water source, by state.

Table 1. Drinking water violation points per year per 1,000 customers for non-tribal and tribal drinking water.

State	Non-Tribal	Tribal	Ratio (Tribal:Non-Tribal)
AK	5.40	2.82	0.5
AL	0.04	0.00	0.0
AZ	0.67	2.09	3.1
CA	0.27	1.08	4.0
CO	0.45	0.97	2.2
CT	0.80	0.00	0.0
FL	0.15	0.44	2.9
IA	0.56	0.94	1.7
ID	1.70	6.35	3.7
KS	0.24	9.56	40.6
MA	0.18	35.71	201.1
MI	0.60	0.37	0.6
MN	0.20	0.60	3.0
MS	0.18	2.11	11.4
MT	2.72	3.29	1.2
NC	0.46	0.00	0.0
ND	0.39	0.67	1.7
NE	0.96	2.27	2.4
NM	1.53	1.82	1.2
NV	0.29	11.53	39.8
NY	0.27	1.10	4.1
OK	1.85	1.12	0.6
OR	1.03	1.91	1.8
RI	0.35	50.00	143.6
SD	0.88	0.78	0.9
TX	0.65	0.11	0.2
UT	0.79	9.23	11.7
WA	0.35	4.73	13.5
WI	0.68	0.80	1.2
WY	1.30	1.35	1.0

Arizona, California, Iowa, Idaho, Minnesota, Montana, Nevada, Utah, and Wyoming at a greater percentage than non-tribal water customers. On the other hand, tribal drinking water quality was better in Alabama, Colorado, Connecticut, Florida, Kansas, Massachusetts, Michigan, Mississippi, North Carolina, North Dakota, Nebraska, Rhode Island, South Dakota, Texas, and Wisconsin, which all had state-wide MCL/TT violations, while none were reported on tribal lands. In addition, New Mexico, New York, Oklahoma, and Oregon had MCL violations that affected a greater population of non-tribal customers than tribal customers. The average percentage of customers in Indian Country affected by health-based violations was 8.6%, while that for non-tribal populations was 7.7% (Table 2, Figure 8).

Public Notice Violations

Public notice violations occur when the drinking water facility fails to notify customers of a SDWA violation (MCL exceedance) or for monitoring and reporting violations. Results showed that 25 of the 30 states had no public notice violations in Indian Country, while Arizona, California, Nevada, New Mexico, and Utah did. The violations in California and Nevada were due to failure to notify Indian Country residents of monitoring and reporting violations, and not due to MCL exceedances. Facilities in Arizona and New Mexico failed to notify tribal customers of violations of arsenic,

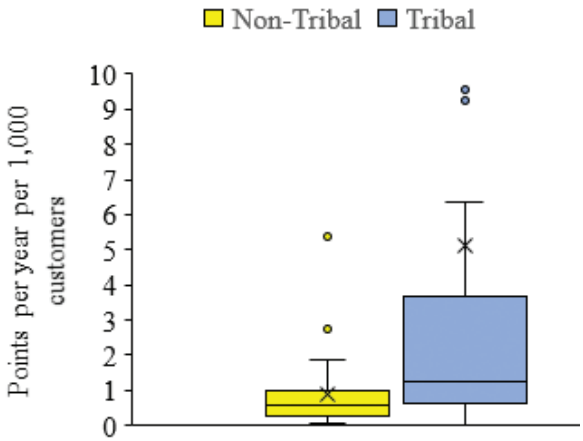

Figure 5. Drinking water violation points of non-tribal and tribal water, state aggregated. The difference is significant at $p < 0.05$.

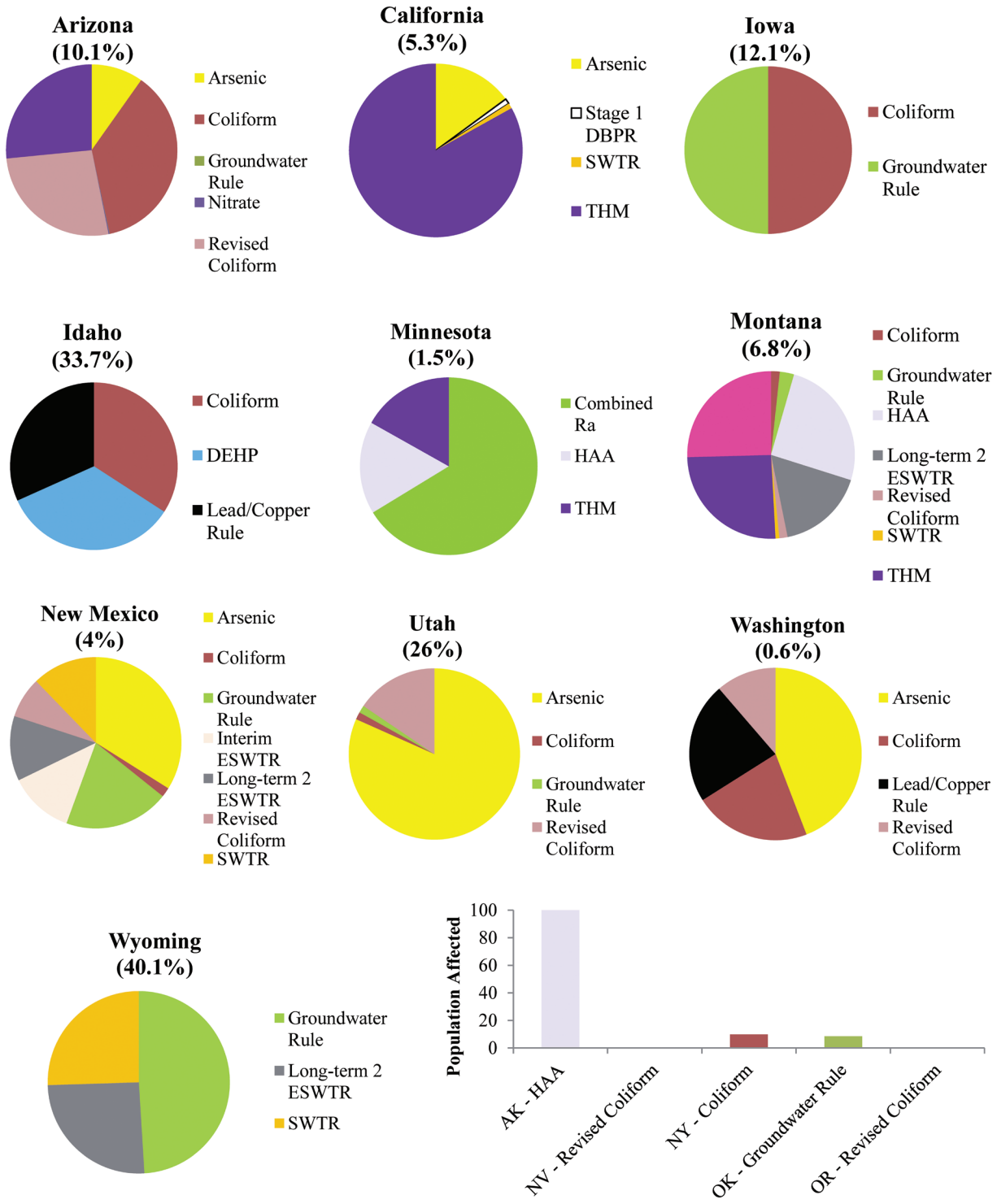

Figure 6. Health-based violations by state, with Indian Country population percentage affected in parentheses. Each pie chart is broken down by contaminant, and the bar graph shows states impacted by only one contaminant or rule violation. ESTWR = enhanced surface water treatment rule; SWTR = surface water treatment rule; HAA = haloacetic acid; THM = trihalomethane; Ra = combined radium; DEHP = diethyl hexyl phthalate; DBPR = disinfection by-product rule; NV = 0.3%; OR = 0.2%.

nitrate, total HAA, total THM, coliform, and revised coliform rules, with Arizona customers affected at a higher frequency than New Mexico customers. Facilities in Utah failed to notify the public of violations of the Stage 2 disinfectant and disinfection by-product rule (DBPR) and arsenic.

Arizona, California, Nevada, and Utah had public notice violations affecting a greater percentage of tribal customers than non-tribal customers. A number of states had public notice violations in non-tribal facilities (CO, CT, FL, IA, ID, KS, MS, NC, NM, OR, TX, WI), but no violations in tribal facilities (Table 2). Nationwide, public notice reporting was high for both Indian Country (97%) and non-Indian Country (97.3%), correlating to few violations.

Monitoring and Reporting Violations. Nearly two-thirds of the states analyzed had higher monitoring and reporting violations in Indian Country than in non-tribal facilities (Table 2, Figure 8). When averaged over the nationwide populations, monitoring and reporting violations affected 16% of non-tribal customers, while 32% of Indian Country drinking water customers were impacted.

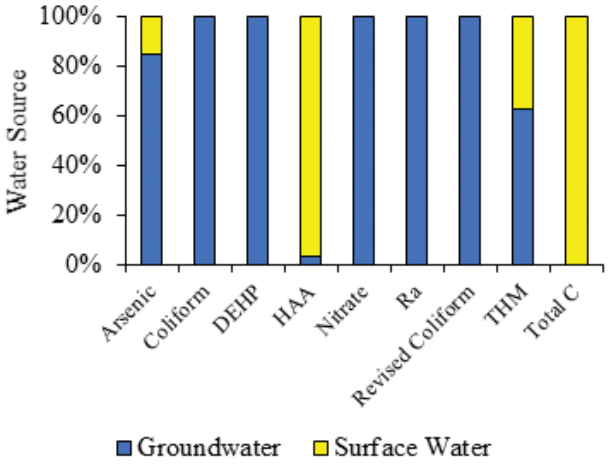

Figure 7. Contaminant by source water in Indian Country. Disinfection by-products (such as HAAs) form when carbon in the water source combines with chlorine or other halogens added during treatment for disinfection. Hence, HAA violations are more commonly associated with utilities relying on surface water sources. DEHP = diethylhexylphthalate; HAA = haloacetic acids; Ra = radium; THM = trihalomethane; C = carbon.

Analysis of Drinking Water Violations by Facility Size

The U.S. EPA defines a small drinking water facility as one serving less than 10,000 customers. Small drinking water facilities tend to have more violations compared to larger facilities (Rahman et al. 2010; Rubin 2013), and thus it was decided to analyze data according to facility size. As a first step, we looked at facility number and customers served in Indian Country. Of the 1,001 tribal drinking water facilities monitored under ECHO, 97.6% qualified as small treatment systems. The data set was then disaggregated by state, size (< or > 10,000 customers), and tribal/non-tribal facilities. The percentages of facilities with health-based, monitoring/reporting, and public notice violations were calculated for each state (Figure 9). For health-based violations, the facility average for tribal water was 10.9%, and 8.9% for non-tribal facilities. While the differences between non-tribal and tribal facilities were not statistically significant overall, individual state disparities exist covering the range (whiskers) and outliers (dots). We did not observe an increase in violations with smaller utilities, though the limited data set for tribal facilities that serve > 10,000 customers may have contributed to the lack of significance.

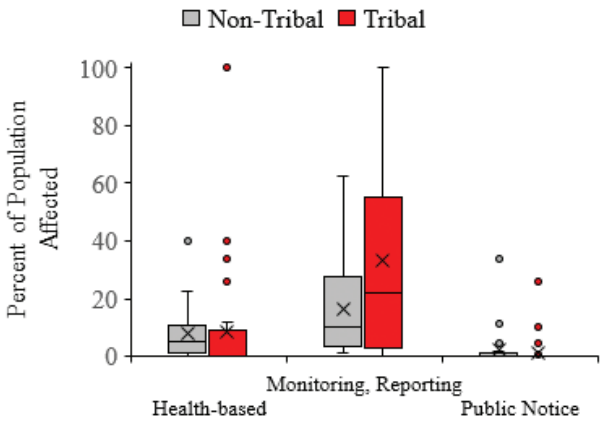

Figure 8. Percent of customers affected by drinking water quality violations. Tribal and non-tribal state data were aggregated in this analysis. The box encompasses upper and lower quartiles, the whiskers show the upper and lower range of data, the dots are outliers, the horizontal line is the median, and "x" is the average of the data set.

Table 2. Percentage of customers affected by drinking water violations by state.

	Health-based MCL/TT		Monitoring & Reporting		Public Notice	
State	Non-Tribal	Tribal	Non-Tribal	Tribal	Non-Tribal	Tribal
AK	9.7	100.0	24.8	0.0	0.1	0.0
AL	0.2	0.0	4.1	0.0	0.0	0.0
AZ	8.3	10.1	27.4	28.2	0.0	10.3
CA	3.4	5.3	9.0	14.5	0.2	1.1
CO	4.5	0.0	28.0	0.0	0.3	0.0
CT	0.4	0.0	41.9	51.1	1.1	0.0
FL	4.5	0.0	29.1	0.0	1.0	0.0
IA	9.7	12.1	1.4	12.1	0.2	0.0
ID	12.0	33.7	62.3	22.2	4.6	0.0
KS	3.5	0.0	7.9	70.5	1.2	0.0
MA	10.4	0.0	17.7	100.0	0.1	0.0
MI	1.1	0.0	3.7	6.9	0.0	0.0
MN	0.7	1.5	0.9	30.2	0.0	0.0
MS	3.9	0.0	3.2	100.0	1.3	0.0
MT	4.9	6.8	20.4	6.4	0.0	0.0
NC	5.2	0.0	10.2	0.0	1.9	0.0
ND	0.0	0.0	4.4	25.6	0.0	0.0
NE	22.5	0.0	2.9	2.8	0.3	0.0
NM	13.3	4.0	33.6	26.8	6.1	0.8
NV	0.1	0.3	2.4	48.9	0.0	4.3
NY	40.0	9.8	4.7	0.0	0.0	0.0
OK	18.8	8.4	41.0	2.5	0.0	0.0
OR	1.1	0.2	10.1	22.1	0.7	0.0
RI	0.1	0.0	3.0	100.0	0.0	0.0
SD	6.5	0.0	1.8	28.1	0.1	0.0
TX	5.8	0.0	20.1	87.5	11.4	0.0
UT	14.5	26.0	40.8	95.2	0.0	26.0
WA	17.1	0.6	13.4	66.9	0.0	0.0
WI	2.6	0.0	10.5	20.4	34.0	0.0
WY	6.8	40.1	5.8	20.8	0.0	0.0

Drinking Water Disparities

When analyzing drinking water disparities in under-served communities, many factors play a role, including source water, treatment facility type, and responsiveness to rule violations. In this data set, we have access to the source water type and violations of the SDWA, but not the facility, precise water source, and depth to water table for groundwater sources. We can compare tribal and non-tribal water demographics within the state, and so this poses the question, does tribal water quality reflect what is happening in the state, or is there a water quality difference that requires attention?

To assign a value to water quality disparities, we established a point-based per capita ratio that compares tribal and non-tribal violations. Tribal points per capita per year were divided by non-tribal values to obtain the ratio (R):

$$R_{disparity} = \frac{((Violation\ points,\ 5yr)\ /\ (5*state\ population))_{\text{Indian-Country}}}{((Violation\ points,\ 5yr)\ /\ (5*state\ population))_{\text{Non-Tribal}}}$$

A ratio greater than one indicates more EPA SDWA violations for Indian Country than for non-tribal lands, and a ratio greater than 1.5 ($R_{1.5}$) is equivalent to 50% more water quality violation points per capita in Indian Country. Using the $R_{1.5}$ cut-off, which was arbitrarily selected, we determined that there were evident water quality disparities in Indian Country for 60% of the states surveyed (Table 1). They include Arizona, California, Colorado, Florida, Iowa, Idaho, Kansas, Massachusetts, Minnesota, Mississippi, North Dakota, Nebraska, Nevada, New York, Oregon, Rhode Island, Utah, and Washington. Water quality data, based on points accrued, were better for tribal customers in Alaska, Alabama, Connecticut, Michigan, North Carolina, Oklahoma, South Dakota, and Texas. In Montana, New Mexico, South Dakota, Washington, and Wisconsin, violation points were similar in Indian and non-Indian Country.

Conclusions

These findings show there are water quality disparities in Indian Country as measured by points accrued due to drinking water violations. On an average point violation basis, which includes MCL, TT, public notice, and monitoring/reporting,

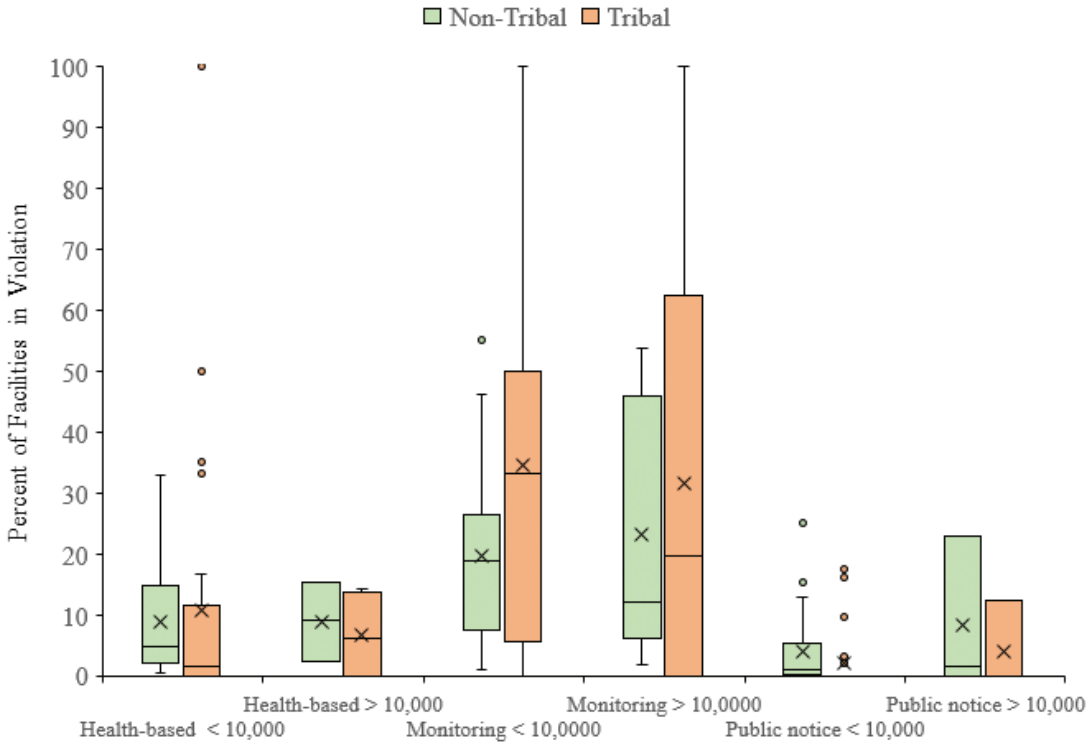

Figure 9. Percent of facilities with drinking water violations, by facility customer size.

a number of states had tribal facilities with poorer water quality compared to non-tribal facilities within the same state. An evaluation of specific rules showed little violation of public notice for both groups analyzed. There were greater differences when it came to violations of monitoring and reporting, with 32% of Indian Country facilities affected, whereas 16% of non-tribal facilities had similar violations. MCL violations affected some states more than others, though ultimately, the total point violation system projected the greatest apparent disparities. For facilities to reduce water quality disparity, monitoring and reporting must be addressed in addition to upgrades in treatment technology affecting the quality of produced drinking water. At a minimum, this will reduce violation points, bringing facilities to compliance.

Author Bio and Contact Information

Otakuye Conroy-Ben (Oglala Lakota) (corresponding author), is an environmental engineer and faculty member at Arizona State University. Originally from the Pine Ridge Indian Reservation, she received a B.S. in Chemistry from the University of Notre Dame, and a Ph.D. in Environmental Engineering from the University of Arizona. Her research interests include water quality, wastewater pollution, endocrine disruption, and antibiotic resistance. She may be contacted at: otakuye.conroy@asu.edu or School of Sustainable Engineering and the Built Environment, Arizona State University, 660 S College Ave., Room 507, Tempe, AZ 85281.

Rain Richard is a Ph.D. student at Arizona State University in environmental engineering. She has a B.S. in Molecular and Cellular Biology from the University of Arizona, a B.S.E. in Chemical Engineering and a M.S. in Environmental Resource Management from Arizona State University. She worked in industry for several years prior to making her transition to research. Her current research focus is the impact of chlorinated solvents on the PPAR endocrine disrupting pathway. She may be contacted at rain.richard@asu.edu.

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