JPS
Journal of Policy Studies

Bae, J., & Kang, S. (2022). Another Injustice? Socio-Spatial Disparity of Drinking Water Information Dissemination Rule Violation in the United States. *Journal of Policy Studies*, *4*(37), 77–89. https://doi.org/10.52372/jps37405

Articles

Another Injustice? Socio-Spatial Disparity of Drinking Water Information Dissemination Rule Violation in the United States

Junghwan Bae [a], Soyoung Kang [b]

Keywords: Consumer Confidence Reports, Drinking Water Injustice, Environmental Justice, Spatial Clusters, Environmental Vulnerability

https://doi.org/10.52372/jps37405

Vol. 4, Issue 37, 2022

While a growing number of environmental justice (EJ) studies demonstrate that contaminated drinking water disproportionately affects low-income communities and poor communities across the United States, little attention has been paid to inequalities in drinking water quality information dissemination compliance. The information dissemination rule violation does not fulfill water governor's responsibility for securing water safety, and also not meet the right-to-know provision as a fundamental element for human rights. This study examines patterns of the Confidence Customer Reports (CCR) rule violation at a county-level. Within the EJ perspective, we conducted spatial analysis of the CCR rule violation, and examined vulnerability factors that may be related to the violation likelihood. This study collected the CCR rule violation from 2016 to 2018 through the Safe Drinking Water Information System. Our study's findings indicated that there are 150 counties as the geographical hot spots of CCR rule violations, which are concentrated in some parts of Texas, Oklahoma, and Louisiana in South region. The regression analysis showed that the ethnic minority and the county's poverty rate are significant predictors of the CCR rule violation. The results suggest that information access to the report about drinking water quality is not equally disseminated across the nation. The information asymmetry may exist particularly in poor communities of color, reflecting the main framing of environmental injustice in the United States.

Introduction

Environmental justice (EJ) assumes that all the people have the right to be free from environmental hazards with a fair and equal treatment regardless of race, class, and national origin. With the EJ assumption, EJ researchers examine whether low-income communities and communities of color are disproportionately exposed to environmental toxins, ranging from the sitting of hazardous waste facilities to air pollution (see Bullard, 2001). EJ studies have also documented that drinking water pollution has the disproportionate impact on poor people of color. In a series of those studies, several sociologists and geographers have found that there are socio-spatial patterns of the probability of residents' exposure to drinking water contamination, concluding that unsafe drinking water has a racial, ethnic and class composition of a community in the United States (Bae & Lynch, 2022; Balazs et al., 2011; Balazs & Ray, 2014; Fedinick et al., 2019; Schaider et al., 2019; Stillo & Gibson, 2017).

While a growing number of EJ studies demonstrate that contaminated drinking water disproportionately affect low-income communities and poor communities across the nation, little attention has been paid to inequalities in the access of information about consumer's drinking water. Equal access to information about what we drink is a key element of the public right-to-know provision in the 1996 Amendments of Safe Drinking Water Act (SDWA). Under the revised federal law, the Consumer Confidence Reports (CCR) rule was created that all the water systems are required to provide an annual report summarizing information about source water detected contaminants and compliance of safety regulations. The CCR rule is intended to enhance transparency of water systems and encourage consumer education about potential risks pertaining to drinking water quality, treatment, and management of water supply, which can improve drinking water safety and public health (Siegel, 2019).

Therefore, we expect that the CCR rule contributes to address the needs of vulnerable communities by increasing customer's confidence in their drinking water system and promoting the open exchange of information about water safety between water governors, water system operators and customers. In opposite, however, unavailability of drinking water quality information, as the outcome of the CCR rule noncompliance, violates the right-to-know provi-

a Institute of Law and Policy, Jeju National University, jhbjus@gmail.com

b Department of Police Science, Konkuk University, kkangssyy@kku.ac.kr

sion and weakens drinking water safety and reliability. Additionally, if the racial, ethnic, and poverty composition of a community affects the likelihood of CCR rule violations, it also reflects another environmental injustice that vulnerable communities are likely to be less informed about any regulated contaminants detected in their drinking water, exacerbating their experience of water-related jeopardy.

Considering the U.S. drinking water injustice demonstrating that the probability of exposure to drinking water contamination is associated with living under-resourced communities, we also raise a related question whether the CCR rule noncompliance has a racial, ethnic and poverty composition of a community across the United States, which remains, to our knowledge, empirically unaddressed. This study, thus, fills the gap by asking 'whether there are disproportionate concentrations of CCR rule violations in particular areas; and the racial, ethnic, and poverty composition of communities affects the violation likelihood?' To respond these questions, spatial analysis and multivariate regression are used to examine patterns of CCR rule violations at the county-level across the U.S.

First, we present the current context of U.S drinking water injustice and the CCR rule based on the EJ framework. With the background in mind, the following section raises research questions regarding socio-spatial patterns of the CCR rule noncompliance. And then, research methodology including the specific procedures and research techniques are presented. The final section provides a discussion of the results and a conclusion.

Background: Environmental Justice and Drinking Water Problems

The term, *environmental justice,* is broadly used in research on unequal distribution of environmental benefits and hazards between different groups of people (Brulle & Pellow, 2006; Lynch et al., 2017; Walker, 2012). In practice, environmental justice is specifically referred. For example, according to the U.S. EPA (2016), environmental justice is defined as "the fair treatment and meaningful involvement of all people in environmental decision process regardless of race, class, income or national origin… It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work". The key dimension of the EPA's definition is concerned with justice to people, particularly race, class, income, and national origin that are equally treated and protected (Walker, 2012).

Inspired by the Civil Right movements in the United States, EJ research become widespread in the 1980s, which was intersected with environmentalism and social justice (Brulle & Pellow, 2006). In the past decades, EJ studies reveal race- and class-based disparities in the exposure to environmental hazards (e.g., Bullard, 1990; Lavelle & Coyle, 1992), limited access to adequate environmental services/benefits along with race and income (e.g., Lynch, 2016), and lax enforcement of environmental regulations for ethnic minorities and low-income communities (e.g., Konisky, 2009). Those studies indicate that race, ethnicity, and poverty matter in environmental problems, resulting in environmental injustice that is often used interchangeably with environmental racism and environmental inequality (Lynch et al., 2017).

EJ researchers have also begun to study for drinking water problem in the United States. A growing number of studies have documented that water-related benefits such as clean water resources and adequate water infrastructure are not necessarily commonly accessible, and burdens such as high rates of nitrates in drinking water are unevenly distributed across the nation (Bae & Lynch, 2022; Balazs et al., 2011; Balazs & Ray, 2014; Fedinick et al., 2019; Schaider et al., 2019; Siegel, 2019; Stillo & Gibson, 2017). In a series of those research, Balazs and Ray (2014) developed 'drinking water disparities framework' to explain the root-cause and persistence of social disparities in exposure of contaminated drinking water. They suggest that historical and structural factors – such as legacies of racial discrimination in land-use planning, the sitting of toxic facilities through the path of least resistance, and disinvestment of water infrastructure – result in the inequitable distribution of safe drinking water. Particularly, historically less-empowered communities (e.g., areas in Califonia's San Joaquin Valley) face drinking water challenges intersected with cumulative impacts of environmental hazards and ongoing selective annexation in urban policy (London et al., 2018). Adverse health consequences – such as cumulative cancer risks – are also related with living in those disadvantaged communities among poor and minority populations who are chronically exposed to contaminated drinking water (Uche et al., 2021).

Even though low-income communities and communities of color have disproportionate burden of drinking water pollution, their voices for water safety have been excluded from water policies (Vanderwarker, 2012). Bullard (2001) noted that the minority communities in the Deep South are threatened by water contamination from polluting industries, referring to the region as a 'sacrifice zone' where "local governments and big business take advantage of people who are politically and economically powerless" (pp. 163-164). In addition, as the Flint water crisis has shown, drinking water injustice is also facilitated by inadequate response of the government that fails to include vulnerable populations in important decision-making processes (See also Clark, 2018). The Michigan Civil Rights Commission (MCRC) report (2017) indicates that while Flint residents faced lead-poisoned drinking water for more than a year, the local and state governments did not react immediately to remedy contaminated water. As people of color and/or poor people are less likely to have political influence and resources to pressure on the government, environmental risks to those are likely overlooked or captured by the voice from more affluent groups with political resources (Bullard, 1990; Vanderwarker, 2012). The MCRC report concludes that "the Flint Water Crisis provides a lens through which we can recognize the complex merger of racialized structure, overt racism, racial history and disparate impact… This crisis offers a painful lesson, one that will be repeated if we do not learn from it" (2017, p. 11).

Consumer Confidence Report for Drinking Water Safety

The federal environmental agencies and state governments have worked to solve disproportionate burden of contaminants in drinking water facing low-income communities and poor populations by integrating EJ considerations. Their efforts include the amended legislation of the Safe Drinking Water Act (SDWA) – that was originally established in 1974 and amended in 1986 and 1996 – by recognizing "source water protection, operator training, funding for water system improvements, and public information as important components of safe drinking water." (EPA, 2004). The SDWA – the main federal law that protects the quality and safety of America's drinking water regardless of race, color, and income – has particularly emphasized the importance of public information, consultation, and risk communication to achieve drinking water equity and sustainability. To meet the role and legal responsibility, the EPA required community water systems to provide customers with public information materials about their drinking water, and promulgated the Consumer Confidence Report (CCR) rule in 1998. Specifically, SDWA Section 1414(c)(4)(A)[1] states that all community water systems must mail (or by online) to each customer at least once annually a report including "a brief and plainly worded definition of the terms maximum contaminant level goal (MCLSs), maximum contaminant level (MCLs), variances, and exemptions and brief statements in plain language regarding the health concerns that resulted in regulation of each regulated contaminant. The regulations shall also include a brief and plainly worded explanation regarding contaminants that may reasonably be expected to be present in drinking water." All community water systems are, therefore, required to prepare and provide an annual Consumer Confidence Report about the source and quality of drinking water they deliver, including required information about the concentration of contaminants in their drinking water in relation to regulatory levels chemicals, health risks caused by violations of the SDWA, treatment technique requirements, and additional information (EPA, 2004).[2]

Given the purpose of the CCR rule, it may positively affect drinking water safety in two ways. First, as the CCR rule plays a crucial role in compliance with the public right-to-know provisions in the SDWA, it can be used as a communication tool that starts a dialogue between community water systems and customers, encouraging the open exchange of information regarding source water assessments, health effects data, and water system operations. This report is useful to help local customers make informed decisions about their drinking water with a better understanding (Siegel, 2019). The CCR rule is also helpful to increase transparency and encourage public participation in decision-making process of local drinking water policies, which can improve customer's confidence in their drinking water quality and create opportunities for meaningful interaction between local customers and decision makers (EPA, 2012). Second, as prior studies found that information dissemination regulations for toxic chemicals release (such as the Emergency Planning and Community Right-to-Know Act) improve collective action for affected people to strengthen regulatory enforcement (Shapiro, 2005; Stephan, 2002), the CCR rule is being touted as a useful tool to increase public awareness of drinking water safety. Detected contaminants tables shown in the report may likely confront with negative publicity from affected residents and environmental advocacy groups (Siegel, 2019). Thus, the information regulation encourages water agency decision makers to proactively protect against potential harm of contamination in drinking water, which also contribute to safe drinking water equity.

Another Injustice in the CCR Rule?

While many studies indicate race- and class-based disparity in safe drinking water quality, empirical studies that reveal patterns of the CCR rule noncompliance within the EJ perspective are insufficient. Fundamentally, as the EJ assumption stated positively, benefits of the CCR rule should be equally distributed regardless of race, ethnicity, and income, which meet the goal of EJ securing 'equal protection of laws.' In other words, the CCR rule violation does not fulfill water governor's responsibility for securing water safety,

1 The Safe Drinking Water Act mandates CCRs to include at minimum:
- Sources of water
- Any regulated contaminants detected and corresponding MCLSs, MCLs, level of detection in water system and for any regulated the contaminant health concerns
- Compliance status with National Primary Drinking Water Regulations
- Notification if the system is operating under a variance or exemption and the basis on which the variance or exemption was granted
- Information on monitoring for Cryptosporidium, Radon, unregulated contaminants for which monitoring is required
- Statement that presence of contaminants does not necessarily pose a health risk that more information can be obtained by call the U.S. EPA.

2 The CCR rule also requires additional information in the annual water quality report including:
- A detected contaminant table to display information
- Additional definitions for "treatment technique," "action level," "maximum residual disinfectant level goal" and "maximum residual disinfectant level"
- Specific health information about arsenic and nitrate when detected at certain levels, in addition to lead and its effects on children
- A multilingual statement about the information of the report as required following a primary agency determination that there are large proportions of non-English speaking residents
- Water system contact information
- Ground water rule unaddressed significant deficiencies

and also not meet the right-to-know provision as a fundamental element for human rights.

Numerous EJ studies claimed that origins of socio-spatial patterns with drinking water-related problems are partially attributed from drinking water policy that operates at a business model. At the federal/state level policy, economic purposes for water industry such as dams and irrigation are prioritized over concerns with the water-related service equity (Vanderwarker, 2012). At the local level, based on the market logic strategy, municipal development patterns that usually prioritize infrastructure investment on urban areas surrounded by wealthier populations tend to exclude rural communities among poor and minority populations from water infrastructure investment (London et al., 2018).

The profit-oriented policy is likely to undermine safe drinking water regulations including the CCR rule enforcement, because stricter standard and tighter enforcement of laws increases potential expenses for municipalities and community water systems that are required to have adequate monitoring systems, trained staff, updated facilities, and advanced treatment technologies. Within the cost-benefit process in environmental policy, water regulators tend to delay additional regulations and oblige water system's preference for minimal enforcement (Lauren et al., 2018; Siegel, 2019). For example, the federal water agency has a system that can provide waivers for correcting water safety regulation noncompliance targeted at water systems serving under-resourced rural areas with small populations of color, because of the small tax base of paying customers. While the exemption system helps ease the financial burden of water systems, it likely threatens the precautional function – it does not detect the existence of water contamination until the harm has appeared, worsening the current drinking water injustice issue (Siegel, 2019)

Adding to the profit-oriented policy, fragmented water system is likely to affect geographical inequity in the CCR rule compliance across the nation. There are over 51,000 water suppliers in the U.S. When comparing other public service systems in the U.S. – there are approximately 3,000 natural gas utilities and 3,888 electric utilities in the U.S – the American water infrastructures are too decentralized to be managed and regulated efficiently.[3] Because of fragmented water system, there is much duplication of effort that impedes operational efficiencies for drinking water safety (Levin et al., 2002). To note, many water systems serving rural areas and poor communities of color that are already exacerbated by aging infrastructure and decades of underinvestment are left to depend on state and federal supports (Del Real, 2019; Vanderwarker, 2012). However, such funding is competitive and not always reliable because of too many water systems across the nation (see also, London et al., 2018). Economically disadvantaged communities have restricted access to loans and grants, since funding eligibility criteria requires operational, technical, and managerial capacities. Even recently, although the U.S. federal government has enacted the water infrastructure law that pledges about $50 billion to address decades of water underinvestment and aging infrastructure, many smaller and poor cities still face difficulties because they are required to pay for specialized staff members to set up applications for the grants (Flavelle et al., 2022). Taken together, the CCR compliance seems to a challenge for poor, minority-populated communities.

Combining these ideas, we expect CCR rule noncompliance more frequently occur in lower-income and minority communities that have already suffered from decades of underinvestment and inadequate protection of environmental policy, which will form another environmental injustice in drinking water context. Based on the background, this study raises research questions below:

- *First, are there spatial concentrations of the CCR rule noncompliance across the nation?*
- *Second, does the CCR rule noncompliance constitute a form of injustice? That is, how is the violation related with measures of social difference?*

To answer the questions, we, first, examines whether CCR rule violations appear to be randomly distributed or whether they present spatial clusters across the U.S at a county-level. Subsequent analysis examines whether CCR rule violation clusters are related with the racial, ethnic and poverty segment of a county.

Data and Methods

Our study uses the data from the Safe Drinking Water Information System (SDWIS)[4] federal report search website in the United States. The SDWIS database – that is regularly recorded by self-reported information from community water system – includes status of the system's compliance of CCR rule. We downloaded drinking water data from the violation tab for CCR rule between January 1, 2016 and December 31, 2018.

Dependent Variable

As county-level locations for each community water system are only known through the SDWIS dataset, the unit of analysis is a county. CCR rule violation frequencies per community water system were aggregated to the county level. The violation includes failure to notify customers of

3 When comparing the water systems with other countries – for example, the U.K. has fewer than 30 – the U.S water systems are also relatively fragmented. The bigger areas and relatively low population density of the U.S. possibly explain the many water systems. However, as a study indicated (Levin et al., 2002), "the U.S. water industry has remained quite decentralized even while local public services such as schools and police have consolidated substantially (p.44)."

4 See EPA, "Safe Drinking Water Information System (SDWIS) Federal Reporting Services," https://www.epa.gov/ground-water-and-drinking-water/safe-drinking-water-information-system-sdwis-federal-reporting.

compliance status regarding national primary drinking water regulations and additional information (such as treatment technique and monitoring results) in the annual water quality report. We exclude community water systems serving less than 500 customers because those systems are more likely to report violation status inadequately (Allaire et al., 2017; Rubin, 2013). The study samples (i.e., counties) in the dataset are 2,966.

Considering the data collection strategy, this study has a limitation that the county-level analysis is not able to identify the exact location of affected communities or households. However, the SDWIS dataset provides the county-level location served by community water systems that is the only data available at this time to examine socio-spatial disparity in CCR rule compliance. It is at the county that primary independent variables of interest lie in this study. Table 1 indicates descriptive statistics for the dependent variable and all other factors.

Vulnerability Factors: Race, Ethnicity, and Poverty

Environmental justice research evaluates race/ethnicity and poverty as vulnerability factors that affect environmental disparities in the location of hazardous facilities and in the exposure to pollution (Taylor, 2014; Walker, 2012). These indicators can be also used to identify and characterize less privileged areas that have less regulatory enforcement of environmental laws (Konisky et al., 2021). With the environmental justice perspective, we expect those vulnerability factors to be important determinants of noncompliance patterns of the CCR rule.

This study uses three standard measures in the environmental justice literature to evaluate a race, ethnicity and poverty composition of community (Allaire et al., 2017; Balazs et al., 2011; Hamilton, 1995; Schaider, 2019; Walker, 2012). Our measure of race is the percentage of Black residents in a county; the measure of ethnicity is the percentage of non-white Hispanic residents in a county; and the measure of poverty is the percentage of households below the poverty rate in a county. Each variable is measured at the county-level, obtained from 2012-2016 American Community Survey data of 5-year estimate (U.S. Department of Commerce, Bureau of the Census, 2016).

Control Variables

We included several control variables that may affect CCR rule violations. This study included average voter turnout (average voting rate of 2012-2016 presidential elections) and the proportion of non-profit organization in a county as a proxy for the potential for political activity that influence local decision-making process for environmental regulation and enforcement (Hamilton, 1993, 1995; Konisky & Schario, 2010; Levine, 2016; Zahran et al., 2008). The voting rate data[5] was downloaded from Election Administration and Voting Survey and the measure of non-profit organization proportion come from the 2012-2016 American Community Survey data. We also included educational attainment variable (% population over age 24 with bachelor degree) and age variable (% over 65 years old) by using the 2012-2016 American Community Survey data, which may influence collective reaction for environmentally sensitive situations (White, 2003).

It is important to control urbanization effects on drinking water safety regulation. Community drinking water systems located in rural areas or less populated communities are more likely to suffer from lack of financial resources for water system management and operation because of their declining customers (Siegel, 2019). It might be related to the likelihood of the CCR rule violation. This study includes two urbanization variables: a metro counties dummy (vs. nonmetro) variable (OMB, 2014) and a county-level population density per square mile (U.S. Department of Commerce, Bureau of the Census, 2016).

Considering the drinking water regulatory system, agency enforcement decisions of the SDWA are also affected by state politics (Konisky & Schario, 2010). Since state governments have the authority to supervise drinking water systems within each state's jurisdiction to meet water safety regulations, we need to control state political factors. We included the average League of Conservation Voters (LCV) voting scores on environmental issues including environmental/racial justice, water and clean air, public health, and climate change for each state's U.S. House and Senate members during 2016 to 2018. The scorecard reflects the agreement of experts from more than 20 environmental justice and conservation groups who select

5 For the voting rates, see U.S. Election Assistance Commission*, 2012 Election Administration and Voting Survey:* *A Summary of Key Findings*, Retrieved from https://www.eac.gov/assets/1/6/2012ElectionAdministrationandVoterSurvey.pdf.; U.S. Election Assistance Commission, *The Election Administration and Voting Survey: 2016 Comprehensive Report*. Retrieved from https://www.eac.gov/assets/1/6/2016_EAVS_Comprehensive_Report.pdf.

Table 1. Descriptive Statistics for the Variables in the Study (n=2,966)

Variable	Mean	SD	Min	Max
CCR rule violations	1.105	3.017	.00	52
% Black	8.729	14.194	.00	86.2
% Non-white Hispanic	9.058	13.808	.00	99
% Poverty	16.414	6.427	3.7	53.9
Average of voting rate (2012&2016)	59.054	9.371	27.9	92.5
% Non-profit organization	4.835	2.785	.70	28
% Adult with B.A.	20.594	8.936	4.9	73.7
% Ages 65 and above	17.442	4.331	6.2	57.3
Population density (per square mile)	190.013	927.759	.30	34127.9
Metro county (metro=1, nonmetro=0)	.370	.483	.00	1.00
Water systems per county	7.368	12.020	1.00	42
State-level				
League of Conservation Voters (LCV)	29.722	22.854	.00	97
Region (dummy coded)				
Midwest	.309	.462	.00	1.00
West	.158	.365	.00	1.00
South	.485	.499	.00	1.00
Northeast	.068	.252	.00	1.00

key votes on which congressional representatives should be scored.[6] It indicates how leaderships in the state government protect environment and public health, and helps us to distinguish which legislators are working for solving environmental problems. The LCV's scorecard rate is based on a scale of 0 to 100, which is calculated by diving the number of pro-environmental votes cast by the total number of votes scored. We used the average LCV voting score to control the effect of state environmental politics on water system's regulatory enforcement decision.

As there are multiple water systems within a county, it controls for 'numbers of community water systems in a county' to reduce possible bias associated with larger counties and those with more systems. To account for possible regional variation in both social demographic patterns and CCR violence frequency, four regional indicator 'dummy' variables (Northeast, South, Midwest, and West) are also considered.

Analysis and Results

Spatial Pattern of CCR Rule Violations

A preliminary analysis was conducted for spatial distribution of CCR rule violations using GeoDa program. The Figure 1 indicates the geographical distribution of violation occurrence across the nation, during 2016-2018. Violations of CCR rule vary largely across spatial locations. As Figure 1 shows, some of the counties with the most frequency of CCR rule violations were found in the Southwest and South region including New Mexico, Texas, Oklahoma, Louisiana, and Florida. The violations were also prevalent in parts of the Northeast region including New Hampshire, New Jersey, and Pennsylvania. By using standard deviation of the violations, there were 89 counties (2.89%) that are the highest prevalence locations. Overall, 19.12% (n = 567) of all counties exceed the mean violation (1.105).

Next, the intense hot spots (i.e., spatial clusters) of CCR rule violations were present via local spatial autocorrelation. Spatial autocorrelation was accessed by means of a global Moran's I statistic. First, it tested the null hypothesis of spatial randomness – no spatial dependence associated with frequency of CCR rule violations. Values of the Moran's I range -1 to +1, and a significant and positive value of the statistic indicates positive spatial autocorrelation, which can reject the null hypothesis of spatial randomness, meaning that similar values are spatially clustered together.[7] In other words, hot spot of the violation is a county that experiences high prevalence of CCR rule violations committed by water systems, and is also surrounded by neighboring counties with high prevalence of the violations.

6 See the detailed information for the National Environmental Scorecard, https://scorecard.lcv.org.

7 In opposite, a significant and lower negative value means high negative spatial autocorrelation – values are clustered by dissimilar values.

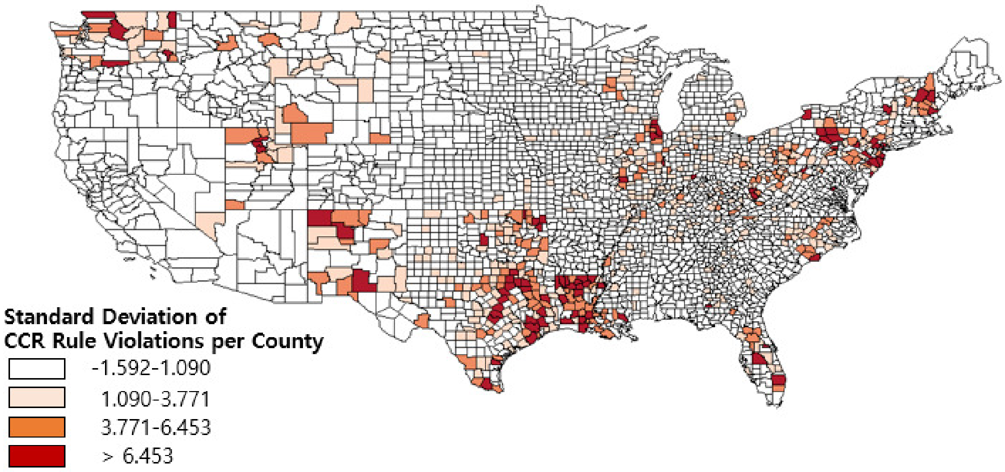

Figure 1. Geographic Distribution (Standard Deviation) of CCR Rule Violations, 2016-2018.

By estimating the Moran I's statistic for CCR rule violation during the study period, the coefficient was 0.268, which was statistically significant at the 0.05 level (the result outcome is not presented here). The result rejects the null hypothesis of spatial randomness and indicates spatial clustering. It means that CCR rule violations are not randomly distributed, but there are hot spot locations where counties with high frequency of violations are significantly adjacent to one another.

Even though the Moran's I statistic considers the complete date sets as a global statistic of spatial autocorrelation, it does not identify the presence of clusters. We can obtain insights for spatial clusters of the CCR rule violations by using a local indicator of spatial association (LISA), the local Moran's I statistic. As Figure 2 shown below, a modified Moran scatterplot map in this study indicates spatial clusters of high prevalence of counties in red as hot spots, so called "High-High" violation clusters occurred by using a combination of the information in a Moran scatterplot map and the significance of the local Moran's I statistic.[8] These findings seem similar to Figure 1, but the spatial cluster analysis provides the advantage of determining whether violation clusters are significant. There were 150 counties as hot spots of CCR rule violations, which are particularly founded in some counties of Texas, Oklahoma, and Louisiana in South region. Hot spots also appear in parts of Northeast region including New Hampshire, New Jersey, and Pennsylvania.

Zero-Inflated Negative Binominal Regression Analysis

For the next analysis, the zero-inflated negative count model was employed to examine whether CCR rule violations are more widespread in vulnerable communities such as ethnic minority and poor areas. As the dependent variable has positive integer values, count models are appropriate for the analysis such as Poisson regression, negative binomial regression (NBRM), zero-inflated counts regression (ZIP) and zero-inflated negative binomial regression (ZINB) (see Long & Freese, 2001). The ZINB equation was applied, because the frequency of CCR rule violation has positive integer values, and a linear regression model is not appropriate for the count dependent variable (Long & Freese, 2001).[9] In addition, the dependent variable has large number of zeros. There are 65.7% of counties (n=1,950) that report a zero in the dataset, which means no violation of the CCR rule during the study period. These data characteristics seem suitable for the ZINB model that is specifically designed to analyze count dependent variables with excess zeros (Long & Freese, 2001). To decide whether the ZINB model best fits this data compared with other count models such as ZIP and NBRM model, a likelihood-ratio (LR) test and Vuong test were conducted.

First, the LR test examined a null hypothesis that the value of the overdispersion parameter (log alpha) equals zero to find whether a ZINB fit the data better than a ZIP model (Long & Freese, 2001). As the Table 2 shown, the LR test result indicates that this parameter (log alpha=1329.99) is statistically significant ($p < 0.001$), indicating the null hypothesis that alpha equals zero should be rejected. Thus, the ZINB model fits this data better than

8 LISA is usually applied to find four different categories: high-high, high-low, low-high, and low-low. And the one that is not part of any categories is regarded as non-clustered one. This current study only presents a high-high cluster.

9 If count dependent variables are analyzed suing a linear regression model, heteroscedasticity issue will appear, which affects the size of standard error estimates.

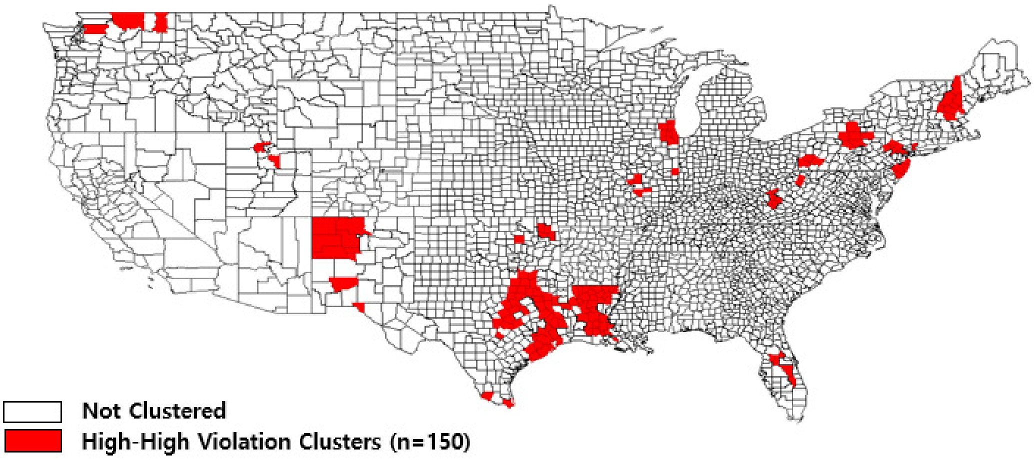

Figure 2. Hot Spots of CCR Rule Violations

Table 2. Zero-Inflated Negative Binomial Regression (n=2,966).

	CCR Rule Violation	
	b	SE
% Black	-.004	.004
% Non-white Hispanic	.008**	.003
% Poverty	.025**	.009
% Voter turnout	-.015*	.006
% Non-profit community org.	-.026	.021
% Adult with B.A.	.002	.006
% Ages 65 and above	.016	.011
Population Density (per square mile)	$-2.24 \times 10^{-4**}$	7.44×10^{-5}
Metro county	-.025	.092
Number of Water System per County	.077***	.006
LCV score	-.011***	.002
Region (South omitted)		
Northeast	1.22***	.247
Midwest	-.102	.126
West	.074	.131
Chi-square (d.f.)	387.97 (14)***	
Likelihood ratio test	1329.99***	
Vuong test	7.14***	

Note: Table indicates estimates from the negative binomial part of ZINB model only. Significance levels: * p<.05 ** p<.01 *** p<.001.

the ZIP model. Second, the Vuong test reports a z-score of 7.14, which is statistically significant ($p < 0.001$). It indicates that the ZINB model improve the fit over the NBRM model (Long & Freese, 2001). Thus, our test results present that the ZINB model statistically fits this data best comparing other models.

In Table 2, main findings are that CCR rule violation occurrence was statistically related with the proportion of Hispanic residents ($p < 0.01$) and poverty rate ($p < 0.01$). In the model, both ethnicity and poverty were significant and positively related with the frequency of CCR rule noncompliance during the study period. In the case of the non-white Hispanic variable, a 10 percent change in the percentage of Hispanic population in a county would predict a 0.8 increase in frequency for the CCR rule noncompliance. In the case of the Poverty variable, a 10 percent change in the percentage of poor households in a county would translate into a 2.5 increase in frequency for the CCR rule noncompliance.

Counter to our environmental justice hypotheses, our model did not support the relationship between the Black population and the CCR rule violation, while the Hispanic population and poverty rates were statistically related with the dependent variable. Perhaps it is due to the fact that the hot spots of water-related problems are particularly found in the Texas colonias, California's Central Valley and the rural South where are predominately Hispanic residents with their population increasing, which reflects the association with CCR rule noncompliance (Anderson, 2008; London et al., 2018; Schaider et al., 2019). It, then, does not demonstrate that the Black was statistically associated with the CCR rule violation at county-level demographics. It assumes that the absence of race effect may be affected by the limitation of the current analysis using the unit of county level (see also Ringquist, 1998). Thus, we suggest subsequent studies on the association between race, ethnicity, poverty and the CCR rule violation with different level of aggregation such as census tracts and different method approaches such as longitudinal study.

The outcomes regarding control variables in the ZINB model are as follows. It predicts that the CCR rule violation occurrence had a negative association with the percentage of voter turnout ($p < 0.05$). That is, areas with higher voting rate see less frequency of violation. However, the non-profit community organization variable was not related with the dependent variable. In addition, no statistically significant relationships were found for the proportion of adult with the bachelor degree and the proportion of the ages 65-and-above. Considering the effect of urbanization in the model, sparsely populated areas were statistically related with CCR rule violation ($p < 0.01$). That is, water systems in less populated areas are more likely to violate the right-to-know provision – even though the metro county dummy variable was not related with the noncompliance. In addition, the more water systems in areas, the more violation frequency ($p < 0.001$). The LCV variable was statistically associated with violation occurrence ($p < 0.001$). It suggests that when the state government has more concern on environmental issues, counties under the state authority tend to comply with the CCR rule.

Subsequently, the marginal effect of ethnicity and poverty on the CCR rule violation is presented in Table 3. First column in the table indicates the percent change in the expected number of violation occurrence in a county for each unit change, all other variables held constant at their means. The second column shows the percent change with respect to standard deviation. For each unit increase in percent Hispanic per county, there is about a 1.44 percent increase in the number of the CCR rule violation, which amounts to a 0.21 percent increase for one standard deviation change. For each percentage increase in county poverty, there is about a 6.49 percent increase in the number of violation occurrence. For a one standard deviation change for county poverty, this equates to about a 0.54 percent increase. The county poverty effect is somewhat larger than ethnicity effect for the CCR rule violation.

Conclusion

Prior EJ studies focused on race-and class-based disparity in the exposure to contaminated drinking water. Particularly, disadvantaged unincorporated communities in Texas colonias and the rural South lack access to clean water due to underinvestment, aging infrastructure, and discrimination of urban policy (Anderson, 2008; London et al., 2018). Several researchers also indicated that predominately Hispanic communities suffer from drinking water contamination that may pose a threat to their health (Balazs et al., 2011; Pilley et al., 2009; Schaider et al., 2019).

This study raised a related question. The main concern was with geographical patterns of CCR rule violations at the county level. Our study's finding presented that there are 150 counties as the geographical hot spots of CCR rule violations, which are concentrated in some parts of Texas, Oklahoma, and Louisiana in South region. The ZINB analysis result showed that the ethnic minority (non-white Hispanic) and the county's poverty rate are significant predictors of the CCR rule violation.

The CCR rule, generally, requires community water systems to regularly report to their consumers on drinking water quality, detected risks in water supply, and compliance status with water safety regulations. Our study findings, however, suggest that the consumer confidence report is not equally disseminated across the nation. The CCR rule violation appears to be more prevalent in poor, minority-populated areas.

Limited access to the drinking water quality report or the CCR rule noncompliance means consumers do not make sure whether their drinking water is safe or not (Fortin, 2017). That is, the noncompliant water systems fail to improve awareness of customers to potential risks in their drinking water. Our findings indicate that the information asymmetry may exist in poor communities of color inhabited particularly by Hispanic residents, reflecting the main framing of environmental injustice in the United States. Those affected communities are less likely to receive the water quality report, reducing their knowledge of susceptibility to water contamination, which may worsen the current drinking water injustice.

Although environmental governors have good intentions in drinking water management and regulation with the democratic norm embedded in the environmental law, we argue that the drinking water information dissemination disparity results in part from a complicated regulatory system under the profit-oriented water policy as mentioned before. With the 1996 Amendment of SDWA, the federal authority of drinking water safety falls dawn to state and local governments, tolerating different allowable standards of safe drinking water across states. Under substantial variability of regulatory systems, some states may undermine their legislation improving drinking water quality and enforcing water regulations, because of financial burden that comes with strict standard of environmental laws (Siegel, 2019). The near-exclusive control of state/local governments is, thus, likely to make a misalignment between the interests of water systems and the public health protection.[10] Some government agencies provide preferential treatment for water systems when enforcing water regulations; for example, there are waivers for fixing violations targeted for water systems with financial incapability (Siegel, 2019). As such, the CCR rule may also be differently enforced at the state/local level, when regulatory application is too costly (see Franz, 2011). With the cost-benefit perspective, minimal- or non-enforcement for the CCR rule noncompliance may alleviate the financial burden of water systems. However,

Table 3. Estimated Effects of Ethnicity and Poverty on CCR Rule Violations.

Variable	Percent Change	Percent Change for Standard Deviation Change
% Hispanic	1.441	0.212
% Poverty	6.487	0.534

Note: The predicted change in county-level CCR rule violation are estimated from the ZINB model shown in Table 3.

such lax regulatory system tends to overlook cumulative risks to low-income and minority communities, intensifying the existing inequalities of the current water system. Thus, we needs a revised regulatory system that makes the Consumer Confidence Reports equally accessible and available online in actual time by particularly supporting water systems in poor, minorities-populated areas (see also Siegel, 2019).

While this study first examined whether there are socio-spatial disparities of the CCR rule compliance with the environmental justice framework, there are several limitations that need to be addressed. First, violation records from the EPA Safe Drinking Water Information System are known to be underestimates of actual occurrence (Allaire et al., 2017). As mentioned before, the EPA has allowed water systems to have exemptions from monitoring and reporting for contaminated drinking water if they have financial incapacity to meet the regulation. Therefore, violation occurrence of the CCR rule is likely to be much greater than reported in this study. Second, our analysis using county-level demographics is challenging for identifying community characteristics served by each community water system. Considering prior EJ studies (Atlas, 2001; Lavelle & Coyle, 1992; Liu, 2001; Lynch et al., 2004; Ringquist, 1998; Stretesky & Hogan, 1998), subsequent research needs to apply different unit of analysis such as census tracts or ZIP code. Third, our study separately measures each racial and ethnic minority and population below poverty at a county level. Given recent EJ studies that consider a combined effect of social vulnerability, the measurement strategy for the EJ indicators needs to be clarified in the subsequent study. Last, we used the non-religious nonprofit organizations proportion in a county as a proxy variable for community political activity, but could not discern whether these organizations are working for environmental issues or not (see also, Oh & Park, 2013). The subsequent study needs to address the measurement validity issue.

Beyond community water systems, future study should be done on the safety and contamination of U.S. private wells. According to the United States Geological Survey (USGS, 2009), about 42 million households depend on private wells (Dieter & Maupin, 2017). However, the private wells are not regulated by SDWA[11] – any kind of water testing and reports is not required. With lack of environmental inspections/regulations, it is expected that contamination in the wells disproportionately impacts low-income rural communities via polluted source water and chemical spills.[12] Future research needs to focus on national trends in drinking water wells as well as find whether environmental injustice exists in communities relying on the private wells.

Acknowledgement

This manuscript is conducted using a part of the author's (Junghwan Bae, 2021) dissertation dataset and methodology for a journal article.

Funding

We acknowledge no funding for this manuscript.

Submitted: April 08, 2022 KST, Accepted: September 07, 2022 KST

10 An example of trade-off between water system's interest and public health is that, according to Siegel (2019, p. 37), the water system "would have an incentive to have the threshold for acceptable contamination set as high as possible, thereby making the utility's treatment costs as low as possible."

11 According to the EPA's website, *"EPA does not regulate private wells nor does it provide recommended criteria or standards for individual wells."* Retrieved from https://www.epa.gov/privatewells.

12 In 2009, the USGS also indicated, based on a sampling of about 2,100 wells across the nation, 23% of them were polluted by chemical contamination – at a level of a potential health risk (USGS, 2009). Among various types of contaminants in those wells, high concentration nitrate pollutant was found, especially in agriculture areas, which come from excessive fertilizer use and can be transmitted through groundwater. In addition, in Wisconsin, approximate 6% of the state's private wells (i.e., 42,000 out of 676,000) were contaminated with serious level of nitrates, or E. coil bacteria that may threaten human health (Healy, 2018; Wisconsin Council Report, 2021).

References

Allaire, M., Wu, H., & Lall, U. (2017). National trends in drinking water quality violations. *Proceedings of the National Academy of Sciences of the United States of America*.

Anderson, M. (2008). Cities inside out: Race, poverty, and exclusion at the urban fringe. *UCLA Law Review*, *55*, 1095–1160.

Atlas, M. (2001). Rush to judgement: An empirical analysis of environmental equity in U.S. Environmental Protection Agency Enforcement Actions. *Law Sociological Review*, *35*, 633–682.

Bae, J. H., & Lynch, M. J. (2022). Ethnicity, poverty, race, and the unequal distribution of US Safe Drinking Water Act violations, 2016-2018. *The Sociological Quarterly*. https://doi.org/10.1080/00380253.2022.2096148

Balazs, C., Morello-Frosch, R., Hubbard, A., & Ray, I. (2011). Social disparities in nitrate-contaminated drinking water in California's San Joaquin Valley. *Environmental Health Perspectives*, *119*(9), 1272–1278. https://doi.org/10.1289/ehp.1002878

Balazs, C., & Ray, I. (2014). The drinking water disparities framework: On the origins and persistence of inequities in exposure. *American Journal of Public Health*, *104*(4), 603–611. https://doi.org/10.2105/ajph.2013.301664

Brulle, R. J., & Pellow, D. N. (2006). Environmental justice: Human health and environmental inequalities. *Annual Review of Public Health*, *27*(1), 103–124. https://doi.org/10.1146/annurev.publhealth.27.021405.102124

Bullard, R. D. (1990). *Dumping in Dixie: Race, Class, and Environmental Quality*. Westview Press.

Bullard, R. D. (2001). Environmental Justice in the 21st Century: Race Still Matters. *Phylon (1960-)*, *49*(3/4), 151. https://doi.org/10.2307/3132626

Clark, A. (2018). *The Poisoned City: Flint's Water and the American Urban Tragedy*. Metropolitan Books.

Del Real, J. (2019, November 29). How racism ripples through rural California's pipes. *The New York Times*. https://www.nytimes.com/2019/11/29/us/water-racism-california.html

Dieter, C. A., & Maupin, M. A. (2017). *Public supply and domestic water use in the United States, 2015* (U.S. Geological Survey Open-File Report 2017-1131). https://doi.org/10.3133/ofr20171131

Fedinick, K. P., Taylor, S., & Roberts, M. (2019). *Water Down Justice*. Natural Resources Defense Council. https://www.nrdc.org/resources/watered-down-justice

Flavelle, C., Rojas, R., Tankersley, J., & Healy, J. (2022, September 4). Mississippi crisis highlights climate threat to drinking water nationwide. *The New York Times*. https://www.nytimes.com/2022/09/01/us/mississippi-water-climate-change.html

Fortin, J. (2017, May 4). America's tap water: Too much contamination, not enough reporting, study finds. *The New York Times*. https://www.nytimes.com/2017/05/04/us/tapwater-drinking-water-study.html

Franz, A. (2011). Crimes against water: Non-enforcement of state water pollution laws. *Crime, Law and Social Change*, *56*(1), 27–51. https://doi.org/10.1007/s10611-011-9308-3

Hamilton, J. T. (1993). Politics and social costs: Estimating the impact of collective action on hazardous waste facilities. *The Rand Journal of Economics*, *24*(1), 101. https://doi.org/10.2307/2555955

Hamilton, J. T. (1995). Testing for environmental racism: Prejudice, profits, political power? *Journal of Policy Analysis and Management*, *14*(1), 107. https://doi.org/10.2307/3325435

Healy, J. (2018, November 3). Rural America's own private Flint: Polluted water too dangerous to drink. *The New York Times*. https://www.nytimes.com/2018/11/03/us/water-contaminated-rural-america.html

Konisky, D. M. (2009). Inequities in enforcement? Environmental justice and government performance. *Journal of Policy Analysis and Management*, *28*(1), 102–121. https://doi.org/10.1002/pam.20404

Konisky, D. M., Reenock, C., & Conley, S. (2021). Environmental injustice in Clean Water Act enforcement: Racial and income disparities in inspection time. *Environmental Research Letters*, *16*(8), 084020. https://doi.org/10.1088/1748-9326/ac1225

Konisky, D. M., & Schario, T. S. (2010). Examining environmental justice in facility-level regulatory enforcement. *Social Science Quarterly*, *91*(3), 835–855. https://doi.org/10.1111/j.1540-6237.2010.00722.x

Lauren, C., Sarango, M., & Harlan, S. L. (2018). *Environmental justice and sustainable urban water systems: Community voices from selected cities in the United States*. Northeastern University Press.

Lavelle, M., & Coyle, M. (1992). Unequal protection: The racial divide in environmental law. *National Law Journal*, *15*(3), S1-12.

Levin, R. B., Epstein, P. R., Ford, T. E., Harrington, W., Olson, E., & Reichard, E. G. (2002). U.S. drinking water challenges in the twenty-first century. *Environmental Health Perspectives*, *110*(suppl 1), 43–52. https://doi.org/10.1289/ehp.02110s143

Levine, J. R. (2016). The privatization of political representation: Community-based organizations as nonelected neighborhood representatives. *American Sociological Review*, *81*(6), 1251–1275. https://doi.org/10.1177/0003122416670655

Liu, F. (2001). *Environmental justice analysis: Theories, methods and practice*. Lewis.

London, J., Fencl, A., Watterson, S., Jarin, J., Aranda, A., King, A., Pannu, C., Seaton, P., Firestone, L., Dawson, M., & Nguyen, P. (2018). *The struggle for water justice in California's San Joaquin Valley: A focus on disadvantaged unincorporated communities*. UC Davis Center for Regional Change.

Long, J., & Freese, J. (2001). *Regression Models for Categorical Dependent Variables Using State*. A Stata Press Publication.

Lynch, M. J. (2016). The ecological distribution of community advantage and disadvantage: Power structures, political economy, communities, and green-state crime and justice. *Critical Criminology*, *24*(2), 247–262. https://doi.org/10.1007/s10612-016-9313-z

Lynch, M. J., Long, M. A., Stretesky, P. B., & Barrett, K. L. (2017). *Green criminology: Crime, justice, and the environment*. University of California Press. https://doi.org/10.1525/9780520964228

Lynch, M. J., Stretesky, P., & Burns, R. (2004). Determinants of environmental law violation fines against oil refineries: Race, ethnicity, income, and aggregation effects. *Society & Natural Resources*, *17*(4), 333–347. https://doi.org/10.1080/08941920490278782

Oh, Y. M., & Park, J. S. (2013). The effect of political institutions on the use of citizen participation programs. *Korean Journal of Policy Studies*, *28*(2), 25–48. https://doi.org/10.52372/kjps28202

Pilley, A. K., Jacquez, S., Buckingham, R. W., Rao, S. P., Sapkota, K., & Kumar, S. (2009). Prevalence of arsenic contaminated drinking water in southern New Mexico border colonias [Abstract]. *American Public Health Association 137th Annual Meeting and Exposition on Water and Public Health, 7-11 November 2009, Philadelphia, PA*.

Ringquist, E. J. (1998). A question of justice: Equity in environmental litigation, 1974-1991. *Journal of Politics*, *60*(4), 1148–1165. https://doi.org/10.2307/2647735

Rubin, S. (2013). Evaluating violations of drinking water regulations. *Journal of American Water Resource Association*, *105*, E137–E147.

Schaider, L. A., Swetschinski, L., Campbell, C., & Rudel, R. A. (2019). Environmental justice and drinking water quality: Are there socioeconomic disparities in nitrate levels in U.S. drinking water? *Environmental Health*, *18*(1), 3–15. https://doi.org/10.1186/s12940-018-0442-6

Shapiro, M. D. (2005). Equity and information: Information Regulation, environmental justice, and risks from toxic chemicals. *Journal of Policy Analysis and Management*, *24*(2), 373–398. https://doi.org/10.1002/pam.20094

Siegel, S. (2019). *What's Wrong with What We Drink: Troubled Water*. St. Martin's Press.

Stephan, M. (2002). Environmental information disclosure programs: They work, but why? *Social Science Quarterly*, *83*(1), 190–205. https://doi.org/10.1111/1540-6237.00078

Stillo, F., & Gibson, J. M. (2017). Exposure to contaminated drinking water and health disparities in North Carolina. *American Journal of Public Health*, *107*(1), 180–185. https://doi.org/10.2105/ajph.2016.303482

Stretesky, P., & Hogan, M. J. (1998). Environmental justice: An analysis of Superfund sites in Florida. *Social Problems*, *45*(2), 268–287. https://doi.org/10.2307/3097247

Taylor, D. E. (2014). *Toxic Communities: Environmental Racism, Industrial Pollution, and Residential Mobility*. New York University Press.

The Michigan Civil Rights Commission. (2017). *The Flint Water Crisis: Systemic Racism through the Lens of Flint*. Michigan Department of Civil Rights.

Uche, U. I., Evans, S., Rundquist, S., Campbell, C., & Naidenko, O. V. (2021). Community-level analysis of drinking water data highlights the importance of drinking water metrics for the State, Federal environmental health justice priorities in the United States. *International Journal of Environmental Research and Public Health*, *18*(19), 10401. https://doi.org/10.3390/ijerph181910401

U.S. Department of Commerce, Bureau of the Census. (2016). *2012-2016 American community survey (ACS) 5-year data profile*. U.S. Department of Commerce, Bureau of the Census.

U.S. Environmental Protection Agency. (2004). *Understanding the Safe Drinking Water Act, EPA 816-F-04-030*. U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (2012). *Consumer Confidence Report (CCR) Rule Retrospective Review Summary*. U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (2016). *Drinking Water: EPA Needs to Take Additional Steps to Ensure Small Community Water Systems Designed as Serious Violators Achieve Compliance* (Report No. 16-P-0108). U.S. Environmental Protection Agency.

U.S. Geological Survey. (2009). *Contaminants in 20 percent of U.S. Private Wells*. https://www.usgs.gov/media/audio/contaminants-20-percent-us-private-wells

U.S. Office of Management and Budget. (2014). *Metropolitan Area Designations by OMB: History, 2010 Standards, and Uses* (Congressional Research Service Report, CRS-14-R42005). https://www.everycrsreport.com/files/20140606_R42005_cc88d5c754b797d095e0880142d7c28aa739d871.pdf

Vanderwarker, A. (2012). Water and environmental justice. In J. Christian-Smith & P. H. Gleick (Eds.), *A Twenty-First Century U.S. Water Policy* (pp. 52–89). Oxford University Press. https://doi.org/10.1093/acprof:osobl/9780199859443.003.0003

Walker, G. (2012). *Environmental Justice: Concepts, Evidence, and Politics*. Routledge.

White, H. (2003). Syndrome behavior and the politics of environmental justice. In Our Backyard: A Quest for Environmental Justice. In G. Visgilio & Whitelaw (Eds.), *Our Backyard: A Quest for Environmental Justice* (pp. 107–124). Rowman & Littlefield.

Wisconsin Council Report. (2021). *Wisconsin Groundwater Coordinating Council Report to the Legislature*. Wisconsin Department of Health Services. https://dnr.wi.gov/topic/groundwater/documents/GCC/GwQuality/Nitrate.pdf

Zahran, S., Hastings, D. W., & Brody, S. (2008). Rationality, inequity, and civic vitality: The distribution of treatment, storage, and disposal facilities in the Southeast. *Society & Natural Resources*, *21*(3), 179–196. https://doi.org/10.1080/08941920701618195