

Article

Distributive Disturbances: Examining Community Exposure to Drinking Water Contaminants Amidst the Jackson, Mississippi (USA) Water Crisis

Ambria N. McDonald ^{1,*}, Yolanda J. McDonald ² , Andrea Chow ¹, Julia Kosinski ¹ and Dorceta E. Taylor ¹ 

¹ School of the Environment, Yale University, 195 Prospect Street, New Haven, CT 06511, USA; dorceta.taylor@yale.edu (D.E.T.)

² Department of Human and Organizational Development, Vanderbilt University, 1212 21st Avenue South, Nashville, TN 37203, USA

* Correspondence: ambria.mcdonald@yale.edu

Abstract

Community water systems in the United States provide drinking water to more than 300 million people annually, making their reliability fundamental to public health. In regions with long histories of racial segregation and unequal infrastructure maintenance, water system failures can deepen existing environmental injustices. This study examines water quality conditions in the Jackson, Mississippi, metropolitan area following the 2022 distribution system collapse and a decade of repeated noncompliance with the Safe Drinking Water Act's Lead and Copper Rule (LCR). Using the U.S. Environmental Protection Agency's 2024 updated LCR tap sampling protocol, water samples from 29 sites were collected. Samples were analyzed for lead, copper, iron, zinc, chlorine, sulfate, pH, and total dissolved solids concentrations. Chlorine-to-sulfate mass ratios (CSMR) were also calculated to evaluate corrosion potential. Demographic surveys, statistical analyses, and geospatial visualizations were used to interpret neighborhood-level patterns. Our findings show that all sites met primary drinking water standards and complied with LCR action levels but exceeded secondary drinking water standards at 100% of study sites. Seven sites exhibited CSMR values above the threshold, indicating increased susceptibility to corrosion. These results highlight the need for targeted corrosion control, treatment optimization, and ongoing monitoring, particularly in historically marginalized communities.

Keywords: drinking water; water quality; water crisis; lead and copper rule; tap sampling; chlorine-to-sulfate mass ratio; pH; lead; noncompliance



Academic Editor: Fang Yenn Teo

Received: 6 October 2025

Revised: 12 January 2026

Accepted: 28 January 2026

Published: 5 February 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and

conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

Public drinking water in the United States is delivered through 152,000 public water systems (PWSs) [1]. These systems provide water to at least 15 service connections or 25 people for a minimum of 60 days annually. Community water systems (CWSs), a subset of PWSs, serve the same population year-round. Currently, 51,000 CWSs provide drinking water to 90% of the U.S. population—approximately 301 million people [2]. Despite technological and operational differences across rural and urban settings, the provision of safe drinking water remains intrinsically linked to a community's public health.

Public water supply and water system performance are equally tied to local government oversight and the technical, managerial, and financial (TMF) capacity of municipal utilities. CWSs must implement several federal mandates, including the Safe Drinking

Water Act (SDWA), including the Lead and Copper Rule (LCR), to safeguard public health; yet some systems struggle to meet these requirements [3–5]. Patel and Schmidt [6] note that the major vulnerabilities contributing to CWS noncompliance include aging infrastructure, distribution system contamination, and workforce capacity limitations, often compounded by external political or economic pressures.

Financial instability further exacerbates these challenges. CWSs rely on municipal bonds, federal grants and loan programs, and user fees [7]. Smull et al. [8] add that monetary policy, tax policy, market forces, and industrial activity greatly influence utility finances. TMF capacity has increasingly been recognized as a vulnerability affecting a water system's ability to provide safe drinking water [9–11]. When TMF capacity is stretched, and financial support is insufficient, regulatory compliance falters and public health risks emerge, which often intensify due to community sociodemographic characteristics and/or climate-related stressors.

These systemic vulnerabilities intersect with broader patterns of environmental inequality. Downey et al. [12] argue that environmental inequality is strongly linked to race and emerges from historical and ongoing racialized inequities in income, political power, and residential segregation. Such inequalities are fundamentally rooted in environmental racism, or structures and systems that distribute environmental burdens and protections along racial and class lines. Evidence shows that Black and Hispanic communities bear disproportionate pollution burdens [12–14] and remain underrepresented in regulatory and planning processes [14]. This lack of representation limits the ability of marginalized communities to influence decisions that directly affect their health and safety.

These historical and structural dynamics are vividly reflected in the Jackson, Mississippi, water crisis. Exposing Jackson's fragile infrastructure and prompting a visit by former EPA Administrator Michael Regan, winter storms in February 2021 caused multiple water main breaks. The City of Jackson also issued a public notice on 19 July 2022, outlining LCR violations and longstanding corrosion control failures dating back to 2015. The City noted that the water system had been under an Administrative Compliance Order on Consent with EPA Region 4 since July 2021 due to repeated noncompliance [15]. Although water insecurity in Jackson dates back to 2015, the Crisis did not reach national prominence until 29 August 2022, when a historic rainfall caused flooding at the Ross Barnett Reservoir (the City's primary water source) and overwhelmed the intake system at the O.B. Curtis Water Treatment Plant. The resulting pump failures left more than 150,000 residents without clean drinking water, and others under a boil-water notice for an indeterminate period of time [16]. Jackson residents have endured intermittent boil-water notices for months at a time, with over 1000 notices issued between 2016 and 2022 [16,17].

Under the SDWA Public Notification Rule, CWSs must issue boil-water notices after disruptions such as water main breaks or exceedances [18]. These notices instruct residents to boil water for three minutes to eliminate microbial contamination. However, boiling does not remove metals and may increase metal concentrations, including lead [19–21]. Consequently, Jackson residents may have heightened their lead exposure during these notices.

Jackson's water crisis cannot be understood without acknowledging structural racism in its water governance structure. Jackson's population—now 82.5% Black, with 24.5% living below the poverty line—has steadily declined since the 1980s, even as the water system continued to serve a large and aging infrastructure footprint. Former Mayor Harvey Johnson, elected in 1997 as Jackson's first Black mayor, identified four contributors to the City's water system decline: population loss linked to safety concerns, rising poverty, suburban annexations that diverted tax revenue, and systemic racism. Johnson emphasized that portions of Jackson's water distribution network still contain undersized pipes similar to those found in the landmark 1971 *Hawkins v. Shaw* case (where Black residents of Shaw,

Mississippi successfully sued their town for discrimination after discovering that majority-Black neighborhoods were served by smaller, inadequate pipes that produced chronically low water pressure [22]). Johnson pointedly noted that similar pipes in Jackson failed during the 2021 winter storm, contributing to City water main breaks [23].

Systemic racism has also shaped state-level decisions regarding financial support in Jackson. In 2009, the state of Mississippi authorized a one-percent sales tax increase to support Jackson's infrastructure only after creating a state-controlled commission to oversee spending—an unprecedented requirement not imposed on majority-White cities like Tupelo, where a similar measure passed without external oversight [23,24]. Such actions align with broader patterns of political disenfranchisement. As the Washington Post reports, "Mississippi has a long history of White political leaders purposefully, and sometimes illegally, steering needed funding away from Black communities" [25] (p. 1). These dynamics illustrate how environmental racism operates through state-level decision-making, fiscal policy, and institutional power, which could exacerbate public health risks.

Health disparities in the region further underscore the magnitude of the water crisis. Qingmin Meng [26,27] examined public health disparities in connection to the water crisis between eight cities (Jackson, Flora, Ridgeland, Brandon, Canton, Flowood, Madison, and Byram) among 12 health outcomes (arthritis, cancer, high cholesterol, heart disease, kidney disease, obesity, asthma, high blood pressure, diabetes, stroke, lost teeth, and chronic obstructive pulmonary disorder [COPD]). Meng found that Jackson and Canton (both with Black populations totaling more than 70% of the population) had much worse outcomes when compared to neighboring cities for nine out of twelve indicators (COPD, stroke, kidney disease, asthma, high blood pressure, heart disease, diabetes, obesity, and loss of teeth). Subsequently, Meng [27] operationalized the water crisis as an indicator of health outcomes and found a significant correlation between the percentage of Black residents, public health outcomes, and the ongoing crisis in Jackson, indicating that the crisis exacerbated poor health outcomes. According to the U.S. Census Bureau [24], 29.1% of Jackson's population is deemed vulnerable due to age, chronic disease, or disability: 7.1% of the population is under the age of five, 9.0% has a chronic disease such as Diabetes and High Blood Pressure or a disability, and 13.1% are over the age of 65.

Against this backdrop, the Jackson Water Study was developed to examine water quality, exposure risks, and resident experiences in a community facing an active drinking water crisis. The study evaluated metallic and corrosive water quality parameters (lead, copper, iron, zinc, sulfate, chlorine, pH, and total dissolved solids) across household and business taps in Jackson, Byram, and Terry. It also assessed whether boiling water increased metal concentrations beyond EPA's Maximum Contaminant Levels (MCLs), a concern given longstanding boil-water notices and EPA guidance noting that boiling does not remove metals and may increase concentrations [19–21].

Existing research on lead exposure often examines long-term outcomes [28–30], housing- and school-based exposure [31–33], sampling strategies [34], and lead transport modeling [35,36]. Other works detail how treatment practices influence lead mobility [34,37–40]. Most pointedly, Schaider et al. [41] demonstrate that millions of Americans were exposed to nitrate exceedances in chronically noncompliant CWSs, underscoring the importance of violation-based research, while Sadler et al. [42] linked corroded plumbing, stagnation time, and older housing stock to elevated pediatric blood lead levels in Flint, Michigan.

Contributing to environmental exposure, public health, and regulatory compliance discourse, this study addresses three primary objectives: (1) characterize tap water quality across households and businesses in the Jackson metropolitan area, with special attention to lead using the 2024 Lead and Copper Rule Improvements (LCRI) protocol [43]; (2) evaluate

exposure to drinking water contaminants among vulnerable populations; and (3) assess whether boiling alters metal concentrations. Guiding these objectives, we expect water quality to vary across the metropolitan area, with concentrations of one or more contaminants surpassing EPA MCLs. We anticipate that households with vulnerable residents will be more likely to encounter exceedances, although substantial differences between homes with young children and those with older adults are not foreseen. Because Jackson residents have faced recurring boil-water notices, we further expect that boiling will appreciably change contaminant levels and that post-boil samples will not be compliant with EPA regulatory thresholds [44,45]. In light of recent federal regulatory changes, we also anticipate that lead concentrations measured using the 2024 LCRI sampling protocol, both before and after boiling, will fall below EPA's lead action level. Finally, we expect sociodemographic characteristics such as household income, educational attainment, and residential location to influence susceptibility to contaminant exposure. Figure 1 shows a map of Hinds County, Mississippi, United States of America, highlighting the three cities.

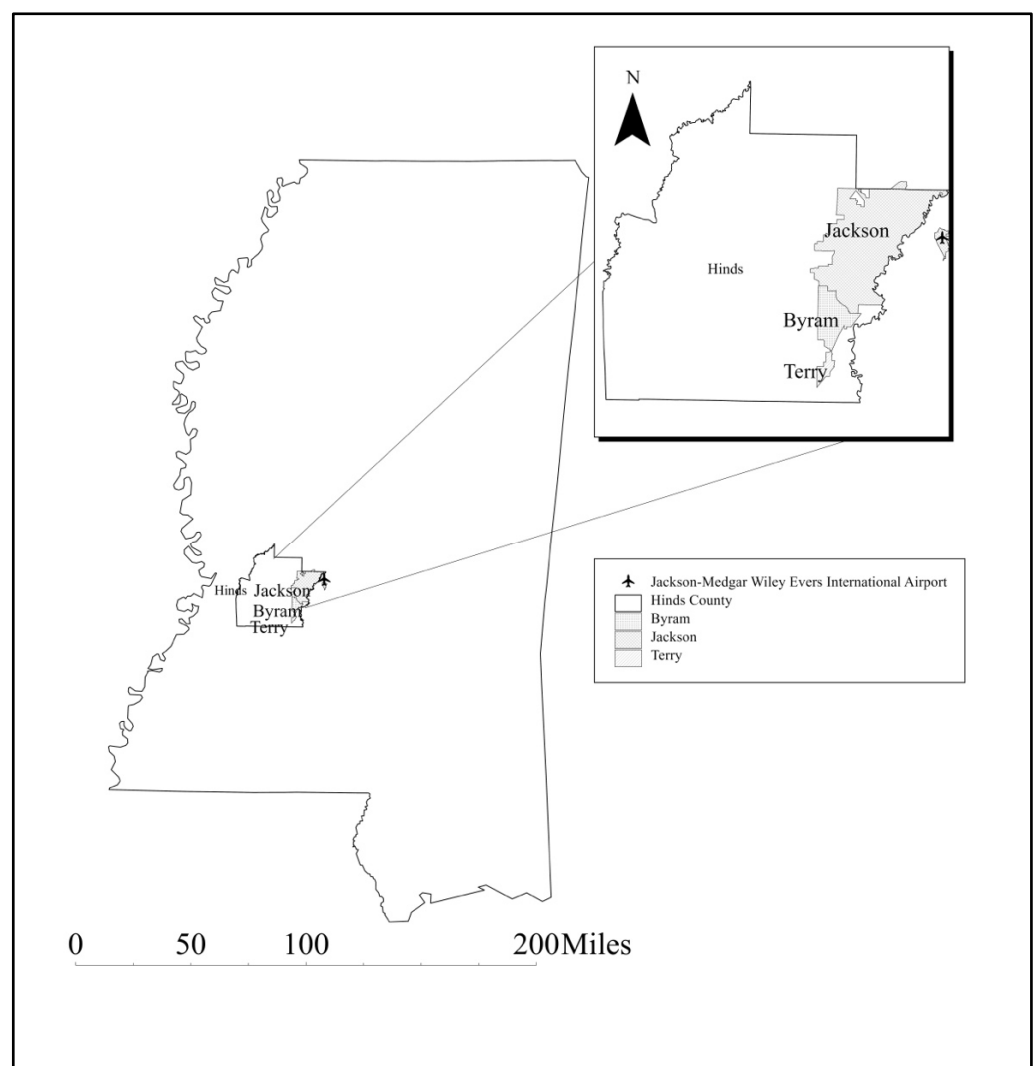


Figure 1. Study area map showing the state of Mississippi and an inset highlighting Hinds County. The inset also depicts the three cities included in the analysis (Jackson, Byram, and Terry) and the Jackson–Medgar Wiley Evers International Airport.

2. Methodology

2.1. Inclusion Criteria

Residents living in households with vulnerable populations and businesses serving vulnerable populations were encouraged to participate. Households were eligible if they included at least one pregnant or nursing woman, a child aged five or younger, or an individual aged 65 or older. Businesses qualified if they were early education or daycare centers supporting children aged five years or younger, or retirement communities, including nursing homes, assisting residents aged 65 or older. All locations had to receive drinking water from *Jxn Water* (the City's municipality).

2.2. Participant Recruitment & Enrollment

Jackson metropolitan residents were invited to sign up for in-home or in-business water quality testing through newspaper advertisements (*Jackson Advocate*) and radio broadcasts (90.1 FM and 103.45 FM) during May 2024. The *Jackson Advocate* (a historical Black-owned newspaper) ran advertisements from 23 May 2024 to 5 June 2024, and featured a front-page news story about the study on 31 May 2024. The principal investigator also participated in talk-radio broadcasts on 19 May 2024 and 22 May 2024 to encourage participation.

Traditional methods, such as neighborhood canvassing and distributing flyers at coffee shops and libraries, were also employed. Residents could also express interest via a 24/7 phone line set up by Yale University's Central IT Department. Further, given the significant role of religion in Mississippi, particularly within communities of color, church-based recruitment was also conducted. The principal investigator spoke at three churches across the metro area on 12 May 2024, 19 May 2024, and 26 May 2024.

Support from local leaders further bolstered recruitment efforts. Jackson Ward 4 Councilman Brian Grizzell helped identify churches and contacts. At the same time, Central District Public Service Commissioner De'Keither Stamps endorsed the study through a support letter and featured the principal investigator on his weekly podcast.

After recruitment ended on June 5th, all eligible participants were organized into a spreadsheet by geographic cluster (Jackson Wards 1–7, Byram, and Terry), de-identified, and selected through systematic random sampling using the RAND function in Microsoft Excel 365 [46]. A total of 29 participants were selected—26 households and three businesses. Participant addresses were geocoded into geographic coordinates and mapped using ArcGIS Pro Version 3.4 [47]. We conducted a series of tabular and spatial joins to assign participants to the *Jxn Water* service area and Jackson wards, enabling the creation of a sampling schedule. Figure 2 depicts sampling locations in the study across Jackson, Byram, and Terry, MS.

Enrolled participants received a confirmation email with scheduling details and an overview of what to expect on sampling day. Each evening, participants were contacted by phone to confirm their appointment for the next business day and reminded not to use their water for six consecutive hours prior to sampling to comply with EPA tap sampling protocol [48].

2.3. Parameter Selection

The water sampling protocol and parameters to be tested were informed by two Flint, Michigan studies [49,50]. Pieper et al.'s 2017 [49] study examined lead and iron concentrations at a home that had been condemned by the City of Flint after increasingly toxic water lead levels were found across three months in 2015 (during the City's mandated LCR sampling procedure). Deeming it the "ground zero home," they found that indoor and outdoor lead service lines, both made of galvanized iron (composed of zinc, lead, and cadmium), were contributing to lead levels in the "ground zero home's" water supply. Moreover,

Pieper et al.'s 2018 [50] study took a longitudinal approach of examining household water lead levels over the entire duration of the Flint Water Crisis (August 2015–August 2017) and used a community-based participatory research protocol. As members of the Virginia Polytechnic Institute and State University research team that supplied home water testing kits to Flint residents, 156 households participated in four waves of water quality research. During that study, the team quantified lead, iron, and phosphate (an indicator of corrosion control in the distribution system) levels.

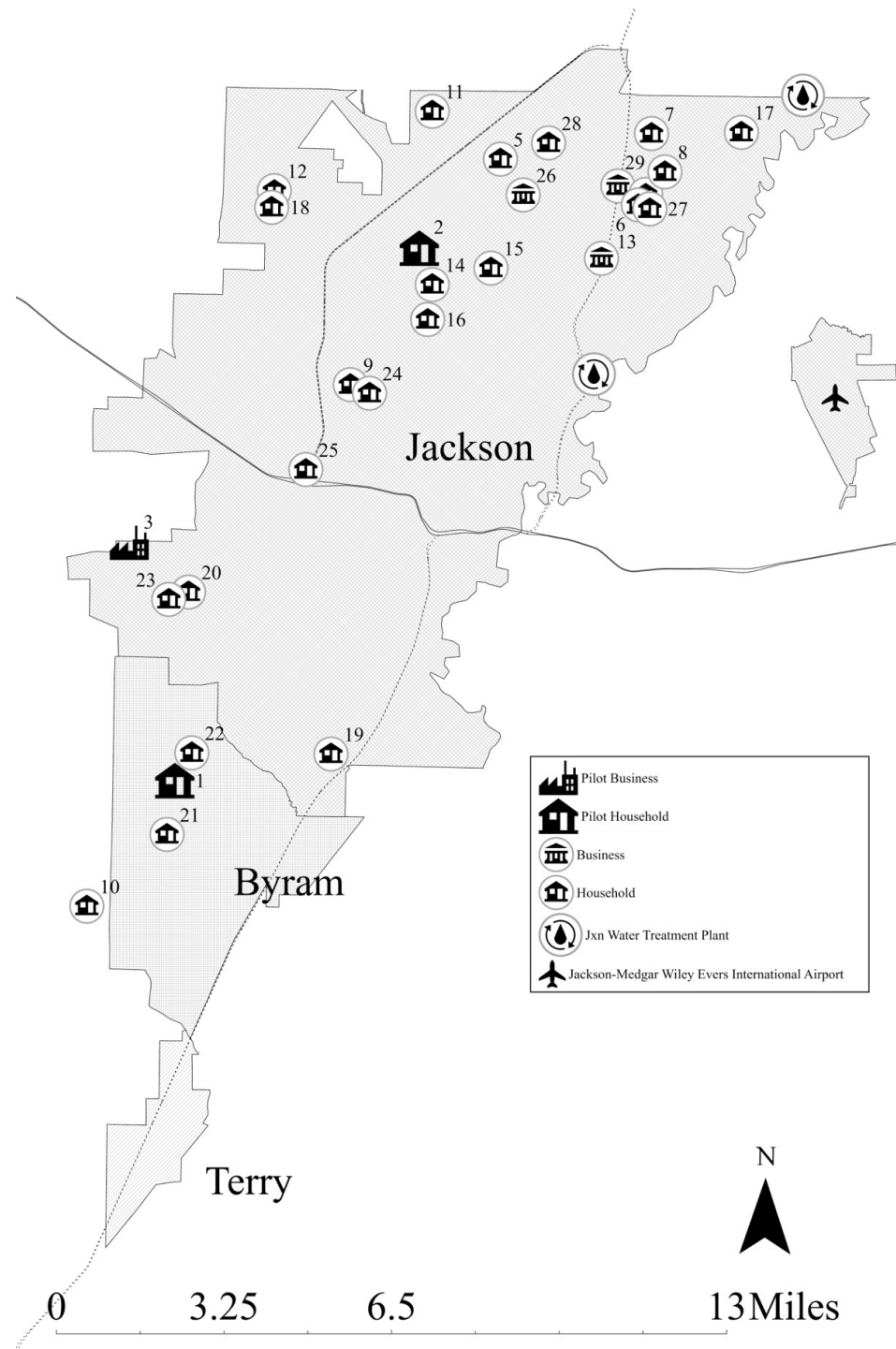


Figure 2. Detailed map of the study area within Hinds County, Mississippi, showing the distribution of 29 sampling locations across Jackson, Byram, and Terry. Sampling points are categorized by building structure and are displayed alongside major interstates, municipal boundaries, two drinking water treatment plants and the Jackson–Medgar Wiley Evers International Airport.

Additionally, the selection of parameters was guided by the existing literature. Studies on chloride-to-sulfate mass ratios [(CSMR) a unitless measure of corrosion in service lines and premise plumbing that examines chloride and sulfate concentrations] [40] and its fluctuation with treatment techniques [38], and presence of corroded solder [34,37,39] highlighted its importance in understanding potential corrosivity of Jackson's water supply and hotspots of corroded distribution pipes or service lines. CSMR is measured on a scale between zero and one. A low CSMR (<0.2) indicates low corrosion potential, while a moderate CSMR (0.2–0.5) suggests increasing risk [40]. Ratios above 0.5 are considered moderate to high and indicate greater lead-leaching potential. CSMR typically is measured by chloride ion concentrations, but for this study, total chlorine is used in lieu.

Zinc (Zn) was also selected because it is used as a corrosion inhibitor when combined with other metals to make alloys. Zinc often ends up in public water supply due to corrosion of galvanized steel or galvanized iron pipes, because it is used as a coating agent to prohibit corrosion of iron or steel [35]. In both cases, zinc is easily mobilized in water supplies because it reacts with corrosive water (high dissolved solids, low pH) [35]. Similarly, copper (Cu) is leached into the public water supply after being released from premise plumbing brass fittings [31,34,51]. Total Dissolved Solids (TDS), pH, and temperature were selected due to their nature to promote corrosion of metals in public water supplies [52].

2.4. Water Sample Collection

According to the EPA, for a CWS of Jackson's size (with more than 100,000 service connections), at least 60 samples must be collected to determine compliance with tap testing protocols, unless otherwise specified in a formal agreement between federal and state agencies. Jackson's water supply must adhere to the 60 sampling locations, but due to budget constraints, only 29 locations were sampled. Additionally, EPA published an updated tap sampling technique for the LCR in 2024. The changes outlined in the new legislation mandate that the first and fifth liters of water be collected to detect the lead level in the water supply accurately. Due to this update, the sampling protocol for this study was augmented to reflect these changes.

Water sampling was conducted for 11 days between 11 June 2024 and 25 June 2024, across two research teams. Sampling occurred only during weekdays (Monday through Friday) between 6:00 a.m. and 4:30 p.m. Ten analytes were assessed as indicators of water quality: lead (Pb), copper (Cu), iron (Fe), zinc (Zn), chlorine (Cl), sulfate (SO_4), pH, total dissolved solids (TDS), temperature, and chlorine-to-sulfate mass ratio (CSMR).

According to EPA's Environmental Sampling and Analytical Methods Program [53], the kitchen tap water was collected in five vials at each location. The first vial (or the first liter/first draw) was a plastic container preserved with nitric acid, obtained for metal quantification (including Pb, Cu, Fe, and Zn). The second vial, a plastic container with no preservative, was used to collect a pint of water for chlorine and sulfate quantification. Two and a half liters (signifying the third and fourth liters) were collected in a blank plastic liter bottle and discarded. The third vial, a 1-L plastic container preserved with nitric acid, was obtained to measure lead levels only (the proposed change to the LCR tap sampling protocol). The last two vials (fourth and fifth)—measuring Pb, Cu, Zn, Fe, chlorine, and sulfate—were collected after the water was boiled. After each vial was collected, the tap was turned off to ensure accurate measurement. Only cold tap water was collected because hot water promotes lead leaching [54–56].

2.5. Boiled Water Samples

After collecting the five liters for pre-boil samples, four more quarts of water were obtained from the kitchen sink and collected in a five-quart pitcher for boiling. The

amount of water to boil was derived from dietary guidelines from the U.S. Department of Agriculture under the MyPlate Initiative [57]. Guidelines for whole grains (e.g., pasta or rice) and vegetables were used, as they require the use of boiled water in their preparation. Calculation for the total amount of water to be boiled was averaged across the two food components: four ounces (or 0.5 cups) of whole grains per person equals 16 ounces for a family of four (about one to two quarts of water) and eight to 16 ounces (or one to two cups) of vegetables per person equals 32–64 ounces for a family of four (or about four to six quarts of water) [58].

Before boiling, temperature, pH, and TDS were measured using an apparatus by JulyPanny [59]. The tool was submerged no more than one inch below the water's surface for the measurements. The water was then poured into a 5-quart stainless steel pot (without a lid) and placed on the stove's largest burner, heated using the highest heat setting. The same pot and pitcher were used at each location to ensure uniformity of measurements, and no residuals from household or business cleaning products were introduced. The pot and pitcher were both cleaned with deionized water prior to sample collection and at the end of sample collection.

Using a kitchen thermometer, the boiling water was monitored until it reached 100 °C (212 °F). The temperature was measured at the center of the pot, no more than one inch below the surface. After the water reached boiling point, a timer was started to measure three minutes at a consistent rolling boil per CDC guidelines [19]. The pot with the boiled water was then placed in an ice bath. To create the ice bath, a two- to three-inch layer of ice cubes covered the bottom of a large aluminum foil pan (30 cm × 40 cm × 8 cm).

After the pot was placed on top of the layer of ice cubes, more ice cubes were placed in the tray surrounding the pot to accelerate the cooling process. Cold tap water was then added until the ice was submerged. Also measured from the center of the pot, no more than one inch below the water surface, the water was cooled until it reached 54 °C or 130 °F—a temperature that reduces the risk of scalding [60]. Once cooled, the water was poured into the pitcher to fill the fourth and fifth vials. The fourth vial was obtained for metal quantification (Pb, Cu, Fe, and Zn) after boiling, and the fifth vial was obtained for post-boil quantification of chlorine and sulfate.

Table 1 summarizes the water quality parameters examined in this study, and Figure 3 illustrates the full methodology.

Table 1. Sampling locations and corresponding water quality parameters measured as part of the Jackson Water Study. Tap samples were collected from household and business kitchen faucets, including both unboiled and boiled samples, and analyzed for metals, disinfectant-related chemicals, and indicators of water corrosivity.

Sample Collection Location	Boil Status	Assessment Conducted	Parameters Measured
Household/Business Kitchen	Unboiled	Metallic	Lead, copper, iron, zinc
		Water quality	Chlorine, sulphate
Household/Business Kitchen	Boiled	pH/Total dissolved solids (TDS)	Acidity or alkalinity
		Chlorine-to-sulfate mass ratio (CSMR)	A ratio between chlorine and sulfate will be obtained to determine a corrosivity factor (i.e., if the pipes are corroding and entering the water supply).

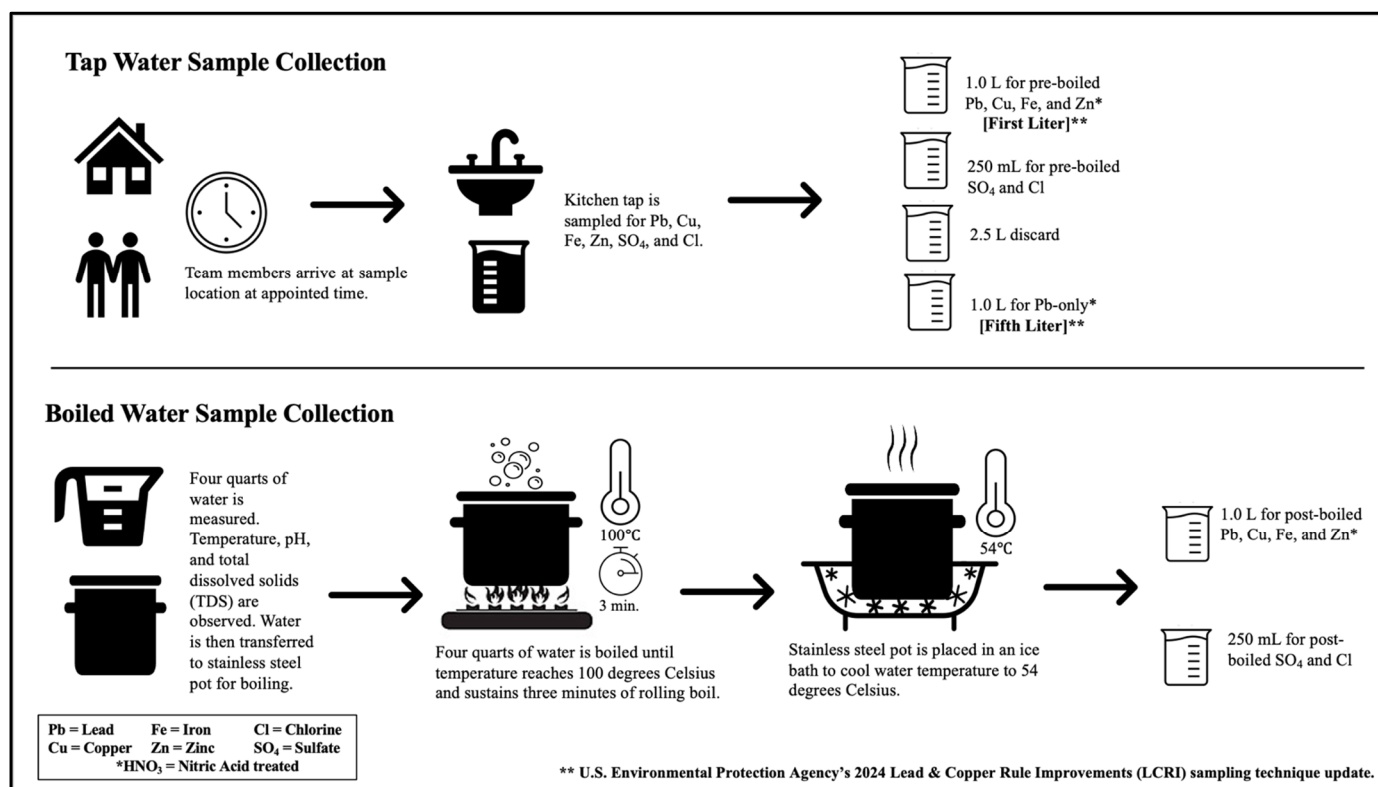


Figure 3. An illustration of the tap and boiled water sampling protocols used in the Jackson Water Study. The top pane depicts the sequence for collecting unboiled tap water samples from kitchen faucets, including team arrival, sampling steps, required volumes, and the analytes measured. The bottom pane details the boiled water sampling procedure, highlighting the collection of initial water, controlled heating and boiling, and the final post-boil sample collection, along with the associated sample volumes and analytical parameters obtained.

2.6. Water Sample Analysis

After collection, all samples were immediately stored in coolers, iced, and delivered daily to Waypoint Analytical Laboratory (WAL) in Ridgeland, Mississippi, then transported to their National Environmental Laboratory Accreditation Program (NELAP) laboratory, in Memphis, Tennessee for analysis. Tables 2 and 3 highlight the water quality parameters, their test methodology, and the EPA's MCL, respectively.

Table 2. Summary of all water quality parameters analyzed in the Jackson Water Study, including associated Chemical Abstracts Service numbers, sample matrices, analytical test methods, and reporting units. All analyses were performed by Waypoint Analytical Laboratory following established U.S. Environmental Protection Agency methodologies.

Parameter	Chemical Abstracts (CAS) Number	Matrix	Test Method	Unit of Measure
Copper	7440-50-8	Aqueous	EPA-200.8 (DW)	µg/L
Iron	7439-89-6	Aqueous	EPA-200.8 (DW)	µg/L
Lead	7439-92-1	Aqueous	EPA-200.8 (DW)	µg/L
Zinc	7440-66-6	Aqueous	EPA-200.8 (DW)	µg/L
Sulfate	14808-79-8	Aqueous	EPA-300.0	mg/L
Chlorine—total residual	7782-50-5	Aqueous	4500CIG-2011	mg/L

Table 3. U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs) for drinking water parameters assessed in this study. Listed values include regulatory limits for lead, copper, iron, zinc, chlorine, sulfate, total dissolved solids, and acceptable pH range, as defined in the National Primary and Secondary Drinking Water Regulations.

Water Quality Standard	EPA MCL for Standard
Lead (Pb)	0.015 mg/L
Copper (Cu)	1.3 mg/L
Iron (Fe)	0.3 mg/L
Zinc (Zn)	5.0 mg/L
Chlorine (Cl)	4.0 mg/L
Sulfate (SO ₄)	250 mg/L
Total Dissolved Solid (TDS)	500 mg/L
pH	6.5–8.5

Note: Source: [45].

2.7. Statistical Models

All statistical analyses were conducted using Minitab Statistical Software Version 22 [61]. The analytic strategy proceeded in sequential stages, beginning with descriptive statistics to characterize sample distributions, followed by bivariate tests to identify significant associations, and culminating in multivariable modeling. Several water quality parameters exhibited substantial positive skew and heteroscedasticity. To address these issues, a Box–Cox transformation ($\lambda \approx 0$, equivalent to a natural log transformation) was applied to stabilize variance and normalize distributions before conducting analysis.

Pearson correlation coefficients and Chi-square tests were used to examine associations between independent and dependent variables. These tests informed model selection by identifying variables with statistically significant or theoretically meaningful relationships. Parametric (paired *t*-test) and non-parametric (Wilcoxon signed-rank test) models were used to evaluate the impact of boiling on water quality, while multiple linear regression models were constructed to assess whether household composition (households with children versus those with elderly residents) was associated with differing exposure levels. In these models, continuous water quality variables (lead, copper, iron, zinc, chlorine, sulfate, pH, and TDS) served as dependent outcomes.

Household sociodemographic characteristics including education level, employment status, income, home location, and length of residence were also operationalized as predictors of water quality concentrations and examined using a multiple regression model.

3. Results

3.1. Participant Demographics

Twenty-six households and three businesses ($n = 29$) met the inclusion criteria and were selected for sampling. Study participants reflected the majority racial demographics of Jackson, Byram, and Terry, with 93% identifying as Black or African-American alone. Household income was collected in ranges (e.g., \$0–\$10,000). The average median household income for study participants fell between \$40,000 and \$49,999, with the majority of participants reporting fixed incomes, such as retiree salaries or social security payments, as their primary source of income. Based on the median income of participants, the poverty level in this sample was 34.6%, which is higher than that reported for the city of Jackson, Byram, Terry, the state of Mississippi, and the United States overall. Despite the poverty levels, 53% of participants reported holding a Bachelor’s degree or higher, while 46% held a high school diploma or reported some college or an Associate’s degree.

To contextualize participant characteristics, Table 4 compares the Jackson Water Study (JWS) sample to local, state, and national demographics (Jackson, Byram, Terry, Mississippi,

and the United States), including population size, race/ethnicity, education, income, age distribution, and poverty. City, state, and national data were obtained from the 2022 U.S. Census American Community Survey five-year estimates.

Table 4. Demographic profile of participants in the Jackson Water Study compared with local (Jackson, Byram, and Terry), state, and national demographic characteristics, including population size, racial composition, educational attainment, median household income, poverty status, and age distribution.

Demographic Characteristics	Water Study	Jackson	Byram	Terry	Mississippi	United States
Total Population	29	153,701	12,666	1304	2,961,279	334,449,281
Race:						
White, alone	3.450%	15.10%	22.00%	24.50%	58.70%	75.30%
Black/African American, alone	96.55%	82.20%	75.10%	73.20%	37.80%	13.70%
Education:						
High School Diploma or higher *	46.70%	87.30%	95.70%	54.30%	86.20%	89.10%
Bachelor's Degree or higher	53.30%	28.70%	37.40%	40.70%	23.90%	34.30%
Income and Poverty:						
Median Income **	\$40,000–\$49,999	\$42,193	\$72,536	\$46,585	\$52,985	\$75,149
% Poverty	34.60%	25.90%	6.80%	9.70%	18.00%	11.10%
Age:						
Less than 5 years old	16.40%	6.60%	4.40%	11.20%	5.90%	5.50%
Under 18 years	29.80%	24.00%	24.10%	52.90%	23.10%	21.70%
Individuals 65 years or older	32.80%	14.30%	10.80%	9.00%	17.60%	17.70%

Notes: Source: [24,62]. * Percentage for the JWS includes high school diploma (or equivalent), some college but no degree awarded, and associates degree. State and national percentages include bachelor's degrees and higher.

** Annual household income was collected as salary ranges.

3.2. Water Quality Parameters

At each location, water samples were collected for lead (Pb), copper (Cu), iron (Fe), zinc (Zn), chlorine (Cl), sulfate (SO₄), pH, and total dissolved solids (TDS). Samples were collected in both pre-boiled (under normal tap conditions) and post-boiled states. Additionally, water analysis results for the metals were provided in micrograms per liter (µg/L), so they were converted to milligrams per liter (mg/L) for consistency across results and comparison to EPA's MCLs for each parameter.

I. Lead, Copper, Iron & Zinc

Due to the LCRI, lead was monitored at both the first (L1) and fifth (L5) liter. For first liter samples, low levels of lead were detected in 19 of 29 samples, with the remaining samples at the minimum reporting limit. From L1 to L5, there was an overall decrease in mean lead concentration from 0.00144 to 0.000742 mg/L. This pattern suggests that Liter 1 captures lead leached during stagnation in household plumbing, while Liter 5 reflects lower levels following flushing, indicating that portions of household plumbing or premise plumbing fixtures are likely sources of lead. From L5 to the boiled sample, mean lead concentration declined further from 0.000742 to 0.0005678 mg/L.

The median lead concentration across all samples was 0.0005, corresponding to the lowest detectable limit, which indicates that most homes had lead levels below quantifiable thresholds. Notably, the standard deviation for L1 (0.0019) was higher than for L5 and boiled samples, reflecting greater variability in first-draw lead concentrations and suggesting household-specific differences in plumbing materials or stagnation conditions. In contrast, boiled samples exhibited the least variation, likely because many measurements were at or near the detection limit. Overall, these findings suggest that lead release in the distribution system is more closely associated with stagnation in household plumbing and mechanical disturbances (e.g., flushing) than with broader, uniform water chemistry conditions. Table 5 provides lead concentrations for each location.

Table 5. Lead concentrations (mg/L) measured at each sampling location for Liter 1, Liter 5, and boiled water samples. The table also presents summary metrics (mean, median, variance, and standard deviation) for each sampling type to characterize overall distribution and variability across the 29 study sites.

Sampling Location	Lead Concentration (mg/L)		
	Liter 1	Liter 5	Liter Boiled
Location 1	0.0005	0.0005	0.0005
Location 2	0.0005	0.0005	0.0005
Location 3	0.0005	0.0005	0.0005
Location 4	0.0005	0.0005	0.0005
Location 5	0.0005	0.0005	0.0009
Location 6	0.0019	0.0018	0.0009
Location 7	0.0017	0.0006	0.0005
Location 8	0.0013	0.0010	0.0007
Location 9	0.0006	0.0005	0.0005
Location 10	0.0031	0.0018	0.0007
Location 11	0.0052	0.0011	0.0006
Location 12	0.0005	0.0005	0.0005
Location 13	0.0008	0.0005	0.0005
Location 14	0.0009	0.0005	0.0005
Location 15	0.0009	0.0005	0.0005
Location 16	0.0006	0.0007	0.0005
Location 17	0.0005	0.0005	0.0005
Location 18	0.0005	0.0005	0.0005
Location 19	0.0005	0.0005	0.0005
Location 20	0.0005	0.0005	0.0005
Location 21	0.0005	0.0005	0.0005
Location 22	0.0015	0.0005	0.0005
Location 23	0.0006	0.0005	0.0005
Location 24	0.0005	0.0005	0.0005
Location 25	0.0029	0.0008	0.0005
Location 26	0.0005	0.0005	0.0005
Location 27	0.0094	0.0025	0.0009
Location 28	0.0032	0.0012	0.0006
Location 29	0.0005	0.0005	0.0006
Mean	0.0014	0.0007	0.0006
Median	0.0006	0.0005	0.0005
Variance	0.0000036	0.0000002	0.0000000
Standard Deviation	0.0019094	0.0004978	0.0001329

For the other metals, iron was detected at low levels in 28 first-liter samples, and zinc was detected at low levels in 14 first-liter samples, with the remaining samples in compliance with applicable standards. Copper was consistently detected in all 29 samples and was the only metal without any below-detection results. All measured concentrations for copper, iron, and zinc remained below EPA maximum contaminant levels (MCLs), and many were at or near minimum detection limits.

II. Chlorine, Sulfate, & Chlorine-to-Sulfate Mass Ratio (CSMR)

Chlorine and sulfate were measured in all 29 samples. Chlorine was below the detection limit in five samples; in the remaining 24 locations, chlorine concentrations decreased after boiling, which is consistent with the volatilization of chlorine when heated. Sulfate showed no below-detection results, and post-boil sulfate concentrations were generally stable.

CSMR was calculated using the measured chlorine and sulfate concentrations. CSMR values exhibited substantial variability across the system, with seven locations having a

corrosion factor greater than 0.5, indicating increased potential for galvanic corrosion at these sites. Spatially, the northern and northeastern portions of Jackson were more likely to exhibit lower CSMR values (<0.5), while higher CSMR values (>0.5) were observed primarily in the southern and southwestern portions of Jackson, including Byram. Clusters of high-CSMR points were observed in west Jackson and near the Byram boundary, potentially corresponding to areas with legacy infrastructure issues or known problem segments of the water distribution system. Figure 4 shows the spatial distribution of CSMR values and highlights locations with CSMR above or below the 0.5 threshold.

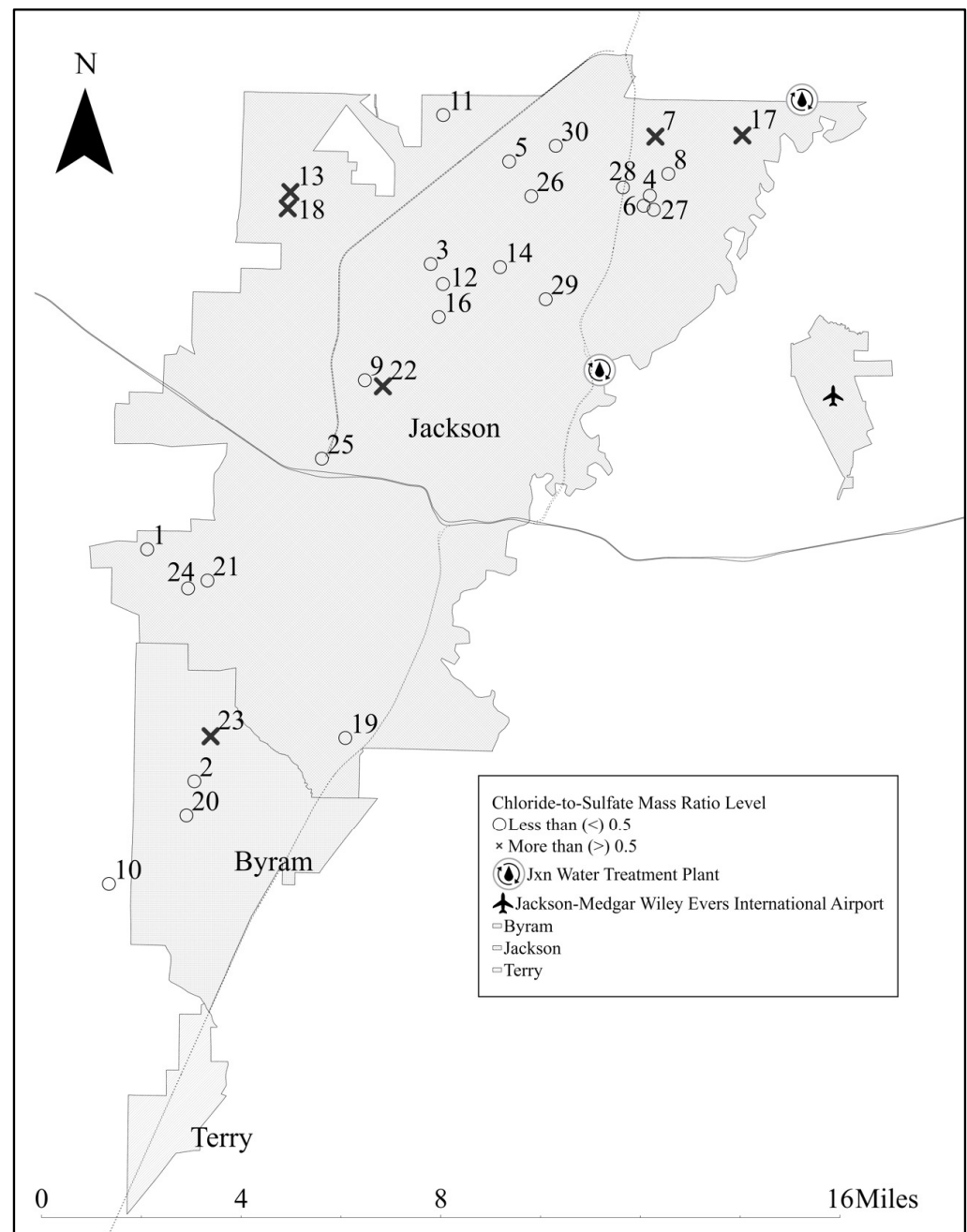


Figure 4. Spatial distribution of Chlorine-to-Sulfate Mass Ratio (CSMR) values across the 29 sampling locations in the Jackson Water Study, indicating whether each site exceeded or fell below the corrosion-relevant threshold of 0.5. Locations with CSMR > 0.5 are dispersed throughout the service area, suggesting elevated potential for galvanic corrosion in multiple zones rather than being confined to a specific subregion. This spatial pattern implies that corrosivity risk is influenced by system-wide water chemistry conditions rather than localized anomalies in the distribution network.

III. pH, Total Dissolved Solids (TDS), and Temperature

Field measurements were obtained for pH, TDS, and temperature, with temperature monitored at ambient, rolling boil, and post-boil stages. Across all 29 locations, pH levels exceeded the EPA secondary standard range, with values indicating high (9–10) to very high (>11) alkalinity. Some locations recorded pH values as high as 11.72, 12.03, and 12.21. Spatially, the highest pH values (11.01–12.5) were concentrated in central and northeastern Jackson, east of Interstate 55 and near Byram, while moderately elevated pH values (9.5–11.0) were more common in west Jackson, including clusters along Interstates 220 and 20. Figure 5 illustrates the spatial distribution of pH values, and Figure 6 presents a scatterplot of pH levels for all sampling locations, highlighting exceedances relative to the EPA's recommended range. Supplemental Table S1 summarizes all the water quality parameter concentrations in the pre-boiled and post-boiled states for each sampling location, and Supplemental Table S2 provides an overview of the mean, standard deviation, variance, skewness, and kurtosis for each parameter (Tables S1 and S2).

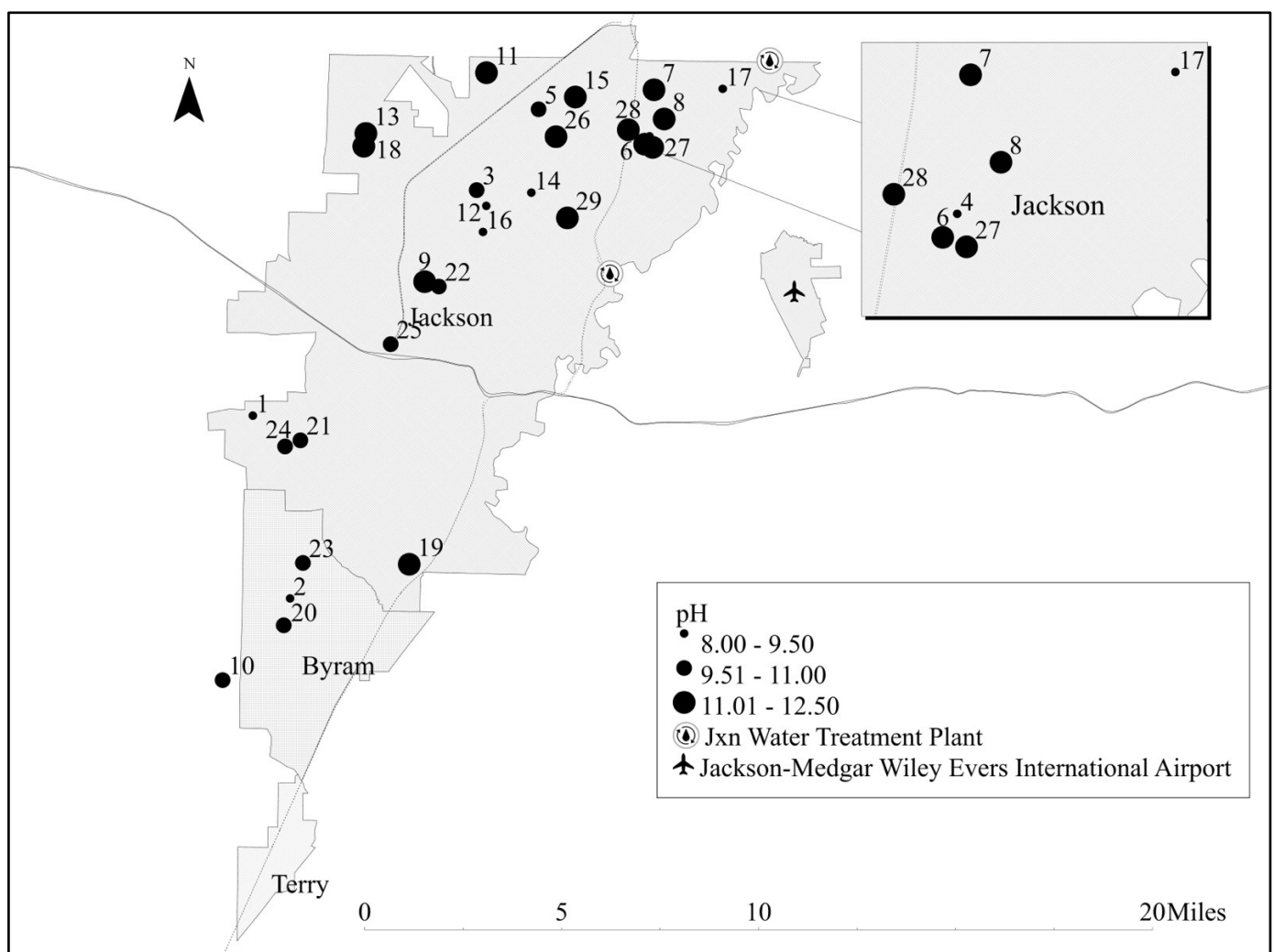


Figure 5. Spatial distribution of pH values measured across the Jackson metropolitan area, with point sizes representing pH magnitude. Elevated pH values were observed throughout the service area, with no apparent geographic clustering, indicating that high alkalinity is a system-wide condition rather than a localized phenomenon.

In terms of TDS, although TDS concentrations complied with the EPA secondary standard of 500 mg/L, many locations had TDS levels between 150 and 300 mg/L, indicating appreciable dissolved mineral content. Spatial visualization revealed a distinct area of concern: the highest densities of elevated TDS values (up to 311 mg/L) were concentrated in southwest Jackson, Byram, and Terry. While these TDS levels are not acutely hazardous, prolonged exposure to higher TDS can affect taste, contribute to household pipe scaling, and may contribute to bioaccumulation-related long-term health concerns [52,63]. Figure 7 depicts the localized nature of elevated TDS concentrations across the study area.

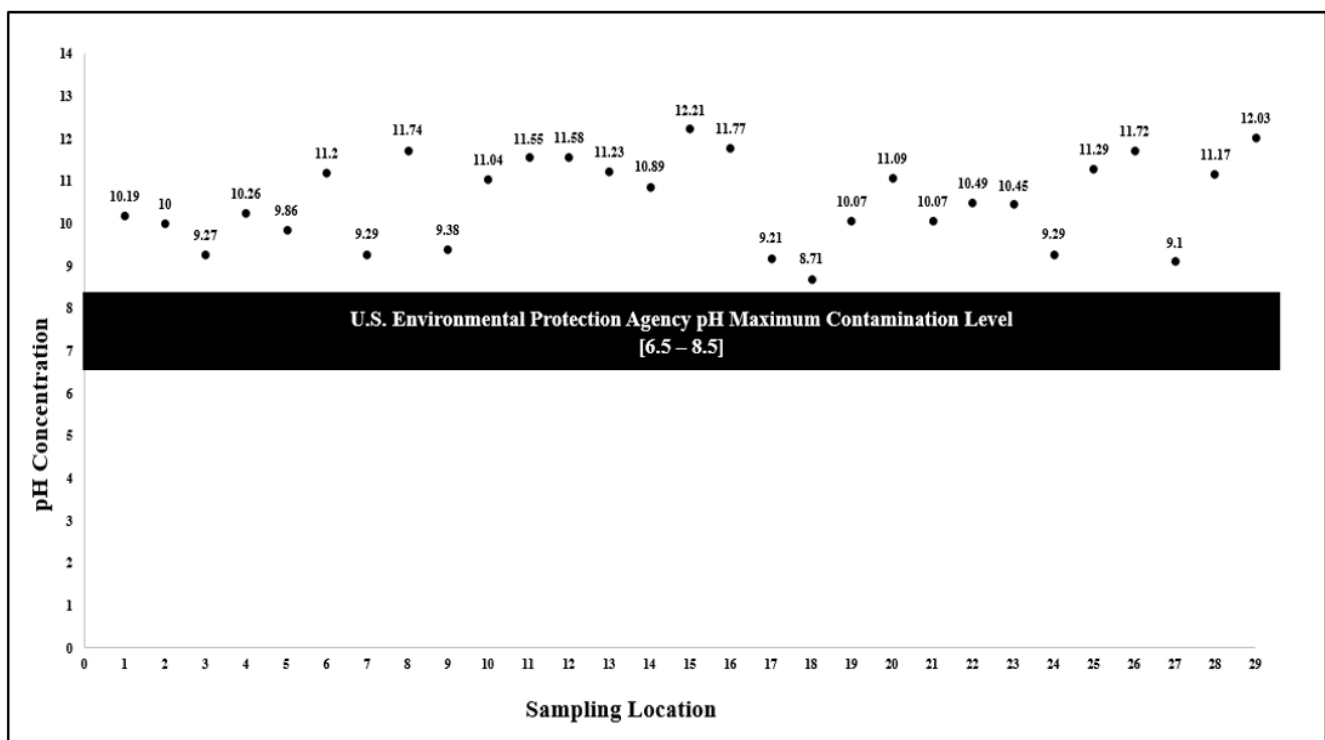


Figure 6. Scatterplot of pH values measured at each of the 29 sampling locations in the Jackson Water Study, plotted against the U.S. EPA recommended pH range for drinking water (6.5–8.5). All sampling locations exhibited pH values above the upper regulatory threshold, indicating system-wide elevation in alkalinity with potential implications for corrosion control performance and the solubility and mobility of metals within the distribution system [64–66].

IV. Combined Water Quality Parameters (pH, TDS, & CSMR)

When pH, CSMR, and TDS are evaluated together, distinct spatial patterns emerge. Elevated pH and elevated CSMR values are distributed across much of the service area, reflecting a system-wide influence of treatment and overall water chemistry. In contrast, higher TDS concentrations are more concentrated in the southern and southwestern parts of the network. Figure 8 combines pH, TDS, and CSMR values at each sampling location and demonstrates regions with higher TDS often overlap with zones of elevated CSMR, while high pH is more broadly distributed. These conditions are critical in shaping corrosion potential and metal release and have important implications for corrosion control and water treatment strategies tailored to different areas of the distribution network.

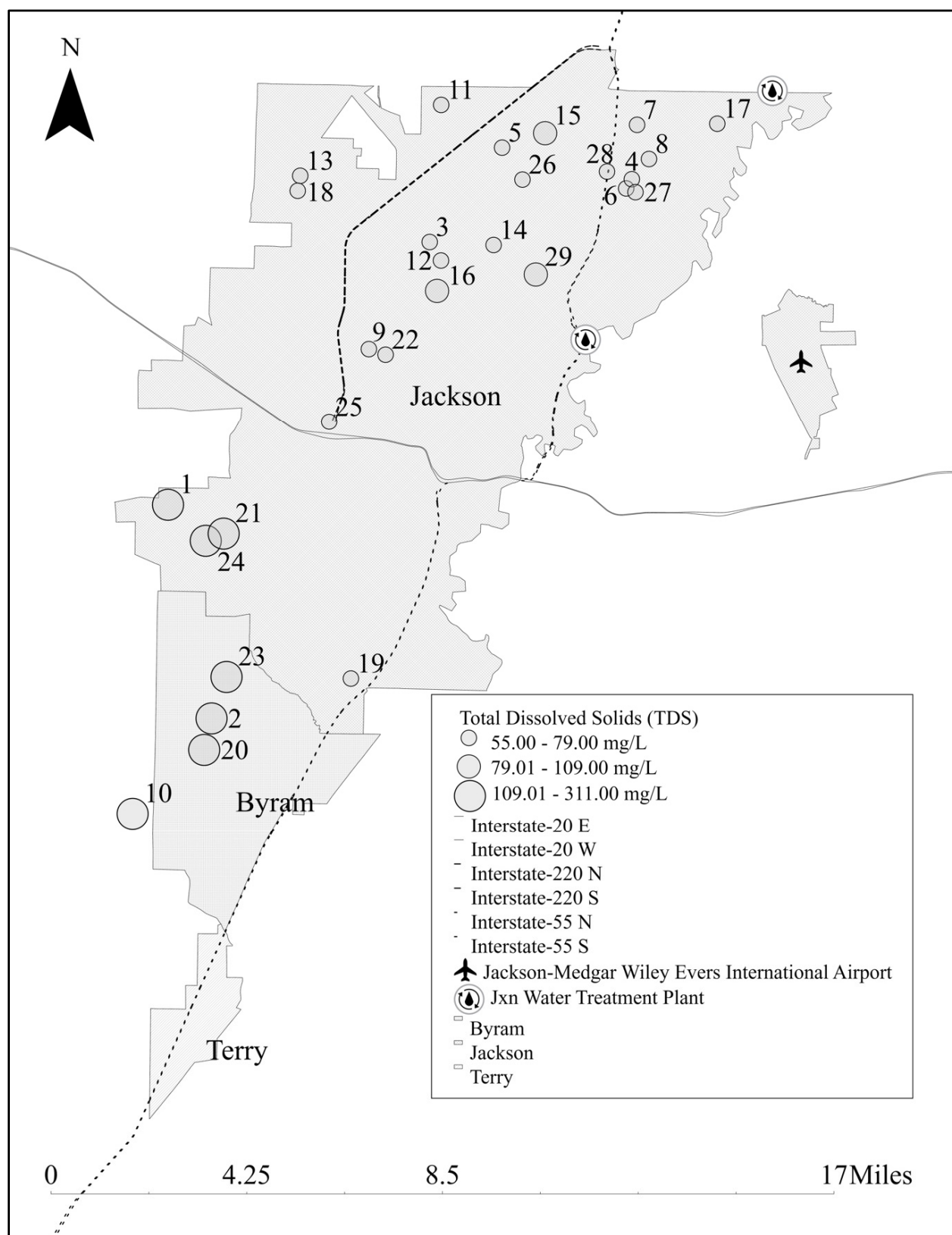


Figure 7. Spatial distribution of total dissolved solids (TDS) across the Jackson metropolitan area, with circle size indicating magnitude. TDS levels varied substantially, with elevated values concentrated in the southern and southwestern portions of the service area. This spatial pattern suggests localized differences in water chemistry.

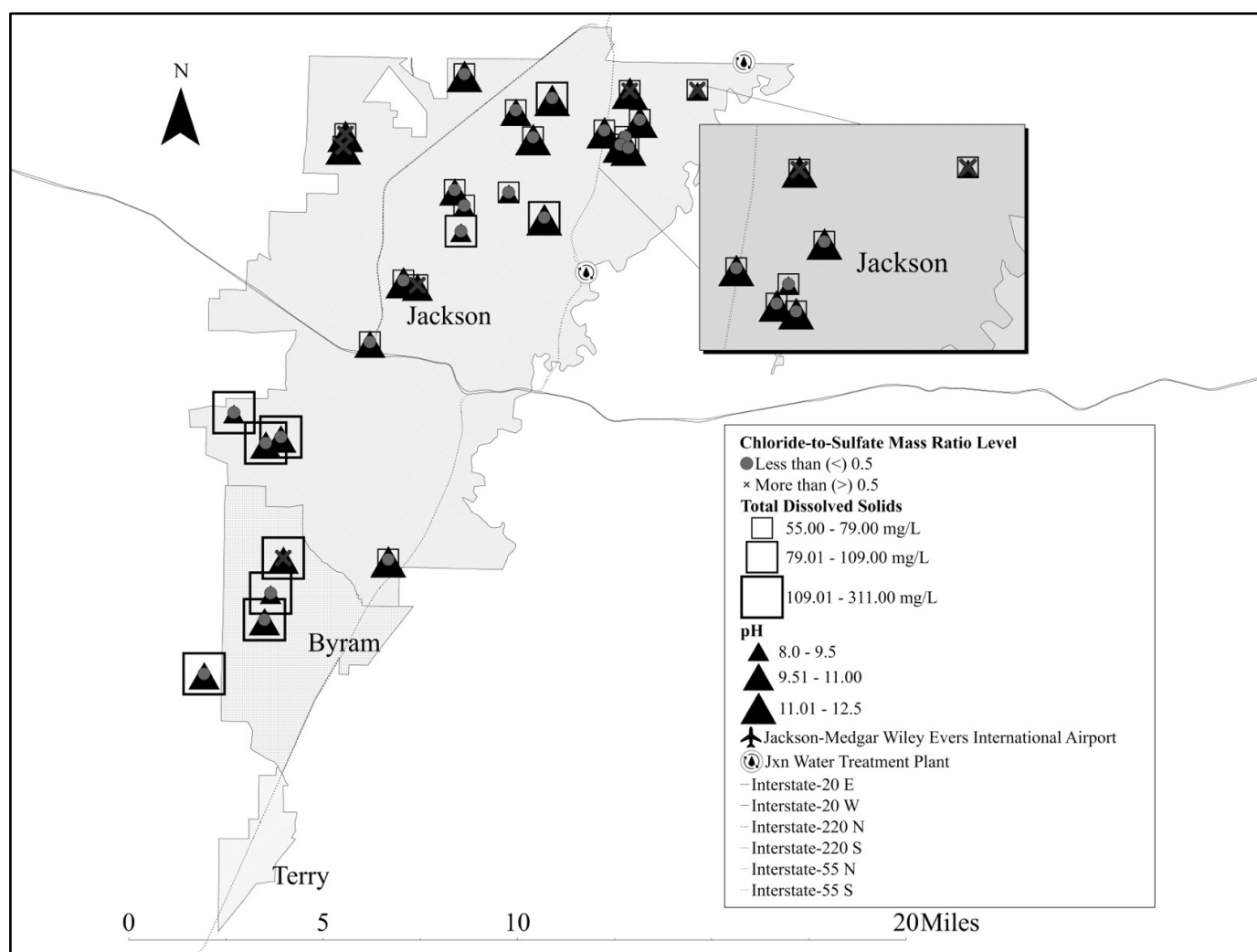


Figure 8. Spatial distribution of pH, Chlorine-to-Sulfate Mass Ratio (CSMR), and total dissolved solids (TDS) across sampling locations in the Jackson metropolitan area. The combined map shows that pH and CSMR levels are elevated across much of the system, while higher TDS concentrations appear more concentrated in the southern portion of the service area. Together, these patterns indicate that several aspects of water chemistry vary across the distribution system and may influence differences in water quality from one area to another.

3.3. Statistical Analysis

Due to the presence of outliers in some water quality parameter concentrations, a Box–Cox transformation (natural log transformation) was applied to mitigate heteroskedasticity and skewness. Both parametric (paired t -test, linear regression) and non-parametric (Wilcoxon signed-rank) tests were performed on the transformed data, given that means are more sensitive to outliers.

I. Pre-boiled samples versus Post-boiled samples

To determine if there was a difference in water quality parameters between pre-boiled and post-boiled water, paired t -tests and Wilcoxon signed-rank tests were performed for lead, copper, iron, zinc, chlorine, sulfate, and CSMR values. Total dissolved solids and pH data were not collected for post-boiled measurements and were therefore excluded from these models.

For lead, both statistical tests showed that boiling significantly reduces its concentration, consistent with the small but measurable decrease in mean levels. However, residual lead remained detectable in many samples, underscoring that boiling does not fully remove

lead from tap water. The paired *t*-test for copper suggested a statistically significant reduction, while the non-parametric test did not, indicating that the effect of boiling on copper is less certain and may be influenced by outliers or the small sample size. In the case of iron, iron displayed the least variance among the tested metals, and boiling did not significantly reduce concentrations. Zinc, on the other hand, significantly reduced concentration after boiling—confirmed by both statistical tests.

Chlorine showed a statistically significant decline in both tests, reflecting a substantial loss of free chlorine during boiling. Sulfate concentrations, however, reflected no meaningful change in the paired *t*-test, while the Wilcoxon signed-rank test indicated a small but statistically significant increase. These results are likely due to concentration effects or measurement variability rather than chemical transformation.

Finally, CSMR was significantly reduced by boiling in both parametric and non-parametric analyses, consistent with the decrease of chlorine concentrations relative to sulfate. Table 6 summarizes pre- and post-boil concentrations, variances, and the results of both tests for each parameter.

II. Linear Regression

Given the known health risks of lead and other water contaminants on vulnerable populations, households with children and adults aged 65 years or older were enrolled to evaluate potential differences in exposure. Multiple linear regression models were used to examine whether the presence of children or elderly individuals in a household was associated with differences in water parameter concentrations.

The models revealed that households with elderly residents had significantly higher sulfate concentrations, with a coefficient of 0.875, a *p*-value of 0.030, and a 95% confidence interval of (0.093, 1.658). This suggests a meaningful association between households with elderly occupants and elevated sulfate levels, potentially reflecting differences in plumbing, water use patterns, or geographic location. Elevated sulfate in drinking water can arise from treatment processes, pipe corrosion, or environmental sources. This is particularly important given that high sulfate concentrations can have laxative effects and may exacerbate dehydration or digestive issues.

Similarly, households with children exhibited significantly higher TDS concentrations, with a coefficient of 0.558, a *p*-value of 0.045, and a 95% confidence interval of (0.012, 1.104). TDS includes inorganic salts and small amounts of organic matter, which may indicate degradation of plumbing materials or localized or area-specific water chemistry. In both models, positive coefficients suggest that the presence of children or elderly occupants is associated with higher concentrations of the respective parameters. Table 7 summarizes regression coefficients, standard errors, *p*-values, and confidence intervals for lead, copper, iron, zinc, chlorine, sulfate, pH, TDS, and CSMR in households with children and households with elderly residents.

Table 6. Pre-boil and post-boil concentrations of water quality parameters across all sampling locations, with paired statistical tests assessing the effects of boiling. Boiling significantly reduced lead, zinc, and chlorine levels, indicating sensitivity of these constituents to heating or volatilization. Copper showed a modest decline, while iron and sulfate remained largely unchanged. CSMR values decreased due to chlorine loss. Together, these results show that boiling alters certain aspects of water chemistry, particularly chlorine and trace metals, while most dissolved constituents remain stable.

Parameter	Pre-Boil				Post-Boil				Paired T-Test Results						Wilcoxon Signed Rank Test Results			
	Average Concentration	Standard Deviation	Variance	Median	Average Concentration	Standard Deviation	Variance	Median	p-Value	Lower Bound CI	Upper Bound CI	T-Value	Standard Deviation	Mean	p-Value	Lower Bound CI	Upper Bound CI	W-Value
Lead	0.00144	0.0019094	0.0000036	0.001	0.0005678	0.000133	0.0000	0.001	0.016 **	0.00017	0.00157	2.56	0.00184	0.0009	0.001 **	0.00005	0.00118	145
Copper	0.03748	0.0414862	0.0017211	0.021	0.0238176	0.020186	0.0004	0.015	0.025 **	0.00186	0.02548	2.37	0.03105	0.1367	0.074	−0.0007	0.01735	300.5
Iron	0.11514	0.0754225	0.0056886	0.100	0.1002070	0.001114	0.0000	0.100	0.295	−0.0137	0.04360	1.07	0.07540	0.0149	0.371	0.00000	0.00000	3
Zinc	0.02830	0.0445429	0.0019841	0.100	0.0102345	0.000878	0.0000	0.010	0.036 **	0.00125	0.03487	2.2	0.04419	0.0181	0.001 **	0.00145	0.00880	120
Chlorine	1.20379	0.9535540	0.9092660	0.972	0.5117930	0.4148740	0.1721	0.447	0.000 **	0.44600	0.93800	5.77	0.64500	0.6920	0.000 **	0.42150	0.89550	294
Sulfate	9.18414	13.993500	195.81700	3.620	9.2344800	9.6588700	93.294	4.160	0.985	−5.35	5.25000	−0.02	13.9300	−0.0500	0.000 **	−1.32	−0.485	29
pH	10.5569	1.0120000	1.0241400	10.49	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TDS	117.839	84.868700	7202.7000	72.00	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CSMR	0.27841	0.2774290	0.076967	0.130	0.1179660	0.1150720	0.01324	0.089	0	0.0821	0.2388	4.19	0.206	0.1604	0	0.057	0.249	406

Notes: N = 29. Confidence Interval at 95%. ** Statistically significant.

Table 7. Linear regression results comparing water quality parameter concentrations between households with children and households with elderly residents. Most parameters showed no statistically significant differences between the two household groups, indicating broadly similar water chemistry conditions. However, households with children exhibited significantly higher total dissolved solids (TDS), while households with elderly residents displayed significantly higher sulfate concentrations. These differences suggest localized variation in dissolved mineral content but do not indicate widespread demographic-based disparities in overall water quality.

Parameter	Households with Children						Households with Elderly Residents					
	N	Coefficient	SE Coefficient	p-Value	Lower Bound CI	Upper Bound CI	Coefficient	SE Coefficient	p-Value	Lower Bound CI	Upper Bound CI	
Lead	26	−0.282	0.334	0.407	−0.973	0.409	−0.062	0.358	0.865	−0.803	0.680	
Copper	26	0.689	0.161	0.398	−0.662	0.984	0.529	0.427	0.227	−0.354	1.412	
Iron	26	−0.074	0.153	0.631	−0.291	0.387	0.048	0.164	0.773	−0.291	0.387	
Zinc	26	0.146	0.345	0.676	−0.567	0.859	0.482	0.370	0.205	−0.283	1.247	
Chlorine	26	0.163	0.615	0.794	−1.11	1.435	0.429	0.66	0.522	−0.935	1.794	
Sulfate	26	0.548	0.353	0.134	−0.181	1.278	0.875	0.378	0.030 **	0.093	1.658	
pH	26	0.0286	0.045	0.534	−0.065	0.122	0.033	0.049	0.509	−0.0678	0.133	
Total Dissolved Solids	26	0.558	0.264	0.045 **	0.012	1.104	0.240	0.283	0.405	−0.345	0.825	
Chlorine-to-Sulfate Mass Ratio	26	−0.410	0.809	0.618	−2.083	1.264	−0.493	0.868	0.575	−2.288	1.302	

Notes: Confidence Interval at 95%. ** Statistically significant.

III. Multiple Regression

Multiple regression analyses were conducted using sociodemographic variables obtained from household surveys (education level, employment status, household income, location of home, and length of residency in home and City) as predictors of water quality concentrations for the 26 households in the study. In the full model, TDS emerged as the only water quality parameter that demonstrated a relationship with the sociodemographic predictors. After the model was restricted to TDS and the sociodemographic variables, *location of the home* (north versus south of Interstate 20) was a statistically significant predictor, with a coefficient of 0.784, a p -value of 0.004, and a 95% confidence interval of (0.286, 1.282). When non-informative sociodemographic variables were removed, the final model was refit with location as the sole predictor; location remained significant (coefficient 0.775, p -value 0.001, and CI of [0.357, 1.193]), and model performance improved (adjusted $R^2 = 35.31\%$). These results suggest that household-level sociodemographic factors have limited influence on TDS, but indicate that households south of Interstate 20 consistently experience higher TDS concentrations, which was also observed in the spatial patterns in Figure 7. Together, these findings show that spatial position within the distribution network could influence exposure to higher TDS concentrations. Table 8 summarizes the full and reduced models for TDS and sociodemographic variables.

Table 8. Multiple regression models evaluate the association between total dissolved solids (TDS) concentrations and household socioeconomic characteristics. Across all sociodemographic predictors (educational attainment, employment status, household income, length of residence in the home or city) none were significantly associated with TDS levels. In contrast, the location of the home was a significant predictor in both the full and reduced models, indicating that spatial position within the distribution system, rather than socioeconomic factors, is the primary driver of variation in TDS. Model fit statistics (R^2 and adjusted R^2) further support location as the dominant explanatory factor for household-level TDS differences.

Demographic Variable	Total Dissolved Solids (TDS) in Households					
	N	Coefficient	SE Coefficient	p -Value	Lower Bound CI	Upper Bound CI
Educational Attainment	26	0.081	0.274	0.772	−0.494	0.655
Employment Status	26	−0.144	0.265	0.595	−0.699	0.412
Household Income	26	0.282	0.285	0.336	−0.315	0.878
Length in Home	26	−0.347	0.255	0.190	−0.881	0.188
Length in City	26	0.161	0.261	0.545	−0.385	0.706
Location of Home	26	0.784	0.238	0.004 **	0.286	1.282
R-squared	47.63					
Adjusted R-squared	31.09					
Location of Home	26	0.775	0.202	0.001 **	0.357	1.193
R-squared	37.90					
Adjusted R-squared	35.31					

Notes: Confidence Interval at 95%. ** Statistically significant.

4. Discussion

Annually, the United States produces roughly 270,000 metric tons of lead for uses ranging from car batteries and metal alloys to food additives and drinking water service line materials [67]. As Jacobs and Brown [68] (p. 235) emphasize, lead remains a “multimedia pollutant” that can be encountered through drinking water, food, consumer products, hobby activities, and other pathways. Within public water systems, especially those with lead service lines, lead contamination arises primarily from corrosion and leaching of legacy plumbing materials. The 1991 Lead and Copper Rule was designed to mitigate these

risks by setting action levels for lead (0.015 mg/L) and copper (1.3 mg/L) and requiring corrective actions when exceedances occur. Today, between nine and twelve million lead service lines remain in service across U.S. community water systems, serving an estimated 22 million people daily [69]. As LaNier [70] (p. 173) observed, community water supply reflects the “political, social, and economic development of this country” and the degree to which public officials are attentive to public health. More recent work by Teodoro et al. [71] (p. 25) shows that contamination episodes are most common in places that are “both poor and nonwhite”, underscoring the racialized and classed distribution of water-related harm.

This study examined water quality conditions across the Jackson, Mississippi, metropolitan area following the 2022 distribution system collapse, repeated noncompliance with the LCR, and numerous boil-water notices. Overall, the findings indicate that none of the studied metals (Pb, Cu, Fe, Zn) or the primary contaminants chlorine and sulfate exceeded U.S. EPA MCLs at the time of sampling. However, several parameters approached or exceeded secondary drinking water standards and revealed meaningful spatial and distributional patterns. Lead concentrations were generally at or near laboratory reporting limits, but localized elevation in first-draw or flushed samples suggests that household plumbing remains an important source of risk [72]. Combined with the presence of lead service lines elsewhere in the system, these results highlight the need for ongoing lead service line replacement and targeted monitoring, especially in older housing stock and vulnerable populations, even when system-wide averages appear compliant.

This study also documented elevated TDS concentrations, though still below the EPA secondary standard of 500 mg/L. Many locations had TDS levels between 150 and 300 mg/L, a range at which taste and odor complaints commonly increase [52,73]. These values likely reflect a combination of groundwater intrusion, distance from treatment facilities, and interactions with aging pipes, particularly in South Jackson, Byram, and Terry—areas historically served by the J.H. Fewell Water Treatment Plant. Following infrastructure failures at J.H. Fewell, all drinking water is treated and distributed from the O.B. Curtis plant, which could be increasing hydraulic complexity and residence times in some downstream areas [16,74,75]. Elevated TDS at the observed levels is not acutely toxic, but it can signal broader water quality issues, including the presence of metals, salts, and organic contaminants [64]. Chronic exposure, especially among young children and older adults with preexisting health conditions, may exacerbate concerns related to hydration, kidney function, and the cumulative burden of contaminants [76,77].

Regression analyses reinforced the importance of spatial location within the distribution network. In the multiple regression models, some household-level socioeconomic indicators (i.e., income, education, employment, and length of residence) were not significant predictors of TDS. Instead, the location of the home emerged as the key determinant: residents living south of Interstate 20 consistently experienced higher TDS values. The reduced model, which retained only location as a predictor, explained a substantial proportion of the variation in TDS and aligned with spatial mapping that showed higher TDS in southwest Jackson, Byram, and Terry. These findings suggest that place-based infrastructure conditions, rather than individual household demographics, contribute to variability in dissolved mineral content. Nonetheless, because these higher-TDS areas are also socioeconomically marginalized, the burden of poorer aesthetic quality and potential long-term health risks still falls disproportionately on Black, lower-income communities.

Corrosion-related indicators further underscore the intersection of water chemistry and infrastructure aging. Seven sampling locations exhibited CSMRs above the 0.5 threshold, indicating that at least 24% of study participants may be consuming water with conditions favorable to galvanic corrosion. Mapping revealed that lower CSMR values tended to occur closer to the O.B. Curtis plant, with higher CSMR values emerging downstream,

particularly in Byram and the southwestern portions of the service area. This pattern suggests that treatment may effectively control corrosivity at the plant, but that conditions change as water travels through older or more complex parts of the distribution system. While CSMR is not currently a regulated parameter, the present study supports its use as a secondary indicator of corrosion potential and a complementary tool for identifying locations where lead monitoring and infrastructure remediation should be prioritized.

The patterns observed for pH were equally notable. Every sampled location exceeded the EPA's secondary standard range (6.5–8.5), with many pH readings above 11. Such high alkalinity can alter corrosion dynamics, potentially increasing metal leaching under certain conditions, undermining chlorine disinfection, and posing risks to sensitive individuals [38,39,52]. The widespread, consistently elevated pH values suggest system-wide overcorrection in corrosion control. In communication with the court-appointed manager of Jackson's water system, the research team learned that the high pH resulted from intensified corrosion control measures to address prior lead exceedances and from the consolidation of production at the O.B. Curtis plant following infrastructure collapse at J.H. Fewell. These adjustments may have reduced lead solubility under certain conditions, but when high pH coincides with elevated CSMR and TDS, the combined effect can still favor corrosion, scale formation, and plumbing damage [34,78].

Notwithstanding these notable results, a few limitations are disclosed. First, the boiling protocol used here was designed to reflect real-world practices in households and businesses responding to boil-water notices. However, these results must be interpreted in light of varying kitchen environments across the study sites (i.e., gas versus electric ranges, ventilation, or recent plumbing upgrades), which may influence heating dynamics, sedimentation of metals, and volatilization rates of gases. These variables were not explicitly modeled and may confound estimates of boiling effects. Second, the demographic composition of the study participants primarily reflects the impacts on Black households and businesses. Despite efforts to recruit a socioeconomically, racially, and ethnically diverse participant pool, resource constraints limited outreach via major media outlets (e.g., prime-time television, the Clarion Ledger). Attempts to partner with additional churches and businesses yielded limited success. While this focus is analytically valuable for understanding environmental inequities, it also limits generalizability to more racially or socioeconomically mixed populations. Third, the sample size is reflective of a pilot study ($n = 29$), and no statistical power calculation was performed, which may have reduced the ability to detect some associations. Fourth, this study did not explicitly incorporate environmental or infrastructure variables such as pipe materials, proximity to water mains, or precise building age into the regression models. These unmeasured factors could be important confounders and may explain some of the observed spatial variation in TDS, CSMR, and metals. Fifth, this study was conducted in the context of a single, large community water system serving more than 100,000 connections. Hence, findings may not be directly generalizable to smaller systems, rural utilities, or systems with different treatment practices and infrastructure histories.

Future studies should explore more controlled laboratory experiments to replicate boiling conditions and better isolate the effects of heating, evaporation, and particulate sedimentation. Integrating infrastructure data (e.g., service line material, pipe diameter, repair history) and more granular spatial modeling would also improve understanding of how distribution system characteristics shape household exposures.

5. Conclusions

Research has well-established that communities of color face disproportionate exposure to environmental hazards, including unsafe drinking water. The findings here

align with this extensive research and highlight that longstanding inequities in public water infrastructure financing and regulatory oversight compound community impacts and exacerbate public health risks.

The results underscore the need for sustained water quality monitoring, long-term infrastructure investment, improved communication between public officials and residents, and offer actionable guidance for municipal and public health stakeholders. Spatial mapping of pH, TDS, and CSMR values also provides a basis for localized corrosion control, prioritization of pipe replacement programs, and community-specific health outreach. Finally, the results highlight that even when primary MCLs are not exceeded at a given sampling time, secondary standards, spatial patterns in TDS and CSMR, and persistently high pH levels can signal ongoing vulnerabilities in water quality and infrastructure. These findings challenge narrow interpretations of LCR compliance that focus on system-wide metrics rather than household-level exposures and cumulative risk in marginalized communities.

In this context, the Jackson Water Study offers critical insights into how regulatory noncompliance, infrastructural decay, and systemic racism intersect in the lived experience of a community in an active drinking water crisis. Policy efforts must prioritize lead service line replacement in historically marginalized communities; offer more flexible infrastructure financing options, and enhance transparency with the public regarding regulatory action. Ultimately, targeted and data-driven interventions remain essential for safeguarding public health and advancing environmental equity in affected communities, rather than episodic crisis response or punitive enforcement actions, they are critical to realize the promise of safe, equitable drinking water in Jackson and similarly situated communities around the world.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/w18030424/s1>. Table S1. All water quality parameter concentrations per sampling location. Table S2. Descriptive statistics of water quality parameter concentrations.

Author Contributions: Conceptualization, A.N.M.; methodology, A.N.M., Y.J.M. and D.E.T.; software, A.N.M., A.C., J.K.; E validation, A.N.M., Y.J.M. and D.E.T.; formal analysis, A.N.M.; investigation, A.N.M., A.C., Y.J.M. and J.K.; resources, A.N.M.; data curation, A.N.M.; writing—original draft preparation, A.N.M., A.C., J.K.; writing, review and editing, A.N.M., Y.J.M., A.C., J.K. and D.E.T.; visualization, A.N.M., D.E.T.; supervision, D.E.T.; project administration, A.N.M.; funding acquisition, A.N.M. All authors have read and agreed to the published version of the manuscript.

Funding: Funding for this project was provided by Yale University Graduate School of Arts and Sciences Dean's Emerging Scholars Award, Yale University's Institute for Biospheric Studies, and the Justice, Equity, Diversity, and Sustainability Initiative (JEDSI) Laboratory.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Yale University (Protocol #2000037006 on 23 January 2024) and Vanderbilt University (Protocol #240956 on 4 July 2024).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in this study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

CAS	Chemical Abstracts Service
CDC	Center for Disease Control and Prevention
CFR	Code of Federal Regulation
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disorder
Cl	Chlorine
CSMR	Chlorine-to-Sulfate Mass Ratio
Cu	Copper
CWS	Community Water System
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
Fe	Iron
GIS	Geospatial Imaging System
JWS	Jackson Water Study
L1	Liter One
L5	Liter Five
LCR	Lead and Copper Rule
MCL	Maximum Contaminant Level
µg/dL	Microgram per Deciliter
µg/L	Microgram per Liter
mg/L	Milligram per Liter
MS	Mississippi
NELAP	National Environmental Laboratory Accreditation Program
Pb	Lead
PWS	Public Water System
SDWA	Safe Drinking Water Act
SE	Standard Error
SO ₄	Sulfate
TDS	Total Dissolved Solid
TN	Tennessee
TMF	Technical, Managerial, and Financial
US	United States
WAL	Waypoint Analytical
Zn	Zinc

References

1. U.S. Environmental Protection Agency. Information about Public Water Systems. Available online: <https://www.epa.gov/dwreginfo/information-about-public-water-systems> (accessed on 30 December 2023).
2. Office of Disease Prevention and Health Promotion. *Safe Drinking Water Information System (SDWIS)*; U.S. Department of Health and Human Services: Washington, DC, USA, 2013. Available online: <https://odphp.health.gov/healthypeople/objectives-and-data/data-sources-and-methods/data-sources/safe-drinking-water-information-system-sdwis> (accessed on 30 December 2023).
3. Allaire, M.; Wu, H.; Lall, U. National trends in drinking water quality violations. *Proc. Natl. Acad. Sci. USA* **2018**, *115*, 2078–2083. [CrossRef]
4. McDonald, Y.; Jones, N. Drinking water violations and environmental justice in the United States, 2011–2015. *Am. J. Public Health* **2018**, *108*, 1401–1407. [CrossRef]
5. Statman-Weil, Z.; Nanus, L.; Wilkinson, N. Disparities in community water system compliance with the Safe Drinking Water Act. *Appl. Geogr.* **2020**, *121*, 102264. [CrossRef]
6. Patel, A.; Schmidt, L. Water access in the United States: Health disparities abound and solutions are urgently needed. *Am. J. Public Health* **2017**, *107*, 1354–1356. [CrossRef] [PubMed]
7. Greer, R. A review of public water infrastructure financing in the United States. *WIREs Water* **2020**, *7*, e1472. [CrossRef]

8. Smull, E.; Patterson, L.; Doyle, M. Rising market risk exposure of municipal water service providers in distressed cities. *J. Water Resour. Plan. Manag.* **2022**, *148*, 04021093. [CrossRef]
9. Paxton, C.; Anderson, K.; McDonald, Y. The water sector industry workforce: A quantitative case study, Tennessee, USA. *Util. Policy* **2022**, *76*, 101356. [CrossRef]
10. Hughes, S. A multidimensional approach to evaluating the vulnerability of drinking water systems. *J. Environ. Policy Plan.* **2022**, *24*, 210–226. [CrossRef]
11. Teodoro, M.; Switzer, D. Drinking from the talent pool. *Public Adm. Rev.* **2016**, *76*, 564–575. [CrossRef]
12. Downey, L.; Dubois, S.; Hawkins, B.; Walker, M. Environmental inequality in metropolitan America. *Organ. Environ.* **2008**, *21*, 270–294. [CrossRef]
13. Bullard, R. Race and environmental justice in the United States. *Yale J. Int. Law* **1993**, *18*, 319–335. Available online: <https://openyls.law.yale.edu/handle/20.500.13051/6282> (accessed on 10 August 2024).
14. Taylor, D. *Toxic Communities*; NYU Press: New York, NY, USA, 2014.
15. City of Jackson. *City of Jackson Public Water System ID#MS0250008: Lead and Copper Rule Treatment Technique Violations—Water Quality Parameters Not Meeting Minimum Values and Failure to Install Corrosion Control*; City of Jackson: Jackson, MS, USA, 2022.
16. Office of Inspector General, U.S. Environmental Protection Agency. *State Program Deficiencies and Inadequate EPA Oversight of State Enforcement Contributed to the Drinking Water Crisis in Jackson, Mississippi*; Report No. 24-E-0055; EPA: Washington, DC, USA, 2024.
17. Vanderbilt University Drinking Water Justice Laboratory. Jackson, Mississippi, USA, Drinking Water History Timeline Process. 2023. Available online: <https://lab.vanderbilt.edu/dwjlab/lab-resources/jackson-mississippi-usa-drinking-water-history-timeline-process/> (accessed on 7 November 2023).
18. Public Notification Rule, 65 C.F.R. § 25982. 2000. Available online: <http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100529C.txt> (accessed on 30 December 2023).
19. Centers for Disease Control and Prevention. Making Water Safe in an Emergency. Available online: <https://www.cdc.gov/water-emergency/about/index.html> (accessed on 30 December 2023).
20. U.S. Environmental Protection Agency; U.S. Consumer Product Safety Commission; U.S. Department of Housing and Urban Development. *Protect Your Family from Lead in Your Home*; EPA: Washington, DC, USA, 2021. Available online: <https://www.epa.gov/sites/default/files/2020-04/documents/lead-in-your-home-portrait-color-2020-508.pdf> (accessed on 30 December 2023).
21. U.S. Environmental Protection Agency. *Emergency Disinfection of Drinking Water*; EPA: Washington, DC, USA, 2022. Available online: <https://www.epa.gov/ground-water-and-drinking-water/emergency-disinfection-drinking-water> (accessed on 30 December 2025).
22. Ellington, C.; Jones, L. Hawkins v. Town of Shaw: The court as city manager. *Ga. Law Rev.* **1971**, *5*, 734–749. Available online: https://digitalcommons.law.uga.edu/cgi/viewcontent.cgi?article=1040&context=fac_artchop (accessed on 13 April 2025).
23. Johnson, H. Challenges of an aging water system: The Jackson water crisis—A research commentary. *Online J. Rural Urban Res.* **2022**, 5–21. Available online: https://www.jsums.edu/education/files/2022/03/2022.OJRUR_JacksonWaterCrisis_Special.Issue_Final_.pdf (accessed on 13 April 2025).
24. U.S. Census Bureau. DP05: ACS Demographic and Housing Estimates (2018–2022). Available online: <https://data.census.gov> (accessed on 7 November 2024).
25. Ward, T. The water crisis in Jackson has been decades in the making. *Wash. Post*, 13 September 2022. Available online: <https://www.washingtonpost.com/made-by-history/2022/09/13/water-crisis-jackson-has-been-decades-making/> (accessed on 21 August 2023).
26. Meng, Q. Urban water crisis causes significant public health diseases in Jackson, Mississippi, USA. *Sustainability* **2022**, *14*, 16325. [CrossRef]
27. Meng, Q. Urban water crisis and its relationship to health inequities against Black communities in the USA. *J. Clean. Prod.* **2023**, *411*, 137356. [CrossRef]
28. Edwards, M.; Triantafyllidou, S.; Best, D. Elevated blood lead in young children due to lead-contaminated drinking water: Washington, DC, 2001–2004. *Environ. Sci. Technol.* **2009**, *43*, 1618–1623. [CrossRef]
29. Hanna-Attisha, M.; LaChance, J.; Sadler, R.; Champney Schnepf, A. Elevated blood lead levels in children associated with the Flint drinking water crisis. *Am. J. Public Health* **2016**, *106*, 283–290. [CrossRef] [PubMed]
30. Gleason, J.; Nanavaty, J.; Fagliano, J. Drinking water lead and socioeconomic factors as predictors of blood lead levels in New Jersey’s children between two time periods. *Environ. Res.* **2019**, *169*, 409–416. [CrossRef] [PubMed]
31. Deshommes, E.; Laroche, L.; Nour, S.; Cartier, C. Source and occurrence of particulate lead in tap water. *Water Res.* **2010**, *44*, 3734–3744. [CrossRef] [PubMed]
32. Deshommes, E.; Andrews, R.; Gagnon, G.; McCluskey, T.; McIlwain, B.; Dore, E.; Nour, S.; Prévost, M. Evaluation of exposure to lead from drinking water in large buildings. *Water Res.* **2016**, *99*, 46–55. [CrossRef]

33. Miller-Schulze, J.; Ishikawa, C.; Foran, J. Assessing lead-contaminated drinking water in a large academic institution: A case study. *J. Water Health* **2019**, *17*, 728–736. [CrossRef]
34. Cartier, C.; Nour, S.; Richer, B.; Deshommes, E.; Prévost, M. Impact of water treatment on the contribution of faucets to dissolved and particulate lead release at the tap. *Water Res.* **2012**, *46*, 5205–5216. [CrossRef] [PubMed]
35. Dalmieda, J.; Kruse, P. Metal cation detection in drinking water. *Sensors* **2019**, *19*, 5134. [CrossRef]
36. Riblet, C.; Deshommes, E.; Laroche, L.; Prévost, M. True exposure to lead at the tap. *Water Res.* **2019**, *156*, 327–336. [CrossRef]
37. Knowles, A.; Nguyen, C.; Edwards, M.; Stoddart, A.; McIlwain, B.; Gagnon, G. Role of iron and aluminum coagulant metal residuals and lead release from drinking water pipe materials. *J. Environ. Sci. Health A* **2015**, *50*, 413–423. [CrossRef] [PubMed]
38. Nguyen, C.; Clark, B.; Stone, K.; Edwards, M. Role of chloride, sulfate, and alkalinity on galvanic lead corrosion. *J. Mater. Eng. Perform.* **2011**, *67*, 065005-1–065005-9. [CrossRef]
39. Nguyen, C.; Stone, K.; Edwards, M. Chloride-to-sulfate mass ratio: Practical studies in galvanic corrosion of lead solder. *J. Am. Water Works Assoc.* **2011**, *103*, 81–92. [CrossRef]
40. Edwards, M.; Triantafyllidou, S. Chloride to sulfate mass ratio and lead leaching to water. *J. Am. Water Works Assoc.* **2007**, *99*, 96–109. [CrossRef]
41. Schaidler, L.; Swetschinski, L.; Campbell, C.; Rudel, R. Environmental justice and drinking water quality. *Environ. Health* **2019**, *18*, 3. [CrossRef]
42. Sadler, R.; LaChance, J.; Hanna-Attisha, M. Social and built environmental correlates of predicted blood lead levels in the Flint water crisis. *Am. J. Public Health* **2017**, *107*, 763–769. [CrossRef]
43. U.S. Environmental Protection Agency. National Primary Drinking Water Regulations for Lead and Copper: Improvements (LCRI). Available online: <https://www.federalregister.gov/documents/2024/10/30/2024-23549/national-primary-drinking-water-regulations-for-lead-and-copper-improvements-lcri> (accessed on 30 December 2025).
44. U.S. Environmental Protection Agency. *EPA and the City of Jackson, Mississippi Reach Agreement to Improve Drinking Water and Protect Public Health*; EPA Region 4 News Release; EPA: Washington, DC, USA, 2021. Available online: <https://www.epa.gov/newsreleases/epa-and-city-jackson-mississippi-reach-agreement-improve-drinking-water-and-protect> (accessed on 30 December 2023).
45. U.S. Environmental Protection Agency. *National Primary Drinking Water Regulations*; EPA: Washington, DC, USA, 2021. Available online: <https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations> (accessed on 30 December 2023).
46. Microsoft. RAND Function. Microsoft Support: Redmond, WA, USA. Available online: <https://support.microsoft.com/en-us/office/rand-function-4cbfa695-8869-4788-8d90-021ea9f5be73> (accessed on 22 April 2024).
47. Environmental Systems Research Institute. *ArcGIS Pro*, Version 3.4; ESRI: Redlands, CA, USA, 2024. Available online: <https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview> (accessed on 22 April 2024).
48. U.S. Environmental Protection Agency. National Primary Drinking Water Regulations for Lead and Copper: Improvements (LCRI); Proposed Rule. *Fed. Regist.* **2023**, *88*, 84878. Available online: <https://www.federalregister.gov/documents/2023/12/06/2023-26148/national-primary-drinking-water-regulations-for-lead-and-copper-improvements-lcri> (accessed on 30 December 2023).
49. Pieper, K.; Tang, M.; Edwards, M. Flint water crisis caused by interrupted corrosion control. *Environ. Sci. Technol.* **2017**, *51*, 2007–2014. [CrossRef]
50. Pieper, K.; Martin, R.; Tang, M.; Walters, L.; Parks, J.; Roy, S.; Devine, C.; Edwards, M. Evaluating water lead levels during the Flint water crisis. *Environ. Sci. Technol.* **2018**, *52*, 8124–8132. [CrossRef]
51. Hu, J.; Gan, F.; Triantafyllidou, S.; Nguyen, C.; Edwards, M.A. Copper-induced metal release from lead pipe into drinking water. *Corrosion* **2012**, *68*, 1154. [CrossRef]
52. Yousefi, M.; Saleh, H.; Mahvi, A.; Alimohammadi, M.; Nabizadeh, R.; Mohammadi, A. Data on corrosion and scaling potential of drinking water resources using stability indices in Jolfa, East Azerbaijan, Iran. *Data Brief* **2017**, *16*, 724–731. [CrossRef]
53. U.S. Environmental Protection Agency. *SAM Chemical Methods*; EPA: Washington, DC, USA, 2025. Available online: <https://www.epa.gov/esam/sam-chemical-methods> (accessed on 5 January 2024).
54. McNeill, L.; Edwards, M. The importance of temperature in assessing iron pipe corrosion in water distribution systems. *Environ. Monit. Assess.* **2002**, *77*, 229–242. [CrossRef]
55. Triantafyllidou, S.; Burkhardt, J.; Tully, J.; Cahalan, K.; DeSantis, M.; Lytle, D.; Schock, M. Variability and sampling of lead (Pb) in drinking water. *Environ. Int.* **2021**, *146*, 106259. [CrossRef] [PubMed]
56. U.S. Environmental Protection Agency. *Basic Information about Lead in Drinking Water*; EPA: Washington, DC, USA, 2025. Available online: <https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water> (accessed on 15 October 2023).
57. U.S. Department of Agriculture, Food and Nutrition Service. *Start Simple with MyPlate*; USDA: Washington, DC, USA, 2022; Available online: https://myplate-prod.azureedge.us/sites/default/files/2022-01/SSwMP%20Mini-Poster_English_Final2022_0.pdf (accessed on 5 January 2024).

58. McGee, H. *How Much Water Does Pasta Really Need?* N.Y. Times: New York, NY, USA, 2009; Available online: <https://www.nytimes.com/2009/02/25/dining/25curi.html> (accessed on 5 January 2024).
59. JulyPanny. *EZ-9901 [Apparatus]*; JulyPanny: Shenzhen, China, 2023.
60. American Burn Association. Scald Burns. Available online: <https://www.ameriburn.org/patients/common-types-of-burns/scald-burns> (accessed on 5 January 2024).
61. Minitab, LLC. *Minitab*, Version 22; Minitab, LLC: State College, PA, USA, 2023.
62. U.S. Census Bureau. *QuickFacts: Mississippi*; U.S. Census Bureau: Washington, DC, USA, 2024. Available online: <https://www.census.gov/quickfacts/fact/table/MS,US/EDU635222> (accessed on 8 November 2024).
63. World Health Organization. *Guidelines for Drinking-Water Quality*, 4th ed.; WHO: Geneva, Switzerland, 2022.
64. U.S. Environmental Protection Agency. *Corrosion Manual for Internal Corrosion of Water Distribution Systems*; EPA 570/9-84-001; EPA: Washington, DC, USA, 1984.
65. Tam, Y.; Elefsiniotis, P. Corrosion control in water supply systems. *J. Environ. Sci. Health A* **2009**, *44*, 1251–1260. [[CrossRef](#)]
66. Kim, E.; Herrera, J.; Huggins, D.; Braam, J.; Koshowski, S. Effect of pH on the concentrations of lead and trace contaminants in drinking water. *Water Res.* **2011**, *45*, 2763–2774. [[CrossRef](#)] [[PubMed](#)]
67. Lenntech. Lead—Pb. Available online: <https://www.lenntech.com/periodic/elements/pb.htm> (accessed on 15 October 2023).
68. Jacobs, D.; Brown, M. Childhood lead poisoning 1970–2022: Charting progress and needed reforms. *J. Public Health Manag. Pract.* **2023**, *29*, 230–240. [[CrossRef](#)] [[PubMed](#)]
69. The White House. *Fact Sheet: The Biden–Harris Lead Pipe and Paint Action Plan*; Executive Office of the President: Washington, DC, USA, 2021. Available online: https://waterprogramportal.org/wp-content/uploads/2025/02/001_Skip-to-content.pdf (accessed on 15 October 2023).
70. LaNier, J. Historical development of municipal water systems in the United States 1776–1976. *J. Am. Water Works Assoc.* **1976**, *68*, 173–180. [[CrossRef](#)]
71. Teodoro, M.; Zuhlke, S.; Switzer, D. *The Profits of Distrust*; Cambridge University Press: Cambridge, UK, 2022.
72. Hatam, F.; Blokker, M.; Prévost, M. Integrated flushing and corrosion control measures to reduce lead exposure in households with lead service lines. *Water* **2025**, *17*, 2297. [[CrossRef](#)]
73. Devesa, R.; Dietrich, A. Guidance for optimizing drinking water taste by adjusting mineralization as measured by total dissolved solids (TDS). *Desalination* **2018**, *439*, 147–154. [[CrossRef](#)]
74. Sunny, I.; Husband, P.S.; Boxall, J.B. Impact of hydraulic interventions on material loading and discolouration risk. *Water Res.* **2020**, *169*, 115224. [[CrossRef](#)]
75. Prest, E.; Schaap, P.; Besmer, M.; Hammes, F. Dynamic hydraulics in a drinking water distribution system influence suspended particles and turbidity, but not microbiology. *Water* **2021**, *13*, 109. [[CrossRef](#)]
76. Weidemann, D.K.; Weaver, V.M.; Fadrowski, J.J. Toxic environmental exposures and kidney health in children. *Pediatr. Nephrol.* **2016**, *31*, 2043–2054. [[CrossRef](#)] [[PubMed](#)]
77. Kshirsagar, A.; Zeitler, E.; Weaver, A.; Franceschini, N.; Engel, L. Environmental exposures and kidney disease. *Kidney360* **2022**, *3*, 2174–2182. [[CrossRef](#)]
78. Ibrahim, A.; Aleem, F.; Ahmed, A. Corrosion and scale formation problems in water systems. In *Proceedings of the International Conference on Water, Energy, and the Environment*; American University of Sharjah: Sharjah, United Arab Emirates, 2011; pp. 1–7.

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.