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Authors

Beutel-DePrano, Ian

Song, Mingrui

Liu, Haizhou

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Occurrence of PFAS chemicals in public drinking water systems in the United States: a comprehensive analysis of near-complete EPA UCMR5 database

Ian Beutel-DePrano, Mingrui Song and Haizhou Liu *

New federal drinking water standards on per- and polyfluoroalkyl substances (PFAS) were recently established in the United States; however, the occurrence and speciation of PFAS in public drinking water systems nationwide is poorly understood. This letter provides an urgently needed comprehensive analysis on PFAS occurrence in American public drinking water systems, *via* data mining on the most updated US EPA 5th round of Unregulated Contaminant Monitoring Rule database as of May 2026, representing 95% of eventual data entries and more than 1.9 million water samples from >10 000 public water systems. Data analysis showed that the most widely occurring PFAS compounds were PFPeA, PFHxA, PFBS, PFBA, PFOS, PFOA, PFHxS and PFHpA, detected by 3.3–13% of public water facilities nationwide. 90th percentile concentrations of these compounds ranged from ca. 7 to 17 ng L⁻¹, with PFBA, PFOS and PFOA exhibiting the highest concentrations. 6.7–6.8% of all drinking water samples had either PFOA or PFOS concentration exceeding 4 ng L⁻¹. Eastern U.S. and Pacific Southwestern regions have the highest percentages (4.6–19%) of public water systems with PFOA or PFOS level exceeding 4 ng L⁻¹. The occurrence of PFAS was also modestly associated with the dependence of groundwater as the drinking water source, with higher chances of PFOA or PFOS at more elevated levels in drinking water when associated with a groundwater source. This study provides new insights into PFAS occurrence nationwide, and can assist public water systems proactively prepare for PFAS treatment prioritization and future regulatory compliance.

1. Introduction

Known as “forever chemicals”, per- and polyfluoroalkyl substances (PFAS) are a group of more than 10 000 synthetic chemicals that are widely used in food packaging, pesticides, cleaning products, textile, and aqueous film-forming foams.^{1,2} Environmental exposure to PFAS leads to its accumulation in humans and animals.^{3–5} Because of their toxicologic effects

Water impact

This communication provides an urgently needed comprehensive analysis on PFAS occurrence in American public drinking water systems, *via* data mining on the US EPA UCMR5 databased updated as of January 2026, representing more than 10 000 public water systems nationwide. This study can assist public water systems proactively prepare for PFAS treatment prioritization and future regulatory compliance.

linked to cancers, reproductive defects, endocrine and immunological disruptions,^{6–10} U.S. EPA recently established the first-ever federal drinking water standards for two PFAS chemicals, specifically, a maximum contaminant level (MCL) of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) each at 4 ng L⁻¹.¹¹ Many U.S. States have also set their guidance or notification levels on additional PFAS chemicals in drinking water.

In light of new PFAS regulations, a better understanding of PFAS occurrence in American public drinking water systems is urgently needed to prepare water treatment facilities nationwide for future treatment needs and regulatory compliances, as well as to facilitate the development and implementation of PFAS treatment technologies to most needed communities and regions. Prior studies have found that PFOA was the most commonly detected PFAS with concentrations up to hundreds of ng L⁻¹ in selective States in the U.S.^{12,13} Although selective national PFAS monitoring data were reported from the 3rd round of Unregulated Contaminant Monitoring Rule in 2016,^{14–16} the less sensitive analytical methods and limited number of PFAS samples in earlier rounds of UCMR sampling programs did not represent the current PFAS landscape.

In January 2026, US EPA released the most updated PFAS monitoring data in public drinking water systems under the 5th round of Unregulated Contaminant Monitoring Rule (UCMR5).¹⁷

The updated UCMR5 database represents a nearly complete data set of extensive sampling results the US EPA

Department of Chemical and Environmental Engineering, University of California at Riverside, Riverside, CA 92521, USA. E-mail: haizhou@engr.ucr.edu;
Fax: +1 (951) 827 5696; Tel: +1 (951) 827 2076

expects to receive by the completion of reporting in 2026, including more than 1.9 million water samples from >10 000 public water systems, therefore providing chronologically the first comprehensive window to evaluate the occurrence, speciation and geographic distributions of PFAS in drinking water nationwide. Although the UCMR5 online database has accessible data summary, it is not directly available to systematically analyze PFAS concentration, speciation, geographic distribution, and the potential sources of contamination. Furthermore, the statistical comparison of different PFAS chemicals with respect to their occurrence at both the national and regional levels are not immediately accessible. Therefore, an in-depth analysis on the monitoring data is urgently needed to understand the PFAS contamination in public water system at the national scale.

Accordingly, to understand the overall extent of PFAS contamination in national drinking water systems, this study aimed to: (1) evaluate the concentration distribution of PFAS chemicals at both the national and State scales; (2) analyze the geographic distribution of PFAS occurrence; and (3) assess the correlations between the drinking water sources and PFAS occurrence and identify hot spots of elevated PFAS water systems.

2. Methods and database

Data analyzed in this study were accessed in May 2026 from the most recent UCMR5 database that was updated in January 2026 by US EPA.¹⁸ The database contains a total of 1 863 306 PFAS drinking water samples collected from 10 297 public water systems between January 2023 and January 2026. This updated database represents 95% of all data entries from public water systems that will eventually be sampled upon the conclusion of UCMR5 program by the end of 2026. A total of 29 PFAS chemicals were analyzed in UCMR5 based on EPA method 533 (ref. 19) or 537.1,²⁰ the minimum reporting levels (MRLs) of each PFAS was summarized in Table S1 of the SI. In order to eliminate the potential bias from geographic regions with more samples, separate data analysis was conducted based on the total number of samples and the number of public water facilities, respectively. In particular, the sample-number-based analysis counted each sample in the database as an independent event, regardless of the sample facility location and time. In contrast, the facility-based analysis only counted the average PFAS concentrations of all available samples from the same water facility (either a water treatment or delivery facility) as one data entry. Only samples with a reporting PFAS values above its MRL were counted and averaged for that particular facility. A majority of PFAS chemicals, especially the most widely detected PFAS group, have similar MRLs ranging between 3 and 5 ng L⁻¹. The facility-based average value instead of mean value was used for analysis to minimize bias from excluding samples with PFAS levels below MRLs. Accordingly, the facility-based analysis is a most conservative estimate of the PFAS occurrence. When plotting samples geographically, zip codes asso-

ciated with each public water system in the database were extracted to obtain geographic information. If one public water system contained multiple zip codes, the facility with the highest average concentration was selected to prioritize the “worst case” hotspot for that specific zip code location.

3. Results and discussion

3.1. Concentration distribution of most widely occurring PFAS compounds

Our comprehensive UCMR5 analysis shows that the top eight most widely occurring PFAS chemicals – based on the percentage of public water facilities with averaged sample PFAS concentration exceeding its respective MRLs – are PFPeA, PFHxA, PFBS, PFBA, PFOS, PFOA, PFHxS and PFHpA (Fig. 1A). Specifically, PFPeA was the most widely detected PFAS, found in 13% of water systems, followed by PFHxA (detected in 11.2% of water systems), PFBS (10.9%), PFBA (10.5%), PFOS (8.7%), PFOA (8.5%), PFHxS (6.6%) and PFHpA (3.3%). This frequency detection based top ranking list

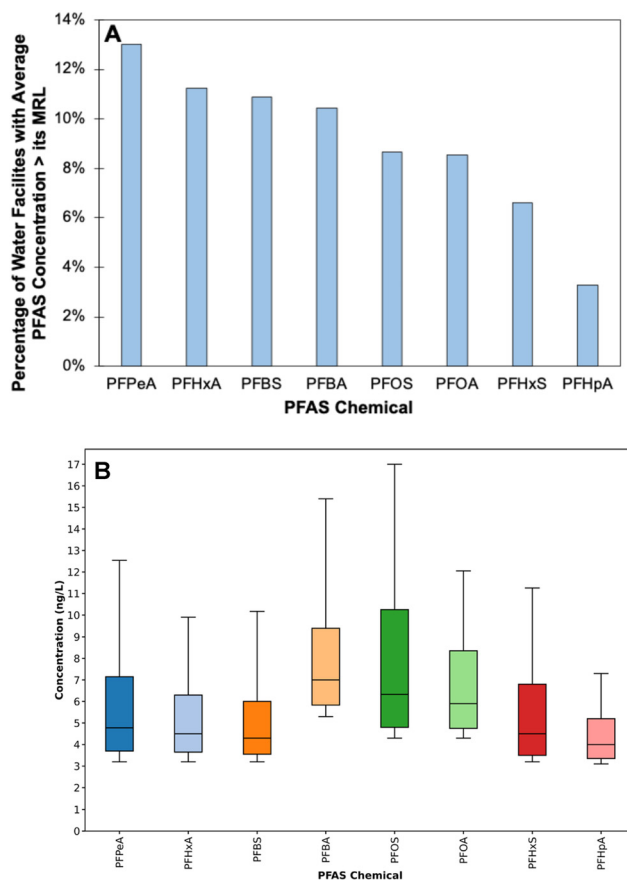


Fig. 1 Most widely detected PFAS chemicals in public drinking water systems and their concentration distribution. (A) The percentage of water facilities with average PFAS concentration above its minimum reporting level. (B) PFAS concentration distribution. The whiskers of the box plot represent the 10th and 90th percentiles of concentration. The bottom middle and upper lines of the box represent the 25th, 50th and 75th percentile values.

includes many short-chain PFAS chemicals (e.g., PFPeA and PFHxA) in addition to long-chain PFOA and PFOS, as short-chain PFAS chemicals have been widely used in various industrial process and consumer products, and exist as transformation products from long-chain PFAS degradation in the environment.

Among those top eight PFAS compounds, PFBA, PFOA and PFOS exhibited the highest concentrations (Fig. 1B). Specifically, the 10th, 50th and 90th percentile distribution of facility-based PFBA concentration was 5.3, 7.0 and 15.4 ng L⁻¹, respectively. The 10th, 50th and 90th percentile PFOA concentration was 4.3, 5.9 and 12.1 ng L⁻¹, respectively. The 10th, 50th and 90th percentile PFOS concentration was 4.3, 6.3 and 17 ng L⁻¹, respectively. Other five most widely detected PFAS compounds exhibited a 50th percentile concentration between 4.0 and 4.8 ng L⁻¹ (Fig. 1B). 90th percentile concentrations of these top eight compounds ranged from *ca.* 7 to 17 ng L⁻¹. Furthermore, the other 21 PFAS chemicals in the UCMR5 database were detected less frequently, occurred in less than 1% of public water facilities (Fig. S1A), and exhibited a median concentration ranging from 2 to 26 ng L⁻¹ (Fig. S1B).

On the basis of the total number of public water facilities, approximately 5.5 % of participating systems nationwide reported PFOA levels between 4 and 7 ng L⁻¹, 2.0% between 7 and 11 ng L⁻¹, 0.6% were between 11 and 15 ng L⁻¹, and 0.5% above 15 ng L⁻¹ (Fig. 2A). With respect to PFOS, approximately 4.9% of participating utilities reported PFOS levels between 4 and 7 ng L⁻¹, 1.9% between 7 and 11 ng L⁻¹, 0.9% between 11 and 15 ng L⁻¹, and 1.1% above 15 ng L⁻¹ (Fig. 2B). The results are consistent with the previous site-specific studies in which PFOS were reported in concentration ranges of below MRL to several tens of ng L⁻¹.^{13,21–23} Furthermore, PFPeA, PFHxA, PFBS and PFBA exhibited similar nationwide concentration distributions, *i.e.*,

approximately 5.2–9.6% of systems with these PFAS chemical concentration between its respective MRL and 7 ng L⁻¹, 1.1–3.3% between 7 and 11 ng L⁻¹, 0.4–0.8% between 11 and 15 ng L⁻¹, and 0.5–1.1% above 15 ng L⁻¹ (Fig. S2A–D). PFHxS and PFHpA also exhibited similar nationwide concentration distribution, with 2.9–5.1% of systems with these two PFAS chemical concentrations between its respective MRL and 7 ng L⁻¹, and 0.4–1.6% of systems above 7 ng L⁻¹ (Fig. S2E and F).

Sample number-based analysis was additionally conducted to quantify the distributions of PFAS concentration nationwide. Approximately 4.0% of total drinking water samples reported PFOA levels between 4 and 7 ng L⁻¹, 1.6% between 7 and 11 ng L⁻¹, 0.6% were between 11 and 15 ng L⁻¹, and 0.4% above 15 ng L⁻¹ (Fig. 2C). With respect to PFOS, approximately 3.6% of participating utilities reported PFOS levels between 4 and 7 ng L⁻¹, 1.6% between 7 and 11 ng L⁻¹, 0.8% between 11 and 15 ng L⁻¹, and 0.9% above 15 ng L⁻¹ (Fig. 2D). Furthermore, PFPeA, PFHxA, PFBS and PFBA exhibited similar nationwide sample distributions, *i.e.*, approximately 3.8–7.7% of samples with these PFAS chemical concentration between its respective MRL and 7 ng L⁻¹, 0.9–2.7% between 7 and 11 ng L⁻¹, 0.3–0.9% between 11 and 15 ng L⁻¹, and 0.4–0.9% above 15 ng L⁻¹ (Fig. S3A–D). PFHxS and PFHpA also exhibited similar nationwide concentration distribution, with 2.0–3.7% of samples with these two PFAS chemical concentrations between its respective MRL and 7 ng L⁻¹, and 0.3–1.3% of systems above 7 ng L⁻¹ (Fig. S2E and F).

3.2. Geographic distribution of PFOA and PFOS in drinking water

The statistical distribution of PFOA and PFOS levels in treated drinking water was further analyzed based on the number of reporting water facilities in each US EPA region. EPA Regions 4, 5, 6 and 9 had the largest number of monitoring water systems in the database due to large populations in these regions. Among all regions, EPA Regions 1, 2, 3, 4 and 9 have the highest percentage of water utilities with PFOA levels higher than 4 ng L⁻¹, *i.e.*, 26.5%, 22.3%, 20.2%, 11.3% and 6.2%, respectively (Fig. 3A). EPA Regions 1, 2, 3, 4 and 9 also have the highest percentage of water utilities with PFOS levels greater than 4 ng L⁻¹, *i.e.*, 14.3%, 14.4%, 17.2%, 14.2%, and 8.4%, respectively (Fig. S4A). These 5 EPA regions cover a total of 25 U.S. States in the Pacific Southwestern and Eastern U.S. Additional facility-based analysis using public water system zip codes shows the East Coast, Midwest and California have the largest percentage of water facilities with PFOA or PFOS concentrations exceeding 4 ng L⁻¹ (Fig. 3B and S4B). Furthermore, similar trends on the geographic distribution of PFOA and PFOS levels were observed based on the total number of samples analyzed from UCMR5. EPA Regions 1, 2, 3, 4 and 9 have the highest percentage of drinking water samples analyzed with PFOA levels greater than 4 ng L⁻¹, *i.e.*, 19.1%, 18.1%, 13.8%, 9.8% and 4.6% respectively (Fig. S5A). EPA Regions 1, 2, 3, 4 and 9 also have the highest percentage of water utilities with PFOS levels greater than 4 ng L⁻¹, *i.e.*, 9.8%, 10.4%, 11.8%, 12.7%, and 6.4%, respectively (Fig. S5B).

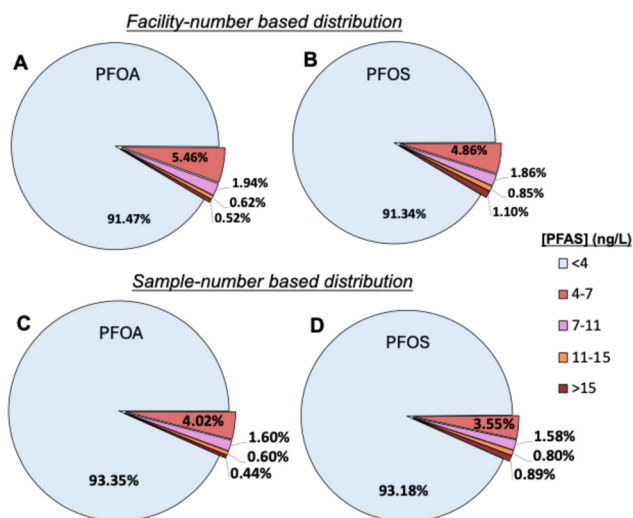


Fig. 2 Distributions of PFAS concentrations in drinking water. This analysis is based on data from the US EPA UCMR5 database. (A) Facility number-based PFOA distribution; (B) facility-number-based PFOS distribution; (C) sample number-based PFOA distribution; (D) sample number-based PFOS distribution.

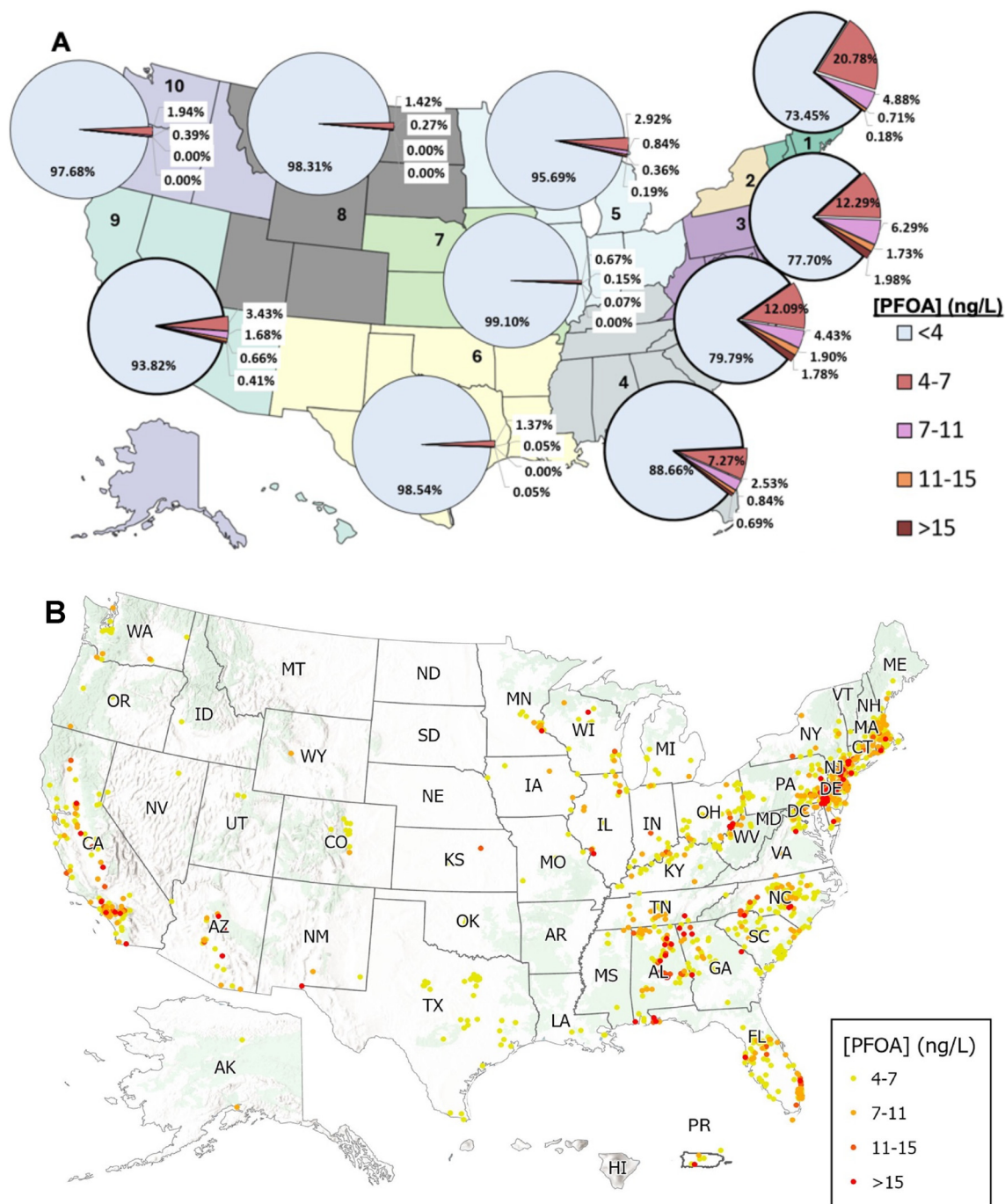


Fig. 3 Facility number-based nationwide distribution of PFOA occurrence. (A) Distribution of PFOA based on US EPA regions; (B) location map of individual public water systems with highest facility average PFOA concentration in a zip code.

Statistical analysis showed that the level of PFAS in drinking water was modestly associated with the dependence on groundwater as the drinking water source, as the chances of higher PFOA or PFOS levels in drinking water was increased when it comes from a groundwater source (Fig. 4A). Approximately 66% of water facilities with PFOA concentrations ranging between 4 and 10 ng L⁻¹ use groundwater as the drinking water source. The percentage increased to 71% with PFOA at 7–10 ng L⁻¹, 83% at 10–15 ng L⁻¹ and 87% with PFOA >15 ng

L⁻¹. Similar trend was observed for PFOS (Fig. 4B). It is consistent with the UCMR3 database trend, where the average total PFAS concentrations were higher in groundwater than in surface water.²⁴ The modest positive correlation between the PFAS occurrence and its dependence on groundwater is likely due to the fact that aquifer has a high probability of historical contamination from sources of PFAS release *via* human activities, or PFAS transport from contaminated soil or sediment to groundwater.^{12,25,26}

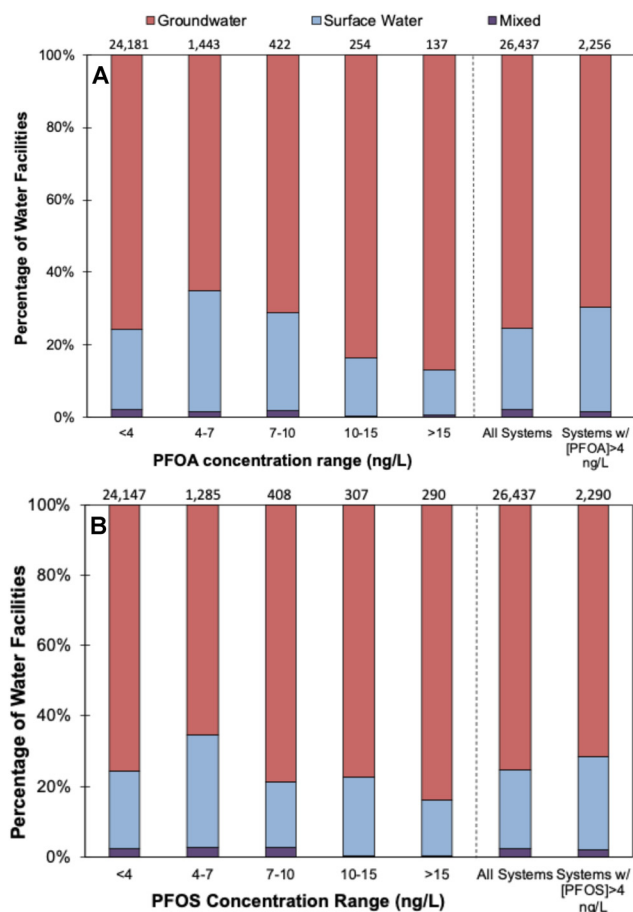


Fig. 4 Sources of drinking water and its correlation with PFAS occurrence. (A) Distribution of water facilities on the basis of PFOA occurrence. (B) Distribution of water systems on the basis of PFOS occurrence. "Mixed" means a combination of groundwater and surface water. Numbers on the top of the bars show the total number of facilities in that concentration range.

3.3. Environmental implications and limitations

The study analyzed PFAS occurrence in drinking water based on the most updated US EPA UCMR5 database in January 2026 in light of the newly established PFAS federal drinking water standards. Statistical analysis showed that PFPeA, PFHxA, PFBS, PFBA PFOS, PFOA, PFHxS, and PFHpA are the most widely detected PFAS compounds, and approximately 3.3–13% of public drinking water systems nationwide had at least one of these PFAS exceeding its respective minimal reporting level. Among the most widely detected PFAS chemicals, PFBA, PFOA and PFOS in drinking water exhibited the highest concentration of statistical distribution, with a median concentration at 7, 5.9 and 6.3 ng L⁻¹, respectively. Data analysis also shows that the likelihood of a higher PFAS level in drinking water is modestly elevated with the dependence of groundwater as the drinking water source, as anthropogenic PFAS release and subsequent transport likely impacted PFAS occurrence in the groundwater. These traits of PFAS occurrence and geographic distribution obtained from

this study can inform public water systems for PFAS treatment and regulatory compliance.

Conflicts of interest

H. L. is a co-founder of Water Illumination Inc. that develops UV PFAS treatment technologies. All other authors have no competing financial interests.

Data availability

The data supporting this article have been included as part of the supplementary information (SI).

Supporting information: Additional plots on PFAS concentration and geographic distributions, and the correlations between PFAS concentrations and drinking water sources. See DOI: <https://doi.org/10.1039/d6ew00586a>.

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