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Per- and Polyfluoroalkyl Substances (PFAS) in Urban Stormwater Runoff: Insights from a Roadside Rain Garden

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Abstract

Urban stormwater runoff is increasingly recognized as a critical but underexplored pathway for per- and polyfluoroalkyl substances (PFAS) to enter aquatic environments. This work investigated the occurrence and behavior of 40 PFAS compounds in stormwater runoff entering a roadside rain garden in Secaucus, New Jersey, during six storm events between August 2023 and July 2024. Total PFAS concentrations (Σ40 PFAS) ranged from 1437 to 1615 ng/L, with perfluorobutane sulfonate (PFBS, 239–303 ng/L) and perfluorohexanoic acid (PFHxA, 115–137 ng/L) consistently emerging as dominant species. Perfluorocarboxylic acids (PFCAs) and perfluorosulfonic acids (PFSAs) together accounted for over 70% of the total PFAS mass. Despite its intended role in water quality improvement, the rain garden showed no measurable change in PFAS concentrations (differences of only 0.03–1.10%). These findings highlight the persistence and mobility of PFAS in urban stormwater runoff and the limited efficacy of conventional green infrastructure in mitigating PFAS contamination. Furthermore, they underscore the ineffectiveness of conventional green infrastructure for PFAS mitigation and the urgent need for advanced treatment technologies integrated into urban water management frameworks.

Keywords: PFAS contamination; urban stormwater; green infrastructure; rain garden

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1. Introduction

Urban stormwater runoff has emerged as a significant yet underrecognized contributor to freshwater pollution, particularly in densely populated areas [1–4]. While past concerns have focused on conventional pollutants such as heavy metals and nutrients, attention has recently expanded to include emerging contaminants like per- and polyfluoroalkyl substances (PFAS), owing to their persistence, mobility, and toxicity in both aquatic and terrestrial systems [5,6]. As emerging contaminants, PFAS are synthetic compounds defined by robust carbon-fluorine bonds that confer unique properties such as chemical stability and resistance to environmental breakdown [7,8]. As a result of these attributes, they are commonly found in industrial and consumer applications, including aqueous film-forming foams (AFFFs), pharmaceuticals, cosmetics, textiles, and food packaging [9]. Their persistence and bioaccumulative nature have earned them the label "forever chemicals," raising significant concern over their environmental and health impacts [9,10].

Although PFAS contamination is well-documented in industrial effluents and wastewater discharges, urban stormwater runoff has received comparatively less attention as a PFAS exposure pathway. Urban environments present a wide range of diffuse PFAS sources, including traffic-related materials (e.g., lubricants, brake fluids, road marking paints), firefighting foams, building materials (e.g., cement additives, hoses, cables), household waste and street dust, food packaging, and atmospheric deposition [4,11–16]. For instance, street sweeping analysis in various urban areas in Florida identified up to 37 different PFAS compounds, with concentrations as high as 41.24 ng/g [14], while surface runoff in Albany, NY, reached PFAS concentrations of 81.8 ng/L [12]. Similarly, runoff in Saskatoon, Canada, averaged 9 ng/L [17]. Zushi et al. [18] reported that urban rivers receive a higher PFAS load from stormwater runoff than the effluent from wastewater treatment plants. In the U.S., researchers identified the presence of PFAS in 100% of urban stormwater samples from seven storm events, with perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) being the most frequently reported PFAS compounds [19].

Recent research has also emphasized the role of surface runoff as a diffuse but significant PFAS source to aquatic systems. Urban surfaces such as roads, pavements, rooftops, and landscaped areas accumulate PFAS from atmospheric deposition, vehicular activity, and consumer product residues. During rainfall events, these surfaces mobilize PFAS into stormwater, which then transports them to receiving waters without treatment. This pathway contributes substantially to short-chain PFAS loading, owing to their high solubility and mobility, and poses risks of long-term contamination, groundwater infiltration, and bioaccumulation in aquatic ecosystems [20].

Given the occurrence of PFAS in stormwater, green infrastructure (GI), such as rain gardens and bioswales, may play a crucial role in mitigating their transport, as GI is structured to retain, infiltrate, and treat stormwater runoff at its source to improve urban stormwater quality [21–24]. Although the effectiveness of GI in reducing conventional pollutants is well established, its capacity to retain or remove PFAS remains largely unexamined. Research on PFAS in stormwater is still in its early stages, and the absence of regulatory guidelines for PFAS in stormwater complicates efforts to assess risks and implement water reuse strategies [25]. Furthermore, data on PFAS occurrence and concentration in urban runoff remain limited, impeding informed decision-making in stormwater management and policy development. This represents a critical research gap, especially as GI is increasingly viewed as a first line of defense against a broad spectrum of stormwater contaminants [10,26]. To address this research gap, this study aimed to (1) assess and characterize the occurrence of PFAS in urban stormwater runoff, and (2) evaluate the performance of a rain garden in reducing PFAS concentrations from stormwater runoff. The findings from this research contribute to a more comprehensive understanding of PFAS behavior in urban hydrological systems and the role of GI in PFAS mitigation.

2. Materials and Methods

2.1. Chemicals and Reagents

A set of 40 PFAS compounds and matching isotopically labeled standards was procured from Wellington Laboratories Inc. (Guelph, ON, Canada), following the U.S. EPA Draft Method 1633 version 4 [27] (Table S1, in Supplementary Information). Detailed descriptions of the Non-Extracted Internal Standard (NIS) and Extracted Internal Standard (EIS) are included in Table S2 and Table S3, respectively. HPLC-grade acetonitrile from Fisher Scientific Inc. (Waltham, MA, USA) was used to prepare the stock solutions for individual standards and stored at −20 °C. Ammonium acetate (CH3COONH4, HPLC-grade, ≥99%) was purchased from Sigma-Aldrich (St. Louis, MO, USA), while HPLC-grade

acetonitrile (ACN) and methanol (≥99% purity) were sourced from Fisher Scientific Inc., Waltham, MA, USA.

2.2. Site Description and Stormwater Sample Collection

Stormwater samples were collected from a rain garden located in Secaucus, New Jersey, USA (40.789543° N, 74.056534° W). This rain garden is an integral component of an urban stormwater management system designed to reduce runoff and improve water quality in a highly developed area. To the best of our knowledge, there are no known direct PFAS sources in the immediate vicinity. Excess runoff from the area is directed into a drainage system that ultimately discharges into the Hackensack River.

Four lysimeters were installed within the rain garden to facilitate water sampling. The sampling locations, including inlet and outlet flow directions, are illustrated in Figure 1. Each lysimeter was constructed using 10.2 cm high-density polyethylene (HDPE) pipes, with the lower 15 cm perforated and installed below ground, allowing subsurface water to enter (Figure S1). A fiberglass mesh covered the perforated section to prevent clogging by large particles. The top of the lysimeters was sealed with a PVC cap to avoid contamination from debris and precipitation. For surface runoff sampling, a separate set of HDPE pipes with sealed bottoms was used. These were open at the top, flush with the ground surface, and covered with fiberglass mesh. Water samples were collected using a hand pump, with thorough decontamination procedures in place to prevent cross-contamination. Prior to each collection, the pump and tubing were rinsed with deionized (DI) water and purged with samples.

Figure 1. Lysimeters locations for sample collection and inlet flow direction. (Image credit: authors).

Sampling was conducted between August and December 2023 (once per month), with additional collections in June and July 2024, capturing six distinct stormwater events. Each event was closely monitored to ensure representative stormwater sampling at the rain garden site. Following sample collection, water samples were transferred into PFAS-free HDPE bottles and stored at 4 °C until analysis. Rainfall data for each sampling event were obtained from the Secaucus station of the New Jersey Weather and Climate Network [28] located approximately 1.4 miles southwest of the study area. Rainfall depths and durations for each monitored storm event are summarized in Table S4. Grab samples of inflow and

leachate were collected using lysimeters and inlet samplers, while total inflow and outflow volumes were not measured due to discrete sampling.

2.3. Extraction Procedures and Instrumental Methods for PFAS Analysis

PFAS extraction was performed in duplicate following the U.S. EPA Draft Method 1633 version 4 [27]. Each stormwater sample was extracted and analyzed in duplicate to verify measurement consistency. Each sample was spiked with an EIS mix containing nine labeled PFAS (Table S2). PFAS compounds were extracted using solid-phase extraction (SPE) with WAX cartridges (150 mg, Waters Corporation, Milford, MA, USA). The extracts were fortified with a Non-Extracted Internal Standard (NIS) mix of twenty labeled PFAS (Table S3). PFAS analysis was performed using a Waters ACQUITY UPLC (Ultra Performance Liquid Chromatography) system coupled with a triple quadrupole mass spectrometer (Waters Corporation, Milford, MA, USA) operated in ESI (−), MRM mode. To suppress system/background PFAS, a delay column (ZORBAX Eclipse Plus C18, 50 × 3 mm, 1.8 µm; Agilent, Santa Clara, CA, USA) was installed post-mixer. Samples and standards (50 µL) were injected into a BEH C18 analytical column (100 × 2.1 mm, 1.7 µm; Waters). Mobile phases were A: 20 mM ammonium acetate in water and B: acetonitrile, delivered at 0.25 mL min^{-1}. The mobile phase gradient is provided in Table S5. The cone voltages and collision energies were optimized by syringe infusion (20 µL min^{-1}) using MS Scan/Daughter Scan. Two transitions (quantifier/qualifier) were monitored where available. Compound-specific MRM transitions for targets, NIS, EIS, and MS parameters are listed in Tables S6–S8.

2.4. Quality Assurance and Quality Control

To ensure the reliability of the analysis, laboratory control samples were spiked at twice the limit of quantification in each batch. Signal-to-noise ratios were maintained at ≥3:1 for quantification and confirmation ions, and ≥10:1 for analytes with only quantification ions. The recovery of internal standards was monitored to assess extraction efficiency, and calibration coefficients (R^2) for all target analytes were maintained above 0.99. To account for potential background contamination from lysimeter components, DI water was passed through the fiberglass mesh and lysimeter, and the effluent was analyzed. Any detected PFAS concentrations were subtracted from corresponding stormwater measurements to ensure accuracy. Calibration curves were generated from at least six standards (0.5–500 ng/L) containing isotopically labeled analogs. Method detection limits (MDLs) for individual PFAS ranged from 0.23 to 0.76 ng/L, and limits of quantification (LOQs) ranged from 0.5 to 2.0 ng/L, depending on the compound.

3. Results and Discussion

3.1. PFAS Distribution and Dominant Species in Stormwater Runoff

Stormwater runoff, particularly during large storm events, often exceeds the infiltration capacity of green infrastructure and is redirected to stormwater systems or nearby surface waters, which leads to contamination in aquatic systems [2]. In this study, 40 PFAS species were monitored during six stormwater events at the inlet of an urban rain garden. The summed PFAS concentrations (Σ40 PFAS) ranged from 1437 to 1615 ng/L (Figure 2, with detailed concentrations listed in Table S9). Among all six sampling events, consistent patterns emerged in the dominance of specific PFAS compounds. Perfluorooctanoic acid (PFOA), perfluorobutane sulfonate (PFBS), perfluorohexanoic acid (PFHxA), and perfluorooctane sulfonate (PFOS) were shown as the most prevalent species, which aligns with findings from previous studies [9,12,14,17,29,30].

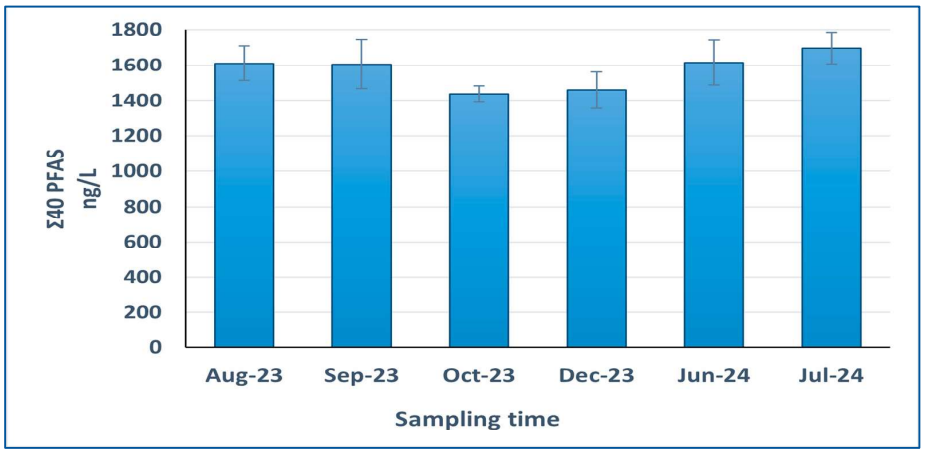

Figure 2. Concentrations of Σ40PFAS (ng/L) during six stormwater events. For each event, two replicate samples were extracted and analyzed; the data are presented as mean (n = 2) ± standard deviation.

The remarkably consistent PFAS concentrations observed across all six stormwater events, despite seasonal variability, suggest a persistent and homogeneously distributed source of contamination within the study area. This uniformity may be due to a combination of factors: (1) the omnipresence of PFAS-laden materials in urban surfaces, including roads and buildings, which provide a continual reservoir for wash-off [31,32]; (2) atmospheric deposition acting as a steady background input [14]; and (3) limited variation in land use characteristics across the drainage area, resulting in similar pollutant profiles in each event. Unlike conventional pollutants that may be highly influenced by specific event characteristics (e.g., first flush, antecedent dry period), PFAS (particularly short-chain compounds) exhibit low sorption potential and are not readily sequestered in soils or sediments, leading to consistently high mobility and detectability in stormwater.

PFBS emerged as the dominant species, with concentration values varying from 239 to 303 ng/L, surpassing other compounds like PFBA, PFHxA, and PFOA across all sampling events. The prevalence of PFBS suggests a significant role for short-chain PFAS in urban stormwater runoff, consistent with increasing regulatory restrictions on long-chain PFAS [30]. As a common substitute for PFOS, PFBS is widely used in industrial applications such as stain repellents and surfactants [33]. Furthermore, its high mobility in environmental systems likely contributes to its increased presence in stormwater runoff samples [1]. Additionally, PFBS serves as a degradation product of longer-chain PFAS, indicating that the breakdown of complex PFAS compounds may be contributing to the persistence and accumulation of short-chain PFAS in stormwater systems [34].

Following PFBS, PFHxA was the second most abundant species, with concentrations ranging from 115 to 137 ng/L. As a byproduct of long-chain PFAS degradation, PFHxA has been widely adopted as a replacement for PFOA in industrial and commercial applications, including coatings, lubricants, and surfactants [9,34]. The strong presence of PFHxA in runoff and leachate samples may be associated with traffic-related sources such as vehicle emissions, tire wear, and roadway sealants [35]. While PFBA was also detected across multiple events, its concentrations were relatively moderate, fluctuating between 64 and 78 ng/L. As a short-chain PFAS, PFBA is utilized in a broad spectrum of items—from industrial materials to everyday products, such as cleaning agents and coatings [4,16].

These compounds are known for their high-water solubility, low sorption affinity, and resistance to degradation, which enhance their mobility and persistence in urban hydrological pathways [32]. The prevalence of these specific compounds may also indicate that local runoff is influenced more by consumer product residue and road runoff than by industrial discharges. Their frequent detection in atmospheric samples also implies that

deposition may be a sustained input source [36]. The chemical characteristics of PFBS and PFHxA, especially their low molecular weight, favor rapid transport and accumulation in stormwater over time, leading to their consistent dominance in all sampling events.

Compared to prior studies, stormwater runoff PFAS levels in this study were much higher. For instance, the Hackensack River was found to have Σ5 PFAS (PFOA, PFOS, PFHxA, PFPeA, and PFBS) concentrations of 20.2 ng/L [37], far lower than the levels observed in stormwater samples from this study. Similarly, a study in Saskatoon, Canada, reported mean PFAS concentrations of 9.0 ng/L in stormwater [17], while stormwater samples from Alabama showed a maximum average of 237 ng/L across six PFAS compounds (PFHpA, PFOA, PFPeA, PFOS, PFBS, and PFHxA) [38]. Additionally, in Florida's Pensacola Bay System, ΣPFAS levels reached 677 ng/L near a coastal airfield [39].

The elevated concentrations measured in this study may be explained by multiple co-occurring factors: (1) the location of the study site within a high-density urbanized area with significant vehicular traffic and impervious surface coverage; (2) the cumulative effect of multiple non-point sources discharging PFAS into a small catchment with limited dilution capacity; and (3) the legacy load of PFAS in urban materials and catch basin residues that continue to leach into runoff over time. Furthermore, the use of high-sensitivity EPA Method 1633 likely contributed to a broader PFAS detection compared to previous studies employing less inclusive methods.

The findings from this study highlighted the significance of urban stormwater as a substantial source of PFAS contamination in surface water bodies. In particular, the significant prevalence of short-chain PFAS compounds, like PFBS, PFHxA, and PFPeA, across nearly all stormwater runoff and leachate samples underscores the increasing dominance of these contaminants in urban environments. Their widespread use, persistence, and mobility in water systems highlight the potential role of traffic-related activities, such as tire degradation, brake pad wear, and roadway runoff, in PFAS contamination [40]. Additionally, the environmental breakdown of long-chain PFAS into their short-chain counterparts further amplifies their presence in stormwater runoff. Their consistent detection across all sampling events demonstrates that stormwater is not a sporadic or event-driven source of PFAS, but rather a persistent and chronic pathway of contamination.

3.2. PFAS Class Distribution in Stormwater Runoff

The 40 monitored PFAS species in this study were classified into seven chemical categories (Table S9): 13 Perfluorocarboxylic Acids (PFCAs), 8 Perfluorosulfonic Acids (PFSAs), 3 Fluorotelomer Sulfonates (FTSs), 3 Fluorotelomer Carboxylic Acids (FTCAs), 8 Perfluoroalkyl Sulfones (PASFs), 2 Perfluoroether Carboxylic Acids (PFECAs), and 3 Perfluoroether Sulfonic Acids (PFESAs). PFCAs accounted for the highest fraction of the total PFAS in stormwater samples, followed by PFSAs, with these two groups comprising over 70% of the Σ40 PFAS (Figure 3). Other PFAS groups contributed less than 10% each, similar to findings from Chen et al. (2023) [41], where PFCAs represented 68% of Σ26 PFAS in stormwater. Bai and Son (2021) [42] and Olmsted et al. (2021) [43] also observed a predominance of PFCAs over PFSAs in U.S. surface waters and stormwater pond sediments.

3.3. Assessment of PFAS Concentration Change Across a Rain Garden

Concentration change across the rain garden was evaluated based on a comparison of cumulative PFAS concentrations (Σ40 PFAS) in inflow and leachate samples across six stormwater events. The results indicated minimal differences in PFAS concentrations between inflow and leachate samples, suggesting that the system did not measurably alter PFAS concentrations (Figure 4). For example, in August 2023, the total PFAS concentration in the inflow was 1645 ng/L, while the average leachate concentration was 1640 ng/L, a

negligible decrease. Similarly, narrow differences were seen in September 2023 (1608 ng/L for inflow vs. 1591 ng/L for leachate), October 2023 (1439 ng/L for inflow vs. 1428 ng/L for leachate), December 2023 (1462 ng/L for inflow vs. 1461.5 ng/L for leachate), June 2024 (1616 ng/L for inflow vs. 1600 ng/L for leachate), and July 2024 (1697 ng/L for inflow vs. 1666.5 ng/L for leachate).

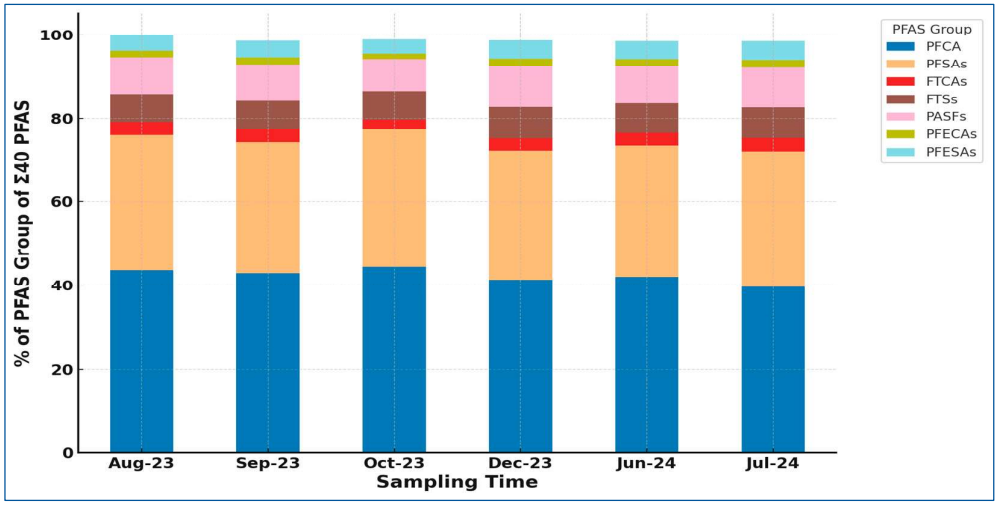

Figure 3. Fractions of PFAS groups in the stormwater.

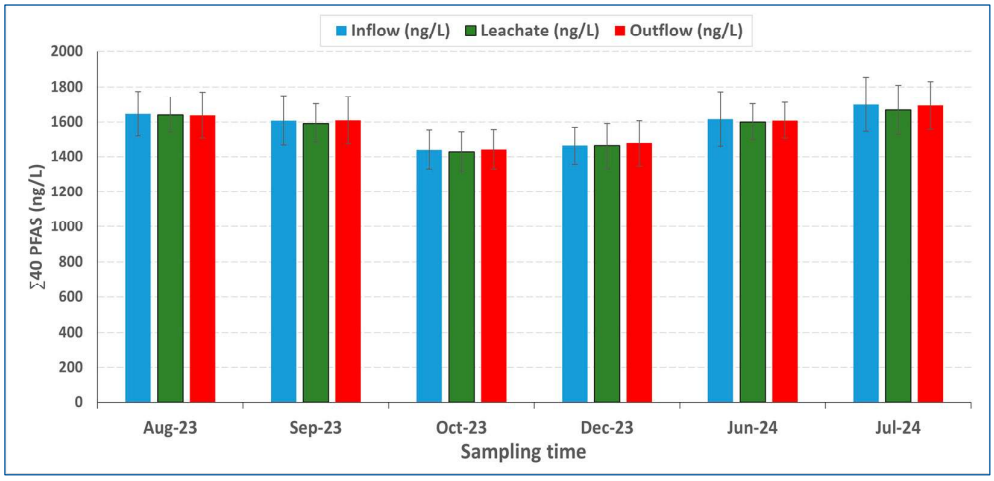

Figure 4. Σ40 PFAS concentrations (ng/L) in runoff and leachate samples across sampling events. The data are shown as mean (n = 2) ± standard deviation.

The observed differences between inflow and leachate concentrations across all sampling events were marginal, with reductions ranging from 0.03% to 1.10%, indicating that the studied rain garden had essentially no impact on PFAS concentrations in stormwater runoff. The monitored storm events ranged from 28.4 mm to 88.3 mm of rainfall, with durations between 9 and 21 h (Table S4). These rainfall depths are representative of moderate to large storm events for the region. Given the grab-sampling approach, inflow and leachate volumes could not be directly compared. However, the consistently small concentration differences (0.03–1.10%) between inflow and leachate samples across all events indicate that the rain garden did not measurably affect PFAS concentrations.

While slight variations were noted over time, no clear seasonal trend was evident, suggesting that factors such as storm intensity, antecedent conditions, or variability in

PFAS input sources may have influenced these results. These findings emphasize the persistence of PFAS in urban stormwater and the limitations of current rain garden designs in mitigating their mobility. Importantly, the lack of measurable removal was consistent across both long- and short-chain PFAS, highlighting the inadequacy of conventional rain garden soils and vegetation to sorb or degrade these compounds. Given the extremely low organic carbon partitioning and strong resistance to biodegradation of PFAS, this finding is unsurprising but critical. It underscores the need for engineered enhancements (e.g., ion-exchange resins, activated carbon amendments, engineered mulch) if green infrastructure is to play a meaningful role in PFAS management.

3.4. Potential Sources of PFAS in Stormwater Runoff

PFAS contamination in precipitation, including rainfall and snow, is widespread before surface contact. Rainfall-induced runoff is likely to transport PFAS, having potentially come into contact with polluted dust and suspended soil particles prior to reaching nearby water bodies. As a result, stormwater is widely recognized as a significant pathway for PFAS entry into surface aquatic environments [44,45]. Xiao et al. (2012) [19] also found that rainfall was a significant contributor to PFAS in stormwater runoff from residential areas.

At the Secaucus study site, the rain garden drains an area composed primarily of impervious surfaces (Figure S2). Roadways and parking areas represent the largest fraction of the catchment and are heavily trafficked, providing significant potential inputs of PFAS from tire wear, brake pads, and vehicle fluids. Surrounding commercial and municipal buildings contribute to rooftop runoff, which may carry PFAS from roof coatings, sealants, and construction materials. Only a small fraction of the catchment consists of pervious or landscaped areas, where residues from urban dust or consumer products may also contribute. This land use composition explains why short-chain PFAS species such as PFBS and PFHxA were consistently dominant, reflecting traffic-related and building-derived sources characteristic of highly impervious urban catchments.

Urban land uses and local activities also contribute to PFAS loading. Set-out residential waste [44], biosolid-amended gardens [32], and urban dust can all serve as PFAS sources. Additionally, traffic areas are especially critical contributors due to emissions from brake wear, tire degradation, vehicle fluids, and pavement erosion [46,47]. Road dust studies in Australia showed higher PFAS levels in high-traffic zones than in industrial areas, and street runoff PFAS concentrations have been found to exceed those in wastewater treatment effluent by severalfold [48–51]. The strong association between traffic intensity and PFAS loading [52] suggests that transportation corridors are a major non-point source of PFAS, particularly for short-chain species. Their fine particulate form and high environmental mobility make them readily transportable into receiving waters during rain events.

Additional sources of PFAS in urban stormwater include building materials (e.g., sealants, adhesives, roofing materials) [53], food packaging waste in public litter streams [9], laundry effluent from washing PFAS-treated textiles [54], atmospheric deposition from nearby incineration facilities, and residues from historical uses of aqueous film-forming foams (AFFF) [55]. Even areas with no current point sources may still exhibit elevated PFAS levels due to the legacy contamination and slow degradation of PFAS-containing infrastructure. The diffuse and ubiquitous presence of PFAS in the urban built environment thus results in a complex mixture of both legacy and contemporary sources contributing to runoff during rain events.

4. Conclusions

The findings of this study underscore the prevalence of PFAS in urban stormwater runoff and highlight its potential role as a significant, yet underappreciated, source of PFAS

contamination in freshwater systems. Stormwater samples contained total PFAS concentrations (Σ40 PFAS) ranging from 1437 to 1615 ng/L, dominated by PFBS (239–303 ng/L) and PFHxA (115–137 ng/L), with PFCAs and PFSAs together comprising more than 70% of the total PFAS mass. Despite the rain garden's intended role in improving water quality, it did not measurably affect PFAS concentrations, with differences not exceeding 1.1% across all sampling events. This limited performance indicates that conventional green infrastructure designs may fall short when addressing persistent and mobile contaminants like PFAS. Given these findings, future research should emphasize understanding the specific sources and routes of PFAS within urban stormwater systems, examining the seasonal and spatial variability of PFAS transport, and evaluating the effectiveness of advanced stormwater treatment technologies. To improve PFAS management, policymakers and urban planners must integrate PFAS monitoring into stormwater management frameworks, design infrastructure that accounts for emerging contaminants, and develop updated regulatory guidelines. Ultimately, addressing PFAS contamination in stormwater is crucial for protecting freshwater resources and ensuring the long-term sustainability of urban water management practices. This study bridges a critical knowledge gap in PFAS dynamics in urban stormwater and informs the development of more effective mitigation strategies for emerging contaminants.

5. Recommendations

The findings from this study indicate that conventional rain gardens and similar green infrastructure have a negligible impact on PFAS concentrations in stormwater runoff. Based on these results, the following recommendations are proposed:

- Enhanced treatment media: Incorporate engineered amendments such as activated carbon, ion-exchange resins, or engineered mulch into rain garden designs to improve PFAS retention.
- Monitoring integration: Include PFAS monitoring in stormwater quality assessment frameworks to better capture the contribution of diffuse urban sources.
- Source control strategies: Reduce PFAS inputs at the source by targeting traffic-related materials, building products, and waste streams that act as primary contributors in impervious catchments.
- Policy development: Update urban water management guidelines to explicitly address PFAS, including setting concentration benchmarks for stormwater reuse and discharge.
- Future research: Evaluate the long-term performance of modified green infrastructure systems, including seasonal variability, leaching behavior, and combined treatment approaches, to determine sustainable PFAS mitigation strategies.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/w17202982/s1: Table S1: Targeted PFAS species used in this study; Table S2: Isotopically labeled PFAS species in the extracted internal standard (EIS) used in this study; Table S3: Isotopically labeled PFAS species in non-extracted internal standard (NIS) used in this study; Table S4: Storm events analyzed during this study; Table S5: Mobile phase gradient method employed for elution; Table S6: Mass Spectrometry tuning parameters for the target PFAS species; Table S7: Mass Spectrometry tuning parameters for the isotopically labeled PFAS species in the non-extracted internal standard (NIS); Table S8: Mass Spectrometry tuning parameters for the isotopically labeled PFAS species in the extracted internal standard (EIS); Table S9: Average concentrations (ng/L) of the detected PFASs in the stormwater samples; Figure S1: Leachate lysimeter. Figure S2: Author-prepared schematic of land use within the Secaucus rain-garden drainage area showing roads/parking (gray), buildings/rooftops (light yellow), green/landscaped areas (tree symbol), and the red area indicates the rain garden location.

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Data Availability Statement: The data supporting the findings of this study are available within the article and its Supplementary Materials. Additional raw data or materials may be made available upon reasonable request to the corresponding author. No publicly archived datasets were generated during this study.

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Conflicts of Interest: The authors declare no conflicts of interest.

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