First quantitative measurements of PFAS in ambient air in France (Auvergne-Rhône-Alpes region)

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Summary

PFAS (Per- and Polyfluoroalkyl Substances) are synthetic compounds that have been widely used in industry since the 1940s and are present in many everyday consumer products. They feature a carbon-fluorine bond that is highly resistant to environmental degradation, which gives them physicochemical properties valuable to industry for producing coatings with specific characteristics, such as non-stick, waterproof, or flame-retardant surfaces. These so-called "forever chemicals" now include more than 10,000 distinct PFAS compounds.

However, these persistent properties come at a cost to human health and the environment. Since the 2000s, the toxicity of PFAS has been well documented. One of the best-known compounds, PFOA, was classified as a carcinogen in the fall of 2023. In October 2025, ANSES proposed, as part of a monitoring strategy, a list of 247 PFAS selected based on their toxicity, including the existence of toxicological reference values, classification as carcinogenic, mutagenic, reprotoxic, or endocrine disrupting substances, and available ecotoxicity data). PFAS have also been detected in the blood of most of the French population (Esteban, Santé Publique France). While Toxicological Reference Values (TRVs) for ingestion exist for several dozen PFAS, no TRVs for inhalation are currently available, which limits the interpretation of ambient air measurements.

Recent measurements of water and soil in the Auvergne-Rhône-Alpes region have identified several contaminated sites, particularly in the Lyon area (Générations futures, Le Monde, Dauchy et al., 2023). The mechanisms of transfer between water, air, and soil remain poorly understood. Although air is directly impacted by PFAS emissions and acts as a major carrier of these pollutants, it has been studied very little. Standardized protocols for assessing PFAS concentrations in ambient air have not yet been established. Since 2023, Atmo AuRA has undertaken work to develop and implement a method aimed at estimating the first quantitative levels of PFAS in the region, with a focus on the Lyon basin, where two fluoropolymer-producing industries are located. Measurements were performed using high-flow samplers equipped with a quartz filter to collect the particulate phase and a polyurethane foam (PUF) to capture the gaseous or semi-volatile phase. Sampling was conducted between November 2023 and December 2025 at two sites: central Lyon (urban background site, designated LC) and Pierre-Bénite (urban site under industrial influence, designated PB). Thirty-eight PFAS were analyzed, based on the list of substances targeted in water measurements and industrial emissions.

These initial results provide, for the first time, an estimate of the quantitative concentrations of PFAS in ambient air. In urban areas of Lyon, concentrations were in the range of tens of picograms per cubic meter [pg/m^3], averaging 25 pg/m^3, while in Pierre-Bénite, an area influenced by fluoropolymer manufacturers, concentrations reached hundreds of pg/m^3, with an average of 244 pg/m^3. Among the compounds analyzed, PFHxA and 6:2FTS were present at higher levels than other substances, accounting on average for 61% of the total sample masse in central Lyon and 88% in Pierre-Bénite. These results are likely linked to local fluoropolymer production, where industrial emission measurements conducted under prefectural decrees have confirmed the prevalence of these two compounds at high levels (µg/m^3). PFOA and PFOS, whose use has been banned since 2009 and 2020, respectively, were also detected at much lower levels (approximately 2%). These relatively long half-lives of these compounds contribute to their persistence in the environment, even several years after their use and release. However, the profiles of PFAS in ambient air differ from those observed in soil and sediments, suggesting that the detected airborne compounds are not primarily associated with the resuspension of historical soil contamination.

These results represent the first quantitative data on PFAS concentrations in ambient air in the Lyon region, and indeed in France, providing a foundation for the creation of a valuable database that will notably support ANSES's work on toxicological reference values (TRVs). At this stage, however, Atmo AuRA emphasizes that no reference method currently exists, and that the limited number of available results requires caution when interpreting their representativeness of residents' exposure. Ongoing work with INERIS, conducted as part of the interministerial plan, together with the implementation of an AFNOR standard, is expected to facilitate the continued consolidation of methodologies and the deployment of additional measurements in the region in the near future.

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1.1 PFAS in ambient air

1.1.1 Ubiquitous and persistent chemical compounds

Per- and polyfluoroalkyl substances (PFAS) form a large family of synthetic chemical compounds that first developed in the 1950s, although they were initially discovered in 1938 (Owens, 2021). PFAS are characterized by the replacement of conventional carbon-hydrogen (C–H) bonds with carbon-fluorine (C–F) bonds, among the strongest known in organic chemistry. This unique feature imparts exceptional properties to PFAS, including resistance to high temperatures, chemical inertness, water- and oil-repellency, and remarkable durability (Tang, 2025). These properties have made PFAS the material of choice for a wide range of industrial and domestic applications, such as water-repellent textiles, non-stick cookware, food packaging, firefighting foams, paints, protective coatings, and technical fluids.

However, this molecular stability, which renders PFAS virtually indestructible, is also responsible for their persistence in the environment. PFAS degrade very little under the influence of light, heat, or biological processes (ANSES, 2025b). This extreme resistance has earned them the nickname “forever chemicals,” reflecting their tendency to accumulate and persist in both natural and biological systems (Faust, 2023).

1.1.2 Sources and environmental dispersion of PFAS

PFAS originate from both direct industrial sources and diffuse sources (INERIS 2025):

- Industrial sources: emissions related to the production, use, or processing of fluorinated compounds in sectors such as chemicals, aerospace, electronics, textiles, and plastics;
- Diffuse sources: everyday consumer products (cosmetics, clothing, utensils, packaging, etc.) that release residues into the environment through direct discharge into wastewater (e.g., during showering or bathing), leaching from waste (rainwater “washing” packaging), and from storage or incineration facilities (D’Ambro et al., 2021);
- Secondary sources: waste treatment sites, sewage sludge application, industrial liquid discharges, or leaching from contaminated soil.

Once released, PFAS are highly mobile: they can migrate into groundwater, accumulate in soil, and disperse through the atmosphere. This mobility explains why PFAS have been detected far from industrial sources, including in polar regions (Wong et al., 2018).

1.1.3 Atmospheric transport: a mechanism still poorly understood

While PFAS are now well documented in surface water, groundwater, and soils, their presence in ambient air remains poorly characterized (Faust, 2023). Yet the atmosphere represents a major pathway for their dispersion at local, regional, and global scales.

Atmospheric emissions of PFAS may originate from:

- Industrial processes that use or produce PFAS.
- Thermal waste treatment, including incineration, co-incineration, and pyrolysis.
- Volatilization from contaminated surfaces, such as water, soil, firefighting foams, and products in use.

Once released into the atmosphere, some PFAS exist in gaseous form, while others adsorb onto fine particulate matter (PM_{10}, $PM_{2.5}$). These particles act as an effective transport medium, capable of carrying PFAS over long distances before they are removed from the atmosphere via dry or wet deposition (Faust, 2023).

This mechanism helps explain the widespread distribution of PFAS and their potential to contaminate ecosystems far from emission sources.

However, current knowledge remains limited:

- Ambient air monitoring data are still very scarce, both in France and internationally;

- Sampling and analysis methods have not yet been standardized or harmonized across laboratories;
- Detection limits and reference values for airborne exposure are still being established. (ANSES, 2025b)

Thus, despite recognition of the atmospheric pathway as a potential source of contamination, the actual concentrations in air, their chemical forms (gaseous or particle-bound), and their deposition dynamics remain largely unknown. In general, most PFAS are primarily associated with fine or ultrafine particles ($PM_{2.5}$ and $PM_{0.1}$), with the notable exception of PFOS, which is typically found in the coarse aerosol fraction ($>PM_{2.5}$ and $<PM_{10}$) (Faust, 2022; Li et al., 2024).

1.1.4 Bioaccumulation and impacts on human health and ecosystems

Once released into the environment, PFAS accumulate in living organisms—a process known as bioaccumulation—and can become increasingly concentrated as they move up the food chain (biomagnification). The human body lacks effective mechanism to eliminate these compounds, leading to their gradual accumulation in the blood and tissues (Tang, 2025).

The identified health effects include:

- Disruption of the hormonal (endocrine) system);
- Increased risk of certain cancers;
- Impairment of the immune system;
- Fertility and developmental disorders (ANSES, 2025a).

From an environmental perspective, PFAS contribute to long-term contamination of aquatic and terrestrial environments, affecting aquatic organisms, terrestrial wildlife, and crops. Their extreme persistence and mobility across environmental media (air, water, and soil) raise concerns about their cumulative impact on ecosystems and potentially on climate.

Certain fluorinated PFAS may indeed contribute to the greenhouse effect, although their global warming potential is generally lower than that of conventional fluorinated gases (PFCs, HFCs, SF_6, etc.) (Owens, 2021).

1.1.5 Limited knowledge of PFAS in ambient air

To date, most research and monitoring programs have focused on water and sediment contamination, where PFAS are more easily quantified.

Air, by contrast, is a complex and largely unexplored matrix for several reasons:

- Concentrations are extremely low, typically in the ng/m^3 or even pg/m^3 (i.e., 10^{-12} to 10^{-15} grams per cubic meter of air);
- PFAS exist in multiple chemical forms, each exhibiting different behaviors;
- Analytical protocols are still under validation;
- Sampling and analysis remain costly (Faust, 2023).

Consequently, very little background data are available at the national or European level to characterize PFAS in ambient air. The few studies conducted—primarily near industrial sites—indicate that the atmosphere can serve as a significant transfer pathway, potentially explaining the presence of these substances in regions far from emission sources (Tang, 2025).

This situation highlights the need for exploration monitoring campaigns aimed at:

- Documenting concentration levels in ambient air;
- Identifying the most prevalent PFAS;
- Understanding their dispersion and deposition mechanisms;
- Laying the groundwork for a harmonized monitoring network in the future

It should be noted that, in studies of PFAS in ambient air, distinguishing between the particulate and the gaseous phases is critical from a health perspective. This distinction determines not only the pathways by which these pollutants enter the human body, but also the organs they may affect and their residence time in the body (De Silva, A. O., et al. (2021)).

1.2 PFAS in southern Lyon: a pilot region addressing an emerging issue

1.2.1 Historical industrial context favoring PFAS dispersion

The southern part of the Lyon metropolitan area constitutes a major industrial hub, historically centered on the chemical, petrochemical, and fluorinated materials industries.

The Rhône Valley, south of Lyon, is home numerous facilities classified as requiring special environmental protection (ICPE), some of which produce or use fluorinated compounds in their processes. Among these, two industrial sites, located in the Pierre-Bénite, Saint-Fons, and Feyzin area have been identified as potential sources of PFAS emissions into various environmental compartments due to their fluoropolymer production activities.

This industrial profile, combined with the proximity of densely populated urban areas and major waterways- particularly the Rhône River- renders the region especially vulnerable to environmental contamination.

Studies conducted over recent years have highlighted significant PFAS contamination in aquatic environments and soils, demonstrating the extent of local dispersion (OECD, 2015).

Between 2020 and 2023, several surveys documented the presence of PFAS in the environment (ARS and DREAL 2025), with a particular focus on southern Lyon, notably in:

- Surface and groundwater in the Lyon metropolitan area (Teymoorian et al., 2025);
- Agricultural and urban soils in southern Lyon (Dunsin et al., 2025; Dauchy, 2023);
- Occasionally in local food products, prompting precautionary measures and consumption restrictions (e.g., fishing, eggs, vegetables).

These findings have led authorities to reinforce environmental monitoring, initiate public health studies, and develop information tools for the affected populations.

1.2.2 A pilot region within the Interagency PFAS Action Plan (2023–2027)

Given the unprecedented and concerning nature of this contamination, the southern Lyon area has been designated by the DREAL Auvergne–Rhône-Alpes as a pilot region under the 2023–2027 Interministerial Action Plan on PFAS (DREAL 2025 Roadmap).

This national plan seeks to coordinate efforts to understand, monitor, and mitigate the risks associated with PFAS across France (Interministerial Action Plan 2023–2027).

The plan’s priorities are structured around five key areas:

1. Improve knowledge of PFAS emissions, environmental dispersion, and human exposure;
2. Strengthen environmental monitoring, notably by mobilizing regional monitoring networks;
3. Reduce risks and limit the use of PFAS in consumer products;
4. Promote innovation and research on alternative processes and analytical techniques;
5. Inform and engage public and private stakeholders, as well as civil society.

This plan is complemented by ANSES 2024 consultation on PFAS,, which aims to evaluate environmental contamination, prioritize substances for monitoring, and propose toxicological reference values for long-term oral exposure (ANSES, 2025b).

In this context, multiple stakeholders at both the national and regional levels are collaborating to advance the various priorities of the plan.

1.2.3 A collaborative effort by public authorities and scientific stakeholders

The approach to addressing the PFAS contamination in the southern Lyon area relies on close cooperation among multiple stakeholders:

- The Auvergne–Rhône-Alpes Regional Directorate for Environment, Development, and Housing (DREAL), responsible for regulatory oversight and industrial site monitoring;
- Decentralized government agencies (Prefecture, Regional Health Agency [ARS], and Office for Building and Housing [OFB]) tasked with risk management and public communication;
- Atmo Auvergne–Rhône-Alpes, as an accredited air quality monitoring association (AASQA), mobilized to investigate PFAS presence in ambient air;
- Academic and technical laboratories (LCSQA, INERIS, ANSES, CNRS, universities) for the development and validation of analytical methods;
- Local authorities, involved in the implementation of regional actions and public information campaigns.

The collaboration aims to provide an objective assessment of the environmental situation, improve understanding of contamination mechanisms, and propose appropriate measures to protect both the environment and the populations (WHO, 2025).

1.2.4 Ambient air: the final component to investigate

To date, monitoring efforts have primarily focused on water and soil, where PFAS are more frequently detected.

However, the atmospheric pathway remains a significant blind spot:

very little, if any, baseline data exists on PFAS concentrations in ambient air in southern Lyon, nor on their seasonal or spatial variability (ANSES, 2025b).

Yet, the atmosphere plays a critical role in:

- The dispersion of PFAS emitted locally or transported via air masses;
- Their secondary deposition onto soils and surface waters;
- Potential inhalation exposure of populations living near industrial zones.

In this context, Atmo Auvergne–Rhône-Alpes took the initiative, as early as 2023, to develop an ambient air sampling method aimed at of generating the first quantitative data on airborne PFAS. This work was supported by the Region, the Lyon Metropolis, and DREAL Rhône. This initiative precedes regulatory requirements, responding to strong social expectations while providing an initial scientific knowledge base for this still largely unexplored environmental matrix (ECHA, 2023).

1.3 Atmo AuRA’s exploratory work on ambient air

In this context, and to address a growing need among its members and the region’s residents, Atmo Auvergne-Rhône-Alpes initiated exploratory work in 2023 on the quantitative measurement of PFAS in ambient air, combining innovation, methodological rigor, and inter-institutional cooperation.

The main objectives of this work are to:

- Develop and test active sampling protocols capable of detecting PFAS at extremely low concentrations in the air;
- Generate high-quality data to inform public policy, research, and local risk management initiatives;
- Maintain ongoing scientific monitoring to integrate the latest findings from international studies;
- Collaborate with national reference laboratories and stakeholders (LCSQA, INERIS, ANSES, BQA) for analytical validation and inter-laboratory comparisons;
- Promote exchanges among AASQA to share lessons learned and harmonize measurement practices at the national level;

Given the local context, the initial work focused on the Lyon metropolitan area, where PFAS had already been detected in other environmental matrices and in the air using indicative methods. Methodological testing, not detailed here, enabled the first exploratory measurements, allowing for the quantification of PFAS presence and concentrations in ambient air across the Lyon metropolitan area. The primary aim of this work is to enhance knowledge and support public decision-making. These findings may also inform the national discussion on measurement methods, reference values, and future regulatory frameworks for PFAS int the atmosphere.

Ambient air monitoring complements measurements conducted at emission points under the March 2025 prefectural order issued by the DREAL Rhône, which governs the monitoring of atmospheric emissions around industrial sites in southern Lyon, as well as the October 31, 2024 order, concerning the analysis of per- and polyfluoroalkyl substances in atmospheric emissions from incineration, co-incineration, and other thermal waste treatment facilities. These decrees represent the first regulatory acknowledgment of the need to quantify PFAS in the atmosphere, complementing existing monitoring efforts in aquatic environments.

The measurement campaigns conducted by Atmo Auvergne-Rhône-Alpes since 2023 therefore provide a novel and complementary perspective for characterizing atmospheric contamination levels.

2. Materials and Methods

2.1 Sampling device

To date, no validated and standardized method exists for sampling PFAS in ambient air. Based on the literature (Atmo AuRA, PFAS Note 2024) and tests conducted since 2023 by Atmo Auvergne-Rhône-Alpes - including assessments of reproducibility, blanks, sampling duration, and matrix effects- an initial sampling method was developed and applied in this study. It should be noted that work on sampling methods is ongoing, in parallel with efforts contributing to the national interministerial PFAS plan, in collaboration with INERIS.

To obtain both qualitative and quantitative concentrations, sampling was performed using high-flow samplers (DA-80, Digitel) traditionally employed in air quality monitoring networks for the collection of particulate matter, organic compounds, metals, pesticides, and other pollutants.

Precautions were implemented on the sampler and throughout the sampling and transport chain to minimize the risk of contamination, loss, or degradation of the collected PFAS. Additional measures were taken during the analytical phase by the selected accredited laboratory.

The samplers were modified by reducing the flow rate to 250 L/min (or 15 m^3/h) to prevent clogging of the matrices. For the particulate phase, quartz filters (PallFlex 150 mm), commonly used in monitoring, were selected. For the gaseous phase, several methodologies are under evaluation, but for the initial measurements, polyurethane foam (PUF, TISCH) was chosen (TISCH).

Measurements were conducted as part of methodological testing. To ensure that PFAS concentration exceeded detection limits samples were collected over a 96-hour period. This duration may be revised during standardization, particularly for industrial monitoring, where 24-hour sampling may be implemented

Figure 1: DA-80 and sampling holders

2.2 Monitoring sites

Measurements were initiated in the Lyon basin to test sampling methodologies. Accordingly, samplers were installed at the “Sud Lyonnais – Pierre-Bénite” monitoring station, located less than one kilometer south of the fluoropolymer production site. This area has already been studied in other environmental matrices (soil, water) and has shown high PFAS levels (e.g., Dauchy, 2023; ARS and DREAL, 2025). The expected elevated PFAS concentrations in ambient air here make it suitable for methodological testing. In this location, prevailing winds are from the north and southwest.

At the same time, the “Lyon centre” monitoring station, situated approximately six kilometers north of the industrial site, was selected as the reference site to assess background levels in the Lyon basin (Figure 2).

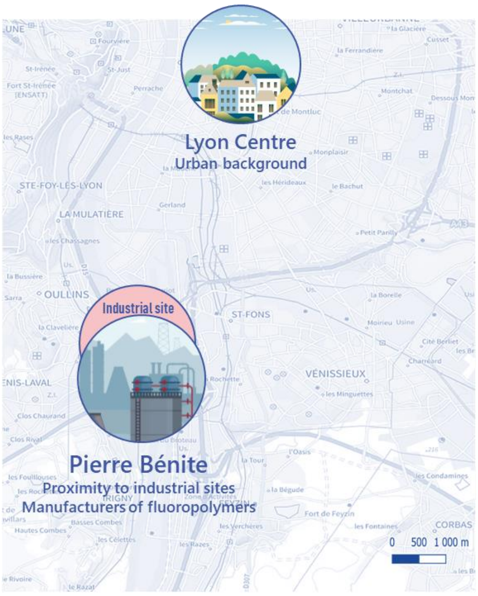


Figure 2: Localization of the two sampling sites

Several monitoring campaigns have been conducted since October 2023 across different seasons. Table 1 summarizes the various sampling periods. It should be noted that these sampling periods were not designed to provide representative average concentrations for the sampling areas, as specific criteria regarding frequency and seasonal coverage would have been required. Nonetheless, these campaigns provide an initial estimate of PFAS levels in the studied locations.

Table 1: Calendar of the sampling dates both sites since 2023

96h samples	Pierre-Bénite	Lyon centre
Thursday, October 26, 2023	OK	OK
Monday, November 6, 2023	OK	OK
Friday, May 31, 2024	OK	X
Wednesday, June 5, 2024	OK	X
Monday, June 10, 2024	OK	X
Friday, June 14, 2024	OK	OK
Tuesday, September 10, 2024	OK	X
Saturday, September 14, 2024	OK	X
Saturday, November 16, 2024	OK	X
Wednesday, November 20, 2024	OK	X
Tuesday, November 26, 2024	OK	X
Saturday, November 30, 2024	OK	X
Saturday, March 8, 2025	OK	OK
Wednesday, March 12, 2025	OK	OK
Sunday, March 16, 2025	OK	OK
Thursday, March 20, 2025	OK	OK
Saturday, June 21, 2025	OK	OK
Wednesday, June 25, 2025	OK	OK
Sunday, June 29, 2025	OK	OK
Thursday, July 3, 2025	OK	OK
Tuesday, September 30, 2025	OK	OK
Saturday, October 4, 2025	OK	OK
Monday, November 17, 2025	OK	OK
Monday, November 24, 2025	OK	OK
Friday, November 28, 2025	OK	OK
Tuesday, December 2, 2025	OK	OK

During each campaign, and for every site and matrix, a blank sample was collected. All blank values were below the limit of quantification.

2.3 Samples chemical analyses

The samples were sent to an accredited laboratory for analysis of the compounds listed in European Directive 2020/2184 on the quality of water intended for human consumption (20 compounds), as well as those specified in the U.S. OTM-45 standard (18 compounds) for a total of 38 compounds.

Table 2 : List of the 38 PFAS analyzed by LC-MS

Classification	Substances	Abbrevation	Classification	Substances	Abbrevation
13 PFCA Perfluoro alkyl acid	n-perfluorobutanoic acid	PFBA	**10 PFSA** Perfluoroalkane sulfonic acid	perfluorobutane sulfonic acid	PFBS
	n-perfluoropentanoic acid	PFPeA		perfluoropentane sulfonic acid	PFPeS
	n-perfluorohexanoic acid	PFHxA		perfluorohexanesulfonic acid	PFHxS
	perfluoroheptanoic acid	PFHpA		perfluoroheptanesulfonic acid	PFHS
	n-perfluorooctanoic acid	PFOA		L-perfluorooctane sulfonic acid	PFOS
	n-perfluorononanoic acid	PFNA		perfluorononane sulfonic acid	PFNS
	n-perfluorodécanoic acid	PFDA		perfluorodecanesulfonic acid	PFDS
	n-perfluoroundécanoic acid	PFUnDA		perfluoroundecane sulfonic acid	PFUDaS
	n-perfluorododécanoic acid	PFDoDA		perfluorododecanesulfonic acid	PFDoaS ou PFDoDS
	n-perfluorotridécanoic acid	PFTrDA		perfluorotridecane sulfonic acid	PFTDaS
	n-perfluorotétradécanoic acid	PFTeDA	**3 FOSA** Perfluoroalkane sulfonamides	Perfluorooctanesulfonamide	PFOSA
	n-perfluorohexadécanoic acid	PFHxDA		N-ethyl-1-perfluorooctanesulfonamide	N-EtFOSA
	n-perfluorooctadécanoic acid	PFODA		N-methylperfluoro-1-octanesulfonamide	N-MeFOSA
4 FTS Fluorotelometer sulfonic acids	1H,1H,2H,2H-Perfluorohexanesulfonic acid	4:2 FTS	**2 FOSE** Perfluorinated sulfonamide ethanol	2-(n-ethylperfluoro-1-octanesulfonamido)ethanol	N-EtFOSE
	1H,1H,2H,2H-perfluorooctanosulfonic acid	6:2 FTSA		2-(n-methylperfluoro-1-octanesulfonamido)ethanol	N-MeFOSE
	8:2 fluorotelomer sulfonic acid	8:2 FTS	2 Fluorinated remplacement chemicals	2-methyl-3-oxahexanoic undecafluoro acid	HFPO
	1H,1H,2H,2H-perfluorododecanesulfonic acid	10:2 FTS		3H-4,8-dodecafluoro-dioxanonoic acid	Adona
2 FOSAA Perfluorinated sulfonamidoacetic acids	N-ethylperfluoro-1-octanesulfonamidoacetic acid	N-EtFOSAA	2 additional targets	2H,2H,3H,3H-perfluorooctanoic acid	FTCA 5:3
	N-methylperfluoro-1-octanesulfonamidoacetic acid	N-MeFOSAA		2H,2H-perfluorooctanoic acid	FTCA 6:2

Among the 38 identifiable and quantifiable PFAS, the compounds were classified and grouped according to their chemical function (Figure 3): 13 perfluorinated carboxylic acids (PFCA), 4 fluorotelomer sulfonic acids (FTS), 2 perfluorooctanesulfonamidoacetic acids (FOSAA), 10 perfluorosulfonic acids (PFSA), 3 perfluorooctanesulfonamides (FOSA), 2 perfluoroalkanesulfonamide ethanols (FOSE or FASE), 2 commercial substitute compounds (Adona and HFPO-DA [GenX], PFOA substitutes used in PTFE production), 2 fluorotelomer carboxylic acids (5:3 FTCA and 6:2 FTCA).

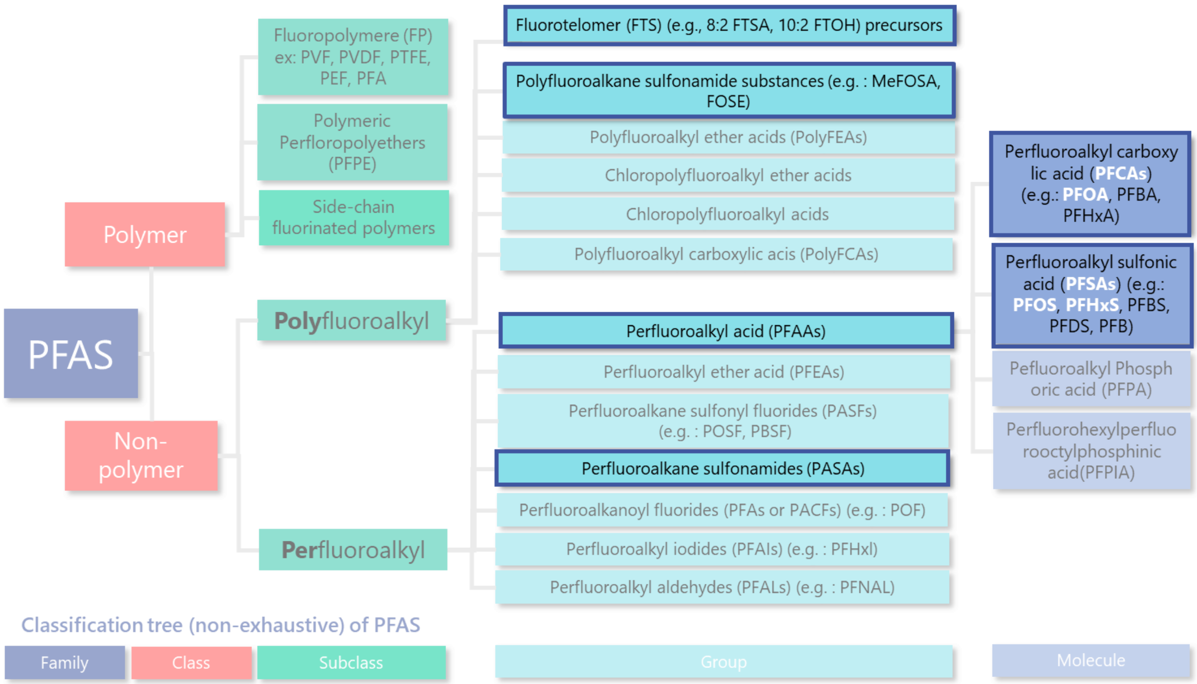


Figure 3 : Non-exhaustive classification tree of PFAS

Limit of detection and quantification

Analyses were performed using LC-MS (liquid chromatography coupled with mass spectrometry). The detection limit was set at one-third of the quantification limit. With an analytical quantification limit of 0.25 ng per medium and assuming a theoretical air sample volume of 1,440 m^3, the corresponding quantification limit in ambient air is 0.18 pg/m^3 for all compounds and 0.03 pg/m^3 for PFOS and PFOA (see table in the Appendix).

3. Results

The total PFAS concentration is expressed in picograms per cubic meter (pg/m^3) and represents the sum of the PFAS quantified in both the particulate phase (quartz filter) and the gaseous phase (PUF foam). This unit corresponds to the order of magnitude commonly measured for dioxins in air; however, it is approximately one million times lower than the concentrations of conventional air pollutants. It should be noted that, at these concentration levels, measurement uncertainties are very high on the order of 50%, compared with up to 30% for conventional pollutants.

3.1 Average PFAS levels

Figure 4 shows the average concentrations of the 38 PFAS compounds measured and identified in samples collected from the Lyon city center and Pierre-Bénite sites since 2023. These averages are based on a limited number of measurements (see Table 1) and do not represent annual averages, as the sampling was designed to ensure seasonal representativeness, even though different seasons were covered. Moreover, information on the operating periods of fluoropolymer-producing industries is not available. Therefore, these averages should be interpreted with caution, but they nevertheless provide a first step toward quantifying PFAS concentrations in ambient air in the Lyon basin.

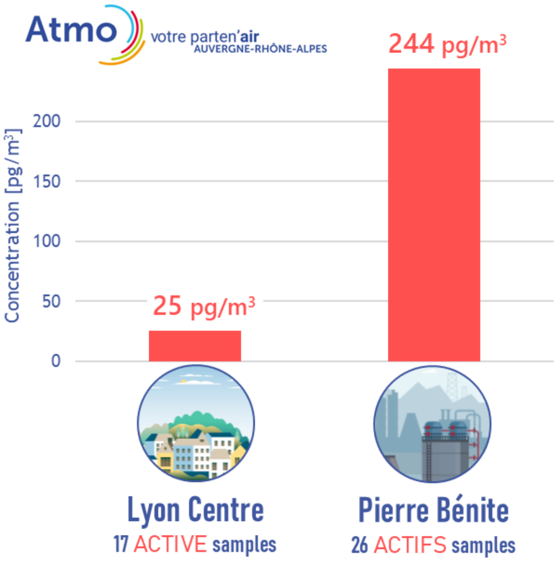


Figure 4 : Average concentrations of the 38 PFAS compounds (particulate + gaseous phases) measured at the Lyon Centre and Pierre-Bénite sites since 2023. Averages are based on a limited number of measurements. Measurement uncertainty is approximately 50%.

Figure 4 shows that PFAS are detected in both environments—industrial and urban— with concentrations in the range of tens of picograms per cubic meter in the urban area of central Lyon (average 25 pg/m^3) and hundreds of pg/m^3) in Pierre-Bénite (average 244 pg/m^3), an urban area influenced by fluoropolymer producers. The high levels observed at the Pierre-Bénite site, along with the chemical profiles presented in Section 3.3, indicate a local industrial influence.

It is important to note, as previously mentioned, that no standardized reference method currently exists and differences in sampling and analytical methodologies introduce significant uncertainties when attempting to compare these results with data reported in the literature. In addition, the number and type of PFAS analyzed vary between studies. Considering only studies that employed active sampling and measured the full set of compounds, it is possible to compare the average levels measured in Pierre-Bénite and central Lyon with those reported in the literature (e.g., Faust, 2023).

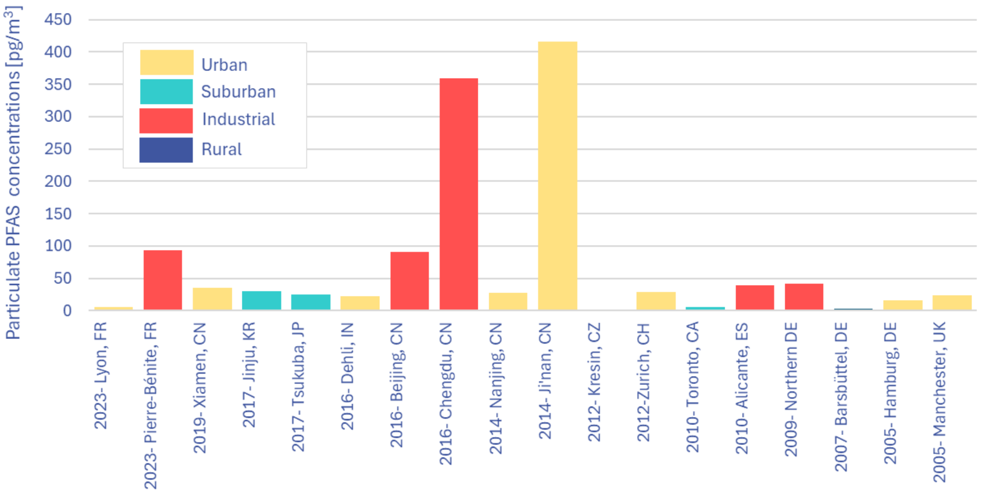


Figure 5 : Comparison of PFAS levels in the particulate phase with literature data, adapted from Faust 2023

Figure 5 shows the average PFAS concentrations measured at each site type (industrial, urban, suburban, and rural). This comparative analysis presents data for the particulate matter fraction only. The measurements at the urban background site in central Lyon fall within the same concentration range as most urban background sites reported in the literature (tens of pg/m^3). In contrast, concentrations at the Pierre-Bénite site comparable to those observed at urban sites in China and industrial sites (hundreds of pg/m^3). It should be noted, however, that information on the types of industries at the referenced industrial sites is lacking, and that this comparison should therefore be interpreted with caution.

3.2 Temporal variations in concentrations

Temporal trends in PFAS concentrations (particulate + gaseous phases) at the two monitoring sites can be examined in detail. Figure 6 shows these trends since 2023 based on the conducted sampling campaigns. Differences between the two sites are clearly visible (LC in yellow and PB in blue). Considerable variability is observed between individual sampling campaigns, with lower concentrations in fall and winter (tens of pg/m^3) and higher concentrations in spring and summer (hundreds of pg/m^3). This seasonal pattern suggests that temperature and compound volatilization influence ambient PFAS concentrations.

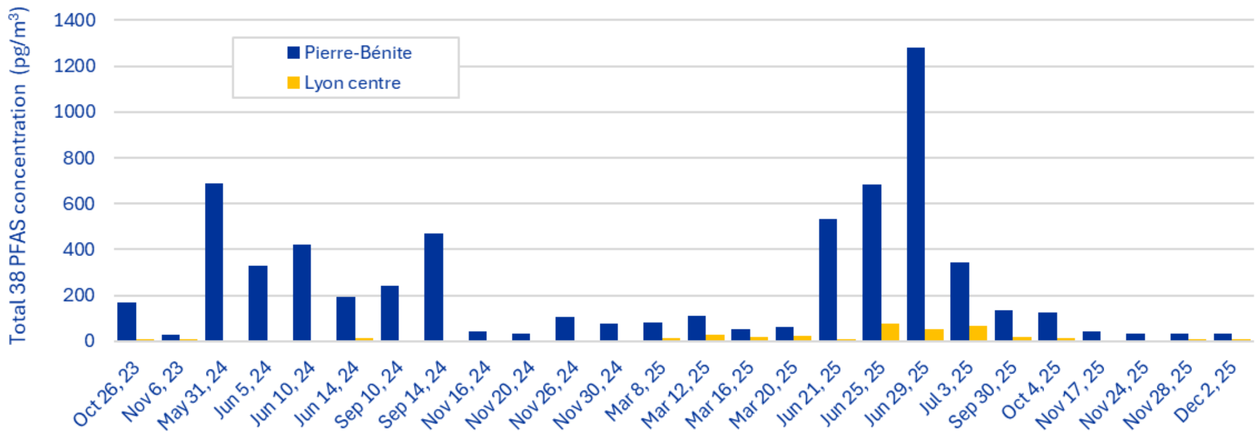


Figure 6 : Time series of the total concentrations of the 38 PFAS measured at Pierre-Bénite site (blue) and at central Lyon (yellow)

Total PFAS concentrations at the Lyon city center site range from 11 pg/m^3 to 77 pg/m^3, whereas at the Pierre-Bénite site they range from 29 pg/m^3 to 1,280 pg/m^3. By way of comparison, PFAS concentrations measured at the emission points of fluoropolymer-producing industries under prefectural decrees are in the order of µg/m^3, or 10^6 times higher. Nevertheless, PFAS levels appear to have decreased by a factor of 10 to 1,000 with the new protocols implemented in late 2024, reaching concentrations in the range of a few hundred ng/m^3. The first measurements at incinerator exhausts-under the October 31, 2024, decree- on the analysis of PFAS in atmospheric emissions from incineration, co-incineration, and other thermal waste treatment facilities- are now being conducted. Results in AuRA, particularly in southern Lyon, indicate concentrations around 10 ng/m^3 (DREAL, November 2025).

Pollutant emissions and concentrations

Please note, however, that these should not be confused:

- **Pollutant emissions** refer to the quantities of pollutants directly released into the atmosphere by human activities (factory or residential chimneys, vehicle exhausts, agriculture, etc.) or by natural sources (volcanoes, or compounds emitted by vegetation and soil).
- **Pollutant concentrations** characterize the quality of the air we breathe.

Air quality depends on emissions, even though there is no simple, direct link between the two. In fact, air quality results from a complex balance between the amount of pollutants released into the air and a whole series of phenomena to which these pollutants are subjected once in the atmosphere under the influence of meteorological conditions: transport, dispersion by wind and rain, deposition, or chemical reactions among the pollutants themselves or under the influence of sunlight.

It should be noted that toxicological reference values are established by considering what humans breathe, not what is emitted.

The influence of meteorological parameters on PFAS concentrations can also be examined. Meteorological data were obtained from the Solaize weather station. Figure 7 presents PFAS concentrations according to prevailing wind direction (i.e., the direction from which the wind originates) at each of the two monitoring sites (north and southwest).

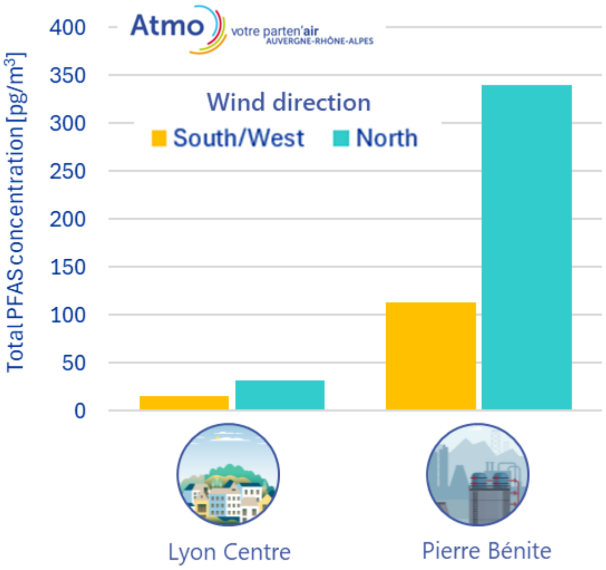


Figure 7 : PFAS concentrations at the Lyon city center site (left) and the Pierre-Bénite site (right) based on the prevailing wind direction.

The Lyon city center site is located north of the industrial zone, whereas the Pierre-Bénite site lies to thesouth of the fluoropolymer manufacturers (Figure 2). Relatively small variations are observed at the Lyon centre site, while concentrations increase sharply under a north wind at the PB site, indicating that industrial emissions are being transported southward. Over the course of a year, north winds prevail approximately 45% of the time during this study.

Other meteorological parameters, such as temperature and precipitation, also merit further investigation.

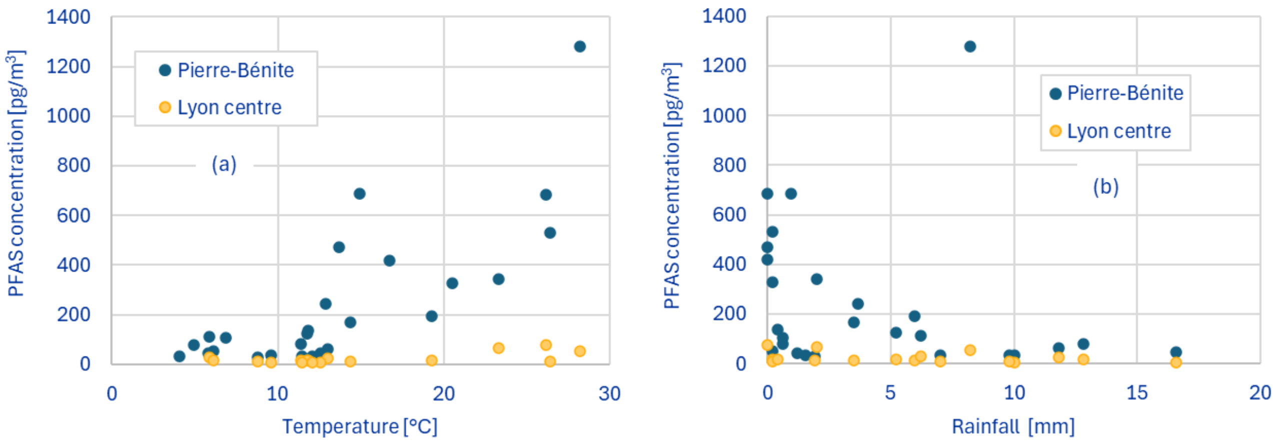


Figure 8 : Effect of temperature (a) and precipitation (b) on PFAS levels observed at the two sites (LC in yellow and PB in blue)

Figure 8 (a) shows the variation in PFAS concentration as a function of temperature. An increase in in PFAS concentrations is observed with rising ambient temperatures at both sites, with a more pronounced effect at the Pierre-Bénite site, near industrial sources, where very high levels - up to 1.4 ng/m³ - were measured during periods of elevated temperatures.

Figure 8 (b) presents PFAS concentrations in relation to precipitation. Higher precipitation appears to reduce measured concentrations, likely due to atmospheric washout. It should be noted, however, that during a 96-hour sampling period, alternating periods with and without precipitation may bias this interpretation, as other factors could contribute to concentrations changes.

The influence of the industrial activity intensity could not be assessed due to a lack of information on operational schedules during the measurement periods. This parameter could be critical, as variations in production may directly affect emissions.

3.3 Chemical profiles

To further investigate, it is important to examine which compounds among the 38 PFAS measured can be identified and quantified. Analysis of the PFAS composition (Figure 9) shows that 13 compounds account for 95 -99% of the total measured mass of the 38 PFAS, at both sites.

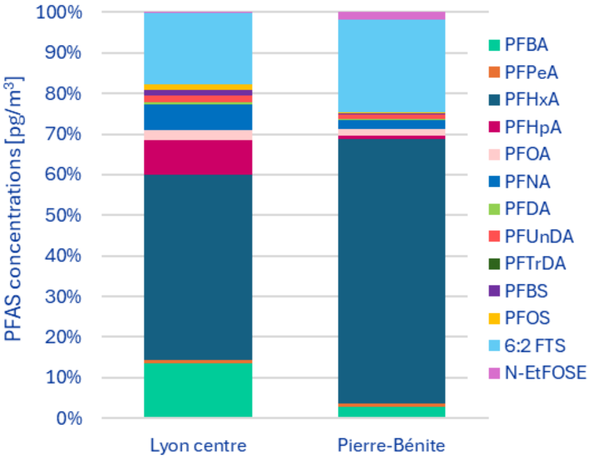


Figure 9 : Chemical profiles of PFAS measured and identified in central Lyon (left) and Pierre-Bénite (right)

Among the PFAS analyzed, PFHxA and 6:2FTS were detected at higher levels than the other compounds at both sites (accounting on average for 61% of the total PFAS mass in central Lyon and 88% at Pierre-Bénite). These results are likely linked to local fluoropolymer production activities (DREAL – web page on the southern Lyon area), as these two compounds also predominate in emission measurements from the two industrial fluoropolymer manufacturers. In these industrial emission measurements, one manufacturer primarily emitted PFHxA (96–100%), while the second primarily released 6:2 FTS (up to 91% at certain emission points, with concentrations reaching µg/m³) along with PFHxA. By prefectural order, the company using 6:2 FTS was required to cease its use by the end of 2024, resulting in a significant reduction of emissions at its discharge points, although some residual levels remain. It should be noted that the prefectural order bans the use of 6:2 FTS but does not explicitly prohibit its atmospheric emissions. The other facility ceased using PFHxA at the end of 2025. Further measurements may confirm these trends. Other potential contributors to ambient air PFAS include incinerators, wastewater treatment plants, additional nearby sources. Initial measurements conducted under the October 31, 2024, decree indicate that PFAS concentrations at incinerator outlets are approximately 100 times lower than at the fluoropolymer production facilities. While PFHxA and 6:2 FTS remain, the main compounds detected in these emissions, their levels are roughly two orders of magnitude lower than those observed from the sector's industrial sources.

PFOA and PFOS, whose use has been banned since 2009 and 2020, respectively due to their classification as carcinogens, were also detected in the samples, albeit at much lower levels (approximately 2%). These compounds have relatively long half-lives, which contributes to their persistence in the environment even several years after their use and release.

In addition to these substances, other compounds from the same PFCA class as PFHxA were detected, including PFNA, PFBA, PFUnDA, PFHpA, PFPeA, and in some samples, PFDA, PFTrDA, and PFDoDA. Compounds from the FOSE class, such as N-EtFOSE, were also observed, and traces of N-MeFOSE were found in some samples.

Variations in the chemical profiles can also be examined across the different sites and seasons (Figure 10), highlighting seasonal or spatial shifts in PFAS composition.

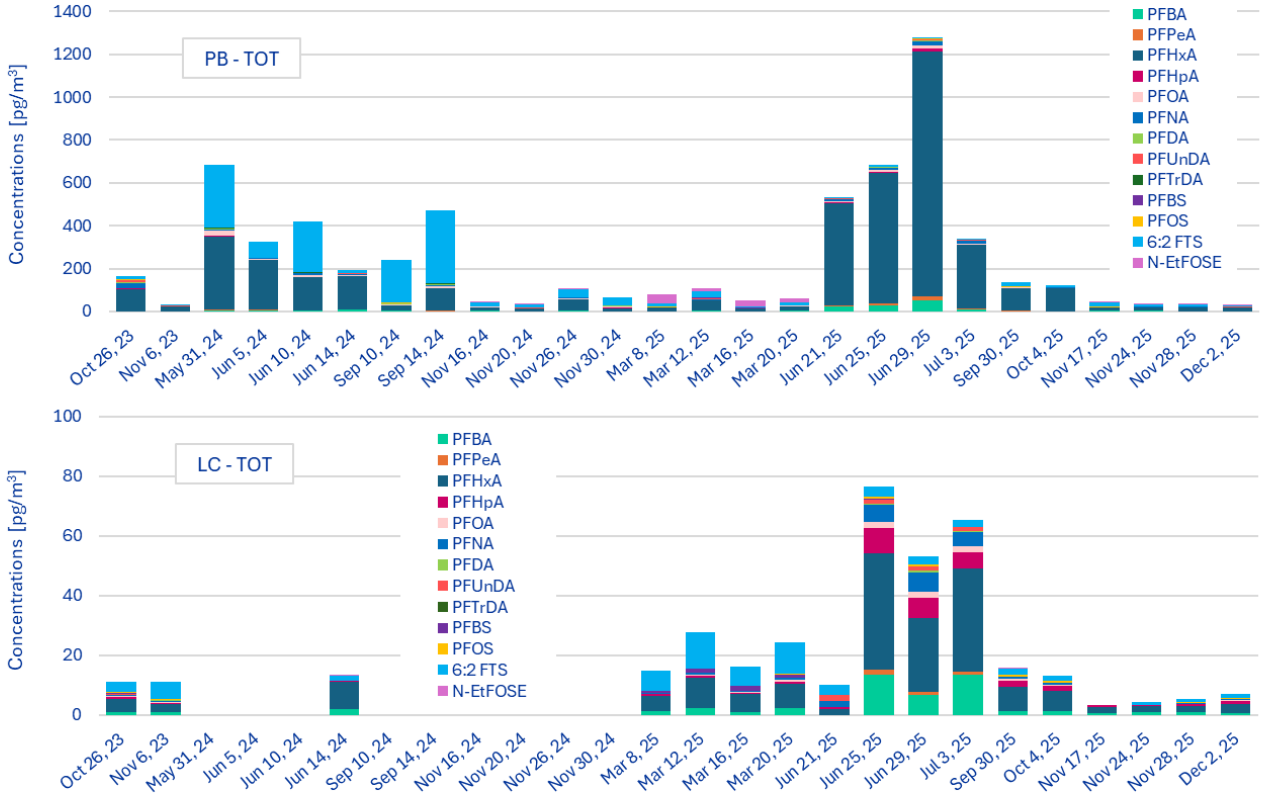


Figure 10 : Chemical profiles of PFAS at the two sites across various monitoring points since 2023 (PB at the top and LC at the bottom).

As shown in Figure 10, PFHxA (dark blue) is the predominant compound in all samples and at both sites. For the 6:2 FTS (light blue), also a major contributor, a decrease in concentrations is observed at the Pierre-Bénite site beginning in early 2025, linked to production changes implemented by one of the manufacturers. This decline appears slightly later at the Lyon centre site, occurring after March 2025. At the Pierre-Bénite site, concentrations remained relatively consistent across all samples through the end of 2024. Changes then became apparent, with notable levels of N-EtFOSE (pink) emerging in March 2025. This perfluoroalkane sulfonamide ethanol is a precursor to PFOS and other PFAS. A sharp increase in total PFAS concentrations was observed in June 2025, reaching up to 1,280 pg/m^3, associated with elevated levels of PFBA, PFPeA, PFHpA, PFOA, and PFNA.

It should be noted that during the November/December 2025 measurements, one of the industrial facilities underwent a shutdown to modify its production lines and eliminate the use of PFHxA in its production processes.

For central Lyon, a similar change was observed in June 2025, with higher total concentrations and a predominance of PFCA-class compounds.

3.4 Gas-particle partitioning of PFAS

Another important aspect to consider when assessing the potential impact of PFAS is their partitioning between the particulate and gaseous phases. Although this differentiation remains subject to significant methodological uncertainties, the initial results allow for the identification of emerging trends (Figure 11). This differentiation is critical, as PFAS in the gaseous and particulate phases may follow different exposure pathways and could lead to varying health effects depending on the compounds involved.

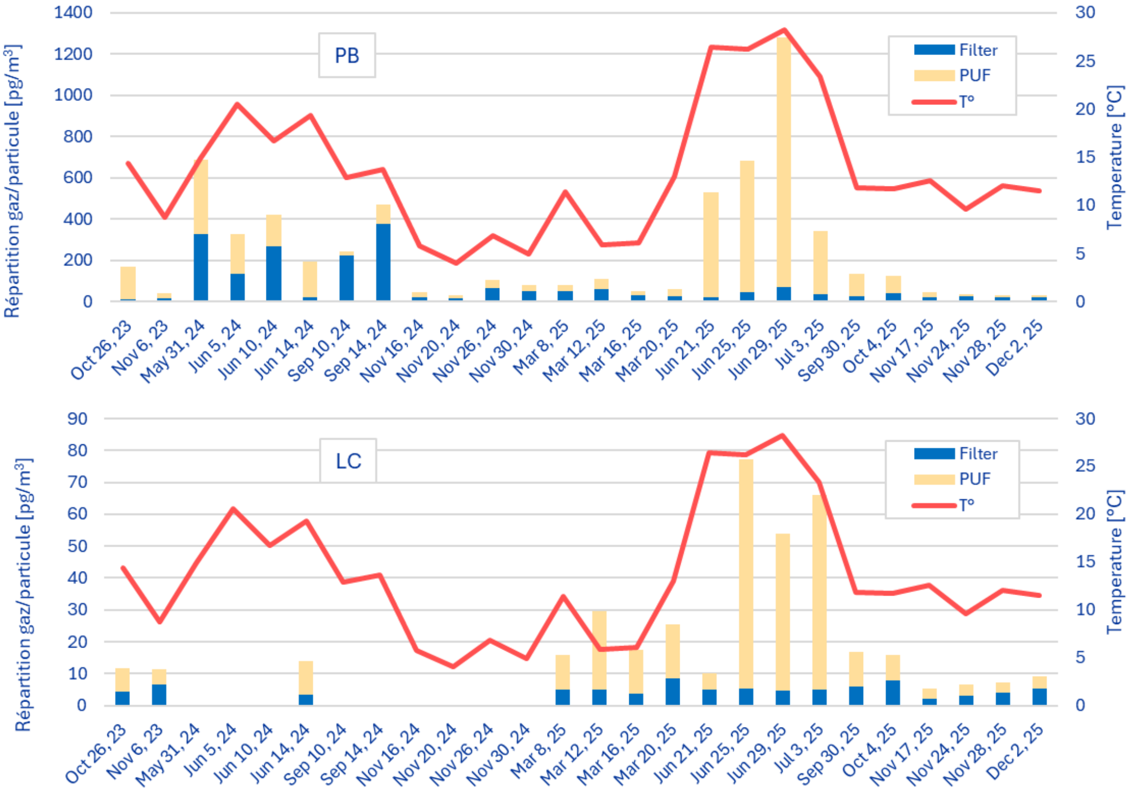


Figure 11 : Temporal evolution of PFAS partitioning between the particulate phase (filter, blue) and the gaseous phase (PUF, yellow) at the two monitoring sites, together with temperature (°C, red); Pierre-Bénite (PB) in the upper panel, Lyon centre (LC) in the lower panel.

Figure 11 illustrates the partitioning between the gas phase (yellow) and the particulate phase (blue) at the two monitoring sites across the different sampling periods and seasons. A clear increase in the gas-phase fraction is observed during the summer months, correlated with higher temperatures (red curve), accounting for more than 94% of total PFAS concentrations (gas + particulate phases). The particulate phase appears relatively stable at the Lyon centre (LC) site, with concentrations ranging from 5 to 10 pg/m^3. In contrast, greater variability is observed at the Pierre-Bénite (PB) site, with concentrations ranging from 10 to 376 pg/m^3, likely reflecting the influence of industrial emissions.

At the PB site, the gaseous fraction represents between 8% and 96% of the total PFAS measured, with average contributions of 46% in winter and 76% in summer. At LC, the gaseous fraction ranges from 42% to 93%, with average values of 67% in winter and 81% in summer.

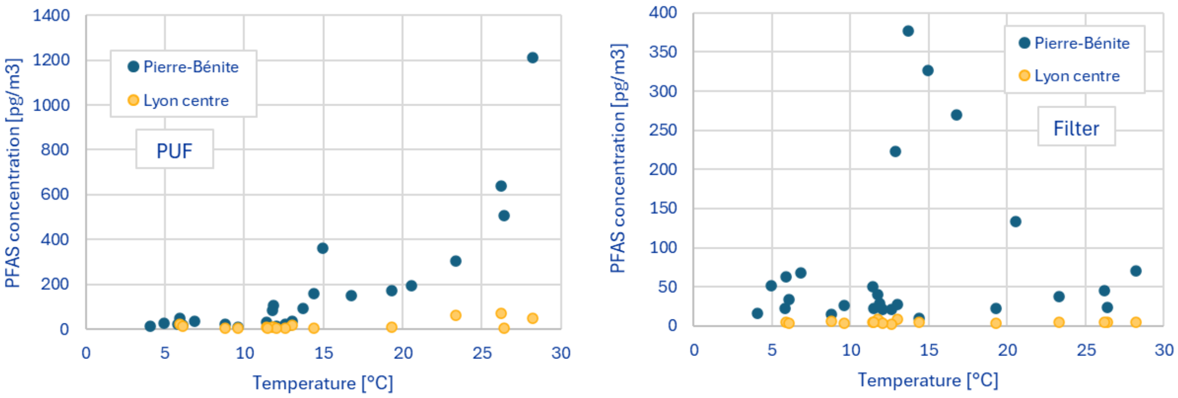


Figure 12 : Effect of temperature on PFAS concentrations at PB (blue) and LC (yellow) sites, for the gas phase (left panel) and the particulate phase (right panel)

Figure 12 illustrates the effect of temperature on the PFAS concentrations in each phase. A clear increase in gas-phase PFAS concentrations (measured on the PUF) is observed with rising ambient temperature, a phenomenon that is particularly pronounced at the PB site. Although a correlation is also observed in the particulate phase (measured on filters), it is less pronounced.

It is also relevant to examine how gas-particle partitioning varies depending on the specific compounds measured.

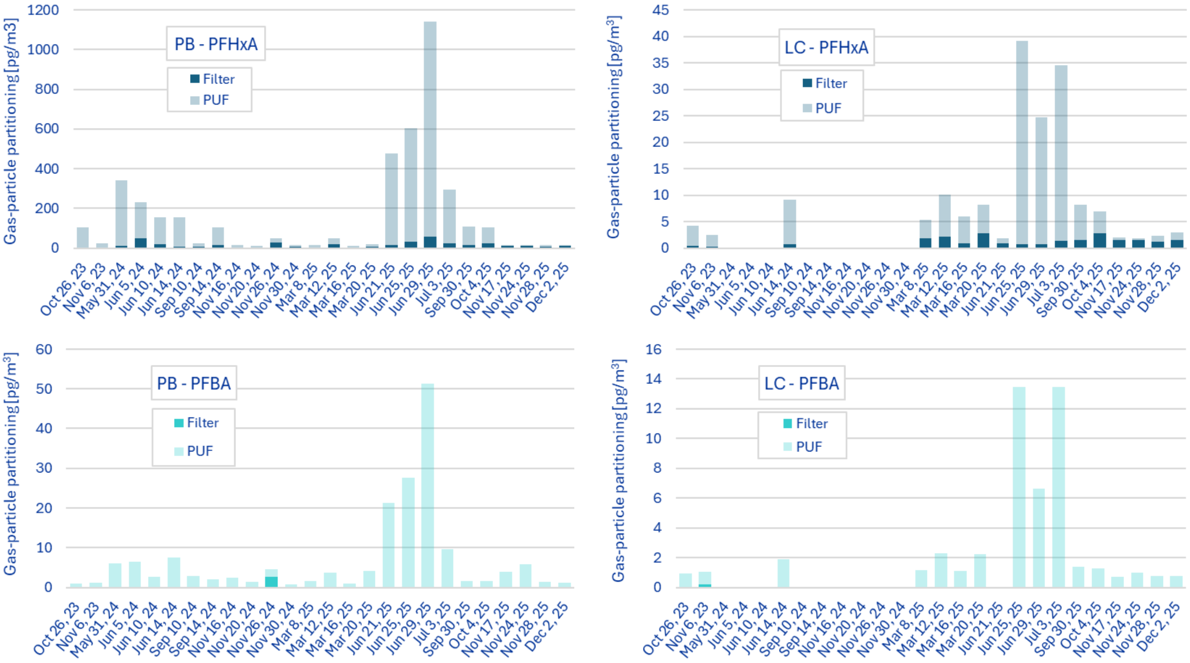


Figure 13 : Gas-particle partitioning of PFHxA and PFBA at the two monitoring sites, with PB on the left and LC on the right. The particulate phase (filter) is shown in dark colors and the gas phase (PUF) in light colors.

As shown in Figure 13 (and in Appendix 2), PFHxA, PFHpA, PFBA, PFPeA, and PFBS are predominantly present in the gas phase.

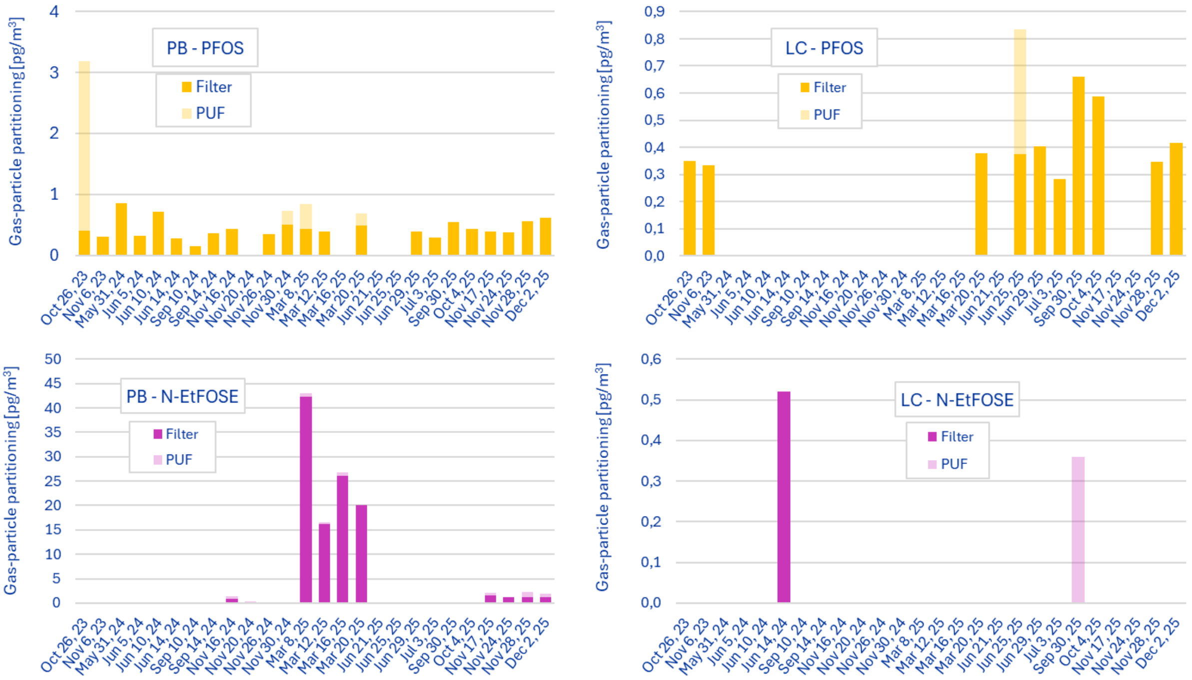


Figure 14 : Gas-particle partitioning of PFOS and N-EtFOSE at the two monitoring sites, with PB on the left and LC on the right. The particulate phase (filter) is shown in dark colors and the gas phase (PUF) in light colors.

For compounds such as PFOS, N-EtFOSE, and PFTrDA, Figure 14 (and Appendix 2) shows that they are predominantly associated with the particulate phase.

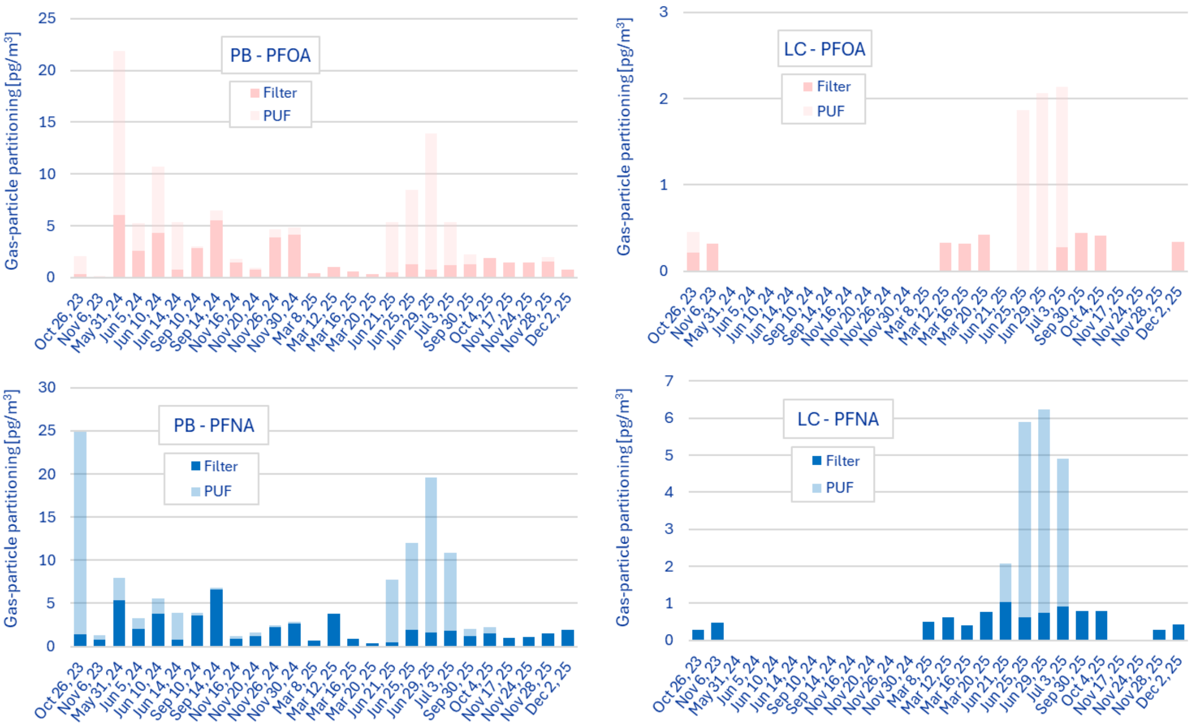


Figure 15 : Gas-particle partitioning of PFOA and PFNA at the two monitoring sites, with PB on the left and LC on the right. The particulate phase (filter) is shown in dark colors and the gas phase (PUF) in light colors.

Finally, other compounds are predominantly found in the particulate phase, although their peaks are primarily driven by a sharp increase in the gas phase during summer, particularly for PFOA, PFNA, PFDA, and PFUnDA (Figure 15 and Appendix 2).

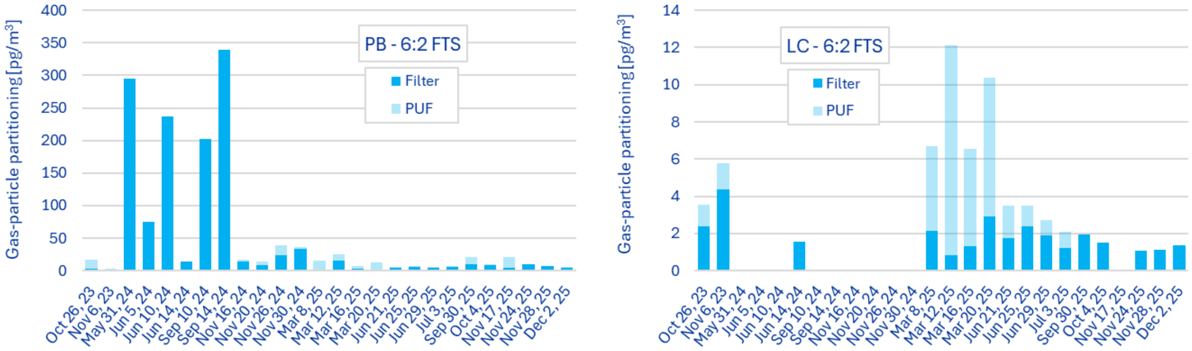


Figure 16 : Gas-particle partitioning of 6:2 FTS at the two monitoring sites, with PB on the left and LC on the right. The particulate phase (filter) is shown in dark colors and the gas phase (PUF) in light colors.

For 6:2 FTS, Figure 16 shows that at the site closest to major PFAS sources (PB, left), it appears to be predominantly present in the particulate phase, whereas at the urban background site (LC, right), the peaks seem to be mainly driven by an increase in the gas phase during summer.

In summary, and as confirmed by Yamazaki et al. (2021), PFAS in ambient air exhibit a gas-particle partitioning that strongly depends on their volatility, which in turn is governed by chain length and functional group. Shorter, neutral compounds preferentially occur in the gas phase, whereas longer, ionized species are more likely to be associated with particles. Similarly, atmospheric studies such as Yang et al. (2025) indicate that longer-chain perfluoroalkyl carboxylic acids (PFCAs) and perfluoroalkyl sulfonic acids (PFSAs), particularly PFOS, tend to be predominantly found in the particulate phase, whereas certain short-chain PFAS and fluorotelomers are more frequently detected in the gas phase.

3.5 Comparisons of chemical profiles across matrices

It is interesting to compare the profiles obtained in ambient air, as presented above, with those from other matrices such as soil and nearby deposition samples, in order to identify potential secondary sources, particularly the resuspension of compounds previously trapped in soils. These comparisons should, however, be interpreted with caution, as the studies were not conducted during the same time periods; they therefore represent only preliminary comparisons.

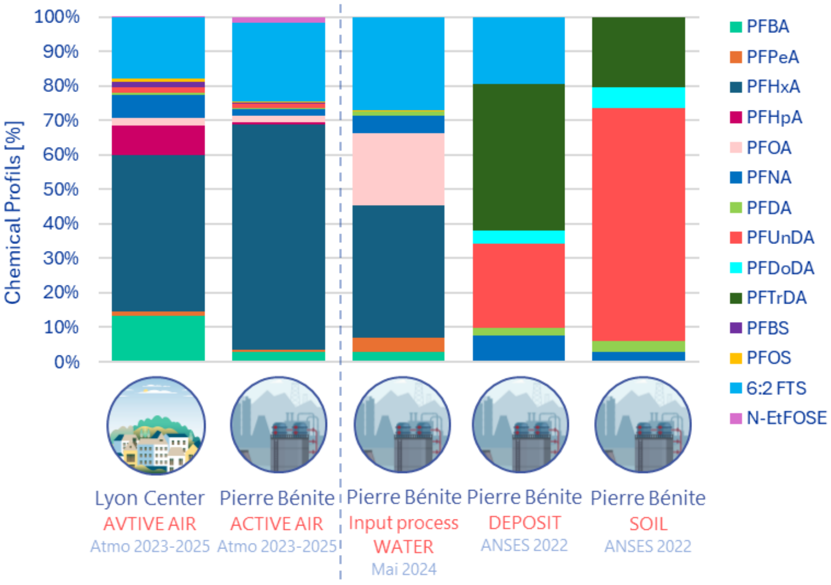


Figure 17: Profiles of active air samples (left) compared with soil and water deposition samples

Thus, in Figure 17, we observe that the chemical profiles of sediments and soils differ markedly from those measured in ambient air, suggesting that the compounds present in the air do not appear to originate from the resuspension of substances previously deposited in soils or sediments. As discussed above, volatility and functional group play a key role in environmental distribution of PFAS. In this context, PFAS detected in surface soils are predominantly long-chain compounds (>C8), which tend to be less mobile and less volatile. Indeed, long-chain compounds are more strongly adsorbed onto soil particles than short-chain compounds due to their higher hydrophobicity, which limits their leaching into deeper soil layers and their uptake by plants. Conversely, short-chain compounds, which are less strongly adsorbed and more water-soluble than long-chain compounds, tend to migrate more readily into plants and groundwater. This pattern is illustrated in Figure 17 in the water supplying the intake of one of the industrial fluoropolymer manufacturers, which shows a profile enriched in short-chain compounds. it should also be noted that within plants, long-chain compounds are more likely to accumulate in roots whereas short-chain compounds are more readily translocated to leaves and fruits.

4. Conclusion and perspectives

The results presented in this report represent the first quantitative measurements of PFAS in ambient air conducted in the Auvergne-Rhône-Alpes region - and indeed in France - using active sampling at both an urban background reference site (Lyon centre, LC) and a pilot site (Pierre-Bénite, PB) influenced by fluoropolymer manufacturers. Concentration levels range from tens of pg/m³ in central Lyon (25 pg/m³) to hundreds of pg/m³ in Pierre-Bénite (244 pg/m³), with peaks values reaching up to 1,280 pg/m³.

Among the targeted molecules, PFHxA and 6:2FTS were found at higher levels than the other compounds, accounting on average for 61% of the total mass of samples from central Lyon and 88% in Pierre-Bénite. These results may be linked to fluoropolymer production activities in the area, where industrial emission measurements, conducted under prefectural orders have shown the predominance of these two compounds at levels reaching up to the µg/m³ range. PFOA and PFOS, whose use has been banned since 2009 and 2020, respectively (as they are classified as carcinogenic substances), were also detected in the samples in much lower proportions (approximately 2% of the total mass). The persistence of these compounds in the environment, even several years after their use and release, is facilitated by their relatively long half-lives. Since the profiles (i.e., the relative proportions of each substance) in ambient air differ from those found in soils and sediments, this suggests that the compounds detected in the air are unlikely to be related to the resuspension of historically contaminated soils.

In addition to emissions, meteorological conditions play a significant role in the observed concentrations. Wind patterns transporting emissions from PFAS-producing industries toward monitoring sites lead to increased concentration levels. Similarly, an increase in temperature was associated with higher PFAS levels, particularly in the gas phase. Finally, rainfall appears to reduce particulate phase PFAS levels through atmospheric scavenging. However, the 96-hour sampling periods make interpretation more complex.

These results therefore represent the first quantitative data on PFAS concentrations in ambient air in the Lyon region - and indeed in France - and pave the way for the establishment of a valuable database that will, in particular, support ANSES's work on deriving inhalation-based TWI values (ANSES Request). These data also contribute to studies on transfers between environmental compartments (air, water, soil, and biota), for example through the ASTEROPA project, which aims to investigate the links between PFAS exposure and the risk of testicular cancer, combining epidemiological analysis, environmental fate and transport of PFAS, and citizen engagement.

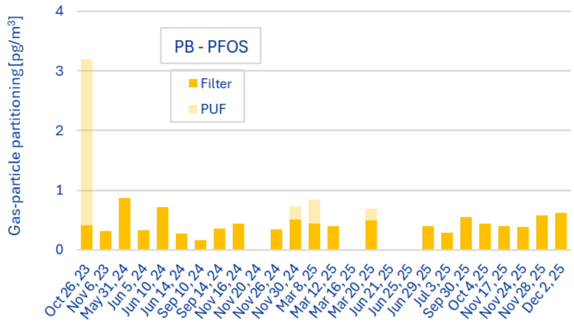
At this stage, however, Atmo AuRA notes the absence of a standardized sampling method (for both gaseous and particulate phases) and emphasizes that the limited number of available results calls for caution when assessing their representativeness of residents' exposure. The work carried out with INERIS as part of the interministerial plan to develop a harmonized sampling method with a view to establishing an AFNOR standard, should make it possible to standardize the sampling protocol and subsequently support the deployment of new measurements in the region. From a compound perspective, the molecules currently being targeted are the same as those monitored in water. However, the air matrix remains poorly characterized and identifying the predominant compounds in this matrix-through broader targeted analyses, non-targeted approaches, or Top-Assay methods to determine the total organic fluorine content- would be highly valuable for improving understanding of this environmental compartment. Finally, comparing PFAS profiles across different sources and geographical areas within the region remains an important objective for future work.

Appendices

Appendix 1: Chemical identification of the 38 PFAS targeted and their limits of quantification

Classe	Substances	Abbreviation	Formula	CAS	LOQ	Units
PFCA Perfluoro alkyl acid	n-perfluorobutanoic acid	PFBA	C4HF7O2	375-22-4	0.25	ng/support
	n-perfluoropentanoic acid	PFPeA	C5HF9O2	2706-90-3	0.25	ng/support
	n-perfluorohexanoic acid	PFHxA	C6HF11O2	307-24-4	0.25	ng/support
	perfluoroheptanoic acid	PFHpA	C7HF13O2	375-85-9	0.25	ng/support
	n-perfluorooctanoic acid	PFOA	C8HF15O2	335-67-1	**0.05**	ng/support
	n-perfluorononanoic acid	PFNA	C9HF17O2	375-95-1	0.25	ng/support
	n-perfluorodécanoic acid	PFDA	C10HF19O2	335-76-2	0.25	ng/support
	n-perfluoroundécanoic acid	PFUnDA	C11HF21O2	2058-94-8	0.25	ng/support
	n-perfluorododécanoic acid	PFDoDA	C12HF23O2	307-55-1	0.25	ng/support
	n-perfluorotridécanoic acid	PFTrDA	C13HF25O2	72629-94-8	0.25	ng/support
	n-perfluorotétradécanoic acid	PFTeDA		(376-06-7)	0.25	ng/support
	n-perfluorohexadécanoic acid	PFHxDA		(67905-19-5)	0.25	ng/support
	n-perfluorooctadécanoic acid	PFODA		(16517-11-6)	0.25	ng/support
FTS Fluorotelometer sulfonic acids	1H,1H,2H,2H-Perfluorohexanesulfonic acid	4:2 FTS		(757124-72-4)	0.25	ng/support
	1H,1H,2H,2H-perfluorooctanosulfonic acid	6:2 FTSA	C8H5F13O3S	27619-97-2	0.25	ng/support
	8:2 fluorotelomer sulfonic acid	8:2 FTS		(39108-34-4)	0.25	ng/support
	1H,1H,2H,2H-perfluorododecanesulfonic acid	10:2 FTS		(120226-60-0)	0.25	ng/support
2 FOSAA Perfluorinated sulfonamidoacetic acids	N-ethylperfluoro-1-octanesulfonamidoacetic acid	N-EtFOSAA		(2991-50-6)	0.25	ng/support
	N-methylperfluoro-1-octanesulfonamidoacetic acid	N-MeFOSAA		(2355-31-9)	0.25	ng/support
10 PFSA Perfluoroalkane sulfonic acid	perfluorobutane sulfonic acid	PFBS	C4HF9O3S	375-73-5	0.25	ng/support
	perfluoropentane sulfonic acid	PFPeS	C5HF11O3S	2706-91-4	0.25	ng/support
	perfluorohexanesulfonic acid	PFHxS	C6HF13O3S	355-46-4	0.25	ng/support
	perfluoroheptanesulfonic acid	PFHS	C7HF15O3S	375-92-8	0.25	ng/support
	L-perfluorooctane sulfonic acid	PFOS	C8HF17O3S	1763-23-1	**0.05**	ng/support
	perfluorononane sulfonic acid	PFNS	C9HF19O3S	68259-12-1	0.25	ng/support
	perfluorodecanesulfonic acid	PFDS	C10HF21O3S	335-77-3	0.25	ng/support
	perfluoroundecane sulfonic acid	PFUDaS	C11HF23O3S	749786-16-1	0.25	ng/support
	perfluorododecanesulfonic acid	PFDoaS ou PFDoDS	C12HF25O3S	79780-39-5	0.25	ng/support
	perfluorotridecane sulfonic acid	PFTDaS	C13HF27O3S	791563-89-8	0.25	ng/support
3 FOSA Perfluoroalkane sulfonamides	Perfluorooctanesulfonamide	PFOSA	C8H2F17NO2S	754-91-6	0.25	ng/support
	N-ethyl-1-perfluorooctanesulfonamide	N-EtFOSA	C12H8F17NO4S	(4151-50-2)	0.25	ng/support
	N-methylperfluoro-1-octanesulfonamide	N-MeFOSA	C12H8F17NO4S	(31506-32-8)	0.25	ng/support
2 FOSE Perfluorinated sulfonamide ethanol	2-(n-ethylperfluoro-1-octanesulfonamido)ethanol	N-EtFOSE	C12H10F17NO3S	(1691-99-2)	0.25	ng/support
	2-(n-methylperfluoro-1-octanesulfonamido)ethanol	N-MeFOSE	C11H8F17NO3S	(24448-09-7)	0.25	ng/support
2 Fluorinated remplacement	2-methyl-3-oxahexanoic undecafluoro acid	HFPO	C6HF11O3	(13252-13-6)	0.25	ng/support
	3H-4,8-dodecafluoro-dioxanonoic acid	Adona	C7H2F12O4	(919005-14-4)	0.25	ng/support
2 additional targets	2H,2H,3H,3H-perfluorooctanoic acid	FTCA 5:3	C8H5F11O2	(914637-49-3)	0.25	ng/support
	2H,2H-perfluorooctanoic acid	FTCA 6:2	C8H3F13O2	(53826-12-3)	0.25	ng/support

Appendix 2: Gas-particle partitioning of the 13 major compounds detected at the two monitoring sites, with PB on the left and LC on the right. The particulate phase (filter) is shown in dark colors and the gas phase (PUF) in light colors


PB - PFOS
Filter
PUF
Gas-particle partitioning [pg/m³]
0
1
2
3
4
Oct 26, 23
Nov 6, 23
May 31, 24
Jun 5, 24
Jun 10, 24
Jun 14, 24
Sep 10, 24
Sep 14, 24
Nov 16, 24
Nov 20, 24
Nov 26, 24
Nov 30, 24
Mar 8, 25
Mar 12, 25
Mar 16, 25
Mar 20, 25
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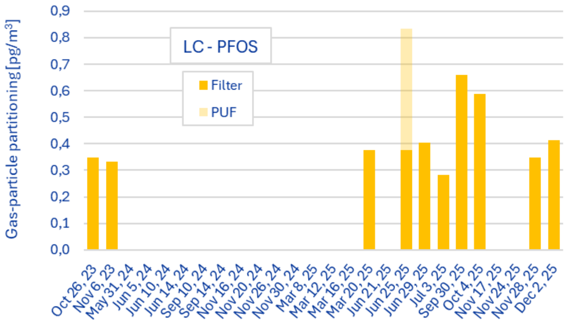
Nov 24, 25
Nov 28, 25
Dec 2, 25


LC - PFOS
Filter
PUF
Gas-particle partitioning [pg/m³]
0,0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
Oct 26, 23
Nov 6, 23
May 31, 24
Jun 5, 24
Jun 10, 24
Jun 14, 24
Sep 10, 24
Sep 14, 24
Nov 16, 24
Nov 20, 24
Nov 26, 24
Nov 30, 24
Mar 8, 25
Mar 12, 25
Mar 16, 25
Mar 20, 25
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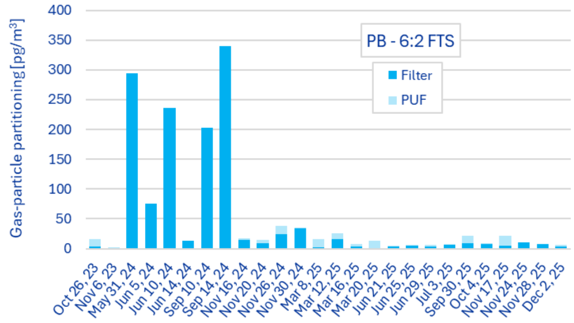
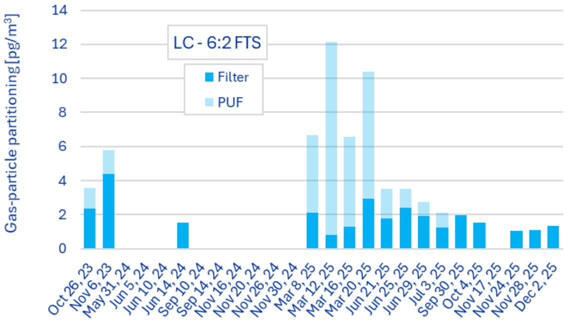
Nov 24, 25
Nov 28, 25
Dec 2, 25


PB - 6:2 FTS
Filter
PUF
Gas-particle partitioning [pg/m³]
0
50
100
150
200
250
300
350
400
Oct 26, 23
Nov 6, 23
May 31, 24
Jun 5, 24
Jun 10, 24
Jun 14, 24
Sep 10, 24
Sep 14, 24
Nov 16, 24
Nov 20, 24
Nov 26, 24
Nov 30, 24
Mar 8, 25
Mar 12, 25
Mar 16, 25
Mar 20, 25
Jun 21, 25
Jun 25, 25
Jun 29, 25
Jul 3, 25
Sep 30, 25
Oct 4, 25
Nov 17, 25
Nov 24, 25
Nov 28, 25
Dec 2, 25


LC - 6:2 FTS
Filter
PUF
Gas-particle partitioning [pg/m³]
0
2
4
6
8
10
12
14
Oct 26, 23
Nov 6, 23
May 31, 24
Jun 5, 24
Jun 10, 24
Jun 14, 24
Sep 10, 24
Sep 14, 24
Nov 16, 24
Nov 20, 24
Nov 26, 24
Nov 30, 24
Mar 8, 25
Mar 12, 25
Mar 16, 25
Mar 20, 25
Jun 21, 25
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Jun 29, 25
Jul 3, 25
Sep 30, 25
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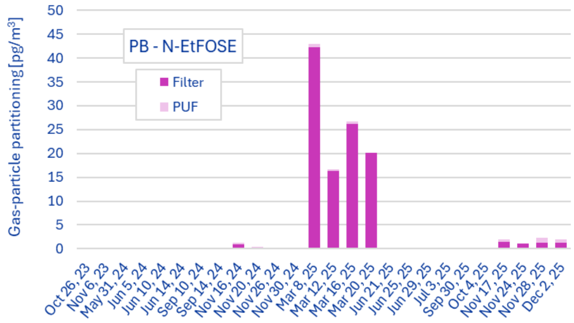
Nov 17, 25
Nov 24, 25
Nov 28, 25
Dec 2, 25


PB - N-EtFOSE
Filter
PUF
Gas-particle partitioning [pg/m³]
0
5
10
15
20
25
30
35
40
45
50
Oct 26, 23
Nov 6, 23
May 31, 24
Jun 5, 24
Jun 10, 24
Jun 14, 24
Sep 10, 24
Sep 14, 24
Nov 16, 24
Nov 20, 24
Nov 26, 24
Nov 30, 24
Mar 8, 25
Mar 12, 25
Mar 16, 25
Mar 20, 25
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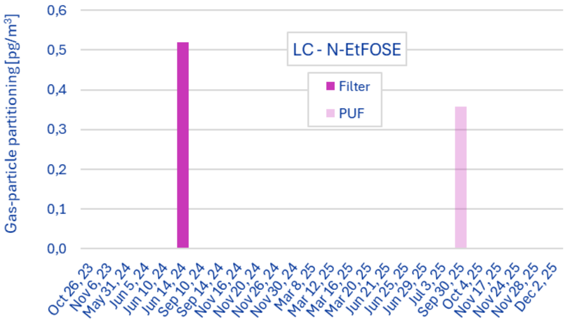
Nov 24, 25
Nov 28, 25
Dec 2, 25


LC - N-EtFOSE
Filter
PUF
Gas-particle partitioning [pg/m³]
0,0
0,1
0,2
0,3
0,4
0,5
0,6
Oct 26, 23
Nov 6, 23
May 31, 24
Jun 5, 24
Jun 10, 24
Jun 14, 24
Sep 10, 24
Sep 14, 24
Nov 16, 24
Nov 20, 24
Nov 26, 24
Nov 30, 24
Mar 8, 25
Mar 12, 25
Mar 16, 25
Mar 20, 25
Jun 21, 25
Jun 25, 25
Jun 29, 25
Jul 3, 25
Sep 30, 25
Oct 4, 25
Nov 17, 25
Nov 24, 25
Nov 28, 25
Dec 2, 25

Bibliography

ANSES (Octobre 2025b) : Composés per- et poly- fluoroalkylés (PFAS) dans différents compartiments : Bilan de la contamination et catégorisation en vue de leur surveillance Connaître, évaluer, protéger. *Avis de l'Anses Rapport d'expertise collective*. https://www.anses.fr/system/files/ERCA2022-SA-0198-RA.pdf

ANSES (Juin 2025a) : Valeurs toxicologiques de référence : Elaboration de VTR long terme pour plusieurs perfluorés, *Avis de l'Anses Rapport d'expertise collective*. https://www.anses.fr/sites/default/files/VSR2022-SA-0198-RA.pdf

Arrêté du 31 octobre 2024 relatif à l'analyse des substances per- et polyfluoroalkylées dans les émissions atmosphériques des installations d'incinération, de co-incinération et d'autres traitements thermiques de déchets, https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000050479313

Atmo AuRA (Avril 2024): Note bibliographique : Les Substances Per- et PolyFluoroalkylées (PFAS) en air ambiant, *Note bibliographique Atmo*, https://www.atmo-auvergnerhonealpes.fr/sites/aura/files/medias/documents/2024-06/Note_Biblio_PFAS-AtmoAura_042024.pdf

ARS (2025), PFAS : focus sur la situation au sud de Lyon. https://www.auvergne-rhone-alpes.ars.sante.fr/pfas-focus-sur-la-situation-au-sud-de-lyon

D'Ambro, E. L., Pye, H. O. T., Bash, J.O., Bowyer, J., Allen, C., Efstathiou, C., Gilliam, R.C., Reynolds, L., Talgo, K., and Murphy, B. N. (2021). Characterizing the Air Emissions, Transport, and Deposition of PFAS. Environmental Science & Technology. https://pmc.ncbi.nlm.nih.gov/articles/PMC7887699/pdf/nihms-1665456.pdf

De Silva, A. O., Armitage, J. M., Bruton, T. A., Dassuncao, C., Heiger-Bernays, W., Hu, X. C., Kärrman, A., Kelly, B., Ng, C., Robuck, A., Sun, M., Webster, T. F., and Sunderland, E. M. (2021). "PFAS Exposure Pathways for Wildlife and Humans: Recent Advances in Identifying and Quantifying Sources and Impact." Environmental Toxicology and Chemistry. https://pmc.ncbi.nlm.nih.gov/articles/PMC7906948/

Dauchy, X., (2023) : Evidence of large-scale deposition of airborne emissions of per- and polyfluoroalkyl substances (PFASs) near a fluoropolymer production plant in an urban area, Chemosphere, Volume 337, October 2023, 139407, https://www.sciencedirect.com/science/article/pii/S0045653523016740

DREAL Auvergne-Rhône-Alpes (2025), Focus sur la situation au Sud de Lyon. https://www.auvergne-rhone-alpes.developpement-durable.gouv.fr/focus-sur-la-situation-au-sud-de-lyon-a23562.html

DREAL (Avril 2025) : Feuille de Route : Pollution aux substances perfluorées (PFAS) : Comment l'état agit en Région Auvergne-Rhône-Alpes, https://www.auvergne-rhone-alpes.developpement-durable.gouv.fr/IMG/pdf/20250416_feuille_route_pfas2025.pdf

Dunsin, S., Pepin, D., Delon, L., Fontaine, J. and Sauvé, S. (2025) : Occurrence of PFAS in Lyon soils: contribution and impact of industrial activities, *Environmental sciences : advanced*, https://pubs.rsc.org/en/content/articlelanding/2025/va/d5va00135h

ECHA (2023) : Substances per et polyfluoroalkylées (PFAS) – Réglementation dans l'UE. European Chemicals Agency. https://echa.europa.eu/fr/hot-topics/perfluoroalkyl-chemicals-pfas

EPA (2021) : Other Test Method 45 (OTM-45) Measurement of Selected Per- and Polyfluorinated Alkyl Substances from Stationary Sources, https://www.epa.gov/sites/default/files/2021-01/documents/otm_45_semivolatile_pfas_1-13-21.pdf

Etude Esteban (2006), Une étude de santé sur l'environnement, la biosurveillance, l'activité physique et la nutrition par santé publique France, https://www.santepubliquefrance.fr/etudes-et-enquetes/esteban#block-65267

EU (2020) : Directive (UE) 2020/2184 du Parlement européen et du Conseil du 16 décembre 2020 relative à la qualité des eaux destinées à la consommation humaine (refonte) (Texte présentant de l'intérêt pour l'EEE), https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000045770552

Faust, J. A. (2023): PFAS on atmospheric aerosol particles: a review, Environmental Science: Processes & Impacts. https://pubs.rsc.org/en/content/articlelanding/2023/em/d2em00002d

Gouvernement français (Avril 2024) : Plan d'actions interministériel sur les PFAS (2023-2027), https://www.ecologie.gouv.fr/sites/default/files/documents/2024.04.05_Plan_PFAS.pdf

INERIS (2025) : Etat des lieux des usages des PFAS et alternatives documentées, https://substitution-perfluores.ineris.fr/sites/substitution-perfluores/files/documents/etat_des_lieux_des_usages_des_pfas_et_alternatives_documentees_v1_ineris_2025.pdf

Kizhakkethil, J. P., Shi, Z., Bogush, A., and Kourtchev, I. (2025) Measurement report: Per- and polyfluoroalkyl substances (PFAS) in particulate matter (PM_{10}) from activated sludge aeration, Atmos. Chem. Phys., 25, 5947–5958, https://doi.org/10.5194/acp-25-5947-2025.

Li, X., Wang, Y., Cui, J., Shi, Y., Cai, Y. (2024), Occurrence and Fate of Per- and Polyfluoroalkyl Substances (PFAS) in Atmosphere: Size-Dependent Gas-Particle Partitioning, Precipitation Scavenging, and Amplification. Environ. Sci. Technol. 58, 9283–9291. https://doi.org/10.1021/acs.est.4c00569.

OECD (2015) : Working Towards A Global Emission Inventory of PFASs: Focus on PFCAs – Status Quo and the Way Forward. OECD Series on Risk Management of Chemicals.

Owens, C. V. Jr (2021)): Review of Source and Transportation Pathways of PFAS, International Journal of Environmental Research and Public Health. https://pubmed.ncbi.nlm.nih.gov/37034823/

Tang, K. H. D. (2025): Hidden Contaminants: The Presence of PFAS in the Air, Water, Soil, Sediments and Ice. Environments. https://www.mdpi.com/2076-3298/12/3/88 .

Teymoorian, T., Delon, L., Munoz, G. and Sauvé, S. (2025): Target and Suspect Screening Reveal PFAS Exceeding European Union Guideline in Various Water Sources South of Lyon, France. February 2025Environmental Science & Technology Letters 12(3). https://pubs.acs.org/doi/10.1021/acs.estlett.4c01126

WHO (2025) : Assessing the occurrence and human health risk of per and polyfluoroalkyl substances (PFAS). World Health Organization. https://www.who.int/activities/assessing-the-occurrence-and-human-health-risk-of-per--and-polyfluoroalkyl-substances

Wong, F., Shoeib, M., Katsoyiannis, A., Eckhardt, S., Stohl A., Bohlin-Nizzetto, P., Li, H., Fellin, P., Su, Y., and Hunga, H. (2018) : Assessing temporal trends and source regions of per- and polyfluoroalkyl substances (PFASs) in air under the Arctic Monitoring and Assessment Programme (AMAP), Atmospheric Environment, 172 (2018) 65-73. https://www.sciencedirect.com/science/article/pii/S1352231017306891?via%3Dihub

Yamazaki, E., Taniyasu, S., Wang, Y. and Yamashita, N. (2021) : Per- and polyfluoroalkyl substances in surface water, gas and particle in open ocean and coastal environment, Chemosphere, Volume 272, June 2021, 129869, https://www.sciencedirect.com/science/article/abs/pii/S0045653521003386?via%3Dihub

Yang, H., Liang, Y., Tian, S., Li, X., and Liu, Y. (2025) : Perfluorinated and Polyfluoroalkyl Compounds in the Atmosphere: A Review, Atmosphere 2025, 16(9), 1070; https://doi.org/10.3390/atmos16091070

Zahm S, Bonde JP, Chiu WA, Hoppin J, Kanno J, Abdallah M, Blystone CR, Calkins MM, Dong GH, Dorman DC, Fry R, Guo H, Haug LS, Hofmann JN, Iwasaki M, Machala M, Mancini FR, Maria-Engler SS, Møller P, Ng JC, Pallardy M, Post GB, Salihovic S, Schlezinger J, Soshilov A, Steenland K, Steffensen IL, Tryndyak V, White A, Woskie S, Fletcher T, Ahmadi A, Ahmadi N, Benbrahim-Tallaa L, Bijoux W, Chittiboyina S, de Conti A, Facchin C, Madia F, Mattock H, Merdas M, Pasqual E, Suonio E, Viegas S, Zupunski L, Wedekind R, Schubauer-Berigan MK. Carcinogenicity of perfluorooctanoic acid and perfluorooctanesulfonic acid. Lancet Oncol. 2024 Jan;25(1):16-17. doi: 10.1016/S1470-2045(23)00622-8. Epub 2023 Nov 30. PMID: 38043561; PMCID: PMC12183505.