

Air quality in the Paris region

SUMMARY 2021



AIR QUALITY IN THE PARIS REGION

Summary 2021

November 2022

This report is an English summary of the annual report on ambient air quality in the Paris region. It gives an overview of the concentrations for the European Union regulated pollutants during the year 2021.

The complete report in french can be downloaded on the Airparif website:

https://www.airparif.asso.fr/sites/default/files/pdf/BilanQA_IDF_2021.pdf

Air quality complete data in the Paris region can be downloaded at:

<https://data-airparif-asso.opendata.arcgis.com/>

Annual air pollution maps are available at <https://www.airparif.asso.fr/surveiller-la-pollution/bilan-et-cartes-annuels-de-pollution>

All data, reports and studies performed by Airparif are publicly available.

Full and free access is granted on the Airparif website.

Any use of part of this report should mention "Airparif, the Observatory of Air Quality in the Paris Region".

Contact us

AIRPARIF - The Observatory of Air Quality in the Paris region
7 rue Crillon 75004 PARIS Phone +33 1 44 59 47 64 Fax +33 1 44 59 47 67
www.airparif.fr

TABLE OF CONTENTS

TABLE OF CONTENTS	5
1. KEY FACTS FOR 2021	6
2. POLLUTANTS EXCEEDING AIR QUALITY STANDARDS	8
2.1 NITROGEN DIOXIDE (NO ₂)	8
2.2 PM ₁₀ PARTICLES	14
2.2 PM _{2.5} PARTICLES.....	21
2.4 OZONE (O ₃)	24
3. POLLUTANTS MEETING AIR QUALITY STANDARDS	30
3.1 BENZENE (C ₆ H ₆)	30
3.2 BENZO(A)PYRENE (BAP)	33
3.3 METALS (LEAD, ARSENIC, CADMIUM AND NICKEL)	34
3.3 CARBON MONOXIDE (CO)	36
3.4 SULFUR DIOXIDE (SO ₂)	37
LIST OF FIGURES	38
GLOSSARY	40

1. KEY FACTS FOR 2021

2020 has been a very special year, due to the health crisis of the Covid-19 and the government measures adopted to deal with it. These various measures have led to a significant reduction in pollutant emissions, in particular those from road and air traffic, and especially during the strict lockdown of the spring. In 2020, a decrease in pollution was observed compared to 2019 and linked to various parameters: both a downward trend for several years due to reduction measures undertaken locally and at national and European level, to which is added a cyclical impact of the measures to restrict some activities put in place because of the pandemic, and the dispersive role of the weather conditions.

Except for ozone, the pollution levels recorded in 2021, compared to 2020, increased at all the measuring stations, but they decreased compared to 2019. This observation is essentially linked to a resumption of activities in 2021, the downward trend in emissions from the residential sector and road traffic and dispersive weather conditions with generally mild temperatures in the winter period, which limited residential heating emissions.

The decrease of the nitrogen dioxide (NO₂) concentrations in the Paris agglomeration continues in 2021. This is consistent with the decline of nitrogen oxides emissions (road traffic, industries, heating) in the Paris region. Near road traffic and on the busiest axes (Boulevard Périphérique, A1 Highway, etc.) the NO₂ mean levels are always way higher than the annual limit value (set at 40 µg/m³), but some roads have passed below this threshold for some years. **In 2021, less than 60 000 inhabitants of the Paris Region are potentially exposed to the exceeding of the annual NO₂ limit value. In addition, almost all the Paris Region residents are exposed to an air that does not comply with the new World Health Organization (WHO) annual (10 µg/m³ annual mean) and daily recommendations (25 µg/m³ at not to exceed more than 3 days per year).**

→ Despite an improvement, few exceedances of the daily and annual limit values for **PM₁₀ particles** are still observed at some roadside sites. In 2021, **less than 1000 inhabitants living in the Paris area and close to main roads were potentially affected by the PM₁₀ exceedance of the daily limit value** (50 µg/m³ not to be exceeded more than 35 days a year). However, 50% of the inhabitants of the Paris Region are exposed to an exceedance of the WHO recommendations (45 µg/m³ not to be exceeded more than 3 days a year).

For **fine particles (PM_{2.5})**, the limit and target values are met. However, the annual mean concentrations are above the World Health Organization recommendations. **In 2021, every inhabitant of the Paris region was affected by an exceedance of these air quality objectives** (5 µg/m³ for the annual mean and 15 µg/m³ not to be exceeded more than 3 days a year for the daily mean).

→ Regarding **ozone (O₃) levels, the quality objective is exceeded every year in the whole Paris region, and especially in sub-urban and rural areas.**

→ After a long period of sharp decrease which began at the end of the 1990's, **benzene (C₆H₆)** levels continue to slightly decline and tend to stabilize (both near traffic and in background situation). The annual limit value (5 µg/m³) is widely complied on the whole region. However, there is a low risk to locally exceed the annual quality objective (2 µg/m³). However, **no inhabitants living in the agglomeration and in roadside conditions are exposed to an exceedance of this threshold.**

→ **Regarding pollution episodes, the information and warning threshold were exceeded 11 days in 2021. These episodes are due to O₃ (1 day) and PM₁₀ (10 days).** This is the lowest number of pollution episode from the last 10 years, due to gloomy summer conditions.

SITUATION OF THE PARIS REGION IN RELATION TO AIR QUALITY STANDARDS FOR DIFFERENT REGULATED POLLUTANTS

Figure 1 shows whether, in 2021, air quality standards (limit value, target value and quality objective) are met or exceeded in the Paris region for the regulated pollutants.



Figure 1: situation in 2021 of the Paris Region in relation to air quality standards for different regulated pollutants (Glossary at the end of this document)

2. POLLUTANTS EXCEEDING AIR QUALITY STANDARDS

2.1 Nitrogen dioxide (NO₂)

Nitrogen dioxide (NO₂) in brief

Nitrogen dioxide remains an important issue in the Paris region.

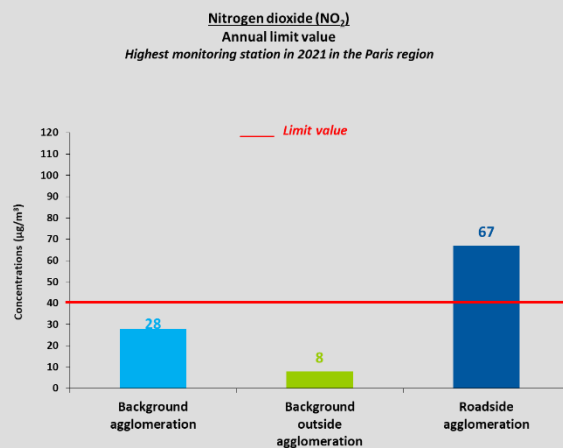
The main source of NO₂ is road traffic.

Although a decrease in annual mean levels in NO₂ is confirmed both in background situation and near road traffic, levels along major roads are still much higher than the EU annual limit value.

In 2021, following 2019, some road traffic sites have annual mean concentrations lower than the annual limit value, resulting in a significant decrease of the inhabitants potentially exposed to an exceedance of this limit.

In 2021, less than 60 000 inhabitants living in the centre of the agglomeration are potentially exposed to an exceedance of the EU annual limit value.

Almost all of the Paris region residents are exposed to an air that does not comply with the new WHO recommendation



Summary of air quality standards exceedances for nitrogen dioxide (NO₂) in the Paris region

SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 2 show the annual mean NO₂ concentrations within the Paris region, with a focus on Paris and surrounding suburbs in 2021.

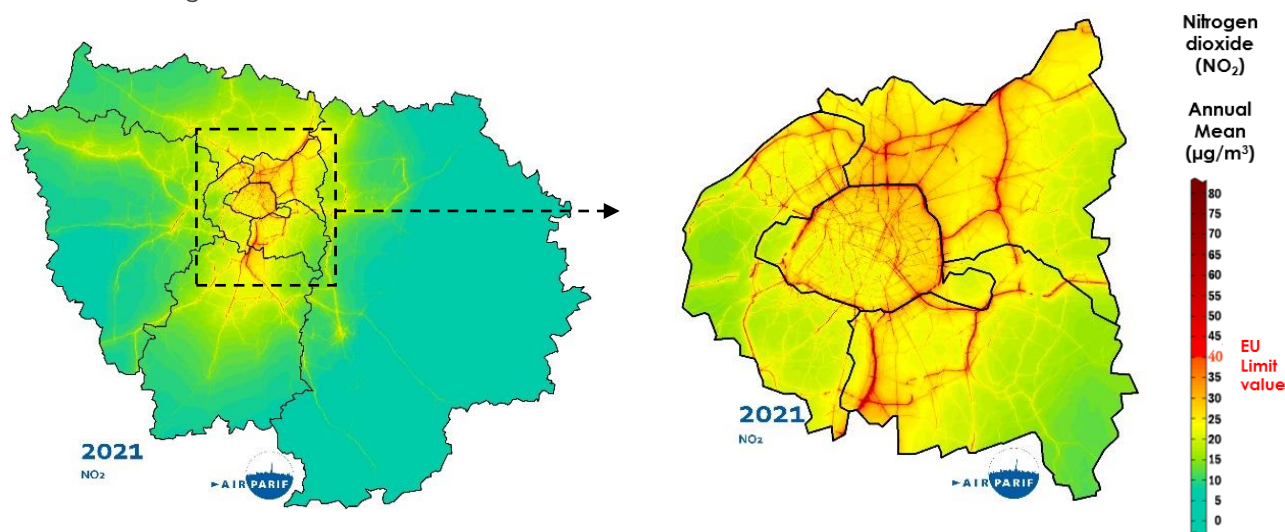


Figure 2: nitrogen dioxide (NO₂) annual mean concentration within the Paris region, with a focus on Paris and surrounding suburbs in 2021

There is a **strong NO₂ background concentrations gradient** between rural areas and the centre of the Parisian agglomeration. Thus, annual mean levels measured within the agglomeration reach 28 µg/m³ (Figure 3) and the mean regional background level of NO₂ is between 6 and 8 µg/m³ in 2021.

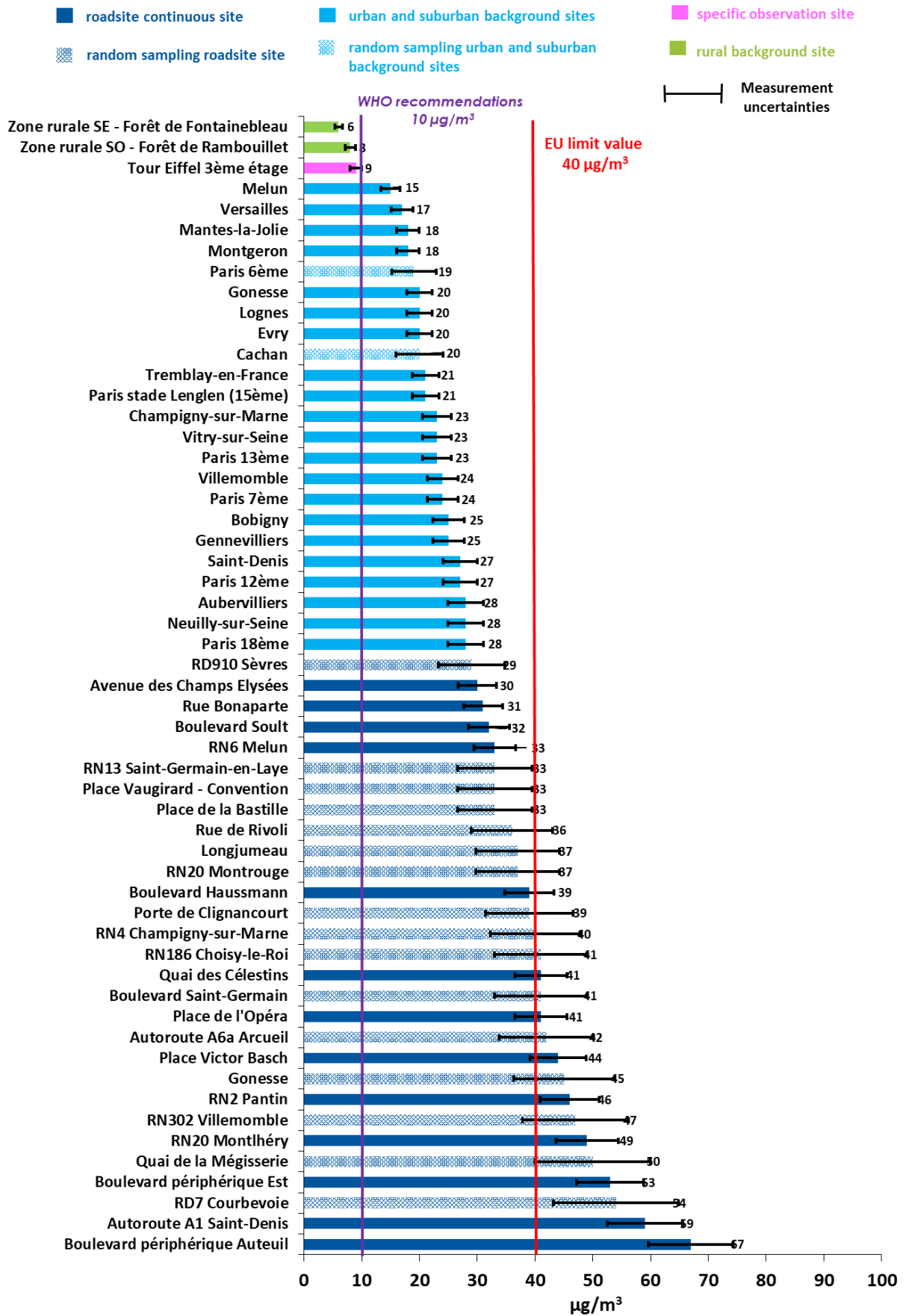
Highest NO₂ mean concentrations are measured within the Paris agglomeration, near major traffic roads (motorways and national highway). In Paris, the right bank of the Seine River is broadly more polluted than the left bank because of higher roads density.

The EU limit value for nitrogen dioxide (40 µg/m³) has been met at all the monitoring stations in background situation. In 2021, background mean concentrations are higher than those measured in 2020 but lower than in the previous years.

NO₂ levels along major roads are more than twice those in background situation. In some cases, they are much higher than the EU annual limit value. The threshold exceedance has been confirmed in 2021 for approximately 600 kilometres of roads and highway connections. This corresponds to approximately 5 % of the main road network modeled by Airparif. These road axes are mainly located in the urban area of Paris.

Between 2019 and 2021, a significant drop in NO₂ levels is observed, both in the background and near road traffic. In Paris, the annual mean concentrations of NO₂ in a background situation have decreased by around 20 % due to the decrease of emissions (renewal of the vehicle fleet and reduction of the road traffic), and the influence of dispersive meteorological conditions, particularly in winter, when NO₂ concentrations are usually maximum.

NO₂ mean concentrations are highly variable from one traffic site to another. It reflects a wide range of concentrations measured near major traffic roads and are due to **differences in traffic conditions** (traffic flow, speed, vehicle fleet) **and topography** that are more or less favorable to the pollutants dispersion.



In addition to continuous measurements of NO₂, discontinuous measurements are performed by AIRPARIF since 2007. These measurements are carried out using passive diffusion tubes during 12 uncontinuous weeks evenly distributed over the year. For these sampling sites, the results reported in this figure represent the average of twelve weeks measurements.

Figure 3: nitrogen dioxide (NO₂) annual mean concentration for all monitoring sites in the Paris region in 2021

In 2021, **60 000 inhabitants are potentially exposed to an exceedance of the NO₂ EU annual limit value (Figure 4)**. They are mainly living within the Parisian agglomeration.

The number of people potentially exposed is way lower in 2021 compared to 2019 (nearly 500 000 inhabitants in 2019). This is mainly explained by the fact that the annual mean concentrations recorded on many axes have fallen below the threshold of the limit value (40 µg/m³).

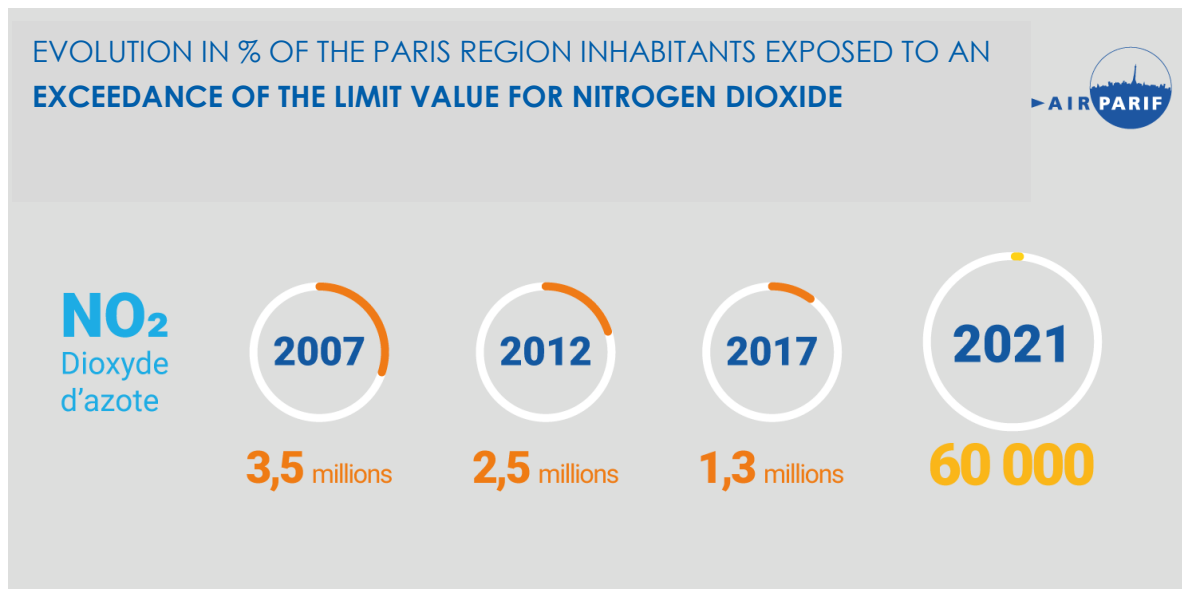


Figure 4: million of inhabitants potentially exposed to a nitrogen dioxide (NO₂) level exceeding the EU annual limit value in the Paris region from 2007 to 2021

As for the hourly limit value (concentration higher than 200 µg/m³ not to be exceeded more than 18 times per year), it is met everywhere in the Paris region in 2021.

In 2021, almost all of the Paris region residents are exposed to an air that does not comply with the annual (reduced to 10 µg/m³ on average annually in 2021) and daily (25 µg/m³ not to be exceeded more than 3 days per year) WHO recommendations.

LONG-TERM TRENDS

The maps in Figure 5 show a pollution pattern with **a downward trend of NO₂ annual mean concentrations between 2007 and 2021 within the Paris region.**

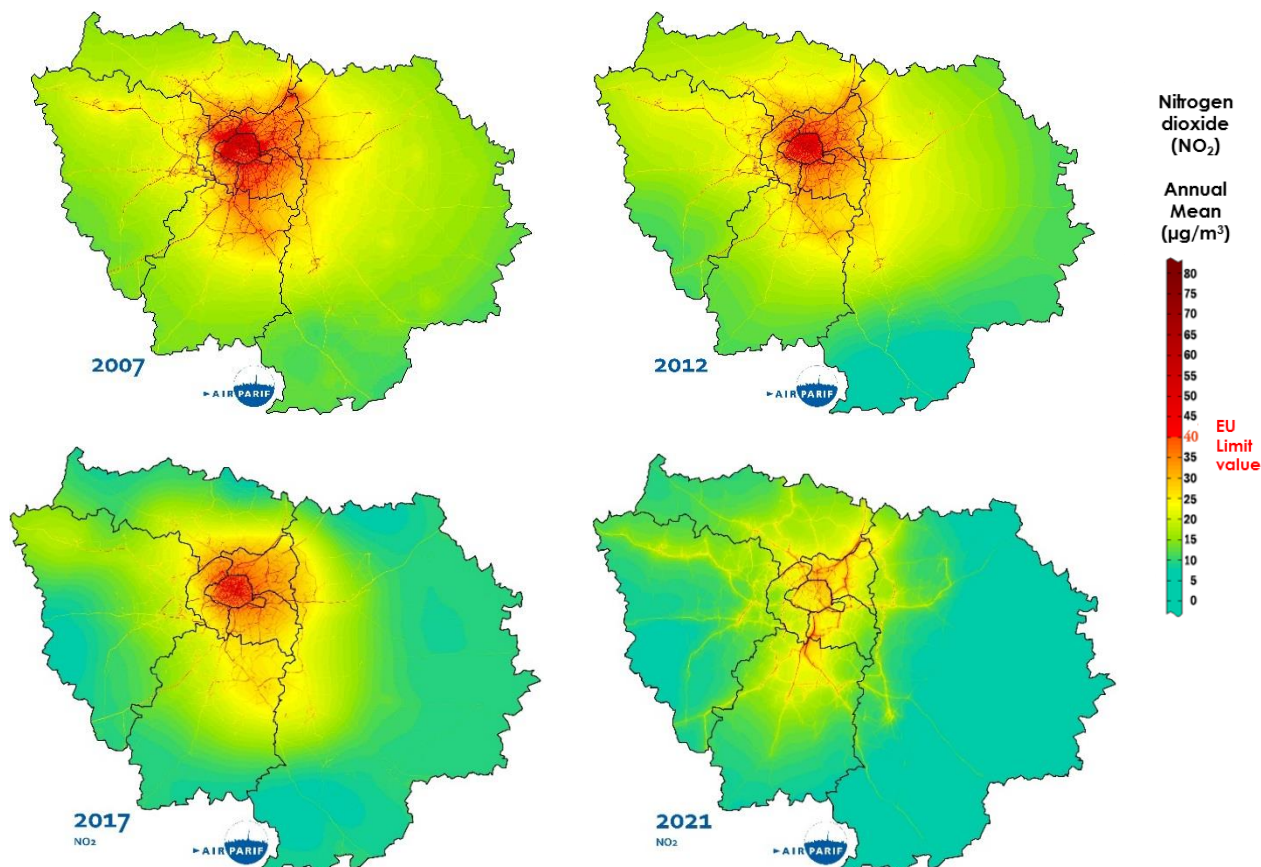


Figure 5: annual mean concentrations of nitrogen dioxide (NO₂) from 2007 to 2021 in the Paris region

A downward trend of NO₂ tri-annual mean levels is observed over the last 10 years on background sites (Figure 6). Technological improvements of emission sources (road traffic, heating, industry) and renewal of the vehicle fleet can explain reduced NO₂ levels. Between 2011 and 2021, the annual background concentrations decreased by around 30 %.

The trend in NO₂ tri-annual mean concentrations is quite different in roadside situation. From 2011 to 2021, annual concentrations in proximity to road traffic decreased by around 45%.

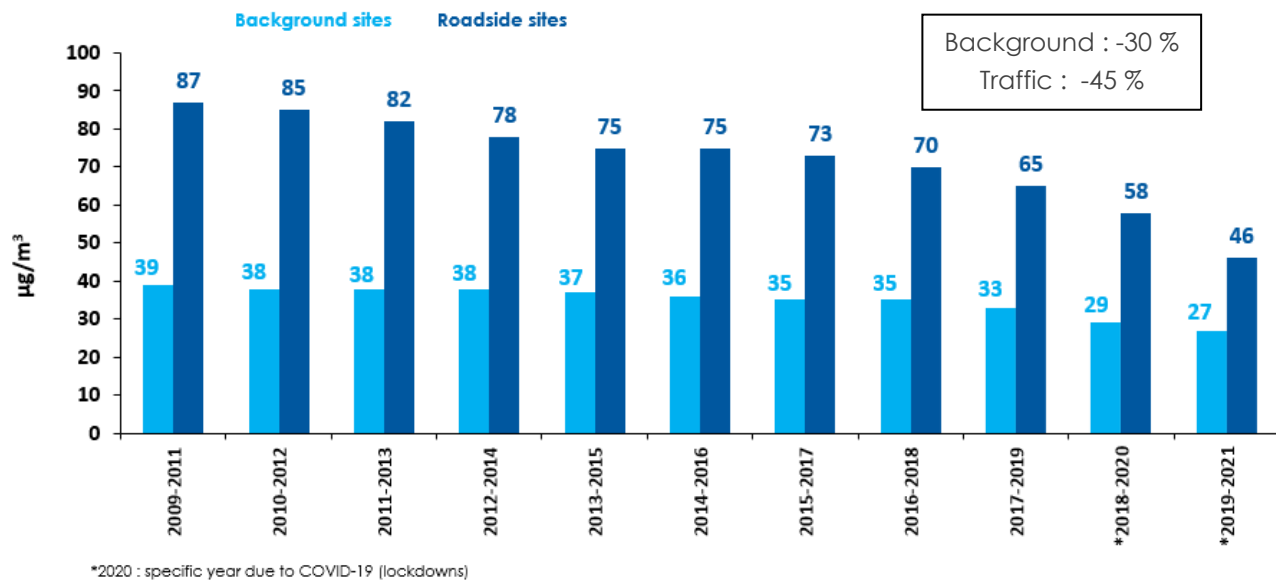


Figure 6: trend in the NO₂ tri-annual mean concentration (based on a sample of the same 6 urban background sites and 5 roadside sites) within the Paris agglomeration from 2009-2011 to 2019-2021

Nitrogen dioxide (NO₂) is a complex pollutant related to direct emissions (from transport, heating and industry sectors) and chemical reactions with other atmospheric pollutants, especially ozone (O₃).

One of the major reasons to the changes of nitrogen dioxide levels, both in terms of background and proximity to road traffic situations, is linked to the renewal of the road fleet and the evolution of NO₂ primary emissions by diesel vehicles.

2.2 PM₁₀ particles

Particulate Matter (PM) in brief

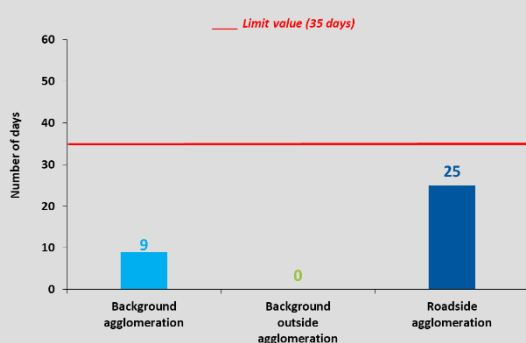
A decreasing trend of the PM is observed, in both background and near traffic situations. Recurrent exceedances of the limit values for PM₁₀ are nevertheless still occasionally observed near traffic.

Less than 1000 of the population is potentially exposed to an exceedance of the PM₁₀ EU daily limit value. Less than 10 000 of the population is potentially exposed to an exceedance of the PM₁₀ quality objective.

Near 80% of the population is potentially exposed to an exceedance of the WHO recommendations

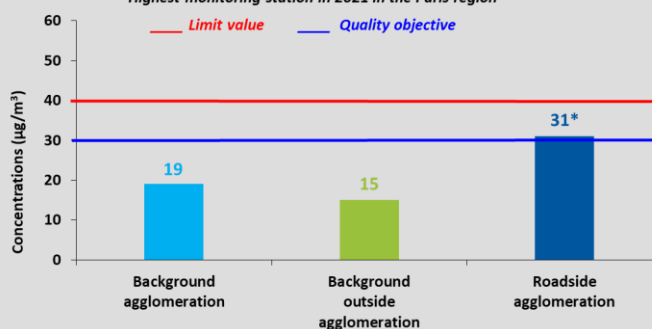
PM_{2.5} levels comply with the annual limit value (25 µg/m³) and with the target value (20 µg/m³). However, they are still much higher than the French quality objective (10 µg/m³). Approximately 50 % of the inhabitants living in the Paris region are still exposed to an exceedance of this threshold. Moreover, every inhabitant of the Paris Region is exposed to an exceedance of the WHO recommendations.

PM₁₀
Daily limit value (number of days >= 50 µg/m³)
Highest monitoring station in 2021 in the Paris region



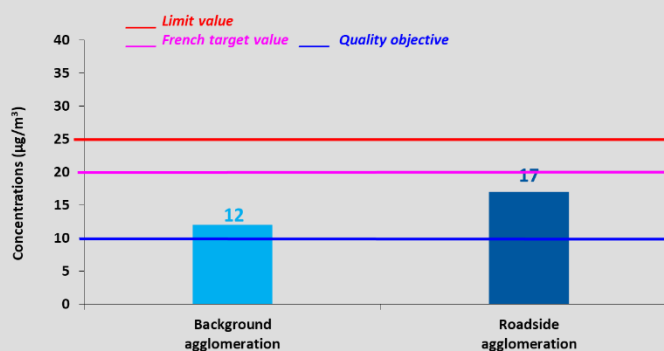
*Without the Autoroute A1 station which was not representative in 2021

PM₁₀
Quality objective and annual limit value
Highest monitoring station in 2021 in the Paris region



*Without the Autoroute A1 station which was not representative in 2021

PM_{2.5}
Annual limit value, French target value and quality objective
Highest monitoring station in 2021 in the Paris region



Summary of air quality standards exceedances for Particulate Matter (PM₁₀ and PM_{2.5}) within the Paris region

EU daily limit value (50 µg/m³ not to be exceeded more than 35 days a year)

The maps in Figure 7 show the PM₁₀ annual number of days exceeding the EU daily limit value within the Paris region, with a focus on Paris and surrounding suburbs in 2021.

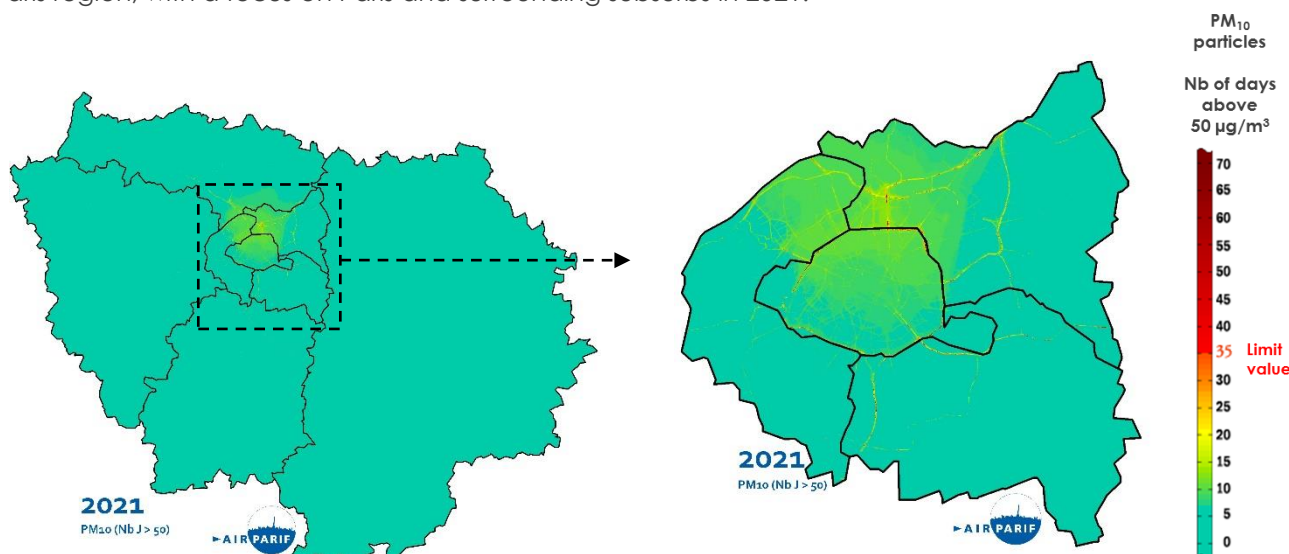


Figure 7: PM₁₀ annual number of days exceeding the 50 µg/m³ EU threshold within the Paris region with a focus on Paris and surrounding suburbs in 2021

In 2021, the EU daily limit value is met in background situation (Figure 8). In 2021, the PM₁₀ annual number of days exceeding the 50 µg/m³ (1 to 9 days) is higher than in 2020 (1 to 4 days) but similar to the one in 2019 (1 to 10 days).

In 2021, the number of days exceeding the 50 µg/m³ at all traffic stations increased compared to the situation in 2020, but decreased compared to 2019. This number is lower than the daily limit at all measurement sites (Figure 8).

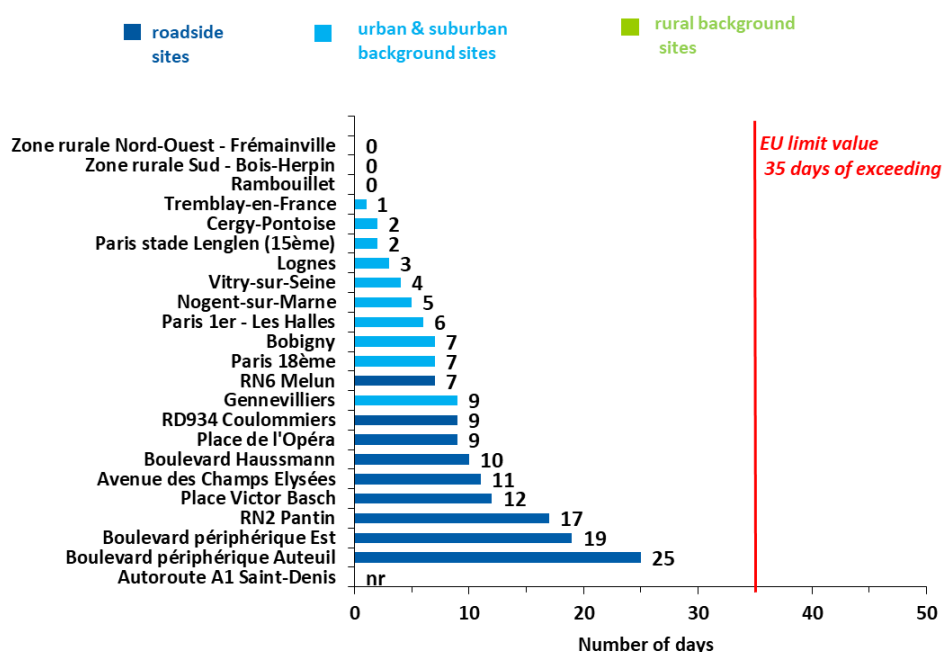


Figure 8: PM₁₀ annual number of days exceeding the 50 µg/m³ EU threshold for all continuous monitoring sites within the Paris region in 2021
nr: not representative

The result of the A1 highway station is unavailable in 2021 due to a significant impact of the construction works of the Paris 2024 Olympic Games nautical complex. However, this station would probably have been very close to the daily limit value in normal conditions, or even exceeded it.

In 2021, less than 1000 inhabitants of the Paris region are potentially exposed to an exceedance of the PM₁₀ EU daily limit value (Figure 9). The number of inhabitants potentially exposed to an exceeding of the daily limit value is the lowest of the last 10 years.

On the other hand, two-thirds of the Paris region residents are exposed to an air that does not comply with the new WHO recommendation (lowered to 45 µg/m³ not to be exceeded for more than 3 days per year).

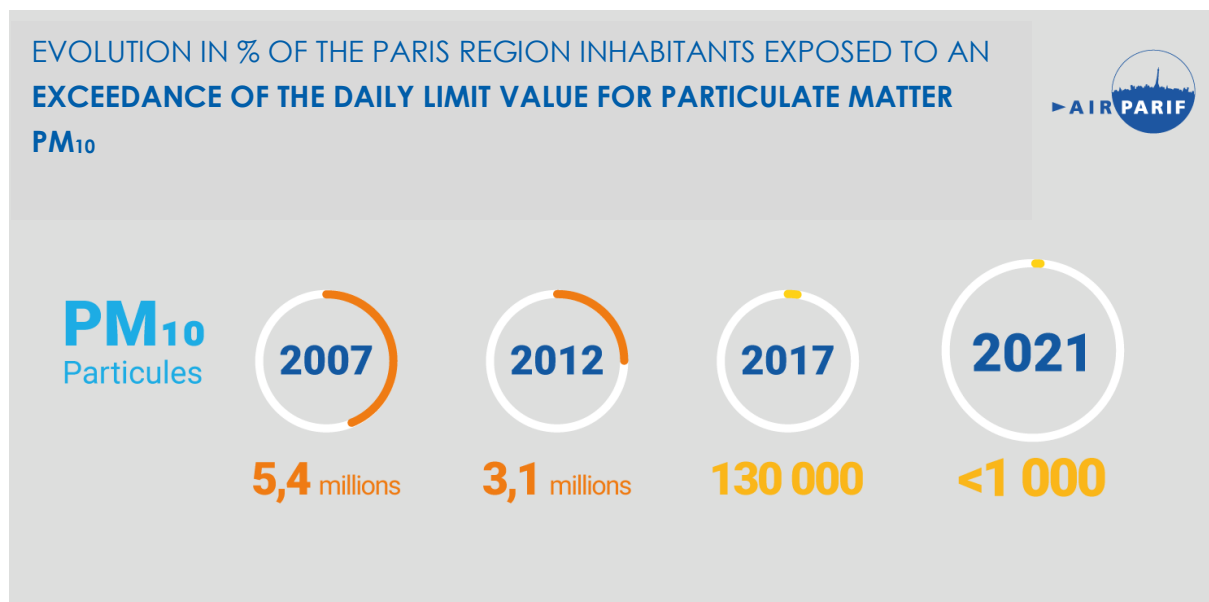


Figure 9: million of inhabitants potentially exposed to a PM₁₀ level exceeding the EU daily limit value within the Paris region from 2007 to 2021

EU annual limit value (40 µg/m³)

The maps in Figure 10 show the annual mean PM₁₀ concentration within the Paris region, with a focus on Paris and surrounding suburbs in 2021.

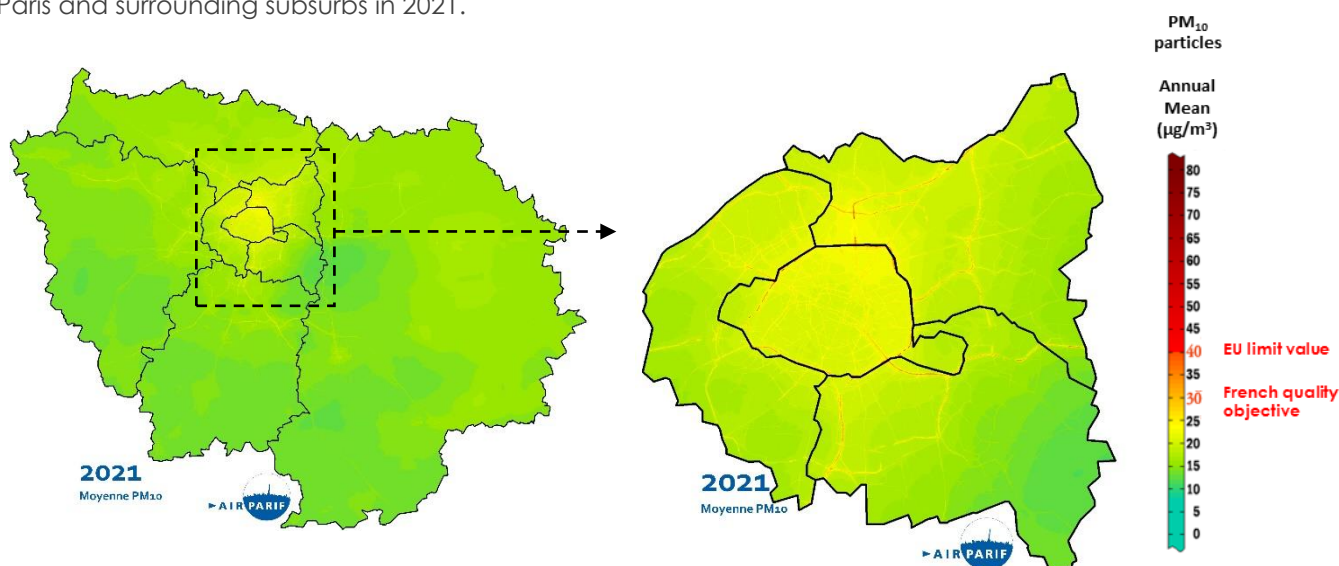


Figure 10: PM₁₀ annual mean concentration within the Paris region with a focus on Paris and surrounding suburbs in 2021

As in the last years, PM₁₀ background levels measured in the Paris agglomeration are fairly homogeneous in 2021 (between 15 and 19 µg/m³). A slight decline in PM₁₀ concentrations from the Paris agglomeration to the periphery of the region is observed (Figure 11). In general, **background annual mean levels are similar to those in 2020 but lower than in 2019.**

PM₁₀ standard annual values (EU annual limit value and French annual quality objective) are widely met in background and rural situations.

Highest PM₁₀ mean concentrations were measured near main roads in 2021. PM₁₀ levels near traffic (21-31 µg/m³) can be up to twice higher than those measured in background situation. PM₁₀ concentrations near traffic are similar to those in 2020 but lower than in 2019.

The EU annual limit value (40 µg/m³) is met at all the traffic monitoring station.

Concentrations near the Paris ring road are close to, or even slightly above, the quality objective. The result from the A1 highway station, usually presenting the maximum mean of the measurement network, is unavailable in 2021 due to a significant impact of the construction works of the Paris 2024 Olympic Games nautical complex. However, estimates show that this station would probably have not exceeded the annual limit value of 40 µg/m³.

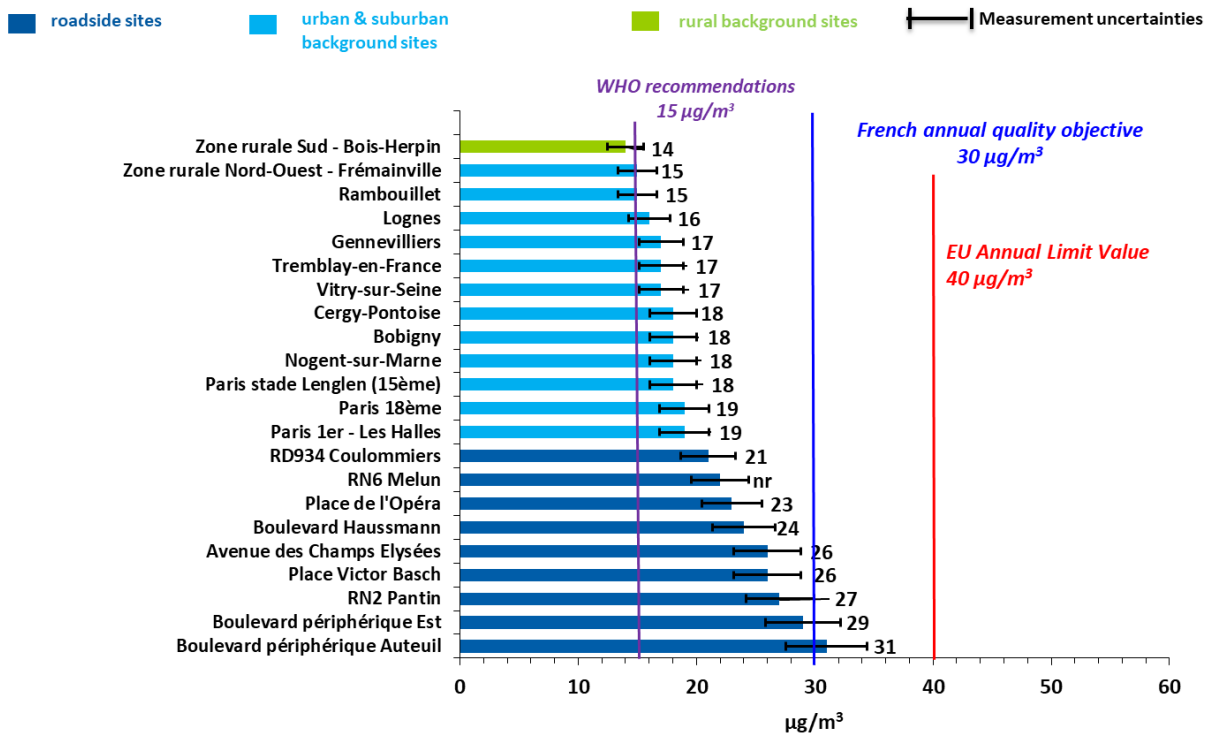


Figure 11: PM₁₀ annual mean concentrations for all continuous monitoring sites in the Paris region in 2021

As in 2019, the number of inhabitants potentially affected by an exceedance of the annual PM₁₀ limit value is very low.

In 2021, more than 9 million of inhabitants, i.e. around 80% of the regional population, are potentially affected by an exceedance of the new WHO annual recommendation (lowered to 15 µg/m³ in 2021).



Figure 12 : Evolution of the number of inhabitants potentially exposed to an exceedance of the WHO recommendations in PM₁₀ in the Paris region from 2007 to 2021

LONG-TERM TRENDS

PM₁₀ show an overall downward trend between 2007 and 2021, as illustrated by the maps in Figure 13, particularly in the heart of the Paris agglomeration.

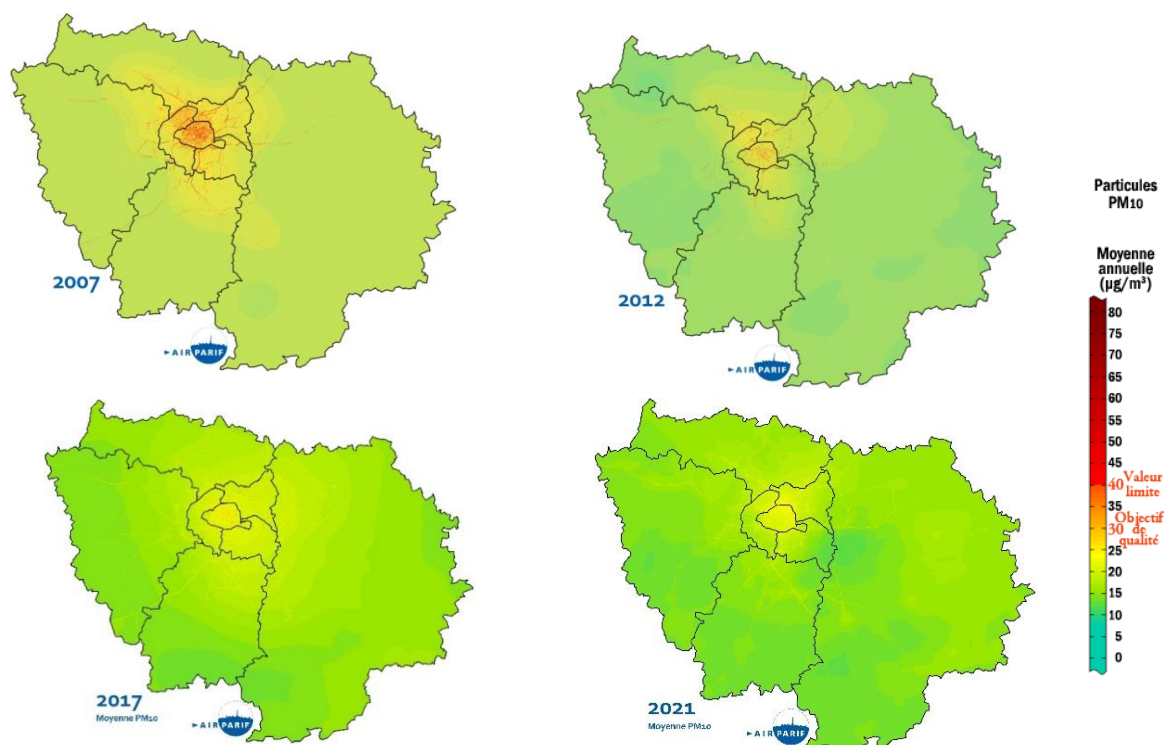


Figure 13 : number of days exceeding the EU daily limit value in PM₁₀ in the Paris region from 2007 to 2021

MEAN ANNUAL TRENDS

The Figure 14 shows **a downward trend of PM₁₀ mean concentrations in background agglomeration. These PM₁₀ levels decreased by about 35 % from 2011 to 2021.** This is related to the PM₁₀ regional emissions reduction. **This decline is particularly strong over the last years in background situation. This decrease is also observed in rural agglomeration.**

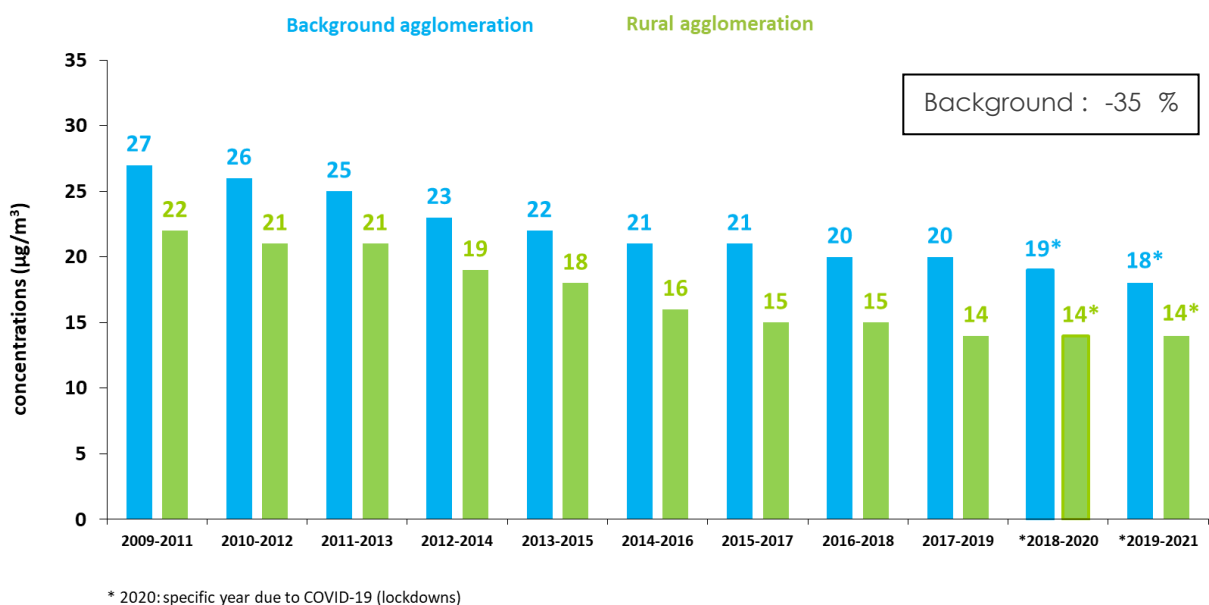


Figure 14: trend in the PM₁₀ tri-annual mean concentration (based on a scalable sample of background sites located within and out of the Paris agglomeration) from 2009-20011 to 2019-2021

The Figure 15 shows **a downward trend of PM₁₀ mean concentrations** of around -40 % for BP Porte d'Auteuil between 2011 and 2021. This trend can be explained by a greater decline in particle emissions from road traffic, especially due to **the progressive introduction of diesel particulate filters**.

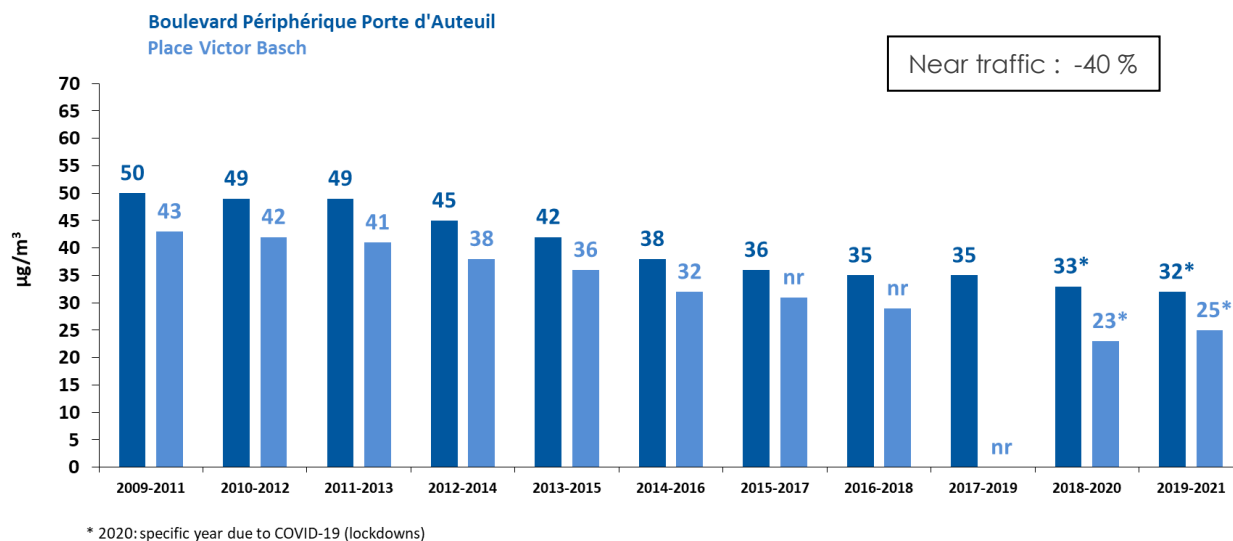


Figure 15: trend in the PM₁₀ tri-annual mean concentration at the Place Victor Basch and BP Porte d'Auteuil stations from 2009-2011 to 2019-2021
nr: not representative

For the Victor Basch station, the year 2019 having been unrepresentative, the 3-year mean 2018-2020 and 2019-2021 are only calculated from 2 years, including the very specific year 2020, which potentially led to an underestimation of the levels.

2.2 PM_{2.5} particles

SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 16 show the annual mean PM_{2.5} concentration within the Paris region, with a focus on Paris and surrounding suburbs in 2021.

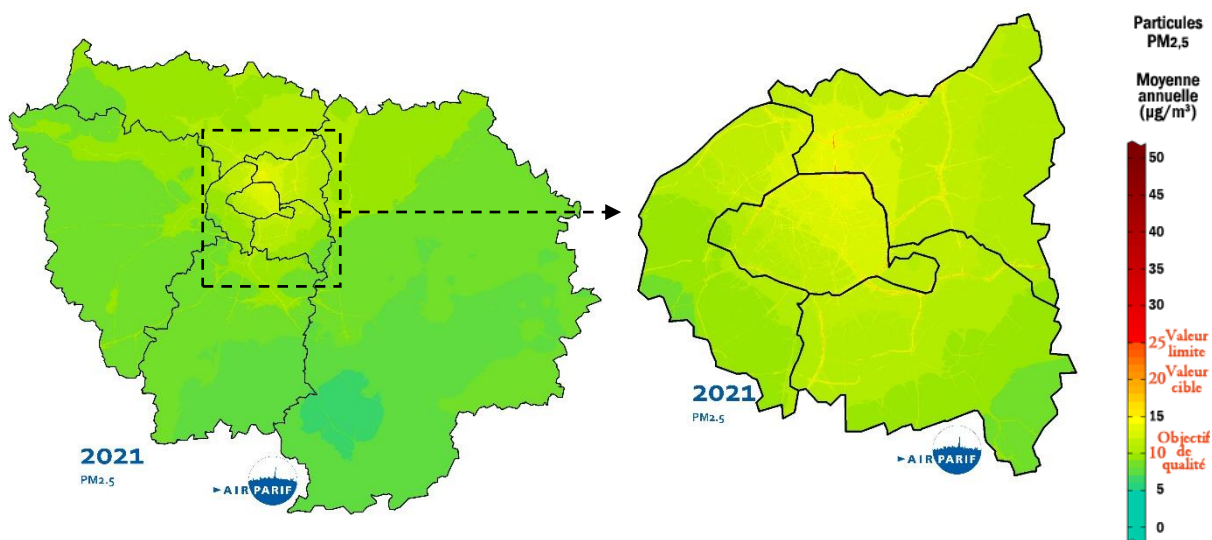


Figure 16: annual mean concentration of fine particles PM_{2.5} in the Paris region, with a focus on Paris and surrounding suburbs in 2021

There is a small difference in PM_{2.5} concentrations between urban and rural areas in 2021. PM_{2.5} annual mean concentrations range from 6 to 10 µg/m³ in rural situation and from 9 to 12 µg/m³ for urban and suburban background sites (Figure 17).

Highest PM_{2.5} mean concentrations are measured within the Paris agglomeration and also near main roads and highway connections. In roadside situation, annual mean PM_{2.5} concentrations range from 11 to 17 µg/m³.

As for the PM₁₀, the annual mean concentrations of PM_{2.5} recorded in 2021 are slightly higher than those measured in 2020 but lower than those of 2019.

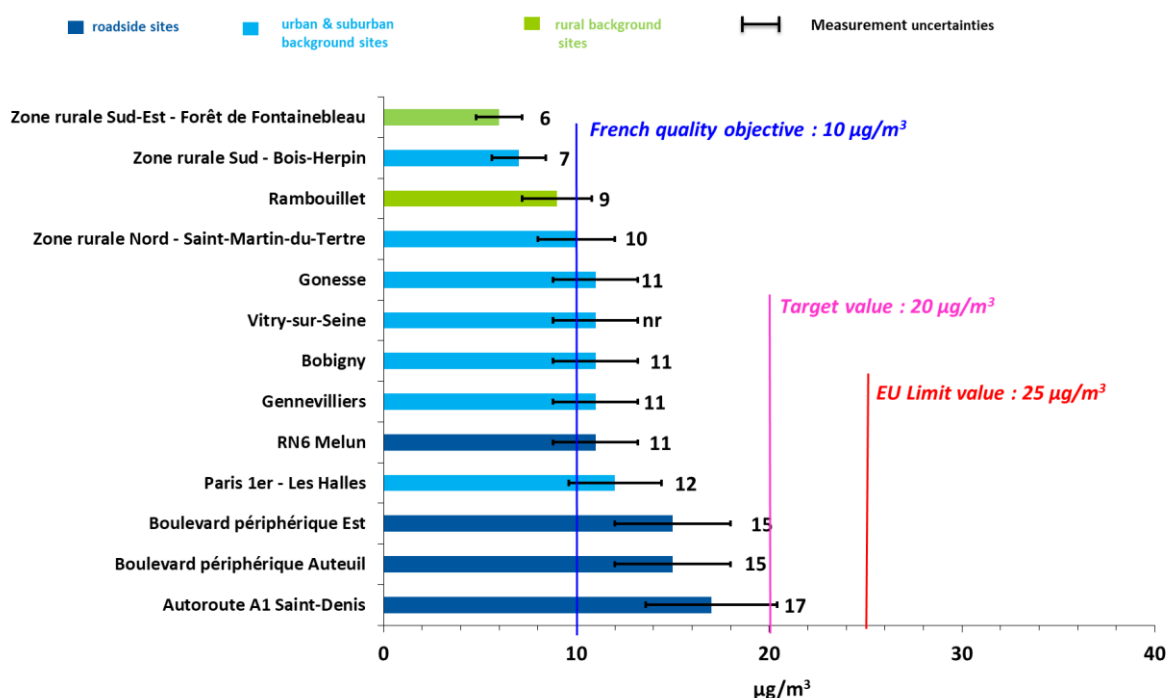


Figure 17: PM_{2.5} annual mean concentration for all continuous monitoring sites in the Paris region in 2021

The EU limit value for fine particles PM_{2.5} (25 µg/m³) and the PM_{2.5} target value (20 µg/m³) are met at all the monitoring stations.

The annual WHO recommendation (reduced to 5 µg/m³ in 2021), as well as the daily WHO recommendation (reduced in 2021 to 15 µg/m³ not to be exceeded more than 3 days per year) are exceeded for the entire Paris region in 2021.

LONG-TERM TRENDS

As for PM₁₀ particles, significant changes related to the occurrence of air pollution episodes are observed for fine particles PM_{2.5}, as illustrated in Figure 18.

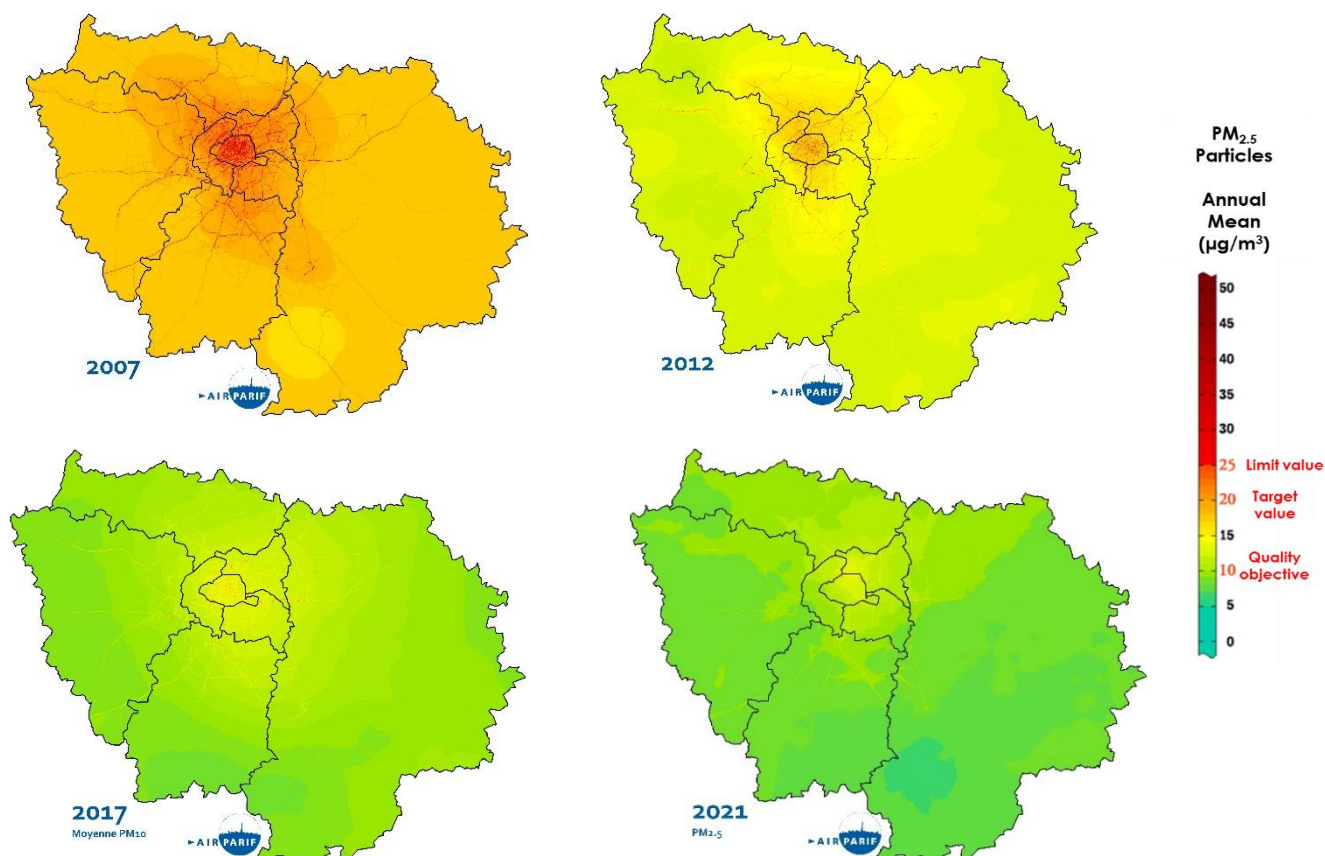


Figure 18: annual mean concentrations of fine particles PM_{2.5} from 2007 to 2021 in the Paris region

PM_{2.5} tri-annual mean levels reflect a significant decline of 40 % from 2009-2011 to 2019-2021 in background situation (Figure 19).

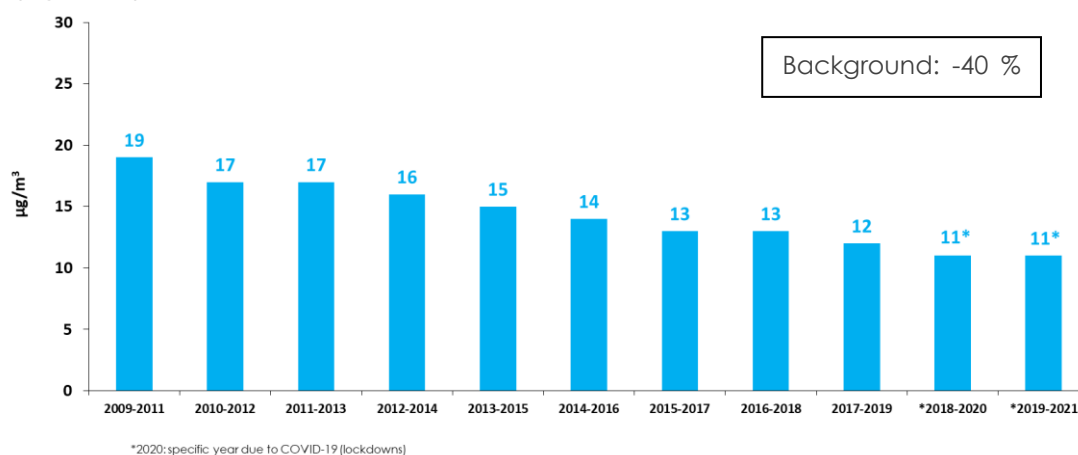


Figure 19: trend in the PM_{2.5} tri-annual mean concentrations (based on a scalable sample of urban background sites) within the Paris agglomeration from 2009-2011 to 2019-2021

The decline of PM_{2.5} concentrations is particularly acute for the Ring road BP Porte d'Auteuil traffic monitoring station (Figure 20). A significant reduction in PM_{2.5} levels of 50 % is observed from 2011 to 2021. As for PM₁₀, this decrease is related to the reduction of primary particles emissions from diesel exhaust linked to the road fleet renewal. **The decrease is greater for PM_{2.5} than for PM₁₀ particles as most of PM_{2.5} particles are emitted in vehicles exhaust.** A large part of PM₁₀ particles are emitted by tyre-wear, brake-wear, road abrasion and dust suspension.

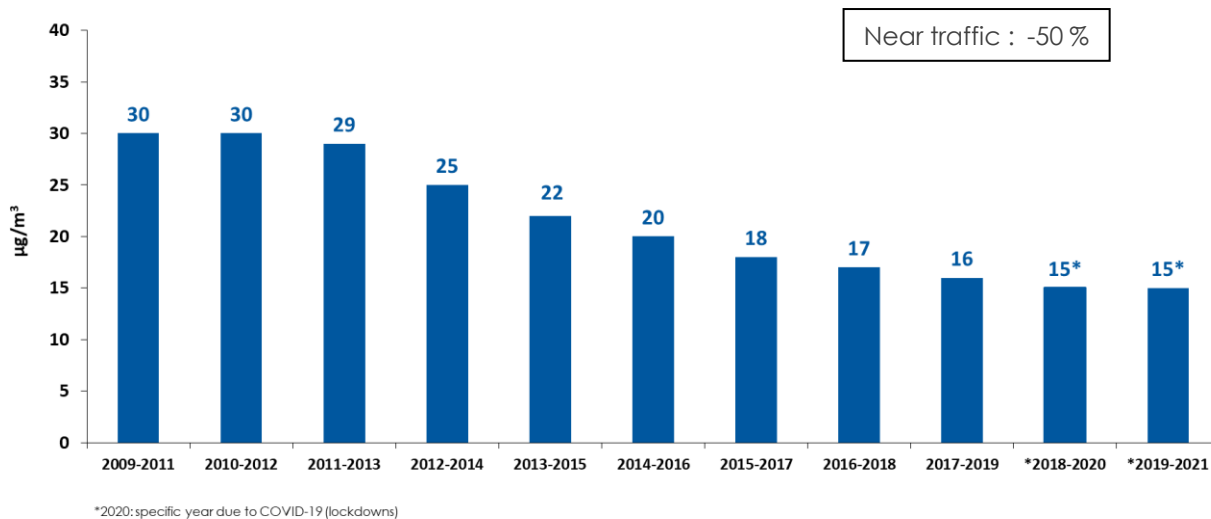


Figure 20: trend in the PM_{2.5} tri-annual mean concentration for the traffic monitoring station Ring road BP Porte d'Auteuil from 2009-2011 to 2019-2021

2.4 Ozone (O₃)

Ozone (O₃) in brief

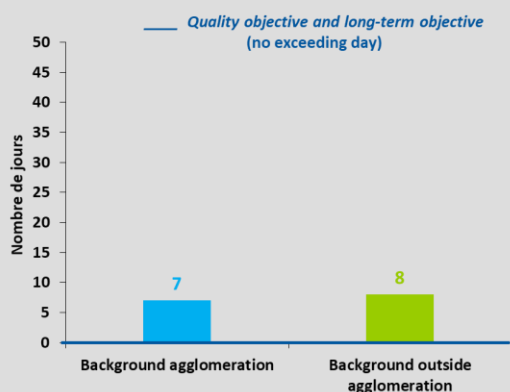
Target value for the protection of Human Health is met in the Paris region in 2021.

Quality objectives for the protection of health and vegetation are exceeded in the region in 2021.

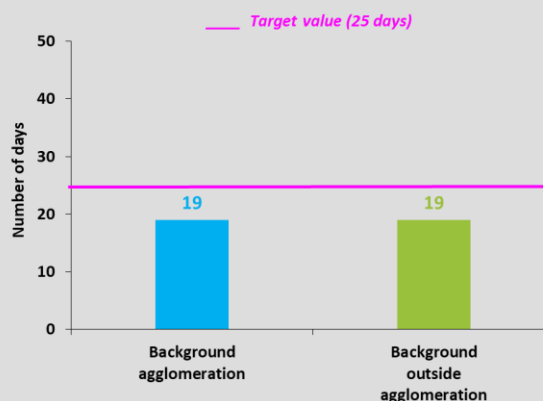
100 % of the population is affected by the exceedance of the WHO recommendation value (100 µg/m³ over 8 hours).

Ozone remains an important issue in the Paris region. It is the only pollutant with increasing annual concentrations.

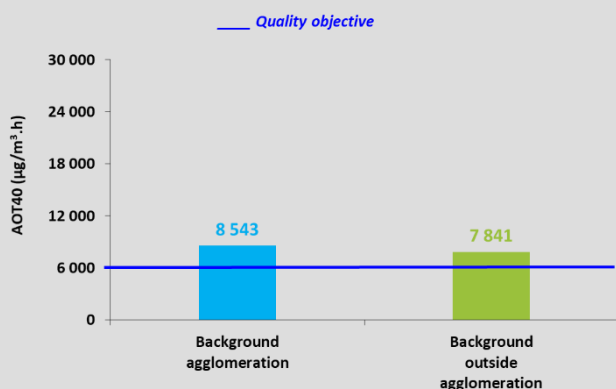
Ozone (O₃) Human Health
Quality objective and long-term objective
Highest monitoring station in 2021 in the Paris region



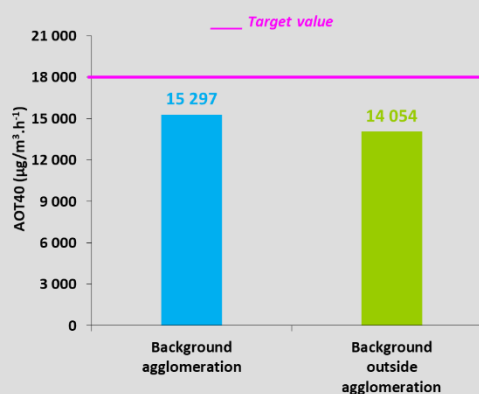
Ozone (O₃) Human Health
Target value
Highest monitoring station in 2021 in the Paris region



Ozone (O₃) vegetation
Quality objective and long-term objective
Highest monitoring station in 2021 in the Paris region



Ozone (O₃) vegetation
Target value
Highest monitoring station in 2021 in the Paris region



Summary of air quality standards exceedances for ozone (O₃) in the Paris region

SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS

Ozone (O₃) is a secondary pollutant (and also a greenhouse gas) not directly emitted to the atmosphere but formed in air from complex reactions between the precursor gases (nitrogen oxides (NO_x) and volatile organic compounds (VOC)) in the presence of sunlight and high temperatures. Meteorological conditions (especially in spring and summer) influence O₃ concentrations.

2021 experienced a gloomy summer, resulting in lower ozone levels than those recorded in the recent years.

Protection of Human Health

Despite these cool summer conditions, **the O₃ quality objective for the protection of human health** (120 µg/m³ on a maximum daily 8-hours mean per civil year) **is exceeded in the Paris region in 2021** (Figure 21), as in previous years. **Suburban and rural areas are more commonly affected than the Paris agglomeration.** Annual prevailing meteorological conditions (mainly summer conditions) have an impact on the number of threshold exceedances.

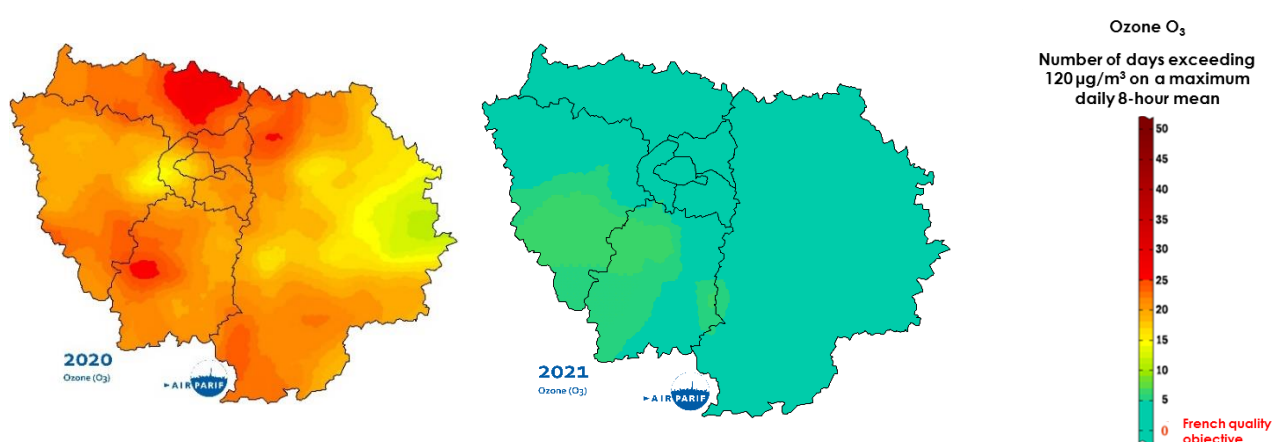


Figure 21: number of days exceeding the French quality objective (=EU long-term objective) threshold of 120 µg/m³ on a maximum daily 8-hours mean (objective = no exceedance) for ozone (O₃) in the Paris region in 2020 and 2021

Due to relatively low insolation and temperatures between June and September, 2021 recorded the lowest number of days exceeding the quality objective in history, much lower than those of 2020 and 2019 (-15 days on average for the network's automatic stations).

In 2021, the most affected area is located in the south-west of the region.

As for the threshold recommended by the WHO (100 µg/m³ not to be exceeded over an 8-hour period), it is exceeded at all points in the region in 2021.

The **target value for the protection of human health** (calculated on a 3-years mean) **is met in the Paris region, on the 2019-2021 period** (Figure 22). This target value was exceeded over the 2017-2019 and 2018-2020 periods due to the intense summers from 2018 to 2020.

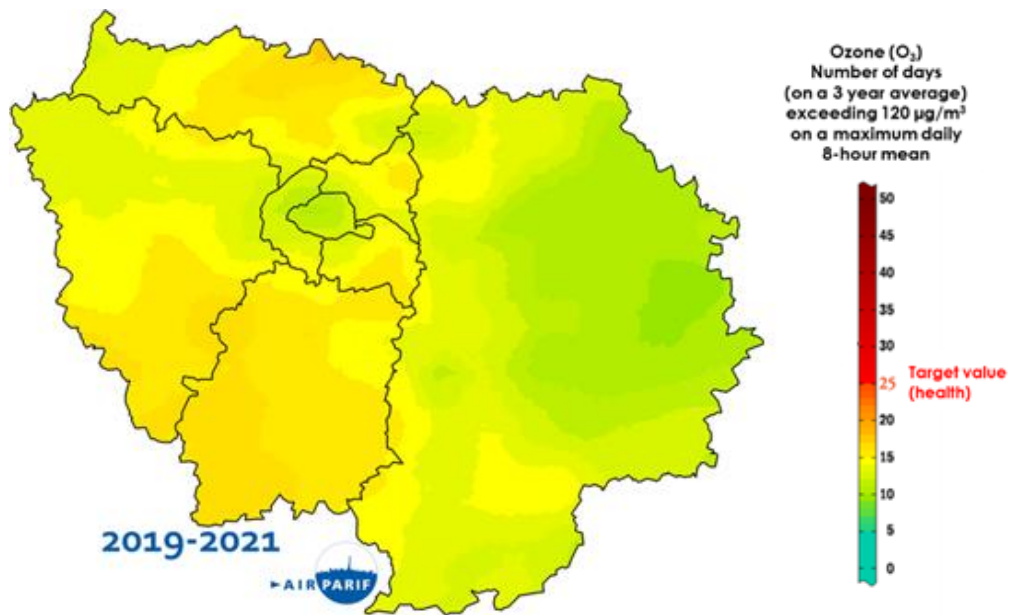


Figure 22: number of days exceeding the O₃ target value for the protection of human health (120 µg/m³ for the daily maximum on an 8-hours mean not to be exceeded more than 25 days per calendar year calculated on a 3-years mean) within the Paris region for the 2019-2021 period

The mean number of days exceeding the O₃ target value is usually higher in rural and suburban areas than in the Paris agglomeration (Figure 23).

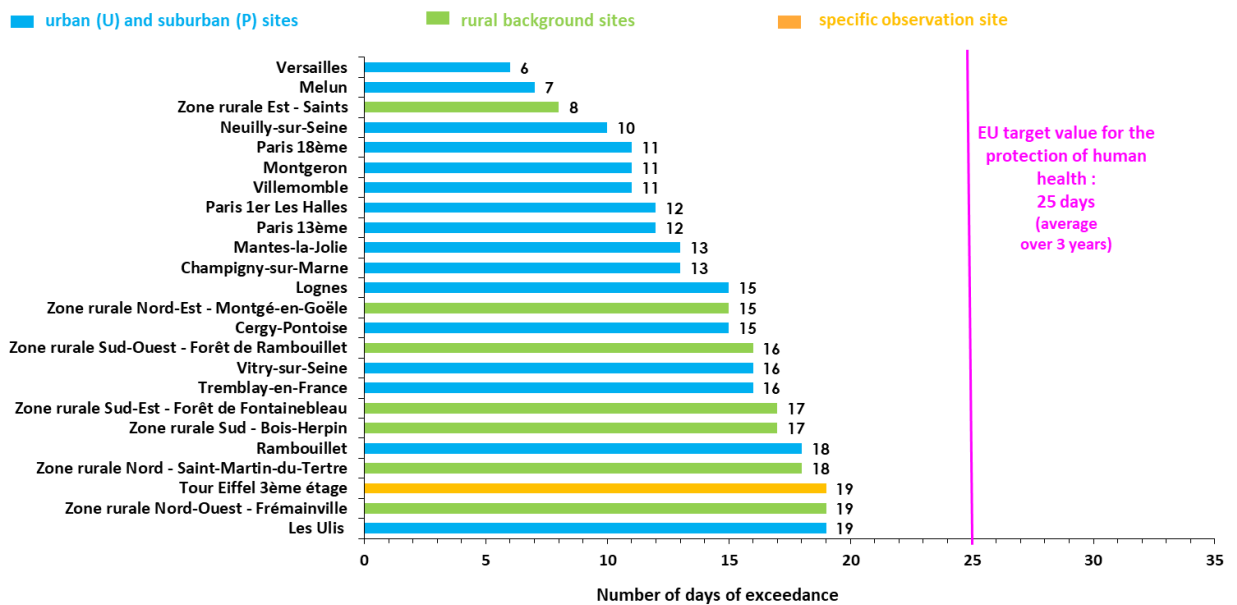


Figure 23: number of days exceeding the O₃ EU target value for the protection of human health (120 µg/m³ 8-hours) in the Paris region (2019-2021 tri-annual mean)

Protection of vegetation

Many scientific studies have revealed the ozone negative effects on the vegetation (forests, ecologically or biologically significant areas and cereal/wheat crops) due to its strong oxidizing action. Consequently, European regulations focus the quality objectives and target values for the protection of vegetation on growing vegetation and crops periods, in the spring and early summer. AOT 40 (corresponding to 'Accumulated Ozone exposure over a Threshold of 40 parts per billion (ppb)') means the sum of the difference between hourly concentrations greater than 80 µg/m³ and 80 µg/m³ over

a given period using only the one-hour value measured between 8.00 am and 8.00 pm Central European Time (CET) each day. It is expressed in $\mu\text{g}/\text{m}^3\cdot\text{h}^{-1}$.

The EU target value for the protection of vegetation ($18\,000\ \mu\text{g}/\text{m}^3\cdot\text{h}^{-1}$) is calculated on a 5-year mean. The mean value is less prone to fluctuations from one year to the next. In 2021, **the EU target value is met in the whole Paris region.** The highest mean recorded per station over the 2017-2021 period is $15\,297\ \mu\text{g}/\text{m}^3\cdot\text{h}^{-1}$.

As every year, the French quality objective for the protection of vegetation ($6\,000\ \mu\text{g}/\text{m}^3\cdot\text{h}^{-1}$ from May to July 8 am to 8 pm, equivalent to EU long-term objective) is exceeded in the Paris region. In 2021, more than half of the stations in the Airparif network recorded levels above the quality objective for the protection of vegetation. Exceedance is generally pronounced in rural and peri-urban areas aimed by this protection threshold (Figure 24).

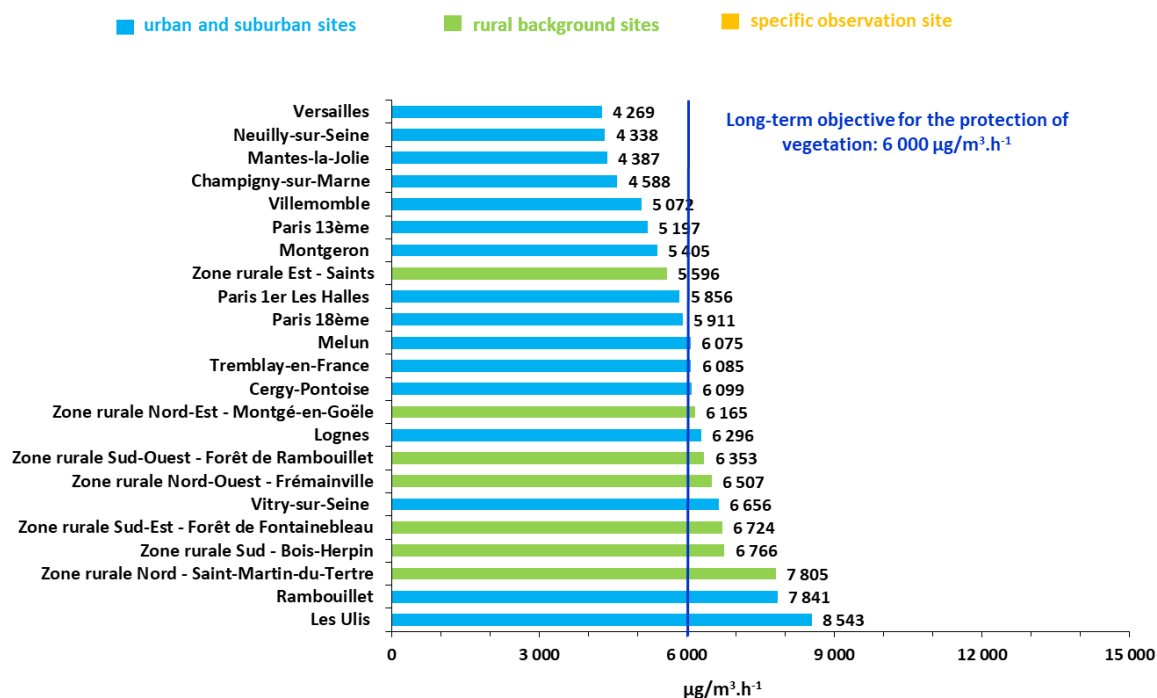


Figure 24: long-term objective in ozone (O_3) for the protection of vegetation (AOT40, threshold of $6\,000\ \mu\text{g}/\text{m}^3\cdot\text{h}^{-1}$) in the Paris region in 2021

MEAN ANNUAL TRENDS FOR THE PROTECTION OF HUMAN HEALTH

The year 2021 is characterized by low insolation and a below-average number of hot days. The mean number of days exceeding the quality objective in the agglomeration and in rural areas in 2021 are the lowest in history and very much lower than the last 3 years which had experienced exceptional summer weather conditions (Figure 25).

Over the period 1998-2020, **the number of exceedance days does not show a clear downward trend. It still exceeds the quality objective** (no exceedance allowed).

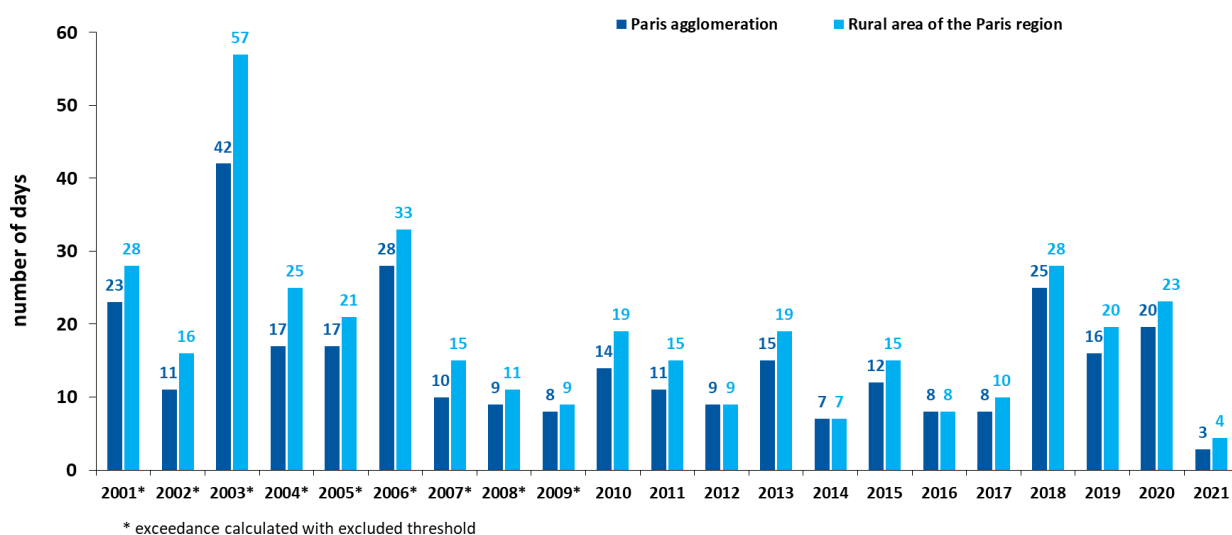


Figure 25: mean number of days exceeding the O₃ french quality objective for the protection of human health (120 µg/m³ 8-hours mean) in the Paris region from 2001 to 2021

Due to the strong dependence to weather conditions, the evolution of the number of days exceeding the threshold of 120 µg/m³ over 8 hours can only be meaningful in the medium term. The number of days exceeding the EU target value for the protection of human health on a 3-year period is shown in Figure 26.

From 2006-2008 to 2016-2018, this regulated threshold has been met in the agglomeration and rural areas of the Paris region. The period from 2007-2009 to 2015-2017 has the lowest number of exceeding days of the entire history.

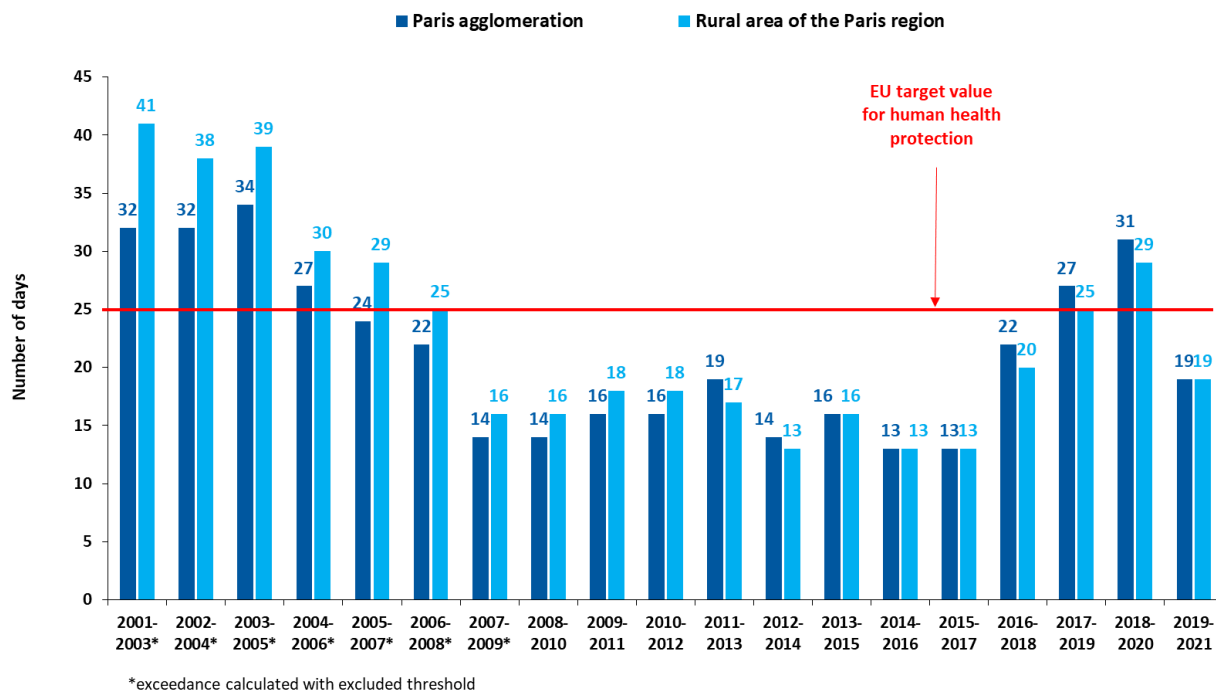


Figure 26: number of days exceeding the EU target value for the protection of human health (120 µg/m³ 8-hour mean, not over 25 days of exceedance on a 3-year period) for the highest monitoring station in the Paris region from 2001-2003 to 2019-2021

The trend of the O₃ tri-annual mean concentrations measured within the Paris agglomeration is shown in Figure 27. These O₃ levels have risen by 25 % between 2011 and 2021. **Between the 2009-2011 period and 2015-2017, urban background ozone levels are statistically stable. Since 2016-2018, the annual mean ozone concentrations have increased again; those measured over the 2018-2020 period being the strongest in history due in particular to the year 2020 when the health crisis led to reductions in NO₂ emissions and consequently an increase in O₃ concentrations (see the 2020 regional report). The 2019-2021 period shows a slight decrease compared to the previous period due to the gloomy summer conditions in 2021.**

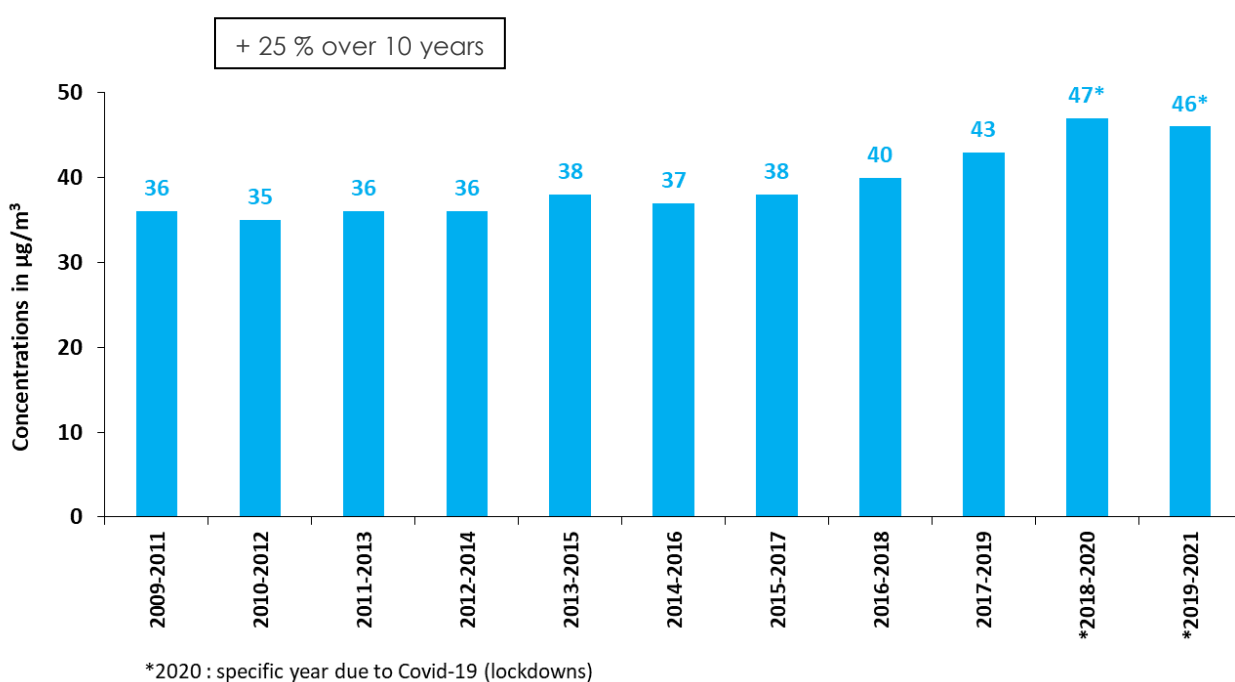


Figure 27: trend in the O₃ tri-annual mean concentrations (based on a sample of the same three urban background sites) within the Paris agglomeration from 2009-2011 to 2019-2021

3. Pollutants meeting air quality standards

3.1 Benzene (C₆H₆)

Benzene (C₆H₆) in brief

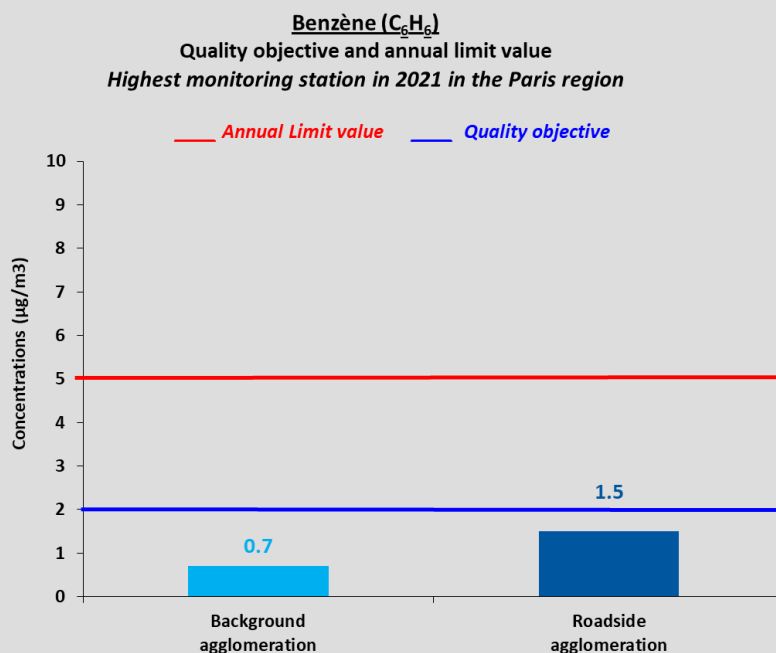
The downward trend of recent years continues and the concentrations measured are the lowest in history (apart from 2020, a specific year due to restrictions on activities due to COVID).

Annual limit value for benzene (5 µg/m³) has been met everywhere in the Paris region since 2006. Complied in background situation, the quality objective (2 µg/m³) can be very locally exceeded near some Parisian roads.

No inhabitant of the Paris region is exposed to an exceedance of the annual quality objective (2 µg/m³).

Since 2010, the decrease has been constant.

Both in a background situation and near road traffic, benzene levels decreased between 2019 and 2021.



Summary of air quality standards exceedances for benzene (C₆H₆) in the Paris region

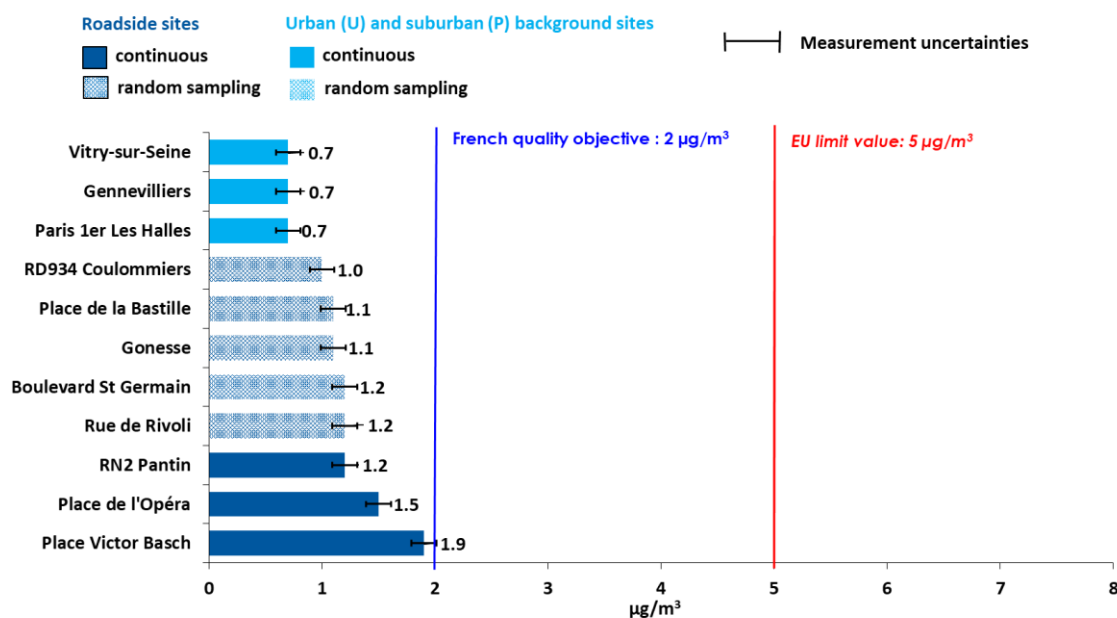
SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS

Background benzene concentrations are lower than the French quality objective and the EU annual limit value (2 and 5 $\mu\text{g}/\text{m}^3$, respectively). In 2021, background benzene levels (from 0.7 $\mu\text{g}/\text{m}^3$) are the lowest of historical data (apart from 2020, a particular year due to restrictions on activities due to COVID) (Figure 28).

Highest annual mean concentrations of benzene are measured near main roads located in the Paris agglomeration, due to traffic-clogged conditions associated with unfavourable conditions for pollution dispersion (street canyons). These concentrations are between 1.0 and 1.9 $\mu\text{g}/\text{m}^3$ for the traffic monitoring stations. They are the lowest of the historical data as well, apart from 2020.

The difference between the concentrations measured on background stations and stations near traffic has never been so small.

In 2021, the French quality objective (2 $\mu\text{g}/\text{m}^3$) is met on every monitoring station. Benzene annual levels are way lower than the EU limit value (5 $\mu\text{g}/\text{m}^3$). For the first time, no inhabitant of the Paris region is exposed to an exceedance of the French quality objective. However, it cannot be ruled out that this value may be exceeded very occasionally on certain Parisian and regional roads.



In addition to continuous measurements of benzene, discontinuous measurements are performed by AIRPARIF since 2007. These measurements are carried out using passive diffusion tubes during 12 uncontinuous weeks evenly distributed over the year. All these sites are characterised by a high pedestrian density and the presence of residences near road axes. For these sampling sites, the results reported in this figure represent the average of twelve weeks measurements.

Figure 28: annual mean concentration of benzene in the Paris region in 2021

MEAN ANNUAL TREND

After a significant decrease of benzene concentrations since the beginning of the 2000's due to the decline in the benzene content of petrol, the levels have been decreasing much more slowly in recent years and tend to stabilize (Figure 29). The benzene mean levels measured over the period 2018-2020 and 2019-2021 are the lowest in history.

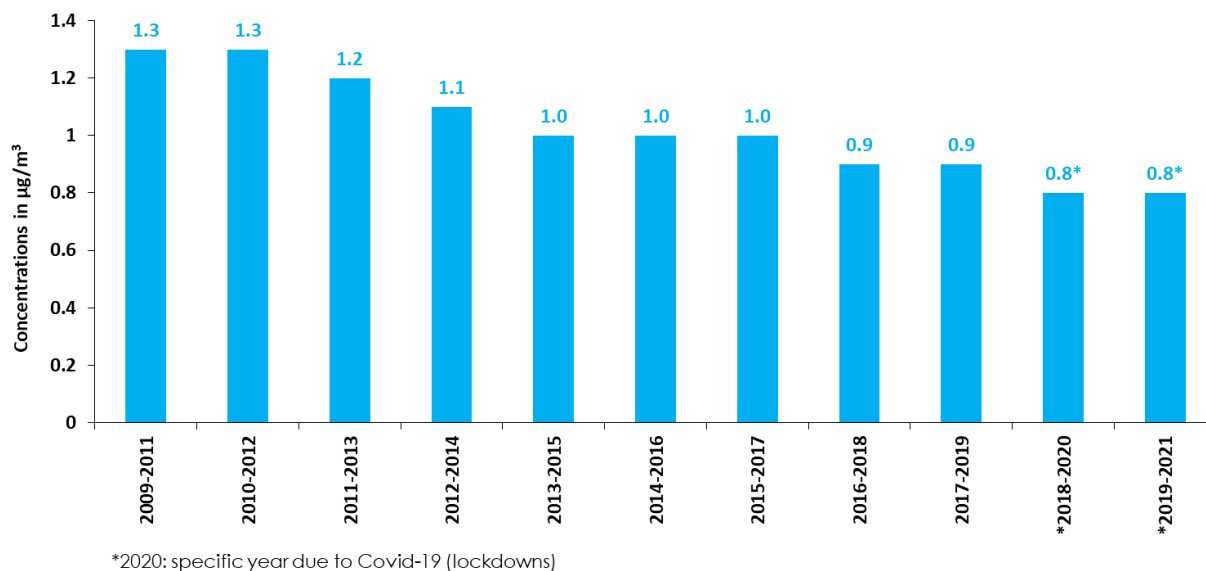


Figure 29: trend in the benzene tri-annual mean concentrations (based on a scalable sample of urban background sites) within the Paris agglomeration from 2009-2011 to 2019-2021

In roadside situation, the trend in benzene concentrations is consistent with those of other primary pollutants directly emitted by road traffic (particles, NO₂). However, a decline in benzene levels is more marked since 2000 (date on which an EU regulation limiting the benzene content in petrol is implemented) (Figure 30). Benzene mean concentrations decline has slowed down substantially since 2007 (-50 % between 2011 and 2021).

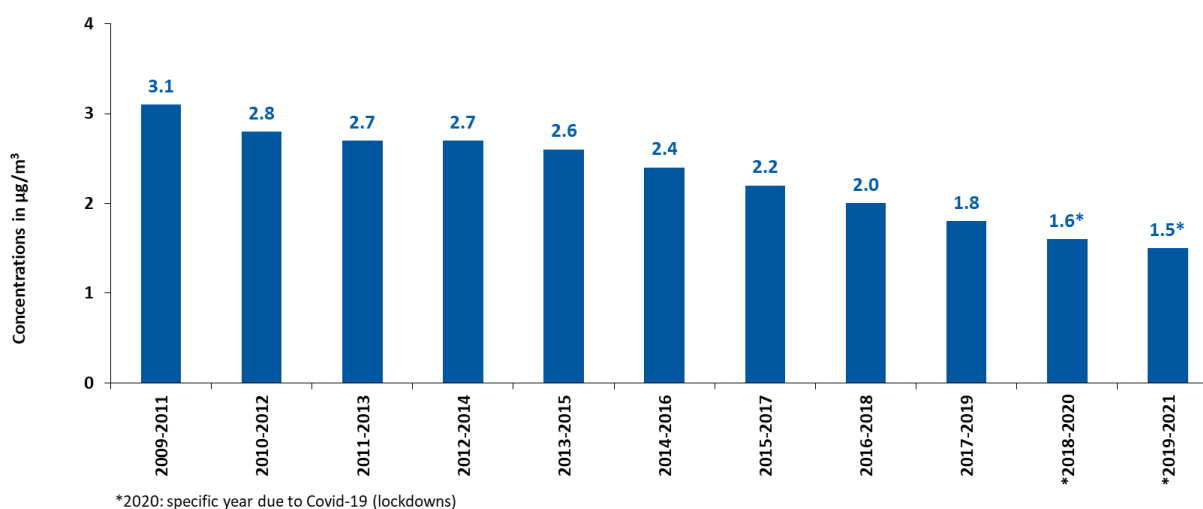


Figure 30: evolution, with an evolving sample of traffic stations, of the benzene mean concentrations over 3 from 2009-2011 to 2019-2021

3.2 Benzo(a)pyrene (BaP)

SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS

The BaP EU target value (1 ng/m³) is widely met on the five Airparif monitoring sites (Figure 31).

In 2021, the BaP levels measured in the Paris region all slightly increased compared to those of 2020, and are similar to those of 2019.

Differences in benzo(a)pyrene concentrations can be observed between background sites. **Local emissions (related to wood burning fireplaces, open uncontrolled burning of wastes) are more significant in suburban residential areas, even in the greater Paris area (Pommeuse), than in Paris and its neighbouring cities.**

The Pommeuse site (77), representative of a residential area consuming firewood in the outer suburbs [Airparif, 2015], records the highest concentrations of BaP of the monitoring network (between 2 and 3.5 times greater than those of the other stations of the network).

The Boulevard Périphérique Est traffic site recorded higher BaP levels than those measured in the Paris 1er Les Halles station.

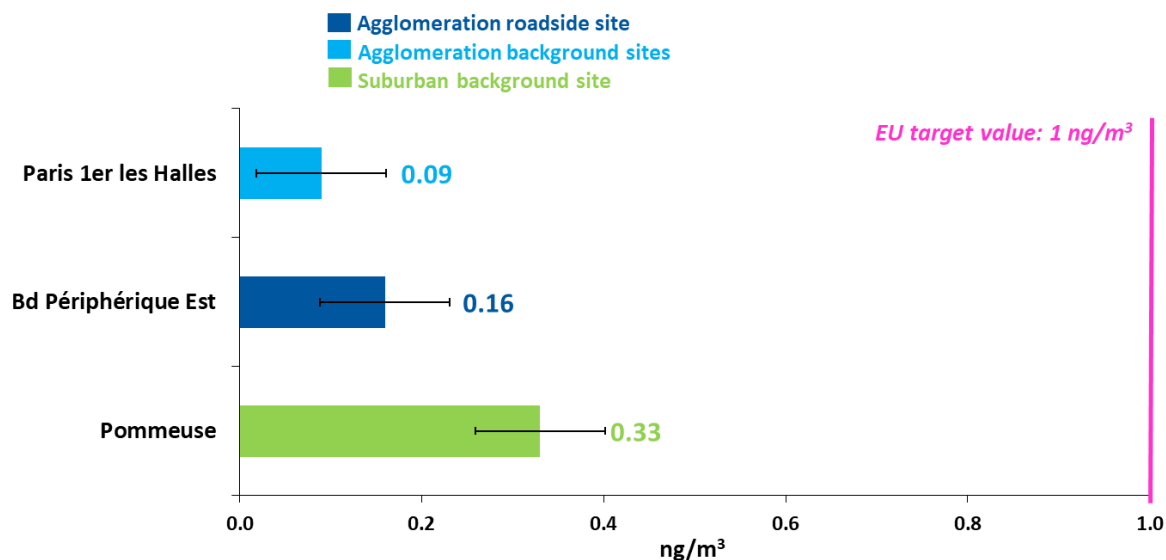


Figure 31: benzo(a)pyrene annual mean concentrations for all monitoring sites in the Paris region in 2021

MEAN ANNUAL TREND

A significant decrease of BaP levels is observed near traffic roads (-87 %) over the last 10 years (Figure 32), linked to the gradual renewal of the rolling fleet. A decrease of the BaP levels of around 60% has been measured since 2011.

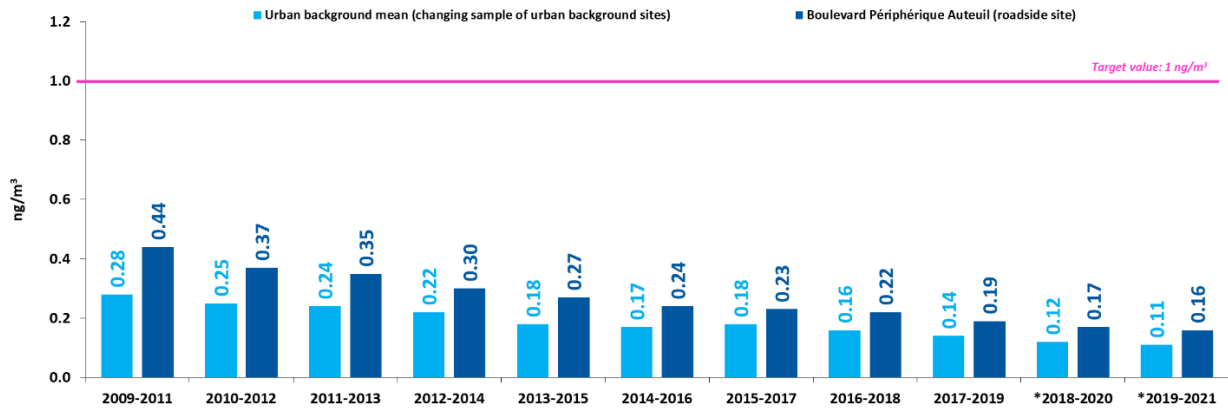


Figure 32: evolution of the benzo(a)pyrene 3-years mean concentrations (based on the means of urban background sites and the Boulevard Périphérique site) in the Paris agglomeration from 2009-2011 to 2019-2021

3.3 Metals (Lead, Arsenic, Cadmium and Nickel)

SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS AND LONG-TERM TRENDS

Lead (Pb), which gradually disappeared from fuels since 2000, has seen its levels decrease significantly and no longer represents a relevant indicator of road traffic today. Each year, lead concentrations are very low and close to the limits of quantification in background and industrial situations (Figure 33). **The EU limit value and the French quality objective for lead are widely met (the 2021 annual value being from 25 to 50 times below air quality standards).** The same observation is also observed in the vicinity of the industrial sites of Limay and Bagneaux-sur-Loing.

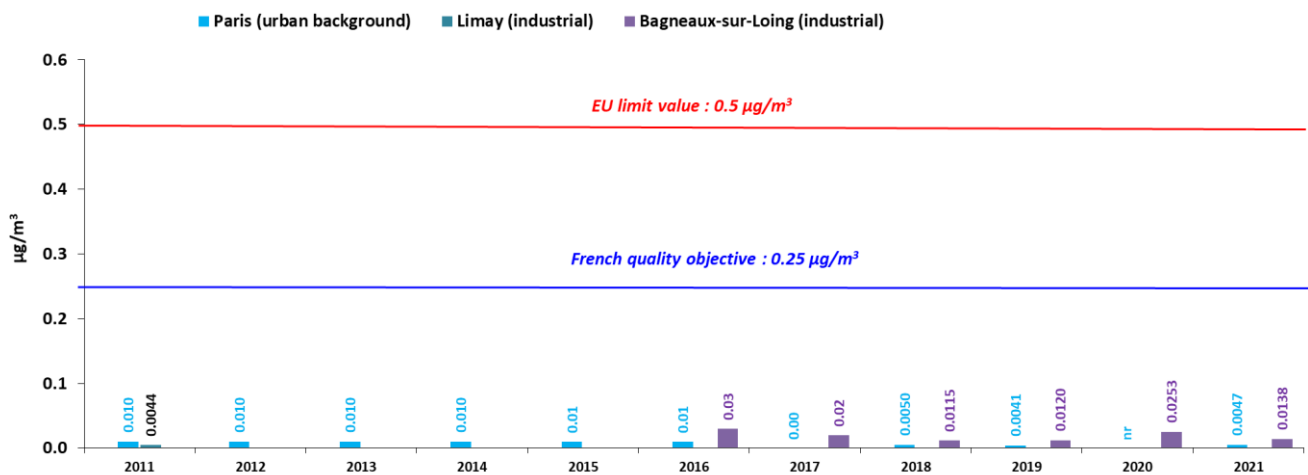


Figure 33: trends in the lead (Pb) annual mean concentration at urban background, roadside and industrial sites within the Paris region from 2011 to 2021

Since 2011, **arsenic (As)** concentrations are globally decreasing. In 2021, the mean annual level of arsenic recorded at the urban background site is slightly higher than the one of 2019, which was the lowest in all history (0.26 ng/m³ in 2021 against 0.22 ng/m³ in 2019) but remains lower than the previous years (Figure 36).

The Limay station, located near a facility emitting this compound, recorded levels higher than those of recent years but is still way below the target value.

For the Bagneaux-sur-Loing station, which recorded levels above the target value in 2019, arsenic concentrations decreased by more than half, way below the target value.

Installed on the municipal territory of Bagneaux-sur-Loing (77), the Keraglass and Corning SAS factories are specialized in the manufacture of glasses special items (glass-ceramic glass, eyeglasses and optical glasses, respectively). This industrial production emits heavy metals, and more particularly lead and arsenic. In the vicinity of Keraglass, significant arsenic emissions were occasionally measured in ambient air. This industrial site is the leading arsenic emitter in the Paris region and the fifth largest national emitter. It should be noted that these emissions can vary greatly from one year to another depending on the productions.

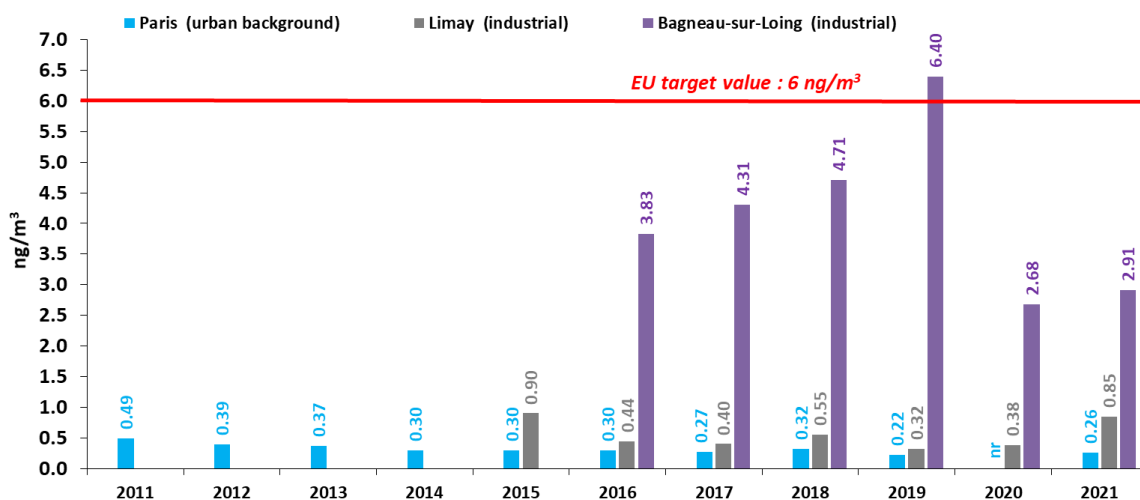


Figure 34: trends in the arsenic (As) annual mean concentrations at urban background, roadside and industrial sites within the Paris region from 2011 to 2021

For **cadmium (Cd)**, background concentrations are rather stable since 2015 besides a slight increase in 2021 (Figure 35). The annual mean recorded in background situation in 2021 is 50 times lower than the European target value set at 5 ng/m³. The Limay site (industrial) recorded an increase, while remaining more than 10 times below the target value. The site of Bagneaux-sur-Loing (industrial) records an annual mean level in cadmium rather stable since 2016.

These values are way lower than the target value of 5 ng/m³.

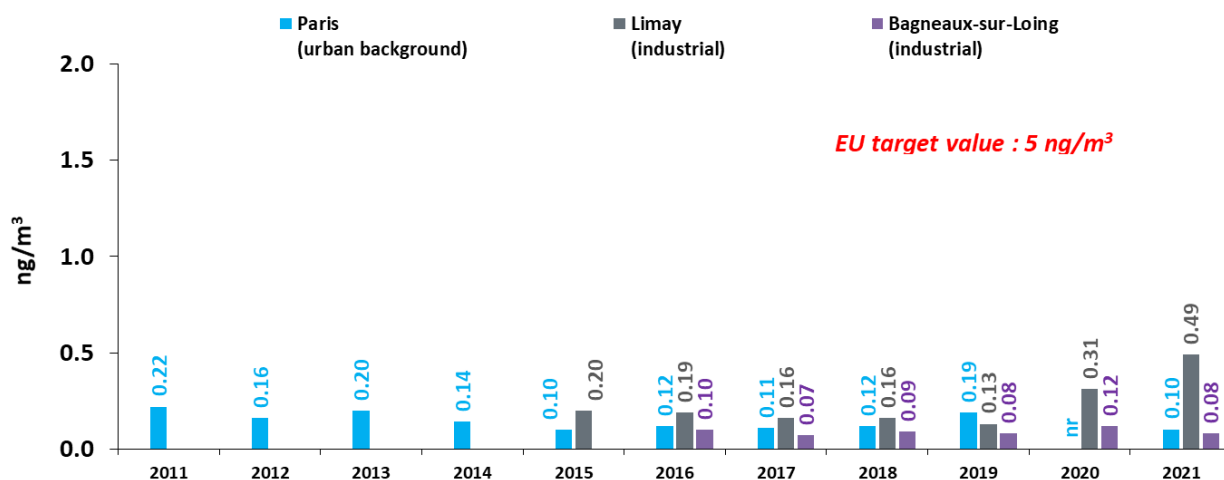


Figure 35: trends in the cadmium annual mean concentrations at urban background, roadside and industrial sites within the Paris region from 2011 to 2021

Regarding **nickel (Ni)**, background concentrations in Paris have been gradually decreasing since 2011 and are comprised in 2021 between 1.53 and 0.90 ng/m³, corresponding to levels 13 to more than 20 times lower than the target value (set at 20 ng/m³) (Figure 36). In 2021, the Limay site recorded the highest nickel annual mean concentrations in history (4.14 ng/m³), due to a few weeks of very high emissions during the summer. The cause of these high concentrations is under investigation. However, the mean annual concentration remains almost 5 times lower than the target value. The Bagneaux-sur-Loing site has seen a steady gradual decline.

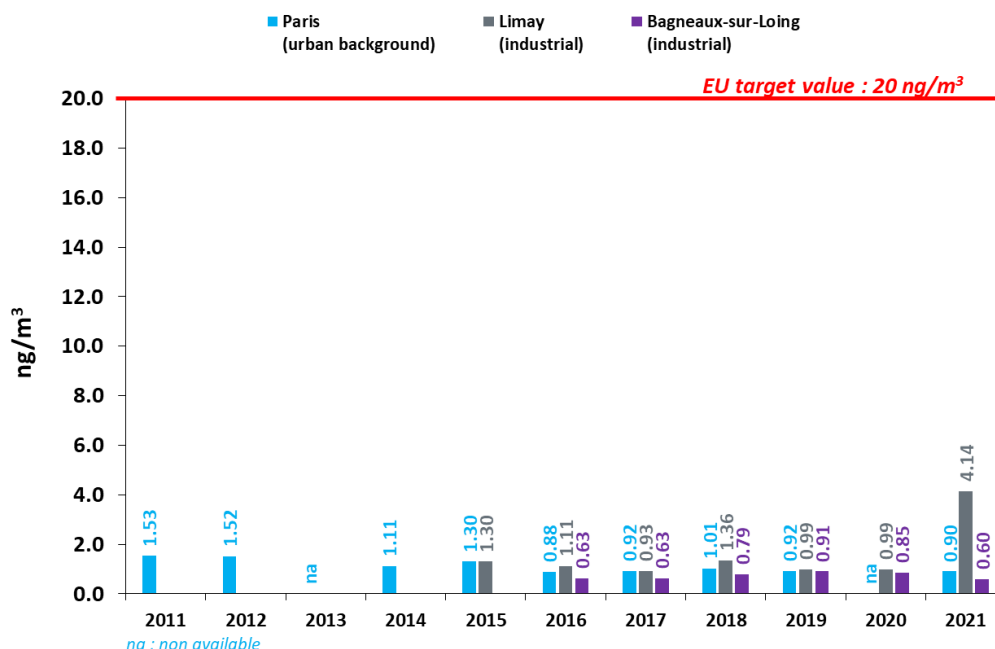


Figure 36: trend in the nickel (Ni) annual mean concentrations at urban background and industrial sites within the Paris region from 2011 to 2021

3.3 Carbon monoxide (CO)

SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS

The carbon monoxide EU limit value for the protection of human health (10 000 µg/m³ for the maximum 8-hours mean) **is widely met near traffic** (Figure 37). In 2021, the mean CO levels are slightly higher than those measured in 2020 on this site but slightly lower than those of 2019.

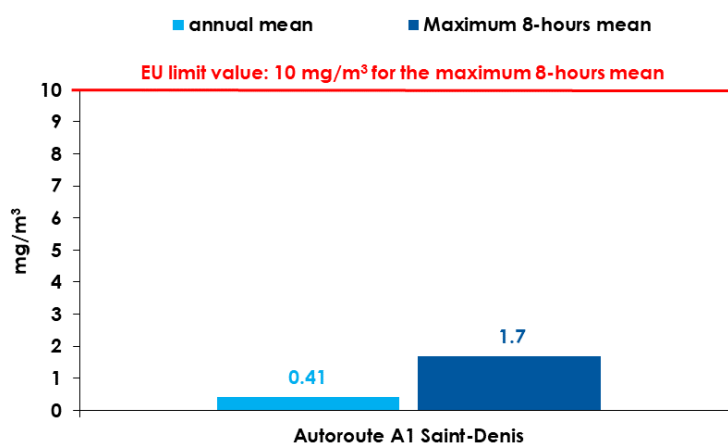


Figure 37: carbon monoxide (CO) annual mean and annual maximum 8-hours mean concentrations for all continuous monitoring sites in the Paris region in 2021

MEAN ANNUAL TREND

CO annual maximum 8-hour mean concentrations have significantly decreased between 2011 and 2021 (- 50 %) (Figure 38). CO levels are, as for other primary pollutants from road traffic, lower in background conditions than in the immediate vicinity of roads. However, the gap tends to stabilize from year to year. Major technological improvements in emissions from on-road vehicles explain this long-term trend.

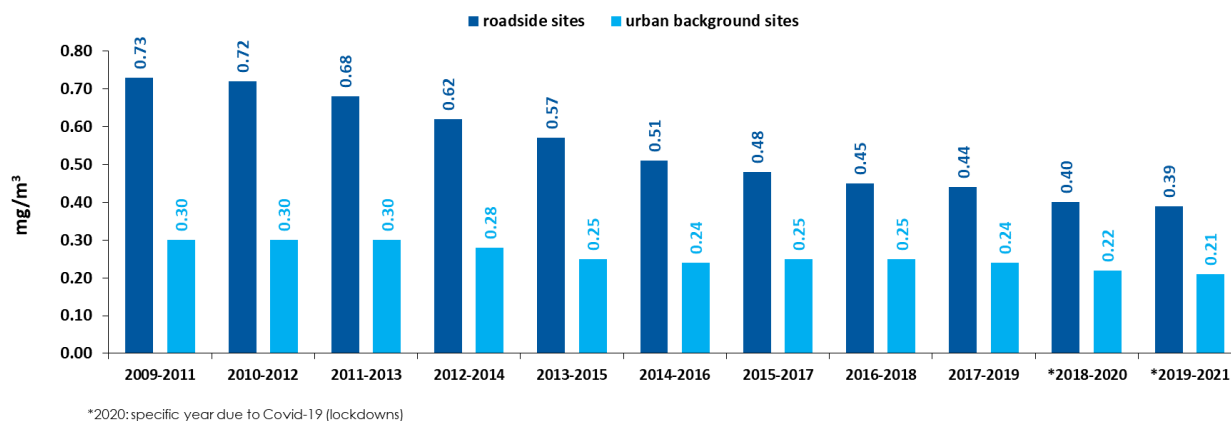


Figure 38: trend in the carbon monoxide (CO) tri-annual mean concentrations at roadside and urban background sites within the Paris agglomeration from 2009-2011 to 2019-2021

3.4 Sulfur dioxide (SO₂)

SITUATION IN 2021 RELATED TO AIR POLLUTION STANDARDS

In 2021, the sulfur dioxide (SO₂) annual mean concentrations are lower than the detection limit (5 µg/m³) at all the monitoring stations, even on the Ringroad BP Auteuil site. **They are way lower than the French quality objective** (50 µg/m³).

SO₂ limit values are also widely met over the whole monitoring stations in the Paris region. No exceedance of the 125 µg/m³ daily threshold and the 350 µg/m³ hourly threshold was observed in 2021.

The levels measured for more than 10 years are all below the detection limit.

LIST OF FIGURES

Figure 1: situation in 2021 of the Paris Region in relation to air quality standards for different regulated pollutants (Glossary at the end of this document)	7
Figure 2: nitrogen dioxide (NO ₂) annual mean concentration within the Paris region, with a focus on Paris and surrounding suburbs in 2021	9
Figure 3: nitrogen dioxide (NO ₂) annual mean concentration for all monitoring sites in the Paris region in 2021	10
Figure 4: million of inhabitants potentially exposed to a nitrogen dioxide (NO ₂) level exceeding the EU annual limit value in the Paris region from 2007 to 2021	11
Figure 5: annual mean concentrations of nitrogen dioxide (NO ₂) from 2007 to 2021 in the Paris region.....	12
Figure 6: trend in the NO ₂ tri-annual mean concentration (based on a sample of the same 6 urban background sites and 5 roadside sites) within the Paris agglomeration from 2009-2011 to 2019-2021	13
Figure 7: PM ₁₀ annual number of days exceeding the 50 µg/m ³ EU threshold within the Paris region with a focus on Paris and surrounding suburbs in 2021	15
Figure 8: PM ₁₀ annual number of days exceeding the 50 µg/m ³ EU threshold for all continuous monitoring sites within the Paris region in 2021 nr: not representative	15
Figure 9: million of inhabitants potentially exposed to a PM ₁₀ level exceeding the EU daily limit value within the Paris region from 2007 to 2021	16
Figure 10: PM ₁₀ annual mean concentration within the Paris region.....	17
Figure 11: PM ₁₀ annual mean concentrations for all continuous monitoring sites in the Paris region in 2021	18
Figure 12 : Evolution of the number of inhabitants potentially exposed to an exceedance of the WHO recommendations in PM ₁₀ in the Paris region from 2007 to 2021	18
Figure 13 : number of days exceeding the EU daily limit value in PM ₁₀ in the Paris region from 2007 to 2021	19
Figure 14: trend in the PM ₁₀ tri-annual mean concentration (based on a scalable sample of background sites located within and out of the Paris agglomeration) from 2009-2011 to 2019-2021	19
Figure 15: trend in the PM ₁₀ tri-annual mean concentration at the Place Victor Basch and BP Porte d'Auteuil stations from 2009-2011 to 2019-2021 nr: not representative	20
Figure 16: annual mean concentration of fine particles PM _{2.5} in the Paris region, with a focus on Paris and surrounding suburbs in 2021	21
Figure 17: PM _{2.5} annual mean concentration for all continuous monitoring sites in the Paris region in 2021	21
Figure 19: annual mean concentrations of fine particles PM _{2.5} from 2007 to 2021 in the Paris region.....	22
Figure 20: trend in the PM _{2.5} tri-annual mean concentrations (based on a scalable sample of urban background sites) within the Paris agglomeration from 2009-2011 to 2019-2021	22
Figure 21: trend in the PM _{2.5} tri-annual mean concentration for the traffic monitoring station Ring road BP Porte d'Auteuil from 2009-2011 to 2019-2021	23
Figure 22: number of days exceeding the French quality objective (=EU long-term objective) threshold of 120 µg/m ³ on a maximum daily 8-hours mean (objective = no exceedance) for ozone (O ₃) in the Paris region in 2020 and 2021	25
Figure 23: number of days exceeding the O ₃ target value for the protection of human health (120 µg/m ³ for the daily maximum on an 8-hours mean not to be exceeded more than 25 days per calendar year calculated on a 3-years mean) within the Paris region for the 2019-2021 period	26
Figure 24: number of days exceeding the O ₃ EU target value for the protection of human health (120 µg/m ³ 8-hours) in the Paris region (2019-2021 tri-annual mean)	26
Figure 25: long-term objective in ozone (O ₃) for the protection of vegetation (AOT40, threshold of 6 000 µg/m ³ .h ⁻¹) in the Paris region in 2021	27
Figure 26: mean number of days exceeding the O ₃ french quality objective for the protection of human health (120 µg/m ³ 8-hours mean) in the Paris region from 2001 to 2021	28
Figure 27: number of days exceeding the EU target value for the protection of human health (120 µg/m ³ 8-hour mean, not over 25 days of exceedance on a 3-year period) for the highest monitoring station in the Paris region from 2001-2003 to 2019-2021	29

Figure 28: trend in the O ₃ tri-annual mean concentrations (based on a sample of the same three urban background sites) within the Paris agglomeration from 2009-2011 to 2019-2021	29
Figure 30: annual mean concentration of benzene in the Paris region in 2021	31
Figure 31: trend in the benzene tri-annual mean concentrations (based on a scalable sample of urban background sites) within the Paris agglomeration from 2009-2011 to 2019-2021	32
Figure 32: evolution, with an evolving sample of traffic stations, of the benzene mean concentrations over 3 from 2009-2011 to 2019-2021	32
Figure 33: benzo(a)pyrene annual mean concentrations for all monitoring sites in the Paris region in 2021	33
Figure 34: evolution of the benzo(a)pyrene 3-years mean concentrations (based on the means of urban background sites and the Boulevard Périphérique site) in the Paris agglomeration from 2009-2011 to 2019-2021	34
Figure 35: trends in the lead (Pb) annual mean concentration at urban background, roadside and industrial sites within the Paris region from 2011 to 2021	34
Figure 36: trends in the arsenic (As) annual mean concentrations at urban background, roadside and industrial sites within the Paris region from 2011 to 2021	35
Figure 37: trends in the cadmium annual mean concentrations at urban background, roadside and industrial sites within the Paris region from 2011 to 2021	35
Figure 38: trend in the nickel (Ni) annual mean concentrations at urban background and industrial sites within the Paris region from 2011 to 2021	36
Figure 39: carbon monoxide (CO) annual mean and annual maximum 8-hours mean concentrations for all continuous monitoring sites in the Paris region in 2021	36
Figure 40: trend in the carbon monoxide (CO) tri-annual mean concentrations at roadside and urban background sites within the Paris agglomeration from 2009-2011 to 2019-2021	37

Glossary

Français	English
Particules	Particulate Matter
Dioxyde d'azote	Nitrogen dioxide
Monoxyde de carbone	Carbon monoxide
Dioxyde de soufre	Sulphur dioxide
Oxyde d'azote	Nitrogen oxide
Plomb	Lead
Autres métaux	Other metals
Normes	Standards
Normes à respecter	Standards to be respected
Normes à respecter dans la mesure du possible	Standards to be respected as much as possible
Recommandations OMS	WHO recommendations
Valeur limite	Limit value
Valeur cible	Target value
Objectif de qualité	Quality objective
Respectée	Met
Dépassée	Exceeded