BACKGROUND // JANUARY 2020

Air Quality 2019

Preliminary Evaluation

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I Air Quality in 2019: Data basis and evaluation methodology

1 Air quality and air pollutants

Air quality is monitored throughout Germany by the individual federal states and the UBA (German Environment Agency/*Umweltbundesamt*). In this respect, air quality is determined on the basis of the amount of air pollutants it contains, which means substances which have a harmful impact on human health and/or the environment. These include, primarily, particulate matter, nitrogen dioxide and ozone.

The pollutant concentrations in the air are measured several times a day at over 600 air monitoring stations throughout Germany (Figure 1). It is the task of the individual federal states to monitor the air quality, therefore most of the data come from their monitoring networks. For the Germany-wide assessment of the air quality, the data gathered by the federal states is collected and evaluated at the UBA.

The evaluation and assessment of the air quality takes place in terms of the limit and target values as defined by the Directive on Ambient Air Quality and Cleaner Air for Europe[1]. The results are also compared with the considerably stricter recommendations of the World Health Organization (WHO).

Figure 1

Overview of the monitoring stations in Germany

Source: German Environment Agency (UBA) 2020

Particulate matter (PM_{10}, $PM_{2.5}$)
is defined as particles which pass through the size-selective air inlet of a monitoring device, which demonstrates a 50 percent efficiency cut-off for an aerodynamic diameter of 10 (PM_{10}) and 2.5 ($PM_{2.5}$) micrometres (µm) respectively. Above all, particulate matter is propagated by combustion processes in motor vehicles, power stations and small-scale furnaces and during the production of metals and steel. It is also propagated by soil erosion and precursors such as sulphur dioxide, nitrogen oxides and ammonia. Particulate matter has been proven to have a negative impact on human health.

Nitrogen dioxide (NO_2)
is a reactive nitrogen compound which occurs in the form of a by-product during combustion processes, particularly in motor vehicles, and can have several negative effects on the environment and health. Nitrogen dioxide affects the respiratory mucous membrane, influences the respiratory function and can lead to a Bronchoconstriction, which may be worsened by the impact of allergens.

Ozone (O_3)
is a colourless and toxic gas which forms a natural layer in the upper atmosphere (stratosphere) and protects the earth from the harmful ultraviolet radiation from the sun (the ozone layer). During intense sunlight, however, it also arises at ground-level due to complex photochemical processes between ozone precursors – primarily nitrogen oxides and volatile organic compounds. High concentrations of ozone can cause people to suffer coughs, headaches and respiratory tract irritations.

1 EU Directive 2008/50/EC, which became German law with the 39th Ordinance Implementing the Federal Immission Control Act (Ordinance on Air Quality Standards and Emission Ceilings – 39. BImSchV).

2 Provisional nature of the information

This evaluation of air quality in Germany in the year 2019 is based on preliminary data which has not yet been conclusively audited from the air monitoring networks of the federal states and the UBA, valid on 20th January 2020. Due to the comprehensive quality assurance within the monitoring networks, the final data will only be available in mid-2020.

The currently available data allows for a general assessment of the past year. The following pollutants were subject to consideration: particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2) and ozone (O_3), since, the measured concentrations are either slightly higher or lower than the limit and target values for the protection of human health for such pollutants.

3 Causes of air pollution

The primary sources of the air pollutants are road traffic and combustion processes in industry, the energy sector and households. Agriculture also contributes to particulate matter emissions due to the formation of what are known as "secondary particles", which are particles that arise from complex chemical reactions between gaseous substances. The degree of the pollution level is also influenced by the weather conditions. In cold weather, emissions (quantity of a pollutant released to the ambient air) often increase because for example heating systems go into increased use. High-pressure weather during the winter, which is often characterised by low wind speeds and a limited vertical exchange of air, means that air pollutants become concentrated in the lower atmospheric strata. High-pressure weather in the summer, with intense sunlight and high temperatures, acts to boost the formation of ground-level ozone.

At high wind speeds and under positive mixing conditions, the levels of pollution fall, however. Inter-year variations in the levels of air pollution are primarily caused by different weather conditions of this kind. They therefore affect the influence of the more long-term development of the emissions.

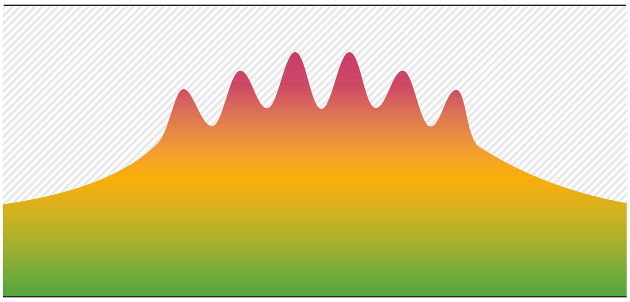
4 Influence of environmental conditions

In the following sections, the concentration values recorded at the individual air monitoring stations are summarised in the form of what are referred to as "pollution regimes". Pollution regimes group air monitoring stations together with similar environmental conditions. The "rural background" regime relates to areas in which the air quality is largely uninfluenced by local emissions. The air monitoring stations in this regime therefore represent the regional pollution level, which is also referred to as the regional background. The "urban background" regime is characterised by areas in which the measured pollutant concentrations can be seen as being typical for the air quality in the city. In this respect, the pollution results from emissions in the city itself (road traffic, heating systems, industry, etc.) and that in the regional background. The air monitoring stations in the "urban traffic" regime are typically located on busy roads. As a result of this, the urban background pollution is joined by a contribution which arises due to the direct road traffic emissions. Figure 2 provides a diagrammatic representation of the contributions by the individual pollution regimes, although it only provides the approximate proportions. Another pollution regime relates to measurements in the vicinity of industrial areas, which are used to assess the contribution of industrial emissions to the air quality in nearby residential areas.

Figure 2

Diagrammatic presentation of the pollution regimes for particulate matter and nitrogen dioxide

Modified according to Lenschow*



■ rural background ■ urban background ■ urban traffic

* Lenschow et al., Some ideas about the sources of PM_{10}, Atmospheric Environment 35 (2001) p. 23–33

II Particulate matter: For the first time no limit value exceedances in Germany

1 PM_{10} – 24-hour values

The limit value for the 24-hour PM_{10} value, which needs to be complied with since 2005, was for the first time not exceeded at any German monitoring station, i.e. none of the about 380 stations measured PM_{10} 24-hour values over 50 µg/m³ at more than 35 days in 2019. Thus, the positive trend of the past years continues. In the previous year the limit value was only exceeded at one industrial station. Since 2012 measurements at all background stations are below the limit value, as shown in Figure 3 (yellow bars).

The recommendations of the World Health Organization (WHO[2]) were not complied with at 36 percent of all air monitoring stations.

Figure 4 shows how many days were recorded on which the limits were exceeded, on average, per month. In this case, 2019 is compared with 2011,

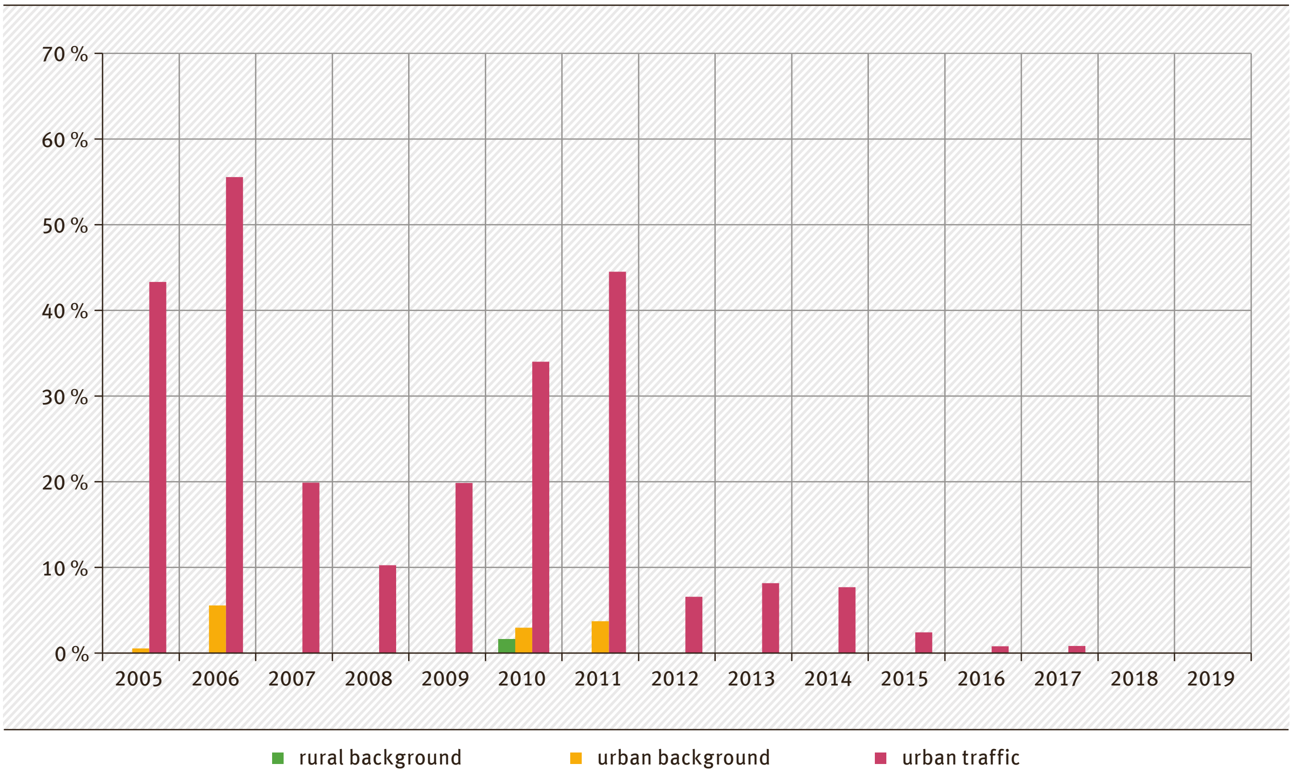
EU limit value
The 24-hour PM_{10} value must not exceed 50 µg/m³ more than 35 times per year.

WHO recommendation
The 24-hour PM_{10} value should not exceed 50 µg/m³ more than 3 times per year.

2 WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global update 2005: http://www.euro.who.int/en/health-topics/environment-and-health/Housing-and-health/publications/pre-2009/air-qualityguidelines.-global-update-2005.-particulate-matter,-ozone,-nitrogen-dioxide-and-sulfur-dioxide

Figure 3

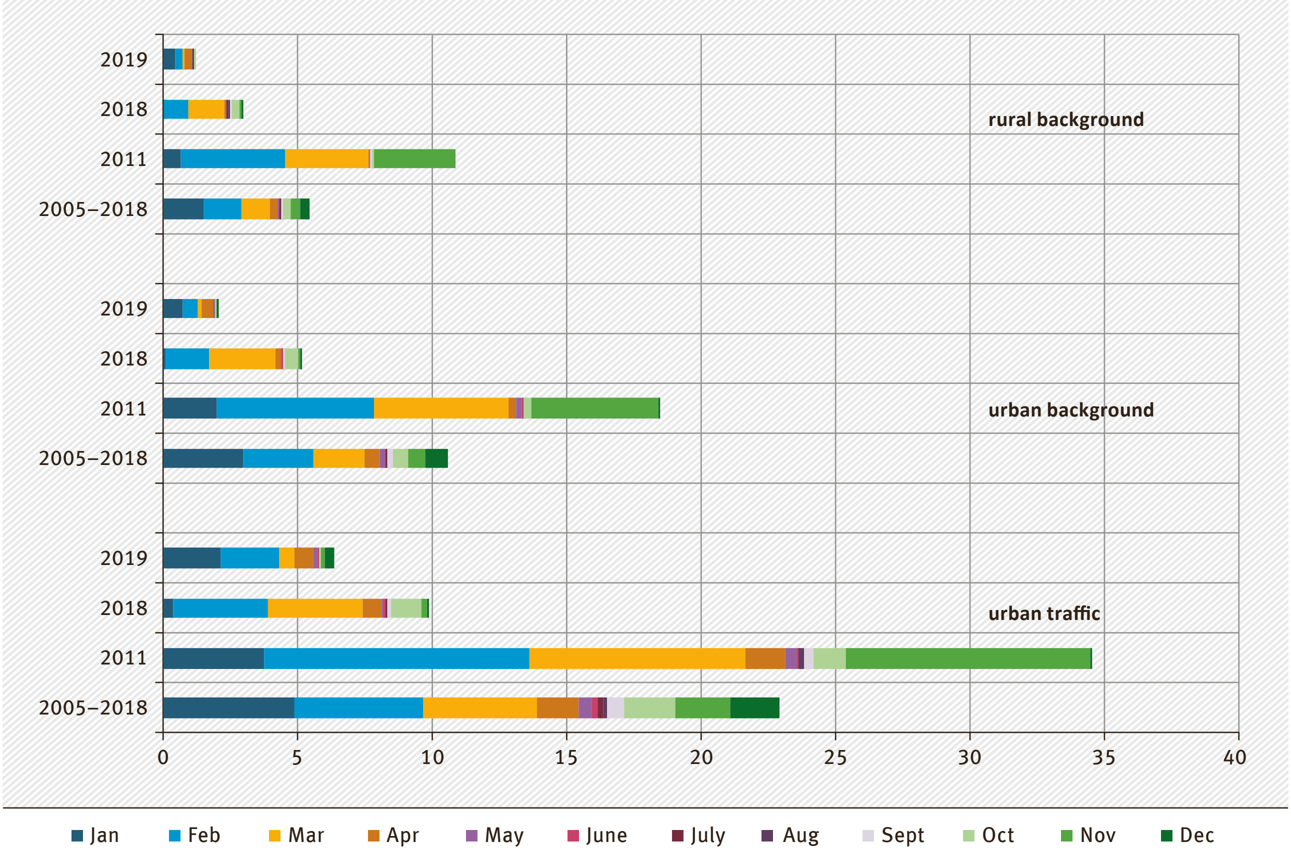
Percentage share of air monitoring stations exceeding the PM_{10} limit value
for the 24-hour values in the corresponding pollution regime, time frame 2005–2019



Source: German Environment Agency (UBA) 2020

Figure 4

Average number of days on which the PM_{10} limit was exceeded (24-hour values > 50 µg/m³) per month in the corresponding pollution regime, shown for the years 2019, 2018, 2011 and the period 2005–2018



Source: German Environment Agency (UBA) 2020

in which the levels of pollution were high due to the frequent occurrence of cold, stable high-pressure weather conditions, with the previous year (2018) and an extended reference period (2005–2018). It can be seen that in 2019 there were only very few days on which the limits were exceeded, most of them occurred in the first months of the year. This goes along with a very dry February and April; the February is even classified as the sunniest since the beginning of the systematic weather observation[3]. The summer was too dry and exceptionally warm, but in September precipitation events stopped the drought. As a result of the mild temperatures in November and December no episodes with high particulate matter concentrations were observed, which are normally characteristic for winter months.

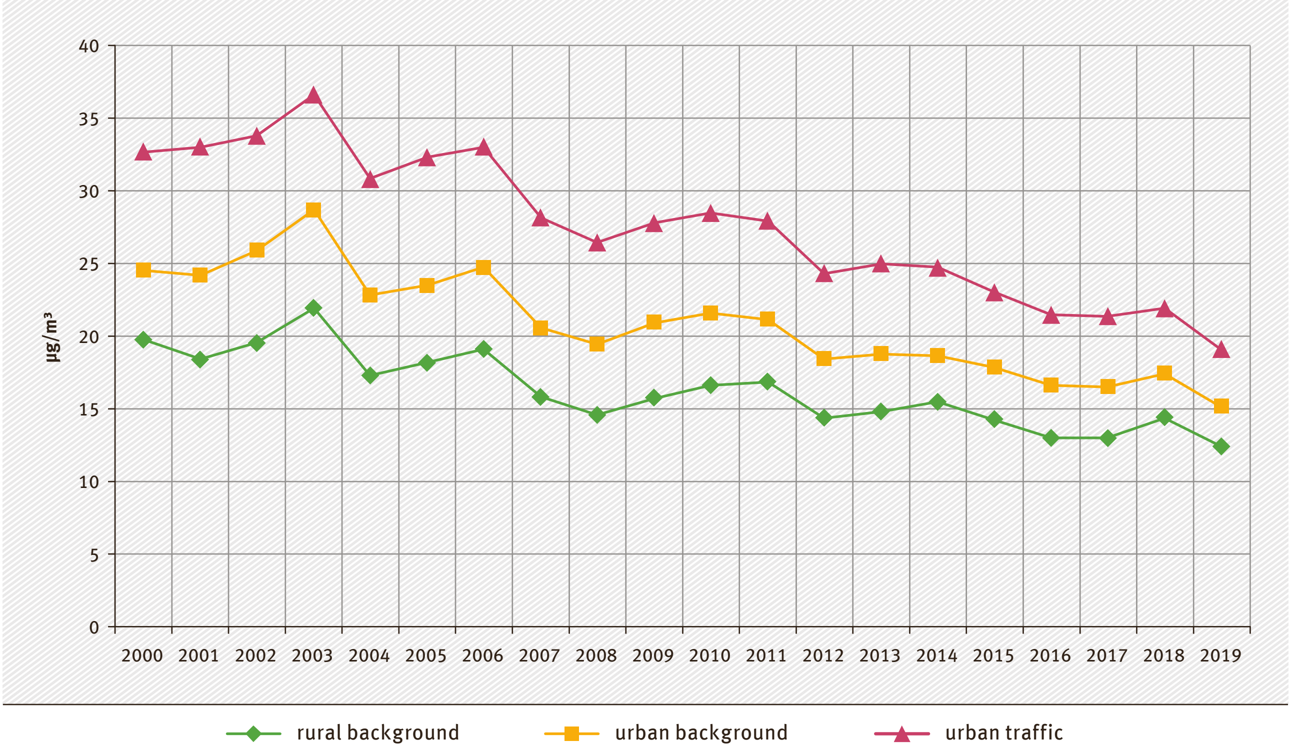
2 PM_{10} – Annual mean values

The exceptionally long, ten-month dry period in 2018, resulted in increased annual mean PM_{10} values. However, in 2019 the decreasing trend of the mean PM_{10} pollution continued. 2019 was the year with the lowest level of pollution compared to the considered period since 2000 (Figure 5). Accompanied by the regional falls in the PM_{10} emissions, the annual mean PM_{10} values also show a clear fall in all pollution regimes throughout the entire period of observation. The progression is also characterised by strong inter-year variations, however, particularly due to the different weather conditions. The PM_{10} limit of 40 µg/m³ as the annual mean value was complied with throughout Germany. 13 percent of the air monitoring stations recorded values that infringed the air quality guidelines proposed by the WHO, however. The vast majority of these air monitoring stations were in urban traffic locations.

3 Press release of the German weather service DWD, 2019: https://www.dwd.de/DE/presse/pressemitteilungen/DE/2019/20191230_deutschlandwetter_jahr2019_news.html?nn=16210

Figure 5

Development of the annual mean PM_{10} values
via selected air monitoring stations in the corresponding pollution regime, time frame 2000–2019



Source: German Environment Agency (UBA) 2020

3 $PM_{2.5}$ – Air pollution

From 1st January 2015, for the smaller fraction of particulate matter which only contains particles with a maximum diameter of 2.5 micrometres (µm), an annual mean limit of 25 µg/m³ applies throughout Europe. In Germany, since 2015 and also in 2019, this value was not exceeded at any air monitoring station. The annual mean $PM_{2.5}$ values decrease during the entire period and for all pollution regimes (Figure 6). The stricter recommendations of the WHO (10 µg/m³ as the annual mean value) were not complied with at more than half of the almost 200 measuring stations (57 %). Furthermore, the WHO recommendation is that the 24-hour $PM_{2.5}$ value should not exceed 25 µg/m³ more than 3 times a year. This recommendation was not complied with at almost all air monitoring stations (98 %). The EU Air Quality Directive also requires the average exposure of the population to $PM_{2.5}$ to be reduced until the year 2020. For this purpose, the Average Exposure Indicator (AEI) was developed. As the initial value for

EU limit value
The annual mean PM_{10} value must not exceed 40 µg/m³.

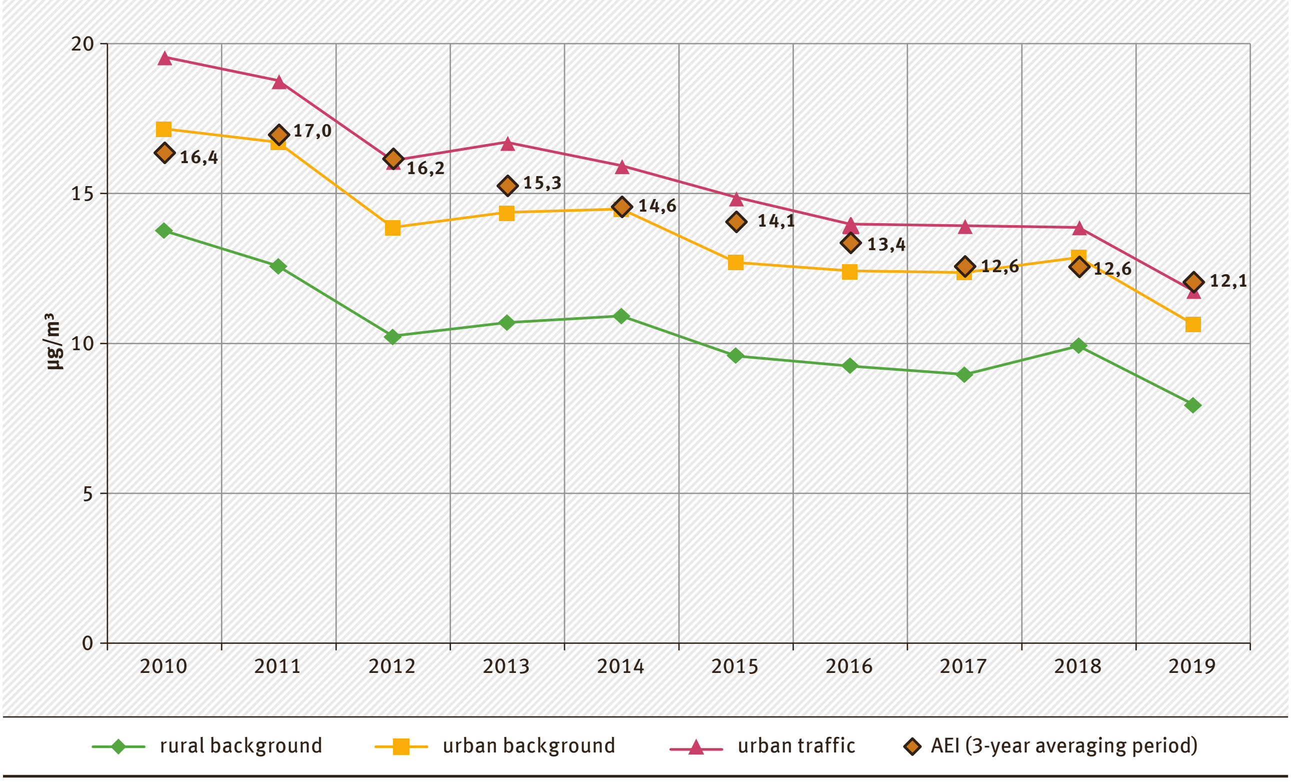
WHO recommendation
The annual mean PM_{10} value should not exceed 20 µg/m³.

EU limit value
the annual mean $PM_{2.5}$ value must not exceed 25 µg/m³.

WHO recommendation
The annual mean $PM_{2.5}$ value should not exceed 10 µg/m³. The 24-hour $PM_{2.5}$ value must not exceed 25 µg/m³ more than 3 times per year.

Figure 6

Development of the annual mean $PM_{2.5}$ values and of the Average Exposure Indicator (AEI) via selected monitoring stations in the corresponding pollution regime, time frame 2010–2019



Source: German Environment Agency (UBA) 2020

Germany for 2010, an AEI of 16.4 µg/m³ was calculated as the average value of the years 2008 to 2010. According to the requirements of the EU Directive, this results in a national reduction goal of 15 percent until 2020. Accordingly, the AEI calculated for 2020 (average value of the years 2018, 2019 and 2020) may not exceed the value of 13.9 µg/m³. In 2019 (average value of the years 2017, 2018 and 2019), the AEI is totalled 12 µg/m³ (estimation, because not for all measuring stations data are already available) and therefore was complied with for the fourth time, together with the 2016's, 2017's and 2018's AEI. Therefore, it can be assumed that the national reduction goal of 15 percent can be reached for 2020.

In addition, from 1st January 2015 onwards, the AEI is not permitted to exceed a value of 20 µg/m³. This value has not been exceeded in Germany since the start of the measurements in 2008.

Exposure

The contact of an organism with chemical, biological or physical influences is known as "exposure". A person is "exposed" to particulate matter, for example.

How is the Average Exposure Indicator (AEI) calculated?

The average exposure indicator is determined as an average value over a period of 3 years from the individual annual mean $PM_{2.5}$ values of selected air monitoring stations with an urban background. This results in a value which is expressed in µg/m³ for each 3-year period.

III Nitrogen dioxide: Further reduction of pollution

1 NO_2 – Annual mean values

Nitrogen dioxide is measured at about 400 automatic monitoring stations across Germany. In addition, about 130 passive collectors measure nitrogen dioxide (see photo). Most of the data of the passive collectors is not yet available and thus not included in this preliminary evaluation. Taking into account all measurement data, available for UBA at 20th January 2020, 24 percent of the air monitoring stations in urban traffic locations exceeded the limit. On the basis of a projection derived from the previous years' data, we estimate the proportion of all air monitoring stations in urban traffic locations that exceeded the limit and thus the identical WHO recommendation in 2019 to be approx. 21 percent (Figure 7, red bars).

The nitrogen dioxide pollution shows a clear decrease in the last decade (Figure 8). In order to minimize the influence of the closure or opening of stations on the development of the average NO_2 values only air monitoring stations were selected for this figure that conducted measurements over an extended period. The levels of pollution are primarily determined by local emission sources – particularly the traffic in urban conurbations – and only show limited inter-year variations due to weather.

EU limit values

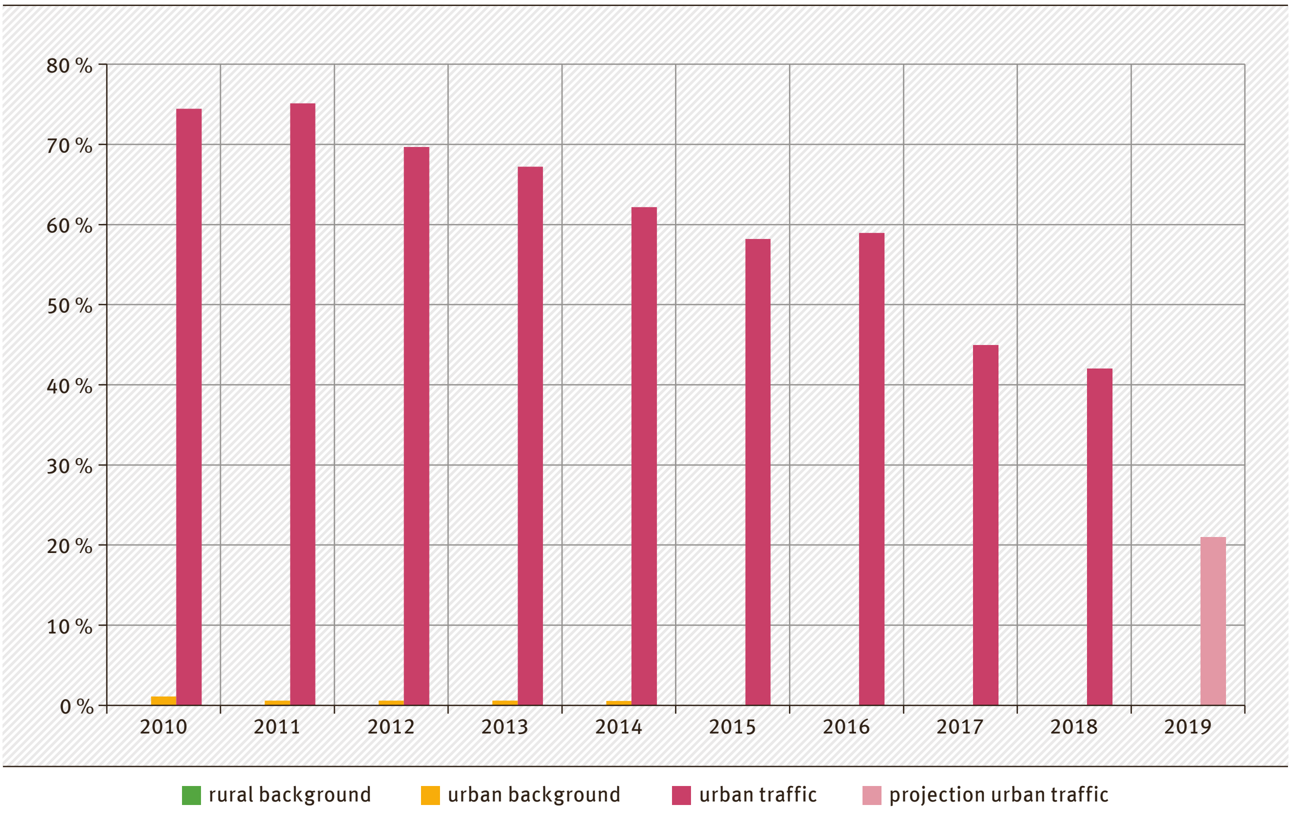
The annual mean NO_2 value must not exceed 40 µg/m³.

WHO recommendation

The WHO recommendation is equivalent to the EU limit value.

Figure 7

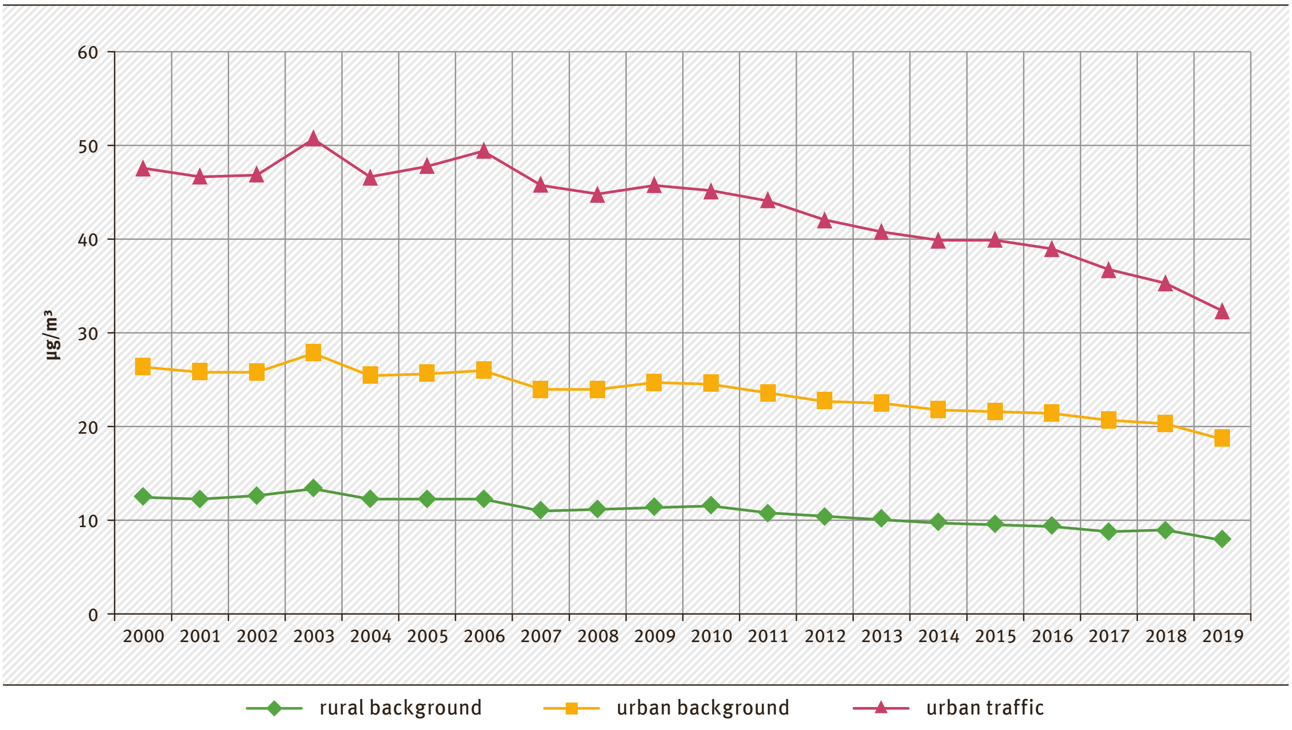
Percentage share of air monitoring stations exceeding the NO_2 limit value for the annual mean in the corresponding pollution regime, time frame 2010–2019



Source: German Environment Agency (UBA) 2020

Figure 8

Development of the annual mean NO_2 values
via selected air monitoring stations in the corresponding pollution regime, time frame 2000–2019



Source: German Environment Agency (UBA) 2020

In rural areas, which are typically a long way from the major sources of NO_2, from 2000–2019, the average annual concentration for all the air monitoring stations amounted to 10 µg/m³ (Figure 8, green curve). At the air monitoring stations with an urban background, the values were well below the limit of 40 µg/m³ (Figure 8, yellow curve). In 2019, like in the previous year, the average NO_2 concentration at urban traffic air monitoring stations was well below 40 µg/m³. Thus, the trend in reduction over the last ten years continues.

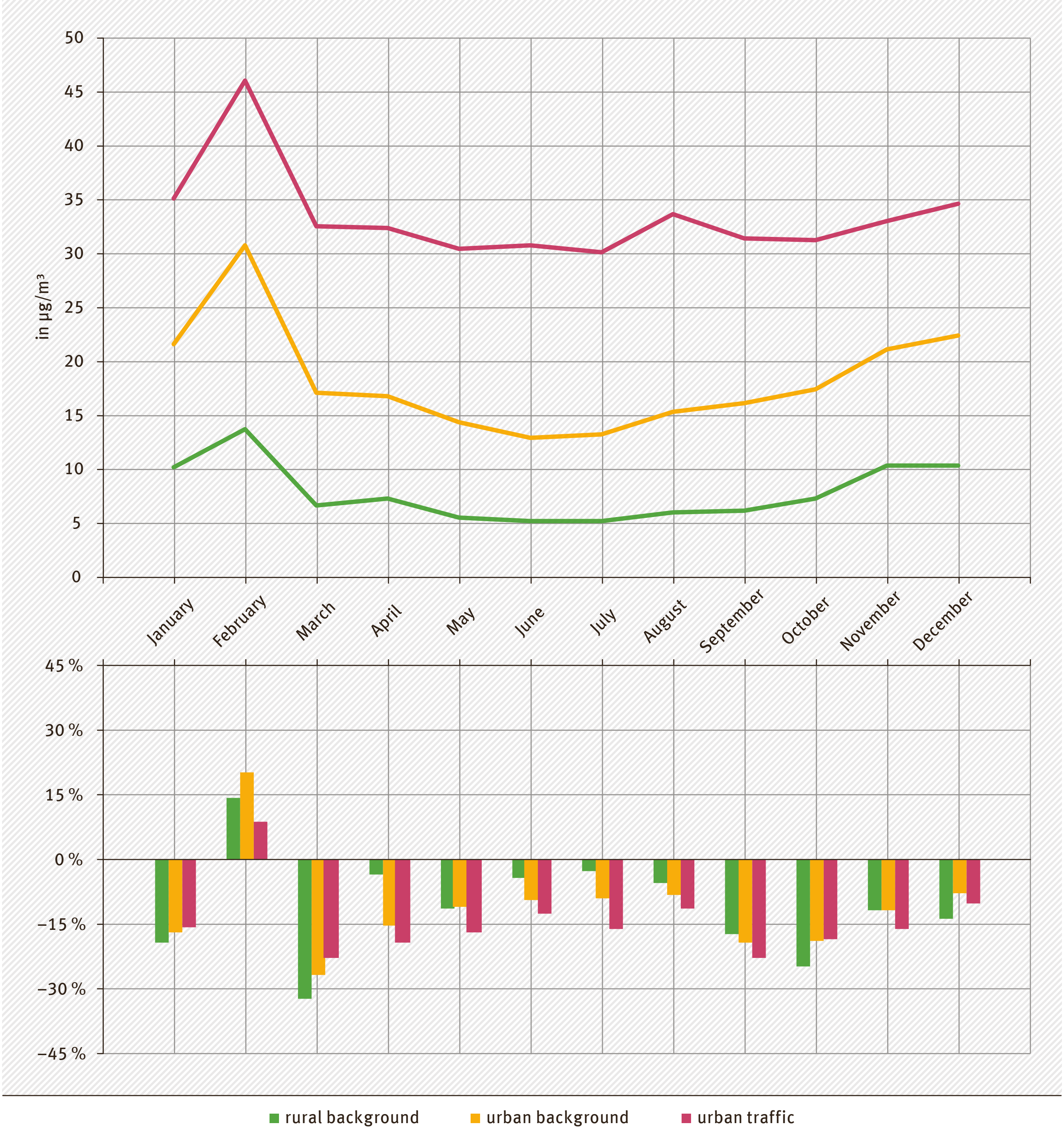
In 2019 the average NO_2 concentration decreased like in the previous year. This reduction is mainly due to 11 months in which the concentration in all pollution regimes was below the average. Figure 9 shows the NO_2 monthly mean values 2019 and its percentage deviation from the average of the four previous years. It can be seen that the average NO_2 concentrations were in all month, except February, below the average of the four years period.

Even though the concentrations at urban traffic stations are generally decreasing, annual mean values of over 40 µg/m³ were still measured at many

Passive collector: A passive collector is a small monitoring device which operates without electrical power and in which several detection tubes absorb the pollutants from the air. The detection tubes are regularly removed and their contents evaluated in the laboratory.

Figure 9

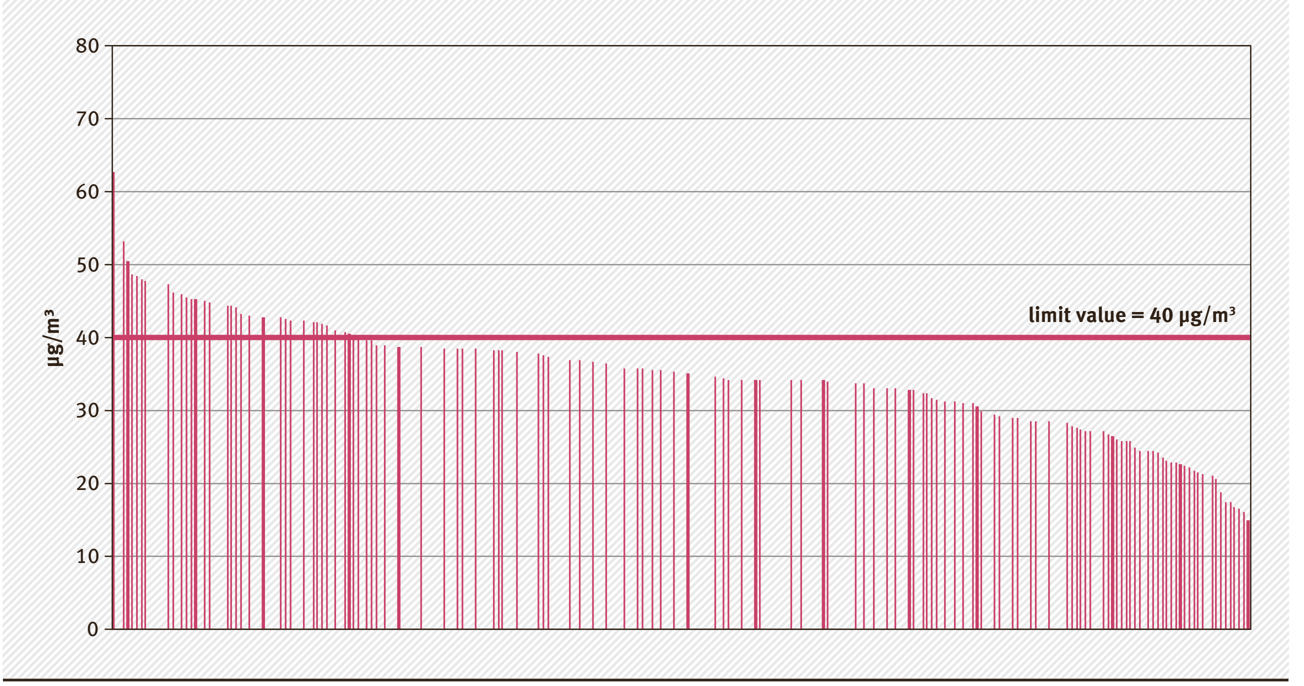
NO_2 monthly mean values 2019 and its percentage deviation from the average of the period 2015–2018



Source: German Environment Agency (UBA) 2020

Figure 10

NO_2 annual mean values 2019
of all urban traffic monitoring stations



Source: German Environment Agency (UBA) 2020

air monitoring stations and cases in which the limits were exceeded were therefore recorded. Figure 10 shows the NO_2 annual mean values of all air monitoring stations in urban traffic locations in descending order.

The gaps result from the missing data of the passive collectors, which are only available in the course of 2020. Their position in the descending order is deduced from the data of the previous year. It becomes clear that there are big differences between the monitoring stations: Some stations exceed the limit value of 40 µg/m³ slightly, whereas other stations exceed the limit value clearly.

2 NO_2 – One hour values

Since 2010, one hour NO_2 values exceeding 200 µg/m³ are only permitted a maximum of 18 times per year. In 2019, like in the previous years, this value was not exceeded. The last time that few exceedances at urban traffic station were recorded was in 2016.

One percent of all air monitoring stations in urban traffic locations failed to comply with the WHO recommendation in 2019.

EU limit value
The one hour NO_2 values must not exceed 200 µg/m³ more than 18 times per year.

WHO recommendation
The one hour NO_2 values should never exceed 200 µg/m³.

IV Ground-level ozone: Overall pollution remains average but shows high peak concentrations

1 O_3 – Information and alert threshold

Ozone is measured at about 260 monitoring stations throughout Germany. In 2019, the highest 1-hour average value amounted to 314 µg/m³. This value is therefore considerably higher than the previous year value (258 µg/m³) and also higher than the maximum values of the previous years. In 2019 the alert threshold of 240 µg/m³ was exceeded at 11 stations during in total 22 hours at three days. In the previous year the alert threshold was exceeded at one single station one time. The information threshold of 180 µg/m³ was exceeded on 19 days. 2019 was an average year with regards to exceedances of the threshold values, compared to the last 20 years.

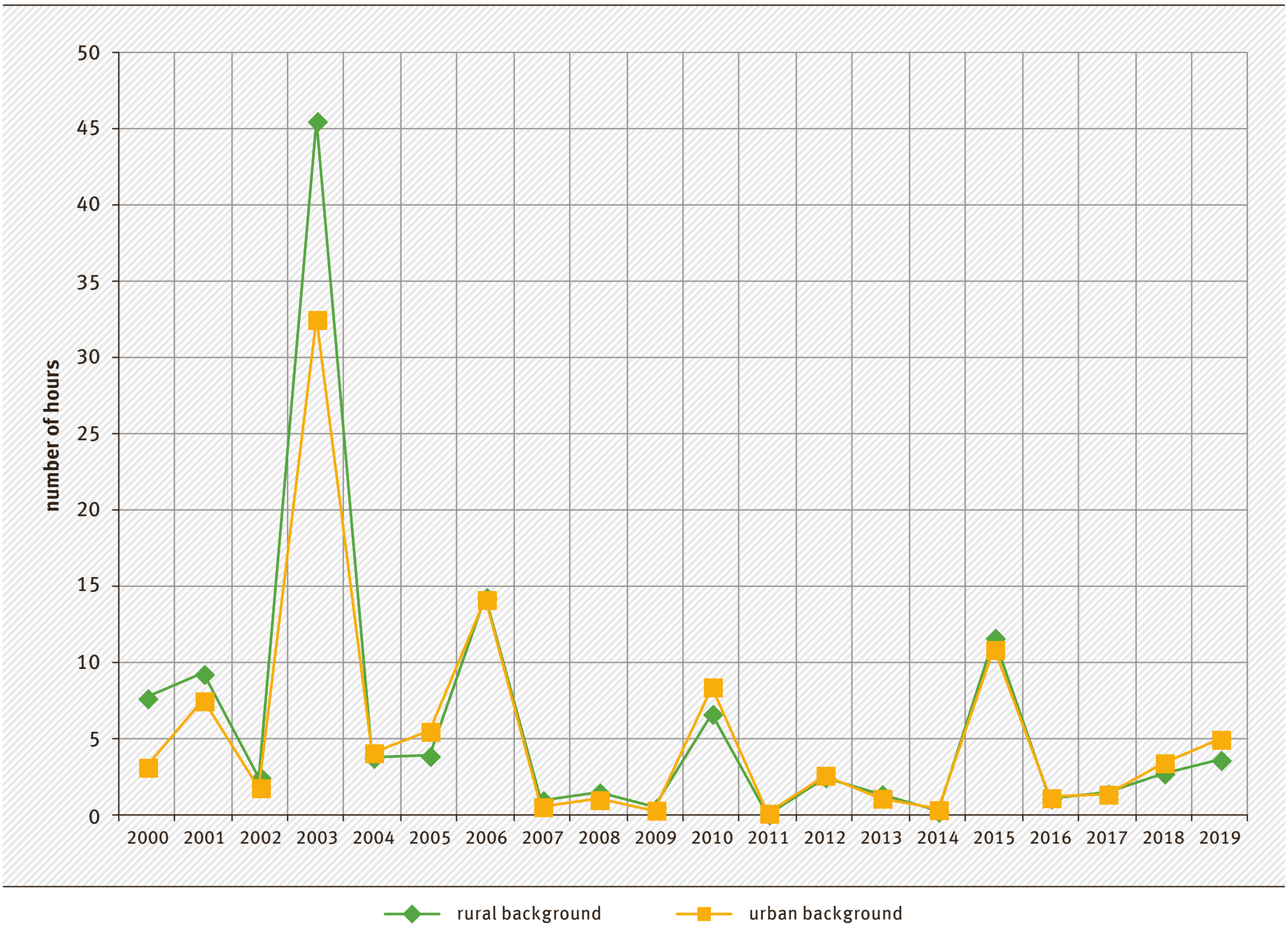
Figure 11 shows that the exceedances of the information threshold vary in a wide range between the years, the record-breaking summer of 2003 sticks out clearly. But also the year 2015, with exceptional hot and dry periods in July and August, was characterised by a higher ozone pollution than 2019.

The reason for the variation of the peak concentration between the years is the high dependency on the weather conditions. In contrast to particulate matter and nitrogen dioxide, ozone is not emitted directly but formed from specific precursors (nitrogen oxides and volatile organic compounds) and with intensive solar radiation. When there are several days of

Figure 11

Hours during which the information threshold (180 µg/m³) for ozone was exceeded

Average over selected monitoring stations



Source: German Environment Agency (UBA) 2020

summery high-pressure weather conditions, ozone can be accumulated in the lower atmospheric layers which leads to high concentrations. These kind of periods with long-lasting summer weather were not observed in the summer 2019, but it was characterised by exceptional high temperatures. Most exceedances of the alert threshold were recorded around 25th July. Exceptional high temperatures of 40 °C and above were measured at these days according to the German Weather Service[4]. Such temperatures are often related to high ozone formation.

2 O_3 – Target value for the protection of human health

In 2019, like in the previous year, the long-term objective for the protection of human health (8-hour average values of over 120 µg/m³) were measured at all monitoring stations (= 100 %), that is the long-term objective is not complied with.

In 2019, an ozone value of 120 µg/m³, as the highest daily 8-hour average value, was exceeded on an average of 24 days per station. Compared to the time period since 2000, this value is slightly above average. In the previous year, which was characterised by higher ozone pollution as a result of sustained high-pressure weather conditions, 37 exceedance days were recorded as an average over all air monitoring stations.

Figure 12 shows the spatial distribution of the number of exceedance days in 2019 in comparison to the last four years. This figure highlights the differences between the years. In 2019, compared to the previous year, less exceedances were recorded but still considerably more than in the years 2016 and 2017. Ozone concentration is generally lower in Northern Germany, particularly so in 2015.

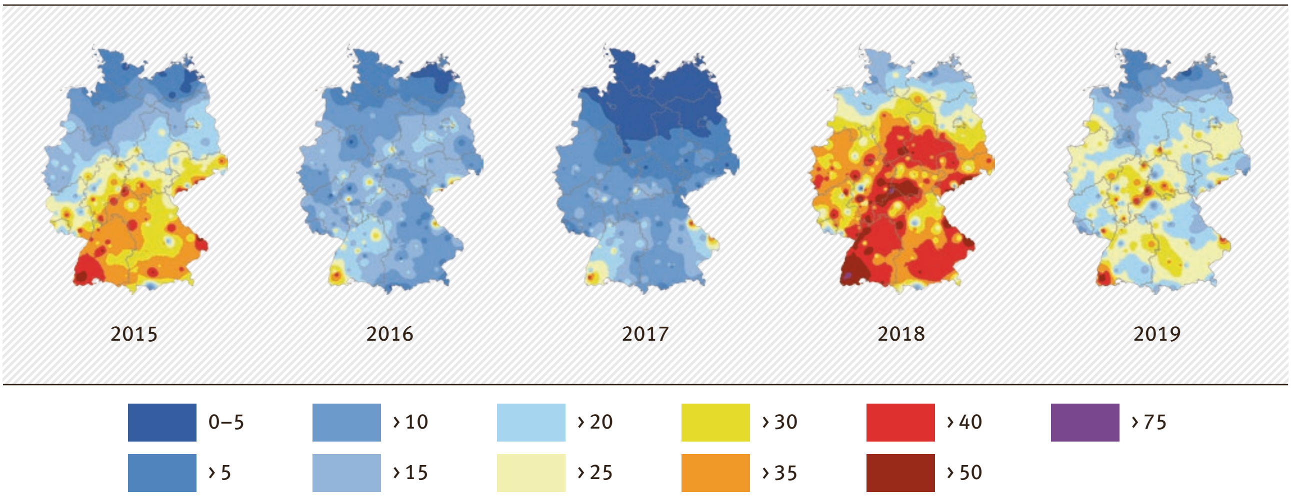
The WHO recommendation that the 8-hour average values should not exceed 100 µg/m³ was missed again.

A 3-year period is monitored for the target value for the protection of human health: on average, an 8-hour average value of 120 µg/m³ may only be exceeded on 25 days. In the most recent averaging period of 2017 to 2019, however, 41 percent of the air monitoring stations exceeded this value on more than 25 days. That are 13 percent more, compared to the previous averaging period. Figure 13 shows that most cases in which the target values were exceeded occurred in rural areas – in contrast to pollutants such as particulate matter and nitrogen dioxide,

4 www.dwd.de/DE/presse/pressemitteilungen/DE/2019/20190730_deutschlandwetter_juli

Figure 12

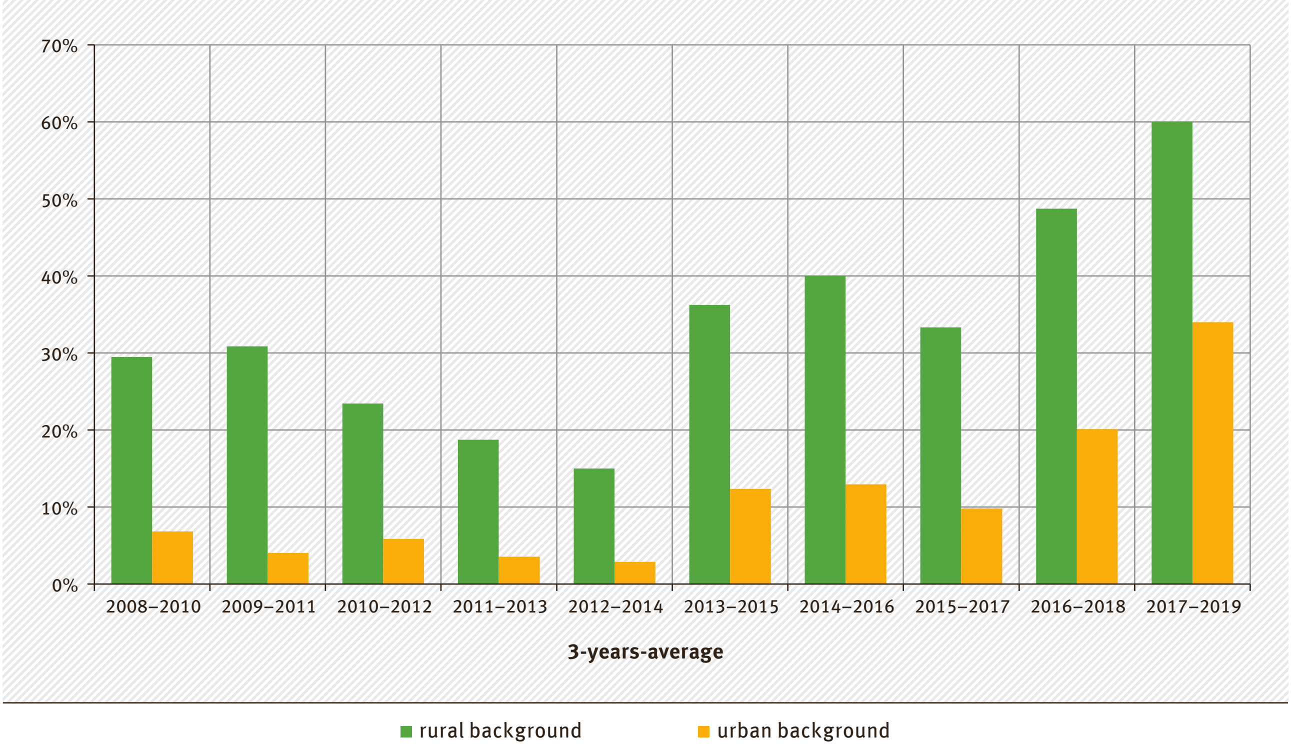
Spatial distribution of the number of days on which the long-term objective for the protection of human health was exceeded (number of days with 8-hour average values › 120 µg/m³)
time frame 2015–2019, based on station measurements and a geostatistical interpolation method



Source: German Environment Agency (UBA) 2020

Figure 13

Percentage share of air monitoring stations recording an exceedance of the target value for the protection of human health, time frame 2010–2019 (in each case, 1-year moving average over 3 years)



Source: German Environment Agency (UBA) 2020

which have the highest concentrations in the vicinity of roads, the ozone values in the vicinity of roads are a lot lower. Therefore, ozone is rarely measured at air monitoring stations in urban traffic locations.

3 O_3 – Protection of the vegetation

According to the EU Air Quality Directive, to determine the target values for the protection of the vegetation (AOT40), only the data from the around 160 air monitoring stations in non-urban locations is considered. For the target value (which has been mandatory since 2010), an averaging over a five-year period is required. The target value (18,000 µg/m³ h obtained from May to July) for the most recent averaging period of 2015 to 2019 was exceeded at 49 out of 160 air monitoring stations (= 31 %, previous year: 40 air monitoring stations = 25 %).

In 2019, the long-term objective for the protection of the vegetation (6,000 µg/m³ h) was complied with at only one monitoring station. In the previous year, the target value was exceeded at every station. In comparison with the last 10 years the ATO40-values at rural background stations were slightly higher in 2019.

New methods of the impact evaluation of ozone have been developed meanwhile. They are recommended for monitoring air pollution impacts according to annex V in the NEC-directive (Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants). In this respect, it isn't just the concentration of ozone, but the meteorological conditions, the opening characteristics of the stomata of the plants and therefore the ozone flux into the plants, which are taken into account.

Information threshold
With ozone values of over 180 µg/m³ (1-hour average value), the general public is notified by the media of the presence of a health risk for particularly sensitive sections of the population.

Alert threshold
With ozone values of over 240 µg/m³ (1-hour average value), the general public is warned by the media of the presence of a general risk to human health.

Target values for the protection of human health
Ozone values of over 120 µg/m³ (highest daily 8-hour average value) are only permitted to occur on a maximum of 25 days per calendar year, averaged over 3 years. Over the long term, the 8-hour average values should never exceed 120 µg/m³ (long-term objective).

WHO recommendation
The 8-hour average values should never exceed 100 µg/m³.

Target values for the protection of vegetation (AOT40)
The term AOT40 (Accumulated Ozone exposure over a Threshold of 40 parts per billion) designates the total sum of the differences between the 1-hour average values exceeding 80 µg/m³ (= 40 ppb) and the value 80 µg/m³ between 8 am and 8 pm in the months of May to July. Since 2010, as 5-year average, the AOT40 target value should not exceed a value of 18,000 µg/m³ h – i. e. 9,000 ppb h and/or 9 ppm h. Over the long term, the value should not exceed a maximum value of 6,000 µg/m³ h in one year – i. e. 3,000 ppb h and/or 3 ppm h.

UBA air quality monitoring station Neuglobsow

V Current air quality conditions throughout Germany – comprehensive information on the Internet or compact information via app

1 How good is the air quality in my neighbourhood?

Air quality in Germany is monitored every hour. About 99 % of the data are delivered by federal states monitoring stations (e. g. State Environmental Agencies). The monitoring stations are operated by the federal states to monitor air quality for the protection of human health. The up-to-date measured data of about 400 monitoring stations are collected by the German Environment Agency (UBA). One hour after the data is recorded, the data are available via the air data web portal and an app. Thereby it is possible to obtain current air quality information at a selected station or across Germany.

The free and ad-free app "Luftqualität" (which means air quality) for Android and iPhone devices by the German Environment Agency was launched in August 2019. The app posts hourly updated data on harmful pollutants such as particulate matter (PM_{10}), nitrogen dioxide and ozone. Furthermore, an air quality index (AQI) provides an instant view of the air quality at every station. Depending on the AQI, the app issues health advice about doing outdoor activities. Users can choose to receive warning alerts when air quality is poor.

UBA's upgraded, newly designed air data web portal allows users to retrieve more detailed information on air quality and do searches on current and past conditions: https://www.umweltbundesamt.de/en/data/air/air-data. A new feature is the air quality index which, just as the app does, provides a quick overview of current conditions. It also offers diagrams of AQI trends from past to present.

2 Air data portal

The data portal offers the option to visualize the data of all available monitoring stations in Germany or of a specific selection of stations. Furthermore, it has maps of Germany which show the concentrations of five air pollutants (particulate matter (PM_{10}), nitrogen dioxide, ozone, sulfur dioxide, carbon monoxide) in specific regions and on specific days, and in some cases, times of day. There is also an ozone forecast for the current day and a two-day outlook. The measured concentrations at all stations for all five pollutants are up-to-date but historical data is also available. Tables of exceedances can be generated for the current year of short-term limit and target values for particulate matter (PM_{10}), nitrogen dioxide and ozone. An annual tabulation option enables users to compare annual mean values from earlier years for each pollutant, going back to 2000.

The choice of the available pollutants and the averaging period is consistent with EU Directive 2008/50/EC[5] specifications for near-time information of the population:

- Particulate Matter – PM_{10} (daily average)
- Nitrogen dioxide – NO_2 (one hour average)
- Ozone – O_3 (one hour average, eight hour average)
- Carbon monoxide – CO (eight hour average)
- Sulfur dioxide – SO_2 (one hour average, daily average)

Monitoring stations: visualization and download of data

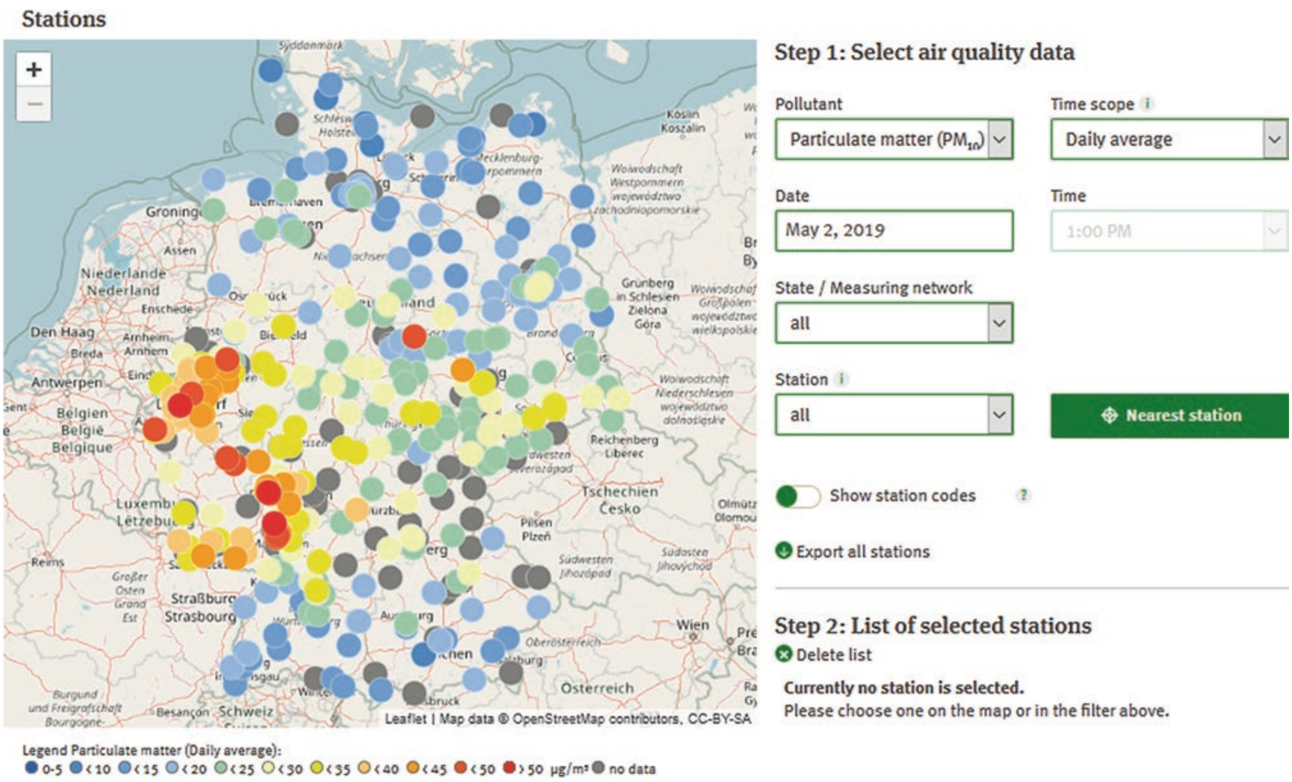
The *stations page* provides measured concentrations of a freely selectable air pollutant at a given time throughout Germany (Figure 14). The colours in the legend provide information on the concentration level, red indicates concentrations harmful for health (exceedance of limit or target values).

Line graphs can be displayed in a diagram to reflect the development of pollution concentrations at individual stations. The pollutant, the station and the time period are freely selectable. This enables the user to not only visualize the development of pollutant concentrations at one station, but to also compare values of different stations (Figure 15). The data and the diagram can be downloaded.

5 and its implementation into German law (39. BImSchV)

Figure 14

PM_{10} daily average concentrations at all German monitoring stations at May 2, 2019



Maps: area maps and forecast

The majority of the monitoring stations measure air pollutants in the rural and urban background. These measurements are therefore representative for not only the direct surrounding, but also for a larger area around the station. These measurements are therefore valid for a spatial interpolation, which provides *maps* for all of Germany. Such maps are helpful to illustrate large scale air pollution events (Figure 16). Measurements which are only representative directly at the location of the monitoring station itself are shown as a coloured dot in the map. This holds especially for traffic and industrial stations.

Beyond the maps for the present and past, the air data portal also offers maps with forecasts for ozone. These *forecast maps* are based on model calculations and actual measurement data. This enables users and particularly very sensitive persons to gather information on current maximum ozone concentrations and a two-day forecast.

How good is the air at each monitoring station? – The air quality index

The *air quality index* provides an instant view of the air quality at every station. It is calculated using the measured concentrations of the three pollutants nitrogen dioxide, particulate matter (PM_{10}) and ozone, with the concentration with the poorest individual result determining the total result of the AQI. The AQI is divided in five classes, from “very good” to “very poor” (Table 1). For every AQI class, there is an assessment about whether or not air pollution is harmful to health or if outdoor activities should be avoided (*more information*).

The current and past index values can be displayed in a map across Germany (Figure 17). If a pollutant at a station is missing, which is relevant for the index, an incomplete circle symbol is noted for the station. This information is relevant as the accuracy of the AQI depends on the completeness of the data.

Users interested in the air quality development over the last days and weeks at a certain station can use the option to display the AQI in line diagrams (Figure 18).

Figure 15

upper panel: development of pollutant concentrations (PM_{10}, ozone and nitrogen dioxide) at UBA's monitoring station Waldhof

lower panel: ozone measurements at Waldhof compared to ozone measurements at other monitoring stations

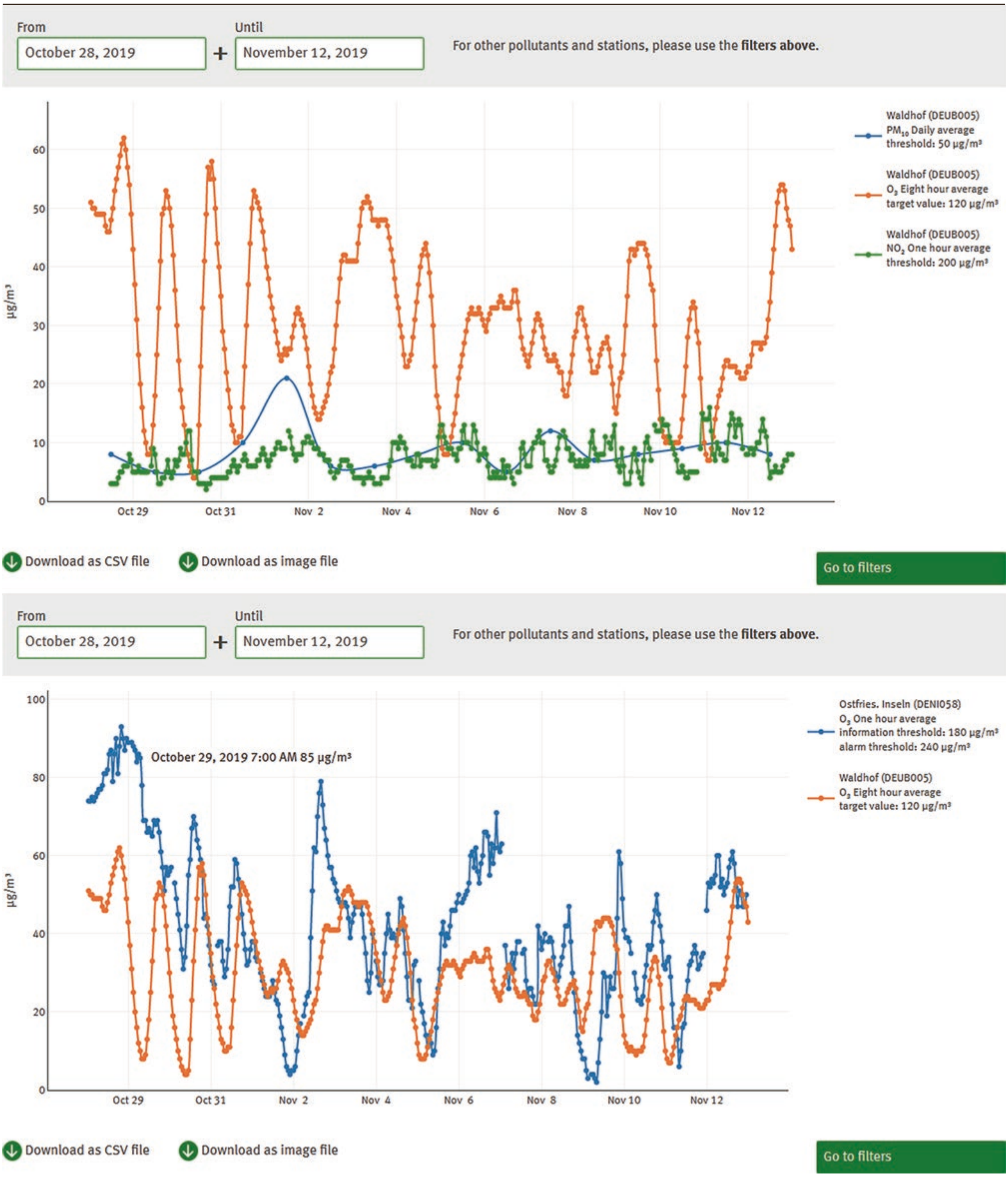


Figure 16

PM_{10} maps from January 31 until February 3, 2019: in the beginning of the period high concentrations only in northeast Germany, then across all of northern Germany, finally a decrease of the concentrations

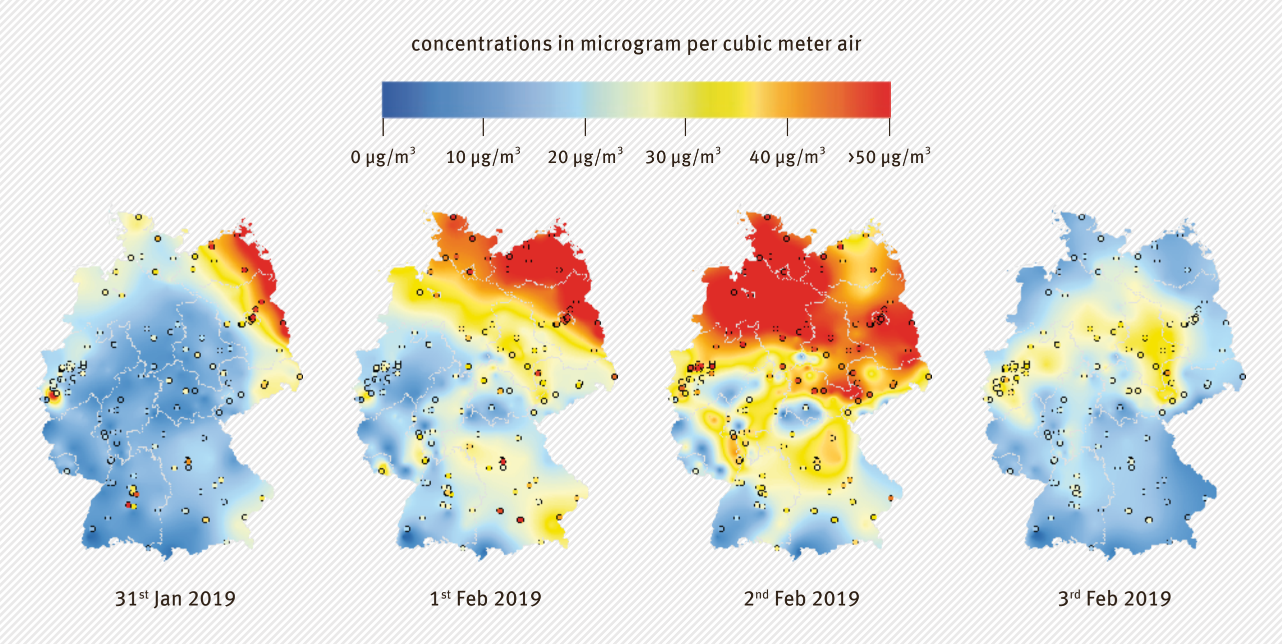


Table 1

AQI classes for the three air pollutants

AQI	hourly average of NO_2 in µg/m³	hourly moving daily average of PM_{10} in µg/m³	hourly average of O_3 in µg/m³
very poor	› 200	› 100	› 240
poor	101–200	51–100	181–240
moderate	41–100	36–50	121–180
good	21–40	21–35	61–120
very good	0–20	0–20	0–60

This provides a quick overview of the AQI class the three pollutants are allocated to during the chosen time period. Furthermore, it shows, for example, which of the pollutants is responsible for the degradation of air quality at the selected station. The appropriate data and figure can be downloaded.

Thus, by means of maps and diagrams it is possible to find out about the past, present and future air quality situation in Germany. In context of EU-wide reporting, air quality is only assessed at every station after the end of the year. Exceedances of the limit value entail extensive measures to improve air quality. Station lists show current and past situations of exceedances.

Figure 17

AQI throughout Germany at February 1, 2019 13:00

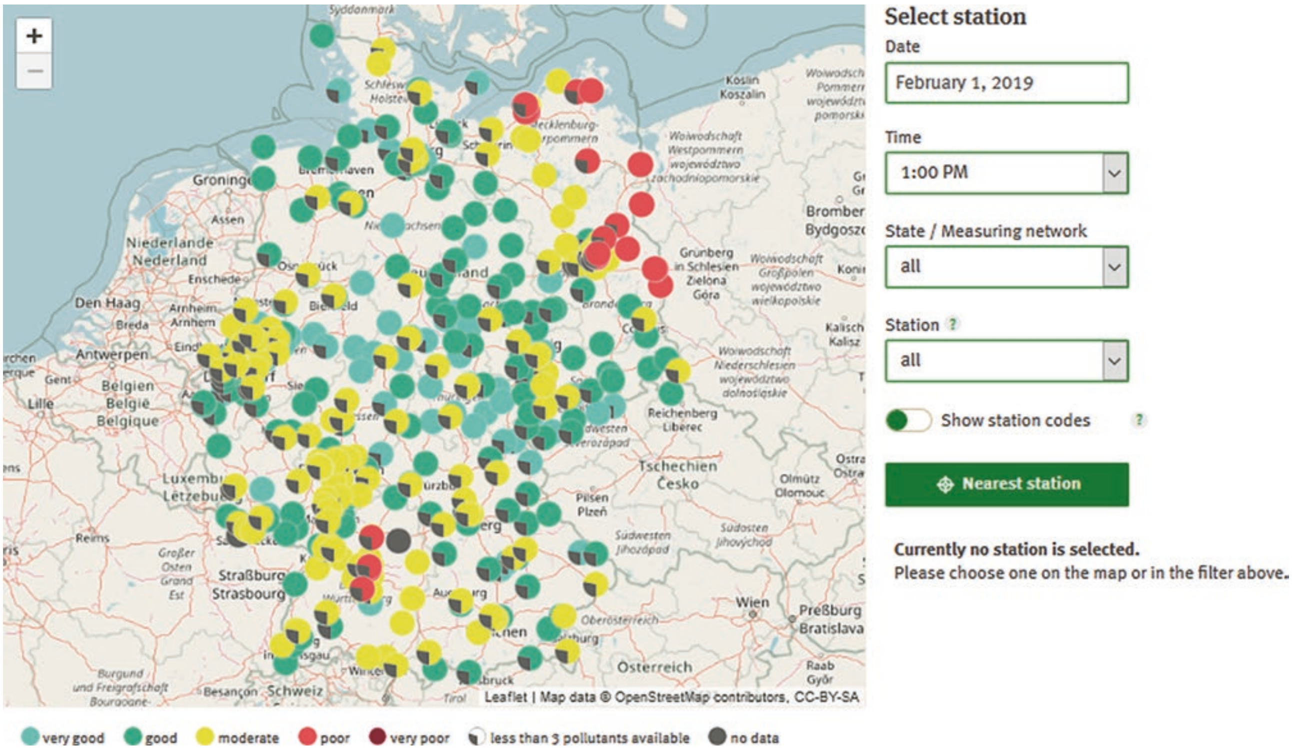
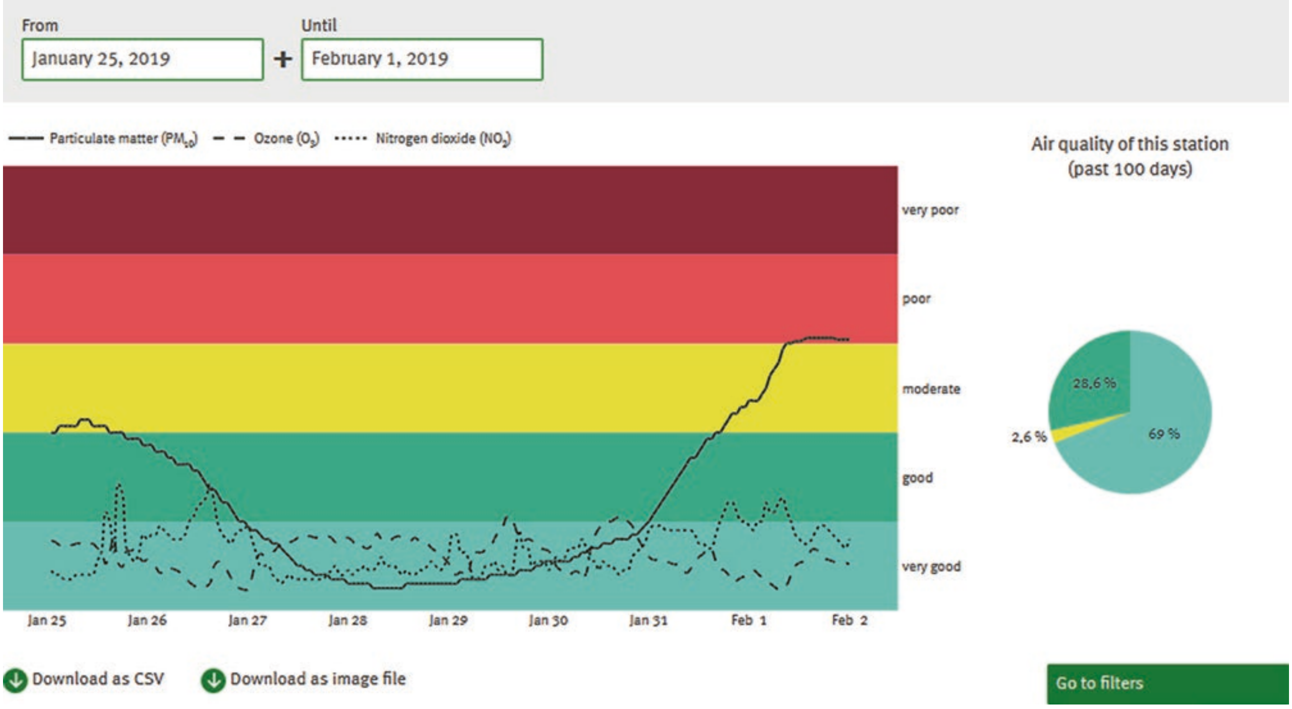


Figure 18

Line graphs of the three AQI pollutants PM_{10}, ozone and nitrogen dioxide at the station Hasenholz from January 25 to February 1, 2019



Exceedances: situation in the current year

The *"exceedances" page* provides tables listing the individual stations and the number of exceedances of the short-term limit[6] and target values[7] of the current year and per month. The tables can be sorted and downloaded.

Annual tabulation: analysis of past years' station data in relation to limit and target values

After the end of a year and when all measurement data are finally quality checked, every station is analysed on its compliance with the limit and target values for the protection of human health. The results of these *analyses* can be displayed as a station list for the past years. The station list can be sorted and downloaded.

6 24-hour PM_{10} limit value, 8-hour ozone target value
7 one hour nitrogen dioxide limit value

3 Air quality to go: The air quality app

Shortly after the data is recorded, the results of the three pollutants particulate matter (PM_{10}), nitrogen dioxide and ozone are available on UBA's app *Luftqualität*. There are three different options to visualize the air quality index and the measurements of a certain monitoring station (Figure 19):

- Localization: display of the nearest monitoring station
- By touching the screen: selection of any monitoring station on a map of Germany
- Free-text search function: search for certain locations/station names

The classification of the monitoring station (urban, rural, urban traffic, industrial) provides information on the character of the surrounding area and on the main emission sources close to the monitoring station. Moreover, it allows conclusions about the spatial representativeness of the monitoring station. The background colour of the display, when choosing a certain station, corresponds to the current AQI and allows therefore a quick overview of the current air

Figure 19

left: overview on the monitoring stations in Berlin, middle: good air quality index at the station Berlin Neukölln, right: free-text search for Berlin

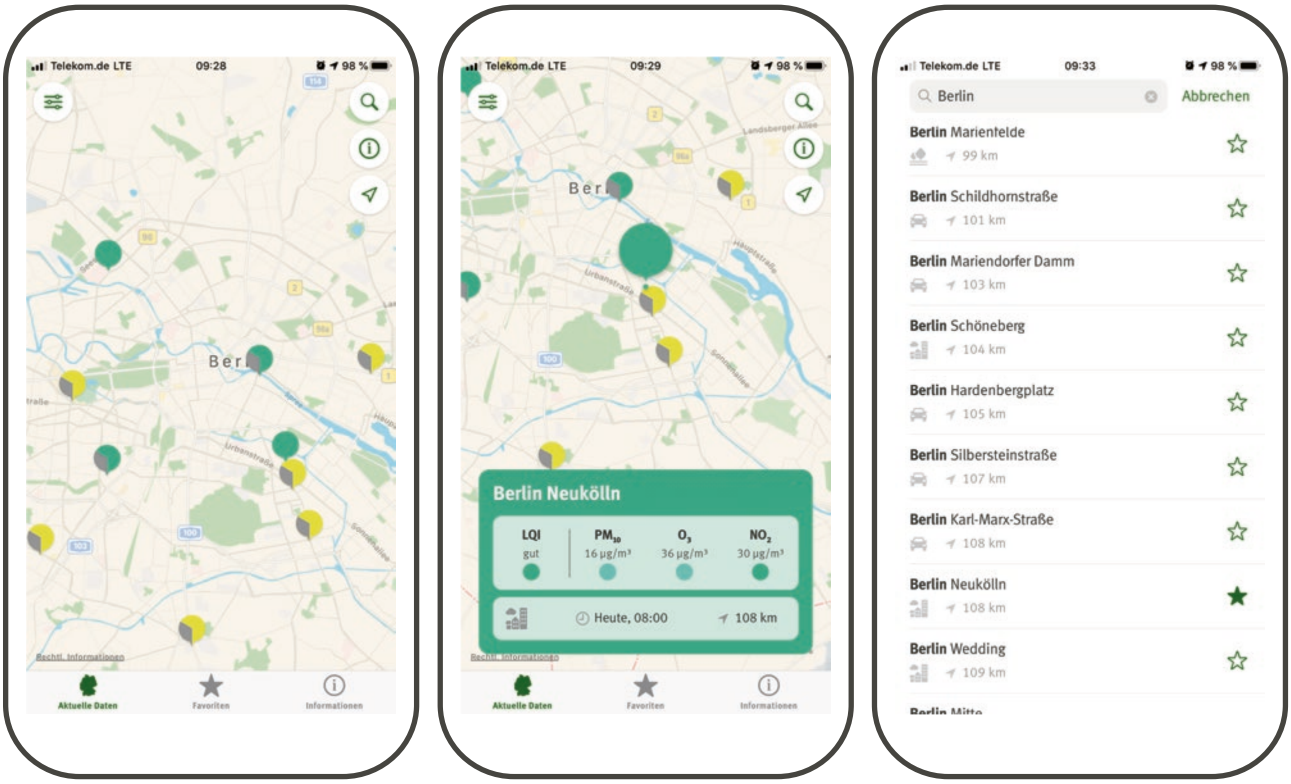


Figure 20

left: detail view for Berlin Neukölln, middle: development of the AQI at the station Berlin Neukölln, right: health advices according to the current AQI

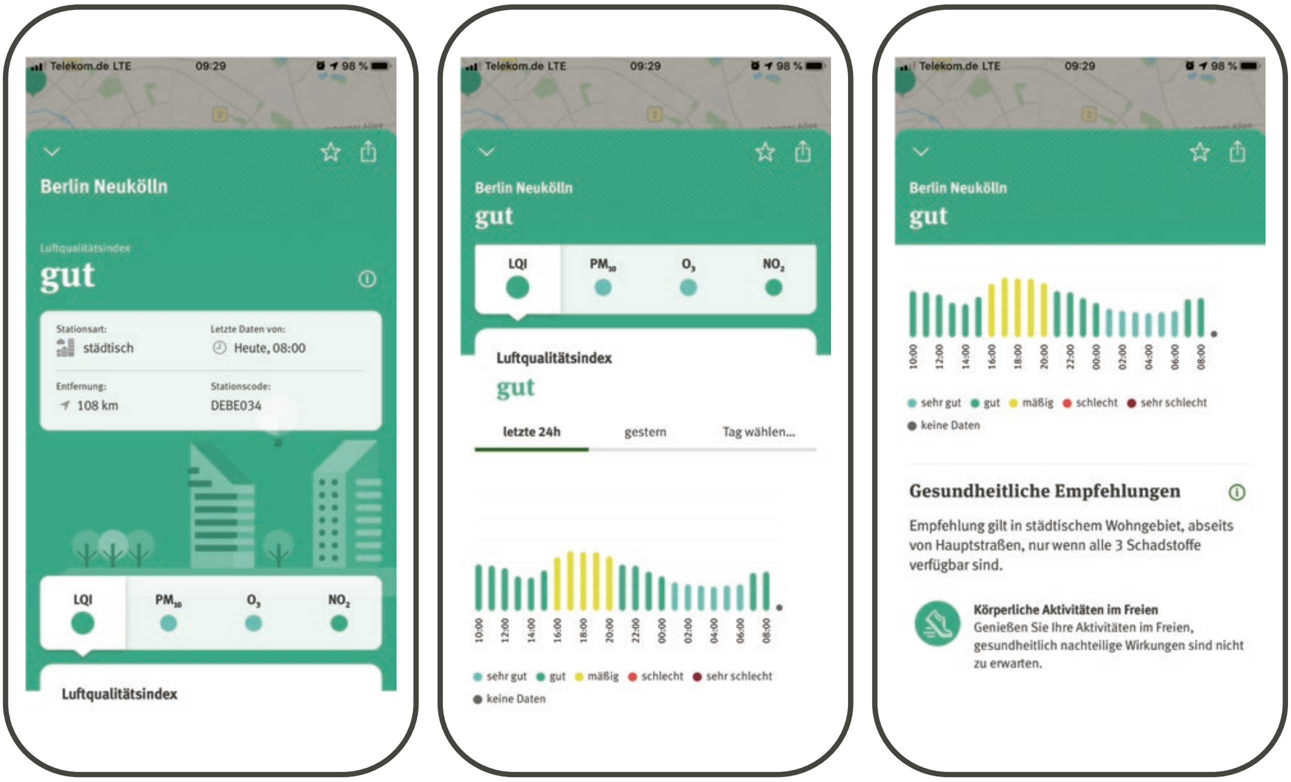


Figure 21

left: favorite list, middle: daily status information and warning alerts for Berlin Frankfurter Allee, right: options for the map and legend for the AQI

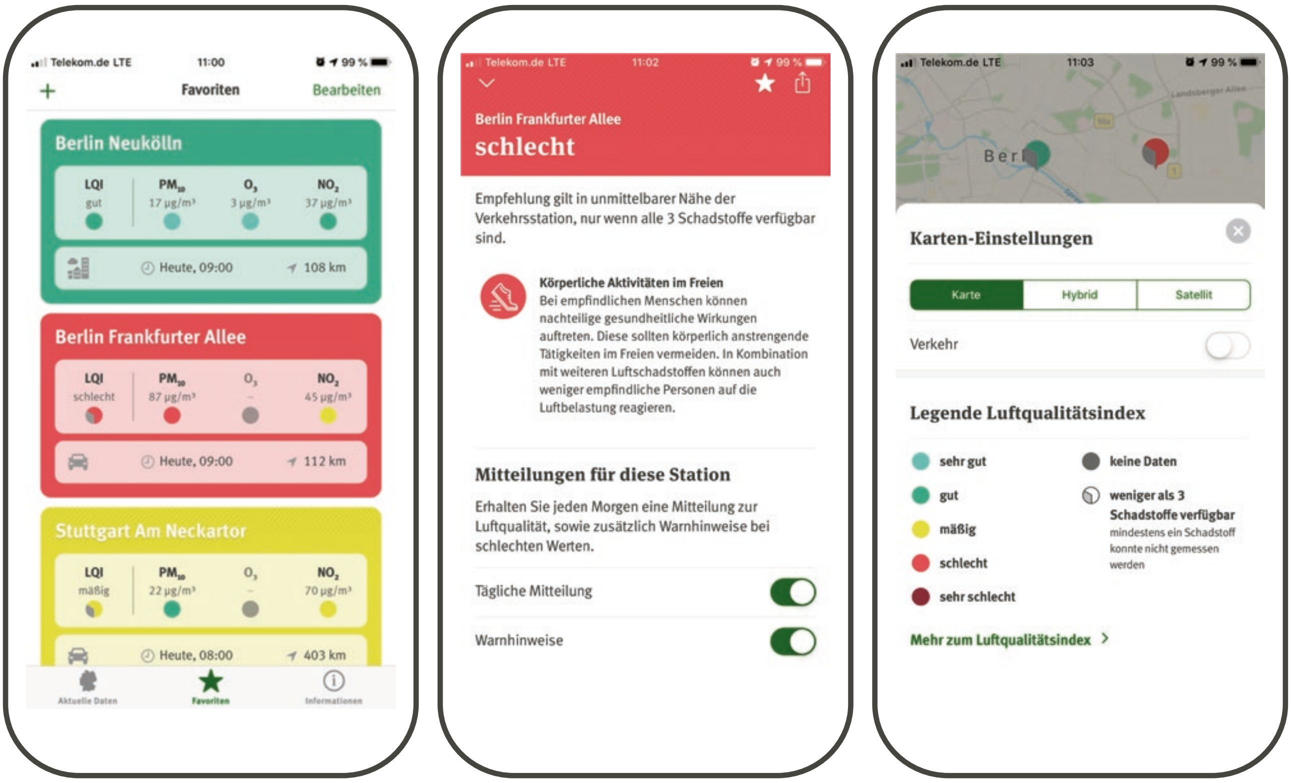
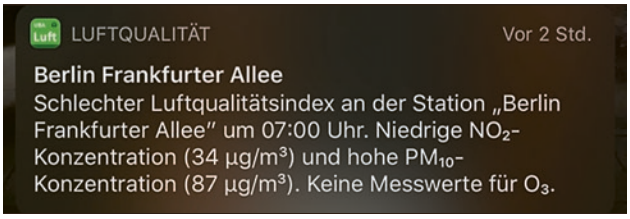


Figure 22

Morning status information on the AQI at the station Berlin Frankfurter Allee



quality situation. The detail view (Figure 20) shows the course of the AQI and the measurements of the last 24 hours or any arbitrary day.

Health-related advices can help to adapt outdoor activities according to an air quality situation. Please note, that the advices and their area of application depend on the station type and the measurements of all three pollutants.

Favourite list and warning alerts

Any stations of interest can be added to a favourite list (Figure 21). Users can choose to receive status information (Figure 22) and hourly warning alerts when air quality is poor at the stations in the favourite list. Sensitive persons can choose to receive warning alerts already when the AQI is moderate.

Future developments

In order to take user feedback into account and to include new features the air quality app is continuously being developed.

Next to a multitude of smaller adaptions, the new version of the app will provide, next to the current and past air quality data, also ozone forecasts. If the forecasted concentrations are exceeding threshold values, warning alerts are sent.

Furthermore, the app will be available for tablets.

Download on the App Store

GET IT ON Google Play

Further information on the topic

Current air quality data:
https://www.umweltbundesamt.de/en/data/current-concentrations-of-air-pollutants-in-germany

Air and air pollution control website:
https://www.umweltbundesamt.de/en/topics/air

UBA map service on air pollutants:
http://gis.uba.de/Website/luft/index.html

UBA map service on low emission zones and air quality plans:
http://gis.uba.de/website/umweltzonen/index.html

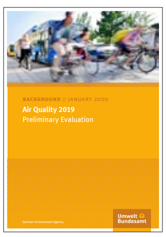
Development of air quality in Germany:
http://www.umweltbundesamt.de/luft/entwicklung.htm

Information on the air pollutant PM_{10}:
https://www.umweltbundesamt.de/en/topics/air/particulate-matter-pm10

Information on the air pollutant NO_2:
https://www.umweltbundesamt.de/en/topics/air/nitrogen-dioxide

Information on the air pollutant ozone:
https://www.umweltbundesamt.de/en/topics/air/ozone

39th Ordinance for the Implementation of the German Federal Imission Control Act (39th BImSchV):
https://www.gesetze-im-internet.de/bimschv_39/



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