IV.1 Suspended particulate matter

Air pollution from suspended particulate matter of PM_{10} and $PM_{2.5}$ fractions remains one of the main problems to be resolved in ensuring air quality in the CR. Exceeding pollution limit levels for PM_{10} and $PM_{2.5}$ continues to contribute to the extent of areas with above-limit air pollution.

IV.1.1 Air pollution by suspended particulates in 2020

Suspended PM_{10} particulate matter

The 24-hour pollution limit level for PM_{10} (the average daily concentration of 50 $\mu g.m^{-3}$ is possible to exceed 35 times a year) was exceeded in 2020 at less than 2% of stations (3 stations of a total number of 156 with a sufficient amount of data for evaluation; Fig. IV.1.1, and Fig. IV.1.2). The cases exceeding the limit value occurred mainly in January, March and December (more than 80% of cases). This is another decrease, similar to previous years, compared to the year 2019, when the daily PM_{10} limit value was exceeded at 5% of stations (7 stations out of 147). The 24-hour limit value was exceeded in 2020 only at the Brno-Zvonařka industrial station (the 36th highest measured 24-hour concentration of 55.5 $\mu g.m^{-3}$), and at two stations in the O/K/F-M agglomeration. At the Brno-Zvonařka station, where the 24-hour concentration limit was exceeded 50 times a year, the limit value is exceeded due to intensive construction activities near the station. In the O/K/F-M agglomeration, this concerns the Ostrava-Radvanice ZÚ industrial station with the 36th highest measured 24-hour concentration in 2020 amounting to 53.2 $\mu g.m^{-3}$ (the limit 24-hour concentration was exceeded there 41 times), and the Věřňovice rural station with the 36th highest measured 24-hour concentration of 52.2 $\mu g. m^{-3}$ (the limit 24-hour concentration exceeded 39 times). At the Věřňovice station, there is a combination of the influence of air pollution from southern Poland and specific rural development on the Czech side of the border, together with specific meteorological conditions in the Olše River valley. Due to these local anomalies, the Věřňovice station is not representative of the Czech countryside. The results of measurements from this station are therefore not included in the following evaluation of the annual trend of monthly concentrations and the development of concentrations.

The pollution limit level for the average 24-hour concentration of PM_{10} was exceeded in 2020 in only 0.001% of the territory of the CR, with approx. 0.002% of the population (Fig. IV.1.3). Compared to previous years (0.3% in 2019, 3.2% in 2018, 8.3% in 2017, 1.4% in 2016, and 2.5% in 2015), this was another decrease in, the area of the CR exposed to the above-limit PM_{10} concentrations (the 36th highest 24-hour concentration), corresponding also to a low number of cases exceeding the limit value at monitoring stations. An inter-annual decrease

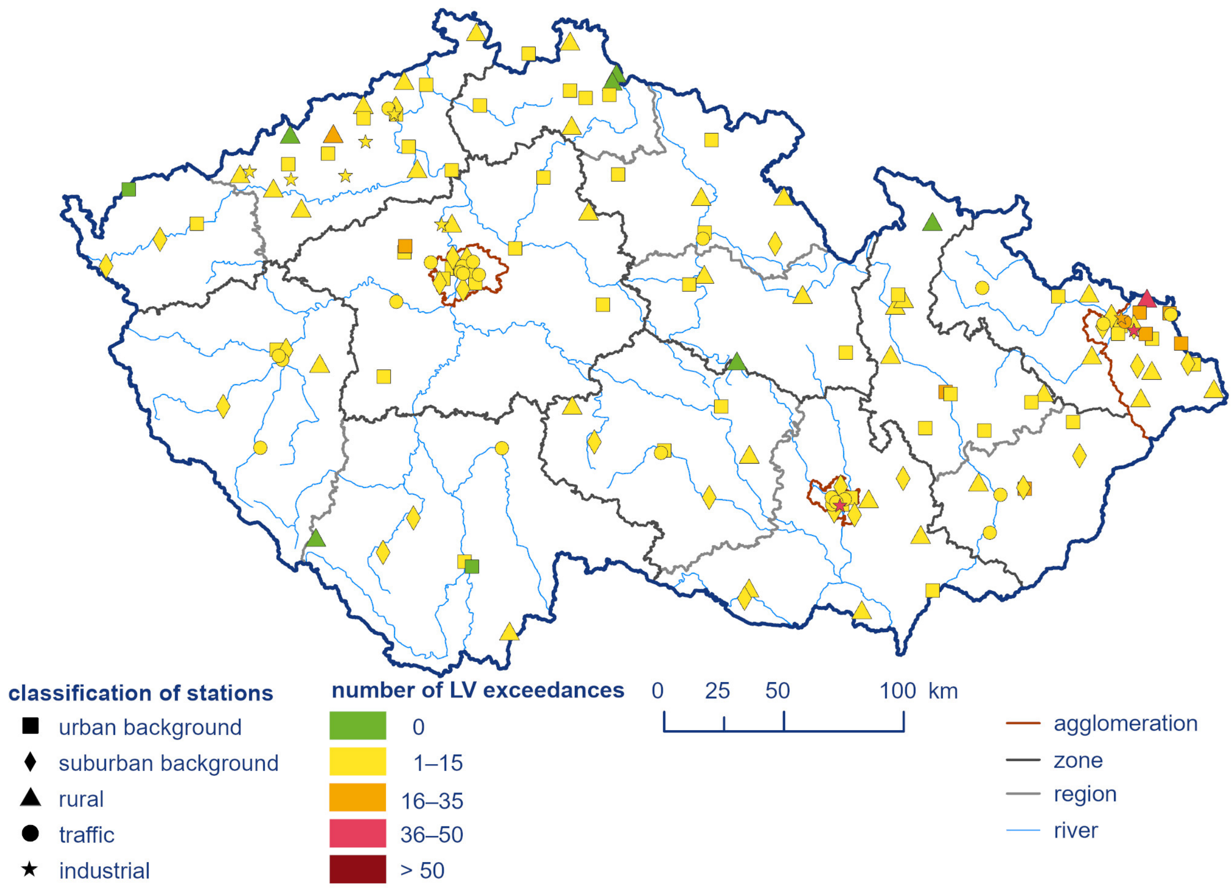


Fig. IV.1.1 Number of cases exceeding the pollution limit value of 24-hour average PM_{10} concentrations at air quality monitoring stations, 2020

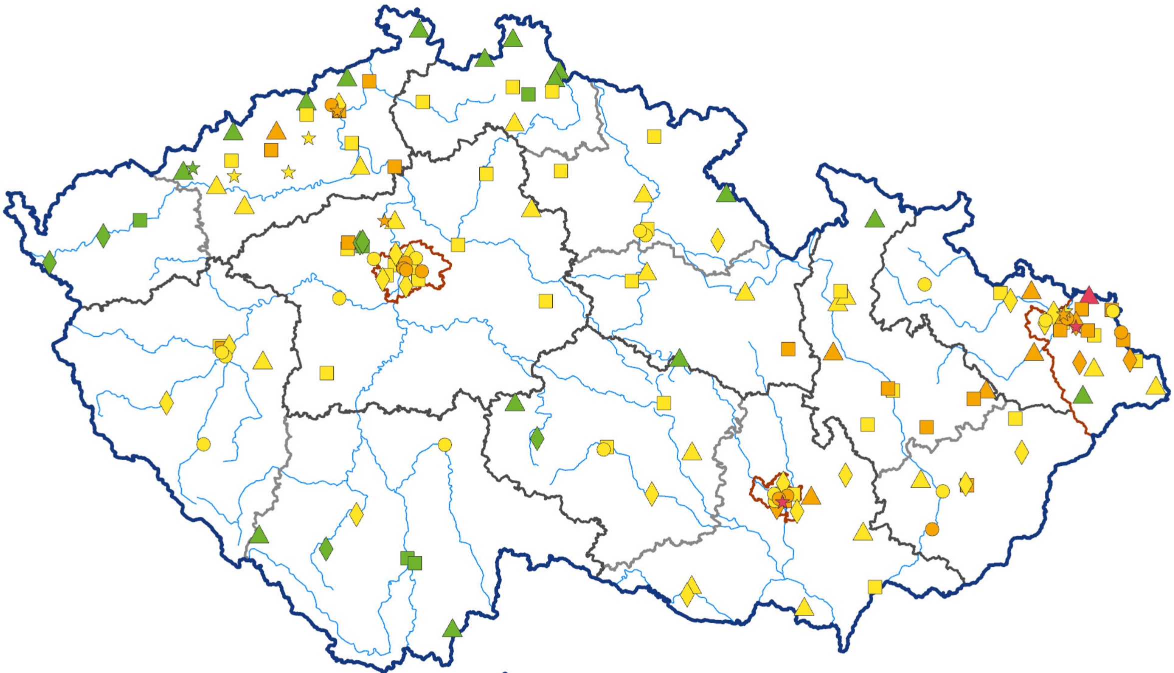


Fig. IV.1.2 The 36th highest 24-hour PM_{10} concentrations at air quality monitoring stations, 2020

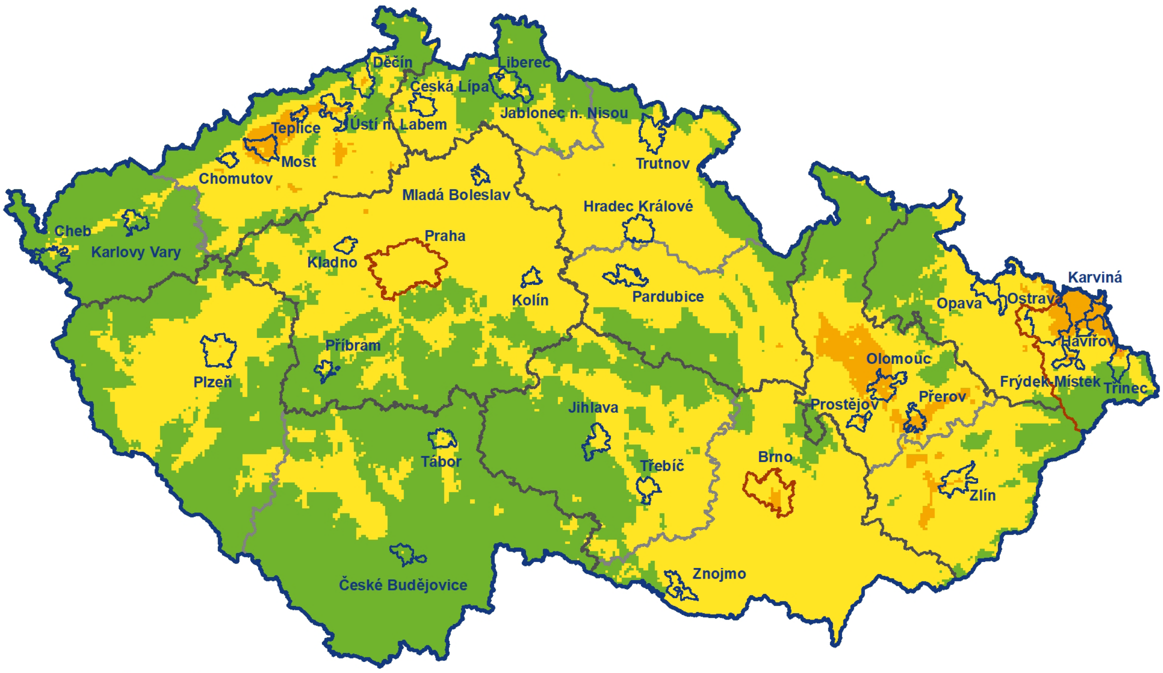


Fig. IV.1.3 Field of the 36th highest 24-hour PM_{10} concentration, 2020

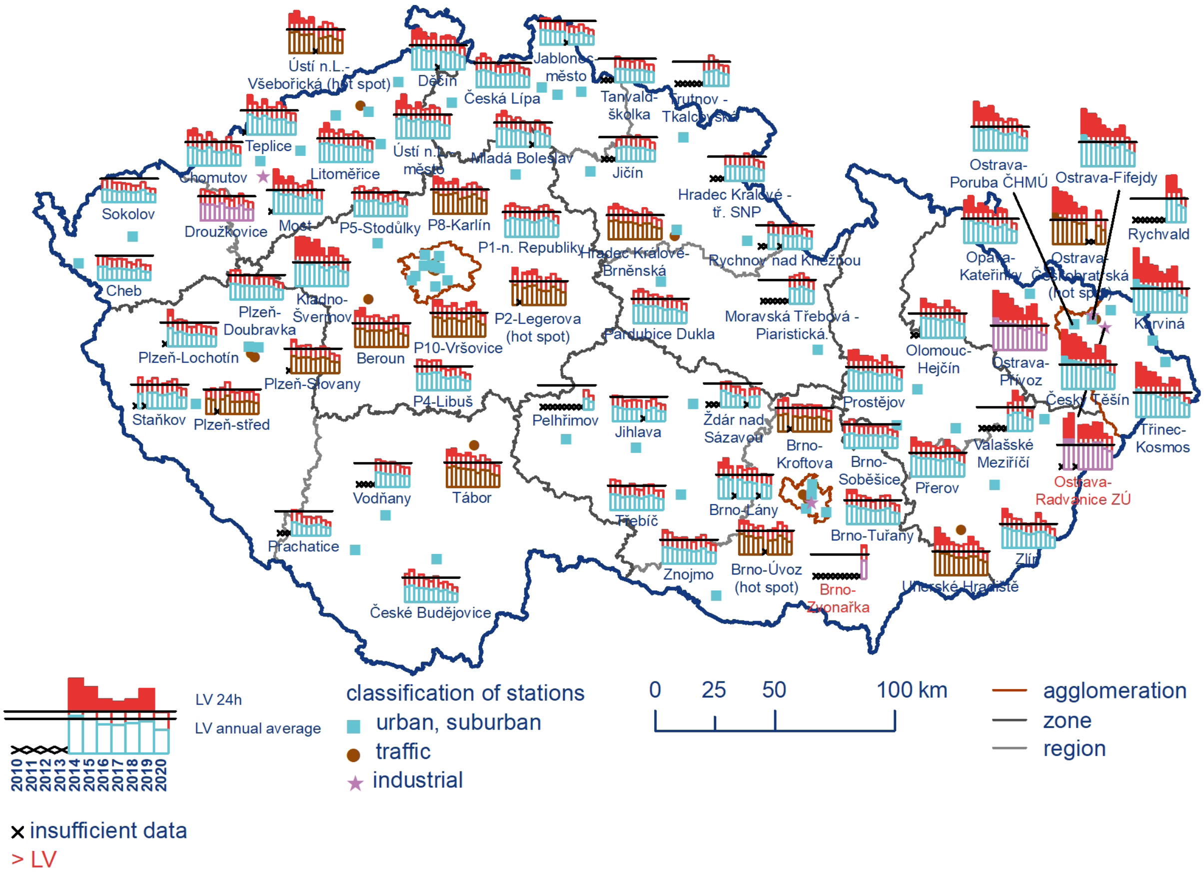


Fig. IV.1.4 The 36th highest 24-hour and annual average PM_{10} concentrations at selected stations of UB, SUB, I, and T classification, 2010–2020

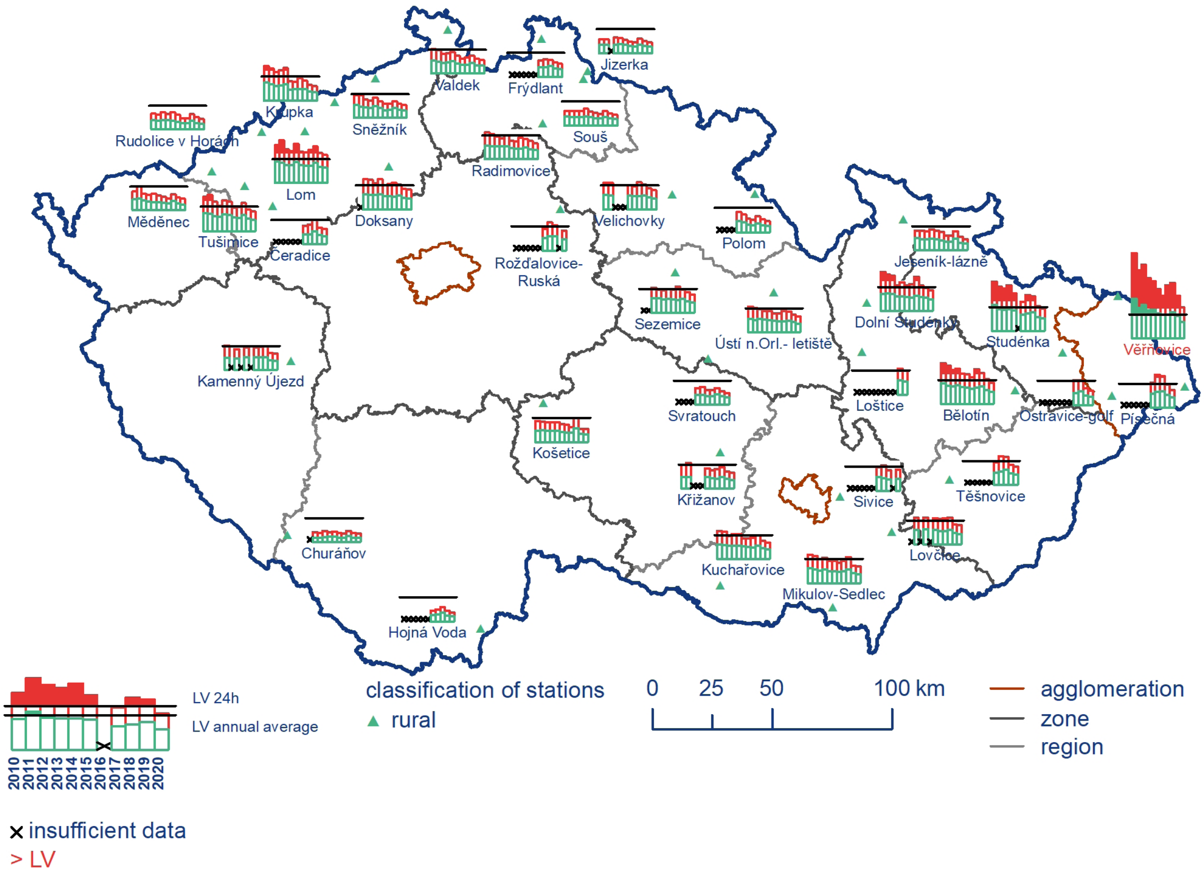


Fig. IV.1.5 The 36th highest 24-hour and annual average PM_{10} concentrations at selected rural (R) stations, 2010–2020

of the concentration was apparent in all zones and regions of the CR. A large part of the territory of the CR (97%) was exposed to a concentration of up to 35 $\mu g.m^{-3}$ in 2020, representing a value below the upper assessment limit set by Act No. 201/2012 Coll., on air protection, as amended. As in previous years (Fig. IV.1.4 and IV.1.5), the O/K/F-M agglomeration was the most polluted continuous area.

The pollution limit level for the average annual concentration of PM_{10} (40 $\mu g.m^{-3}$) was not exceeded at any station in the CR in 2020, which occurred together with 2019 for the second time for the entire history of PM_{10} observation since 1993 (Fig. IV.1.6, Fig. IV.1.7). The highest annual average concentration was measured at the Ostrava-Radvanice TÚ industrial station (29.8 $\mu g.m^{-3}$), Brno-Zvonařka industrial station (29.7 $\mu g.m^{-3}$), and Věřňovice rural station (27.6 $\mu g.m^{-3}$). Apart from these three stations, the highest annual average concentration was mainly measured at the O/K/F-M agglomeration stations and the Lom station in the Ústí nad Labem region. The Lom station also belongs to specific stations, where local heating

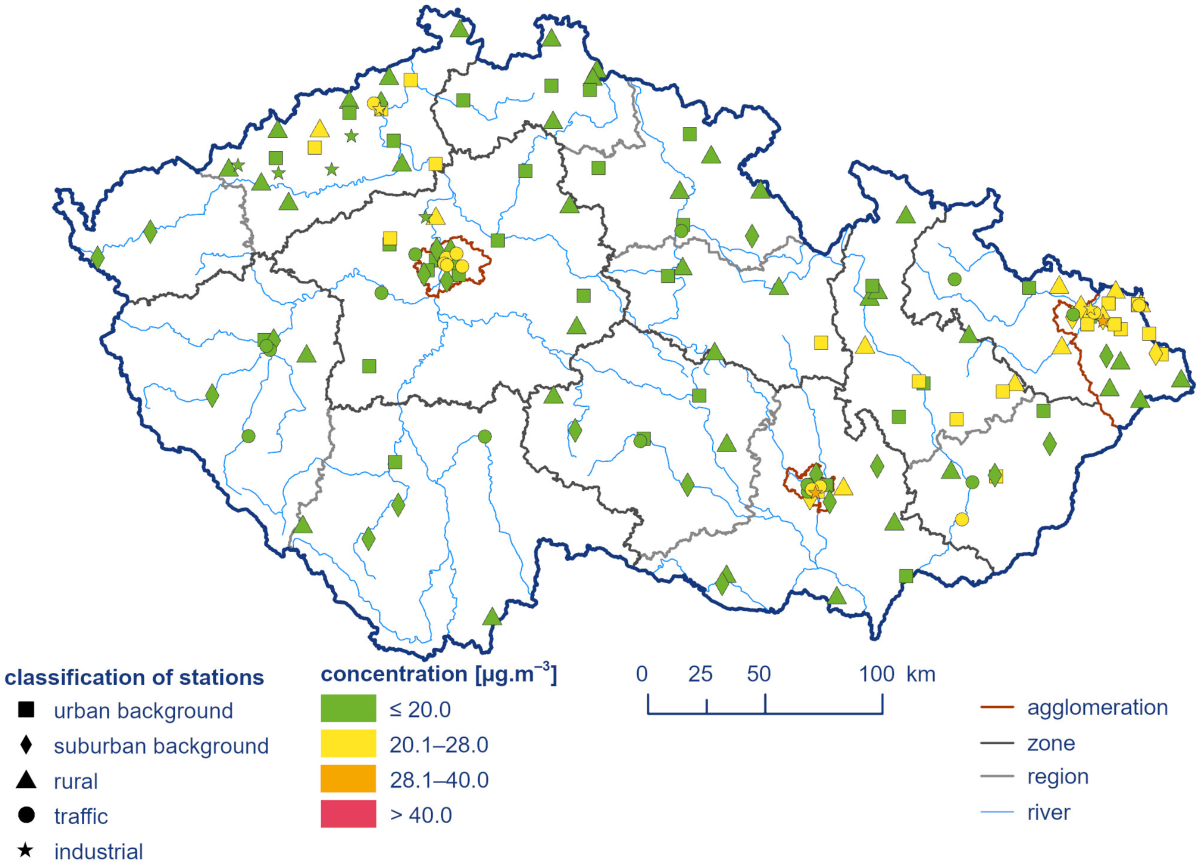


Fig. IV.1.6 Annual average PM_{10} concentrations at air quality monitoring stations, 2020

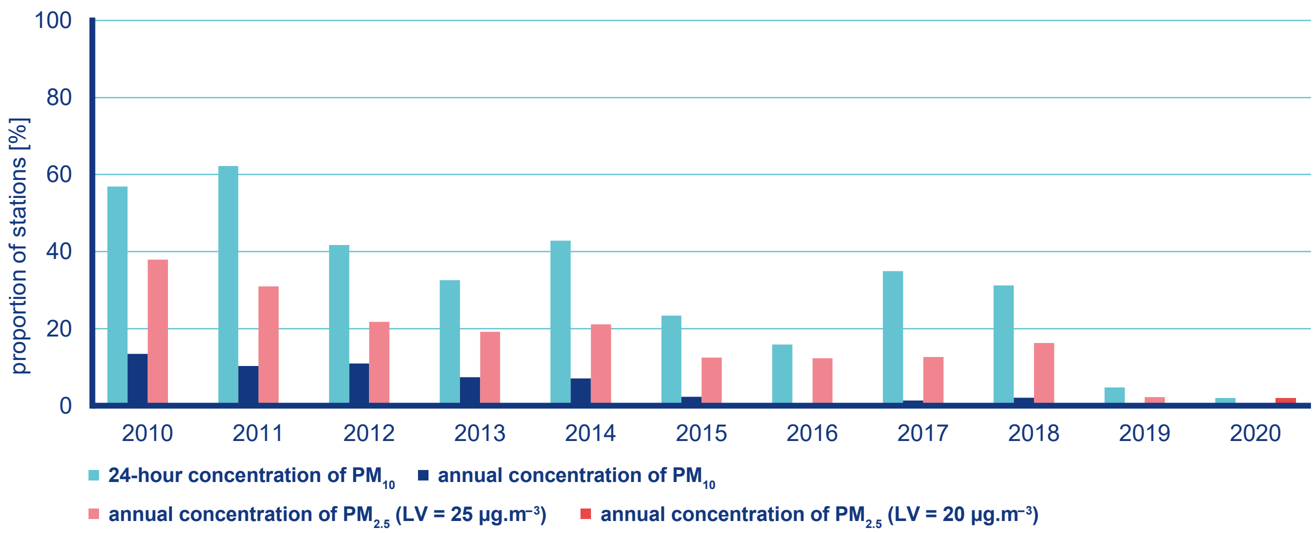


Fig. IV.1.7 Ratio of stations where the pollution limit level of 24-hour average PM_{10} concentration and of annual average PM_{10} and $PM_{2.5}$ concentration was exceeded, 2010–2020

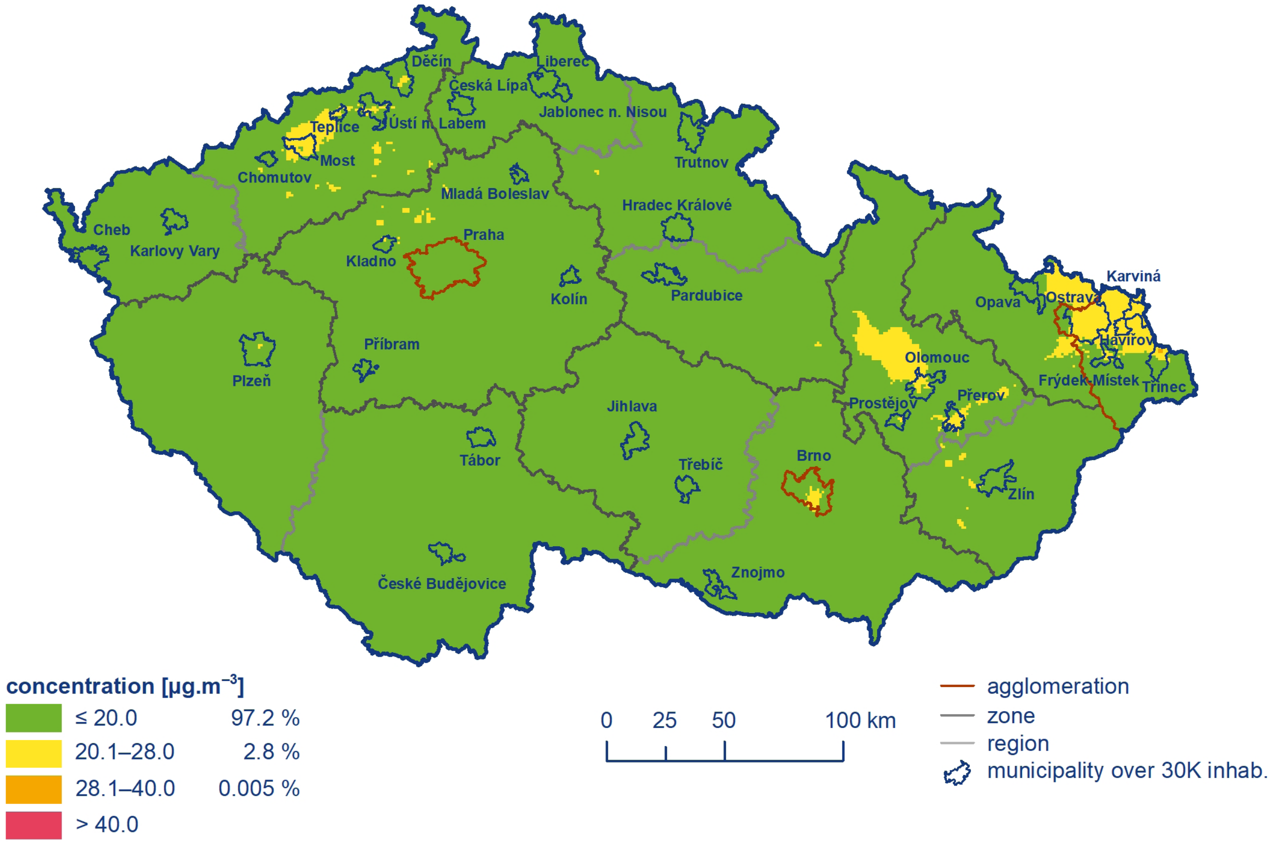


Fig. IV.1.8 Field of annual average PM_{10} concentration, 2020

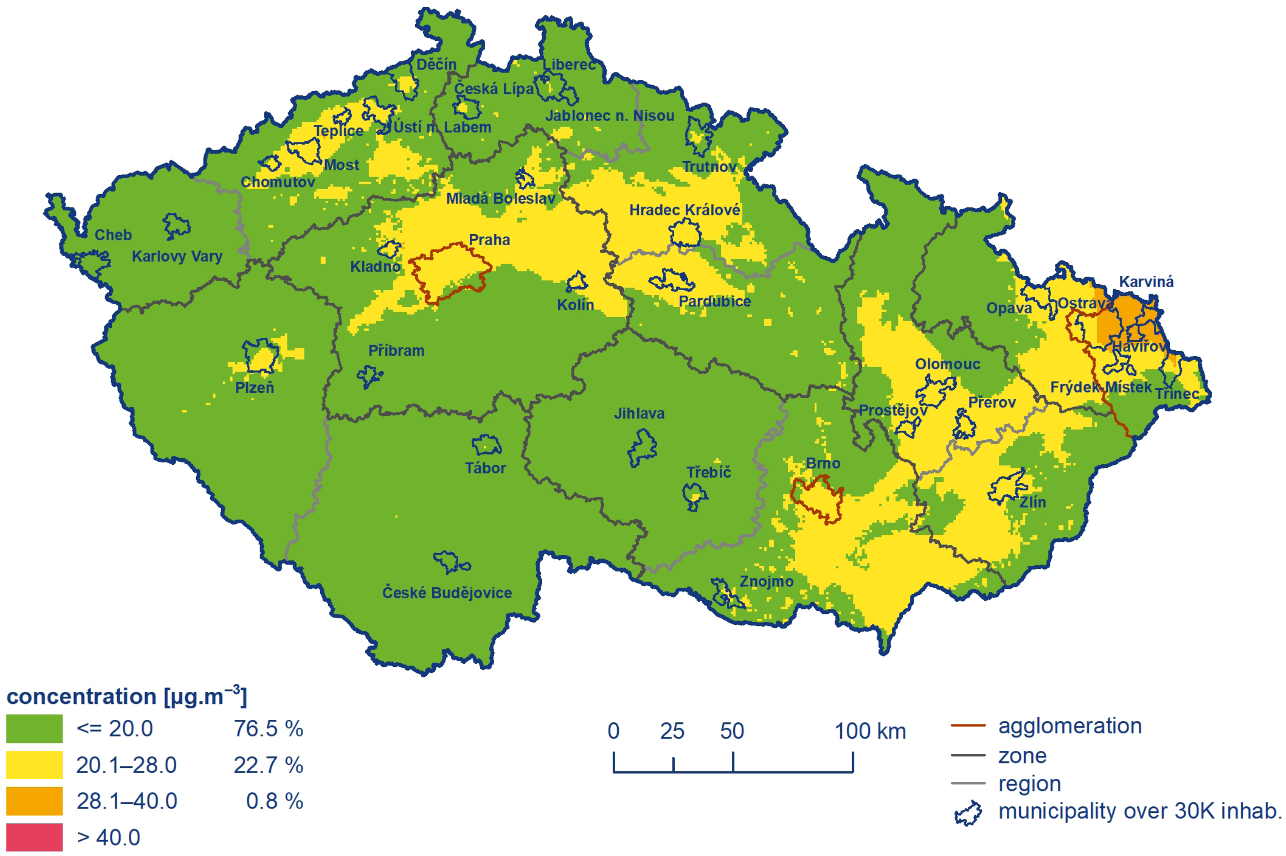


Fig. IV.1.9 Five-year average of annual average PM_{10} concentrations, 2016–2020

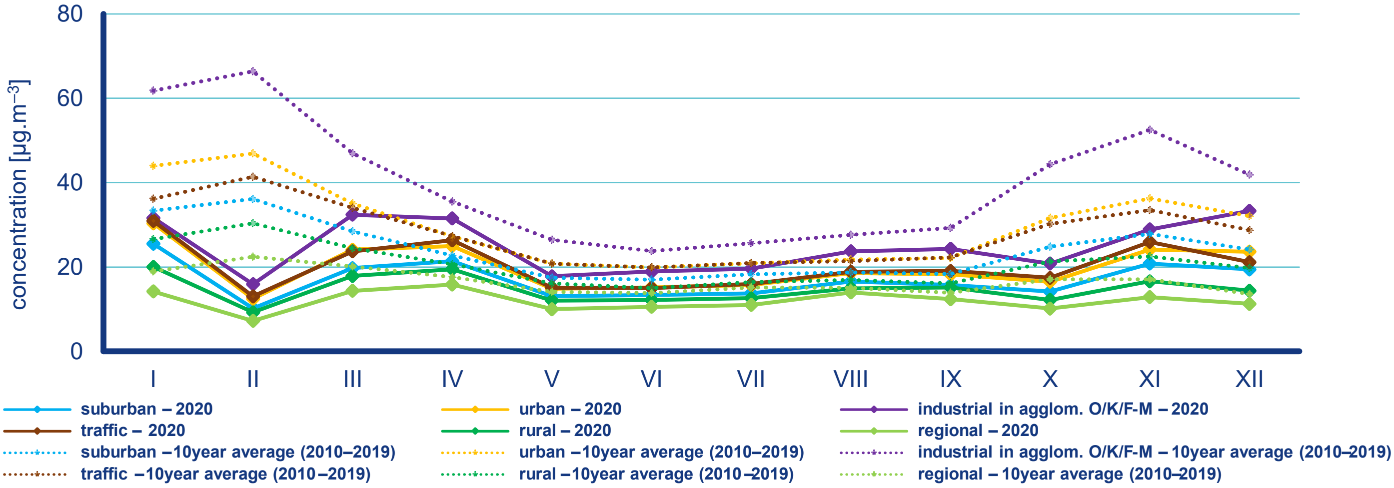


Fig. IV.1.10 Annual course of average monthly PM_{10} concentrations (averages for a given type of station), 2020

from nearby households has also an impact, in addition to emissions from mining activities. Therefore, the measurements from this station are not included in the following evaluation of annual trend of monthly concentrations and concentrations development.

Similar to 2019, no territory of the CR had an above-limit annual average concentration of PM_{10} at a spatial resolution of 1×1 km (Fig. IV.1.8). However, even in previous years the annual average concentration of PM_{10} was exceeded on only small part of the territory of the CR (0.1% in 2018, 0.02% in 2017, and only local cases occurred in 2016 that were not reflected in the map of annual average concentrations at the scale used). In terms of the five-year average of annual average concentrations, the most polluted area is the O/K/F-M agglomeration (Fig. IV.1.9).

PM_{10} concentrations exhibit a clear annual variation, with the highest values in the colder months of the year (Fig. IV.1.10). Higher air PM_{10} concentrations during the colder season are related both to greater emissions of particulates from seasonally operated heating sources and also to poorer dispersion conditions. For example, local heating sources contribute nearly 55% to PM_{10} emissions and 71% to $PM_{2.5}$ emissions in the CR (Fig. IV.1.20 and IV.1.22).

The annual variation of PM_{10} concentrations in 2020 had a less distinct trend compared to the ten-year average. In 2020, the highest concentrations of PM_{10} were measured in January. In March, April, November and December, concentrations were at a very similar level (Fig. IV.1.10). Increased concentrations in March relate to the transport of particles from sandy areas[1] and possibly also to higher heating intensity due to the stay of population in their homes during the emergency state declared on 12 March 2020 (details in Annex II). In April, the concentration level was also affected by the below-normal amount of precipitation. In January, November and December, relatively higher concentrations relate to the occurrence of slightly adverse to poor dispersion conditions and below-normal precipitation amount, in addition, in November and December the situation from March repeated and, as a result of the declared emergency, the people's staying at home increased (details in Annex II).

The lowest average monthly concentration was observed exceptionally in February, when the air pollution within the year ranges usually among the highest. In view of the effect of meteorological conditions, this month of 2020 was very unusual: good dispersion conditions, extremely above average temperatures, and above-normal precipitation amount prevailed, representing a combination of three major factors strongly reducing the level of pollutants in the air.

Based on a comparison of monthly averages of PM_{10} concentrations in 2020 with ten-year average (2010–2019), it can be stated that average monthly concentrations in 2020 were lower by about 7% (April) to 72% (Feburary). The decrease in PM_{10} concentrations at stations was significant especially in February and October (a significant drop of 72% and 45%), but also in January, March and November (by approx. 30%). In the warmer months of the year, the change in concentrations compared to the ten-year average was lower, which again points to the importance of meteorological and dispersion conditions and the importance of seasonal pollution sources during winter months. However, even in the months of the warmer part of 2020 (May-August), significantly lower concentrations were recorded compared to the ten-year average, which, in addition to long-term emission developments, is also likely to be related to the normal to extremely above-normal occurrence of precipitation in these months, except for July. The positive effect of meteorological and dispersion conditions leading to a decrease of concentrations of suspended particles was reflected the most in February and October. The decrease in concentrations was also observed in January, November and December, when, in comparison to the ten-year average, there was a more frequent occurrence of slightly adverse and poor conditions (Fig. III.4 and III.5), namely below-normal precipitation amount and normal temperatures (3.9 °C) in November, and above-normal temperatures in January (0.3 °C) and December (1.7 °C). This is likely to point to the decreasing production of suspended particle emissions due to gradual modernization of emission sources (large sources, household heating boilers, vehicle fleet renovation) and decreasing fuel consumption due to increasing temperatures in the winter months.

1 https://sds-was.aemet.es/forecast-products/dust-forecasts/ensemble-forecast

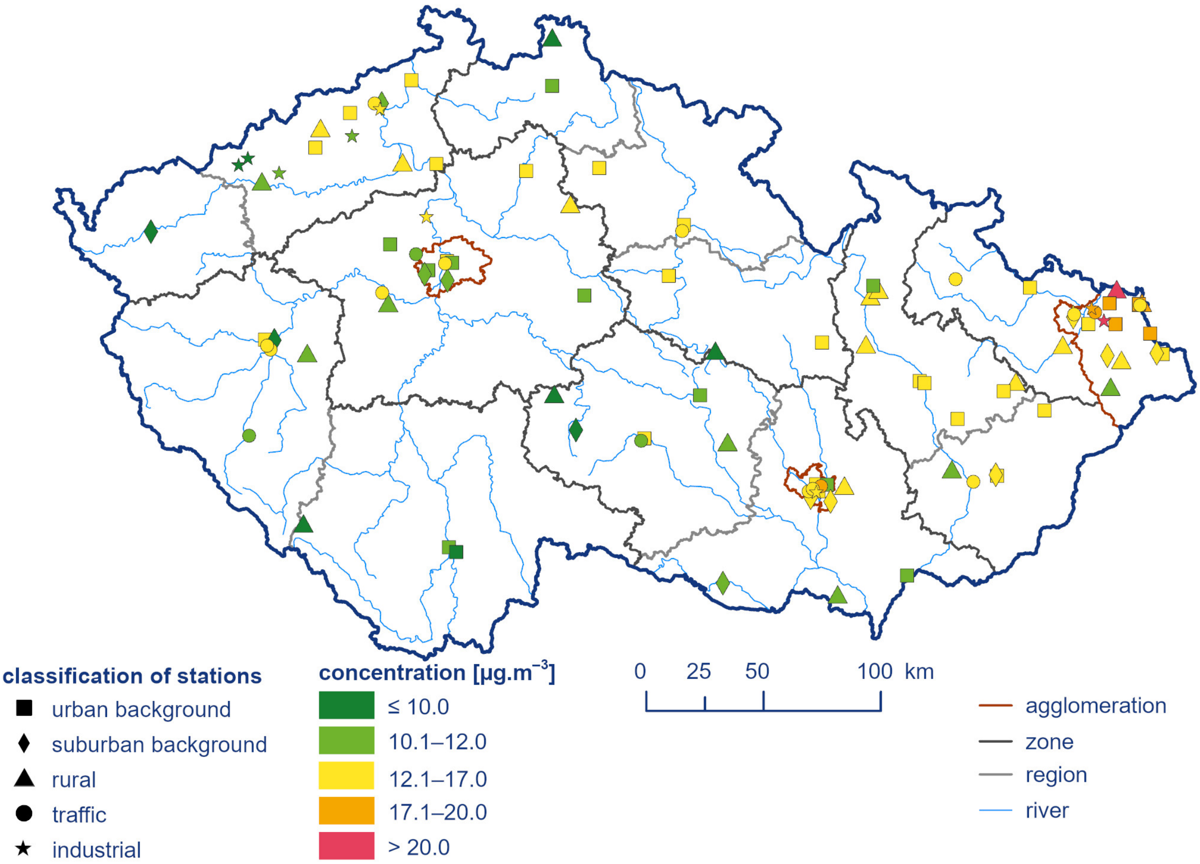


Fig. IV.1.11 Annual average $PM_{2.5}$ concentrations at air quality monitoring stations, 2020

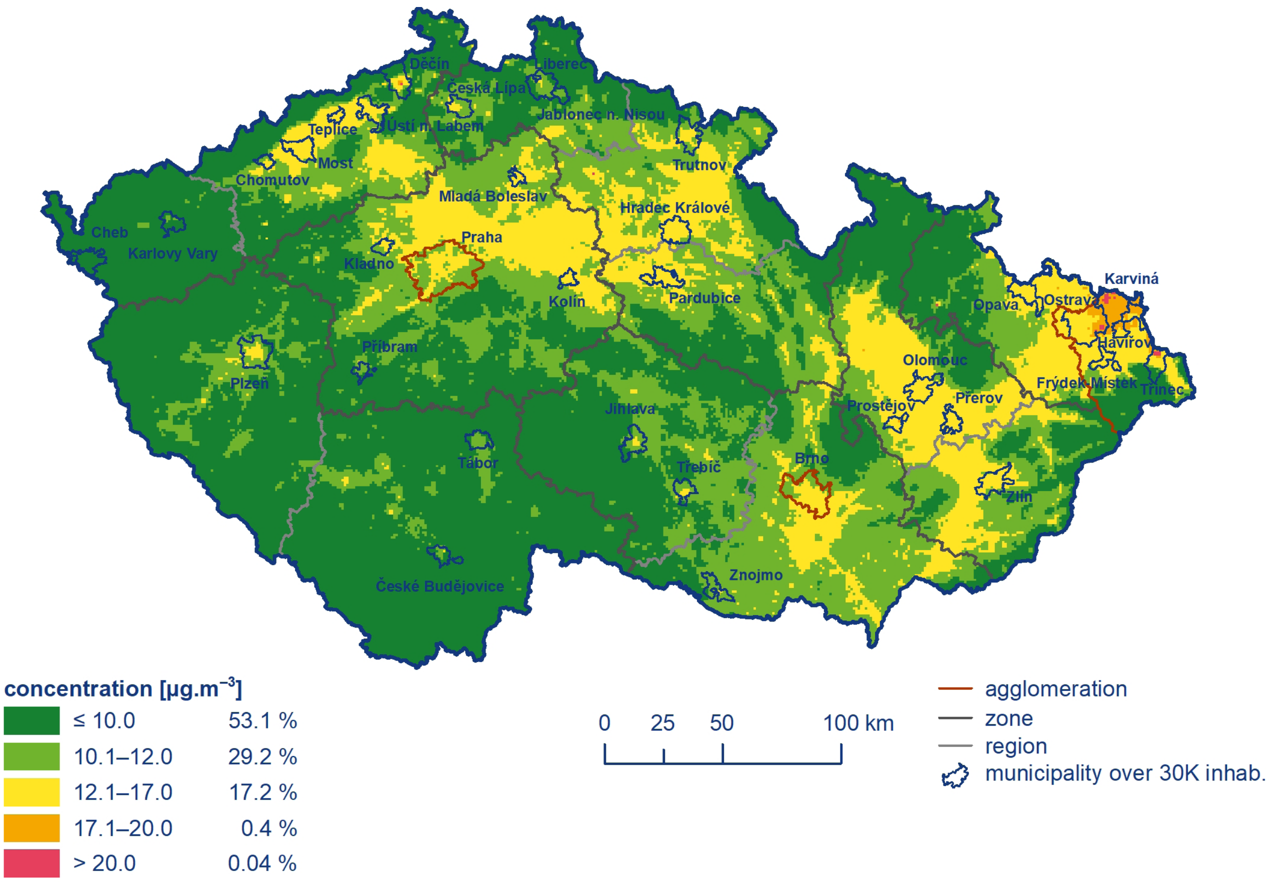


Fig. IV.1.12 Field of annual average $PM_{2.5}$ concentration, 2020

Fig. IV.1.13 Annual average $PM_{2.5}$ concentrations at selected stations, 2010–2020

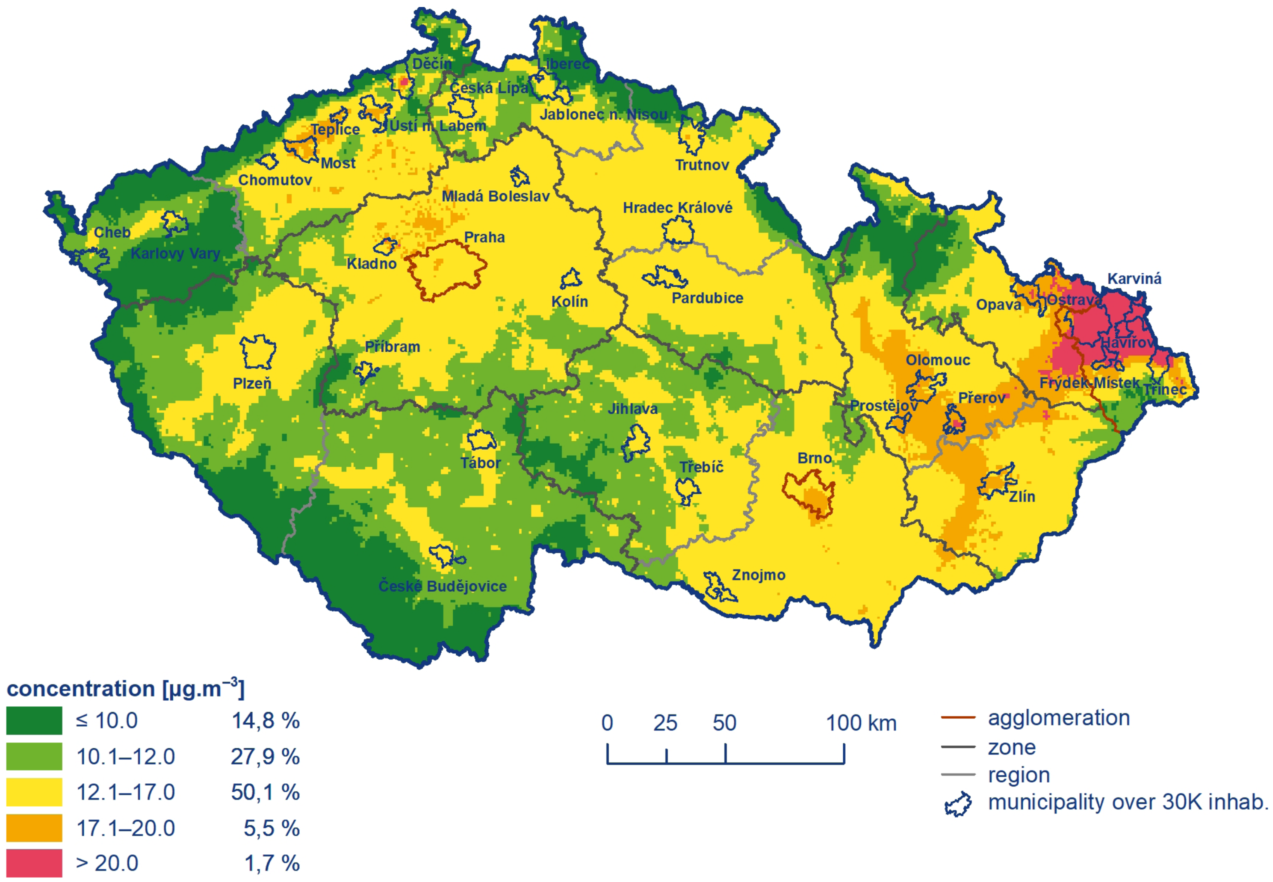


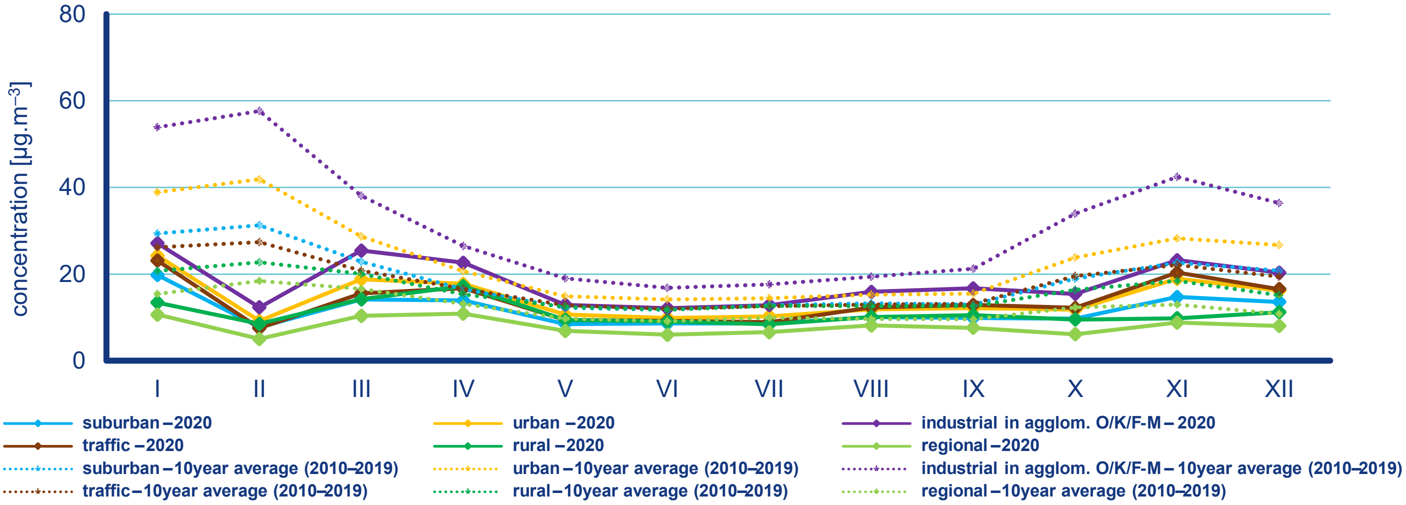
Fig. IV.1.14 Five-year average of annual average $PM_{2.5}$ concentrations, 2016–2020

Suspended $PM_{2.5}$ particulate matter

In 2020, the pollution limit level for the average annual concentration of $PM_{2.5}$ (20 μg.m^{-3}) was exceeded at 2 stations (2%) of a total of 101 stations. Both stations where the average annual concentration of $PM_{2.5}$ was exceeded in 2020 (the Ostrava-Radvanice ZÚ industrial station and the Veřňovice rural background station) are located in the territory of the O/K/F-M agglomeration (Fig. IV.1.11). An annual average concentration of 23.3 μg.m^{-3} was measured at the Ostrava-Radvanice ZÚ station and a concentration of 20.9 μg.m^{-3} at the Věřňovice station. For comparison with previous years, it can be stated that in terms of the limit value valid until 2019 (25 μg.m^{-3}), there would be no station exceeding the limit, constituting a unique situation in history since the beginning of the observation in 2004.

The pollution limit level for the average annual concentration of $PM_{2.5}$ was exceeded in 2020 over 0.04% of the territory of the CR, with approx. 0.2% of the population[2] (Fig. IV.1.12). In terms of the annual limit value valid until 2019 inclusive, no area with above-limit concentration would be specified. For comparison, we also list the following characteristics from previous years related to the former limit: in 2019 it was exceeded over 0.04% of the area with about 0.1% of the population, in 2018, over 1.2% of the area with 6.1% of the population, in 2017 over 0.9% of the area with 4.9% of the population, and in 2016 over 0.5% of the area with 3% of the population.

In the evaluated period 2010–2020, above-limit annual average concentrations of $PM_{2.5}$ were observed mainly on the territory of the O/K/F-M agglomeration (Fig. IV.1.13). In terms of the five-year average of annual average concentrations of $PM_{2.5}$, the most polluted area is the O/K/F-M agglomeration (Fig. IV.1.14).



Note: For regional stations, the condition of data availability at each station for the years 2010 and 2011 was not met.

Fig. IV.1.15 Annual course of average monthly $PM_{2.5}$ concentrations (averages for a given type of station), 2020

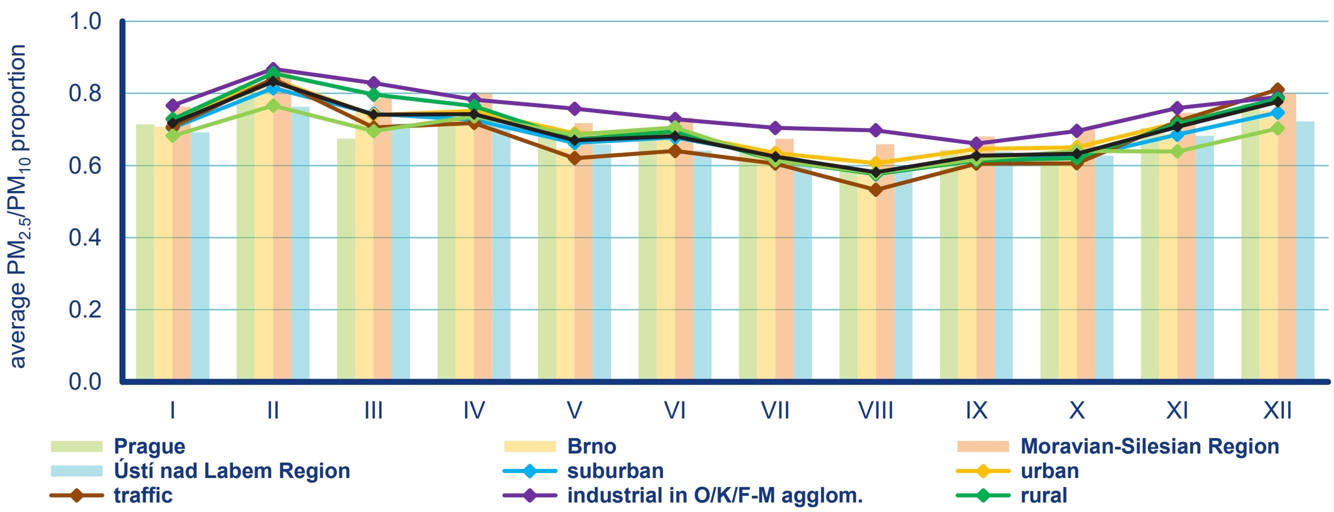


Fig. IV.1.16 Monthly average ratios of $PM_{2.5}/PM_{10}$, 2020

2 In 2020, in connection with EU legislation, a stricter limit value of 20 μg.m^{-3} for the annual average $PM_{2.5}$ concentration entered into force. Until and including 2019, the limit value of 25 μg.m^{-3} applied.

Higher concentrations of $PM_{2.5}$ occur mainly in the colder part of the year (Fig. IV.1.15), and similar to PM_{10}, are a consequence of emissions from heating sources and worsened dispersion conditions. The highest concentrations were observed in January, followed by increased concentrations at similar levels in March, April, November and December. Based on a comparison of 2020 average monthly $PM_{2.5}$ concentrations with the ten-year average (2010–2019), it can be stated that average monthly concentrations in 2020 were lower by about 11% (April) to 76% (February). The decrease in $PM_{2.5}$ concentrations at stations was significant particularly in February and October (a drop of 76% and 48%), but also in March, November and December (about 34%). Monthly $PM_{2.5}$ concentrations show variation very similar to the annual variation of PM_{10}, including a significant decrease in average monthly concentrations compared to their ten-year average.

Ratio of the $PM_{2.5}$ and PM_{10} suspended particle fractions

The ratio of the $PM_{2.5}$ and PM_{10} fractions is not constant but exhibits seasonal variations and is also dependent on the character of the location (Fig. IV.1.16). In 2020, an average value of 85 stations in the CR where $PM_{2.5}$ and PM_{10} are measured simultaneously and have a sufficient number of measurements for evaluation ranged from 0.62 (July) to 0.83 (February). In Prague and Brno, where annual variations are affected by the high proportion of traffic locations, this ratio ranged from 0.59 (July) to 0.82 (February), and from 0.58 (July) to 0.82 (February), respectively. In the Moravian-Silesia region, the ratio ranged from 0.66 (July) to 0.87 (Feburary) and in the Ústí nad Labem region from 0.59 (July) to 0.76 (February). When the ratio of $PM_{2.5}$ and PM_{10} fractions is compared by location type, the ratio at rural locations ranges from 0.58 (July) to 0.86 (February), at urban backgrounds from 0.61 (July) to 0.84 (February), at suburban backgrounds from 0.58 (July) to 0.81 (February), at traffic locations from 0.53 (July) to 0.84 (February), and at industrial locations from 0.66 (September) to 0.87 (February).

The annual variation in the ratio of the $PM_{2.5}$ and PM_{10} fractions is related to a seasonal character of certain emission sources. Emissions from combustion sources exhibit a greater content of the $PM_{2.5}$ fraction than, e.g., emissions from agricultural activities and resuspension during dry and windy weather. Heating in winter can thus lead to a greater content of the $PM_{2.5}$ fraction compared to the PM_{10} fraction. The highest $PM_{2.5}/PM_{10}$ ratio in 2020 was identified in February, regardless of the location type. The occurrence of highly above-normal amount of precipitation in February had a role in this aspect (Chapter III). $PM_{2.5}/PM_{10}$ ratios are generally higher in wet months due to a smaller contribution of resuspension to PM_{10} concentration (Akinlade et al. 2015). Decreases during the spring and beginning of the summer have also been explained by some studies as being a result of the amount of larger biogenic particulates, e.g. pollen (Gehrig, Buchmann 2003).

The $PM_{2.5}$ to PM_{10} ratio is the lowest at traffic locations. When fuel is combusted in traffic, the particulates are mainly in the $PM_{2.5}$ fraction and the ratio should therefore be higher at traffic locations. The fact that this is not the case emphasises the importance of emissions of the largest particulates swirling from the road surface, as well as emissions from the abrasion of tyres, brake linings and roads. The proportion of the larger fraction at traffic stations is also increased as a consequence of resuspension of particulates from the application of grit to roads during winter. Increases in PM_{10} concentrations can also occur as a result of greater road surface abrasion by this grit and the subsequent resuspension of abraded material (EC 2011). On the contrary, a higher ratio of $PM_{2.5}$ to PM_{10} fractions resulting from emissions from combustion processes is observed at industrial stations.

Suspended PM_1 particulate matter

The fine particulate PM_1 fraction was evaluated in 2020 at 12 stations with sufficient amount of data for assessment. The highest annual concentrations (15.4 $\mu g.m^{-3}$) and the maximum daily concentrations (58.3 $\mu g.m^{-3}$) were measured at the Brno-Svatoplukova traffic station, the lowest annual concentrations (6.3 $\mu g.m^{-3}$) and the maximum daily concentrations (35.9 $\mu g.m^{-3}$) were measured at the České Budějovice-Třešň background city station.

IV.1.2 Trends in the concentrations of suspended PM_{10} and $PM_{2.5}$ particulates

The trend in concentrations of suspended PM_{10} particles at particular types of stations is evaluated for the last 11 years, i.e. 2010–2020. The highest concentrations of suspended particulates observed in 2010 were caused especially by the occurrence of poor meteorological conditions in winter and the coldest heating season since 1996 (Fig. III.8). In the period 2011–2016, the 36th highest 24-hour concentrations and the annual average concentrations decreased. The decrease in PM_{10} concentrations was seen at stations in all categories (Fig. IV.1.17–18). A slight increase of concentrations occurred in 2017, mainly due to poor dispersion conditions at the beginning and at the end of the year. In 2018, concentrations again increased on average compared to 2017. In 2019, a significant decrease in concentrations of PM_{10} was observed due to good meteorological and improved dispersion conditions. In 2020, the decrease in PM_{10} concentrations continues. In 2020, concentrations at most stations reached minima in the evaluated period, as well as since the beginning of measurements in the 1990s. Compared to the ten-year average of concentrations from all stations (48.9 $\mu g.m^{-3}$), the 36th highest 24-hour concentration (32,1 $\mu g.m^{-3}$) decreased in 2020 by 34%. The annual average concentration of PM_{10} (18.1 $\mu g.m^{-3}$) decreased in 2020 by more than 30% compared to the ten-year average 2010–2019 of concentrations from all stations (26 $\mu g.m^{-3}$).

The longer-term trend of annual average concentrations of $PM_{2.5}$ can be assessed over the last nine years (in view of data availability and continuous time series at observing stations). Annual average concentrations of $PM_{2.5}$ decreased gradually in the period 2012–2016, an increase was observed in 2017 and 2018, and a gradual decrease again in 2019 and 2020, with a more significant decrease apparent mainly between 2018 and 2019 (Fig. IV.1.19). Compared to the eight-year average 2012–2019 of concentrations from all stations (18.9 $\mu g.m^{-3}$), the annual average $PM_{2.5}$ concentration in 2020 (13.1 $\mu g.m^{-3}$) decreased by 31%.

The continuing decrease in the concentrations of suspended PM_{10} and $PM_{2.5}$ particulates can therefore be attributed to a combination

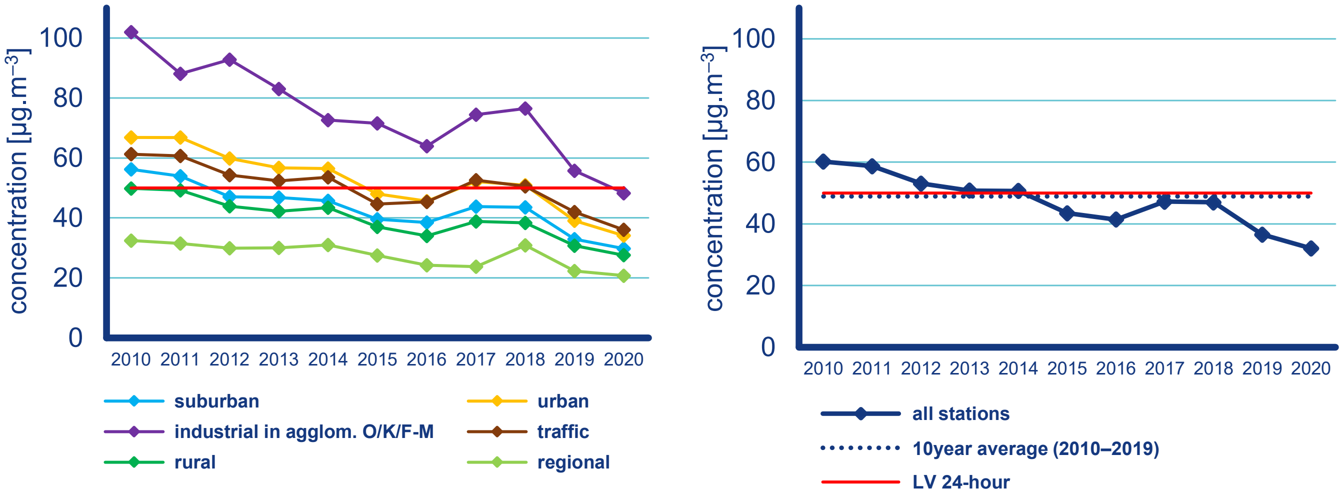


Fig. IV.1.17 The 36th highest 24-hour PM_{10} concentrations at particular types of stations, 2010–2020

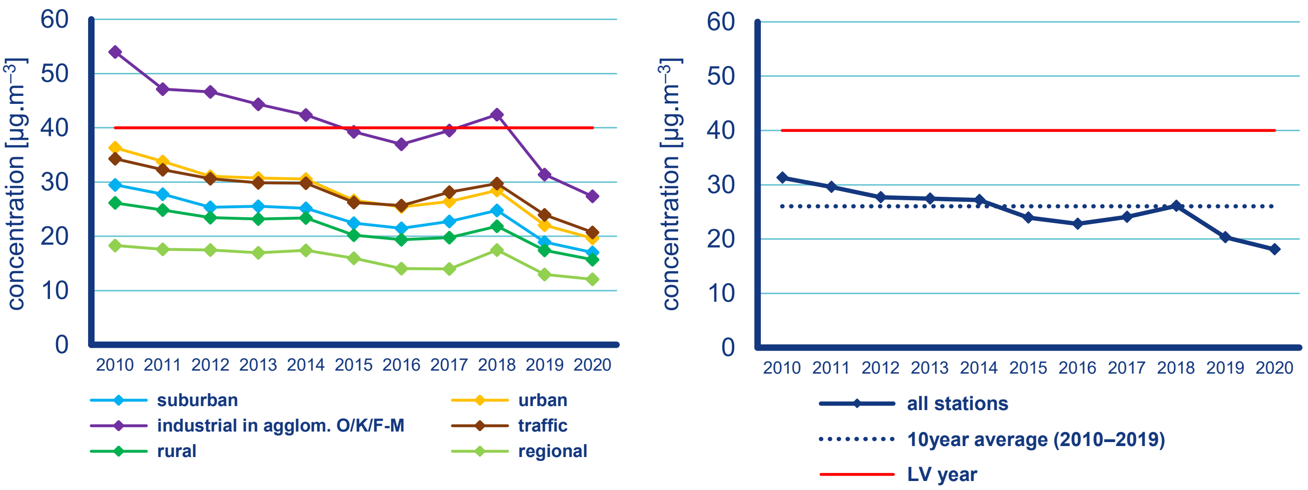


Fig. IV.1.18 Annual average PM_{10} concentrations at particular types of stations, 2010–2020

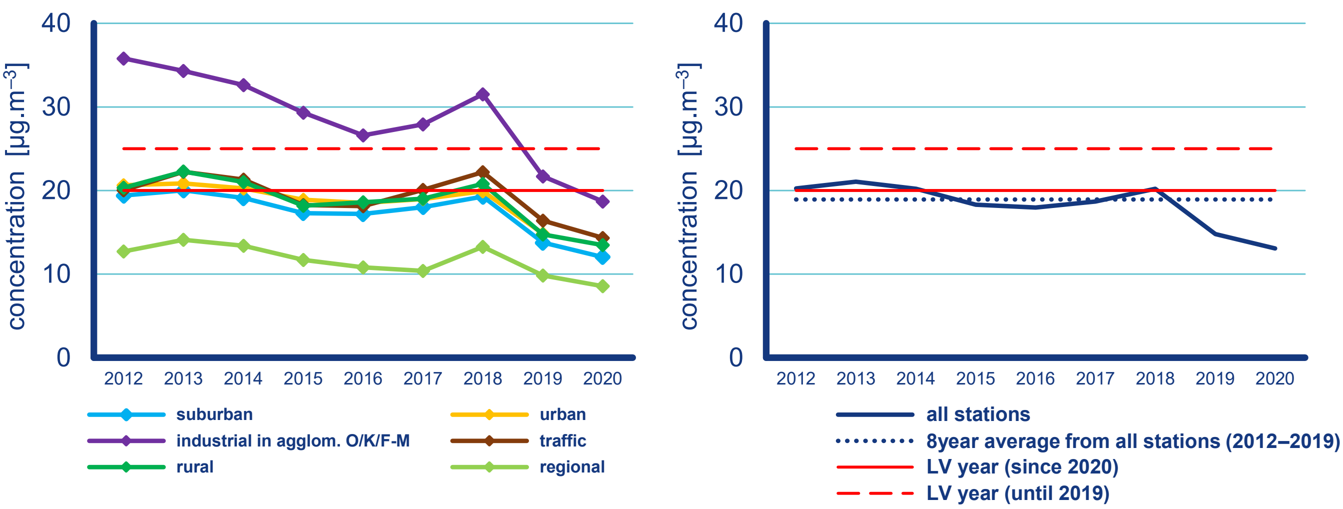


Fig. IV.1.19 Annual average $PM_{2.5}$ concentrations at particular types of stations, 2010–2020

of factors, both good meteorological and dispersion conditions in some months of the year and continued emission reductions due to measures already implemented to improve air quality (replacement of boilers), the ongoing renewal of the vehicle fleet and measures implemented at large sources. The year 2020 was strongly above-normal in terms of temperature in the CR, which led to reduced fuel consumption (decreasing emissions from heating). The impact of measures associated with emergencies declared in the CR on changes in concentrations of suspended particulates is open to discussion. First, there was a decrease in traffic intensity and also a lower fuel consumption resulting in a reduction in emissions of suspended particulates and nitrogen oxides (precursors of secondary suspended particulates). Secondly, the likely higher intensity of heating due to the population staying at home environment led to higher emissions of suspended particulates. A more detailed evaluation of the impact of the state of emergency on the change in air quality in the CR can be found in Annex II.

IV.1.3 Emissions of PM_{10} and $PM_{2.5}$

Aerosols originating from fuel combustion and other industrial activities can exist in the form of solid, liquid or mixed suspended matter. Taken together, these aerosols are termed Total Suspended Particulates (TSP) (solid pollutants (SP) in the Czech legislation). TSP emissions have varying size and chemical composition resulting from the characteristics of the source and the mode of formation. They can contain heavy metals and act as carriers for VOCs and PAHs. The PM_{10} and $PM_{2.5}$ size fractions are most frequently distinguished in emission inventories in relation to pollution limit levels.

Emission inventories of PM_{10} and $PM_{2.5}$ prepared according to current regulations include only the primary emissions of these substances. However, a considerable contribution to airborne concentrations of PM_{10} and $PM_{2.5}$ comes from secondary suspended particulates formed directly in the air from gaseous precursors through physical-chemical reactions. The fraction of secondary suspended inorganic particulates in total $PM_{2.5}$ concentrations in urban environments can vary between 20 and 40% (Vlček, Corbet 2011). According to the model estimate, the contribution of secondary suspended organic particulates of biogenic origin under European conditions can equal 2–4 μg.m^{-3} of $PM_{2.5}$ (Fuzzi et al. 2015).

Compared to emissions of other pollutants, particulate matter emissions in the air originate from a great many significant source types. In addition to sources from which these substances are emitted through controlled chimneys or stacks (industrial sour-

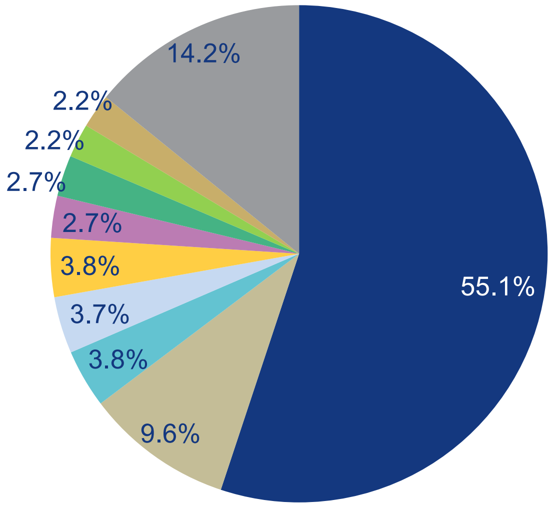


Fig. IV.1.20 Share of NFR sectors in total PM_{10} emissions, 2019

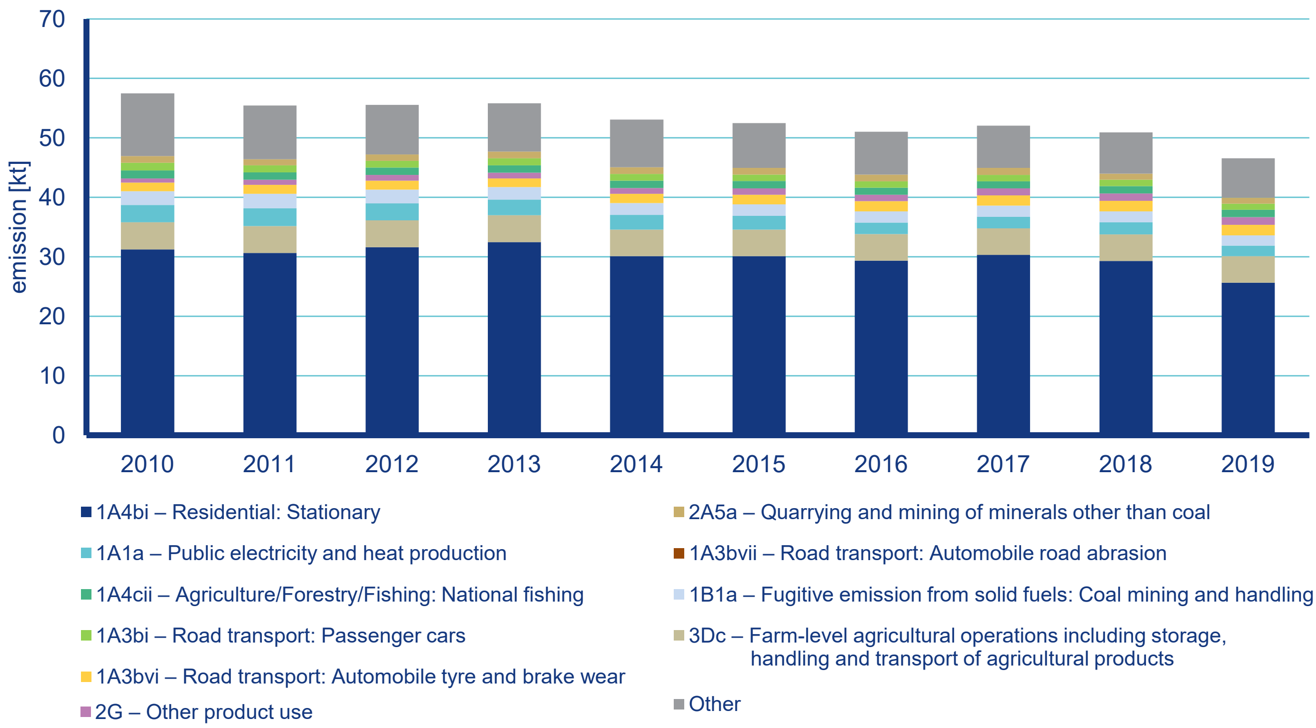


Fig. IV.1.21 Total PM_{10} emissions, 2010–2019

ces, local heating units, transport), significant amounts of PM emissions originate from fugitive sources (quarries, dumping of dusty materials, operations involving dusty materials, etc.). Relevant sources include also emissions from abrasion of tyres, brake linings and abrasion of roads calculated from traffic levels. The air quality is also affected by the resuspension of particles, which is not included in the standard emission inventories.

The main sources of particulate matter emissions in 2019 (Fig. IV.1.20 and Fig. IV.1.22) included the 1A4bi sector — Residential: Heating, water heating, cooking, which contributed 55.1% of PM_{10} substances and 70.5% of $PM_{2.5}$ substances to air pollution on a country-wide scale. Further important sources of PM_{10} emissions included the 3Dc sector – Farm-level agricultural operations including storage, handling and transport of agricultural products, with emissions formed during tillage of the soil, harvesting and cleaning of agricultural crops. This sector represented 9.6% of PM_{10} emissions. A substantial risk to human health is caused by particulates coming from transport, especially from fuel combustion in diesel engines that produce particles with sizes up to hundreds of nanometres (Vojtíšek 2010). Mobile sources (CHMI 2021d) contributed 12.2% to PM_{10} emissions and the same 12.2% to $PM_{2.5}$ emissions in 2019.

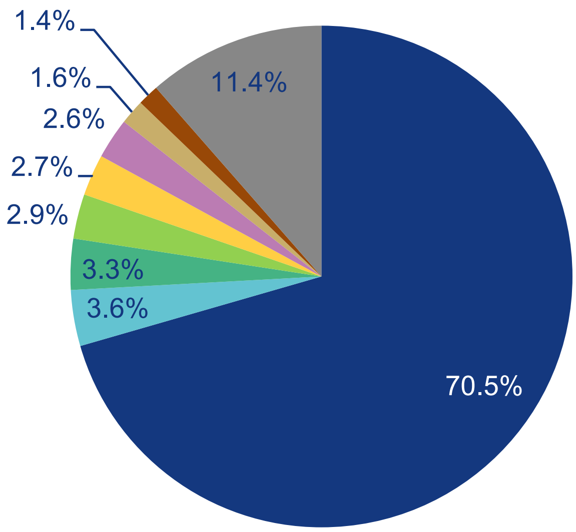


Fig. IV.1.22 Share of NFR sectors in total $PM_{2.5}$ emissions, 2019

Solid fuel consumption in households in the period 2010–2019 can be characterised by a growing trend, related possibly to the economic situation, which stabilized only after 2013. The resulting effect was compensated by natural renewal of the vehicle fleet, a decrease in agricultural production, and the use of the best available techniques for reducing TSP emissions (fabric filters) in the energy and industry sectors. Total PM_{10} and $PM_{2.5}$ emissions in the period 2010–2019 had a declining trend (Fig. IV.1.21 and Fig. IV.1.23).

In individual regions of the CR, the contribution by sectors varies depending on the composition of sources in a given area. Since the main source of PM_{10} and $PM_{2.5}$ emissions is from local heating, the production of these substances is also distributed throughout the territory of the CR along with residential buildings. In the territory of the CR, areas with higher emissions correspond to sites where lignite mining takes place and important energy sources burning solid fossil fuels (particularly the Ústí nad Labe region) or large industrial complexes (the Moravian-Silesia region) are located. The fraction of emissions from transport is greater primarily in large cities.

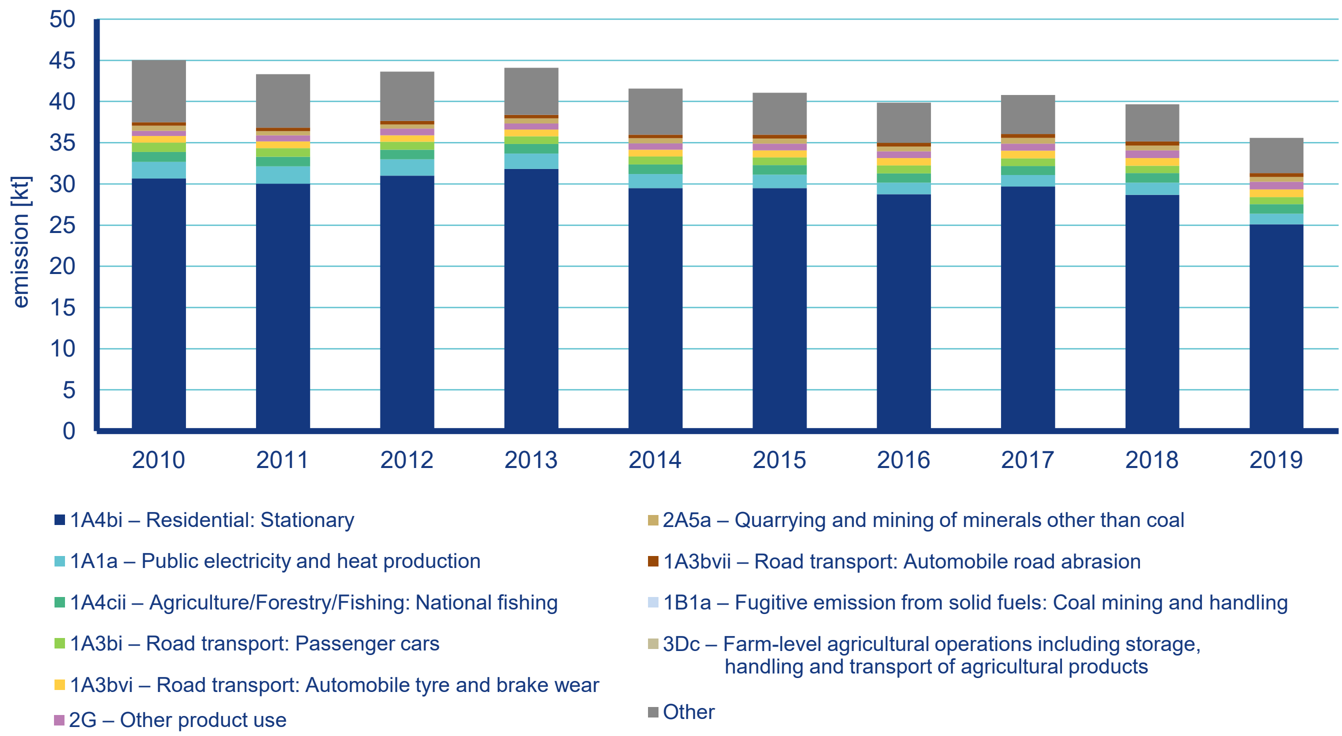


Fig. IV.1.23 Total $PM_{2.5}$ emissions, 2010–2019