V. AIR QUALITY IN AGGLOMERATIONS AND CITIES

For assessing and evaluating the level of air pollution, the Act No. 201/2012 Coll., on protection of the air, divides the territory of the Czech Republic into zones and agglomerations. This chapter deals with detailed evaluation of the air quality in the agglomerations of Prague, Brno and Ostrava/Karviná/Frýdek-Místek, these areas have high population densities; thus the fraction of the population that is exposed there to above-limit concentrations is not negligible. The air quality index also assesses the situation in other, mostly regional, cities of the CR.

V.1 Prague agglomeration

In terms of air pollution, the capital of Prague ranks among the most polluted areas in the Czech Republic (Tab. VII.1.2). This situation is a result of the interaction of a number of anthropogenic and natural factors.

A specific location of Prague in the complex terrain of the Prague basin fundamentally affects the climatic conditions and dispersion conditions in the territory (Ložek et al. 2005). The Vltava River valley is generally insufficiently ventilated and, especially in the colder part of the year, suitable conditions appear here for the formation of temperature inversions resulting in accumulation of concentration of harmful substances in the ground layer of the atmosphere (ČHMÚ 2020d).

The worsened quality of the air in Prague is related mainly to the heavy traffic load. Due to its location, Prague is not only the main cross-road of the road network of the Czech Republic, but is also an important cross-road in international transport. A large portion of main transport roads goes through the centre of Prague. However, the current roadway network inside the city is not capable of absorbing such an enormous concentration of traffic and is overloaded, often even with traffic jams. The factor of high traffic load by vehicles is also a result of the economic strength of the region and the highest rate of motorization in the Czech Republic which reached 715 vehicles per 1,000 inhabitants in 2018, representing 132% of the national average (CENIA 2019). Partial improvement of traffic conditions should follow primarily from completion of by-pass circuit roads around Prague, substantial reduction of individual automotive transport in the most crowded areas and emphasis on railway and municipal mass transport (IPR Praha 2016).

Tab. V.1.1 The territory of the Prague agglomeration with the exceeded limit values of the individual pollutants

Year	PM_{10} annual average	PM_{10} 24h	$PM_{2.5}$ annual average	NO_2 annual average	Benzo[*a*]pyrene annual average	O_3
2012	–	5.61 %	–	1.36 %	88.11 %	0.20 %
2013	–	0.42 %	–	0.56 %	59.61 %	0.20 %
2014	–	5.96 %	–	0.20 %	75.81 %	–
2015	–	–	–	–	41.70 %	0.20 %
2016	–	–	–	0.60 %	54.26 %	2.01 %
2017	–	0.67 %	–	–	67.70 %	15.52 %
2018	–	1.98 %	–	–	19.03 %	97.38 %
2019	–	–	–	–	0.35 %	99.83 %

Due to its historical development, Prague has a developed industrial infrastructure (IPR Praha 2016). In the recent past, a number of unsatisfactory industrial facilities have been closed or production reduced, however, the services sector has grown in importance leading to construction of new commercial and administrative centres, placing considerable demands on transportation services and consumption of energy, including heating. The consumption of solid fuels for heating family houses, especially in suburban parts of the city, also has a considerable effect on the air quality in Prague. The growing popularity of the use of fireplaces and fireplace stoves contributes to deterioration of the air quality. Despite the significant share of gasification, the pollution load from local heating remains significant, especially in the outskirts of the city (MHMP 2020).

V.1.1 Air quality in the Prague agglomeration

Suspended particulate matter PM_{10} and $PM_{2.5}$

In 2019, the limit value for the average 24-hour PM_{10} concentration in the Prague agglomeration was not exceeded at any of 16 monitoring stations with sufficient amount of data for evaluation. The limit value has not been exceeded even in traffic localities where the occurrence of above-limit concentrations was typical in previous years. Most days with daily average PM_{10} concentration exceeding the pollution limit value occurred in January and February (Fig. V.1.1), nevertheless, the permitted limit of 35 cases exceeding the limit value (50 $\mu g.m^{-3}$) was not exceeded at any station. In January to February, 53–80% of average daily concentrations higher than the limit value were recorded at individual stations, probably in connection with the occurrence of moderately poor to poor conditions in January and especially in February (Chapter III). Furthermore, the limit value was significantly exceeded in April, which was the month with the lowest total precipitation in 2019. In October, the cases exceeding the limit value related to the occurrence of poor dispersion conditions. In December, the limit value was exceeded mainly at traffic locations in relation both to the occurrence of lower temperatures during the year and more intensive heating, and to higher emissions from traffic due to increased abrasion of road material due to road maintenance in winter and subsequent resuspension of the material (EC 2011). In 2019, as in previous years, the annual limit values for PM_{10} (40 $\mu g.m^{-3}$) and $PM_{2.5}$ (25 $\mu g.m^{-3}$) were not exceeded at any site that was relevant for the assessment of annual average concentrations (Fig. V.1.2, Fig. V.1.3). In Prague, the highest annual average concentrations of PM_{10} and $PM_{2.5}$ are observed at traffic sites. The highest values of the average annual concentration of PM_{10} in 2019 were observed at the stations of Prague 8-Karlín (25.7 $\mu g.m^{-3}$), Prague 2-Legerova (25.5 $\mu g.m^{-3}$) and Prague 10-Vršovice (25, 4 $\mu g.m^{-3}$). A similar concentration was also observed in the centre of Prague at the Prague 1-nám. Republiky city station (24.8 $\mu g.m^{-3}$). In 2019, the highest values of the average annual $PM_{2.5}$ concentration were measured at the Prague 2-Legerova traffic station (17.3 $\mu g.m^{-3}$). The second highest annual average concentration was measured at the Prague 5-Řeporyje suburban station (17 $\mu g.m^{-3}$) which is located near the residential built-up area where the increase in concentrations occurs due to emissions from heating using solid fuels.

In terms of longer time series of concentrations of suspended particles PM_{10} or $PM_{2.5}$ for the period of 2009–2019 or 2012–2019, respectively, it can be stated that all air pollution characteristics reach higher average values in traffic localities compared to urban and suburban ones (Fig. V.1.2, V.1.3). In the period under review, the highest concentrations were measured in 2010, when the increase in concentrations was due to the repeated occurrence of unfavourable meteorological and dispersion conditions in the winter at the beginning and end of the year. The lowest concentrations were measured in 2015 and 2016, i.e. in the years when there was a significant decrease in the occurrence of poor dispersion conditions. In 2017 and 2018, annual average concentrations of PM_{10} and $PM_{2.5}$ show increase; in 2018 the increase was more significant and was probably related to a strongly below-normal amount of precipitation or with reduced intensity of self-clea-

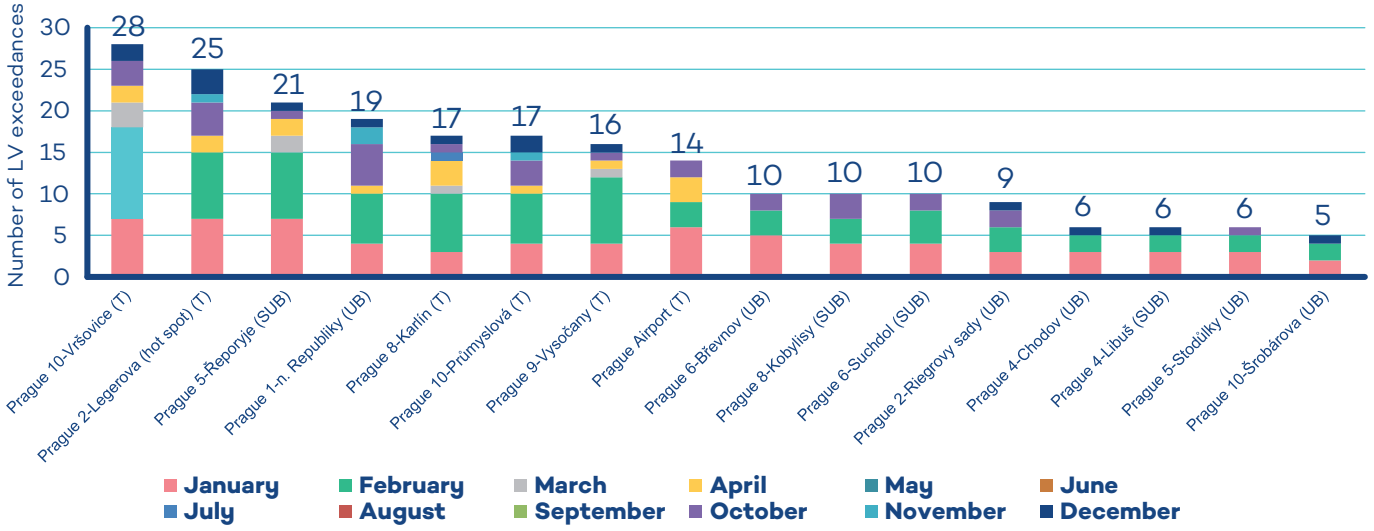

Fig. V.1.1 Number of days with concentrations of PM_{10} > 50 $\mu g.m^{-3}$ by months, including total number of cases exceeding the pollution limit, 2019

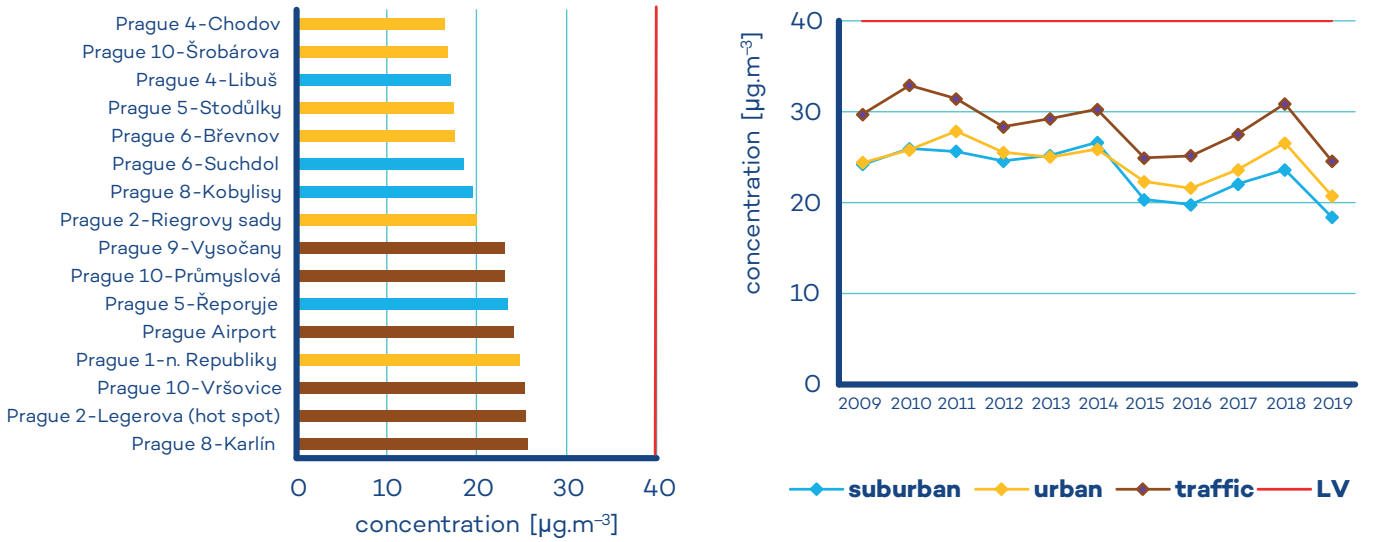

Fig. V.1.2 Annual average concentration of PM_{10} in 2018 and variation of concentrations in 2009–2019

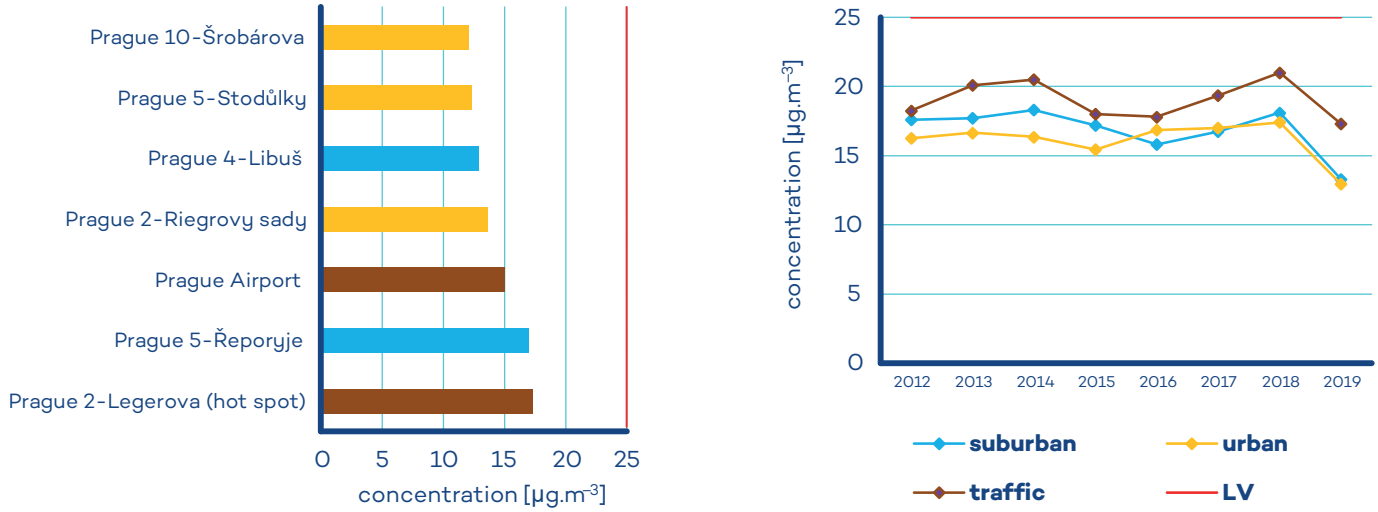

Fig. V.1.3 Annual average concentration of $PM_{2.5}$ in 2018 and variation of concentrations in 2012–2019

ning of the atmosphere and higher resuspension (CHMI 2019). In 2019, there was a significant decrease in the concentrations of suspended particulates PM_{10} and $PM_{2.5}$. Concentrations reached their minima during the evaluated period in urban, suburban and traffic localities. This decrease is due both to the occurrence of abnormally high temperatures in the winter (leading to a reduced need for heating or reduced emissions from sector 1A4bi — Households: heating, water heating, cooking) and the occurrence of mostly good dispersion conditions in the cold season at the end of the year (October-December). It can be expected that the reduction in the emission intensity of vehicles due to the modernization of the vehicle fleet and the ongoing replacement of boilers in households contribute to the improvement of the situation in the Prague agglomeration despite the continuing growth of traffic intensities (CENIA 2019).

Benzo[*a*]pyrene

In 2019, the pollution limit level for the annual average concentration of benzo[*a*]pyrene was not exceeded at any of three stations in the territory of the Prague agglomeration meeting the requirements for the quantity and quality of the monitored data. These include a suburban station of Prague 4-Libuš, and city stations of Prague 2-Riegerovy sady and Prague 10-Šrobárova. Until 2014, the limit value was exceeded annually in at least one monitoring station in the Prague agglomeration (Fig. V.I.4), while in recent years the highest concentrations have been measured in the suburban locality Prague 4-Libuš. In the last five years, the limit was not exceeded at any monitoring station in the territory of Prague, moreover, in 2019, there was the lowest annual average concentration of benzo[*a*]pyrene recorded at Prague stations

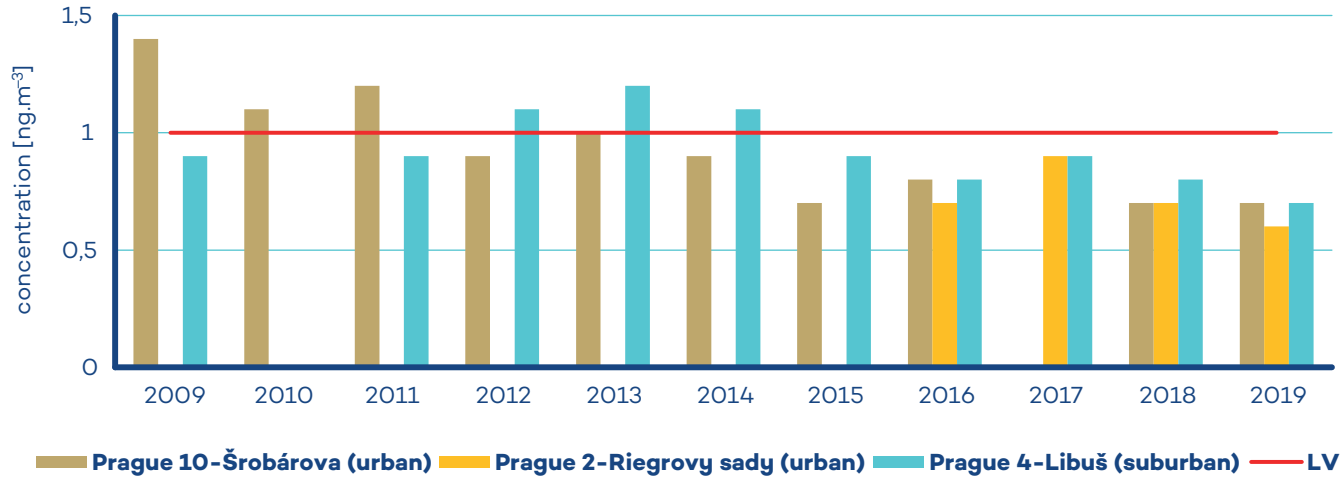

Fig. V.1.4 Annual average concentration of benzo[*a*]pyrene in 2018 and variation of concentrations in 2009–2019

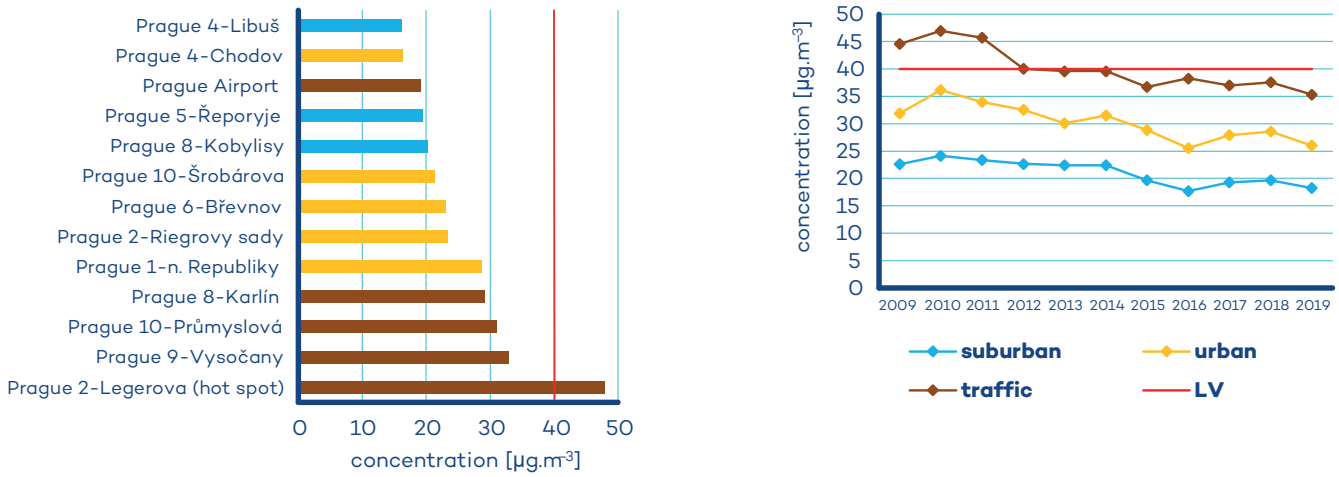

Fig. V.1.5 Annual average NO_2 concentration in 2019 and variation of concentrations in 2009–2019

in the evaluated period 2009–2019. The reason is, similarly to the concentrations of suspended particulates, the occurrence of abnormally high temperatures in the winter months and mostly good dispersion conditions at the end of 2019.

Nitrogen dioxide

The hourly pollution limit value for NO_2 (200 µg.m^{-3}) was not exceeded in 2019 at any of 13 stations relevant for evaluation. The pollution limit value was neither exceeded at any station in Prague (the permitted number of cases exceeding the limit is 18). The highest hourly concentration of 145.6 µg.m^{-3} was measured at the Prague 2-Legerova (hot spot) traffic site at the end of summer holidays on 30 August 2019. Second highest average hourly concentration (143.5 µg.m^{-3}) was measured at the Prague 10-Průmyslová traffic site at the beginning of Easter on 17 April 2019.

The annual pollution limit level for NO_2 (40 µg.m^{-3}) was exceeded at a single station in the Prague agglomeration (Fig. V.1.5). These concerned the traffic station at Prague 2-Legerova (hot spot) where the annual average concentration reached 48 µg.m^{-3}). This traffic station, together with the Prague 5-Smíchov station, experienced exceeding the limit value also in the past years. The Prague 5-Smíchov station could not be included in the assessment of air pollution by NO_2 in the Prague agglomeration in 2019 due to the lack of valid data (measurements at the station were interrupted in April 2019 due to technical reasons)[1]. Nevertheless, it can be assumed that above-limit concentrations of NO_2 may appear

1 http://portal.chmi.cz/files/portal/docs/uoco/web_generator/locality/pollution_locality/loc_ASMI_CZ.html

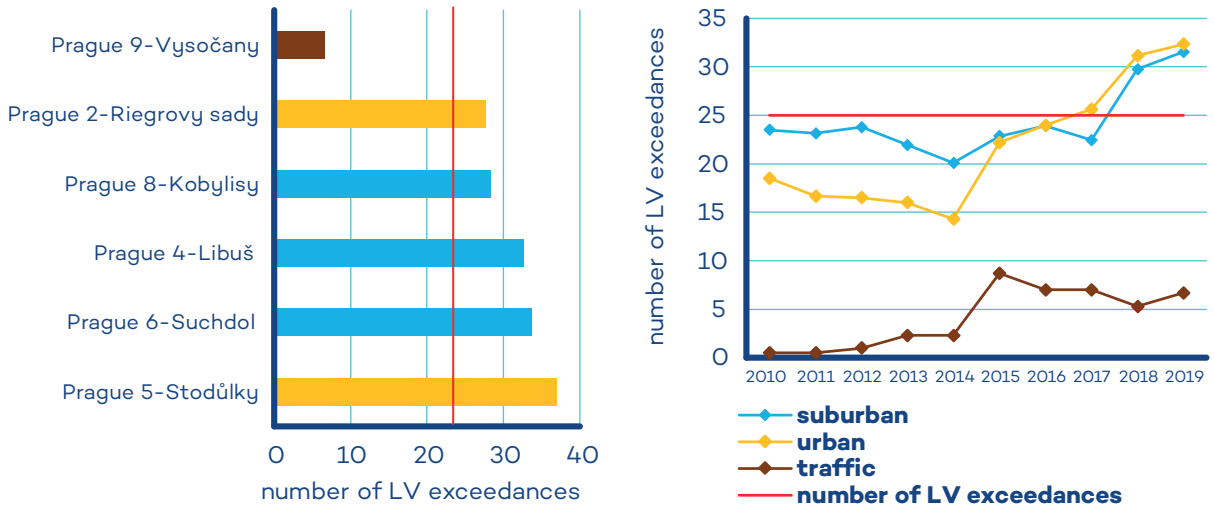

Fig. V.1.6 Number of cases exceeding the pollution limit of O_3 in the average for three years, 2010–2019

also at other exposed traffic locations in the Prague agglomeration equipped with monitoring stations.

The main emission source of nitrogen oxides in Prague is traffic (Fig. V.1.7), which is also reflected in the significantly higher average NO_2 concentrations at traffic sites in comparison with the levels at urban background and at suburban background locations (Fig. V.1.5). In the evaluated period, concentrations reached the peaks at all types of localities in 2010. At traffic locations, the annual average NO_2 concentrations have been gradually decreasing since 2010, and since 2015 their levels have remained below the limit value. In urban and suburban localities, a decrease can be observed between 2010 and 2016, then a slight increase in 2017 and 2018. In 2019, annual average concentrations decreased at all types of stations, at traffic stations they reached the minimum in the period under review. At suburban and city stations, 2019 is the second year with the lowest annual average concentration after 2016.

Ground-level ozone

In 2019, ground-level ozone was measured in 6 localities in the Prague agglomeration. On average in 3 years, 2017–2019, the limit value for ground-level ozone was exceeded at five locations: Prague 5-Stodůlky (37 times), Prague 6-Suchdol (33.7 times), Prague 4-Libuš (32.7 times), Prague 8-Kobylisy (28.3 times) and Prague 2-Riegrovy sady (27.7 times), while the permitted number of cases exceeding the limit value is 25 (Fig. V.1.6). Since 2010, when complete time series of cases exceeding the pollution limit at these sites can be assessed, the limit value was exceeded at the highest number of sites in 2019. In 2018, cases exceeding the limit value were observed at four stations, in 2016–2017 at three stations, in 2010, 2011, 2013 and 2015 only at one, in 2014 even at none. From the point of view of the time variation of the number of cases exceeding the ozone limit value, a stagnating or slightly decreasing trend can be observed from 2010 to 2014, which was interrupted by 2015, when the number of cases exceeding the ozone limit value increased in the average per locality. The upward trend in the following years continued and reached its maximum currently in 2019. In 2015–2019, the increase in ozone pollution characteristics was predominantly due to the above-normal temperature in summer months. Especially 2018 was characterised by temperature above-normal to extremely above-normal and precipitation below-normal in summer months (ČHMÚ 2019), i.e. conditions favourable for creation of ground-level ozone. The year 2019, after 2018, is the second warmest year observed in a series of average values since 1961 (Chap. III). The lowest concentrations are measured in the long-term at the Prague 9-Vysočany traffic station, which corresponds to the ground-level ozone chemistry and fluctuation of its concentration (see Chap. IV.4.3).

Other substances

For other atmospheric pollutants set forth in the legislation (CO, SO_2, benzene, heavy metals), the Prague agglomeration has long been able to meet the pollution limits. After 2000, above-limit average annual arsenic concentration levels were recorded at the Prague 5-Řeporyje locality, for the last time in 2011. Nonetheless, the concentrations of these substances are also affected by the predominant meteorological and dispersion conditions, so that an increase in some pollution level characteristics for these pollutants was recorded, e.g. in 2003, 2006, 2010, 2011 and 2017.

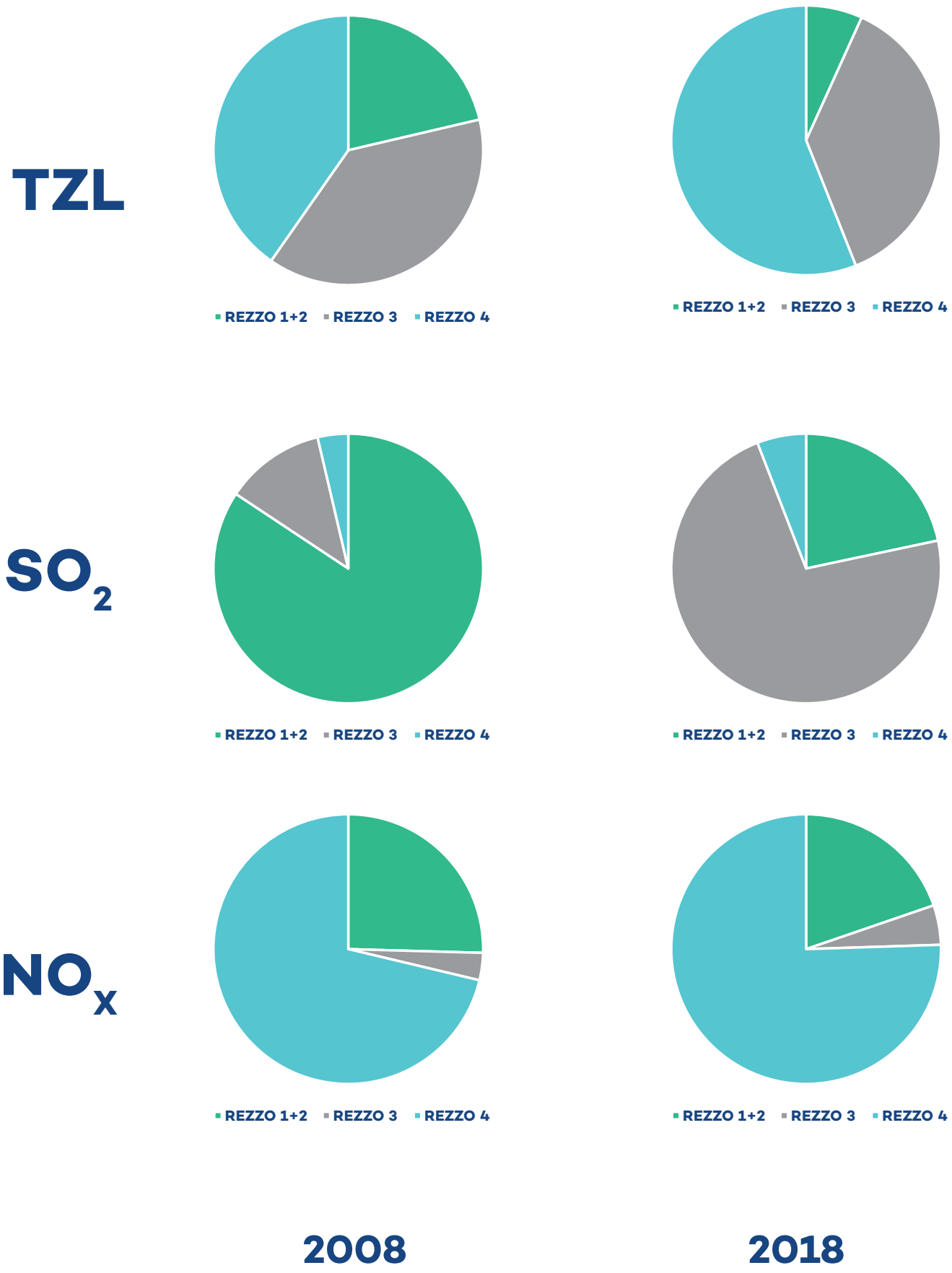

Fig. V.1.7 Emissions of selected pollutants classified according to REZZO, agglomeration of Prague, 2018

V.1.2 Emissions in the Prague agglomeration

At the present time, approx. 1940 places of operation of sources of air pollution included in the REZZO 1 and REZZO 2 databases are individually registered in the territory of the Prague agglomeration. However, only several of them have a substantial effect on overall emissions. These are primarily the Cementárna Radotín, ZEVO Malešice (Pražské služby, a. s.), and other industrial enterprises, such as MITAS, a. s. or Kámen Zbraslav, located at the boundary between Prague and the Central Bohemian region. The sources of TSP also include recycling lines of construction wastes operated either directly at a given location (KARE, Praha, s.r.o., Chodovská) or at other locations of operation, for example, demolitions. Emissions from electricity generation by co-generation units (e.g. WWTP PVaK) continue to increase. Since 2015, the fraction of emissions from the largest heating plants of the Pražská teplárenská, a.s. company in Malešice and Michle decreased substantially, operating only gas-burning boilers already. According to the outputs of SLDB 2011, central heating sources predominate in heating households (52% of households), followed by gas boilers and local gas boilers (together 31% of households). The fraction of heating by electrical energy is significant (approx. 5%), as is that from difficult-to-classify other means (relatively high fraction of approx. 10%). Coal, wood or coke is used as a fuel in only a small part of the housing fund, primarily at the periphery of the city. Similar to housing, there is a prevalence of buildings of the communal sphere connected to central heating sources or having their own gas boilers.

There was a decrease in nearly all monitored emissions at the above-mentioned significant sources in the 2018–2019 period. The only exceptions are NO_x emissions from cement production (Cementárna Radotín). There was a slight increase in reported SPM emissions related primarily to entry into force of the obligation to report emissions from source category 5.11. (production of building materials, recycling lines, etc.), for the first time in 2019. In reality, however, emissions occurred throughout the operation of sources.

The emission load of Prague is rather specific nationwide. Point and areal sources operated in its territory are, with a few exceptions, minor. Following Fig. V.1.7 compiled from data for the year 2018, the greatest share of SPM and SO_2 emissions originates from household heating and of NO_x emissions from traffic. According to the amount of emissions of particular pollutants in 2016 (output of the PZKO processing) in relation to the size of the evaluated area, the Prague agglomeration ranked first in the case of NO_x, VOCs and benzene, second in the case of PM_{10} and lead, third in the case of $PM_{2.5}$, benzo[*a*]pyrene, arsenic, cadmium and nickel, and in seventh place for SO_2.

V.1.3 Summary

The Prague agglomeration is an area where many people are exposed to above-limit air pollution. In the Prague agglomeration, the 24-hour limit values for suspended particulate matter PM_{10} and the annual limit value for nitrogen dioxide have long been exceeded, especially at traffic locations. In the winter months, the limit value for the average 24-hour PM_{10} concentration is often exceeded. The above-limit annual average concentration for benzo[*a*]pyrene in the Prague agglomeration was observed last in 2014 at the Prague 4-Libuš station. Most cases exceeding the pollution limit values correspond to the significant traffic load of the capital city, while local household heating contributes to air pollution during the heating season. In 2019, in contrast to previous years, the 24-hour pollution limit value was not exceeded for the first time in the evaluated period and the annual average concentrations of PM_{10}, $PM_{2.5}$, NO_2 and benzo[*a*]pyrene decreased. The favourable situation in terms of air quality in 2019 is due to mild temperature conditions in the winter months and the occurrence of mostly good dispersion conditions. The renewal of the vehicle fleet and the ongoing replacement of boilers in households also contribute to the improvement of the situation in the Prague agglomeration.

Air pollution by ground-level ozone has a different character — the pollution limit value for ground-level ozone is usually exceeded in the suburban areas of Prague; in 2019 (on average over three years) the limit value was exceeded at five stations out of six, which is so far most in the period since 2010. Smog situations and regulations due to high concentrations of suspended particulate matter PM_{10}, nitrogen dioxide NO_2 and sulphur dioxide SO_2 and smog situations and alerts due to high concentrations of ground-level ozone O_3 were not declared in the Prague agglomeration in 2019 (for details see Chap. V.). In the Prague agglomeration (in 2018), mobile sources account for about 56% of total solid pollutants emissions excluding resuspension, and for about 75% of total nitrogen oxides (NO_x) emissions.