IV.2 Benzo[*a*]pyrene

IV.2.1 Air pollution by benzo[*a*]pyrene in 2020

Air pollution by benzo[*a*]pyrene is one of the main air quality problems in the CR. In 2020, the annual average concentration of benzo[*a*]pyrene exceeded the pollution limit value (1 ng.m^{-3}) at 40% of stations (i.e. 21 of a total of 53 stations with a sufficient number of measurements for evaluation; Fig. IV.2.1). In 2020, the area with above-limit concentrations of benzo[*a*]pyrene decreased again and the pollution limit was exceeded on 4.6% of the area of the CR, with approx. 19% of the population of the CR (in 2019 with approx. 27.5%). The largest reduction of the area exceeding the benzo[*a*]pyrene limit value in comparison with the previous year took place in the Zlín and Olomouc regions. However, as in previous years, a number of towns and municipalities were assessed as areas exceeding the limit value. The regions with the highest concentrations of benzo[*a*]pyrene in the long term remain the Moravian-Silesia, Zlín and Olomouc regions (Fig. IV.2.3).

The highest annual average concentrations of benzo[*a*]pyrene have long been recorded in the whole area of the O/K/F-M agglomeration (Fig. IV.2.4) due to the highest emission loads in the CR (from various types of sources) and the impact of cross-border transmission from Poland. As in previous years, the highest annual average concentration of benzo[*a*]pyrene (7.7 ng.m^{-3}) in 2020 was recorded at the Ostrava – Radvanice ZÚ industrial station, where the limit value was exceeded more than seven times. In addition to regular measurement of benzo[*a*]pyrene at stations of the national air quality monitoring network, other localities are also measured in this area using a subsidy from the budget of the Moravian-Silesia region. In 2020, air pollution was monitored in the Mizerov, Věřňovice[1], Chotěbuz, Ostrava-Hošťálkovice and Opava-Komárov municipalities, where above-limit concentrations of benzo[*a*]pyrene were observed, in some cases even among the highest in the CR (Věřňovice, Mizerov and Chotěbuz). In 2020, a year-round measurement of benzo[*a*]pyrene was also carried out in the municipality of Bolatice, as part of the CHMI research activities, where the third highest annual average benzo[*a*]pyrene concentration in the CR was measured. Resulting measurements at these localities of the Moravian-Silesia region in 2020 confirmed model data on the area distribution of concentrations of suspended particles and benzo[*a*]pyrene in the area of the Czech-Polish border. Especially in the case of benzo[*a*]pyrene concentrations in the Czech-Polish border area of interest, pollution dominates the adjacent Polish part of southern Silesia. The impact of transboundary pollution transport is most pronounced in the concentration levels measured in the valley localities of border ri-

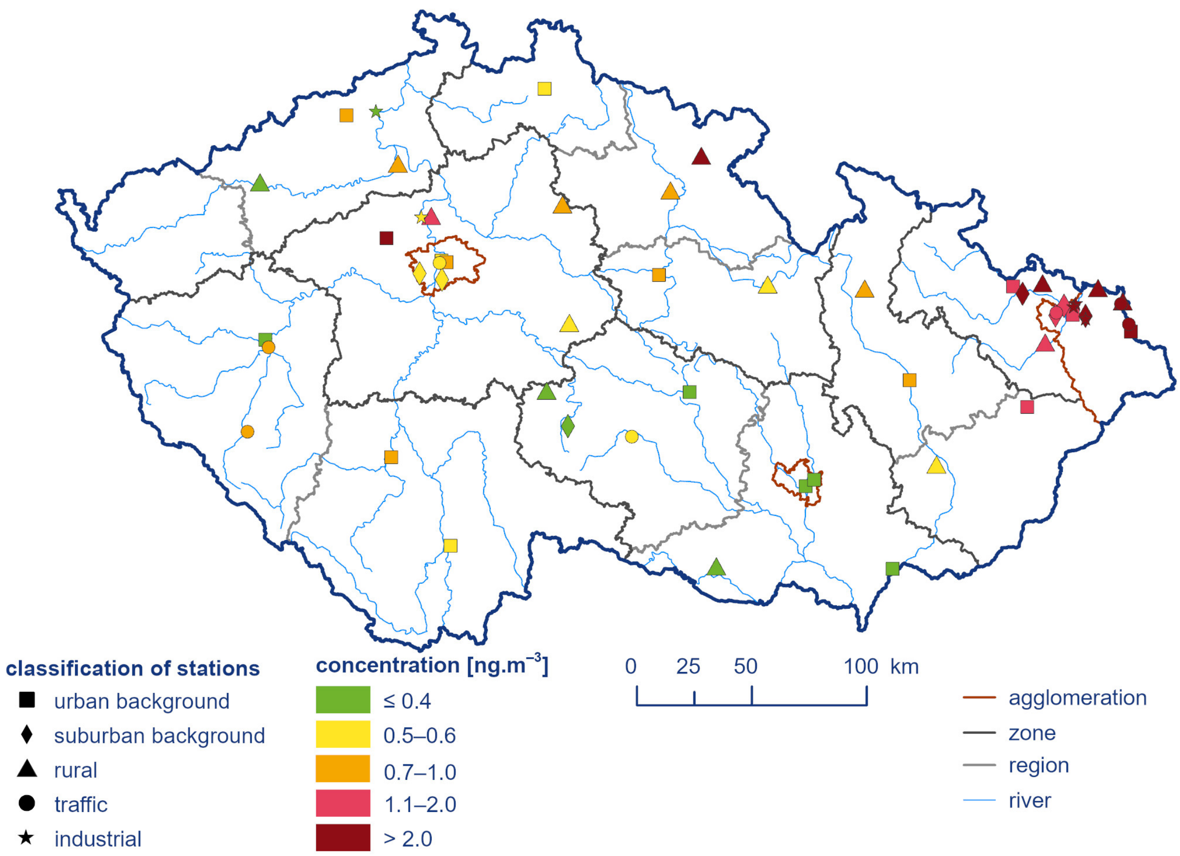

Fig. IV.2.1 Annual average concentrations of benzo[*a*]pyrene at air quality monitoring stations, 2020

1 https://www.chmi.cz/files/portal/docs/poboc/OS/OCO/prehledy/mizerov_vernovice/prhl_kraj12.htm

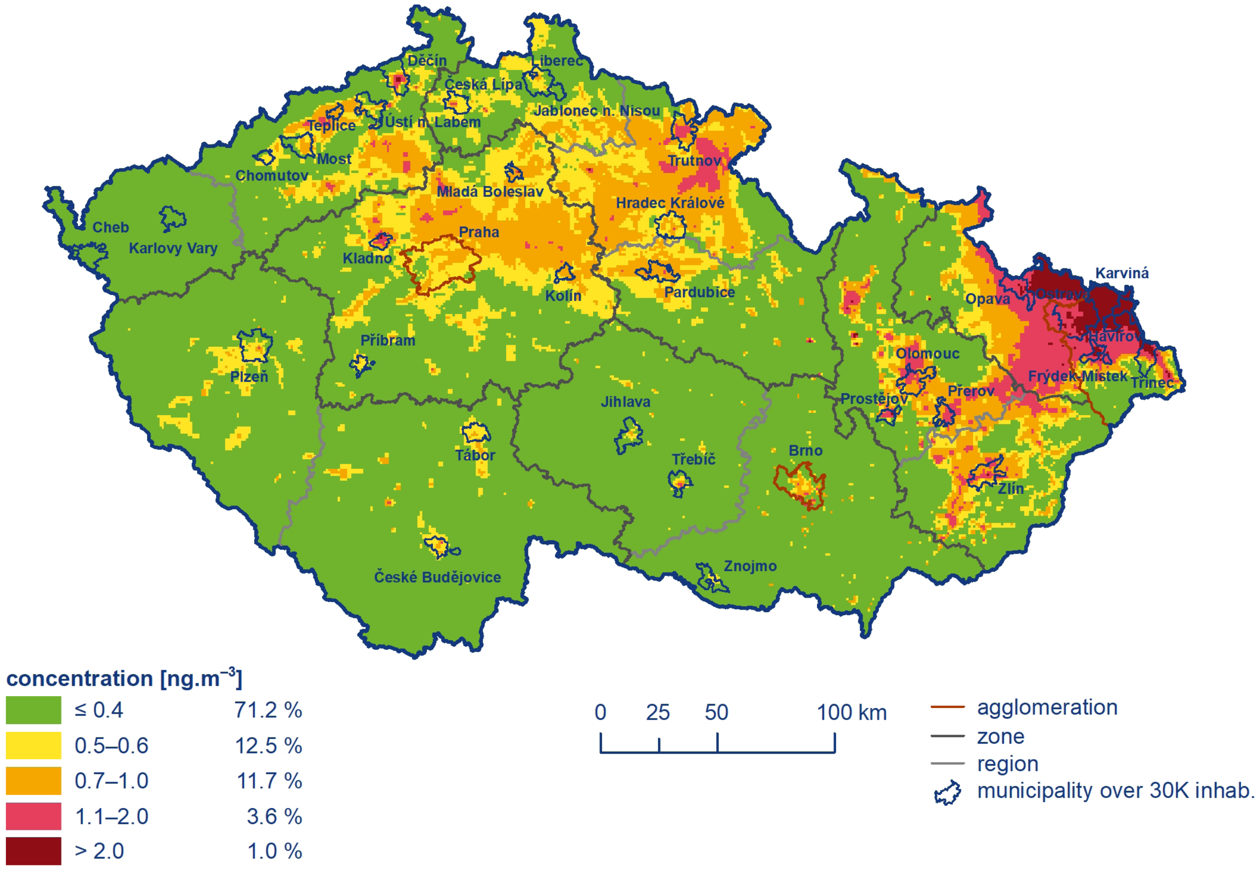

Fig. IV.2.2 Field of annual average concentration of benzo[a]pyrene, 2020

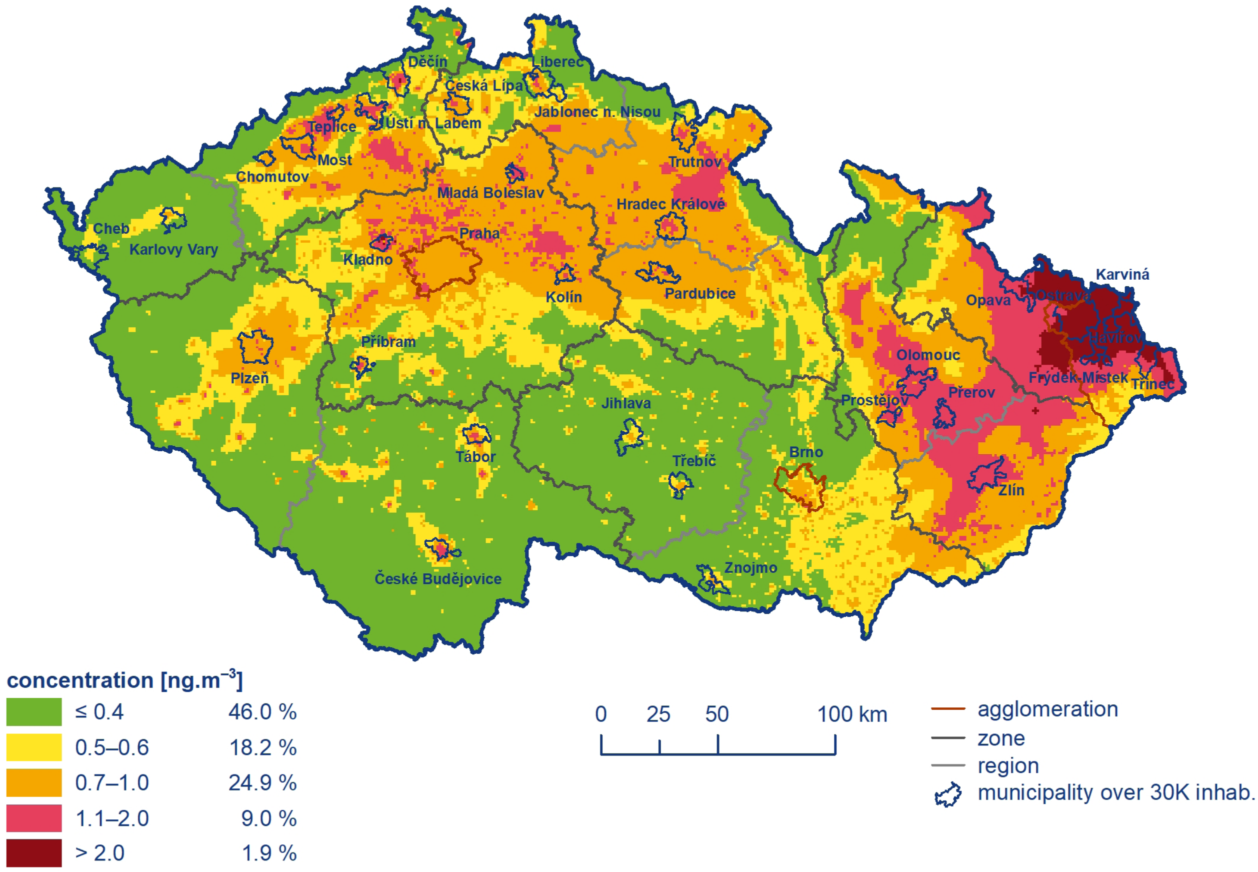

Fig. IV.2.3 Five-year average of annual average concentrations of benzo[a]pyrene, 2016–2020

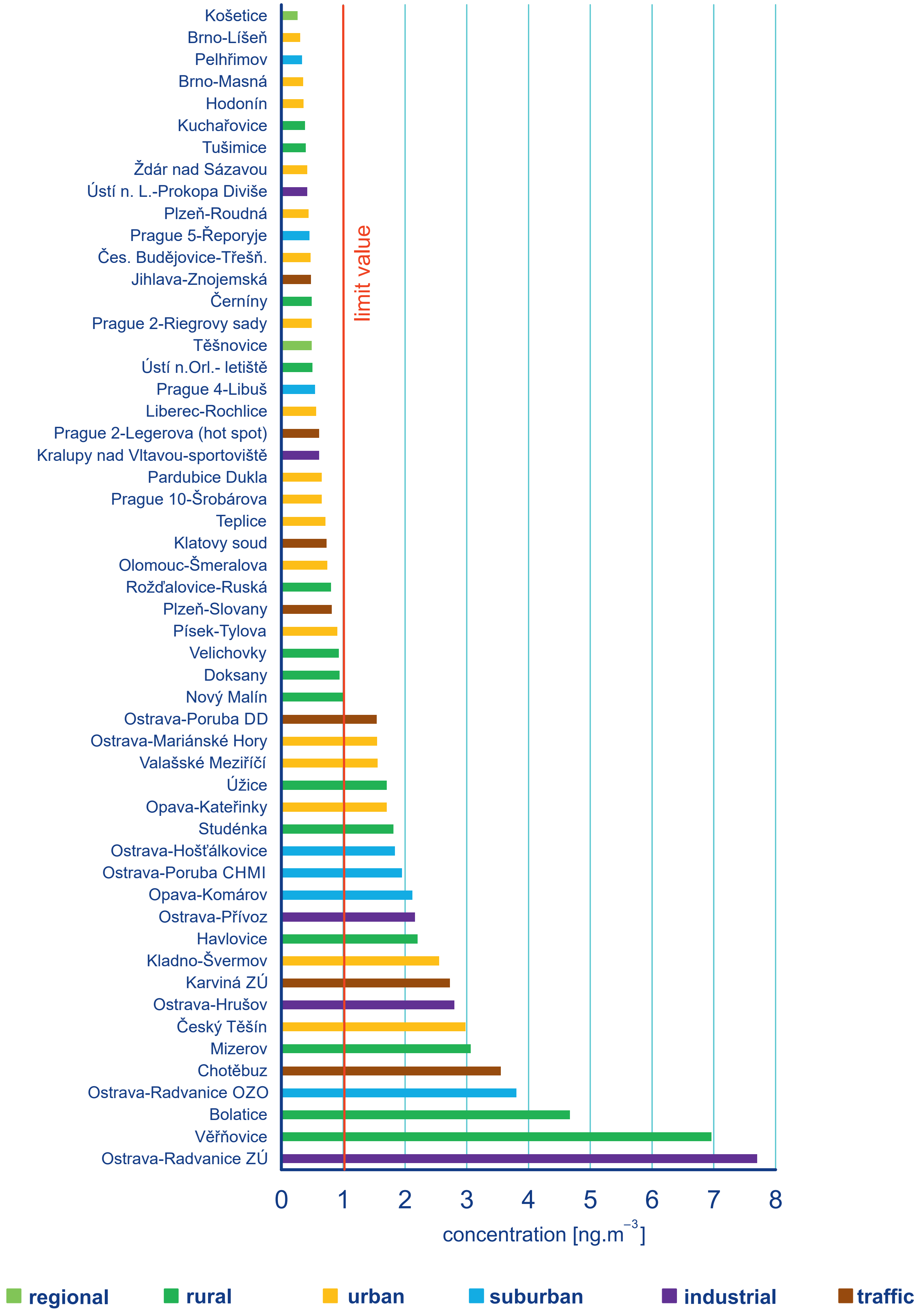

Fig. IV.2.4 Annual average concentrations of benzo[*a*]pyrene at monitoring stations, 2020

vers, which are comparable to the industrial localities in Ostrava. The concentration gradient between Polish and Czech localities is clearly documented by the CHMI report on measurements in the aforementioned area.

Apart from the O/K/F-M agglomeration, higher concentrations of benzo[*a*]pyrene linked to dense built-up areas of family houses with local heating units close to a monitoring station were recorded in the Kladno area (Kladno – Švermov urban station). Above-limit values can also be expected in other municipalities with a higher proportion of household heating with solid fuels where benzo[*a*]pyrene is not routinely measured. This is evidenced, for example, by benzo[*a*]pyrene measurements in Havlovice in the Hradec Králové region with an annual average benzo[*a*]pyrene concentration of 2.2 ng.m^{-3}, which is more than twice the limit value. On the contrary, lower annual average concentrations of benzo[*a*]pyrene are observed in the South Moravia and Vysočina regions. Below-limit values of benzo[*a*]pyrene concentrations are also measured in large cities (Prague, Brno, Plzeň, České Budějovice), i.e. in cities with a high proportion of remote central heating. The lowest average annual concentration of benzo[*a*]pyrene (0.3 ng.m^{-3}) was observed at the Košetice regional station, which monitors background concentrations of polluting substances in the CR. Regional localities are not directly affected by local emission sources, but are only affected by the long-range transport of pollutants in combination with meteorological and dispersion conditions. Low concentrations of benzo[*a*]pyrene can therefore be expected also in places away from the direct impact of emission sources and in well-ventilated localities (natural mountain areas).

It must be borne in mind that the estimates of annual average benzo[*a*]pyrene concentrations (Fig. IV.2.2) is accompanied by considerably greater uncertainties than for the other evaluated substances. The uncertainty in the map is due in part to the limited number of measurements at rural regional stations and the absence of more extensive measurements in smaller settlements

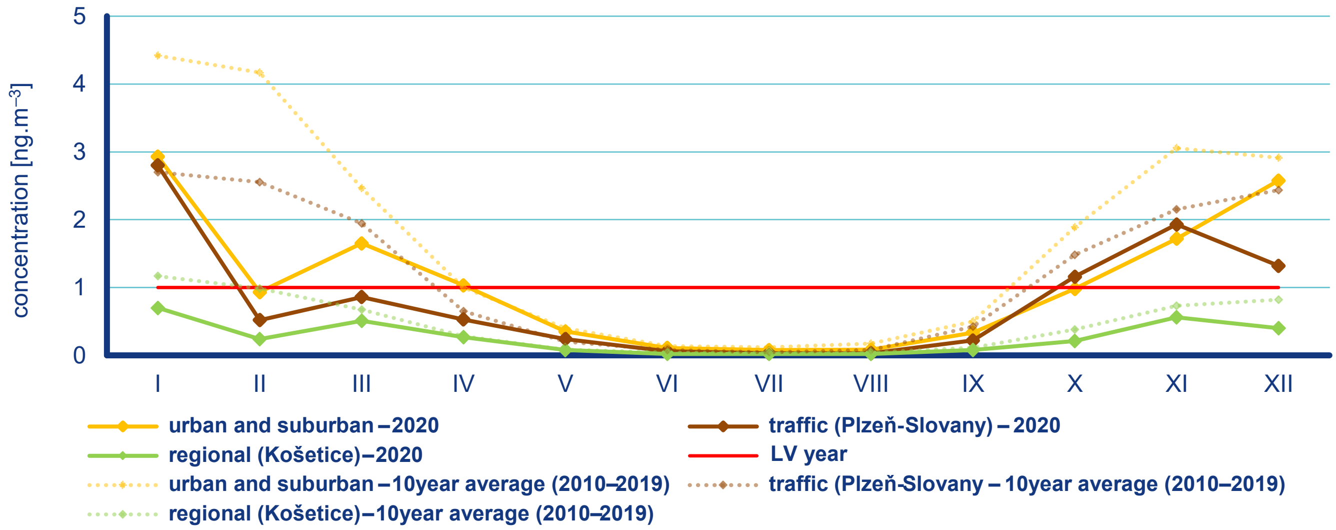

Fig. IV.2.5 Annual course of average monthly concentrations of benzo[*a*]pyrene (averages for a given type of station), 2020

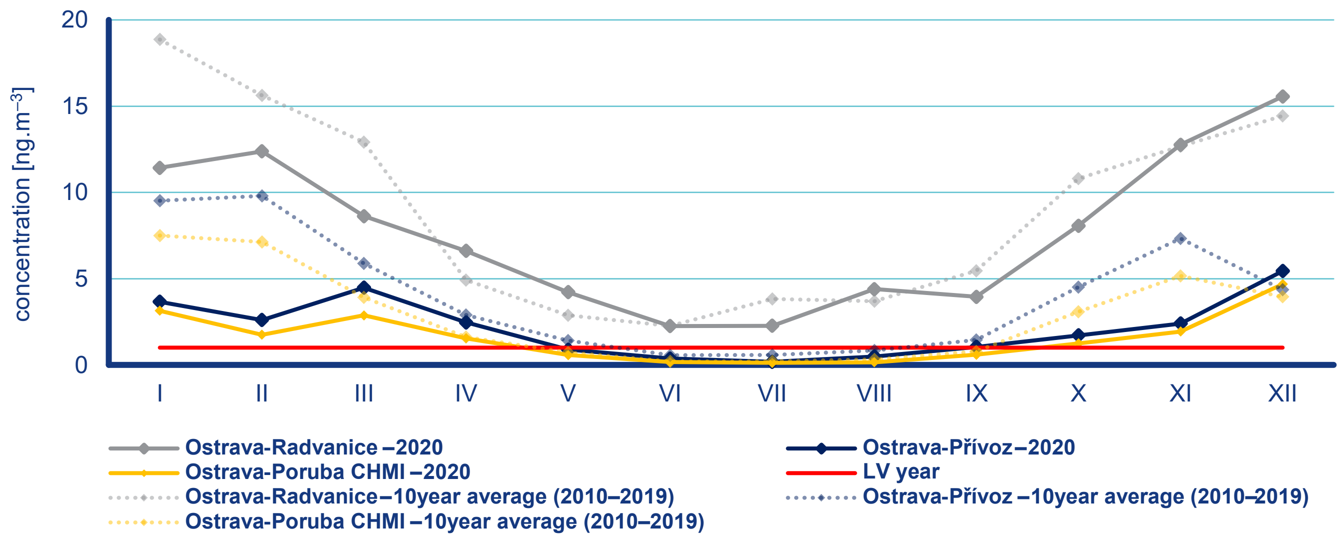

Fig. IV.2.6 Annual course of average monthly concentrations of benzo[*a*]pyrene at Ostrava-Radvanice, Ostrava-Přívoz and Ostrava-Poruba CHMI

in the CR, where the effect of local heating units on air pollution by benzo[*a*]pyrene would be demonstrated. The CHMI is trying to counter this by using rotating stations, which will allow the monitoring of multiple sites over a period of several years. The assessment of the year-on-year change in the extent of the territory affected and population exposed to above-limit concentrations of benzo[*a*]pyrene is also accompanied by greater uncertainty. The number of stations with measurements of benzo[*a*]pyrene is limited particularly by the high costs of laboratory analyses and the capacity of laboratories for processing benzo[*a*]pyrene samples. The uncertainties in the maps are described in detail in Annex I.

Benzo[*a*]pyrene concentrations exhibit a distinct annual variation (Fig. IV.2.5, Fig. IV.2.6), with maxima in winter that are related to emissions from seasonal anthropogenic sources – local heating units (i.e. the most significant source of benzo[*a*]pyrene emissions; Fig. IV.2.9) and worsened dispersion conditions. The annual variation of monthly benzo[*a*]pyrene concentrations clearly reflects the effect of emissions from local heating, with a rate (or intensity) influenced by the number of heating days during the heating season, which determines fuel consumption and can be expressed using so-called degree-days. The value of the annual average benzo[*a*]pyrene concentration at all stations except industrial stations in the O/K/F-M agglomeration, respecting a set limit value, is significantly influenced by concentration levels during the cold period of the year, as benzo[*a*]pyrene concentrations are minimal in summer months. In summer, concentrations decrease due to improved dispersion conditions, increased chemical and photochemical decomposition of PAHs at higher levels of solar radiation and high temperatures, and naturally mainly due to decreased emissions from anthropogenic sources (Li et al. 2009; Ludykar et al. 1999; Teixeira et al. 2012). Based on a comparison of the monthly averages of benzo[*a*]pyrene concentrations with the ten-year average (2010–2019) shows that average monthly concentrations at urban and suburban background stations were lower in all months of 2020 (Fig. IV.2.5). A significant decrease in benzo[*a*]pyrene concentrations (by almost 3.2 $ng.m^{-3}$, i.e. by 80% compared to the ten-year average 2010–2019) at urban and suburban background stations occurred in February due to atypical meteorological and dispersion conditions in the month. Significantly improved dispersion conditions, extremely above-average temperatures, and above-normal precipitation establish a combination of three fundamental factors that strongly reduce the level of pollutants in the air. Significantly lower monthly benzo[*a*]pyrene concentrations compared to the long-term average were also observed in January (1.5 $ng.m^{-3}$, 34% lower), October (0.9 $ng.m^{-3}$, 48% lower), and November (1.3 $ng.m^{-3}$, 44% lower). The monthly benzo[*a*]pyrene concentration in December at background stations was lower by only 0.3 $ng.m^{-3}$ (approx. 12%), mainly due to increased monthly benzo[*a*]pyrene concentrations at stations in the O/K/F-M agglomeration (Fig. IV.2.6). The annual trend of monthly concentrations at the Košetice regional station is similar to that at suburban and urban stations, but with significantly lower values of benzo[*a*]pyrene concentrations.

Fig. IV.2.7 Annual average concentration of benzo[*a*]pyrene at selected stations, 2010–2020

Fig. IV.2.6 shows the annual variation of the monthly average benzo[*a*]pyrene concentrations at the Ostrava-Přívoz and Ostrava-Radvanice ZÚ industrial stations, where in addition to the cross-border transmission of pollution from Poland typical for the entire Ostrava-Karviná area, there is an enormous emission load from a combination of sources from local heating and industry. For comparison, the graph also shows data from the Ostrava-Poruba CHMI background urban station, which monitors the level of background concentrations in the city of Ostrava. At the Ostrava-Přívoz station, a significant decrease in monthly concentrations in the winter months at the beginning of the year was observed compared to the long-term average, and the monthly average benzo[*a*]pyrene concentrations were lower in all months except December. Compared to the city background station Ostrava-Poruba CHMI, the values at the Ostrava-Přívoz station are slightly higher, however, the annual variation is similar for both stations. Monthly concentrations of benzo[*a*]pyrene at the Ostrava-Radvanice ZÚ station are several times higher than at the Ostrava-Přívoz and Ostrava-Poruba CHMI stations and fluctuate in comparison to the long-term average 2010–2019. The largest decrease in benzo[*a*]pyrene concentrations compared to the long-term average 2010–2019 at the Ostrava-Radvanice ZÚ station was recorded in January (7.4 $ng.m^{-3}$, 39% lower), in February (3.3 $ng.m^{-3}$, 21% lower), although less pronounced compared to other stations, and in March (4.3 $ng.m^{-3}$, 33% lower). On the contrary, the largest increase in concentrations was recorded in April (by 1.7 $ng.m^{-3}$, 34% higher) and in May (by 1.3 $ng.m^{-3}$, 46% higher).

Concentrations above 1 $ng.m^{-3}$ occur at industrial stations in the O/K/F-M agglomeration throughout the year, including the summer months, which demonstrates the year-round impact of emissions from industry in the area.

In December, higher average concentrations of benzo[*a*]pyrene were recorded at all three aforementioned stations in the O/K/F-M agglomeration compared to the long-term average. In addition to worsened dispersion and meteorological conditions, the higher concentrations were probably due to the higher intensity of heating resulting from the population stay in the home environment during the emergency (Annex II).

IV.2.2 Trends in benzo[*a*]pyrene concentrations

Benzo[*a*]pyrene concentrations at individual types of stations is evaluated for the period of the last 11 years, i.e. 2010–2020. The average annual concentrations of benzo[*a*]pyrene at localities have been fluctuating during the evaluated period, with a decline seen in areas of the highest air pollution load (the Kladno area and the O/K/F-M agglomeration) (Fig. IV.2.7). In the year-on-year comparison of 2019/2020, benzo[*a*]pyrene concentrations decreased at 24 of 32 stations (i.e. at 75% of stations) with data available for both years compared. The most significant decrease was recorded at the Ostrava Radvanice ZÚ industrial station, namely by 1 $ng.m^{-3}$ (13%). However, concentrations of benzo[*a*]pyrene there still exceed the limit value by almost seven times. There was no increase in the annual average concentration of benzo[*a*]pyrene at any station in 2020.

Annual average concentrations of benzo[*a*]pyrene at all types of stations were the lowest in 2020 for the evaluated period 2010–2020 (Fig. IV.2.8); however, in some cities they still remained above the limit level. Compared to the ten-year average 2010–2019, there was a decrease in benzo[*a*]pyrene concentrations at all types of stations except industrial stations in 2020, by an average of about 30%. At most stations where benzo[*a*]pyrene has been monitored for a long time, the lowest values of annual average concentrations for the entire observation period were recorded in 2020. The improvement was mainly due to atypical meteorological and dispersion conditions in February, when the most significant decreases in monthly benzo[*a*]pyrene concentrations were recorded, as well as declining fuel consumption due to rising winter temperatures in recent years. The decrease in benzo[*a*]pyrene concentrations is also due to measures implemented to improve

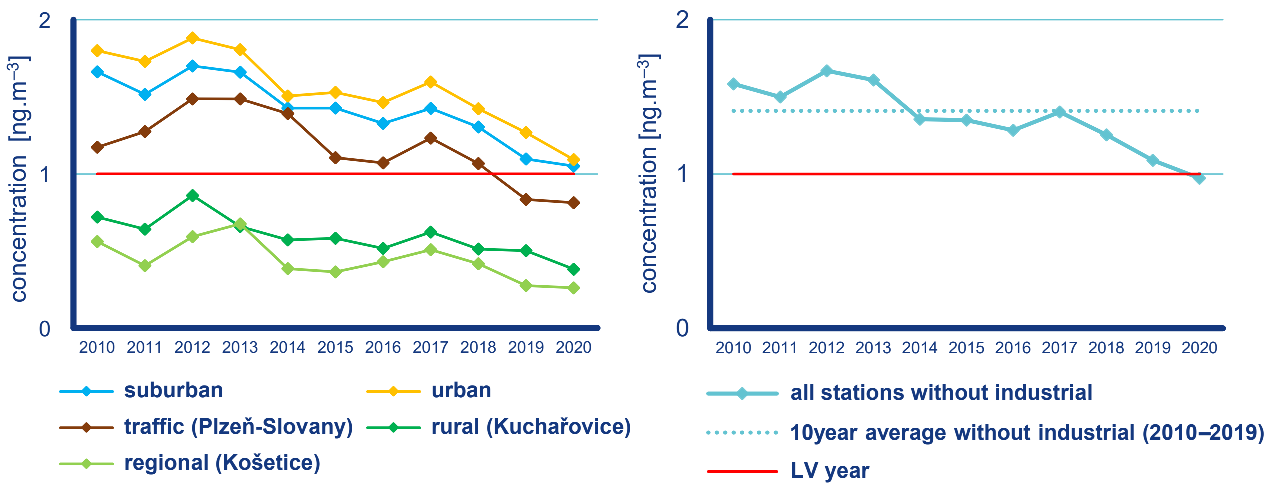

Fig. IV.2.8 Annual average concentration of benzo[*a*]pyrene at particular types of stations, 2010–2020

air quality, especially the renewal of boilers in households. The evaluation of the impact of the implemented measures is examined within the project TITSMZP704 – Measurement and analysis of air pollution with emphasis on the evaluation of the share of individual groups of sources – financed with state support of the Technology Agency of the CR under the BETA2 Program. An evaluation of the impact of the measures implemented is examined within the project TITSMZP704 – Measurement and analysis of air pollution with emphasis on the evaluation of the share of individual groups of sources – funded with state support of the Technology Agency of the CR under the BETA2 Program, the results of which will be available at the end of 2021.

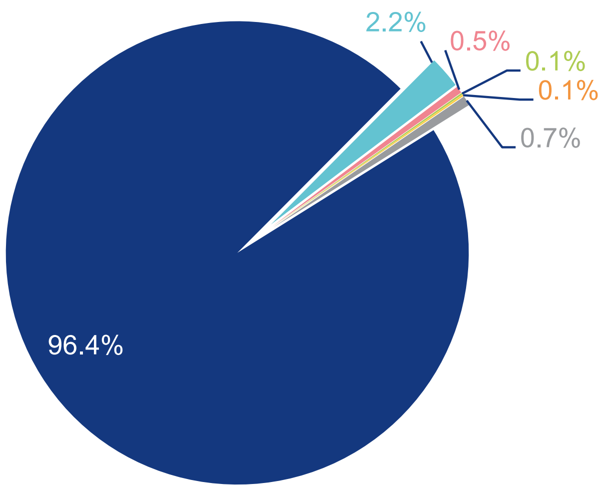

Fig. IV.2.9 Share of NFR sectors in total benzo[*a*]pyrene emissions, 2019

IV.2.3 Emissions of benzo[*a*]pyrene

PAHs, of which benzo[*a*]pyrene in particular is monitored in view of air protection, are produced almost exclusively by combustion processes during which the organic combustible substances present are not sufficiently oxidised. Benzo[*a*]pyrene is a product of incomplete combustion at temperatures of 300 to 600 °C. Thus, one of its most important sources is the combustion of solid fuels in low-capacity boilers, particularly household heating systems.

In view of predominant contribution of the sector 1A4bi – Residential: Heating, water heating, cooking, emissions of benzo[*a*]pyrene are distributed over the territory of residential buildings throughout the CR, and their amounts in the 2010–2019 period depended primarily on trends of consumption of solid fuels in households (Fig. IV.2.10). An estimate of emissions from open burning of waste (NFR 5C2) has newly been added for the entire period, which accounted for 2.24% of total emissions in 2019. The impact of transportation is apparent mainly along motorways, roadways with high traffic and in the territories of larger urban units. The greatest burden from emissions of benzo[*a*]pyrene occurs in the Moravian-Silesia region due to the higher proportion of black coal combustion in bulk-burning type household boilers as well as presence of the metallurgical industry and coke production.

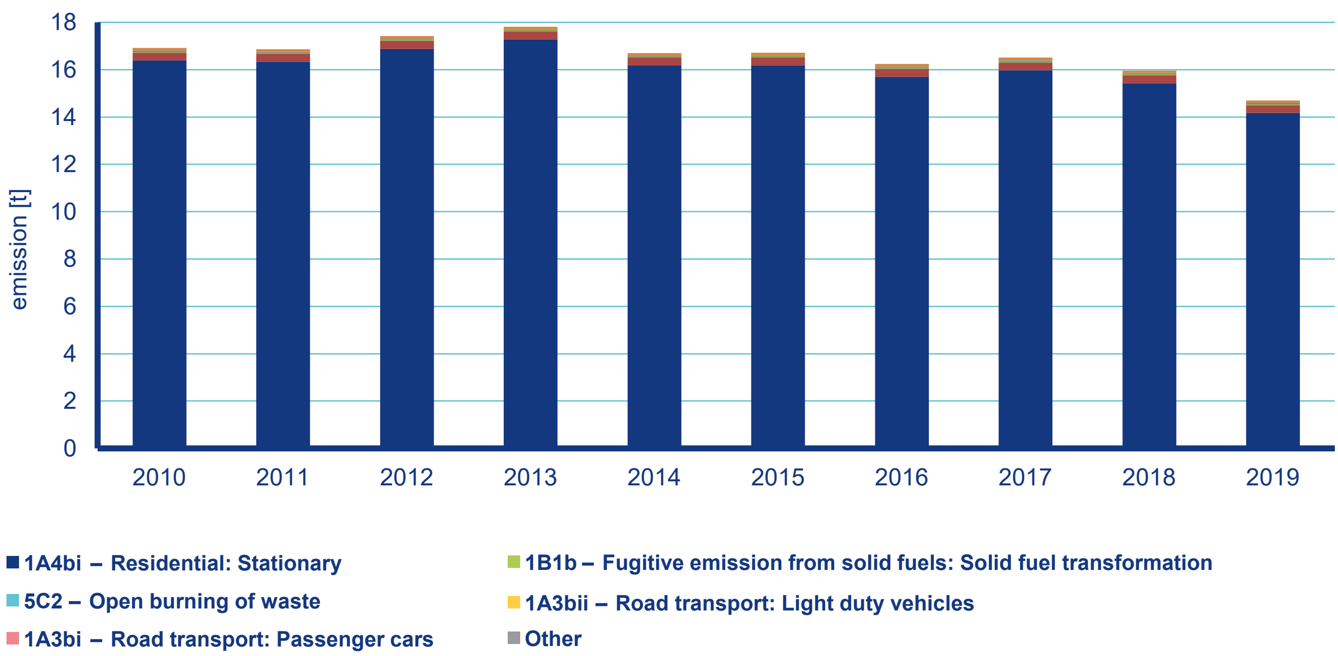

Fig. IV.2.10 Benzo[*a*]pyrene total emissions, 2010–2019