IV.2 Benzo[*a*]pyrene

IV.2.1 Air pollution by benzo[*a*]pyrene in 2019

Air pollution by benzo[*a*]pyrene is one of the main air quality problems in the Czech Republic. In 2019, the annual average concentration of benzo[*a*]pyrene exceeded the pollution limit value (1 ng.m^{-3}) at 41% of stations (i.e. 19 of a total of 46 stations with sufficient number of measurements for evaluation; Fig. IV.2.1). Thus, in the year-on-year comparison 2018/2019, there was a further decline, as in 2018 exceeding of the limit was recorded at 58% of stations (in 2017 at 66%). A number of cities and municipalities, similar to previous years, were evaluated as territories where the pollution limit levels were exceeded (Fig. IV.2.2). In 2019, the area with above-limit concentrations of benzo[*a*]pyrene decreased and the pollution limit was exceeded on 8.4% of the area of the Czech Republic (in 2018 on 13% of the area of the CR) with approx. 27.5% of the population of the CR (in 2018 with approx. 35.6%). The largest decrease of the area in which the limit value of benzo[*a*]pyrene was exceeded in comparison with the previous year 2018 occurred in the Krušné hory and Kladno areas. The regions with the highest concentrations of benzo[*a*]pyrene remain the Moravian-Silesia, Zlín and Olomouc regions (Fig. IV.2.3).

It must be borne in mind that the estimate of the fields of annual average concentrations of benzo[*a*]pyrene (Fig. IV.2.2) is accompanied by considerably greater uncertainties than for the other evaluated substances. Limited number of measurements at rural regional stations and the absence of more extensive measurements in smaller settlements in the Czech Republic where the air pollution by benzo[*a*]pyrene would demonstrate the fundamental effect of local heating units take also part in the uncertainty of the map. The CHMI is trying to counter this effect with the method of rotating stations which will allow monitoring of multiple sites over a period of several years. Thus, 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 a capacity of laboratories for processing the benzo[*a*]pyrene samples. The uncertainties in the maps are described in detail in Annex No. 1.

The highest annual average concentrations of benzo[*a*]pyrene have long been recorded in the whole area of the Ostrava/Karviná/Frýdek-Místek agglomeration (O/K/F-M) (Fig. IV.2.4) due to the highest emission load in the Czech Republic (from various types of sources) and the impact of cross-border transmission from Poland (for details see Chap. V.3). As in previous years, in 2019 also, the highest annual average concentration of benzo[*a*]pyrene (8.7 ng.m^{-3}) was recorded at the Ostrava – Radvanice ZÚ industrial station where the limit value was thus exceeded more than eight times. Apart from the O/K/F-M

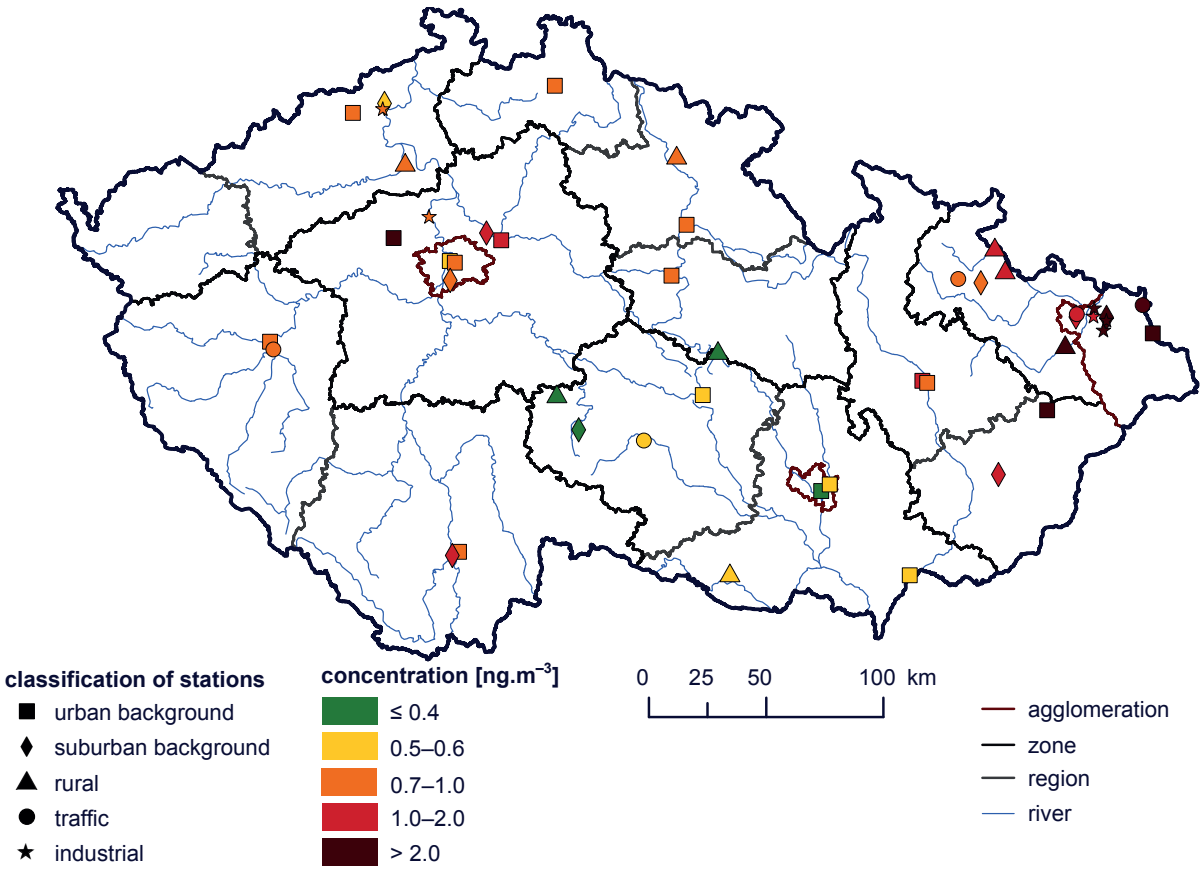

Fig. IV.2.1 Annual average concentrations of benzo[*a*]pyrene in the ambient air quality network, 2019

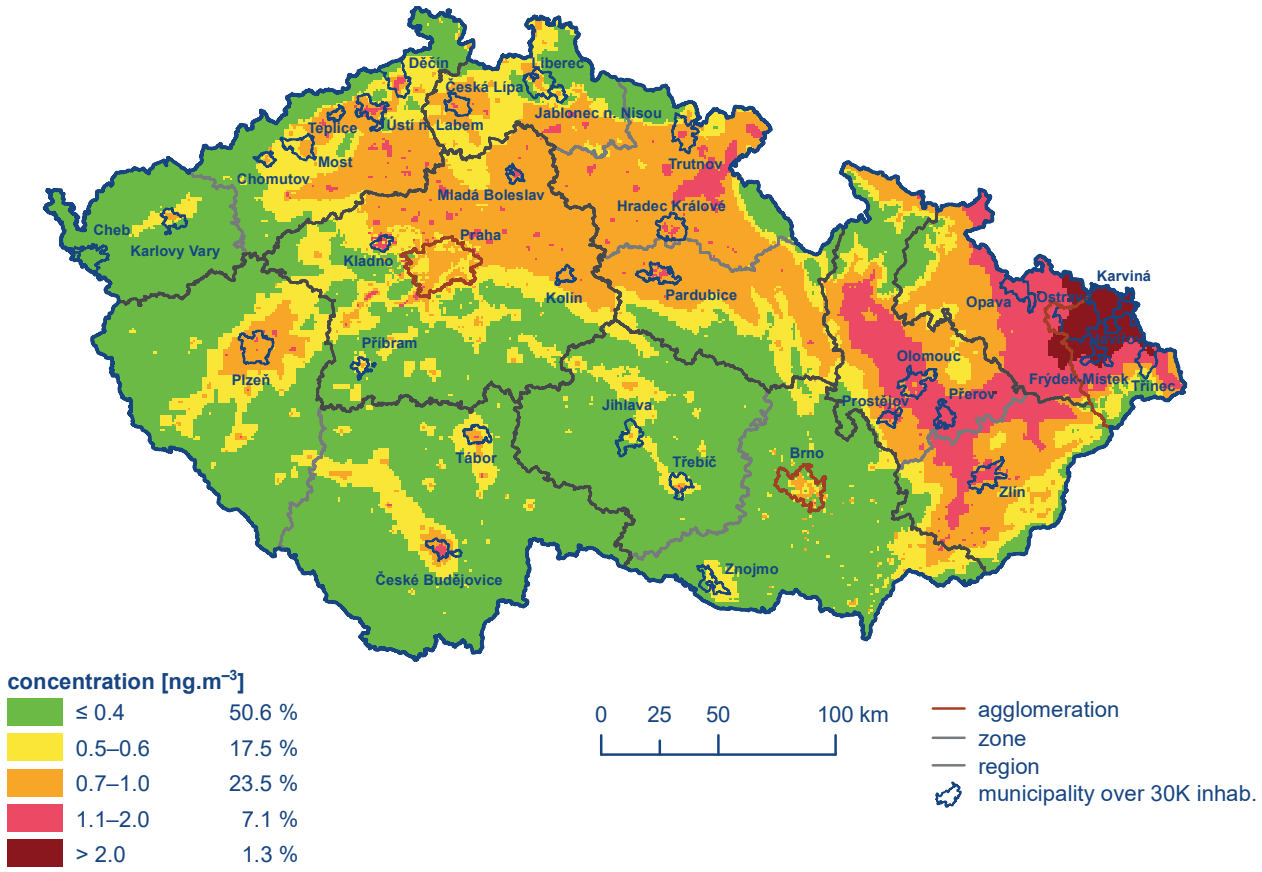

Fig. IV.2.2 Field of annual average concentration of benzo[*a*]pyrene, 2019

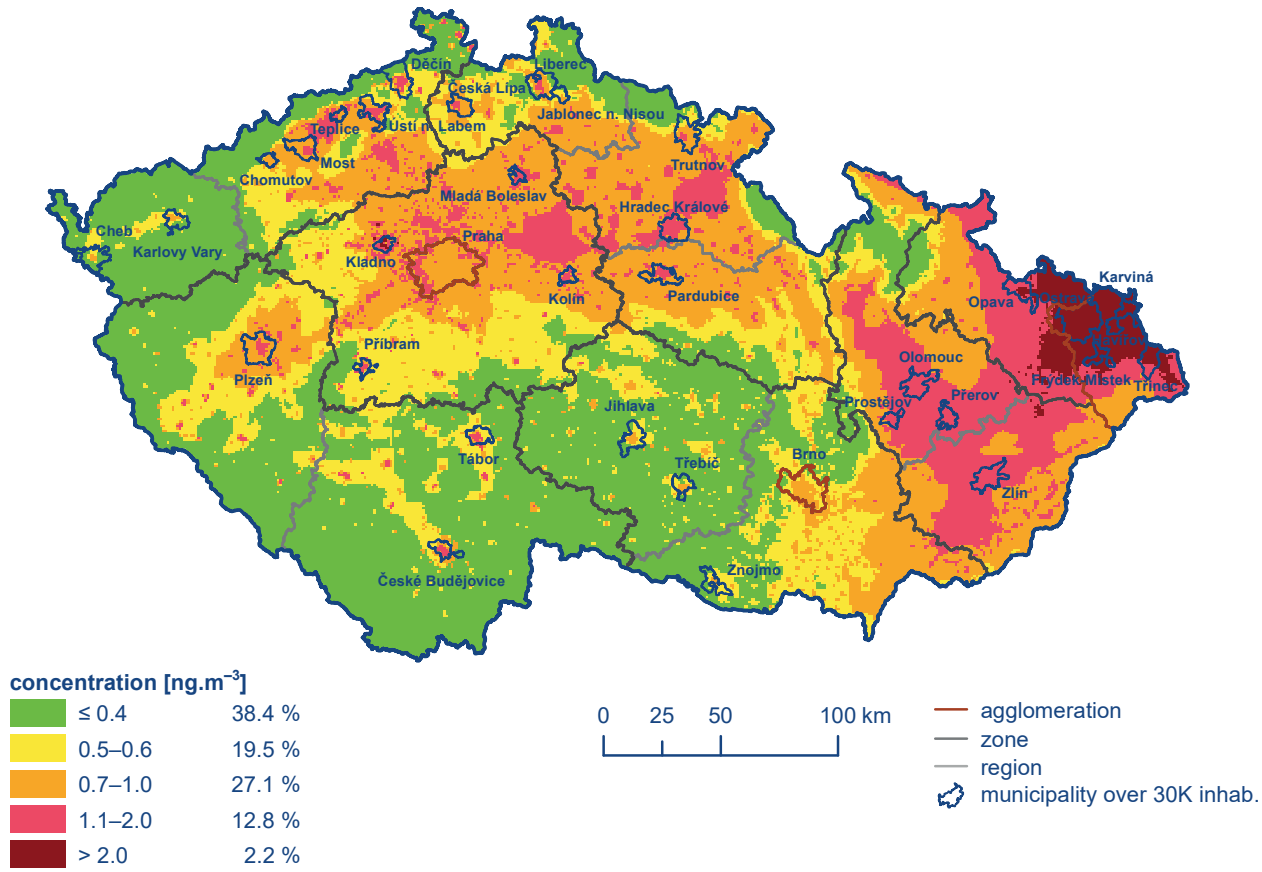

Fig. IV.2.3 Five-year average of annual average concentrations of benzo[*a*]pyrene, 2015–2019

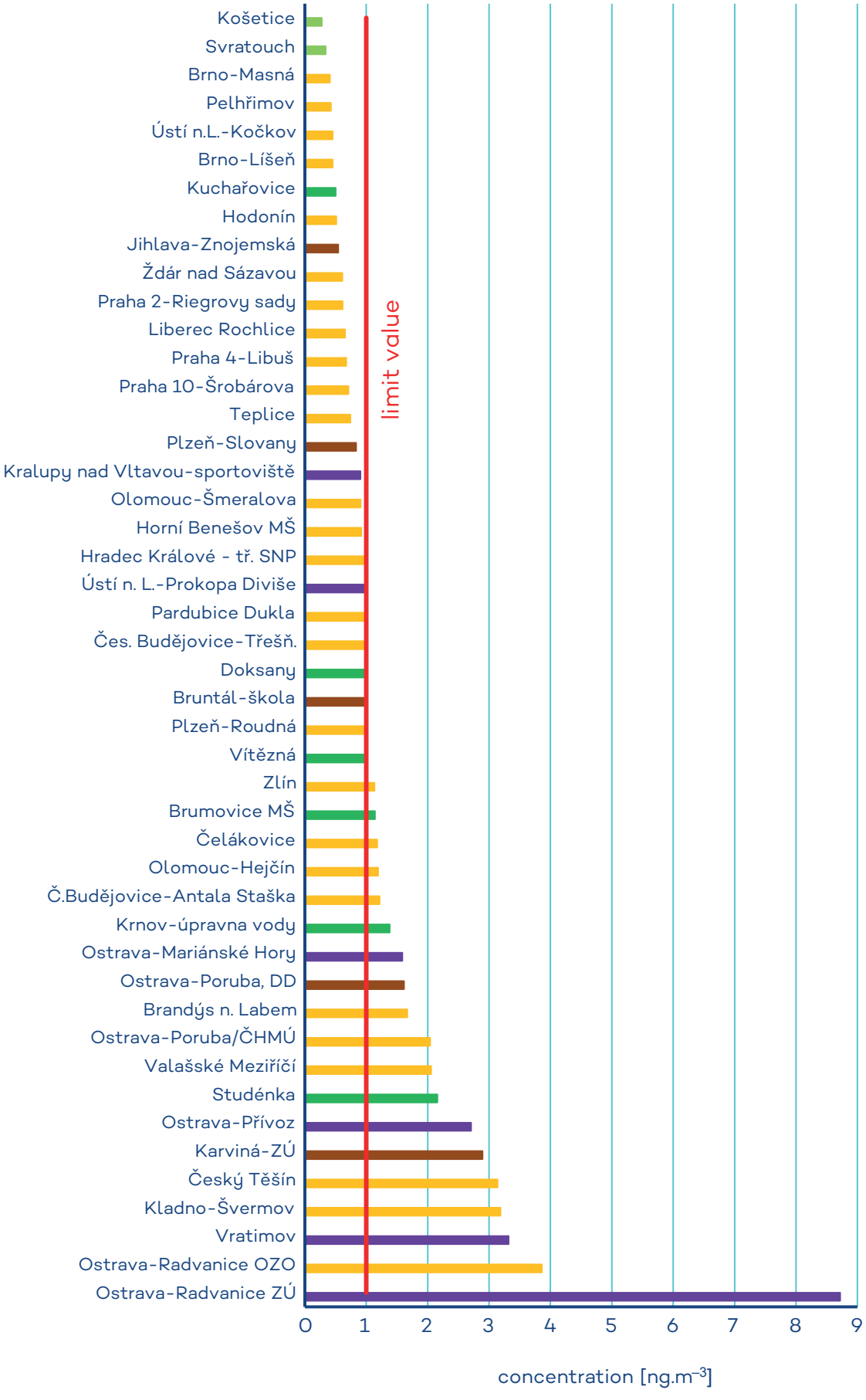

Fig. IV.2.4 Annual average concentrations of benzo[*a*]pyrene at monitoring stations, 2019

agglomeration, higher concentrations of benzo[*a*]pyrene linked to the dense built-up area of family houses with local heating units close to the monitoring station are recorded in the Kladno area (Kladno – Švermov station). Above-the-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. On the contrary, the lowest annual average concentrations of benzo[*a*]pyrene can be expected in places distant of direct exposure to emission sources and well ventilated localities (natural mountain areas). The lowest average annual concentration of benzo[*a*]pyrene (0.3 ng.m^{-3}) was observed at the Košetice and Svratouch regional stations, i.e. stations that monitor background concentrations of polluting substances in the Czech Republic. These stations 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. Below-limit values of benzo[*a*]pyrene concentrations are also recorded in large cities with congested traffic (Prague, Brno) where this traffic does not have a major increasing effect on the average annual benzo[*a*]pyrene concentrations, similarly as a link to local heating, because there is a high proportion of remote central heating in these cities.

On the contrary, exposure to above-limit levels of benzo[*a*]pyrene occurs also in municipalities in which its concentrations are not routinely monitored. This is repeatedly confirmed by measurement of concentrations of benzo[*a*]pyrene at various stations subsidized from the budget of the Moravian-Silesia region[1], such as Krnov (1.4 ng.m^{-3}) and Bruntál-škola (1.0 ng.m^{-3}) in 2019, Třinec-Konská (3.1 ng.m^{-3} in $PM_{2.5}$) and Třinec-Nebory (2.4 ng.m^{-3} in $PM_{2.5}$) in 2018 and Český Těšín-bus station (4.4 ng.m^{-3}), Vražné (3.3 ng.m^{-3}), and Opava-University garden (1.8 ng.m^{-3}) in 2017. High values of daily benzo[*a*]pyrene concentrations in winter months associated with local heating of households were also recorded during three-year (2015–2017) campaign measurements in small settlements of Ostopovice and Moravany in the South Moravia region (CHMI 2018). On the basis of the above observations, it can be assumed that in small settlements where benzo[*a*]pyrene concentrations are not regularly monitored and where solid fuel heating predominates, carcinogenic benzo[*a*]pyrene levels may reach above the limit level.

Benzo[*a*]pyrene concentrations exhibit a distinct annual variation (Fig. IV.2.5) 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 course of monthly benzo[*a*]pyrene concentrations clearly copies the effect of emissions from local heating, the rate (or intensity) of which is mainly influenced by the number of heating days during the heating season, which determines fuel consumption and can be expressed using so-called degree-days. In summer, on the other hand, concentrations decrease due to improved dispersion conditions, increased chemical and photochemical decomposition of PAHs at higher levels of solar radiation and high temperatures, and of course mainly due to decreased emissions from anthropogenic sources (Li et al. 2009; Ludykar et al. 1999; Teixeira et al. 2012). The average monthly concentrations of benzo[*a*]pyrene in summer at background stations often range around the limit of detection (0.03 ng.m^{-3}) while at industrial locations in the agglomeration (O/K/F-M) daily concentrations reach even more than 1 ng.m^{-3} which shows the year-round effect of emissions in these areas. A comparison of the monthly averages of benzo[*a*]pyrene concentrations with ten-year average (2009–2018) shows that the average monthly concentrations at urban and suburban background stations were lower (by about 20–60%) in all months of the year except April and May when they remained at a similar level. Significant decrease in benzo[*a*]pyrene concentrations at urban and suburban background stations occurred especially in the winter months. The decrease in concentrations can be attributed to a decrease in benzo[*a*]pyrene emissions from local furnaces, a decrease in the number of heating days in individual months and good dispersion conditions, but also to measures already implemented (e.g. boiler replacement). The evaluation of the impact of the implemented measures is examined within the project TITSMZP704

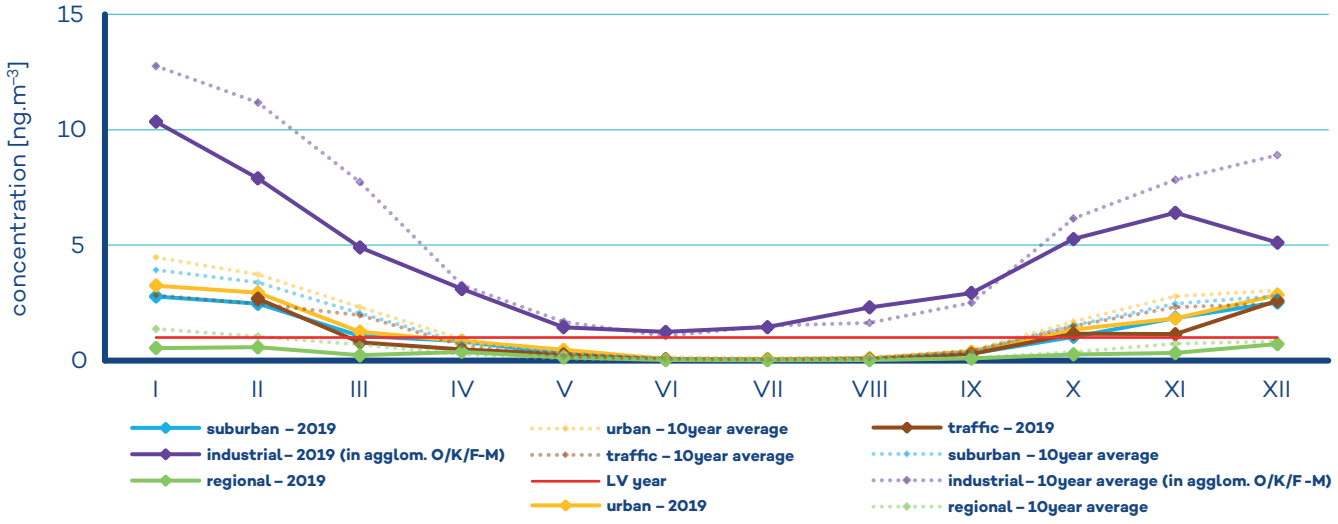

Fig. IV.2.5 Annual course of average monthly concentrations of benzo[*a*]pyrene, 2019

1 For detailed annual evaluation see www.chmi.cz, https://air.zuova.cz/DAUS/article/detail/1.

– 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 Czech Republic under the BETA2 Program, the results of which will be available at the end of 2021. The annual course 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. A significant drop in monthly concentrations in the winter months at the beginning of the year was recorded at industrial stations in the Ostrava/Karviná/Frýdek-Místek (O/K/F-M) agglomeration where in addition to the cross-border transmission of pollution, typical for the entire Ostrava-Karviná area, an enormous emission load from a combination of emission sources from local heating and industry takes place.

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

Benzo[*a*]pyrene concentrations at individual types of stations is evaluated for a period of the last 11 years, i.e. 2009–2019. The average annual concentrations of benzo[*a*]pyrene at localities have been fluctuating in the last ten years during the evaluated period and do not show a significant trend. They decrease in the areas of the highest air pollution load (Kladno area and the Ostrava/Karviná/Frýdek-Místek agglomeration) (Fig. IV.2.6). Although there was an increase in the number of heating days in the year-on-year comparison 2018/2019, resulting from subnormal temperature conditions in May, benzo[*a*]pyrene concentrations decreased at 25 of 33 stations (i.e. at 76% of stations) with data available for both years compared. The most significant decrease was recorded at the Ostrava-Přívoz industrial station, namely by 2 ng.m^{-3} (60%). However, the concentrations of benzo[*a*]pyrene still exceed there the limit value almost three times. Significant decreases in benzo[*a*]pyrene concentrations were recorded at all stations in the Moravian-Silesia region except the Ostrava-Radvanice ZÚ industrial station where an increase in the average annual concentration of benzo[*a*]pyrene by 1 ng.m^{-3} (approx. 12%) was recorded. In the year-on-year comparison 2017/2018 there was a decrease at 22 stations out of 33 (i.e. to 67%) that had data available for both years compared. The highest decrease, by 1.9 ng.m^{-3}, was recorded in the Ostrava-Radvanice industrial site but it is still the locality with the highest values of benzo[*a*]pyrene concentrations in the Czech Republic. A significant decrease of concentrations (by 0.6 ng.m^{-3}) was recorded in both localities in the Zlín region (Zlín and Valašské Meziříčí) but again the values exceeded the limit value. Good dispersion conditions and the overall warm character of the winter period in 2018 contributed positively to the decrease in annual average benzo[*a*]pyrene concentrations in most regions having a positive effect on the annual heating season expressed in degree-days which was considerably below normal (Fig. III.5). Lower number of heating days results in lower fuel consumption. A slight increase in the average annual concentrations of benzo[*a*]pyrene was recorded in 8 localities of which 6 were in the Moravian-Silesia region and further at the Doksany and Hodonín stations where the annual average concentration increased only slightly by 0.1 ng.m^{-3}. The highest increase of 1.2 ng.m^{-3} was identified at the Ostrava-Přívoz industrial site (4.7 ng.m^{-3}).

Annual average concentrations of benzo[*a*]pyrene at all types of stations were the lowest in 2019 for the evaluated period 2009–

Fig. IV.2.6 Annual average concentrations of benzo[*a*]pyrene in the ambient air at selected stations, 2009–2019

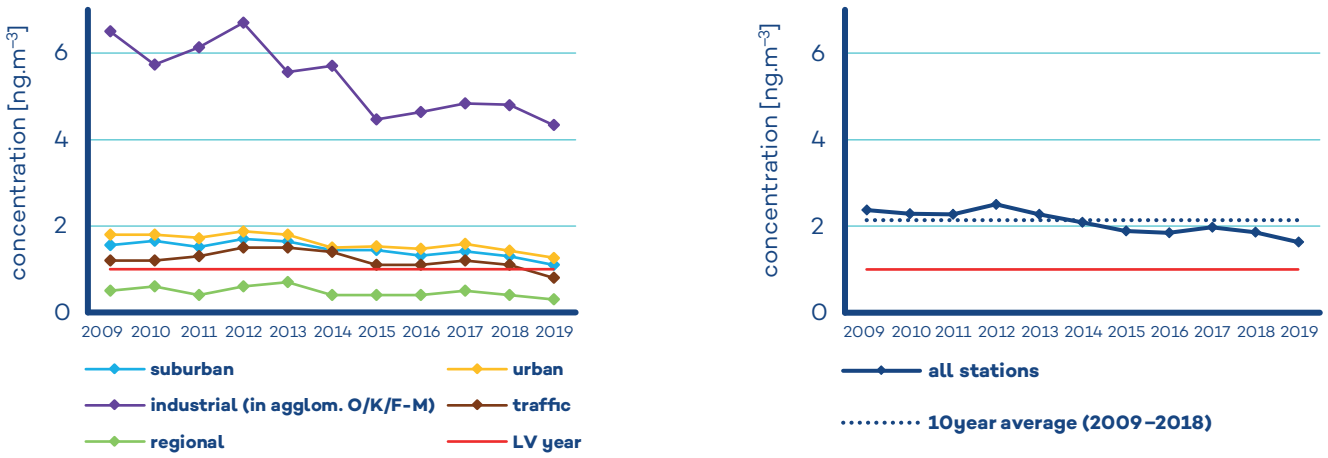

Fig. IV.2.7 Annual average concentration of benzo[*a*]pyrene at particular types of stations in the Czech Republic, 2009–2019

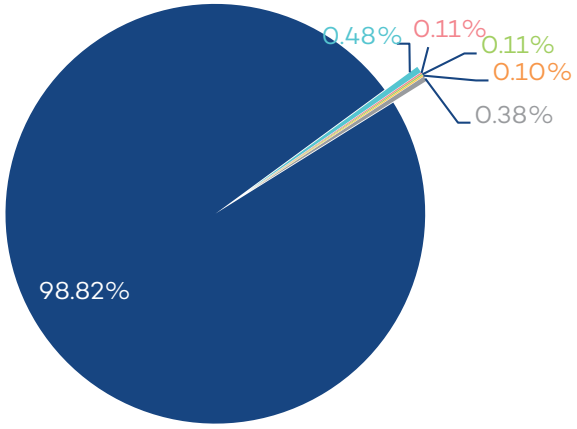

Fig. IV.2.8 Total emissions of benzo[*a*]pyrene sorted out by NFR sectors, 2018

2019 (Fig. IV.2.7), however, in many cities they still remain above the limit level. Compared to the ten-year average 2009–2018, in 2019 there was a decrease in benzo[*a*]pyrene concentrations at all stations by an average of about 20%. The good dispersion conditions that have occurred in the Czech Republic in the last five years, the lower number of heating days in the winter months and the measures implemented to improve air quality, including the renewal of boilers in households, have contributed to the improvement of the situation.

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

Emissions of PAHs, of which benzo[*a*]pyrene is monitored in view of air protection in particular, 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

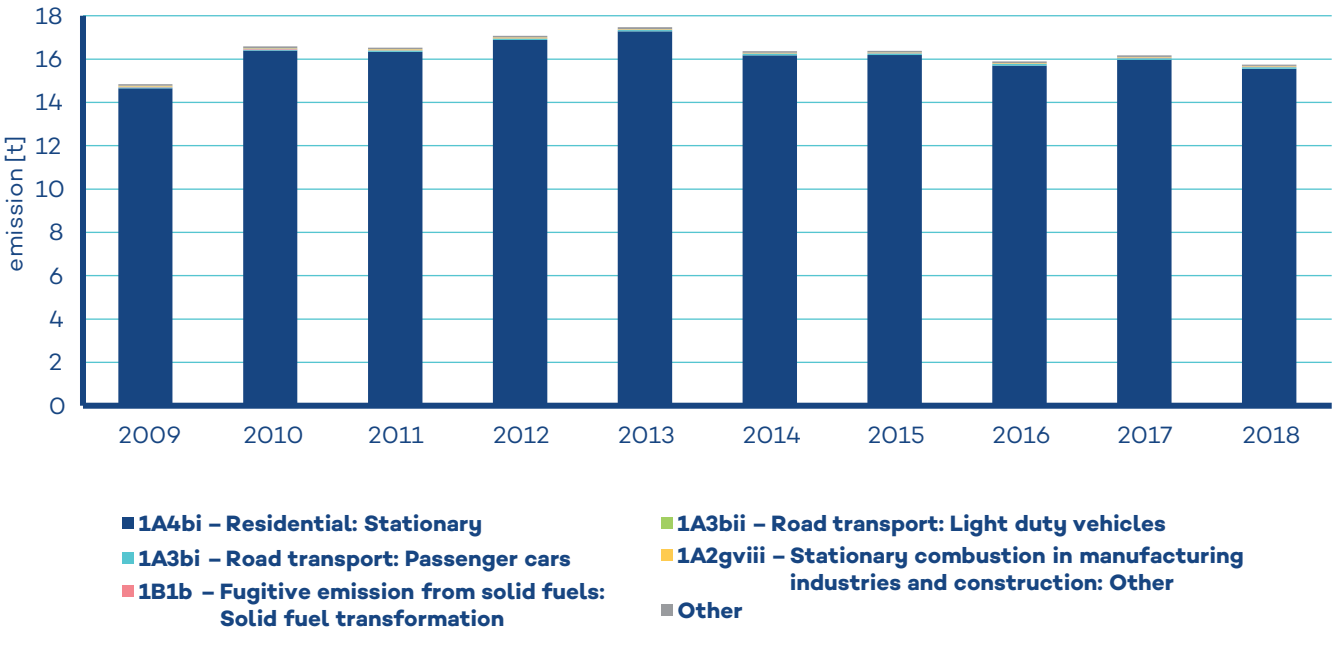

Fig. IV.2.9 The development of benzo[*a*]pyrene total emissions, 2009–2018

to 600 °C. Thus, one of its most important sources is the combustion of solid fuels in low-capacity boilers, particularly household heating systems.

Sector 1A4bi – Residential: Stationary contributed 98.8% to national benzo[*a*]pyrene emissions in 2018. The combustion of solid fuels, especially coal, in older types of boilers (top-burning and bulk-burning type of combustion) is the main reason for such a large percentage. According to estimates, up to 69% of all boilers for burning solid fuel in households in the Czech Republic in 2018 consisted of top-burning and bulk-burning boilers. The impact of the transport sector is estimated at 0.8% (Fig. IV.2.8).

In view of predominant contribution of sector 1A4bi, emissions of benzo[*a*]pyrene are distributed over the territory of residential buildings throughout the Czech Republic and their amounts in the 2009–2018 period depended primarily on evolution of consumption of solid fuels in households (Fig. IV.2.9). The impact of transportation is apparent mainly along motorways, roadways with high traffic and in the territories of larger urban units. The greatest burden by emissions of benzo[*a*]pyrene occurs in the Moravian-Silesia region due to higher proportion of black coal combustion in bulk-burning type boilers in households (Fig. IV.2.10).

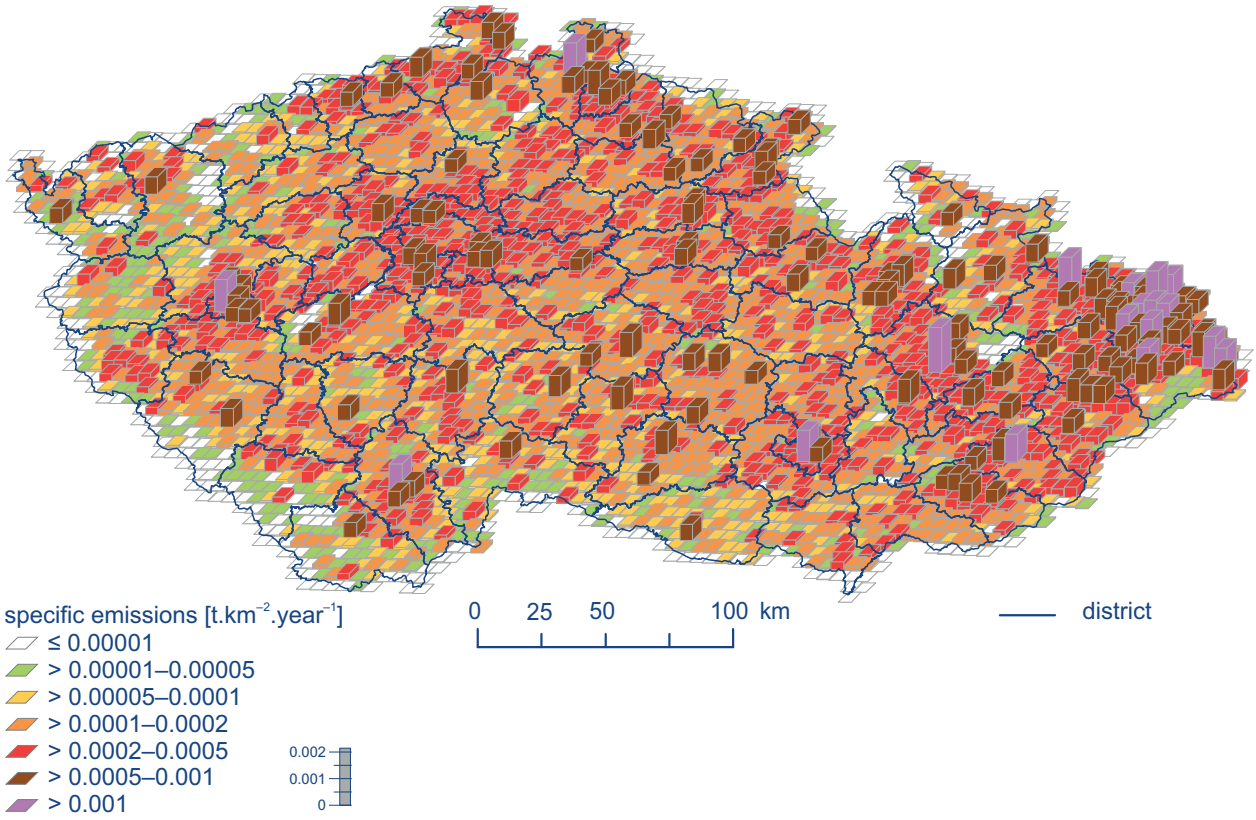

Fig. IV.2.10 Benzo[*a*]pyrene emission density from 5 x 5 km squares, 2018