ACKNOWLEDGEMENT

The “Air Pollution in the Czech Republic in 2019” yearbook is the result of the joint efforts of the collective of authors of the air quality staff of CHMI, including experts at regional offices of the Institute.

The CHMI data on air quality presented in this yearbook were measured in the National Air Quality Monitoring Network; the necessary analyses were performed by air quality laboratories. The collected data were subsequently verified and processed within the Air Quality Information System database which also includes information on the air quality provided by cooperating institutions. These mainly comprise the health institutes, ČEZ, a. s., the Forestry and Game Management Research Institute, p. r. i., the Czech Geological Survey, the Institute of Hydrobiology, municipal authorities and other contributors. The database also includes information from the border areas of Germany, Poland and Austria.

The operation and development of the emission database is provided in cooperation with the IDEA-ENVI, Ltd. The collection of REZZO 1 and 2 data, reported through ISPOP, is provided by CENIA, the Czech Environmental Information Agency. The Czech Statistical Office, the Transport Research Centre, p. r. i. and the Research Institute of Agricultural Technology, p. r. i. also participate in the preparation of the emission inventory. The background data used for modelling the level of pollution are also provided by the Military Geographic and Hydrometeorology Office in Dobruška, the Road and Motorway Directorate of the Czech Republic and the Institute of Transportation Engineering of the Capital City of Prague.

The yearbook for 2019 is structured with a focus on clarity and comprehensibility of the text. Emphasis is placed on indication of the context and interpretation of the measured data in relation to meteorological conditions and other factors that affect pollution load as well as on evaluation of the state and trends of air quality in the Czech Republic forming the basic topic of the publication.

I would like to thank all my colleagues who contributed to preparation of this yearbook. I would also like to extend my thanks to the employees of cooperating organisations for their contributions. Special thanks are due to the editors of the yearbook, RNDr. Leona Vlasáková, Ph.D. and Bc. Hana Škáchová, for conscientious work in coordinating preparation of the texts and graphic annexes. I am convinced that this material will be a valuable tool for your work. We greatly welcome any suggestions and recommendations for improvement of the provided services.

Prague, October 2020

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Air Quality Director

SUMMARY

Ambient air pollution by benzo[*a*]pyrene, suspended particulates in the PM_{10} and $PM_{2.5}$ fractions, and ground-level ozone is a major problem for air quality in the Czech Republic. Most air pollution characteristics exhibit a decreasing course in the evaluation period 2009–2019 (Fig. 1). Nonetheless, the concentrations of these pollutants, which have serious consequences for human health, have exceeded the pollution limit values every year at a number of locations of the Czech Republic (Fig. 2).

The air pollution levels in a particular year depend on the amounts of emissions and the prevailing meteorological and dispersion conditions. **In 2019, the lowest air pollution concentrations of air pollutants were observed within the evaluation period 2009–2019** (except for ground-level ozone, benzene and cadmium). **The decrease in the concentration of air pollutants in 2019 can be attributed to a combination of factors.**

The year 2019 was extremely above-normal in terms of temperature and normal in terms of precipitation. Due to the occurrence of extremely above-normal temperature conditions, a lower number of heating days was also recorded in winter months of 2019. In addition, in 2019, compared to the ten-year average, there were improved dispersion conditions. These factors lead to lower emissions from heating and better diffusion of emissions from various sources. At the end of the year — in November and December — usual poor dispersion conditions did not occur in comparison with other years.

The preliminary emission assessment for 2019 indicates further reductions for all major pollutants (SPM, SO_2, NO_X, CO, VOC and NH_3). The REZZO 1-2 sources contributed the most to the decrease in emissions of SO_2, NO_X (including precursors of suspended particles among other substances) and CO. The decrease in air pollution concentrations can also be attributed to the measures implemented to improve air quality, i.e. the replacement of boilers, the continuing renewal of the vehicle fleet and technical implementations in reducing emissions from the listed sources. Despite a slight increase in the number of degree days in the heating period of 2019 compared to 2018 (by about 4%), the estimate of emissions from fuel consumption in households demonstrates that the modernization of the composition of combustion equipment in households due to legislative measures affected the amount of emissions.

There are significant regional differences in air quality within the Czech Republic. **The most loaded regions in terms of air quality have long been the Ostrava/Karviná/Frýdek-Místek agglomeration (O/K/F-M) and the Moravian-Silesia and Central Moravia zones.** Regions with deteriorated air quality include the agglomerations of Prague and Brno and the Central Bohemia, Northeast and Northwest zones. On the contrary, in the Southwest and Southeast zones, air pollution limits are only exceeded in very small areas (Chapter VII). In 2019, there was the most significant reduction of the area with above-limit concentrations in relation to a decrease in the concentrations of benzo[*a*]pyrene and suspended PM_{10} particles in the agglomerations of Prague and Brno and in the Central Moravia zone.

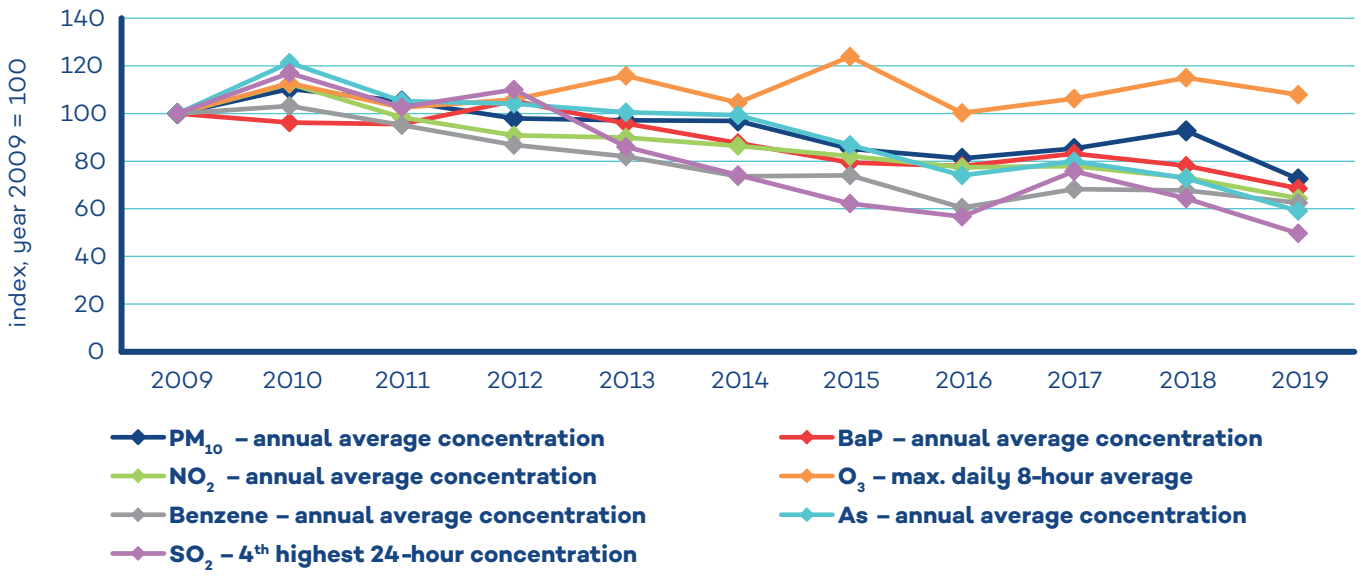

Fig. 1 Selected air pollutants characteristics, 2009–2019

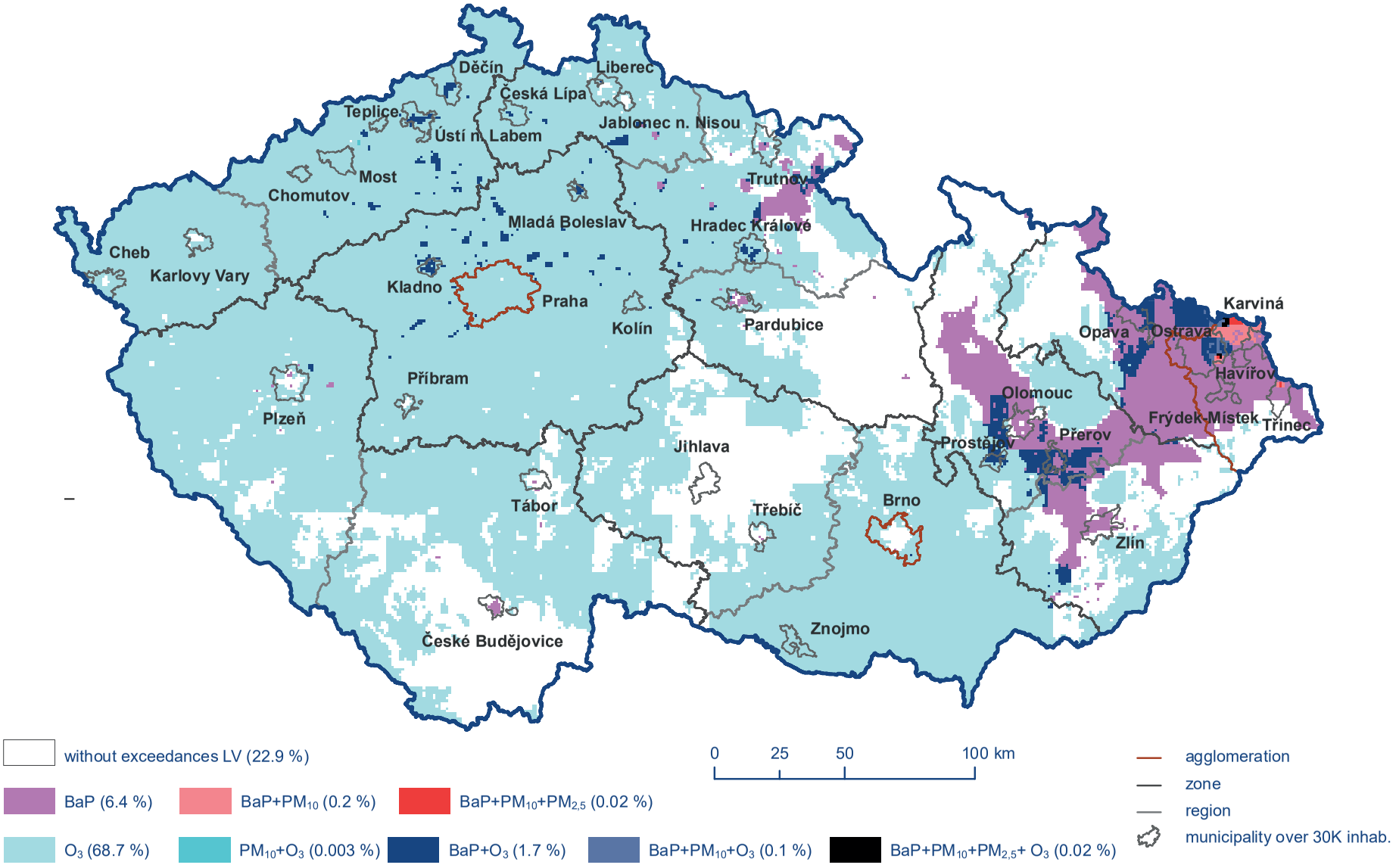

Fig. 2 Areas with exceeding of the health protection limit values for selected groups of pollutants, 2019

The high concentrations of pollutants **in the O/K/F-M agglomeration** are caused not only by the Czech sources but also by transfer of emissions from Poland. Industrial production is highly concentrated on both sides of the border with a high density of built-up areas with local solid-fuel heating and a well-developed transportation infrastructure (Chap. V.3). **In the Prague and Brno agglomerations**, the most problematic are the high concentrations of suspended particulate matter and nitrogen dioxide at localities loaded by heavy traffic. The REZZO 3 (predominantly local heating of households) and REZZO 4 categories of sources contribute the most to SPM emissions, while the most important contributor to NO_x emissions is the REZZO 4 category (Chap. V.1 and Chap. V.2). Resuspension of particulate matter and soil erosion, not included in emission inventories, and locally also construction activities also play a significant role in the air pollution load by suspended particles.

Deteriorated air quality is a problem not only in agglomerations and larger cities, but also in small settlements where local heating makes a considerable contribution to air pollution by suspended particulates and benzo[*a*]pyrene. It can be assumed that increased to above-limit concentrations may also occur in municipalities where these pollutants are not measured as indicated by, for example, campaign measurements in eight small settlements of the Czech Republic[1] or measurement of benzo[*a*]pyrene concentrations at various stations subsidized from the budget of the Moravian-Silesia region[2] (Chap. IV.2).

A substantial part of the Czech Republic is exposed to above-limit concentrations of ground-level ozone every year. Generally, because of the chemistry of ozone formation, these areas are not the most densely populated ones like for benzo[*a*]pyrene and suspended particulates PM_{10} and $PM_{2.5}$. However, due to the size of the area, a significant part of the population of the Czech Republic is also exposed to the above-limit ozone concentrations.

Air quality in the Czech Republic in 2019 in relation to the pollution limit values for protection of human health

In 2019, areas with exceeded pollution limit levels, excluding ozone, covered approx. 8.4% of the territory of the Czech Republic inhabited by approx. 27.5% of the population. These areas were delimited because of exceeding the pollution limit values for benzo[*a*]pyrene and suspended particulates PM_{10} and $PM_{2.5}$. **Areas exceeding pollution limit values, including ground-level ozone, covered, in 2019, approx. 77.1% of the territory of the Czech Republic inhabited by approx. 75.6% of the population** (Chap. VII).

The daily pollution limit value for suspended particulates PM_{10} was exceeded at 0.3% of the territory of the Czech Republic inhabited by approx. 0.9% of the population. The annual pollution limit value for PM_{10} was not exceeded at any station in the Czech Republic in 2019, for the first time in the evaluated period 2009–2019. **The annual pollution limit value for suspended particulates $PM_{2.5}$ was exceeded at 0.04% of the territory of the Czech Republic inhabited by approx. 0.1% of the population.** In 2019, above-limit concentrations of suspended particulates were observed in the O/K/F-M agglomeration, in the Moravian-Silesia region without the O/K/F-M agglomeration, and in the Ústí nad Labem and Central Bohemia regions. During the evaluated period, a gradual decrease was observed in the concentration of PM_{10} and $PM_{2.5}$ until 2016, including, a slight increase in 2017 and 2018, and a significant decrease in 2019 reaching the minima for the evaluated period 2009–2019.

Similar to previous years, **the pollution limit value for benzo[*a*]pyrene was exceeded in a number of cities and municipalities (8.4% of the area of the Czech Republic inhabited by approx. 27.5% of the population)**. Estimation of fields of annual average concentrations of benzo[*a*]pyrene is affected by the greatest uncertainties of all the monitored substances resulting not only from insufficient density of measurements, especially at rural regional stations and in small settlements in the Czech Republic. From the viewpoint of pollution by benzo[*a*]pyrene, the air quality in small settlements is substantially affected by local heating units (Chap. IV.2). In the longer term, a modest slightly decreasing trend can be observed for benzo[*a*]pyrene concentrations between 2010 and 2016, with subsequent slight increase in 2017 and 2018 and a decrease in 2019. The annual average concentrations of benzo[*a*]pyrene at all types of stations were the lowest in 2019 within the evaluated period 2009–2019, however, above limit concentrations still remain in many cities.

The annual pollution limit value for nitrogen dioxide was exceeded in 2019 at a single station, namely the Prague 2-Legerova traffic hot spot. However, it can be assumed that the limit was also exceeded at other sites with high traffic load where measurements are not performed. The hourly pollution limit value was not exceeded for NO_2 (Chap. IV.3). In the longer term, NO_2 concentrations are slowly decreasing, and the lowest NO_2 concentrations for the entire evaluated period 2009–2019 were recorded in 2019.

The pollution limit value for ground-level ozone was exceeded at 70.5% of the territory of the Czech Republic inhabited by approx. 56.9% of the population (average for 2017–2019; Chap. IV.4). The cause is represented by favourable meteorological conditions for the formation of ground-level ozone (a year with highly above-normal temperature, occurrence of subnormal amount of precipitation in June and July) which led to increase of concentrations and more frequent exceeding the O_3 pollution limit value in 2019. O_3 concentrations do not show a significant course and their level in individual years depends mainly on the meteorological conditions of the given year; the highest concentrations were measured in 2013, 2015 and 2018. All these years are characterized by the occurrence of favourable meteorological conditions for the ozone formation.

1 The project TITSMZP704 — Measurement and Analysis of Air Pollution with Emphasis on the Evaluation of the Share of Individual Groups of Sources — funded with the state support of the Technology Agency of the Czech Republic

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

The **pollution limit values for benzene, heavy metals, sulphur dioxide and carbon monoxide** were not exceeded in 2019 (Chap. IV.5, IV.6, IV.7 and IV.8).

Air quality in the Czech Republic in 2019 in relation to the pollution limit values for protection of ecosystems and vegetation

The limit value of O_3 for the protection of vegetation (AOT40 exposure index) was exceeded at 25 stations out of a total of 39 rural and suburban stations. At the same time, the area of the territory with the occurrence of above-limit AOT40 values increased. An increase in the AOT40 exposure index for 2019 compared to 2018 was observed at a majority of 32 stations evaluated in both periods.

The pollution limit values for sulphur dioxide and nitrogen oxides for protection of ecosystems and vegetation were not exceeded at any rural location where measurements were performed.

Exceeding the upper assessment limit (UAT) of the annual average concentration of SO_2 occurred in 2019 only in small areas of the Moravian-Silesia region. In this region and in the Ústí nad Labem region, the UAT of the average concentration for the winter period 2019/2020 was exceeded in a small area. In the Moravian-Silesia region, the limit value for annual and winter average concentrations was exceeded, but only in the cities of Ostrava and Třinec. This exceeding is based on a model calculation when constructing the map. Above-limit concentrations of NO_x occur mainly in the vicinity of roadways; the results of model evaluation indicate that for the most valuable natural areas of the Czech Republic the pollution limit value for NO_x was exceeded over only a very small area of three protected landscape areas (Chap. IV.3 and VII.2).

Smog warning and regulation system

In 2019, a total of 5 smog situations and 2 regulations due to elevated PM_{10} concentration were announced lasting overall 385 hours (or 162 hours for regulations). All smog situations and regulations occurred in January, in 5 of the 16 SWRS regions. Regulations were announced on the territory of the O/K/F-M agglomeration without the Třinec area and in the Třinec area. Only smog situations were announced in the Moravian-Silesia zone, and in the Zlín and Olomouc regions.

6 smog situations were also announced in 2019 due to high ground-level ozone concentrations lasting overall 90 hours. Smog situations were announced particularly in the third decade of June 2019 (5 situations) and in the Ústí nad Labem region also at the end of July. No alert has been issued in any SWRS area.

Emissions of pollutants

The year-on-year comparison of the production of emissions of the main pollutants in 2018 and 2019 confirms the expected reduction of emissions from energy and industrial sources. Preliminary data on emissions from transport indicate that there were no significant changes compared to 2018. **The model assessment of emissions from the use of fuels in households reflects a positive effect of boiler replacement determined from sales statistics and information on subsidies provided for boiler modernization or changes in the technique of heating. The decrease in emissions from household heating** took place for all pollutants except for SO_2 (a slight increase in the average sulphur content of brown coal) and NH_3 (an increase in the share of biomass).

The sector of **local household heating** continued in 2018 to make a significant contribution to pollution of the ambient air, specifically in emissions of **PM_{10} by 58%, $PM_{2.5}$ by 74%, carbon monoxide by 67%, VOCs by 43%, arsenic by 37%, cadmium by 44% and benzo[*a*]pyrene by 98.8%. A significant contribution by the public energy and heat production sector predominated in emissions of sulphur dioxide (20%) and nickel (11%). Sectors of road freight transport, passenger cars, off-road vehicles and other machinery, for example in agriculture and forestry**, contributed most in emissions of **nitrogen oxide (59%)**.

Atmospheric deposition

The year 2019 was normal in terms of precipitation in the Czech Republic. The average annual precipitation of 634 mm represents 92% of the long-term normal 1981–2010.

The total deposition of sulphur in 2019 reached 33,032 tonnes over the area of the Czech Republic, compared to the value of 34,581 tonnes of the total deposition in 2018. The highest values were reached in the Krušné hory and the Ostrava area. Partial components of sulphur deposition also reached lower values.

The total nitrogen deposition on the area of the Czech Republic reached 54,749 tonnes in 2019, compared to 2018, when the total deposition was 57,674 tonnes. The highest values were reached in the Jeseníky, Moravian-Silesian Beskydy, Orlické hory, Šumava and Novohradské hory areas. Partial components of nitrogen deposition also reached lower values except for wet deposition of reduced forms and total wet nitrogen deposition.

The total deposition of hydrogen ions on the area of the Czech Republic was equal to 2,535 tonnes in 2019. Compared to 2018 (2,805 tonnes), this is a slight decrease. The deposition of hydrogen ions in the Šumava, Krušné hory, Jizerské hory, Orlické hory, Hrubý Jeseník and Moravian-Silesian Beskydy areas reached the highest values. A slight decrease has also been recorded for the dry component of hydrogen deposition, while the wet component was comparable to 2018.

Wet and dry deposition of lead in 2019 was lower compared to 2018. The highest values were attained in mountain areas and in the Ostrava area.

Wet deposition of cadmium increased in 2019, in the opposite, dry deposition of cadmium was lower compared to 2018. Similar to previous years, the highest values were attained in the Jablonec nad Nisou district.