

SUMMARY

Concentrations of some pollutants having serious consequences for human health still exceed the pollution limit values at a number of locations in the Czech Republic. These are mainly carcinogenic benzo[a]pyrene, suspended PM₁₀ and PM_{2.5} particulates, and ground-level ozone (Tab. 1, Fig. 1). Nevertheless, the year 2021 was good in terms of air quality. Air pollutant concentrations in 2021 reached the second lowest values (after 2020, in which the best air quality was observed historically) within the assessment period 2011–2021¹, or the lowest values within the assessment period 2011–2021 (Fig. 2). **Concentrations of air pollutants**, except for ground-level ozone, **decrease significantly** over the evaluated period 2011–2021 (Tab. 1).

The relatively good air quality in the Czech Republic in view of pollutants except ozone in 2021 was mainly contributed by the less frequent occurrence of adverse conditions in January and November compared to the previous ten-year average 2011–2020. In the case of ozone, the significant drop in concentrations in 2021 was due to a decrease in concentrations in warmer months of the year². The decrease in ozone concentrations in April, May, July and August 2021 compared to the ten-year average for the period 2011–2020 corresponds to mostly normal to strongly subnormal temperatures and normal to above-normal precipitation in these months (i.e., suppression of meteorological conditions suited for the formation of ground-level ozone). **Continuously implemented measures to improve air quality (replacement of boilers in households, measures on important sources and renewal of the vehicle fleet) contribute to the improvement of air quality in the long term.**

Areas exceeding air pollution limits excluding ground-level ozone covered 6.1 % of the territory of the CR with approximately 20 % of the population in 2021. The classification of these areas was mostly due to exceeding the annual pollution limit for benzo[a]pyrene. Exceeding the daily pollution limit for PM₁₀ and the annual pollution limit for PM_{2.5} suspended particles in 2021 contributed to the inclusion of territories to these areas in a minimal extent. Above-limit areas were the largest in the O/K/F-M agglomeration and in the Central Moravia zone. In addition, in the O/K/F-M agglomeration, the vast majority of inhabitants

(96 %) are exposed to concentrations above the limit, and this is the most exposed area in the CR for a long time.

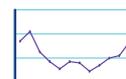
Areas exceeding air pollution limits including ground-level ozone covered 6.4 % of the territory of the CR with approximately 20 % of the population in 2021. In the year-on-year comparison of 2020/2021, there was a significant reduction (by approx. 59 %) in the area with at least one pollution limit exceeded including ozone. This resulted from relatively low concentrations of ground-level ozone measured in the last two years, 2020 and 2021, and the following reduction of the area exceeding the O₃ pollution limit in 2021 to only 0.2 % of the territory of the Czech Republic with 0.02 % of the population (the pollution limit is evaluated over a three-year period 2018–2020 or 2019–2021).

The level of air pollution depends in a given year on the amount of emissions and the prevailing meteorological and dispersion conditions. **In terms of temperature and precipitation, 2021 was normal in the CR. Compared to the 2011–2020 ten-year average, most months of 2021 could be classified as standard in view of dispersion conditions.** The exception was May with much better dispersion conditions and February with deteriorated dispersion conditions. In January and November, the months with generally the highest concentrations, poor conditions occurred less frequently compared to 2011–2020 decade values. **In the long term, pollutant emissions also decrease.** In 2021 (preliminary data) there was the lowest production of SO_x emissions and the second lowest production of TSP, NO_x, NH₃ and NMVOC emissions for the evaluated period 2011–2021³.

In 2021, similarly to 2020, states of emergency were declared on the territory of the CR in connection with the occurrence of the SARS-CoV-2 coronavirus. From the point of view of the potential change in air quality in the CR, the most significant month was March, when even movement between districts was prohibited and thus there was a fundamental reduction in the transportation mobility of population. It can be assumed that under normal conditions without protective measures to limit the pandemic, the measured concentrations of NO₂ and NO_x in 2021 would be higher. Due to the heterogeneous composition of PM₁₀ emission

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- 1 Concerning suspended PM_{2.5} particulates, the period 2012–2020 was evaluated to comply with the condition of sufficient amount data.
 - 2 In these months, high to the highest concentrations of ground-level O₃ occur within the calendar year, in contrast to other pollutants reaching the highest concentrations in the cold part of the year.
 - 3 For details concerning the emission situation in 2021, see the section on Emissions of pollutants.

Tab. 1 Air quality in the Czech Republic in 2021 – key facts



Pollutant	Population exposed to above-limit concentration	Area with above-limit concentration	Concentration trend for the period 2011–2021
PM ₁₀	0.4 %	0.1 %	↓
PM _{2.5}	1.5 %	0.3 %	↓
benzo[a]pyrene	19.7 %	6.1 %	↓
NO ₂	0 %	0 %	↓
O ₃	0.02 %	0.2 %	↕
benzene	0 %	0 %	↓
As	0 %	0 %	↓
Cd	0 %	0 %	↓
Ni	0 %	0 %	↓
Pb	0 %	0 %	↓
SO ₂	0 %	0 %	↓

Note:

The key data in the table are based on the following pollution characteristics:

annual average concentration for PM_{2.5}, NO₂, benzo[a]pyrene, Pb, Ni, Cd, As, and benzene; 36th highest 24-hour average concentration for PM₁₀; 26th highest maximum daily 8-hour concentration for O₃; 4th highest 24-hour average concentration for SO₂.

Trends in concentrations were analysed using the non-parametric Mann-Kendall test with a significance level of $p < 0.05$ (Mann 1945; Kendall 1955).

sources and their strong link to dispersion and meteorological conditions, no significant changes in concentrations could be expected as a result of emergency measures.

Air quality in 2021 in relation to pollution limit values for the protection of human health and for the protection of ecosystems and vegetation

The daily pollution limit value for suspended particulates PM₁₀ was exceeded at 0.1 % of the territory of the CR, inhabited by approx. 0.4 % of the population. The annual pollution limit value for PM₁₀ was not exceeded at any station in the Czech Republic in 2021, which occurred, since 2019, for the third time in the complete history of PM₁₀ measurements starting in 1993. The annual pollution limit value for suspended particulates PM_{2.5} was exceeded at 0.3 % of the national territory, inhabited by approx. 1.5 % of the population (for more see Chap. IV.1).

The annual pollution limit value for benzo[a]pyrene was exceeded at 6.1 % of the area of the CR, inhabited by approx. 19.7 % of the population. Estimations of annual average concentration fields of benzo[a]pyrene is affected by the greatest uncertainties of all the monitored substances, resulting mainly from insufficient density of measurements, especially at rural regional stations and in small settlements in the CR (for more see Chap. IV.2).

The annual pollution limit value for nitrogen dioxide (NO₂) was not exceeded at any station for the second time in the entire observation period since the 1990s. Higher NO₂ concentrations can be expected near local roads in municipalities and cities with intensive traffic, higher urban development and a dense local transport network, where traffic flow is often reduced. The hourly pollution limit value for NO₂ was not exceeded (for more see Chap. IV.3).

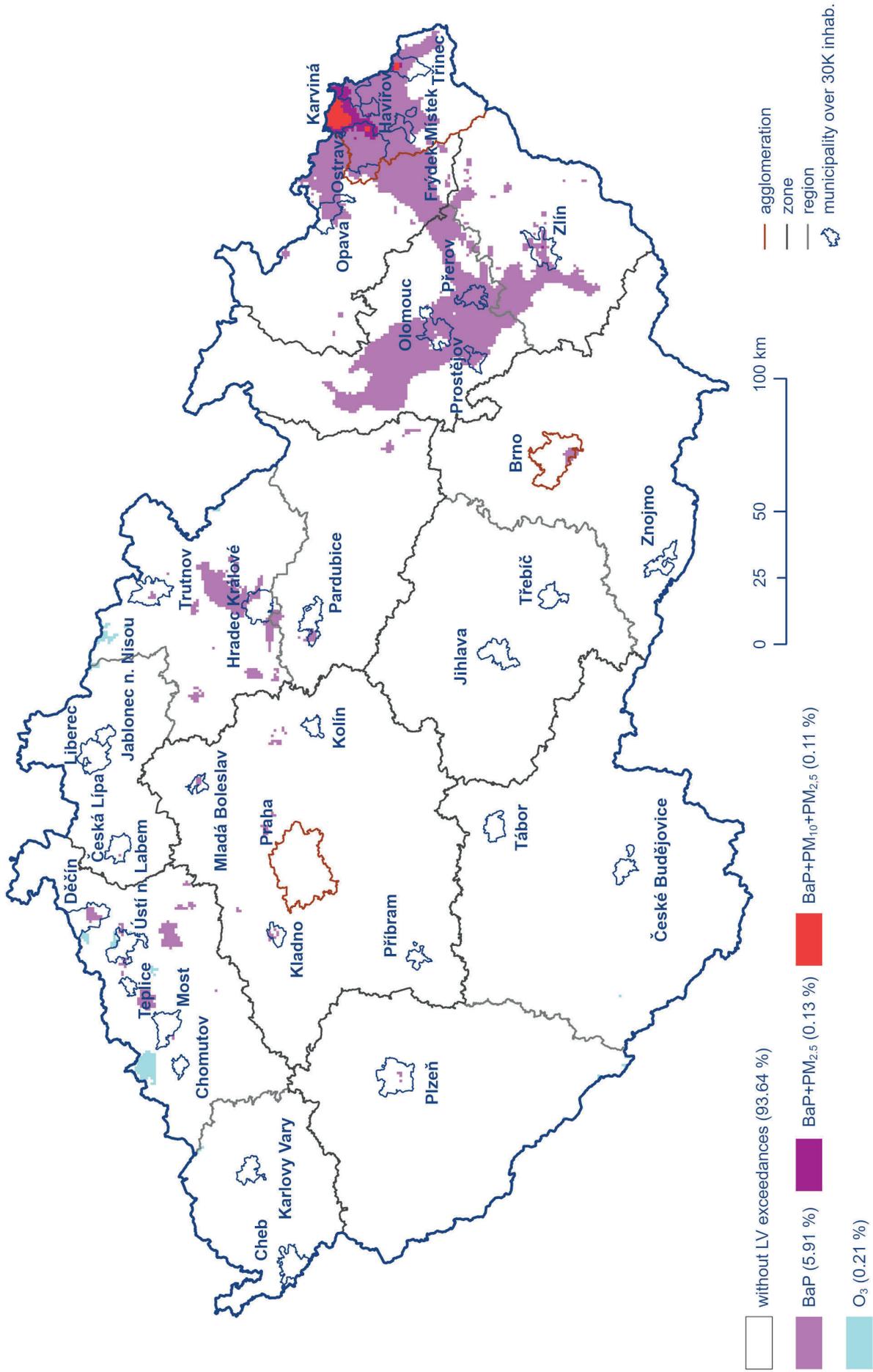


Fig. 1 Areas with exceeding of the health protection limit values for selected groups of pollutants, 2021

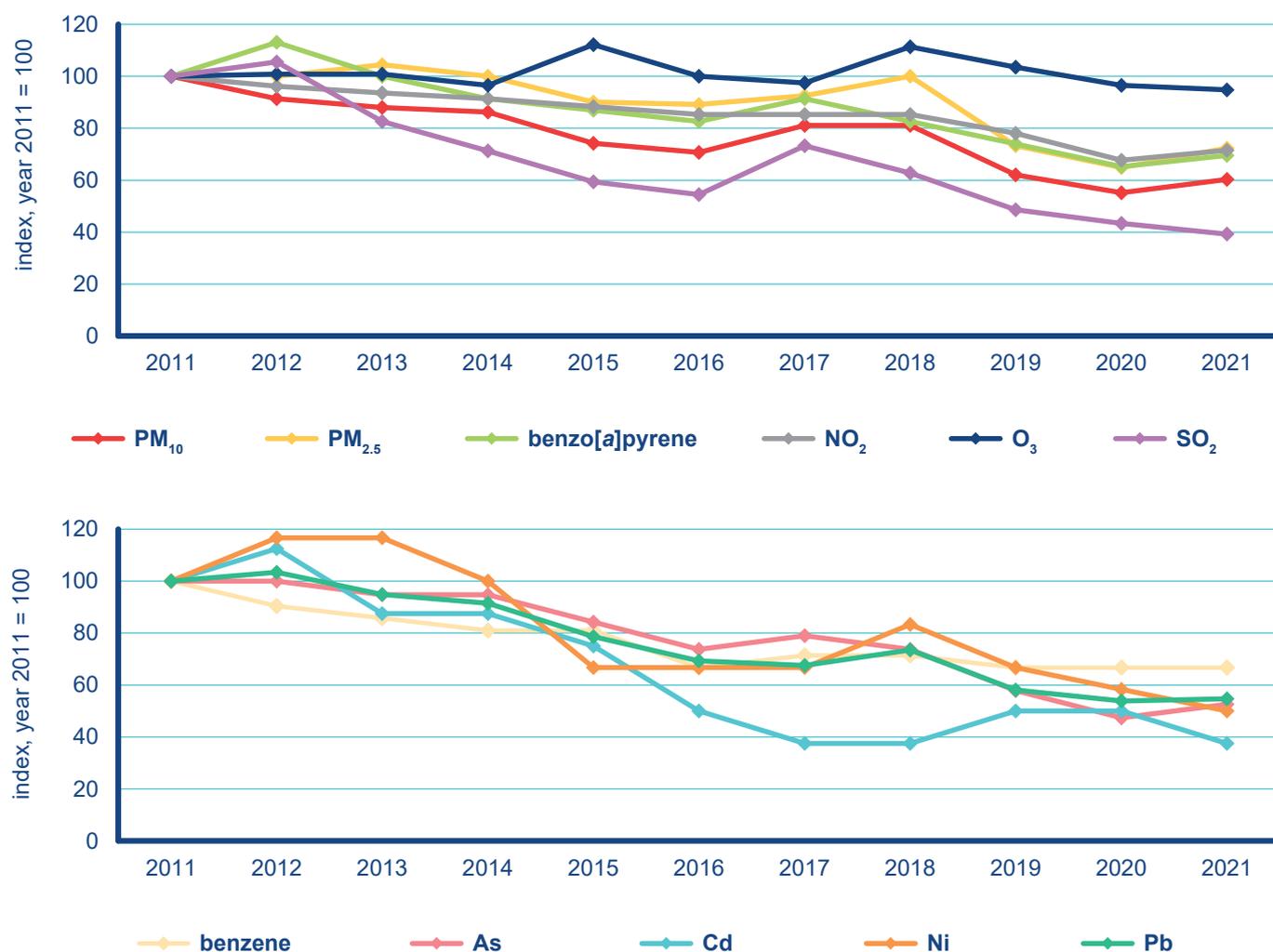


Fig. 2 Selected air pollutants characteristics, 2011–2021

Note: The graphs show the course of the following pollution characteristics:

annual average concentration for PM_{2.5}, NO₂, benzo[a]pyrene, Pb, Ni, Cd, As, and benzene; 36th highest 24-hour average concentration for PM₁₀; 26th highest maximum daily 8-hour concentration for O₃; 4th highest 24-hour average concentration for SO₂.

The pollution limit value for ground-level ozone was exceeded at 0.2 % of the territory of the CR, inhabited by approx. 0.02 % of the population (average for 2019–2021). Within the individual years in the period 2019–2021, almost 70 % of stations had the lowest number of cases exceeding the pollution limit value in 2021 (for more see Chap. IV.4).

The limit value of O₃ for the protection of vegetation (AOT40 exposure index) was exceeded at 14 stations out of a total of 39 rural and suburban stations. The pollution limit values for the protection of ecosystems and vegetation of sulphur dioxide and nitrogen oxides were not exceeded at any rural location where measurements were performed.

Regional differences in air quality

Within the CR, there are significant regional differences in air quality, that can be characterized by the population weighted concentration of pollutants. A comparison of the weighted concentration for the regions of the CR shows that inhabitants in the O/K/F-M and Brno agglomerations, and in the Olomouc, Zlín and Moravian-Silesia regions without the O/K/F-M agglomeration are exposed to the highest concentrations of suspended particulates PM₁₀ and PM_{2.5}. In connection with intensive traffic and restrained traffic flow, the population exposed to the highest NO₂ concentrations belong to two most populous cities of the CR, i.e., Prague and Brno. In 2021, inhabitants in the O/K/F-M and Brno agglomerations and in the South Moravia without Brno, Moravian-Silesia without O/K/F-M and Central Bohemia regions were exposed to the highest weighted O₃ concentrations (26th highest maximum daily 8-hour average in 2021) (for more see Chap. V.3).

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 Republic⁴ or measurement of benzo[a]pyrene concentrations at various stations subsidized from the budget of the Moravian-Silesia region⁵.

The smog warning and regulation system

In 2021, the only smog situation was announced due to high concentrations of PM₁₀ in the territory of the O/K/F-M agglomeration without Třinec. Its total duration was 58 h.

Emissions of pollutants

The preliminary evaluation of emissions for 2021 shows the expected year-on-year increase of all emissions except for SO_x. The increase occurred mainly in emissions from household heating, as a result of a colder heating season (in 2021, the third lowest temperature on heating days for the period 2011–2021 was recorded). Compared to 2020, in which there was a slowdown in production, services provided and consumption of solid and automotive fuels in almost all sectors, there was a renewed increase in 2021, which was manifested by an increase in NO_x and CO emissions from the listed sources. In 2021, SO_x emissions reached the lowest level for the period 2011–2021, when the ORLEN refinery complex in Litvínov, the termination of operation of the Prunéřov I power plant on 30 June 2020, and the reduction of emissions from other important sources for the production of electricity and heat contributed the most to the reduction.

The sector Residential: Heating, water heating, cooking continued to make a significant contribution to ambient air pollution, specifically in emissions of PM_{2.5} particulates (71 %), carbon monoxide (67 %), PM₁₀ (55 %), TSPs (49 %), NMVOCs (37 %), cadmium (52 %), arsenic (33 %), and benzo[a]pyrene (96.3 %). Sector Public electricity and heat production predominated in emissions of sulphur oxides (39 %), nitrogen oxides (19 %), mercury (43 %), and nickel (33 %). Sectors of road freight transport, passenger cars, off-road vehicles and other machinery, for example in agriculture and forestry, contributed in total most in emissions of nitrogen oxide (33.5 %). These data are presented for the last completed year, i.e., 2020.

Atmospheric deposition

The year 2021 was normal in terms of precipitation in the CR. The annual precipitation amount of 683 mm represents 100 % of the 1991–2020 long-term normal.

The total deposition of sulphur in 2021 reached 30 335 tonnes, representing a decrease of less than 1 % compared to 2020 (30 577 t). Higher values were observed in the Krušné hory, Jizerské hory, Krkonoše, Orlické hory, Jeseníky, the Ostrava region, and Moravian-Silesia Beskydy. Compared to 2020, the wet component reached higher values, while the dry component lower.

The total nitrogen deposition on the area of the CR reached 55 383 tonnes in 2021. Compared to 2020 (56 396 t), this was a decrease of 2 %. Higher values occurred in the Jizerské hory, Orlické hory and Jeseníky areas. The wet deposition of reduced forms and the total wet deposition of nitrogen also reached lower values. Conversely, higher values were observed in the deposition of oxidized forms of both sub-components.

The total deposition of hydrogen ions on the area of the CR in 2021 was 2 232 tonnes (Tab. IX.2). The year 2021 is thus comparable to the year 2020, when the value was 2 224 tonnes. The partial components of hydrogen ion deposition are also comparable. The highest values were reached in the Krušné hory area, the Ostrava region, and locally in the Brno region.

Wet and dry deposition of cadmium in 2021 was comparable to 2020. Similar to previous years, the highest values occurred in the Jablonec nad Nisou district. Wet and dry deposition of lead in 2021 was comparable to 2020. The highest values were reached in mountainous areas, in the Příbram region, and in the Ostrava region.

4 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, https://www.chmi.cz/files/portal/docs/reditel/SIS/nakladatelstvi/assets/td_000152.pdf.

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