# HEALTH IMPACTS OF AIR POLLUTION IN THE CZECH REPUBLIC IN 2019

## The population exposure

Manifestation of the effects of air pollutants on health is dependent on their concentration in the atmosphere and time for which people are exposed to these substances. The real exposure during the day, year and during the life of the individual varies greatly and differs depending on the occupation, lifestyle, and concentrations of substances in various locations and environments.

Concentration ranges characterizing the magnitude of urban air pollution by $PM_{10}$ and nitrogen dioxide ($NO_2$), and thus the potential population exposure are shown in Tab. 1.

***Tab. 1 The estimation of $NO_2$ and $PM_{10}$ air pollution in the urban environment and rural background, 2019 (in µg/m³)***

| *Pollutant* | *Rural background* | *Urban environment* | | |
|---|---|---|---|---|
| | | *Minimum value* | *Mean value* | *Maximum value* |
| *Nitrogen dioxide ($NO_2$)* | 4.9 | 10.4 | 16.5 | 48.1 |
| *Particulate matter $PM_{10}$* | 12.3 | 11.3 | 19.8 | 37.5 |

## Health effects of air pollution

### Particulate matter

Aerosol particles are considered the most significant environmental factor associated with mortality not only due to their carcinogenicity, but also because of their systemic proinflammatory action, creation of oxidative stress, changes of electrical processes in cardiac tissue, role in development of atherosclerosis including calcification of cardiac arteries and other effects. There is sufficient evidence that exposure to air pollution causes development of lung cancer. PM aerosol fractions, as the major components of air pollution, were evaluated by IARC separately leading the same conclusion that they represent proven Class 1 human carcinogens. In 2013, the WHO International Agency for Research on Cancer (IARC) based on an independent review of more than thousand studies classified a mixture of substances that are implicated in air pollution as Class 1 human carcinogens [1].

Long-term exposure to PM air pollution results in increased mortality from cardiovascular and respiratory diseases, including lung cancer, chronic bronchitis, decreased pulmonary function in adults and children, and in other health problems. In addition, there is growing evidence on the effect of exposure to particles on the development of diabetes II. type, on neurological development in children and neurological disorders in adults [2].

A safe threshold for aerosol particles has not been determined yet. It is assumed that the sensitivity of individuals in the population has such great variability that the most sensitive subjects are at risk even at very low concentrations. Upon chronic exposure to $PM_{2.5}$, the reduction in life expectancy begins to manifest itself by the average annual concentrations of 5 µg/m³.

Short-term exposure to elevated concentrations of aerosol particles contributes to increased morbidity and mortality (especially cardiovascular and respiratory diseases), number of people hospitalized for cardiovascular and respiratory diseases, infant mortality, respiratory symptom incidence and worsening of asthma.

Quantitative estimate of health effect caused by air pollution have been performed as regards to particulate matter exposure. The basic indicator of health effects from long-term exposure is an estimate of premature deaths in adult population aged over 30 years, excluding external death causes (accident, suicide etc.). This indicator therefore includes premature deaths from particular causes (cardiovascular or respiratory disease, lung cancer etc.) as well as deaths resulting from short-term exposure to PM. Estimates were based on the concentration-response function recommended in the WHO HRAPIE project [4].

Using the mean ratio of the $PM_{2.5}$ fraction contained in $PM_{10}$ 75% during the 2011 – 2019 period (72% in 2019) level enables estimation of the increase in (natural) mortality among the exposed adult population as 4.65% for each 10 $\mu g/m^3$ of the mean annual concentration in excess of the defined counterfactual level of 13.3 $\mu g/m^3$ of $PM_{10}$. The mean concentration in urban environment $PM_{10}$ reached 19 $\mu g/m^3$ in 2019. The overall mortality rate for the CR population aged over 30 years was therefore increased by 4.98% due to long-term $PM_{10}$ exposure. In view of the range of mean annual concentrations of this pollutant from 11 $\mu g/m^3$ to 37.5 $\mu g/m^3$ at sites in different types of localities, the estimate of the ratio of premature deaths from $PM_{10}$ exposure against overall mortality (natural) ranged from values of 2.9% in urban localities with no traffic load to 11.3% in the most by industry and traffic burdened localities.

Because at the time of elaborating this report were not available a detailed demographic data for 2019, it was impossible to employ standard procedure using attributive cases method to estimate premature deaths caused by exposure to aerosol particles. The estimate was therefore made using aggregate data on death counts from the Czech Statistical Office database and the estimate of deaths up to 30 years of age and deaths for external causes. It can be estimated that 3,100 cases of premature deaths due to long-term exposure to PM occurred in 2019.

**Nitrogen dioxide**

Nitrogen dioxide as a component of emission from combustion processes is highly correlated with other primary and secondary pollutants, therefore, it cannot be clearly determined whether the observed health impairment arise from independent effect of $NO_2$ or rather the effect of the whole mixture of substances, in particular aerosol, [5], hydrocarbons, ozone and other substances [6]. The main outcome of short-term exposure to high concentrations of $NO_2$ is an increase in airway responsiveness; based on the impact on changes in the reactivity in the most sensitive asthmatics the WHO recommended value of 1-hour $NO_2$ concentration of 200 $\mu g/m^3$ was derived. The residents of large urban areas affected by transit and targeted traffic have been highly exposed. The recorded annual average values show that in areas heavily burdened by traffic e.g. in Prague agglomeration, reduced lung function, increased incidence of respiratory diseases, increased incidence of asthmatic aggravation and allergies can be expected both in adults and children.

Although quantitative relationships of exposure and health effects of $NO_2$ (e.g. on total, cardiovascular and respiratory mortality) have been established, there cannot by clearly determine the degree of overlap between these effects with the effects of other outdoor air pollutants. That's why experts recommend assessing the health impact of air pollution on the basis of relations of suspended particles in which the effects of other pollutants has been involved [4].

**Ozone**

Ground-level ozone is not emitted directly into the atmosphere. It results from photochemical reactions between oxides of nitrogen and volatile organic compounds. Ozone, which is a typical part of the so-called summer smog episodes, can in the warm season reach the levels affecting health. Ozone has strong irritating effect on the conjunctiva and respiratory tract and at higher concentrations causes breathing problems and mucosal inflammatory response in the airways. Increasingly sensitive to ozone exposure are people with chronic obstructive pulmonary disease and asthma. Short-term and long-term exposure to ozone affects the respiratory morbidity and mortality. Chronic exposure to ozone increases the frequency of hospitalization for asthma exacerbation in children and acute worsening of cardiovascular and respiratory diseases in the elderly [4].

Increase in the daily maximum 8-hour concentration for every 10 $\mu g/m^3$ above the level of 70 $\mu g/m^3$ results in an increase in overall mortality of 0.3%. The impact on respiratory mortality in the population over 30 years of age is estimated at 1.4% for every 10 $\mu g/m^3$ of daily maximum 8-hour average concentrations above 70 $\mu g/m^3$ during the period from April to September [4].

**Carbon monoxide and sulphur dioxide**

Levels of carbon monoxide and sulphur dioxide in outdoor air do not constitute a significant health risk in the measured municipalities, although in the case of sulphur dioxide the threshold effect for 24-h concentration has not been yet detected in epidemiological studies. The 24-hour limit value of 125 $\mu g/m^3$ $SO_2$ was not exceeded at any station in the Czech Republic in 2019. Annual arithmetic means at urban stations ranged from 2 (at the level of national background stations) to 11 $\mu g/m^3$, the estimate of the mean value for unloaded urban localities is 4.2 $\mu g/m^3$. The highest annual arithmetic CO means over 400 $\mu g/m^3$/year were obtained at traffic "hot spot" stations.

**Metals**

There is insufficient scientific evidence concerning the health effects of exposure to airborne heavy metals. Epidemiological studies show the possible influence on the effects of $PM_{10}$ on the cardiovascular system via contained heavy metals including chrome, nickel, cadmium, manganese or mercury [2]. Lead detected in aerosol samples is no longer a health risk in terms of direct exposure since the spread introduction of lead-free petrol. In terms of carcinogenic effects the detected concentrations of cadmium and arsenic do not represent significant health risks in most areas.

**Evaluation of health risks from carcinogens**

An estimate of the theoretical increase of cancer risk caused by long-term exposure to pollutants from outdoor air was carried out for arsenic, nickel, BaP and benzene. The estimate is based on the theory of non-threshold effect of carcinogens and takes into account the linear relationship of dose and effect. For the calculation, unit cancer risk values (UCR) were used, these being the magnitude of the risk of increased probability of oncological disease at a life-long exposure to 1 $\mu g/m^3$ of the carcinogens in ambient air. The UCR values for the assessment of carcinogens (Tab. 2.2.3.1) were taken from WHO materials (Air Quality Guidelines for Europe, Air Quality Guidelines, Global Update 2005, and other sources (US EPA).

***Tab. 2 Unit cancer risk values for the monitored carcinogens***

| *Pollutant* | *Arsenic* | *Nickel* | *Benzo[a]pyrene* | *Benzo[a]anthracene* |
|---|---|---|---|---|
| *UCR* | 1.5E-03 | 3.8E-04 | 8.7E-02 | 1.0E-04 |
| *Pollutant* | *Benzo[b]fluoranthene* | *Benzo[k]fluoranthene* | *Benzo[ghi]perylene* | *Dibenz[ah]anthracene* |
| *UCR* | 1.0E-04 | 1.0E-05 | 1.0E-06 | 1.0E-03 |
| *Pollutant* | *Chrysene* | *Indeno[1.2.3-cd]pyrene* | *Cadmium* | *Benzene* |
| *UCR* | 1.0E-06 | 1.0E-04 | 4.9E-04 | 6.0E-6 |

For the inhabitants of individual urban locality types lifelong exposure to monitored substances was considered and expressed as annual arithmetic means for 2019, allowing calculation of the extent of individual risk.

Tab. 3 summarizes the results on the individual risk for evaluated carcinogens based on recorded concentrations from rural background stations, minimum values of health risk for inhabitants in urban localities with low emission burden and maximum values for inhabitants in the most burdened urban areas. Mean values of individual risk were calculated on the basis of carcinogen concentrations in all types of the monitored urban localities.

***Tab. 3 Estimate of the individual risk from exposure to airborne carcinogens, in number of cancer cases per 1 mil. population, 2019***

| *Pollutant* | *Rural background* | *Urban environment* | | |
|---|---|---|---|---|
| | | *Minimum value* | *Mean value* | *Maximum value* |
| *Arsenic* | 0.74 | 0.30 | 2.44 | 7.20 |
| *Nickel* | 0.12 | 0.10 | 0.40 | 2.20 |
| *Cadmium* | 0.05 | 0.01 | 0.19 | 2.80 |
| *Benzene* | 4.20 | 5.10 | 9.43 | 35.10 |
| *Benzo[a]pyrene* | 32.20 | 34.80 | 160 | 1 084 |

The theoretical increase of cancer risk caused by exposure to pollutants from the outdoor air has not essentially changed for several years and is in the range of $10^{-7}$ - $10^{-4}$ for the different carcinogens (one incremental cancer case per 10 million to 10 thousands population). The greatest long-term contribution represents the exposure to carcinogenic polycyclic aromatic hydrocarbons; in the most burdened industrial urban areas the values represent an incremental lifelong cancer risk by almost one case per 1,000 population.

*References*

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