Human Sensitivity

How does breathing polluted air affect us? What broader impact does it have on our health?

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Human health and quality of life are inseparably linked with the condition of the surrounding environment, and among environmental health hazards, air pollution plays a significant role. Despite some improvement observed in recent years, air pollution still has a negative impact on human health. Human exposure to harmful environmental factors may be short- or long-term (acute or chronic). Short-term exposure usually causes acute reactions, especially in individuals who are particularly susceptible. The World Health Organization (WHO) estimates that around 3 million people die prematurely due to air pollution each year.

The question of exposure

In healthy people, even brief exposure to smog causes inflammation of the respiratory tract, irritation of the conjunctiva, larynx and trachea, pneumonia, fatigue and decreased exercise tolerance. However, in persons with asthma and COPD (chronic obstruc-

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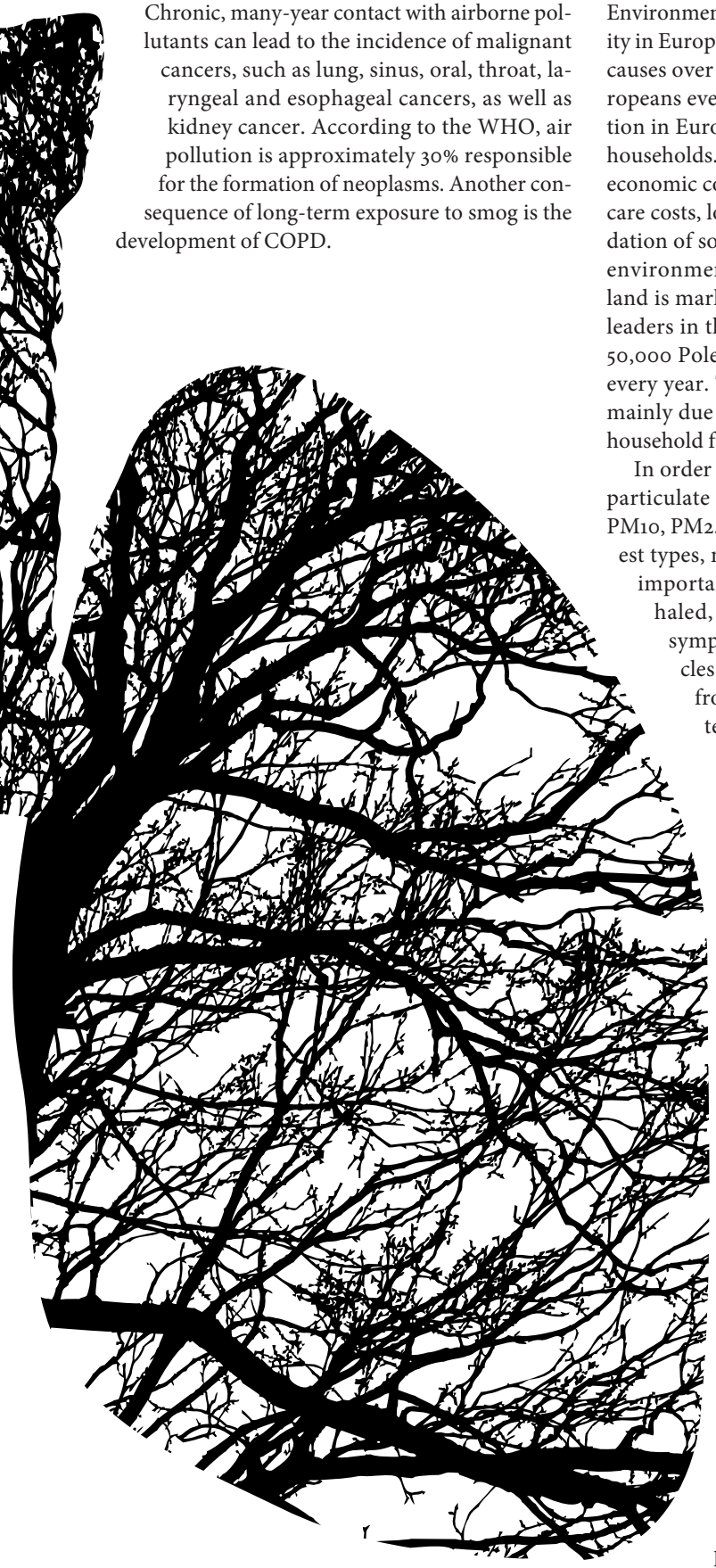
tive pulmonary disease), these conditions become aggravated, often leading to fatalities.

Chronic, many-year contact with airborne pollutants can lead to the incidence of malignant cancers, such as lung, sinus, oral, throat, laryngeal and esophageal cancers, as well as kidney cancer. According to the WHO, air pollution is approximately 30% responsible for the formation of neoplasms. Another consequence of long-term exposure to smog is the development of COPD.



Residents of European cities are at great risk of inhaling polluted air. According to the European Environment Agency (EEA) report titled "Air Quality in Europe 2017", airborne fine particulate matter causes over 400,000 premature deaths among Europeans every year. The main sources of air pollution in Europe are road transport, agriculture and households. Moreover, poor air quality has serious economic consequences, such as increasing healthcare costs, lower employee productivity, the degradation of soil, crops, forests and the entire natural environment. On the smog map of Europe, Poland is marked in red, meaning we are among the leaders in the infamous EU smog ranking. About 50,000 Poles die prematurely due to air pollution every year. The disastrous air quality in Poland is mainly due to emissions from coal combustion in household furnaces.

In order to assess the health impact of airborne particulate matter, it is classified by particle size: PM10, PM2.5, and more recently also PM1. The finest types, namely PM2.5 and PM1, have the most important pathogenic consequences: once inhaled, they cause irritation and respiratory symptoms, mainly cough. The finest particles can also penetrate into the alveoli, and from there they enter the circulatory system. Studies show that in Europe, more than 3% of deaths from cardiovascular disease and 5% of deaths from lung cancer are caused by airborne particulate matter. Some researchers believe that PM2.5 is among the ten most important human health risk factors in the world.

The question of fuel

Air pollution derives both from human activity and from certain environmental factors. The substances routinely monitored include ozone (ground level), airborne particulates, carbon monoxide, nitrogen oxides, sulfur oxide and other sulfur compounds such as hydrogen sulfide. Other substances in the ambient air that affect health include metals (e.g. lead and copper) and hydrocarbons (benzene, formaldehyde and trichlorethylene). Ground level (or tropospheric) ozone is distinguished from stratospheric ozone, which forms a protective layer around the Earth. Tropospheric ozone is a colorless gas pro-

The most common air-pollutant substances and their main sources related to human activity

Substance	Main source
Carbon monoxide	motor vehicles, combustion of wood
Ground level ozone	reaction of nitrogen oxides and volatile organic substances in the presence of sunlight
Nitrogen oxides	motor vehicles, combustion in generating electricity at power plants
Sulfur dioxide	combustion of coal and fossil fuels
Airborne solid particles	motor vehicles, industry, road dust
Reduced sulfur compounds	paper production, refineries, coke ovens

duced through a chemical reaction of nitrogen oxides and volatile organic compounds or hydrocarbons in the atmosphere, with the participation of heat and solar rays. Stagnant air masses allow ozone and its precursors to accumulate, thereby increasing the ozone concentration. Nitrogen oxides are the result of fossil fuel combustion in motor vehicles, power plants and other industrial sources. Volatile organic compounds are also produced by burning fossil fuels, refining gasoline and using solvents; these substances are also produced by forests and plant vegetation. Airborne particles are very small, they can be either in solid or liquid state, and they vary in terms of size, chemical composition and place of origin. They remain suspended in the air for a long time. Coarse particles (less than 10 micrometers) – PM10 – are considered to constitute the inhalable fraction, whereas fine particles (less than 2.5 micrometers) – PM2.5 – are defined as the respirable fraction (penetrating into the alveoli). When coarse particles are inhaled, they accumulate in the lower respiratory tract and damage it in consequence, which leads to a decrease in the amount of surface area for gaseous exchange in the lungs. These particles are most often a byproduct of human activity, especially from the burning of fossil fuels (diesel to the greatest extent).

"Smog" is the term used to describe a chemical suspension produced from photochemical reactions in the atmosphere. Due to the role of heat and sunlight in its production, the highest concentrations of smog occur on warm, sunny days. Summer smog is composed mainly of ground level ozone and suspended particles; winter smog is composed mainly of suspended particles and sulfur dioxide. Smog and the substances of which it is formed can be moved over long distances in the atmosphere by the wind. Despite the widespread view that smog is only a problem in urbanized areas, especially urban centers, ozone levels can be higher in rural areas and suburbs.

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The question of inflammation

In 2010, the American Heart Association (AHA) reviewed reports on the subject, identifying a set of three mechanisms by which dust pollution affects the cardiovascular system. The systemic inflammatory reaction, being a consequence of respiratory tract inflammation, was deemed the first and most important mechanism. The disruption of the autonomous sympathetic system caused by inhaling polluted air was considered the second potential mechanism. The third mechanism, in turn, is based on the direct penetration of airborne fine particulate matter into the bloodstream, and its further interaction with the endothelium of blood vessels, initiating the formation of atherosclerotic plaque. This explains why higher airborne particulate matter levels lead to increased numbers of hospitalizations due to arrhythmia, ischemic events (stroke, myocardial infarction) and hypertension. At the same time, PM has been associated with higher mortality rates for cardiovascular diseases. The mechanism of interaction of

particulate matter and nitrogen oxides leads to the development of chronic airway inflammation, which – in turn – becomes a source of proinflammatory foci in the entire organism. Over many years, this may lead to reduced life expectancy due to the accelerated development of serious diseases, mainly within the respiratory and circulatory systems. At present, the average reduction in the European life expectancy due to air pollution considered to be 9 months.

Inhaled ozone causes an inflammatory reaction, manifested by an increased airway permeability and bronchial hyperreactivity, and is further associated with the impairment of respiratory system function, coughing and dyspnea. However, there is an individual variability in the sensitivity to ozone that cannot be predicted. There is evidence that ground level ozone may exacerbate allergic reactions in persons with asthma. The pathophysiological mechanisms by which fine particles affect the lungs and the heart are not fully understood, because, unlike ozone, fine particulate matter is chemically hetzerogeneous. In controlled clinical trials, the action of nitrogen dioxide and sulfur dioxide reduce lung function in persons with asthma, and carbon monoxide reduces exercise tolerance, especially in persons with coronary heart disease.

The highest doses of pollutants are inhaled during various outdoor activities, work or recreation related. During the morning and afternoon rush hours, the highest level of pollution from car exhausts coincides with the increased number of people travelling to work or school, which results in intensified exposure to pollution.

The question of aging

Smog is most dangerous for children, pregnant women, the elderly, and persons with respiratory problems and allergies. Particulates, mainly PM2.5, have the ability to pass through the alveolar walls and spread within the cardiovascular system, contributing significantly to the development of ischemic heart disease, hypertension, and cardiac arrhythmias. They also exacerbate heart failure and may lead to sudden cardiac death. Patients with coronary disease, the elderly, the obese, persons suffering from diabetes and chronic respiratory diseases, as well as tobacco smokers all face the highest risk.

Smog also contributes to faster aging of the nervous system and increases the risk of Alzheimer's disease and dementia. The substances contained in smog are among the compounds that can also cause fertility problems, allergies, and liver problems. Air pollution in particular harms children's health, even during the fetal period. Such pollutants can cause birth defects and adversely affect such parameters as weight, body length, and head circumference. Children are exposed the most negative effects of breathing contaminated air, for several reasons. First, a child's respiratory system is still immature, meaning it is narrow and short, which increases its susceptibility to harmful influence of particulates. Second, children breathe faster than adults, so they breathe in proportionally more. Another significant factor is that a large percentage of small children breathe through the mouth, rather than through the nose, which is able to trap more pollutants.

The question of miracle-working

We can protect ourselves against smog in several ways. For instance, we could keep our windows shut and stay at home, yet we of course certainly cannot manage to do so all the time. The only effective way to protect ourselves against PM2.5 and PM10 particles is to use special masks with dirt trapping filters, costing upwards of 100 PLN. Indoor air, however, can be effectively cleaned by special and expensive air purifiers containing HEPA filters. The most important recommendation is to minimize the impact of pollution on our bodies, so we should not add voluntarily other harmful factors, for instance in the form of tobacco smoke, whose impact on the human body is much stronger than the influence of smog. The other principles of hygienic lifestyle also remain valid. Still, there are no "miracle drugs" or supplements that might prevent or eliminate the harmful influence of the polluted environment.

Long-term prevention methods include many personal choices that can help reduce air pollution, such as avoiding the use of coal and other fossil fuels, limiting the use of cars and switching to public transport or carpooling, walking or cycling (especially when smog concentration is not high), maintaining cars in good condition, checking emission control systems, switching off the engine while the vehicle is at standstill, choosing vehicles with low fuel consumption, driving at moderate speed and avoiding the use of vehicles and machines with combustion engines (such as motorbikes, motorboats or petrol lawn mowers), applying energy-saving solutions at home, choosing alternatives to household cleaners and oil paints (emitting volatile organic compounds) and proper disposal of toxic household waste. Although education is important in order to motivate people to change their individual behavior, prevention also includes some activities across societies. These include fuel emission and motor vehicle standards, care for urban planning and public transport, as well as international cooperation on cross-border air pollution.

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Further reading:

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