



## THE ANTHROPOGENIC AIR POLLUTION AND HUMAN HEALTH

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### ABSTRACT

Air pollution is a very serious problem worldwide. Anthropogenic air pollution is mostly related to the combustion of various types of fuels. Air pollutant levels remain too high and air quality problems are still not solved. The presence of pollutants in the air has a harmful effect on the human health and the environment. Good air quality is a prerequisite for our good health and well-being.

*“I can only but wonder how the magnificence of the environment is diminishing because of pollution, especially air pollution”*

*Stephen Mynhardt*

**Keywords:** anthropogenic pollution, pollutants, human health, environment,

### INTRODUCTION

Air pollution is both global and national problem as air pollutants released in a particular country can migrate through to the atmosphere and pollute the air elsewhere. We breathe from the moment of birth to our death. Breathing is of vital and constant importance for almost any living being on Earth, not just for us. The poor air quality affects all of us. It damages our health and the environment causing severe losses. The air we breathe comprises various pollutants.

The atmosphere consists of gases with various densities. Dry air is composed of about 78% nitrogen, 21% oxygen and 1% argon. The atmosphere also comprises some water vapours, which, for example, take 0.1% to 4% of the troposphere. In addition, there are thousands of other gases and particles released into the atmosphere from natural and/or anthropogenic sources. The composition of the air is constantly changing. Some substances in it are highly active, i.e. they tend to interact with other substances, forming new ones. As a result, “secondary” pollutants may form, which could be very harmful to human health and the environment. The thermal radiation of the sun, in its turn, acts as a catalyst that facilitates and accelerates chemical reactions.

Air pollution is a significant risk factor for human health in Europe and around the world. A study on air pollution as a global disease-related problem has shown that it is among the top ten health risk factors worldwide. According to the estimates and analyses made so far, pollu-

tion caused the premature death of some 7 million people worldwide, while the premature deaths in the EU caused by pollution are over 400,000 [1]. Air pollution is also classified as a major cause of cancer [2]. The harmful effects of particulate matter (PM<sub>2.5</sub>) and ozone in 2010 caused the premature death of 11 787 people in Bulgaria [3].

Not all substances in the air are considered pollutants. Air pollution is defined as the presence of certain pollutants in the air at levels that have a harmful effect on human health and the environment. The legislation addresses only the air pollution caused by sources of anthropogenic origin. However, not all sources of pollution are anthropogenic. There are many natural phenomena, which also cause air pollution, such as the volcanic eruptions, dust storms and forest fires.

The anthropogenic air pollution is related to the combustion of different types of fossil fuels (solid, liquid, gaseous), as well as to the activity of metallurgical and chemical plants. In this regard, some 20 billion tonnes of CO<sub>2</sub>, 150 million tonnes of SO<sub>2</sub>, up to 53 million tonnes of NO<sub>x</sub>, millions of tonnes of fluorinated substances, Hg, freons and other toxic environmental pollutants are released into the Earth’s atmosphere on yearly basis. The main anthropogenic pollutants are CO<sub>2</sub> and CO, various hydrocarbons, sulphur and nitrogen oxides, heavy metals, various aerosols, photochemical oxidants, O<sub>3</sub>, CH<sub>4</sub>, etc. [4].

The sources of harmful substances released into the air are classified in various categories: thermal power plants, domestic combustion, industrial combustion processes, non-combustible production processes, mining and processing of fossil fuels, use of solvents, road transport, other types of transport, waste treatment and disposal, agriculture, natural sources. Each of these sources releases specific pollutants, namely: SO<sub>x</sub>, N<sub>x</sub>O<sub>y</sub>, non-methane volatile organic compounds (NMVOCs), CH<sub>4</sub>, NH<sub>3</sub>, CO, Hg, Cd, Pb, polycyclic aromatic hydrocarbons (PAHs), dioxins and furans (DF).

Life on Earth has always been accompanied by air pollution associated with various vapours, volcanic eruptions, degassing of magma and various solutions. The air pollutants, in conjunction with the CO<sub>2</sub> and water vapours in the atmosphere, can cause the so-called “greenhouse effect”. We should note that CO<sub>2</sub> plays a significant role in the Earth’s atmosphere. If CO<sub>2</sub> is removed from it, the air temperature will drop by approximately 21°C, and if dou-

bled, the temperature will rise by 4°C [4].

The main pollutants that have harmful effect on human health are nitrogen dioxide, sulphur dioxide, ozone, methane, mercury, black carbon and fine particulates. The pollution measurements made in Bulgaria raise serious concerns about the air quality and show that the whole population breathes air, which is harmful to its health.

Air quality in Europe and Bulgaria is deteriorated mainly by transport, industrial production, agriculture and many more sources. Significant amounts of particulate matter, sulphur dioxide and nitrogen oxides are released from the coal-fired power plants, which indirectly contribute to the formation of ozone as well. The particulate matter (PM<sub>2.5</sub>) and ozone are the greatest threats to human health. The coal-fired power plants' stacks also release heavy metals, such as mercury and persistent organic pollutants (dioxins, polycyclic aromatic chemicals (PAHs)). Air pollution is not the same everywhere. The factories, public and residential buildings release about half of the emissions of PM<sub>2.5</sub> and carbon monoxide.

Particulate matter consists of airborne fine particles. Dust is among the major air pollutants. Its harmful effect on human health depends mainly on the size and chemical composition of the particulates, as well as on the other substances adsorbed on their surface. Dust enters the human body mainly through the respiratory tract, whereas coarser particles are retained in the upper respiratory tract, while fine particles (less than 10 µm in size, or PM<sub>10</sub>) penetrate into the lower parts of the respiratory tract.

**Particulate matter (PM)** is the air pollutant that causes the greatest damage to human health. Dust particles, whether natural or of anthropogenic origin, once airborne, take part in various chemical reactions and increase air pollution. Significant efforts have been made in the last decades to purify the air, and yet air in Europe continues to be harmful to our health and the environment. Dust and ozone air pollution pose a serious risk to public health, impair the quality of life and life expectancy. Different pollutants have different sources and effects. They are so light and mobile in the air that can penetrate not only deep into human lungs, but also into human blood. While some particles get airborne from the ground, others, such as the sulphur dioxide, nitrogen oxides, ammonia, etc. result from

chemical reactions. Particles can be made up of different components and may have different effects on the human body and the environment, depending on their composition [5]. PM<sub>2.5</sub> and PM<sub>10</sub> levels are much higher than those prescribed by the European Union and the World Health Organization [6]. Bulgaria demonstrates the highest level of PM<sub>10</sub> pollution of all EU Member States with an average daily concentration of 77 µg/m<sup>3</sup>, whereby the European Union's limit value is 50µg/m<sup>3</sup>. According to the World Health Organization, 60% of Bulgarian urban population is exposed to dangerous levels of particulate matter (PM<sub>10</sub>) [7]. PM<sub>2.5</sub> levels in the urban areas of Bulgaria are among the highest of all 28 EU Member States [8].

According to a study of the World Health Organization (WHO), particulate matter (PM<sub>2.5</sub>, i.e. particles of less than 2.5 microns in diameter), pollution can be hazardous to human health. Another study made by the WHO, "Review of evidence on health aspects of air pollution", states that the long-term exposure to particulate matter can cause respiratory disease, atherosclerosis and adverse birth outcomes. The WHO study further claims a relationship between the particulate matter pollution and the retarded development of the nervous system, diabetes, and increased mortality rate from respiratory and cardiovascular diseases. The different chemical composition of the particulates can also affect the global climate by warming or cooling the planet. The elemental carbon is one of the major components of the black carbon, which in turn is the most commonly met compound of the PM. It results from the incomplete combustion of fossil fuels and firewood. In particular, black carbon emissions in urban areas are most frequently caused by the motor vehicles' diesel engines. In addition to adverse effects on the human health, the carbon in the particulate matter contributes to the climate changes by absorbing the solar energy, thus warming up the atmosphere [9].

The harmful effect of particulate matter pollution increases highly in the presence of sulphur dioxide in the air. The short-term exposure to 500 µg/m<sup>3</sup> particulate matter and sulphur dioxide increases the overall mortality rate of the population, while the exposure to twice lower levels of the particulate matter and sulphur increases the level of general morbidity and deterioration of the pulmonary function [6].

**THE PM LEVELS IN BULGARIA EXCEED THE EU AND WHO STANDARDS**

<b>PARTICULATE MATTER (PM<sub>2.5</sub>)</b>	<b>PARTICULATE MATTER (PM<sub>10</sub>)</b>
Bulgaria: 23 µg/m <sup>3</sup>	Bulgaria: 43 µg/m <sup>3</sup>
Annual EU limit: 25 µg/m <sup>3</sup>	Annual EU limit: 40 µg/m <sup>3</sup>
Recommended WHO limit: 10 µg/m <sup>3</sup>	Recommended WHO limit: 20 µg/m <sup>3</sup>

\* European Environment Agency. AirBase - public air quality database – air pollution, 2012[10]

**Ozone** is a powerful oxidant found in the stratosphere (the upper layers of the atmosphere), which protects us from the sun's dangerous ultraviolet radiation, but in the lower layers of the atmosphere (e.g. in the troposphere) it is a pollutant that damages human health and nature. It is

formed in the air by the interaction between solar radiation and nitrogen dioxide. High levels of ozone can damage living tissues and cause corrosion to buildings. Ozone penetrates the human body through the respiratory system and exerts its toxic effects.

Ozone's toxicity is directly dependent on the levels of exposure. The short-term effects start with eye irritation, which is reported at ozone levels of about  $200\mu\text{g}/\text{m}^3$ , while at higher levels it may damage the lungs. Based on observations on the ozone's health effects, the WHO recommends a 1-hour exposure limit of 150 to  $200\mu\text{g}/\text{m}^3$ , and 8-hour exposure limit of 100 to  $120\mu\text{g}/\text{m}^3$ . Being powerful and aggressive, once in the human body ozone may cause inflammation of lungs and bronchi. The long and high-level ozone exposure of people suffering from respiratory diseases, such as asthma, as well as from heart diseases, may lead to permanent disability or death.

The fast development of the road transport, especially in the urban areas, has led to the formation of photochemical smog, the sources of which are nitrogen oxides, CO, and hydrocarbons available in the exhaust gases. All this leads to an increase in the ground level  $\text{O}_3$  content. Ozone is considered a toxic substance and is a strong oxidizing agent [11].

**Sulphur dioxide ( $\text{SO}_2$ )** is released into the atmosphere as a result of the use of fossil fuels (by thermal power plants, domestic sources, etc.). Chemical and metallurgical industries also contribute to the sulphur dioxide pollution. Sulphur dioxide penetrates the human body through the respiratory system. There may be observed various effects from the exposure to sulphur dioxide depending on the level and duration of exposure. However, the respiratory system remains the most affected system in case of short-term exposure. There may also be observed individual sensitivity to the sulphur dioxide exposure. For example, people who suffer from asthma are extremely sensitive to it. The population groups, which are most sensitive to sulphur dioxide exposure are the children, the elderly people, the asthmatics, and the people with cardiovascular or chronic pulmonary diseases. Other observed effects on human health include breathing disorders, impaired lungs immunity, etc.

**Nitrogen dioxide ( $\text{NO}_2$ )** is formed mainly in various combustion processes, such as those in the car engines and in the power plant combustion chambers. The main sources are the thermal power plants, industrial enterprises, motor vehicles, the tobacco smoke. In the presence of intense sunlight, the nitrogen dioxide may interact with some organic pollutants in the air to produce ozone as a secondary pollutant. Nitrogen dioxide is a gas, and most of it is absorbed in the body. A considerable part of it may be retained in the lungs for a long period of time. The nitrogen dioxide has a harmful effect. It mainly affects the respiratory functions of the body [11].

**Benzo[a]pyrene (BaP)** is another pollutant that is released mainly through the coal and firewood burnt in the stoves, as well as by the diesel vehicles. In addition to causing cancer, the benzo[a]pyrene (BaP) available in the particulate matter can cause irritation to the eyes, nose, bronchi and throat. Benzo[a]pyrene is mainly inhaled, but it can also enter the body through water and food. There

are many significant studies dedicated to the carcinogenic effect of 3,4-benzo[a]pyrene (BaP) inhaled in the process of smoking [6].

Air pollution affects all of us, but not in the same way and to the same extent. In urban areas, people are exposed to higher pollution levels due to the higher population density. The groups of the people suffering from cardiovascular and respiratory diseases, respiratory allergies, the elderly people and young children are more susceptible to its adverse effects. According to a project funded by the European Commission, air pollution decreases life expectancy by 8.6 months on average. As a pollutant, benzene can seriously damage the genetic material into cells and can cause cancer in case of long-term exposure [9].

**Carbon monoxide (CO)** is one of the most widely spread air pollutants, which is formed by the incomplete combustion of carbon-containing materials. It is a colourless, odourless and tasteless gas, which is slightly lighter than air. It enters the body through breathing and binds to haemoglobin to form carboxyhaemoglobin. Its harmful effects result from the impaired oxygen transfer to the tissues, causing tissue hypoxia and disturbances in oxygen-sensitive organs, such as the blood vessels, brain and heart. The risk to human health depends on the levels and duration of exposure [4].

Lead aerosols are the most widely spread metal-containing aerosol pollutants. The **lead (Pb)** can enter the body through the respiratory and the gastrointestinal tracts. The long-term exposure to lead aerosols may cause nervous system disorders, increased blood pressure, etc. The lead (Pb) in the human body causes disorders of the central nervous system (such as headache, fatigue, memory problems, epileptic seizures, impaired speech and hearing, palsy, eye damage). It changes the chemical composition of blood, which can lead to endocrine and metabolic disorders, gastrointestinal disorders, cardiovascular and renal diseases.

In most of the cases, the anthropogenic **arsenic (As)** pollution is caused by metallurgy, the use of arsenic-based herbicides and pesticides and by burning of low-grade coal. Arsenic penetrates the lungs when breathing contaminated air. Through the blood, it deposits in the kidneys, brain, bones, liver and skin. It is extremely carcinogenic to the human body. The International Agency for Research on Cancer (IARC) classifies arsenic as a proven first-category carcinogen.

**Cadmium (Cd)** is a metal, which occurs in nature as a minor component in most zinc ores. Therefore, zinc production is the most common source of cadmium pollution. Apart from the metallurgical industry, other sources of cadmium pollution are the burning of wastes, the tobacco smoke, etc. Cadmium penetrates the body through breathing and deposits into the liver. Then, it slowly migrates into the kidneys, where it can be found in high concentrations. It can also penetrate the body through the digestive tract. Cadmium precipitates in the soil, from where it enters the plants and through food penetrates the human body. The kidneys are the critical organs subjected to long-term low-

level cadmium exposure. Kidneys get irreversibly damaged if exposed to levels of cadmium in the renal cortex exceeding 200 mg/kg.

**Ammonia (NH<sub>3</sub>)** is a colourless gas with a characteristic pungent, suffocating odour. In high concentrations, it is used as a fertilizer. It is also used in the preparation of soda, medicinal products, for dyeing of fabrics and in refrigeration systems. It damages the human respiratory system. Large amounts of this gas can be found in the atmosphere. Nitrogen reacts with oxygen in the air to form nitrogen oxides. It also reacts with the hydrogen atoms to produce ammonia (NH<sub>3</sub>), which is an air pollutant with harmful effect on human health and the environment. Motor vehicles use fuel which, when burned, changes the nature of many substances. Various air pollutants are released as a result of the combustion processes, such as benzene, sulphur dioxide, carbon monoxide and heavy metals. Some of them have a short-term effect on human health. Other pollutants, however, such as the heavy metals and other persistent pollutants, accumulate in the environment and reach the human body through the food chain [11].

**Chlorine (Cl<sub>2</sub>)** is a yellow-green gas with a pungent, suffocating odour. It is used for chlorination of water, for production of organochlorine compounds, for bleaching of fabrics and paper, and as a disinfectant. It affects the respiratory tract with long-term effects on human body. Over-exposure to chlorine causes pulmonary oedema with lethal outcome.

**Hydrogen cyanide (HCN)** is a colourless gas with bitter almond-like odour. The exposure to hydrogen cyanide causes respiratory failure with lethal outcome.

**Hydrogen sulphide (H<sub>2</sub>S)** is a colourless gas with a strong, pungent odour. It can be found in nature around oil fields, in the volcanic gases and near mineral springs. It is widely used for medical purposes. If inhaled, it irritates the mouth's mucous membrane, and at higher concentrations may cause respiratory failure with lethal outcome.

**Phosgene (COCl<sub>2</sub>)** is a colourless gas. In case of exposure, it causes respiratory failure with a lethal outcome.

**Oil and petroleum products** are global pollutants. The products of their combustion are released in the air. On the other hand, in case of accidental spills, they can directly pollute the soil and terrestrial ecosystems, as well as the aquatic environment. Oil demonstrates relatively slow degradation in the environment. It forms a thin layer on the water surface capable of covering huge areas (1 ton of oil can cover up to 12 sq. km.). Oil is highly toxic to the living organisms, and many of its components are carcinogenic. [11]

Pollution of water basins with oil and petroleum products is the most serious anthropogenic pollution. The severity of an ecological incident will depend on a number of factors related to the quantity and quality of oil, loca-

tion of the incident, duration of leakage, climate conditions. [12]

**Laser printers** are another pollutant, which pollutes the air in the offices by releasing fine particles from the printing powder widely known as "toner". These particles can get into the lungs and consequently into the body where they can cause a number of diseases depending on the chemical composition of the toner. In the worst case, they may cause **cardiovascular problems** and even cancer.

The infections caused by the use of **biological weapons** are extremely dangerous and deadly. Such infections can occur in various ways: through inhalation of dispersed airborne agents, consumption of contaminated water or food, or bite of infected arthropods. Smallpox, Ebola, typhus, Brucella, flu, plague, tuberculosis, hepatitis, etc. have all been identified as etiological agents that may cause horrific infections, if their strains are modified to serve as a bioterrorist weapon. [13]

Anthropogenic release of **nickel (Ni)** into the air (43 thousand tons/year) is about 5 times higher than the quantity released by soil erosion or other natural processes (about 8.5 thousand tons/year). The biochemical properties of heavy metals are different. It has been established that many metals and organometallic compounds are toxic and carcinogenic. [4]

The long-term exposure to air pollutants may cause wide range of chronic and acute health effects ranging from irritation to death. [6, 14] According to recent research data, the long-term exposure to air pollutants is a risk factor for children's health and may cause diabetes in addition to the cardiovascular and respiratory conditions. [6, 15]

There are four stages of gas poisoning:

- Stage one: Slight irritation in the upper airways;
- Stage two: A latency period of 4 – 10 hours without subjective complaints;
- Stage three: Occurrence of pulmonary oedema;
- Stage four: Recovery [11].

The groups, which are most susceptible to air pollution, are pregnant women, children, elderly people and people already suffering from respiratory diseases and other severe medical conditions. Air pollution exists in the form of a mixture of gaseous and semi-volatile substances and particulate matter with widely variable composition.

The chronic obstructive pulmonary disease is a lung disease that is characterized by obstructed breathing and can be life-threatening. The inflammatory response of the body is chronic bronchitis, which causes destruction of the pulmonary alveoli or emphysema. Studies have shown that in areas with high levels of PM, children demonstrate intensive development of the lung functions [16]. Such an effect on the lungs poses an additional risk for development of lung disease at a later stage.

Apart from the respiratory system, the air pollutants affect the **cardiovascular system**. The consequences from the harmful effects of the air pollutants are myocardial infarction, high blood pressure, increased cerebrovascular ischemia and atherosclerosis. There have been found lots

of scientific evidence for the effects on the cardiovascular system resulting from the exposure to air pollutants in recent years [17].

The air pollutants effects on the **autonomic and central nervous systems** include oxidative stress, anxiety, stroke, neurodevelopmental effects, Alzheimer's disease, Parkinson's disease.

Some heavy metals, such as mercury and lead, are well-known air pollutants. Heavy metals have a strong neurotoxic effect on the human body. They are especially harmful to children. Exposure to lead in childhood can lead to decreased cognitive function and problems with visual and spatial orientation. Mercury is also a powerful neurotoxin. Its deposition in the womb can cause foetal impairment affecting the brain and nervous system development and leading to potential mental problems, attention deficit or cognitive abnormalities.

The effects on children's health and reproductive output include low birth weight, premature birth, poor sperm quality. Placenta protects the embryo from the environmentally hazardous substances, but cannot provide full protection against all air pollutants.

Environmental pollution is one of the most important and worrying problems of our time. Today, pollution is not only a real fact, but it already exceeds the generally established limits. Agriculture, industry, transport and radioactivity are the most important environmental pollutants of all. Nature has its own compensatory mechanisms that can cope with the temporary adverse effects endangering life on Earth. In recent years, however, people with their aggressive behaviour and reckless actions keep on destroying the natural resources, thus causing environmental disasters [6].

It can be concluded that:

- about 90% of ammonia emissions and 80% of methane emissions come from agricultural activities;
- more than 40% of nitrogen oxide emissions come from road transport;
- fuel combustion by road transport is a key factor in air pollution;
- approximately 60% of sulphur dioxide comes from the process of energy production and distribution;
- many natural phenomena, including volcanic eruptions and dust storms, release air pollutants into the air;
- landfills, coal mining and gas transmission are sources of methane and ammonia [6].

Replacement of the traditional energy sources with natural gas leads to *environmental effects*, which can be summarized, as follows:

- reduction of the overall quantity of emissions;
- almost complete elimination of the sulphur oxides, dust and black carbon emissions;
- CO<sub>2</sub> emissions are reduced more than 2 times;
- Elimination of the risk of possible spills during the transfer of liquid fuels [4].

Combustion of solid and liquid fuels (such as oil and

coal) should be drastically reduced by:

- Reduction of energy consumption;
- Shifting to renewable energy sources (sun, water, wind, biomass, geothermal energy) [4].

The improvement of air quality, sanitation and a standard of living reduces the risk for the population of contracting diseases caused by the air pollution, such as acute infections of the upper respiratory tract, acute bronchitis, bronchial asthma, pneumonia, chronic pharyngitis, etc., therefore it practically has *both medical and social effect*. One of the solutions to the problem is to reduce private vehicles use in favour of public transport [4].

The Ministry of Health has taken particular measures to ensure protection of public health, as well as to early detect and timely treat the respiratory diseases in children. A prevention programme has been developed for some highly polluted regions, which envisages activities in the following priority areas:

- improving the knowledge of health professionals about the relationship between environmental pollution and the possible harmful effects on the human body;
- reduction of the pollutants released into the environment in order to minimize the health risks for children and elderly people;
- raising the level of awareness regarding personal health and preventive examinations and improvement of the population's health literacy;
- expanding the scope of the preventive examinations of children and elderly people with a focus on the non-specific bronchopulmonary pathology;
- providing better conditions for diagnosis, prevention and treatment of children and students with upper and lower respiratory tract diseases;
- raising public awareness of the harmful effects of environmental pollutants on human health [4, 11, 18].

## CONCLUSION

The search for alternative energy sources continues, and their use gives rise to hopes for solving the existing environmental problems. Wind turbines are widely used as sources of clean energy. The solar energy production costs go down, which makes that type of energy more cost-effective than most of the conventional energy sources. There have been developed power sources which are waste-free, such as the fuel cells that produce electricity and do not release harmful substances because electricity is generated by a chemical reaction.

*“Air pollution is causing damage to human health and ecosystems. Large parts of the population do not live in a healthy environment, according to current standards. To get on to a sustainable path, Europe will have to be ambitious and go beyond current legislation.” - Hans Bruyninckx Executive Director of the European Environment Agency*

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