Air pollution

Physiological needs of man

An adult consumes about 15 kg of air per day, of which, during calm breathing, about 1/2 kg of oxygen is absorbed into the blood and is metabolized in the body.

Compared to the **daily consumption''** ***of approximately*** *1.5 kg of food* ***and about*** *2 l* of water for drinking purposes, this is a considerable amount. Except in exceptional cases, a person is always dependent on the atmosphere in which he immediately finds himself without the possibility of any choice. *Simplified, one can say that a person can be 5 weeks without food, 5 days without water, but only 5 minutes without air*.

The respiratory system is the gate through which not only the "gases" that make up normal air enter the body, but also the "gas emissions" that enter the air as pollutants that are harmful or even toxic to the body.

``Solid emissions *(dust, ash, soot) and ``microorganisms* (bacteria, viruses, mold spores, etc.) enter the body. The physical properties of air (temperature, humidity, ionization, '*barometric pressure*, etc.) are also of great importance. In addition to gaseous elements, the air contains water vapor, the content of which varies from 2 to 3 percent by volume.

Gaseous components of the atmosphere

Sulfur oxide, hydrogen fluoride, hydrogen chloride and sulfane are produced by volcanic activity.

Oxygen. At normal air pressure, the lack of oxygen begins to manifest itself as a distinct problem only when the oxygen concentration drops to ``10-12 percent by volume*.* Unconsciousness, which usually results in death without assistance due to paralysis of the respiratory center, occurs at approximately an oxygen concentration of about 7%.

From the point of view of its effect on humans, '*carbon dioxide* begins to manifest itself only at a concentration of around 2% by reducing attention and reducing the ability to make decisions,

- at a concentration of around 4-6% there is a deepening of breathing, headaches, apathy
- death occurs at around 10% CO_2 concentration.

Carbon dioxide is also used as an indicator of indoor atmospheric pollution due to human presence. The threshold value varies between 0.07 and 0.15%. **Nitrogen** at normal pressure has practically no physiological significance, at higher pressure it is known to be the cause of the so-called caisson disease, which occurs when a person has been for a certain period of time exposed to higher air pressure and is quickly decompressed. In such a case, the nitrogen is expelled in the form of bubbles, which can even cause death, as a result of **gas embolism**, especially of the cerebral vessels. Creating an artificial atmosphere in the pressurized space is one way to avoid this risk. In which nitrogen is replaced by helium, which is less soluble in blood.

In addition to the permanent components of the atmosphere, there are **other components'** ***of natural origin, the concentrations of which fluctuate considerably. They are, in addition to the already mentioned*** *water vapor*, **nitrogen oxides'** and **ozone** ***formed behind the storm in electrical discharges,*** *sulfur dioxide* , **hydrogen fluoride** and **hydrogen chloride** ***of volcanic origin,*** *sulfane* from sour natural gas eruptions, from volcanoes or as a product of the activity of sulfur bacteria. ""Dust and aerosols"" of natural origin in the air represent ""salt particles"" originating from sea water, various types of condensation nuclei, soil and plant parts, of which plant pollens in particular have a health-related impact on a non-negligible part of the population considerable importance, bacterial spores, etc. The concentrations of these substances are usually very low.

The lowest concentration of particles in the air can be found above sea level (4 mg of particles per 1 m^3, mostly salt). In the air over rural areas around **40 mg** of particles per 1 m^3 have been determined, while in places of industrial accumulation values reaching **100 mg/m^{3}< /sup>** even a thousand times higher.

Apart from these natural components, there are other gaseous impurities in the atmosphere in varying amounts, or liquid or solid impurities, which are in relatively low concentrations. While nitrogen is about 78% by volume in normal air, oxygen about 20%, sulfur dioxide is , which enters the atmosphere, e.g., with smoke emissions from burning coal at about '*1 ten-thousandth of % by volume*. These additives are referred to as air pollutants, mostly biologically very aggressive with an adverse effect on people's health.

Physical Properties

Air pressure

Like any other substance, air has its **mass'*, which is manifested by a* ***measurable pressure*. It is quite substantial **- 1.033 kg. cm^{-2}** (or according to the old way of expressing 760 mm of mercury), i.e. **101.3 kPa at 0 °C at sea level**.

Fluctuations around this value usually do not exceed 2.6–4 kPa and are practically unnoticeable for a healthy person. The great importance of air pressure for humans results from the adaptation of all functions associated with breathing to the partial pressure of air components, which are atair pressure around 100 kPa.

The decisive factor is the partial pressure of oxygen, which is 21.3 kPa. At an altitude of "5000 m" above sea level at an atmospheric pressure of "54 kPa" the partial pressure of oxygen is only "11.3 kPa" and at an altitude of "10,000 m" above sea level is **5.6 kPa'**.

As the partial pressure of oxygen in the air decreases, so does its pressure in the alveolar air. However, the drop is greater than the drop in the outside air. The disproportion is caused by the fact that the amount of carbon dioxide and water vapor in the alveolar air does not decrease in proportion to the decrease in the partial pressure of oxygen, but remains practically the same (it is determined by metabolism), so their higher tension further reduces the partial pressure of O_2 . When the partial pressure of oxygen is further reduced in untrained persons, hypoxia occurs.

One can encounter low air pressure when hiking in the mountains, when air conditioning malfunctions in airplanes, etc. People are exposed to "increased air pressure" when working in "very deep mines", but especially when working in "caissons", the work of "divers", etc.

Air ionization

Air ions are tiny particles (molecules, groups of molecules, condensation nuclei, microscopic dust particles) that have an *induced electric charge* (positive or negative), resulting from the loss or gain of an electron. This occurs through the irradiation of molecules, the radiation of radioactive elements or the leakage of radioactive gases from the soil, the effect of cosmic rays and ultraviolet rays. In addition, ``ionization *occurs, for example, during ``water spraying*, also during ``electric discharges.

According to the charge, a distinction is made between airborne positive and negative ions. By size **large, medium and small *or more commonly*** *heavy and light*. Light ions are ionized molecules themselves. Heavy ions are created by adsorption onto condensation nuclei or by aggregation of ionized molecules.

The concentration of ions is the result of a dynamic stability between the forces that continuously form new ions and simultaneously acting destructive events. It changes according to the current circumstances of the atmosphere. It is **higher in the upper layers of the atmosphere'' *or during some work processes (*electric arc welding**, when working with **x-rays'**, in the vicinity of **ultraviolet radiation sources*) ' etc.). Higher concentrations of light ions are also found in*** *around waterfalls'* ***and*** *above the surface of the oceans*.

There are relatively few light ions in the atmosphere of housing estates and industrial zones. Here the amount of **heavy ions'** is increased (20-30 thousand per m^3). Heavy ions are an unstable component of air ionization. They settle quickly and lose their charge. Light ions are around 400-500 thousand per m^3 above the surface of the oceans, while in the polluted atmosphere they drop to **100 in m^3.**

Smoking a single cigarette in the room significantly reduces their concentration for several hours. The content of ions in the air also fluctuates throughout the year. It increases in summer and decreases in winter. The effect of changes in air ionization on the organism is mainly applied through the respiratory organs, where the ions give up their charge most easily. Indicators of their effect are the observation of the activity of the ciliated epithelium in the airways, mucus production, changes in the electroencephalogram, changes in blood pressure, blood pH, basal metabolism, hormone production, breathing rate, temperature, and also subjective feelings of alertness or fatigue.

Several scientific papers have shown that there is a **positive effect of light negative ions'** on hypertension, Basedow disease, bronchial asthma, [[rheumatism]], tuberculosis and also for the overall tuning of the organism.

Negative ions create a feeling of freshness.

On the basis of positive experiences with the action of light negative ions, '*air ionizers* were developed. Most often, the so-called silent corona discharge is used, during which, however, a larger amount of ozone and nitrogen oxides can be produced, which is inappropriate. Other ionizers use some suitable radioactive substance and the last type uses a water spray. Although the last type, which does not add any foreign substances to the atmosphere, would be the most suitable, there are good experiences with corona discharge ionizers. Improvements in performance, reduction of fatigue, etc., were described in various industrial enterprises when using the ionizer.

The so-called *Ozonizers*, which are sometimes recommended for suppressing odors, etc., are completely unsuitable for the irritation of ozone and the nitrogen oxides that are created at the same time. It is particularly inappropriate to use the ionizer in operations where "toxic aerosols" are present in the air. As a result of ionization, the risk of their retention in the lungs of exposed persons increases.

Health importance of basic components of air pollution

Main groups

1. group of substances emitted directly from sources - primary emissions

2. a group of substances created in the atmosphere by reactions between pollutants either with the help of *photoactivation* (mainly UV radiation) or without it - sometimes referred to as *secondary emissions*, they can even bemore efflux than the starting substances. The most well-known of these reactions are those that produce the ``oxidative *(today referred to as summer)* ``*smog*. Very few primary pollutants permanently retain their chemical identity after entering the atmosphere. Therefore, when measuring air pollution and evaluating human exposure to polluted air, we speak of '*immissions*.

Includes

- fine dust and aerosol particles

from gaseous emissions

- sulfur compounds
- nitrogenu
- carbonu
- halides
- organic matter
- radioactive substances

From the aspect of human health, ``microbial *air pollution, which generally also belongs to aerosol or dust emissions, deserves special attention.*

Solid emissions, dust and aerosols

Particles *larger than 100 μm* sediment relatively quickly and therefore have relatively little direct health significance. Because of their size, their interaction with other air pollutants is also limited. They can be ""inorganic dusts"" eg metal particles, silicates, fluorides, oxides, nitrates, chlorides, sulfates, or dusts of organic origin such as tars, bacteria and pollen.

Because of their considerable surface area, they provide a good opportunity for **merging** and **other reactions** ***of gaseous or liquid pollutants adsorbed on them. In addition, they*** *scatter the light*. With their higher content in the air, visibility can be significantly reduced. Depending on their chemical structure, they can be highly *poisonous* to humans, animals and plants. They have a strong **corrosive effect'** on materials, become condensation nuclei for the formation of water droplets and are the reason for the increased occurrence of fogs and clouds in industrial areas.

Solid immissions

Particles smaller than 10 μm are referred to as **aerosol**. By weight, their content in the air is relatively small. They are of great biological importance. In **24 hours*****, almost*** **0.01 g** ***of them reach*** *the respiratory system*, which is several billion particles, mostly smaller than 1 μm, which infiltrate through the bronchial tubes up to alveoli. Particles smaller than 0.01 μm begin to behave as gas molecules. Their retention in the lungs gradually decreases and particles smaller than 0.001 μm are exhaled. When aerosol particles are deposited in the lungs, the most dangerous particles are around 1-2 μm in size, as 90% or more are trapped in the lungs.

Particles larger than **10 μm** are **trapped in the upper respiratory tract**. The ciliated epithelium rebuilds the mucociliary escalator on which dust particles adhere. The cilia oscillate towards the nasopharynx ("out" in the bronchi and "in" in the nasal cavity), so they are eventually swallowed, which is especially important for toxic dusts.

The harmfulness of dusts and aerosols depends on their retention in the lungs, and this is decisively influenced by their dispersity. We determine this with the help of '*microscopic dust examination*, most often with a *lanameter*. Lanameter is a microscope complete with an aperture with a scale. We obtain the basis for the construction of the distribution curve by measuring the size of most often 500 particles of the analyzed dust and sorting them into size classes (2, 2–4, 4–6, 6–8, 8–10, >10 μm). The distribution curve expresses the relative frequency of representation of individual size classes of captured particles and is an essential aid in assessing the extent of the hygienic risk when inhaling a given dust.

'*Chemical composition of the dust* ***is another important factor in assessing the health risk of inhalation. If the dust has no specific biological effects and only causes dusting of the lungs, we speak of*** **biologically inert** ***dust. Usually, however, it is biologically aggressive dust and as a result of its inhalation, various pulmonary "conioses" arise. A classic example of dust with fibroplastic effects is*** *silica dust*. So there will be, especially among miners and grinders the dreaded silicosis.

'*Asbestos dust*, especially after long-term inhalation of long-fibrous dust, can cause a malignant neoplasm of the pleura or pleura in addition to classic asbestosis. Dust containing beryllium during immunosuppression can cause **berylliosis'**. Dusting of the lungs with **iron dust** is referred to as siderosis.

In addition to the dispersity and chemical composition of the dust, its *physical properties* are also of fundamental importance. These include wettability, crystalline structure and dust morphology, i.e. the shape of the inhaled particles. E.g. studies conducted among the inhabitants of the Sahara have shown that although the wind-blown dust is mostly pure silica, silicosis has not been found in the exposed population. These findings were explained by the fact that the siliceous dust of the desert, and therefore its particles, are mainly spherical due to long-term abrasion and only freshly formed particles characterized by edges, points and needle-like structures can cause the formation of typical "silicotic nodules". The significance of the length of asbestos dust fibers for the formation of '*mesothelioma of the pleura* was mentioned above.

Gaseous emissions

"Sulfur" compounds are mainly in the form of "SO_2" and "SO_3" oxides, then "sulfan **and** carbon disulfide'.**These oxides enter the atmosphere during the burning of fossil fuels, the burning of fuel oil, and as a product of various technological processes, similar to sulfane and carbon disulfide, especially in the emissions of the chemical industry.**

Of the nitrogen compounds, its oxides and ammonia are the most important. Nitrogen oxides are produced during "burning" at high temperatures, i.e. primarily in all "power plants" and "heating plants" for fossil fuels, and in the cylinders of piston engines. They can be ``irritating*, after inhalation they are ``absorbed into the blood* to form methemoglobin, and are an important factor in photochemical reactions.

Oxides of **carbon** CO_2 and CO are formed during complete or incomplete combustion of carbon fuels (mainly from automobile traffic). High concentrations of CO can also be found in some workplaces, e.g. in boiler rooms. **1 mg of carbon monoxide'** in m^3 of air blocks *0.16% of hemoglobin* after several hours of breathing.

Heating plants are a source of nitrogen oxides.

Halogen compounds, such as HF or HCl, are released into the atmosphere during some metallurgical processes. There are also known cases of massive damage to vegetation and the occurrence of fluorosis in cattle in the vicinity of the aluminum plant and in the production of phosphoric fertilizers.

There is a large amount of *organic compounds* in polluted air, mainly saturated and unsaturated aliphatic and aromatic hydrocarbons and their oxygenated and hallucinogenic derivatives. They are emitted as vapors or volatile compounds. A number of ``polycyclic aromatic hydrocarbons *(PAHs) have demonstrable ``carcinogenic properties*. Among the organic substances in the air we also find strongly "irritating compounds" such as formaldehyde, formic acid, acrolein and others. The main source of these hydrocarbons are automobile engines, mainly two-stroke and four-stroke gasoline engines. For diesel engines, the main problem is particles containing carcinogenic substances, especially polycyclic aromatics.

Radioactive immission

Radioactive substances, e.g. in the form of radioactive strontium, isotopes of iodine, cesium and other elements, can endanger human health. However, apart from experiments with nuclear weapons, there have not yet been sources that would seriously threaten humans through the air. The current development of nuclear power plants has brought some difficulties almost exclusively in the case of accidents, as it was shown earlier in the accidents at **Windscale'** (1956, England), **Three Mile Island'** (1979, USA) and especially during the accident of the nuclear power plant unit in *Chernobyl* in the year *1986*. A properly operated nuclear power plant is less dangerous in terms of radioactive emissions into the air than a conventional coal-burning thermal power plant.

Secondary emission

The speed, extent of the reaction and the reaction paths by which the components of the emissions react with each other are influenced by the concentration of the reacting substances, the degree of photoactivation (radical formation mainly by ultraviolet radiation), meteorological dispersive factors, particle size and air humidity.

Solid particles are the main basis of atmospheric reactions. Gas molecules are absorbed on their surface. This increase in aerosol particle surface concentration has significant pathophysiological consequences; particles with adsorbed gas increase the toxicity of the gas, especially its local effects, because in contact with the mucous membrane of the respiratory tract, they sometimes reach high concentrations, even if the overall content of the gas in question in the air is small.

In the simplest case, two substances can react together in the air, such as the combination of sulfuric acid aerosol with metal oxides. This example represents neutralization by forming salts. However, this neutralization is unreliable, because there is only very rarely an optimal ratio of both substances that could guarantee its complete course.

In particular, however, some ``metal sulfates *are no less harmful than sulfur oxides themselves.* These sulfates represent the dry phase of acid emissions. Knowing this fact is one of the serious arguments used against the "ammonia method" of emissions desulphurization.

Among the main photochemical reactions triggered by ``UV radiation *that produce secondary emissions of significant health impact are the dissociation of nitrogen dioxide NO_2 into NO and atomic oxygen in the nascent state, which are capable of starting a chain other reactions that produce very irritating substances such as ozone, various radicals (alkyls, formyls) or substances of a peroxidic nature (peroxyacetyl nitrate). In addition to the direct toxicity of these substances, a supporting effect on the development of tumors and a radiomimetic effect (similar to ionizing radiation) are attributed.*

Smog

The name smog has traditionally been used in connection with growing problems in atmospheric pollution, but often incorrectly and in inappropriate contexts. Smog exists in two fundamentally different forms.

- The **reducing type of smog**, the so-called *London* smog, is a mixture of smoke, sulfur oxides and other gaseous residues from coal combustion at high relative humidity and is usually accompanied by dense fogu. The harmful effects of this type of smog are potentiated by the presence of ash, which enables their transport to the lower part of the respiratory tract; it reaches its greatest intensity in the morning, at a temperature of 0–5 °C.
- '*Oxidative type of smog*, the so-called ``Los Angeles smog*, today referred to as ``summer smog*, arises from the combustion of liquid and gaseous fuels and its formation is associated with massive [[air] pollution] by car exhaust gases. This type of smog is also referred to as *photochemical* because photochemical reactions are involved in its formation; it occurs during clear weather, at a temperature of 25-30 °C.

Smoking and air pollution

Smoking has a substantially negative effect on health because, even in areas with the most polluted air and under adverse weather conditions, we usually do not encounter a level of human exposure comparable to that of a heavy smoker. At the same time, a significant improvement in the health status of almost half of the population could be achieved by a radical *restriction of cigarette consumption* without any investments.

The fight against smoking must be based on a long-term, comprehensive program focused especially on youth and women, especially pregnant women.

In addition to counseling services, properly focused mass media should also be used to help people quit smoking. According to recommendation **5, it is considered a promising aid for quitting smoking. world conference** on smoking and health, **Winnipeg 1983**, also **chewing gum'** containing **nicotine'**. Finally, just a quote from the World Health Organization expert memorandum "[Smoking]] and Health" WHO **1975'**, where it is stated that "diseases associated with cigarette smoking are such a significant cause of morbidity and premature death. Cessation of smoking would improve people's health and prolong their lives more than could be achieved by any other preventive medicine action alone."

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