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HYGIENIC ASSESSMENT OF INDOOR AIR CLEANLINESS

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ABSTRACT: People spend most of the day in closed rooms, so the cleanliness of indoor air in residential, educational and working premises affects respiratory health, work capacity, concentration and the functional state of the body. This article considers the hygienic significance of indoor air quality, the physical, chemical and biological indicators used for its assessment, the main internal and external sources of air pollution, the methods of examining indoor air and the preventive measures that improve it. The analysis is based on hygienic literature, World Health Organization guidance on indoor air and current sanitary rules on room microclimate and ventilation. It is shown that indoor air should be assessed as a whole, taking into account air temperature, relative humidity, air movement, carbon dioxide, dust, chemical substances and microbiological indicators, and that the results should be compared with the hygienic norms valid for the given type of room. Organoleptic assessment is only a preliminary step, and carbon dioxide does not represent all pollutants. Regular ventilation, wet cleaning, elimination of pollution sources, appropriate occupancy of rooms and technically sound ventilation systems contribute to cleaner indoor air.

Keywords: indoor air; hygiene; microclimate; carbon dioxide; dust; microorganisms; ventilation; sanitary control; air quality.

INTRODUCTION

The cleanliness of the air in living, study and working rooms is of great importance for maintaining human health. A person spends the larger part of the day indoors, and for this reason the quality of indoor air influences the respiratory system, general work capacity, concentration and the functional state of the organism. Physical and chemical factors of the environment are recognized determinants of health [1], and the quality of the urban environment affects the health of the population in ways that depend on regional conditions [2].

Indoor air may be polluted by human respiration, substances released from the skin and clothing, dust, household chemicals, building materials and microorganisms. In insufficiently ventilated rooms, the content of carbon dioxide may rise, humidity may increase and the risk of biological contamination may appear. In workplaces, air quality is one of the factors considered in the hygienic assessment of working conditions [5].

The hygienic assessment of indoor air cleanliness is therefore one of the important directions of sanitary and hygienic work. The aim of this article is to describe the hygienic significance of indoor air, to systematize its indicators and sources of pollution, to review the methods of its examination and to discuss the measures that help to keep indoor air clean.

METHODS

Scope and source base

This is a scientific-methodological (narrative) article. It is based on the analysis of educational literature on general and communal hygiene, teaching and methodological materials on communal hygiene, World Health Organization guidance on indoor air and air pollution, and current sanitary

rules and hygienic norms on the microclimate and ventilation of rooms. The hygienic assessment follows the general principle of sanitary-hygienic analysis, in which measured or observed values are compared with normative requirements [3, 6]. No new measurements were carried out for this article.

Approaches to the examination of indoor air

Four groups of methods are used to determine the cleanliness of indoor air: organoleptic, instrumental, chemical and microbiological.

1. **Organoleptic examination** evaluates the odor and stuffiness of the air and visible dustiness. It is a preliminary method of assessment and cannot replace laboratory examination.
2. **Instrumental examination** uses a thermometer, hygrometer, anemometer, a CO_2 meter and devices that determine particle concentration. Measurements are taken at different points inside the room and, when necessary, at different times. The general principles of testing and evaluating the parameters of the indoor environment are described in the methodological literature [7].
3. **Chemical examination** determines specific gases and volatile substances in the air with special instruments or by laboratory analysis.
4. **Microbiological examination** is carried out to evaluate the presence of microorganisms: air samples are taken in the prescribed order, usually by sedimentation or aspiration sampling, and examined in the laboratory.

Interpretation of results

The results obtained are compared with the sanitary rules and hygienic norms in force for the corresponding type of room. The assessment is based not on a single indicator but on the totality of all important factors.

RESULTS

Hygienic significance of indoor air

The hygienic condition of indoor air directly or indirectly affects human health and working activity. Clean and sufficiently renewed air helps to maintain a comfortable microclimate, creates optimal conditions for breathing and reduces the risk of airborne spread of some infections. When air quality deteriorates, headache, fatigue, reduced concentration and irritation of the eyes and respiratory tract may be observed. These symptoms may have various causes, so it is not correct to explain them only by indoor air pollution.

Sources of indoor air pollution

The sources of indoor air pollution are divided into internal and external. The main internal sources are:

- an increase in carbon dioxide due to human exhalation;
- particles released from skin, clothing and daily activity;
- dust, textile fibers and paper particles;
- household chemicals and aerosols;
- volatile organic compounds released from furniture, paint and some building materials;
- growth of mold and other microorganisms;
- pollutants released from cooking and heating appliances.

The main external sources are:

- exhaust gases of vehicles;
- emissions of industrial enterprises;
- dust raised by construction and road repair work;

- pollen and other biological particles in outdoor air.

The level of pollution in a room depends on the strength of these sources, the volume of the room, the number of people, cleaning activities and the effectiveness of the ventilation system.

Indicators for the hygienic assessment of indoor air

The indicators used to assess the cleanliness of indoor air, and their hygienic significance, are summarized in Table 1.

Table 1. Indicators for the hygienic assessment of indoor air

Indicator group	Parameters	Hygienic significance
Physical	Air temperature, relative humidity, air velocity	Characterize the room microclimate, affect human heat exchange and comfort; optimal values differ by room type, season and activity.
Chemical	Carbon dioxide (CO_2); carbon monoxide, formaldehyde, volatile organic compounds and other harmful substances when necessary	CO_2 shows the number of occupants and the inflow of outdoor air, but does not represent all pollutants.
Dust	Particle concentration, size and composition	Dust particles may affect the respiratory tract.
Biological	Bacteria, fungal spores and other biological particles	Examined by special microbiological methods when necessary; results are compared with norms according to room function and sampling method.
Odor and ventilation	Odor, ventilation efficiency	Unpleasant odor may indicate sources of pollution, but its absence does not guarantee clean air.

Thus, the physical indicators (air temperature, relative humidity and air velocity) describe the microclimate, while chemical, dust and biological indicators describe the actual contamination of the air. Odor and the state of ventilation complete the picture, and in each case the effectiveness of ventilation and the necessary instrumental measurements are assessed together.

DISCUSSION

Why a complex assessment is necessary

The analysis shows that no single indicator is sufficient to judge the cleanliness of indoor air. Carbon dioxide is a convenient and informative marker of occupancy and ventilation, yet it does not reflect pollutants that come from building materials, household chemicals or combustion, which have to be examined separately when there is a reason to suspect them. The organoleptic method is simple and available, but the sense of smell is subjective and may adapt to a constant odor, and the absence of odor does not prove that the air is clean. For this reason, odor assessment should be supported by evaluation of ventilation and by instrumental measurements.

The symptoms that are usually attributed to poor air, such as headache, fatigue, reduced concentration and irritation of the eyes and airways, are nonspecific. They can be caused by other factors, including lighting, noise, workload and infections, so that conclusions about the role of air quality should be based on measured indicators and not on complaints alone. The comparison of results with the norms valid for the given type of room is also essential, because acceptable values depend on the function of the room, the season and the activity performed.

Measures that improve indoor air quality

The sources of pollution and the factors that determine its level indicate the main directions of prevention. Firstly, rooms should be ventilated in an appropriate manner and mechanical ventilation systems should be kept in good working order. In places where outdoor air is strongly polluted, the time and method of ventilation should be selected according to the conditions, so that ventilation does not bring additional pollutants indoors.

Secondly, regular wet cleaning reduces the re-suspension of dust. Timely removal of waste, elimination of sources of moisture and prevention of mold growth are equally important, since they limit the biological contamination of air. Thirdly, the number of people should correspond to the capacity and ventilation possibilities of the room. Household chemicals should be used according to the instructions and not in excess, and local exhaust ventilation should be used when necessary.

Fourthly, in educational institutions, medical organizations and other public buildings, regular technical maintenance of ventilation systems and, according to need, laboratory control should be organized. The sanitary and hygienic knowledge of the staff responsible for these buildings, which is formed by hygiene education [4], supports the consistent application of these measures.

Scope and limitations

This article is a narrative, methodological analysis and does not contain original measurements. Numerical hygienic limits were intentionally not quoted, because they differ by the type of room, season and the activity performed and are established by the sanitary rules in force. Further studies based on measured indicators in specific residential, educational and medical buildings are needed to relate the described indicators to the health and performance of occupants.

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