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HYGIENIC ASSESSMENT OF INDOOR AIR VENTILATION AND VENTILATION SYSTEMS

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Abstract: This article examines indoor air ventilation and the hygienic assessment of ventilation systems in residential buildings, educational institutions, offices, and other enclosed spaces. Indoor air quality directly affects human health, work performance, concentration, and general well-being. The article analyses natural and mechanical ventilation, air temperature, relative humidity, carbon dioxide concentration, particulate matter, and air exchange effectiveness. Drawing on recommendations from the World Health Organization and international ventilation standards, it explains the importance of ventilation for maintaining a healthy indoor environment. Particular attention is given to regular air quality monitoring, proper maintenance of ventilation equipment, and compliance with sanitary and hygienic requirements. Practical recommendations are provided for evaluating ventilation performance and improving indoor environmental conditions. The findings offer a conceptual basis for maintaining healthier and more comfortable indoor spaces.

Keywords: ventilation, airing, air exchange, hygienic assessment, indoor climate, carbon dioxide, air quality, humidity, filtration, sanitary monitoring.

INTRODUCTION

A significant portion of human life takes place within residential spaces, educational institutions, industrial facilities, and other indoor environments. Consequently, indoor air quality is a crucial factor in protecting public health. In enclosed spaces, the composition of the air changes due to human respiration, various domestic or operational activities, and the release of substances from building materials and furnishings. If air exchange is insufficient, carbon dioxide, humidity, dust, and other pollutants can accumulate. Prolonged exposure to such conditions can lead to discomfort, fatigue, reduced concentration, and an increased risk of certain respiratory illnesses.

Ventilating indoor spaces facilitates the exchange between outdoor and indoor air, helping to reduce the concentration of pollutants. However, simply opening windows or installing a fan is often not enough. The effectiveness of ventilation depends on factors such as the volume of the room, the number of occupants, the quality of the outdoor air, the direction of airflow, and the technical condition of the ventilation equipment. The World Health Organization identifies indoor ventilation as a vital tool for improving air quality and mitigating certain airborne biological risks. The purpose of this article is to analyze methods for ventilating indoor spaces, outline criteria for the hygienic assessment of ventilation systems, and develop practical recommendations for ensuring a healthy indoor environment.

METHODS

In preparing this article, international recommendations, technical standards, and scientific-methodological sources concerning the hygienic assessment of indoor air ventilation systems were examined. The research methodology was based on literature analysis, comparative study, systematization, and the synthesis of hygienic criteria. The study focused on natural and mechanical ventilation systems installed in residential premises, educational institutions, and administrative buildings.

In the first stage of the research, the World Health Organization's recommendations for improving ventilation in indoor spaces, the ASHRAE 62.1-2022 standard, and ventilation guidelines developed by the CDC were reviewed. Based on these sources, the key factors influencing ventilation efficiency were identified. Specifically, room volume, occupancy (number of people), outdoor air quality, airflow direction, filtration capabilities, and the technical condition of ventilation equipment were established as criteria for analysis (WHO, 2021; ASHRAE, 2022).

In the second stage, the indicators necessary for assessing the hygienic status of indoor air were categorized. These were categorized into physical indicators, chemical indicators, and indicators of the technical efficiency of ventilation. Physical indicators included air temperature, relative humidity, and air velocity. Chemical indicators involved monitoring the levels of substances such as carbon dioxide, carbon monoxide, and volatile organic compounds. Technical indicators encompassed airflow rates, the condition of filters, the unobstructed state of air inlets and outlets, and the operational stability of the system.

In the third stage, a procedure for hygienic assessment was developed. This procedure entails an initial inspection of the room, the determination of necessary parameters using measuring instruments, a comparison of the results against relevant regulatory standards, and the formulation of recommendations to address any identified deficiencies. In line with CDC recommendations, filtration and the reduction of pollutant sources—alongside air exchange—were also considered key areas for assessment (CDC, 2023).

This work is based on an analysis of existing literature and recommendations. No direct instrumental measurements were conducted within any specific building or room. For this reason, the results are presented not as new experimental data, but as analytical conclusions and practical evaluation criteria formulated on the basis of scientific sources.

RESULTS

An analysis of literature and international recommendations reveals that the hygienic condition of indoor air depends on several interrelated factors. Primarily, the sufficient intake of outdoor air and the removal of contaminated indoor air are of critical importance. When air exchange is inadequate, pollutants—stemming from human respiration, domestic activities, and building materials—can accumulate. The World Health Organization identifies improved ventilation as a key measure for managing indoor air quality and mitigating airborne biological risks (WHO, 2021).

A second significant finding is that the effectiveness of both natural and mechanical ventilation depends on various conditions. Natural ventilation is a simple, low-energy method; however, its efficiency is influenced by factors such as outdoor temperature, wind direction, building orientation, and the dimensions of windows and doors. Mechanical ventilation allows for the control of airflow, but it requires equipment to be in good working order and subject to regular maintenance. Similarly, ASHRAE standards view the design, operation, and maintenance of ventilation systems as interconnected components essential for ensuring indoor air quality (ASHRAE, 2022). The third finding indicates that a hygienic assessment cannot be limited

to a single indicator. For instance, while carbon dioxide levels can provide useful information regarding the number of occupants in a room and the rate of outdoor air exchange, they do not, on their own, reflect the levels of all potential pollutants. Therefore, factors such as air temperature, humidity, dust, relevant chemical indicators, and airflow rates must also be examined. CDC recommendations emphasize the integration of outdoor air exchange, filtration, and supplementary air-cleaning measures (CDC, 2023).

Based on the analysis, the following sequence for a hygienic assessment has been determined to be appropriate: conducting a visual inspection of the room, identifying the type of ventilation, measuring the necessary parameters, comparing the results against relevant standards, identifying deficiencies, and establishing corrective measures. This approach allows for the evaluation not only of the presence of a ventilation system but also of its actual effectiveness.

DISCUSSION

The analytical results obtained indicate the need for a comprehensive approach when conducting a hygienic assessment of indoor air ventilation systems. The mere presence of windows or the installation of mechanical ventilation equipment does not fully guarantee that air quality meets the required standards. Factors such as sufficient airflow, its proper distribution throughout the room, the effective removal of contaminated air, and the technical operational status of the system are also critical.

According to World Health Organization (WHO) recommendations, the function of a room and its specific usage conditions must be taken into account when evaluating ventilation efficiency. For instance, the presence of many students and a teacher simultaneously in a classroom affects air quality. If air exchange is insufficient during a lesson, carbon dioxide concentrations may rise, leading to a stuffy environment. Therefore, in educational institutions, it is essential to ventilate rooms during breaks, regularly inspect ventilation systems, and ensure that air exchange rates are appropriate for the number of occupants (WHO, 2021).

However, relying solely on natural ventilation as a universal solution under all conditions is not appropriate. When the outdoor air contains high levels of dust, vehicle emissions, or other pollutants, opening windows may allow these substances to enter the room. In such situations, it is advisable to adjust the timing and method of ventilation based on external environmental conditions and, where necessary, employ appropriate filtration systems. ASHRAE standards also treat ventilation, filtration, system control, and maintenance as interconnected aspects of ensuring indoor air quality (ASHRAE, 2022).

Using carbon dioxide (CO2) levels as a metric for hygienic assessment is valuable, though it must be interpreted with caution. While CO2 concentrations provide indirect information regarding room occupancy and air exchange, they do not account for the presence of all chemical and biological pollutants, nor do they confirm that such substances are within safe limits. Therefore, CO2 measurements should be conducted in conjunction with the assessment of air temperature, humidity, and—where appropriate—the detection of dust and other pollutants. CDC recommendations also emphasize an integrated approach that combines air exchange, filtration, and the reduction of pollutant sources (CDC, 2023). In practice, it is necessary to regularly monitor ventilation systems, clean or replace filters in accordance with the manufacturer's instructions, inspect air intake and exhaust ducts, and keep a record of measurement results. These measures help to promptly identify any decline in system efficiency. Furthermore, hygienic requirements pertain not only to air purity but also to maintaining a comfortable temperature, optimal humidity, and ensuring that air movement does not cause discomfort to occupants.

Thus, an effective ventilation system is the result of a combination of technical equipment, proper operation, regular monitoring, and adherence to sanitary-hygienic standards. Since no direct instrumental research was conducted for this article, the conclusions presented do not reflect the actual air quality in any specific building; rather, they provide a scientific and methodological framework for assessing and improving air quality.

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