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METHODS FOR MEASURING AND ASSESSING NATURAL LIGHTING INDICATORS IN INDOOR SPACES

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Abstract: This article examines the theoretical and practical aspects of assessing natural lighting conditions in indoor environments. It discusses the influence of daylight on human health, visual performance, productivity, and indoor hygienic conditions. Particular attention is given to illuminance measurements using a luxmeter, the calculation of the daylight factor, and the application of modern computer-based modelling techniques. The article also considers the principal architectural and environmental factors affecting daylight penetration, methods for interpreting measurement results, and practical recommendations for improving natural lighting in residential, educational, and working spaces. The study emphasizes the importance of combining instrumental measurements with appropriate assessment criteria to ensure reliable conclusions about indoor daylight conditions.

Keywords: daylight, natural illuminance, hygienic assessment, luxmeter, daylight factor, indoor environment, window, sunlight, measurement, lighting quality.

INTRODUCTION

Natural lighting is a key factor in determining the sanitary and hygienic conditions of spaces where people live, study, or work. Sunlight and daylight are essential for creating comfortable visual environments, facilitating the efficient organization of daily activities, and reducing the need for artificial lighting. Consequently, it is necessary to regularly assess the level of natural illumination in residential areas, educational institutions, hospitals, and industrial facilities.

The natural lighting of a space is not determined solely by the presence or size of its windows. Other significant factors include window orientation, the light-transmitting properties of the glazing, the depth of the room, ceiling height, shadows cast by external structures or trees, and the light-reflectance characteristics of wall and ceiling surfaces. Furthermore, variations in external light—influenced by weather conditions and the time of day—also affect measurement results.

The purpose of this article is to systematically examine methods for assessing natural lighting in indoor spaces, explain key calculation parameters, and outline the principles for evaluating the obtained results from a hygienic perspective. The study examines the capabilities and limitations of instrumental measurement, calculation, and computer modeling methods.

METHODS

This study is based on the analysis of scientific literature regarding the determination and assessment of natural lighting levels in rooms, the synthesis of measurement principles, and an explanation of key calculation methods. The methodological framework of the study encompasses the comparative analysis of literature, the description of instrumental measurement techniques, mathematical calculations, and the interpretation of the obtained data based on hygienic standards.

A lux meter is the primary instrument used for the direct assessment of natural lighting. It measures the level of light flux incident upon a given surface—that is, illuminance—in units of lux (lx). During the measurement process, several points are selected on the working surfaces within a room, such as the tops of students' desks or workstations. Recording the values at these points makes it possible to determine how light is distributed throughout the space. External illuminance is also measured under appropriate conditions; in this process, the time interval between internal and external measurements, as well as any changes in sky conditions, must be minimized.

One of the key indicators used in the assessment of natural lighting is the Daylight Factor (DF). It is expressed as a percentage, representing the ratio of the natural illuminance measured at a specific point within a room to the natural illuminance on an external horizontal surface:

$$TYK = \frac{E_{ichki}}{E_{tashqi}} \times 100\%$$

Here, E-internal is the illuminance inside the room, and E-external is the horizontal illuminance in an open outdoor area. For example, if the internal illuminance is 300 lx and the external illuminance is 15,000 lx, the daylight factor is 2 percent.

In addition to calculation methods, computer modeling is also employed. This process accounts for room dimensions, window placement, the light transmittance of the glazing, external obstructions, and the light-reflectance properties of surfaces. The EN 17037 standard outlines the relevant principles for calculating daylight and verifying it through measurements in a completed building. Meanwhile, a 2023 research report by CIBSE provides a detailed examination of calculation methods, the selection of calculation points, and the use of climate data.

For a reliable interpretation of measurement results, factors such as the function of the room, the time of day, weather conditions, and the technical state of the measuring equipment must also be taken into account. The obtained results are compared with the sanitary norms and standards applicable to the relevant type of building.

RESULTS

An analysis of scientific literature and methods for assessing natural lighting has revealed that determining the lighting conditions in a room requires considering several interrelated indicators. A key finding is that drawing hygienic conclusions based solely on window area or the general perceived brightness of a room is insufficient; rather, the level of illumination at various points within the room must be measured using appropriate instruments.

Secondly, the daylight factor helps establish the relationship between indoor and outdoor illumination levels, making it possible to evaluate the extent to which natural light from outside penetrates the room. However, this factor alone does not fully account for the duration of adequate lighting throughout the day, nor does it address potential glare caused by direct sunlight.

Thirdly, the number and placement of measurement points directly influence the quality of the assessment. Since illumination levels may be high near a window but decrease further into the room, measurements should be taken not only near the window but also at various depths throughout the space. Fourthly, modern computational and modeling methods allow for the study of natural lighting throughout the year. The EN 17037 standard also provides for the assessment of lighting metrics based on climate data. Furthermore, an analysis by Bellia et al. highlights the importance of simultaneously considering both the spatial distribution of light and its variation over time.

Thus, an effective approach to accurately assessing natural lighting involves the combined use of instrumental measurements, calculations, and—where necessary—computer modeling techniques. These findings are not based on new experimental measurements, but rather represent conclusions synthesized from an analysis of scientific literature and assessment methodologies.

DISCUSSION

Correct interpretation of the results obtained when assessing natural lighting in rooms is of particular importance. This is because a quantitative indicator of illumination does not always correspond directly to the visual conditions experienced by a human being. For instance, sufficient light at certain points within a room does not guarantee comfortable conditions in other areas. Furthermore, direct sunlight entering through windows, light reflected from external surfaces, and the color of surfaces within the room all influence the overall visual environment.

In their analysis of methods for assessing natural lighting, Bellia, Pedace, and Fragliasso (2017) focused on the relationship between the spatial uniformity of illumination, its temporal availability, and visual comfort. This scientific approach underscores the necessity of examining the distribution of light across various points in a room, rather than relying solely on an average value.

The method for calculating natural lighting based on the "daylight factor" is practically convenient, as it represents the ratio between indoor and outdoor illumination levels. However, this method depends on specific sky conditions and does not provide a comprehensive description of light variations throughout the year. In contrast, modeling based on climate data allows for the analysis of illumination conditions across different periods of the year. A 2024 study by Konuk Taştan et al. demonstrates that the choice of calculation method can significantly influence the results of natural daylight assessments. This underscores the necessity of considering both the local climate—where the building is situated—and the specific objectives of the study when selecting a methodology.

In practical hygienic assessments, the accuracy of the measuring instruments, the appropriate selection of measurement points, and the documentation of external environmental conditions are also critical. If indoor and outdoor illumination levels are measured at different times—particularly when sky conditions have shifted significantly—the reliability of the calculated

coefficient may be compromised. Therefore, it is essential to ensure that measurements are conducted under consistent conditions, recorded at multiple locations, and repeated whenever necessary. To improve natural lighting, it is recommended to regularly clean windowpanes, remove objects that obstruct the path of light, ensure that interior surfaces are finished in light-reflecting colors, and assess the impact of any external obstructions. At the same time, measures taken to increase natural light must not lead to issues such as glare or excessive heat gain.

Consequently, the hygienic assessment of natural lighting should not be limited solely to determining quantitative indicators. A well-founded conclusion regarding lighting conditions in a room can only be reached when instrumental measurements, comparisons against regulatory standards, analysis of light uniformity, and human visual comfort are all taken into account.

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