Innovative: International Multi-disciplinary Journal of Applied Technology
(ISSN 2995-486X) VOLUME 03 ISSUE 2, 2025

The Influence of Favorable Microclimatic Conditions on the Life Expectancy of People and Buildings

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Abstract:

The research examines how beneficial local climate factors impact lifespan for humans while affecting building preservation periods. The growing worldwide focus on sustainable energy usage and productivity requires architects to establish comfortable interior environmental conditions as their primary design priority. This study analyzes critical environmental factors including temperature, humidity, air flow and carbon dioxide measurements because these elements impact human health and structure lifespan with equal importance. Modern energy-efficient technologies have not solved the dilemma between maintaining air-tight construction methods and sufficient ventilation requirements for preventing building-related health problems and moisture-induced structural damage.

The research identifies a critical understanding deficiency about combining energy efficiency methods with ideal microclimatic management in areas which experience wide climatic fluctuations. The researchers used qualitative methods which included literature reviews in combination with case studies and energy-efficient building field observations. Modern energy-aligning windows and insulating technique promote thermal efficiency but creating indoor air quality issues unless they include effective ventilation mechanisms.

Optimal microclimate conditions lead to enhanced human fitness and job performance together with building resistance which shows why a proper balance between energy-saving and comfortable indoor spaces is essential. Research results support the need for introducing ventilating systems as mandatory components in sealed building designs for extended sustainability purposes. A comprehensive understanding from this study directs the development of architectural guidelines as well as construction laws and urban design standards that create buildings which maintain energy standards while focusing on human comfort.

Keywords: energy efficiency; energy saving; comfortable microclimate; temperature; relative humidity; air movement speed; carbon monoxide; thermal capacity of the structure; airtight window frames; noise protection; illumination.

Introduction. Regardless of the functions of buildings, they must be energy-efficient and energy-saving, meet modern requirements, and provide a comfortable microclimate, coziness, adequate lighting, safety, and reliability for people's occupancy, service, and residence.[1] Since people spend the majority of their time indoors, creating comfortable microclimatic conditions has become one of the most pressing issues worldwide. For normal human activity, it is essential to ensure optimal microclimate parameters such as humidity, temperature, lighting, ventilation, insolation, and other factors. Deviation of any of these factors from standard values can lead to rapid fatigue, decreased productivity and product quality, as well as health deterioration.[1]

It is known that a comfortable microclimate in any building is closely linked to its energy efficiency, as a significant portion of energy resources is spent on maintaining the required indoor temperature through heating, cooling, or ventilation. [2]The microclimate of each room is determined by parameters such as temperature, humidity, and air movement speed, which affect the human body. Indicators of a comfortable microclimate are among the conditions ensuring safety and normal human life in buildings.[3]

In the 1970s, following a reduction in oil production in some Arab countries, there was a sharp increase in oil product prices and an oil shortage, posing several problems for importing countries.[4] Life demanded that these states minimize the use of oil products, conserve them, and, if possible, utilize alternative energy sources. Scientific research in energy conservation demonstrated the necessity of designing and constructing exclusively energy-efficient and energy-saving buildings and structures, as they account for 40-50% of total energy consumption [5]

Currently, in almost all countries worldwide, buildings and structures are designed and constructed with energy efficiency and energy-saving requirements in mind. In many nations, projects that do not meet these requirements are not approved for implementation.[6]

The primary goal of all work in various sectors of the economy is to create conditions for people's well-being.[7] In construction, special attention is paid to creating comprehensive comfortable, cozy, and safe conditions for individuals in buildings and structures. [8]

Methodology

The research uses qualitative methods to analyze the effects that microclimate conditions have on building longevity along with the length of human life. The research combines literature studies with field investigations and case analyses to study environmental factors involving temperature, humidity, airflow, and carbon dioxide concentrations because these parameters shape both human satisfaction and structural service lifetime. The research examines essential components for creating comfortable climate-controlled indoor spaces by investigating scientific literature and official requirements and code-based standards.

The researcher examines contemporary buildings with energy-saving features during field observations including buildings which use airtight windows and insulation and ventilation methods. The research studies permit us to measure the practical impact of energy-saving technologies during actual building operations while uncovering the negative aspects which include deteriorated air quality and building damage and higher indoor humidity. The research examines energy-efficient architectural evolution by studying previous implementation approaches which directed present-day building construction methods.

The research includes input from climatology architecture and engineering fields to present an all-encompassing review of microclimatic optimization practices because it requires diverse interdisciplinary expertise. The research outcome allows scientists to investigate direct relationships between interior climate elements and long-run sustainability which helps produce practical design and policy recommendations. The research builds integrated architectural methods which create sustainable balance between energy efficiency needs and human health considerations as well as structural stability to advance sustainable living spaces.

Analysis and Results. In recent years, building design and construction have focused not only on meeting energy efficiency and conservation requirements but also on creating an optimal indoor climate for comfortable living and working conditions.[9]

Since the early 21st century, many older buildings have replaced their windows with modern energy-saving designs. These windows typically feature plastic or aluminum frames and consist of double or triple glazing with sealed air spaces between the panes. In Uzbekistan, since the 2020s, double-glazed (three-layer) units have been produced in collaboration with foreign specialists, including those from the People's Republic of China. These modern windows effectively reduce external noise, temperature fluctuations, and dust ingress but virtually prevent fresh air from entering indoor spaces.[10]

Despite their advantages, the use of such windows can lead to several issues. In rooms equipped with airtight windows lacking specialized ventilation systems, oxygen levels decrease, and concentrations of radon and other harmful gases increase, adversely affecting human health. Additionally, elevated humidity in such spaces promotes the appearance of stains and mold on walls and ceilings, which can be hazardous to health and damage building structures.

In some European countries, the widespread replacement of old windows with modern energy-saving ones has led to the deterioration of historic buildings. Consequently, the term "sick building syndrome" emerged. To prevent such negative outcomes, Europe prohibits replacing old windows with new ones without installing specialized ventilation systems.[11]

In the Russian Federation, since July 1, 2010, Federal Law No. 384-FZ mandates that building and structure design documentation includes provisions for installing specialized devices for air ventilation and conditioning to maintain air quality at sanitary and hygienic levels .[12]

Overall, to ensure comfortable conditions in residential and workspaces, it is necessary to:

- Protect against external dust, moisture, and unpleasant odors.
- Provide sufficient fresh air to remove harmful substances.
- Protect against harmful and unpleasant odors penetrating through various communications.
- Implement measures to prevent gases from the ground (radon, methane) from entering spaces in areas with elevated concentrations.

The concept of "comfortable living conditions" includes:

- ✓ Optimal temperature regime.
- ✓ High-quality air composition (adequate oxygen levels, absence of harmful impurities).
- ✓ Acoustic comfort and other factors.

Indoor air should meet sanitary, hygienic, and technological requirements, including:

- ✓ Gas composition.
- ✓ Purity (absence of foreign impurities).
- ✓ Meteorological parameters (temperature, humidity, air movement speed).

Factors forming a comfortable environment:

- ✓ Air temperature.
- ✓ Relative humidity.
- ✓ Air movement speed.
- ✓ Temperature of enclosing structure surfaces.
- ✓ Heat capacity of structures.
- ✓ Floor temperature.
- ✓ Air quality, especially CO_2 content.
- ✓ Illumination.
- ✓ Noise protection.
- ✓ Type of activity.
- ✓ People's clothing.

Thus, "building microclimate" and "comfortable human occupancy conditions" are interconnected and complement each other.[13]

The heat capacity of building structures plays a significant role in creating a comfortable microclimate. In summer, structures absorb part of the thermal energy and release it in the evening and at night, cooling the room. In winter, they retain heat from the heating system and release it when it's off, preventing drafts and ensuring comfort.

Additionally, the temperature of enclosing structure surfaces affects the sense of comfort. In winter, the temperature of interior walls should not be more than 3°C below the indoor air temperature, and in summer—not more than 3°C above. A floor temperature between 22–24°C is considered comfortable; below 19°C or above 26°C, people feel discomfort. icroclimatic[14]

CO_2 content in the air is also important. Elevated concentrations can lead to increased blood pressure, headaches, and dizziness.[15]

At a concentration of 10%, a person can die from poisoning. In residential and workspaces, CO_2 content should not exceed 0.1%. To achieve this, it's necessary to supply 30 m^3 of fresh air per hour per person.[16]

Therefore, in building design and operation, it's essential to consider not only energy efficiency but also to create conditions for maintaining a healthy and comfortable microclimate, which requires a comprehensive approach and adherence to relevant standards and norms.

Conclusions. Studies demonstrate that favorable microscopic climate elements serve as critical factors for improving human survival rates and increasing building durability while underscoring the united system between energy conservation and air quality management and structural preservation. Modern thermal efficiency technologies including airtight windows and insulation systems generate multiple risks involving bad ventilation conditions and rising humidity levels which cause health problems and reduce building enduring quality. Specialized ventilation systems ought to be integrated in energy-efficient buildings since they provide necessary air circulation while managing humidity and pollutant elimination. Sustainability needs to remain balanced with occupant well-being in all urban planning decisions and construction-related policy making and regulations according to this research data. Researchers need to conduct further study about developing next-generation resilient building designs which integrate smart ventilation features alongside adaptive insulation technology along with sustainable energy solutions for creating comfortable living spaces across multiple climates.

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