MedCrave
Step into the World of Research

Open Access Journal of Science

Short Communication

Open Access CrossMark

Relationship between indoor air quality and space design for human health

Abstract

Although the globalized world in which we live brings technological facilities that favour adaptation to the system, it also entails a disconnection between human beings and the context in which they live. This results in the adoption of patterns and trends that reduce people's quality of life, such as the disconnection between outdoor air pollution and indoor environments. Therefore, this opinion document aims to provide a perspective on the problem and answer the question of whether initiatives to mitigate this phenomenon and educate people about the relationship between indoor air quality and space design are an optimal strategy within the system's framework.

Keywords: air quality, human health, airflow, design

Volume 6 Issue 1 - 2023

Sanyern Y Rico-García
Facultad de Arquitectura, Universidad Francisco de Paula Santander, Colombia

Correspondence: Sanyern Y Rico-García, Facultad de Arquitectura, Universidad Francisco de Paula Santander, Cúcuta (Colombia), Colombia, Tel +61 405 653 786, Email sanyerngarci@gmail.com

Received: June 22, 2023 | **Published:** July 05, 2023

Abbreviations: EPA, united states environmental protection agency; IAQ, indoor air quality; SBS, sick building syndrome; Tn, neutral temperature; HVAC, heating, ventilation, and air conditioning

Introduction

The growth of cities has brought with it many changes in the structure of society. These changes have been altering patterns such as multitasking, building automation, excessive use of electrical appliances, and ease of acquiring products. Although this is part of the globalized world in which we live, it is generating a dissociation from the reality in which we coexist. This, in turn, causes the physical factors of city construction such as schools, homes, parks, etc. to not be projected or adequate for the current conditions to which they are subjected by the activity of modern society. This generates a correlation between the conditions of the interior space of a building and the health of a human being over the years. In turn, this implies the short-term deterioration of its infrastructure.

According to the definition established by the United States Environmental Protection Agency (EPA), indoor air quality (IAQ) refers to the air conditions inside and outside a building, caused by polluting factors that can alter the conditions of comfort and health of human beings, as well as sick building syndrome (SBS), which was defined by the World Health Organization[1] as a collection of symptoms, including pain, headaches, dizziness, irritation, fatigue, nausea, among others. Recent studies show that people are indoors approximately 96% of the time.[2] This implies that their physical and mental growth directly depends on the design and materiality of the spaces they inhabit. A recent investigation developed by Botella[3] supports that when symptoms associated with the respiratory tract reach 20% of the occupants, the building can be diagnosed with SBS. This leads to a context analysis of the building's interior and exterior to establish the causes affecting health conditions. Although this type of analysis focuses on constructed buildings, the SBS prevention bases can be extended to buildings in the projection stage. By using simulation software, the correct airflow and quality can be ensured through design strategies.

When discussing air quality in the lower layers of the atmosphere, has a chemical composition that corresponds to the following: Nitrogen (78.08%), Oxygen (20.95%), Argon (0.93%), Carbon Dioxide (0.03%), and other gases (0.001%).[4] However, in addition to the mentioned gases, the atmosphere also contains varying amounts of water vapour, depending on the thermal and humidity characteristics of a specific location and time. This variability affects the particle containment capacity of the air. Therefore, when air pollution is identified, it is directly related to a change in its chemical composition. This alteration implies an increase in the percentage of gases that have a more harmful effect on human health, such as carbon dioxide, resulting in changes in the central nervous system.

In recent years, premature deaths have been attributed to air pollution. According to data published by the Pan-American Health Organization in 2016, this number reached 4.2 million. These figures have alarmed governments, leading them to promote campaigns to study the sources of contamination and potential mitigations within environmental and infrastructure action plans. However, despite these macro initiatives, education remains outside the responsibility of professionals involved in city construction, such as engineers, architects, and urban planners, among others. Due to a lack of awareness regarding the relationship between air quality and built spaces, these professionals inadvertently delay the mitigation of airborne particles resulting from construction and building maintenance. Consequently, this alteration affects the health conditions of human beings.

The construction sector and its related disciplines bear a significant responsibility in mitigating environmental pollutants. While government initiatives often prioritize the industrial sector, it is crucial to acknowledge that the residential sector typically accounts for 70% of land use in most cities.[5] By directing efforts towards this aspect, not only can we enhance education for users concerning air quality, but we can also add value to the preservation of human health. It is in our homes where we invest most of our time and where human beings develop, making it an essential focal point for these efforts.

When discussing the responsibility of disciplines involved in the construction sector, we emphasize the importance of their education regarding the operation of a building within a specific context. This knowledge enables them to establish a connection between the air quality within the materiality of built space and the prioritization of human health and comfort. To achieve this, the following points must be considered during the design or adaptation of these spaces:

I. Location of the building and understanding of its surroundings.
II. Type, usage, and construction characteristics of the building.
III. Ventilation strategies (natural, mixed, or mechanical modes).
IV. Appliances and furniture selection.
V. Type of activities conducted within the building.

Additionally, factors influencing human comfort should also be considered, such as:

I. Indoor air temperature.
II. Radiant temperature (dependent on the surfaces within the space).
III. Relative humidity (RH).
IV. Air circulation and quality.
V. Lighting conditions.
VI. Sound levels.

Taking these considerations into account, we can speculate that current buildings often overlook the analysis process concerning air quality. This is primarily because contextual conditions within the construction sector are typically not analysed, and adequate calculations are not made to ensure indoor comfort. Although the concept of Sick Building Syndrome (SBS) originated in 1982-1984, it was not until the COVID-19 pandemic (2020-2023) that the significance of SBS and Indoor Air Quality (IAQ) inhuman health gained prominence within the construction sector. This was a result of dissatisfaction with interior spaces lacking proper utilization studies and disregarding user activities. Consequently, this shift in perception influenced the changing demands for housing. People began to experience the consequences of inadequate aspects such as ventilation and natural lighting, eye fatigue caused by inadequate artificial lighting for tasks like reading and sustained work, and the design of unifuncional spaces that restrict the creative development of users.

Even though it may seem that the aspects mentioned above are not relevant when discussing indoor air quality, they play a crucial role. When calculating the necessary air exchanges for a space based on its usage, it takes into consideration not only the equivalent metabolic rate (MET) of the occupants but also the energy load resulting from factors such as usage type, enclosure, lighting, and furniture. These factors, in thermodynamics, influence the interior energy load that must be addressed through ventilation strategies, be it natural, mechanical, or a combination of both, depending on the specific conditions of the ongoing project.

On the other hand, within a design that prioritizes air quality, the maintenance of the building and its materiality is taken into consideration. The chemistry behind the physical structure can be altered due to overexposure to energy, whether through radiation, convection, or conduction. To illustrate this, let us imagine we are inside a house that consists of a living room, dining room, and kitchen (all in one space), two bedrooms, and a bathroom. Let us also imagine that this house is located on the third floor of a building in the centre of Brisbane, Australia. In this area, the average temperature in winter is 12°C, and in summer it reaches 28°C. Although the neutral temperature (Tn) varies with the seasons, for this example, we will focus on these two seasons.

According to the formula Tn = (0.31 x Tmed) + 17.6,[6] in winter, the Tn would be 21.3°C, with a comfort range between 18.8°C and 23.8°C. In summer, the Tn would be 26.3°C, with a comfort range between 23.8°C and 28.8°C. Through this simple exercise, we can observe that specific design strategies are required for each season to conserve or lose energy, while still ensuring relevant air changes for the building's usage.

Although the house may have temporal changes in its context, the interior activities remain constant. Let us imagine that three people live in this house, spending approximately 12 hours a day during the week (8 hours for sleeping, 2 hours for reading, and 2 hours for cooking) and between 14-16 hours on weekends. During weekends, they allocate an additional 2-4 hours for recreational activities that involve changes in metabolic activity (MET). If the house design fails to consider external variables and the internal activity of the occupants, an energy imbalance Will likely occur. In both seasons, there would be an energy gain, which may seem positive during the summer. However, in winter, there would be a discrepancy in the energy gain that remains unfavourable in terms of air renewal. Let us now examine the typical daily behaviour in each season: behaviour

I. Behaviour in summer: To illustrate the house's behaviour during this season, let us consider an average day with a temperature of around 29°C at noon. During this time, it is assumed that the preparation and sharing of lunch take place in the social area. At this specific time, energy is increased from both internal and external sources. In response, users may decide to open the windows, believing that increased airflow will help stabilize the temperature. However, what is not considered is that the outside air being brought inside is also above 29°C, which does not facilitate energy loss but does contribute to air exchange.
II. Behaviour in winter: To describe the behaviour of the house during this season, let us consider an average day with a temperature of around 10°C at 7 am. It is assumed that at this time, breakfast is being prepared and shared in the social area. During this specific time, energy is increased due to internal sources. In response to the cold outside temperature, users may decide to close the windows, limiting air circulation. This lack of airflow hinders the removal of pollutants generated by these internal sources, causing them to accumulate and adhere to the surfaces within the house.

Discussion

As far as I am concerned, If the behaviours are sustained over long periods, the indoor air renewals, which are established according to ASHRAE guidelines based on the type of space usage (2.5 L/s for residential spaces), would be reduced. This reduction implies an accumulation of energy and chemical substances indoors. In response to this issue, the construction industry has implemented Heating, Ventilation, and Air Conditioning (HVAC) systems to compensate for the lack of design prioritizing human comfort and indoor air quality. However, these systems often focus solely on heating and cooling, assuming that cooling is equivalent to ventilation. Consequently, they only provide air conditioning without adequate air exchange. In other words, to implement an HVAC system in a project, it is necessary to analyse the context, including internal and external energy loads, materiality, and maintenance. By considering these factors, it becomes possible to calculate the required air exchanges based on the project's specific usage. It can then be determined whether natural ventilation needs to be supplemented by active systems like air conditioners, extractors, or fans to ensure a comfortable environment within the calculated temperature ranges for each season. Similarly, the education of professionals responsible for city construction must prioritize the health of human beings through an architectural and construction language that caters to their needs.[7–9]

Citation: Rico-García SY. Relationship between indoor air quality and space design for human health. *Open Access J Sci.* 2023;6(1):52–54.
DOI: 10.15406/oajs.2023.06.00192

Conclusion

In conclusion, when discussing the relationship between indoor air quality and space design for human health, it is essential to conduct a specific analysis of the context. While polluted outdoor air can have health implications, it does not guarantee that there will be a direct infiltration of outdoor air into indoor spaces. Therefore, the importance of controlling the chemical substances that may adhere to the building's surfaces is lost if no ventilation system prioritizes proper air exchange based on the specific usage of the space. This disconnection can lead to Sick Building Syndrome (SBS) and increase the risk of respiratory and other associated illnesses, posing a threat not only to physical and psychological well-being but also to the overall quality of life.

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

References

1. Wang BL, Takigawa T, Yamasaki Y, et al. Symptom definitions for SBS (sick building syndrome) in residential dwellings. *International Journal of Hygiene and Environmental Health*. 2008;211(1-2):114–120.
2. Lee T, De Biasio D, Assistant R, et al. *HEALTH AND THE BUILT ENVIRONMENT: INDOOR AIR QUALITY*. 1996.
3. Botella E. *SINDROME DEL EDIFICIO ENFERMO MASTER UNIVERSITARIO EN PREVENCIÓN DE RIESGOS LABORALES*. 2020.
4. Fuentes Freixanet A, Universidad Autónoma Metropolitana (México, D.F.) Unidad Azcapotzalco. *Clima y arquitectura*. Azcapotzalco. 2004.
5. ONU HABITAT. *ONU-Habitat - Vivienda: inviable para la mayoría*. Onuhabitat.org.mx. 2020.
6. Rincón-Martínez J, Martínez-Torres K, González-Tevizo M, et al. Modelos matemáticos para estimar el confort térmico adaptativo en espacios interiores. *Ingeniería Revista Académica de la Facultad de Ingeniería Universidad Autónoma de Yucatán*. 2020;24(1).
7. ASHRAE. *ESTÁNDAR ASHRAE ESTÁNDAR ASHRAE Ventilacion para una Calidad Aceptable de Aire Interior*. 2017.
8. Organizazacion *Panamericana de la Salud. Contaminación del aire ambiental exterior y en la vivienda: Preguntas frecuentes - OPS/OMS | Organización Panamericana de la Salud*. 2008.
9. US EPA. *Introduction to Indoor Air Quality | US EPA*. US EPA. 2019.

Citation: Rico-García SY. Relationship between indoor air quality and space design for human health. *Open Access J Sci.* 2023;6(1):52–54.
DOI: 10.15406/oajs.2023.06.00192