International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Optimizing Indoor Air Quality to mitigate Sick Building Syndrome

Srishti Khandelwal[1], Nishtha Joshi[2]

[1]*Student, Amity School of Architecture & Planning, Amity University Chhattisgarh*
[2]*Professor, Amity School of Architecture & Planning, Amity University Chhattisgarh*

---***---

Abstract - In current scenario, where individuals spend the majority of their time indoors, the quality of the indoor air has become increasingly crucial. This research paper investigates the role of optimizing Indoor Air Quality (IAQ) as a proactive strategy for mitigating Sick Building Syndrome (SBS) within built environments. It examines the relationship between indoor air quality (IAQ) and Sick Building Syndrome (SBS) in workplace settings and explores strategies for enhancing IAQ to mitigate SBS symptoms.

Indoor air quality (IAQ) significantly impacts human health and well-being, with implications for productivity, comfort, and overall quality of life. To ensure safe and healthy indoor environments, various organizations, including the World Health Organization (WHO), Environmental Protection Agency (EPA), and Occupational Safety and Health Administration (OSHA), have established IAQ standards and guidelines. This research aims to conduct a comprehensive analysis of these standards. Moreover, the multifaceted nature of IAQ management is explored through the inclusion of parameters like radon (Rn), relative humidity (RH), and temperature. These factors not only contribute to indoor air quality but also affect occupants' comfort and well-being. By considering both chemical and environmental factors.

Key Words: Indoor air quality, mitigate, policies, Sick building syndrome

1.INTRODUCTION

In today's work environments, the importance of indoor air quality (IAQ) has gained significant attention due to its profound impact on occupant health, comfort, and productivity (ASHRAE, 2021). As individuals spend a substantial portion of their time within workplace settings, ensuring optimal IAQ has become imperative for fostering a conducive and healthy work environment. Concurrently, the emergence of Sick Building Syndrome (SBS) as a prevalent issue within workplaces has underscored the critical need to address IAQ concerns effectively.

Sick Building Syndrome (SBS) is a recognized phenomenon commonly associated with workplace environments, characterized by a range of non-specific symptoms experienced by occupants. These symptoms, which may include headaches, dizziness, eye irritation, and fatigue, often occur when individuals spend extended periods indoors within a particular building. While the exact cause of SBS remains elusive, it is widely believed to be linked to factors such as poor IAQ, inadequate ventilation, high levels of indoor pollutants, and thermal discomfort.

The significant implications of IAQ and SBS for workplace health, safety, and performance, the need for a more proactive approach to IAQ optimization in workplace settings is growing (Sundell, 2004). The vital steps include the implementation of efficient ventilation systems, reduction of sources of indoor pollutants, maintenance of appropriate temperature and humidity, enhanced information of employees and their active involvement in the maintenance of indoor air quality.

Maintaining indoor air quality inside buildings is essential for the well-being, health and productivity of occupants. Among the myriad factors influencing indoor air quality (IAQ), Sick Building Syndrome (SBS) stands out as a significant determinant of occupant health, comfort, and productivity within built environments. Indoor air quality (IAQ) has a significant impact on the health and well-being of building occupants. Poorly maintained indoor environments can lead to the development of Sick Building Syndrome (SBS), a condition characterized by a range of nonspecific symptoms experienced by building occupants. inadequate ventilation, high levels of indoor pollutants, and thermal discomfort.

1.1. Aim

The aim of the research is to explore strategies for optimizing indoor air quality (IAQ) in workplace environments with the goal of mitigating Sick Building Syndrome (SBS) and compare indoor air quality (IAQ) standards and guidelines established by prominent international organizations.

1.2. Objective

- To identify the factors contributing to indoor air quality and the prevalence of Sick Building Syndrome in workplace environments.
- To analyze current international policies and guidelines related to indoor air quality (IAQ) management and SBS prevention in workplace environments.
- Explore the inclusion of environmental factors like radon (Rn), relative humidity (RH), and temperature in IAQ guidelines and their impact on occupant comfort and well-being.

1.3. Methodology

The research methodology involves a literature review to understand correlation between IAQ and SBS. It further includes a comparative analysis of the existing IAQ guidelines issued from relevant documents and official organization websites.

2. Current scenario

In the current scenario, indoor air quality (IAQ) in workplace environments has gained heightened attention and significance, particularly in the wake of the COVID-19 pandemic. Several factors contribute to the evolving landscape of IAQ in workplaces. Recent studies, such as those by Morawska and Milton (2020), have underscored the critical role of IAQ in preventing the spread of respiratory illnesses, including SARS-

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

CoV-2, prompting organizations to prioritize measures to enhance ventilation, air filtration, and indoor air quality monitoring. Additionally, return-to-work strategies are increasingly focusing on ensuring safe and healthy workplaces, with employers implementing ventilation upgrades, air purification systems, and occupancy management protocols. Regulatory guidelines issued by bodies like the Environmental Protection Agency (EPA) reinforce the importance of IAQ management, emphasizing ventilation improvements, air filtration enhancements, and regular IAQ monitoring to minimize the risk of infectious disease transmission (EPA, 2021). Technological advancements in IAQ monitoring and control, as highlighted by Cao et al. (2021), have enabled real-time monitoring of IAQ parameters, empowering organizations to make data-driven decisions to optimize IAQ and create healthier indoor environments for employees. Ultimately, prioritizing IAQ optimization in workplace environments is not only a matter of compliance but also an investment in employee health, well-being, and productivity, as poor IAQ can lead to discomfort, fatigue, respiratory issues, and reduced cognitive performance among employees. Therefore, organizations are increasingly proactive in implementing IAQ optimization measures to create safer, healthier, and more productive work environments for their employees.

3. Sick Building Syndrome (SBS)

Sick building syndrome (SBS) is a condition where building occupants experience negative health and comfort effects, resulting from prolonged exposure to the building environment. Symptoms include headaches, fatigue, concentration difficulties, nausea, and general unwellness. Factors contributing to SBS include inadequate ventilation, chemical contaminants, and biological pollutants like mold.

The WHO definition of Sick Building Syndrome is as follows: "Sick Building Syndrome (SBS) describes situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified (World Health Organization (WHO),1983). The complaints may be localized in a particular room or zone, or may be widespread throughout the building. In contrast, Building Related Illness (BRI) is a term used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants."

4. Indoor Air Quality

Indoor air quality (IAQ) plays a crucial role in contributing to SBS. Poor IAQ, characterized by factors such as inadequate ventilation, chemical contaminants like volatile organic compounds (VOCs), radon, formaldehyde, and biological contaminants like pollen, bacteria, viruses, and mold, can lead to symptoms associated with SBS. Additionally, inadequate ventilation rates can allow indoor air pollutants to accumulate, negatively impacting building occupants and instigating SBS symptoms.

Indoor air quality (IAQ) refers to the quality of the air inside buildings, which can have significant implications for the health, comfort, and well-being of occupants. Several factors contribute to IAQ, including ventilation, temperature, humidity, pollutants, and airborne contaminants (ASHRAE.,2021).

5. Correlation between Indoor Air Quality and Sick Building Syndrome

IAQ encompasses various factors such as the presence of indoor pollutants, ventilation effectiveness, temperature, humidity, and overall cleanliness of the indoor environment. Poor IAQ, characterized by elevated levels of indoor pollutants such as volatile organic compounds (VOCs), particulate matter, and biological contaminants, has been consistently linked to an increased risk of experiencing SBS symptoms (Nezis, I., Biskos, G., Eleftheriadis, K., Fetfatzis, P., Popovicheva, O., Sitnikov, N., et al.,2022). Sick Building Syndrome (SBS) refers to a range of non-specific symptoms experienced by occupants of a building, typically occurring after spending time indoors. These symptoms may include headaches, dizziness, fatigue, eye irritation, and respiratory discomfort. While the exact cause of SBS remains elusive, it is often associated with factors related to IAQ, inadequate ventilation, high humidity levels, and the presence of indoor pollutants.

IAQ Factor	Impact on SBS
Airborne Pollutants	- Inhalation of volatile organic compounds (VOCs), particulate matter, and mold spores can trigger respiratory irritation, headaches, fatigue, and other SBS symptoms.
	- Exposure to formaldehyde and other indoor air pollutants may exacerbate existing SBS symptoms among building occupants.
Inadequate Ventilation	- Insufficient ventilation rates lead to the accumulation of indoor air pollutants, stagnant air, and poor air circulation, creating conditions conducive to SBS.
	- Proper ventilation helps dilute and remove contaminants, improving IAQ and reducing the risk of SBS.
Humidity Levels	- High humidity levels promote mold growth and microbial proliferation, exacerbating respiratory symptoms and contributing to SBS.
	- Low humidity levels can cause dryness and discomfort, impacting occupant well-being and potentially exacerbating SBS symptoms.
Temperature Extremes	- Extreme temperatures, whether too hot or too cold, can affect occupant comfort and productivity, potentially exacerbating SBS symptoms.
	- Proper temperature control is essential for maintaining a comfortable and healthy indoor environment and reducing the risk of SBS.
Building Materials	- Off-gassing from building materials, furniture, and cleaning products releases harmful chemicals into the indoor air, contributing to IAQ issues and triggering SBS symptoms among occupants.
	- Selecting low-emission building materials and furnishings can help minimize indoor air pollutants and reduce the likelihood of SBS.
Occupant Sensitivity	- Individual factors such as pre-existing health conditions, allergies, and sensitivities influence susceptibility to SBS symptoms.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

	- Those with compromised immune systems or respiratory conditions may experience more severe reactions to poor IAQ, exacerbating SBS symptoms.

Addressing IAQ concerns is essential to create a healthy and comfortable indoor environment, particularly in workplaces where occupants spend a significant portion of their time. Implementing strategies such as effective ventilation, source control, regular maintenance, and occupant education can help mitigate IAQ factors and promote better indoor air quality.

6. Strategies to mitigate SBS in workplace

IAQ Strategy	Description	Resources
Effective Ventilation	Ensure proper ventilation systems are in place to supply fresh outdoor air and remove indoor pollutants. Regularly maintain ventilation systems. Consider increasing ventilation rates or implementing demand-controlled systems.	-(ASHRAE Standard 62.1-2021): Ventilation for Acceptable Indoor Air Quality - EPA Indoor Air Quality (IAQ) website - Occupational Safety and Health Administration (OSHA) guidelines
Source Control	Identify and eliminate or reduce sources of indoor pollutants such as VOCs, formaldehyde, and allergens. Choose low-emission building materials and implement policies to control indoor pollutant sources.	- EPA Indoor Air Quality (IAQ) website - Green Seal - Leadership in Energy and Environmental Design (LEED) certification
Regular Maintenance	Conduct routine maintenance of HVAC systems, including filter replacement and duct cleaning, to prevent the buildup of contaminants. Address water leaks promptly to prevent mold growth and moisture-related IAQ issues.	- ASHRAE Handbook - Building Owners and Managers Association (BOMA) guidelines - American Industrial Hygiene Association (AIHA) resources
Humidity Management	Maintain indoor humidity levels between 30% and 60% to prevent mold and microbial growth. Use dehumidifiers or humidifiers as needed. Address moisture sources such as leaks and condensation.	- EPA Indoor Air Quality (IAQ) website - American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) resources - Occupational Safety and Health Administration (OSHA) guidelines
Occupant Education	Educate employees about the importance of IAQ and SBS prevention. Encourage good IAQ practices such as proper ventilation and promptly reporting IAQ concerns.	- EPA Indoor Air Quality (IAQ) website - National Institute for Occupational Safety and Health (NIOSH) resources - Centers for Disease Control and Prevention (CDC) guidelines
Integrated Design Approach	Incorporate IAQ considerations into building design and renovation projects. Design buildings with adequate ventilation, daylighting, and thermal comfort in mind.	- ASHRAE Standard 189.1-2021: Standard for the Design of High-Performance Green Buildings - U.S. Green Building Council (USGBC) resources - International WELL Building Institute (IWBI) standards

In summary, optimizing indoor air quality (IAQ) in workspaces involves implementing strategies such as effective ventilation, source control, regular maintenance, humidity management, occupant education, and an integrated design approach. These measures, supported by various resources and guidelines, contribute to healthier indoor environments, reducing the risk of sick building syndrome (SBS) and enhancing occupant well-being and productivity. By prioritizing IAQ optimization, stakeholders can create workspaces that promote health, comfort, and sustainability for all occupants.

7. Policies related to Sick Building Syndrome and Indoor Air Quality

From the policies outlined below, it is evident that there are various approaches to addressing indoor air quality (IAQ) and mitigating the risks associated with Sick Building Syndrome (SBS). These policies aim to create safer and healthier indoor environments by focusing on factors such as ventilation, pollutant reduction, moisture control, and occupant health and safety.

Parameter	**Occupational Safety and Health Administration (OSHA)**	**Environmental Protection Agency (EPA)**	**World Health Organization (WHO)**
Agency	OSHA	EPA	WHO
Objective	Ensure workplace safety and health	Protect human health and the environment	Promote international public health

Coverage/ Scope	Workplace settings	Various indoor settings (schools, homes, etc.)	Global indoor environments
Specific Focus Areas	Indoor air quality, hazard prevention	Reduction of indoor air pollutants, SBS prevention	Indoor air quality, SBS prevention
Implementation Approach	Regulatory enforcement, guidance, and compliance	Guidance, resources, educational programs	Guidance, recommendations, technical assistance

The Occupational Safety and Health Administration (OSHA) guidelines prioritize the safety and well-being of workers by setting standards for workplace environments, including measures to prevent SBS-related hazards. The Environmental Protection Agency (EPA) guidelines extend beyond the workplace to various indoor settings, providing comprehensive recommendations for improving IAQ and reducing the risk of SBS symptoms.

Building codes and standards play a crucial role in ensuring that new construction and renovation projects meet minimum health and safety requirements, including provisions related to IAQ. Green building certification programs incentivize sustainable building practices, including IAQ considerations, to create healthier indoor environments.

8. Indoor air pollution limits as per different organizations

Indoor air pollutants encompass a wide range of substances that can degrade indoor air quality (IAQ) and impact human health and comfort. These pollutants can originate from indoor and outdoor sources and vary in composition and concentration. Here are some common indoor air pollutants and the various parameters that impact IAQ:

1. **Particulate Matter (PM)**: Particulate matter consists of tiny particles suspended in the air, including dust, allergens, pollen, and smoke. Parameters: Particle size (PM10, PM2.5), concentration (µg/m³), composition, and sources (e.g., combustion, outdoor pollution, indoor activities).

2. **Gases and Vapors**: Gaseous pollutants include carbon monoxide (CO), carbon dioxide (CO2), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), and volatile organic compounds (VOCs). Parameters: Concentration (ppm, ppb), source (combustion, off-gassing from building materials and furnishings), and chemical composition.

3. **Biological Contaminants**: Biological pollutants include mold spores, bacteria, viruses, and allergens from dust mites, pets, and pests. Parameters: Microorganism type and concentration (colony-forming units per cubic meter, CFU/m³), humidity levels, temperature, and ventilation rates.

4. **Formaldehyde and Other Indoor Chemicals**: Formaldehyde is a common indoor chemical emitted from building materials, furniture, and consumer products. Parameters: Concentration (µg/m³), emission rates, ventilation rates, and exposure duration.

5. **Radon**: Radon is a naturally occurring radioactive gas that can seep into buildings from the soil and rock beneath. Parameters: Radon concentration (picocuries per liter, pCi/L), building construction, ventilation rates, and soil composition.

6. **Moisture and Humidity**: Excess moisture and high humidity levels can lead to mold growth, microbial contamination, and degradation of building materials. Parameters: Relative humidity (%), dew point temperature, moisture sources (leaks, infiltration), and building design (ventilation, insulation).

7. **Temperature and Thermal Comfort**: Indoor temperature and thermal comfort influence occupant satisfaction and productivity. Parameters: Temperature (°C, °F), thermal gradients, air movement, and building envelope characteristics.

8. **Ventilation and Air Exchange Rates**: Adequate ventilation is essential for removing indoor pollutants and providing fresh air to occupants. Parameters: Ventilation rates (air changes per hour, ACH), outdoor air supply, exhaust rates, and filtration efficiency.

9. **Occupant Activities and Behaviors**: Indoor activities such as cooking, cleaning, smoking, and use of consumer products can generate pollutants and affect IAQ. Parameters: Duration and frequency of activities, pollutant emission rates, and occupant density.

Effective management of IAQ requires consideration of these parameters and the implementation of strategies such as source control, ventilation, filtration, and humidity control. Regular monitoring and assessment of IAQ parameters are essential for identifying potential sources of pollution and ensuring a healthy indoor environment. The acceptable limits for indoor air pollutants as per standard guidelines are

Parameter	**World Health Organization (WHO)**	**Environmental Protection Agency (EPA)**	**Occupational Safety and Health Administration (OSHA)**
Particulate Matter (PM10)	< 50 µg/m³ (24-hour average)	< 150 µg/m³ (24-hour average)	N/A (Covered under general dust standards)
Particulate Matter (PM2.5)	< 25 µg/m³ (24-hour average)	< 35 µg/m³ (24-hour average)	N/A (Covered under general dust standards)
Carbon Dioxide (CO2)	Not specified; general ventilation guidelines	< 1000 ppm	Not specified; general ventilation guidelines
Carbon Monoxide (CO)	< 10 mg/m³ (8-hour average)	< 9 ppm (8-hour average)	< 50 ppm (8-hour average)

Total Volatile Organic Compounds (TVOCs)	Not specified	Not specified	Not specified
Ozone (O_3)	< 100 µg/m^3 (8-hour average)	< 70 ppb (8-hour average)	< 100 ppb (8-hour average)
Nitrogen Dioxide (NO_2)	< 40 µg/m^3 (1-hour average)	< 100 µg/m^3 (1-hour average)	< 100 µg/m^3 (1-hour average)
Sulfur Dioxide (SO_2)	< 20 µg/m^3 (24-hour average)	< 75 ppb (1-hour average)	< 5 ppm (8-hour average)
Formaldehyde	< 100 µg/m^3 (30-minute average)	< 100 µg/m^3 (30-minute average)	Not specified
Radon (Rn)	< 100 Bq/m^3 (annual average)	< 4 pCi/L (long-term exposure)	Not specified
Relative Humidity (RH)	30% - 60%	Not specified	Not specified
Temperature	18°C - 24°C (64°F - 75°F)	Not specified	Not specified

9. Inclusion of environmental factors in IAQ guidelines

The inclusion of environmental factors such as radon (Rn), relative humidity (RH), and temperature in Indoor Air Quality (IAQ) guidelines is essential for comprehensive indoor air quality management and the promotion of occupant comfort and well-being. Radon exposure poses significant health risks, including an increased risk of lung cancer (EPA, 2020). By addressing radon levels through IAQ guidelines and implementing mitigation strategies, building owners can create safer indoor environments for occupants.

Environmental Factor	**Inclusion in IAQ Guidelines**	**Impact on Occupant Comfort and Well-being**
Radon (Rn)	Often included with recommended action levels or permissible concentration limits to mitigate health risks.	Prolonged exposure to high levels of radon increases the risk of lung cancer. Monitoring and controlling radon levels indoors is essential for occupant health.
Relative Humidity (RH)	Typically included with recommendations to maintain RH within a certain range (e.g., 30% to 60%) to prevent issues like mold growth, microbial contamination, and discomfort.	High humidity levels can promote mold and mildew growth, exacerbating allergies and respiratory problems, while low humidity levels can lead to dry skin, irritated mucous membranes, and increased susceptibility to respiratory infections.
Temperature	Guidelines often recommend maintaining indoor temperatures within a comfortable range (e.g., 20°C to 25°C / 68°F to 77°F) for general occupancy spaces.	Inadequate temperature control can lead to thermal discomfort, thermal stress, and reduced cognitive function, affecting occupant well-being and productivity.

In summary, the inclusion of radon, relative humidity, and temperature in IAQ guidelines underscores the importance of addressing these environmental factors to promote healthier, more comfortable, and safer indoor environments for occupants. By adhering to these guidelines, building owners and operators prioritize occupant health and well-being while ensuring optimal indoor air quality management.

10. CONCLUSION

Based on the comprehensive discussion and review of IAQ standards and guidelines from various organizations, it is evident that a thorough literature review has been conducted. This research paper has analyzed the existing guidelines and standards established by reputed organizations such as the World Health Organization (WHO), the Environmental Protection Agency (EPA), and the Occupational Safety and Health Administration (OSHA). The review has highlighted the importance of addressing multiple indoor air quality parameters to effectively mitigate Sick Building Syndrome (SBS) and promote occupant health and well-being. While there is a degree of consistency among organizations regarding acceptable ranges for certain pollutants, notable differences have been identified, indicating areas for further research and standardization efforts. The study has emphasized the crucial role of ventilation guidelines and the inclusion of parameters such as radon, relative humidity, and temperature, underscoring the multifaceted nature of IAQ management. The literature review has also examined existing policies and standards, providing a comprehensive understanding of the current landscape in this field.

In conclusion, this research paper's thorough literature review and analysis of existing guidelines, standards, and policies related to indoor air quality (IAQ) serve as a solid foundation for further investigation and potential recommendations. While significant alignment exists among IAQ standards across organizations for many pollutants and parameters, ongoing collaboration and research are crucial for refining and harmonizing these guidelines further By synthesizing the available information and identifying gaps or areas for improvement, this study paves the way for ongoing collaboration, research, and refinement of standards to create healthier indoor environments and reduce the prevalence of SBS symptoms among building occupants.

REFERENCES

1.World Health Organization (WHO). (1983). Indoor air pollutants: exposure and health effects.

2.Nezis, I., Biskos, G., Eleftheriadis, K., Fetfatzis, P., Popovicheva, O., Sitnikov, N., et al. (2022). Linking indoor particulate matter and black carbon with sick building. Atmospheric Pollution Research, 13(1), 101292. https://doi.org/10.1016/j.apr.2021.101292

3.ASHRAE. (2021). ASHRAE Standard 62.1: Ventilation for Acceptable Indoor Air Quality. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

4.Morawska, L., & Milton, D. K. (2020). It is Time to Address Airborne Transmission of Coronavirus Disease 2019 (COVID-19). Clinical Infectious Diseases, 71(9), 2311–2313.

5.Environmental Protection Agency (EPA). (2021). Indoor Air Quality (IAQ). Retrieved from https://www.epa.gov/indoor-air-quality-iaq

6.Cao, G., Yao, Y., & Li, W. (2021). Indoor Air Quality Monitoring System Based on Internet of Things. 2021 International Conference on Green Energy and Environment Engineering (CGEEE).

7.World Health Organization. (n.d.). Indoor air quality guidelines. Retrieved from https://www.who.int/teams/environment-climate-change-and-health/air-quality-and-health/indoor-air-pollution/indoor-air-quality-guidelines

8.Environmental Protection Agency. (n.d.). Indoor air quality. Retrieved from https://www.epa.gov/indoor-air-quality-iaq

9.American Society of Heating, Refrigerating and Air-Conditioning Engineers. (n.d.). ASHRAE indoor air quality. Retrieved from https://www.ashrae.org/technical-resources/standards-and-guidelines

10.Occupational Safety and Health Administration. (n.d.). Indoor air quality. Retrieved from https://www.osha.gov/indoor-air-quality-iaq

11.Environmental Protection Agency (EPA). (2020). Radon: Health Risks. Retrieved from https://www.epa.gov/radon/health-risks-radon

12.World Health Organization (WHO). (2021). Indoor Air Pollution. Retrieved from https://www.who.int/health-topics/indoor-air-pollution#tab=tab

13.Mendell, M. J., Fisk, W. J., Kreiss, K., & Levin, H. (2006). Improving the health of workers in indoor environments: priority research needs for a national occupational research agenda. American Journal of Public Health, 96(4), 587-594

14.Sundell, J. (2004). On the history of indoor air quality and health. Indoor Air, 14(Suppl 7), 51-58.