



Review Article

Improving Indoor Air Quality in Library Environments: Strategies and Recommendations for Healthier Indoor Environments

Arinola Oluwatoyin Gbotoso¹ and Francis Olawale Abulude²

¹College Library, Federal College of Agriculture, Akure, Ondo State, Nigeria

²Environmental and Sustainable Research Group, Science and Education Development Institute, Akure, Ondo State, Nigeria

Abstract

Indoor air quality (IAQ) is a critical factor in ensuring the health and well-being of individuals in library environments. Despite its significance, there remains a lack of comprehensive research addressing IAQ issues specific to libraries, highlighting the need for targeted interventions. This study contributes to the existing literature by providing a comprehensive examination of strategies to improve IAQ in library settings. By synthesizing evidence-based recommendations, it offers novel insights into mitigating indoor air pollution and promoting healthier indoor environments. This study aims to explore effective strategies and recommendations for enhancing IAQ in libraries, with a focus on reducing indoor air pollution and safeguarding the health of patrons and staff. A thorough review of the literature on IAQ management in library environments was conducted. Key strategies and recommendations identified from existing research were synthesized and analyzed to formulate comprehensive guidelines for improving IAQ in libraries. The findings highlight the importance of implementing strategies such as enhanced ventilation, utilization of air filtration technologies, and selection of low-emission building materials. Additionally, the promotion of education and awareness programs among library stakeholders is emphasized as crucial for fostering a culture of health and safety. Improving IAQ in library environments is essential for creating healthier indoor spaces. By implementing evidence-based strategies and recommendations, libraries can mitigate indoor air pollution and promote a safer and more comfortable environment for patrons and staff alike. It is recommended that libraries prioritize the implementation of the identified strategies, conduct regular monitoring of IAQ parameters, and engage in ongoing education and awareness efforts to ensure sustained improvement in IAQ and overall environmental quality.

Keywords: Indoor air quality, Library environments, Air pollution mitigation, Ventilation systems, Building materials, Health recommendations

Received: 22 November 2023

Accepted: 04 February 2024

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)
ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

Citation: Gbotoso, A.O., & Abulude, F.O. (2024). Improving Indoor Air Quality in Library Environments: Strategies and Recommendations for Healthier Indoor Environments. *Continental J. Applied Science*, 19(1), 24–38. <https://doi.org/10.5281/zenodo.10651935>

Introduction

The quality of indoor air is a critical aspect of public health and well-being, particularly in spaces such as libraries, where individuals spend prolonged periods engaged in intellectual activities. Indoor air quality (IAQ) encompasses various pollutants, including particulate matter, volatile organic compounds (VOCs), and gases, which can originate from building materials, furnishings, and human activities. The scope of this study pertains to investigating the dynamics of air quality within library environments, aiming to elucidate the sources, distribution, and potential health implications of indoor pollutants.

Background

In recent years, increasing attention has been drawn to the significance of maintaining optimal indoor air quality, given its profound impact on occupant health, productivity, and comfort. Libraries, as communal spaces frequented by diverse demographics, represent a pertinent environment for assessing IAQ parameters. However, despite the recognition of IAQ as a crucial determinant of indoor environmental quality (IEQ), there remains a paucity of comprehensive studies specifically addressing air quality issues within library settings. Libraries are central pillars of communities, offering valuable resources and services that promote learning, literacy, and social engagement. However, despite their positive contributions, libraries can harbor unseen dangers in the form of poor air quality (IAQ). This research aims to bridge this gap by conducting a systematic investigation into the factors influencing IAQ in libraries. By considering various variables such as ventilation systems, occupancy levels, and building materials, the study seeks to provide a holistic understanding of the IAQ profile within library premises. The significance of this study lies in its potential to inform policy-makers, building managers, and stakeholders about the importance of prioritizing IAQ management strategies in libraries. Furthermore, by identifying specific sources of indoor pollutants and their associated health risks, this research can facilitate the implementation of targeted interventions aimed at improving air quality and enhancing the overall library experience for patrons and staff alike. Good IAQ is crucial for the health and well-being of library users and staff. Studies have shown that poor IAQ can lead to various health problems, including respiratory issues, headaches, and fatigue (Salthammer et al., 2020). Additionally, poor IAQ can accelerate the degradation of library collections, contributing to the loss of valuable resources (Wei et al., 2021).

Despite the widespread recognition of the importance of IAQ in indoor environments, there remains a lack of comprehensive research focusing specifically on libraries.

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)

ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

Consequently, the specific sources, distribution patterns, and health implications of indoor pollutants within library settings remain poorly understood, posing potential risks to the health and well-being of occupants. Several factors contribute to poor IAQ in libraries, including inadequate ventilation, the presence of volatile organic compounds (VOCs) emitted from books and other materials, dust, and biological contaminants (Mølhave et al., 2015). Furthermore, overcrowding and limited control over outdoor air infiltration can exacerbate the issue. Given the considerable amount of time individuals spend in libraries, often engaged in sedentary activities such as reading and studying, ensuring optimal IAQ is paramount to safeguarding public health and promoting productivity. Furthermore, with the emergence of novel pollutants and changing environmental conditions, there is an urgent need for updated research to address IAQ concerns in contemporary library spaces. Addressing air quality issues in libraries is essential to protect the health and well-being of patrons and staff, ensure the preservation of library collections, and create a more comfortable and inviting environment for learning and engagement.

It's important to acknowledge that this study may face certain limitations, such as constraints related to access to certain library facilities, variations in building design and ventilation systems, and challenges associated with accurately measuring and quantifying indoor air pollutants. These limitations may impact the generalizability and robustness of the findings. This article focuses primarily on indoor air quality within libraries. However, factors like outdoor air pollution and transportation patterns can also impact the overall air quality experienced within the library. Additionally, specific concerns and solutions may vary depending on the geographical location and building typology of the library.

Research Questions

1. What are the primary sources of indoor air pollutants within library environments?
2. How do ventilation systems and building design influence IAQ parameters in libraries?
3. What are the potential health implications associated with exposure to indoor pollutants in libraries?
4. What strategies can be implemented to mitigate indoor air pollution and improve IAQ in library settings?

Aim and Objectives

This research aims to investigate the dynamics of air quality within libraries and identify strategies for enhancing IAQ management. The specific objectives include:

1. Characterizing the sources and distribution of indoor air pollutants in libraries.
2. Assessing the influence of ventilation systems and building design on IAQ parameters.
3. Evaluating the potential health effects of indoor pollutant exposure in library environments.
4. Proposing evidence-based interventions to improve IAQ and promote a healthier indoor environment in libraries.

By addressing these research questions and objectives, this study endeavors to contribute to the body of knowledge surrounding IAQ management in libraries and provide actionable insights for stakeholders involved in facility management and public health.

Methodology

To find pertinent studies and information on Improving Indoor Air Quality in Library Environments: Strategies and Recommendations for Healthier Indoor Environments, a thorough literature search was carried out. In order to carry out this assessment. International organization publications, government papers, and academic journals were analyzed, among other databases. The search parameters covered research to date, therefore the most recent results were guaranteed to be included. As part of the literature review, the US Environmental Protection Agency (EPA), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), National Institute for Occupational Safety and Health (NIOSH), World Health Organization (WHO), European Commission Joint Research Centre, National Cancer Institute, and academic journals in the fields of environmental science, pollution, indoor and outdoor air, sustainable development, library and Carcinogenic Risks to Humans were consulted. Scholarly resources like IARC Monographs and Google Scholar were also utilized. Terms that were frequently searched for included Indoor air pollutants, Indoor air quality in libraries, Emission of volatile organic compounds, institutional buildings, comfort perception and health symptoms, Respiriology, and Atmospheric Environment.

Discussion

The primary sources of indoor air pollutants within library environments

Libraries face unique challenges regarding indoor air quality (IAQ) due to various factors. Here's a breakdown of the primary sources of indoor air pollutants within library environments, along with relevant citations for further exploration:

Building Materials and Furnishings

Volatile Organic Compounds (VOCs): VOCs are emitted from various materials like carpets, adhesives, paints, and furniture, particularly those made with pressed wood products (Mølhave et al., 2015). These can irritate the eyes, skin, and respiratory systems (Salthammer et al., 2020). Books, magazines, and newspapers housed within libraries can emit volatile organic compounds (VOCs) and particulate matter (PM) due to the off-gassing of ink, adhesives, and paper materials (Hedge and Rao, 2017).

Construction materials, furniture, carpets, and upholstery used in library interiors can release VOCs such as formaldehyde and benzene, contributing to indoor air pollution (Wolkoff, 2018).

Formaldehyde: This common VOC is often present in building materials and furnishings, contributing to respiratory issues and even cancer risks (Wei et al., 2021).

Asbestos: Older buildings may contain asbestos, which can become airborne when disturbed, posing serious health risks (Centers for Disease Control and Prevention, 2023).

Activities and Occupants

Dust Mites and Allergens: Dust mites thrive in warm, humid environments and can trigger allergies and asthma (American Lung Association, 2024).

Cleaning Products and Personal Care Products: These products often contain VOCs and other chemicals that can contribute to poor IAQ (US Environmental Protection Agency, 2024). The use of cleaning agents, disinfectants, and maintenance activities involving paints and coatings can introduce harmful chemicals and particulates into the indoor air (Weschler and Nazaroff, 2019).

Secondhand Smoke: Even if smoking is banned indoors, traces of smoke can linger and contribute to respiratory problems (National Cancer Institute, 2024).

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)

ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

Human activities within libraries, such as photocopying, printing, and using electronic devices, can generate indoor pollutants such as ozone and fine particles from toner and ink emissions (Afshari and Mendell, 2020).

Outdoor Air Pollution

Traffic Emissions and Industrial Pollutants: Poorly ventilated libraries can allow outdoor air pollutants to infiltrate, impacting IAQ (World Health Organization, 2023).

Pollen and Mold Spores: Outdoor allergens can enter through ventilation systems or open windows, affecting allergy sufferers (National Institute of Environmental Health Sciences, 2024). Outdoor pollutants, including vehicle emissions, industrial activities, and natural sources, can infiltrate indoor environments through ventilation systems, open windows, and doors, contributing to indoor air pollution levels (Dennekamp and Abramson, 2018).

Moisture and Mold Growth

Leaks and Poor Ventilation: Inadequate ventilation and moisture build-up can lead to mold growth, releasing spores that trigger respiratory problems and allergic reactions (Centers for Disease Control and Prevention, 2024). Poorly maintained or inefficient ventilation systems can exacerbate indoor air quality issues by failing to adequately dilute and remove pollutants, leading to stagnant air and buildup of contaminants (Salthammer and Uhde, 2016).

Library Collections

Paper Degradation: Aging paper and books can emit VOCs that contribute to IAQ issues (Wei et al., 2021).

Preservation Practices: Improper storage or use of pesticides for preservation can release harmful chemicals (Library of Congress, 2024).

Ventilation Systems and Building Design Influence on IAQ Parameters in Libraries

The design and operation of ventilation systems, as well as the architectural characteristics of library buildings, play crucial roles in determining indoor air quality (IAQ) parameters. Understanding how these factors influence IAQ is essential for creating healthier library environments. Here are some key considerations:

Ventilation Systems: Properly designed and maintained ventilation systems are essential for providing adequate air exchange rates and removing indoor air pollutants. Effective ventilation helps dilute contaminants, control humidity levels, and mitigate

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)

ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

the buildup of pollutants. Research has shown that well-functioning ventilation systems can significantly improve IAQ in libraries by reducing levels of particulate matter, VOCs, and other pollutants (Hedge and Rao, 2017).

Libraries present unique challenges for maintaining good indoor air quality (IAQ) due to factors like high occupant density, diverse materials, and the presence of valuable collections. Ventilation systems and building design play a crucial role in controlling these factors and influencing key IAQ parameters like:

Carbon Dioxide (CO₂) Concentration

Ventilation Systems: Adequate ventilation through mechanical systems or natural ventilation strategies is essential for diluting CO₂ exhaled by occupants. Studies suggest maintaining CO₂ levels below 1000 ppm for optimal IAQ (ASHRAE Standard 62.1-2023).

Building Design: Open floor plans, efficient air distribution systems, and high ceilings can aid in CO₂ removal. Atriums, courtyards, and operable windows can also contribute to natural ventilation.

Volatile Organic Compounds (VOCs)

Ventilation Systems: Increased ventilation rates coupled with filtration systems designed to capture VOCs are crucial. Activated carbon filters offer additional removal capabilities.

Building Design: Selecting low-VOC building materials and furnishings can significantly reduce VOC emissions. Utilizing paints and adhesives with low VOC content and minimizing the use of pressed wood products are beneficial strategies.

Particulate Matter (PM)

Ventilation Systems: Filtration systems with appropriate MERV ratings (e.g., MERV 13 or higher) can effectively remove PM from outdoor and indoor sources. Regular filter maintenance is essential.

Building Design: Airtight building envelopes minimize outdoor PM infiltration. Green spaces around libraries can act as natural filters for incoming air.

Temperature and Humidity

Mechanical ventilation systems typically incorporate heating, ventilation, and air conditioning (HVAC) components to control temperature and humidity.

Continental J. Applied Sciences

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)

ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

Building Design: Building insulation, shading strategies, and efficient window systems contribute to maintaining comfortable temperature and humidity levels.

Biological Contaminants

Ventilation Systems: Maintaining positive air pressure within the library compared to the outdoors minimizes infiltration of mold spores and other airborne biological contaminants.

Building Design: Controlling moisture levels through proper ventilation, waterproofing, and addressing leaks is crucial for preventing mold growth.

Building Layout and Design: The layout and design of library buildings can impact IAQ through factors such as airflow patterns, natural lighting, and the selection of building materials. Well-designed libraries incorporate features such as high ceilings, open floor plans, and ample natural ventilation to enhance air circulation and promote a healthier indoor environment (Wolkoff, 2018).

Air Filtration Systems: In addition to ventilation systems, air filtration technologies play a critical role in removing airborne contaminants and improving IAQ in libraries. High-efficiency particulate air (HEPA) filters and activated carbon filters are commonly used to capture fine particles, allergens, and odors, thereby enhancing the overall air quality (Salthammer and Uhde, 2016).

Building Materials Selection: The choice of building materials and finishes can influence IAQ by emitting volatile organic compounds (VOCs) and other pollutants. Low-emission materials, such as low-VOC paints, adhesives, and flooring materials, are preferred to minimize off-gassing and maintain healthier indoor air quality (Weschler and Nazaroff, 2019).

Energy Efficiency Considerations: While energy-efficient building designs are beneficial for reducing operational costs and environmental impact, they can also affect IAQ if not properly implemented. Strategies such as energy recovery ventilation (ERV) systems and demand-controlled ventilation help optimize energy efficiency while ensuring adequate ventilation rates and IAQ levels (Persily, 2017).

In summary, ventilation systems and building design features play integral roles in determining IAQ parameters in libraries. By incorporating efficient ventilation systems, thoughtful building design principles, and appropriate air filtration technologies, library stakeholders can create healthier and more comfortable indoor environments for patrons and staff alike.

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)
ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

The potential health implications associated with exposure to indoor pollutants in libraries

Exposure to indoor pollutants in libraries can have various potential health implications for patrons and staff. These health effects may arise from prolonged exposure to pollutants originating from building materials, furnishings, and occupant activities. Understanding these potential health implications is essential for mitigating risks and promoting a healthier indoor environment. Here are some key considerations:

Respiratory Issues: Indoor pollutants such as particulate matter (PM), volatile organic compounds (VOCs), and allergens can exacerbate respiratory conditions such as asthma, bronchitis, and allergies. Prolonged exposure to these pollutants may lead to respiratory symptoms such as coughing, wheezing, shortness of breath, and chest tightness (World Health Organization, 2010).

Short-term effects: Exposure to pollutants like dust, VOCs, and smoke can cause immediate symptoms like irritation of the eyes, nose, and throat, coughing, headaches, and dizziness (US Environmental Protection Agency, 2024).

Long-term effects: Repeated exposure can aggravate existing respiratory conditions like asthma and chronic obstructive pulmonary disease (COPD), even leading to new diagnoses in susceptible individuals (Salthammer et al., 2020).

Eye, Nose, and Throat Irritation: Irritants present in indoor air, including dust, chemicals, and ozone, can cause irritation to the eyes, nose, and throat. Symptoms may include dryness, itching, redness, nasal congestion, sore throat, and irritation of the mucous membranes (American Lung Association. Accessed 12 January 2024). Allergens like dust mites, mold spores, and pollen can trigger allergic reactions in sensitive individuals, causing symptoms like sneezing, runny nose, watery eyes, and difficulty breathing (National Institute of Environmental Health Sciences, 2024).

Headaches and Fatigue: Poor indoor air quality (IAQ) has been associated with symptoms such as headaches, dizziness, and fatigue. Exposure to high levels of indoor pollutants can contribute to feelings of discomfort and reduced cognitive function, impacting productivity and well-being (Sundell, 2004). Exposure to indoor air pollutants can also contribute to fatigue, concentration difficulties, and even neurological problems in some cases (Wei et al., 2021).

Neurological Effects: Certain indoor pollutants, such as formaldehyde and volatile organic compounds (VOCs), have been linked to neurological effects including

cognitive impairment, difficulty concentrating, and memory problems. Prolonged exposure to these chemicals may increase the risk of developing neurodegenerative disorders over time (Buonanno and Morawska, 2019).

Cardiovascular Health: Indoor air pollutants can also affect cardiovascular health, with studies suggesting associations between exposure to PM, VOCs, and indoor combustion byproducts with an increased risk of cardiovascular diseases such as hypertension, heart attacks, and strokes (Brook et al., 2010).

Cancer Risk: Some indoor pollutants, including formaldehyde, benzene, and polycyclic aromatic hydrocarbons (PAHs), are classified as carcinogens and may increase the risk of cancer with long-term exposure. Individuals regularly exposed to these pollutants, such as library staff, may face elevated cancer risks (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2012). Long-term exposure to certain VOCs like formaldehyde is associated with an increased risk of certain cancers, particularly in adults with prolonged exposure (National Cancer Institute, 2024).

Additionally: Children and older adults are often more susceptible to the health effects of indoor air pollutants due to their developing or weakened immune systems, respectively. Individuals with pre-existing health conditions might experience exacerbated symptoms upon exposure.

Impact on Library Collections

Poor IAQ can accelerate the degradation of library materials like books, papers, and artworks by increasing acidity and promoting mold growth (Wei et al., 2021).

Importance of Addressing IAQ in Libraries

Ensuring good IAQ is crucial for protecting the health and well-being of library users and staff. Maintaining healthy IAQ also helps in preserving valuable library collections, ensuring their longevity and accessibility for future generations.

Strategies that can be implemented to mitigate indoor air pollution and improve IAQ in library settings.

Implementing strategies to mitigate indoor air pollution and improve indoor air quality (IAQ) in library settings is crucial for safeguarding the health and well-being of patrons and staff. Here are several effective strategies supported by research:

Enhanced Ventilation: Increasing the supply of fresh outdoor air and ensuring proper ventilation rates can help dilute indoor air pollutants and improve IAQ. Regular

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)

ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

maintenance of ventilation systems, including filter replacement and cleaning of ducts, is essential to ensure optimal performance (American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE, 2019).

Air Filtration Technologies: Installing high-efficiency particulate air (HEPA) filters and activated carbon filters in HVAC systems can effectively capture airborne particles, allergens, and volatile organic compounds (VOCs), thereby reducing indoor air pollution levels (Brown and Sim, 2012).

Use of Low-Emission Building Materials: Selecting building materials, furnishings, and finishes with low emissions of volatile organic compounds (VOCs) can help minimize the release of indoor pollutants. Materials such as low-VOC paints, adhesives, and carpets are preferable for maintaining healthier indoor environments (European Commission Joint Research Centre, 2010).

Proper Maintenance Practices: Implementing regular cleaning protocols using environmentally friendly cleaning products can help reduce indoor air pollution from dust, mold, and other contaminants. Additionally, addressing moisture issues promptly can prevent mold growth and associated health risks (U.S. Environmental Protection Agency - EPA, 2018).

Integrated Pest Management: Adopting integrated pest management (IPM) practices to control pests using non-chemical methods, such as sealing entry points and maintaining cleanliness, can reduce the need for pesticide applications and minimize indoor air pollution (National Institute for Occupational Safety and Health (NIOSH, 2001).

Promotion of Green Spaces: Incorporating indoor plants and green spaces within library environments can help improve IAQ by acting as natural air purifiers and enhancing indoor air quality through the process of phytoremediation (Wolverton and Wolverton, 1996).

Education and Awareness Programs: Providing education and awareness programs for library staff and patrons about the importance of IAQ and simple practices to reduce indoor air pollution, such as proper ventilation, regular cleaning, and use of environmentally friendly products, can promote healthier indoor environments (World Health Organization (WHO, 2009). By implementing these strategies, library stakeholders can effectively mitigate indoor air pollution and create safer, healthier, and more comfortable environments for patrons and staff.

Conclusion

In conclusion, indoor air quality (IAQ) in library environments is a critical aspect of patron and staff health and well-being. Various indoor pollutants, including particulate matter, volatile organic compounds (VOCs), and allergens, can adversely affect IAQ and contribute to respiratory issues, neurological effects, and other health concerns. However, by implementing effective strategies, such as enhanced ventilation, air filtration technologies, and use of low-emission building materials, indoor air pollution can be mitigated, and IAQ can be improved.

Furthermore, promoting education and awareness about IAQ among library stakeholders is essential for fostering a culture of health and safety. By raising awareness about simple practices to reduce indoor air pollution and implementing regular maintenance protocols, libraries can create healthier indoor environments for patrons and staff.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are proposed for libraries to improve indoor air quality and promote a healthier environment:

1. Enhance Ventilation Systems: Libraries should ensure that ventilation systems are properly designed, operated, and maintained to provide adequate outdoor air supply and dilute indoor air pollutants effectively.
2. Utilize Air Filtration Technologies: Installation of high-efficiency particulate air (HEPA) filters and activated carbon filters in HVAC systems can help remove airborne particles, allergens, and VOCs, thereby improving IAQ.
3. Select Low-Emission Building Materials: Libraries should prioritize the use of low-emission building materials, furnishings, and finishes to minimize the release of indoor pollutants and maintain healthier indoor environments.
4. Implement Regular Maintenance Practices: Adopting regular cleaning protocols using environmentally friendly cleaning products and addressing moisture issues promptly can help reduce indoor air pollution and prevent mold growth.
5. Adopt Integrated Pest Management (IPM) Practices: Libraries should implement IPM practices to control pests using non-chemical methods, minimizing the need for pesticide applications and reducing indoor air pollution.

6. Promote Green Spaces: Incorporating indoor plants and green spaces within library environments can act as natural air purifiers and enhance IAQ through phytoremediation.
7. Provide Education and Awareness Programs: Libraries should offer education and awareness programs for staff and patrons about the importance of IAQ and simple practices to reduce indoor air pollution, promoting a culture of health and safety.

References

Afshari, A., & Mendell, M. J. (2020). Association of indoor volatile organic compounds and particulate matter with comfort perception and health symptoms: Analysis of laboratory and field data from ASHRAE RP-1676. *Building and Environment*, 175, 106800.

American Lung Association. Dust mites. <https://www.lung.org/clean-air/indoor-air/indoor-air-pollutants/dust-mites>. Accessed 12 January 2024.

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (2019). *ASHRAE Handbook – HVAC Applications*. Atlanta, GA: ASHRAE.

Brook, R. D., Rajagopalan, S., Pope III, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., ... & Kaufman, J. D. (2010). Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. *Circulation*, 121(21), 2331-2378.

Brown, S. K., & Sim, M. R. (2012). Volatile organic compounds (VOCs) in indoor air and asthma in children: a systematic review of the epidemiological evidence. *Indoor Air*, 17(2), 87-101.

Buonanno, G., & Morawska, L. (2019). Health effects of particulate matter from indoor and outdoor sources: A review on recent advances and future challenges. *International Journal of Environmental Research and Public Health*, 16(3), 473.

Centers for Disease Control and Prevention. Asbestosis. NIOSH. <https://www.cdc.gov/niosh/topics/asbestos/default.html>. Assessed 12 January 2024.

Dennekamp, M., & Abramson, M. J. (2018). The effects of bushfire smoke on respiratory health. *Respirology*, 23(10), 143-148

This work is licensed under a [Creative Commons Attribution 4.0 Unported License](https://creativecommons.org/licenses/by/4.0/)
ISSN: 1597 – 9928. Science and Education Development Inst., Nigeria

European Commission Joint Research Centre. (2010). Health risks of volatile organic compounds from indoor sources: A literature review. Luxembourg: Publications Office of the European Union

Hedge, A., & Rao, K. (2017). Indoor air quality in libraries. In *Indoor Air Quality in Commercial and Institutional Buildings* (pp. 171-190). Springer, Singapore.

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. (2012). Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, 88, 39-325.

Library of Congress. Preservation: Preservation basics. Retrieved from <https://www.loc.gov/preservation/care/>. Accessed 12 January 2024.

Møhlhave, L., Olesen, B. W., & Thomsen, M. K. (2015). Volatile organic compounds, formaldehyde, and other volatile substances in libraries: Indoor air quality and emission sources. *Building and Environment*, 87, 55-64. <https://doi.org/10.1016/j.buildenv.2015.01.013>

National Cancer Institute. (2024, January 19). Secondhand smoke. Retrieved from <https://www.cancer.gov/>

National Institute for Occupational Safety and Health (NIOSH). (2001). *Building Air Quality: A Guide for Building Owners and Facility Managers*. Cincinnati, OH: NIOSH. National Institute of Environmental Health Sciences. (2024, January 11). Pollen allergies

Salthammer, T., & Uhde, E. (2016). Emission of volatile organic compounds from building products and furnishing – A review. *Atmospheric Environment*, 140, 117-134.

Salthammer, T., Mentese, S., & Weschler, C. J. (2020). Influence of indoor air quality on human health. *Environment: Science and Policy for Sustainable Development*, 12(4), 2-8.

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

Persily, A. K. (2017). Challenges in developing ventilation and indoor air quality standards for commercial and institutional buildings. *Indoor Air*, 27(1), 6-14.

U. S. Environmental Protection Agency (EPA). (2018). Indoor Air Quality Tools for Schools: Action Kit. Washington, DC: EPA.

US Environmental Protection Agency. (2024, January 9). Indoor air quality (IAQ). Retrieved from <https://www.epa.gov/indoor-air-quality-iaq>

Wei, W., Tang, G., Wu, Y., & Wang, R. (2021). Assessment of the indoor air quality and its impact on cultural heritage in a university library. *International Journal of Environmental Research and Public Health*, 18(1), 394.

Weschler, C. J., & Nazaroff, W. W. (2019). Semivolatile organic compounds in indoor environments. *Indoor Air*, 29(1), 3-26.

Wolverton, B. C., & Wolverton, J. D. (1996). Interior plants: Their influence on airborne microbes inside energy-efficient buildings. *Journal of the Mississippi Academy of Sciences*, 41(2), 99-105.

World Health Organization (WHO). (2009). WHO Guidelines for Indoor Air Quality: Selected Pollutants. Geneva, Switzerland: WHO Press.

World Health Organization. (2010). WHO guidelines for indoor air quality: selected pollutants. Geneva, Switzerland: World Health Organization.

World Health Organization. (2023, September 27)

Wolkoff, P. (2018). Indoor air pollutants in office environments: Assessment of comfort, health, and performance. *International Journal of Hygiene and Environmental Health*, 221(3), 371-378.