# Air Quality in Office Buildings

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## Abstract

This paper will bring the critical debate about the interior office buildings environment and its health implications to a conclusion. The research paper is a descriptive-analytical study that will address both indoor and outdoor air pollutants. The Environmental Protection Agency (EPA) recently launched two major investigations into indoor air quality in over 150 public and commercial buildings to learn more. According to EPA studies of human exposure to air pollutants, indoor air levels of many toxins are 2–5 times, and occasionally more than 100 times, higher than outside levels. Furthermore, both short- and long-term indoor environmental quality is influenced by the materials used in construction and the choices made by architects and designers. As a result, ventilation, construction materials, and furnishings must all be taken into account. The Sick Building Syndrome is a phenomenon or set of situations in which 20% or more of a structure's occupants exhibit symptoms of disease and comfort effects associated with time spent in a building. This paper will simplify and focus the findings of this study to make it easier to use and benefit from and serve as the top of the iceberg of facts and studies that have enabled the researcher to achieve this brevity.

## Keywords
Environment, Air pollutants - Comfort levels, Air quality, Sick Building.

## 1. Introduction
Traditionally, air quality has been discussed in terms of outdoor air. However, the indoor environment, where most of us spend most of our time, has recently gotten much attention. Poor indoor air quality can have a significant personal and economic impact. As a result, indoor air quality is a concern in most buildings. This paper will attempt to bring this critical discussion on the indoor environment and its health-related issues.

For various reasons, people have less control over the indoor environment of their offices than they do at home, and documented health risks are on the rise in today's office buildings. On the other hand, indoor air quality is a relatively recent science that is still in its infancy. The Environmental Protection Agency (EPA) recently initiated two major indoor air quality investigations in over 150 public and commercial buildings to learn more. Indoor levels of certain pollutants can be 2–5 times greater than outside levels, and in some cases, more than 100 times higher, according to EPA studies of human exposure to air pollutants. Furthermore, the choices made by architects and designers regarding construction materials, coatings, and other elements impact both short- and long-term indoor environmental quality. As a result, ventilation, building materials, and furnishings all need to be taken into account. In addition, consistent quantities of breathing gases, such as carbon dioxide, must be maintained in an indoor setting, and the air must be free of substantial contaminants and aromas.

Temperature, humidity, lighting, and sound levels must all be comfortable, and physical settings must be ergonomically constructed to reduce physical weariness and mental stress. Depending on the operations and activities in the buildings, around 900 different contaminants have been identified in indoor environments. The Sick Building Syndrome is a phenomenon or set of situations in which 20% or more of a structure's occupants exhibit symptoms of disease and comfort effects associated with time spent in a building.

The symptoms include eye irritation, nasal irritation, headaches, fatigue, dizziness, nausea, drowsiness, rashes, and skin dryness. Since the 1950s, architects have moved toward creating tightly contained environments controlled by increasingly sophisticated mechanical systems. Unfortunately, the use of advanced materials and inorganic furnishings often resulted in emissions of contaminants.

In structures built since the 1970s, this has been the unavoidable result. As a result, in comparison to earlier buildings, the inside atmosphere is more complex.

According to medical data, asbestos, lead, radon, Volatile Organic Compounds or VCOs, and Poly Chlorinated Biphenyls or PCBs have all been linked to cancer over the last 40 years. In addition, a slew of other bacteria can have a direct impact on human health. Because all of these compounds are frequently identified and live in today's structures, it is vital to locate them and, if there is a risk of exposure to the building's residents, to take corrective action.

### 1.1 Objectives

The study aimed to achieve the following:
The personal and economic impact of poor indoor air quality may be substantial. Buildings have some type of indoor air quality problem. This paper will attempt to bring this critical discussion on the indoor environment and its health-related issues.

The indoor environment is more complex than in older buildings. In the past 40 years, medical evidence has also proved that radon, Volatile Organic Compounds (VCOs), Poly Chlorinated Biphenyls (PCBs), and a host of similar microbes can directly affect human health. Since all such substances are often found and reside in today's buildings, it has become necessary to identify their locations and, if there is a risk of exposure to the occupants of the building, to take corrective action.

## 2. Literature Review

NO2 is a gaseous pollutant produced by the combustion of fossil fuels and other sources such as transportation, combustion processes, and industrial operations (Demirel et al., 2014). (Gaffin et al., 2018). It is also an issue as an indoor air pollutant because there are powerful inside sources of nitrogen dioxide, such as building heating, cooking with fossil fuels, and tobacco smoke (Samet,1991). If no specific indoor sources are known, measured NO2 concentrations are commonly higher in urban areas than in rural areas (Batisse et al., 2017; Demirel et al., 2014) and often higher in outdoor air compared to indoor air (Batisse et al., 2017; Demirel et al., 2014). (Ielpo et al., 2019).

Indoor NO2 concentrations are frequently higher than outside ones, resulting in higher human exposure levels (Bozkurt et al., 2015). Recent epidemiological research has found that early-life NO2 exposure can promote allergic problems, including asthma (Bowatte et al., 2014; Deng et al., 2016), and have long-term effects on lung function, affecting respiratory health throughout life (Bowatte et al., 2014; Deng et al., 2016). (Baoting et al., 2019).

Furthermore, a concentration-response relationship between long-term NO2 concentration and mortality has been demonstrated within the indicated NO2 concentration range, with most concentrations below 20 g/m3 among adults (Raaschou-Nielsen et al.,2012). Yet, little is known about NO2 exposures in indoor settings like offices, where roughly 30% of the adult population spends their weekdays; however, there is more information about NO2 exposures at home. (Morawska et al., 2017); A concentration-response relationship between long-term NO2 concentration and mortality has also been demonstrated within the indicated NO2 concentration range, with most concentrations below 20 g/m3 among adults (Raaschou-Nielsen et al.,2012). Yet, little is known about NO2 exposures in indoor settings, such as offices, where approximately 30% of the adult population spends their weekdays; however, more information is available about NO2 exposures at home. As a result, building airtightness and insulation have improved for energy conservation. Still, there have been some detrimental implications, such as sick building syndrome, various chemical sensitivities, respiratory diseases, and increased carcinogen exposure (Sundell et al., 2011). As a result, the requirement for improved indoor air quality (IAQ) and energy efficiency in ventilation is seen as essential for constructing appropriate heating, ventilating, and air-conditioning (HVAC) systems (Mardiana-Idayu and Riffat, 2012). As a result, numerous building design researchers have devised enhanced ventilation systems to achieve higher comfort and improved IAQ while using less energy (Liddament, 2000),(Zhou and Haghighat, 2009).

Outside combustion-related pollutants can enter the Interior through traditional ventilation, penetrating windows and doors, and a building's structural faults; smoking is prohibited (Gaffin et al., 2018). Building and indoor environmental factors, such as indoor humidity and building size, as well as indoor and outdoor sources and human activities, can affect nitrogen dioxide levels indoors (WHO, 2010). However, there is a shortage of information on these traits in office environments. Moreover, although HVAC systems have advanced to a high level of technological maturity, IAQ and thermal comfort can still be an issue due to unexpectedly low air volume and inefficient indoor circulation patterns (Chenery, et al, 2016); (Korea Energy Economics Institute, 2014). As a result, it appears that sticking to the traditional ventilation plan with a well-regulated air exchange rate (ACH) is no longer cost-effective or sustainable in terms of energy efficiency (Ren and Cao, 2020). A new intelligent and dynamic indoor environment control system that improves the existing ventilation system must be designed to address this issue.

## 3. Methods

The research methodology is divided into two mainframes;First: A theoretical study that describes and studies indoor air contaminants and outdoor air contaminants.Second: An analytical study of factors and causes affecting the indoor environment in office buildings and follow the typical changes and problems there.Third: the result of this study will show in a summarized and focused manner to make it easier to use and benefit from, to serve as the tip of the iceberg of the facts and studies that have enabled the researcher to achieve this brevity.

## 4. Data Collection

### 4.1 Contaminants in Indoor Air

New construction materials, products, and furniture that emit a substantial quantity of potentially harmful chemicals into the air are examples of interior contaminants. The use of high-tech office equipment generates a substantial amount of new pollutants. “Figure 1″. Indoor pollutants are exacerbated by the use of cleaning chemicals, aerosols, and cleaning fluids. (Leung., et al. 2007)

Figure 1. Healthy material used in office buildings

The presence of people breathing and producing body odors has an impact on indoor air quality. “Figure:2”. Smoking can significantly damage the indoor environment “Figure 2”. Similarly, glare from artificial lighting and visual stress

from computer terminals can create headaches and eye irritation, while chairs and desks that are too low for the job might produce weariness.


Figure 2. The interior environment is harmed by various scents and smoking.

### 4.2 Contaminants in the Outdoor Air

While there may be too many outside sources of pollution, this paper focuses on those that occur solely indoors. Just a few examples include pollen, dust, fungal spores, industrial pollutants, vehicle exhaust, dumpster odors, unhygienic debris, and re-entrained (pulled back into the building) exhaust from the building itself or nearby structures.” Figure 3”.

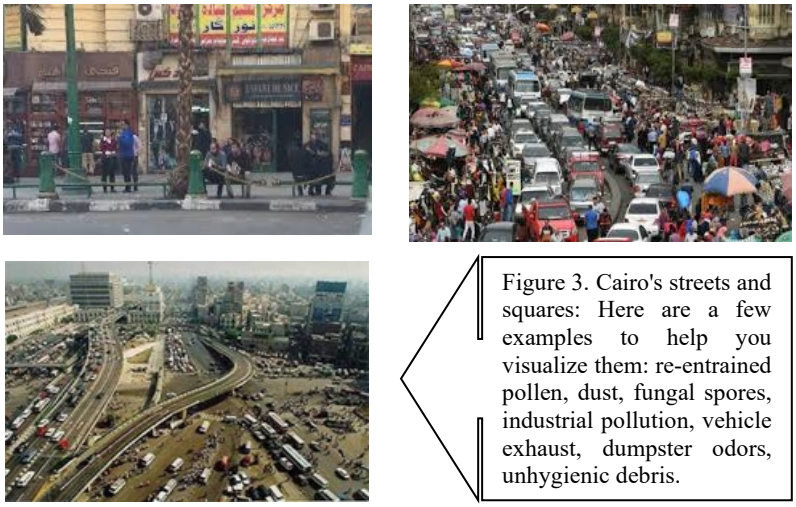

Figure 3. Cairo's streets and squares: Here are a few examples to help you visualize them: re-entrained pollen, dust, fungal spores, industrial pollution, vehicle exhaust, dumpster odors, unhygienic debris.

### 4.3 Causes and Sources Affecting the Indoor Environment

The architect must avoid contamination transmission along pollution channels. It's worth noting that the HVAC system's plenum may be reliant on vacant sections. The air quality in these plenums will be affected by the materials used in the structural system. For example, if steel is used, it must be fireproofed, and the fireproofing might be a source of contamination into the airstream “Figure 4”.

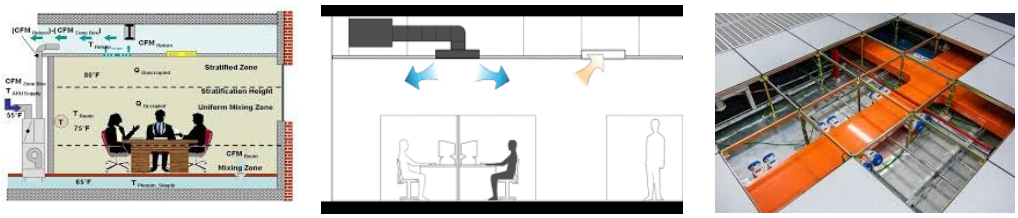


Figure 4. Interior and exterior views of the through–the–wall unit

Cementitious fireproofing can get dusty, flake, and degrade with time. “Figure 5”

Figure 5. The air quality in these plenums will be affected by the materials used in the structural system.

If wood is utilized in a location where moisture is present, it can host bacteria, or pests “Figure 6”.

Figure 6. In the workplace, wood provides a risk of harboring bacteria or pests.

VCOs are organic chemical-based goods' evaporating molecules. These substances are emitted by a variety of cleaning and maintenance agents and construction materials. Indoor pollution also contains aromatic hydrocarbons, alcohol, ketones, aldehydes, ethers, esters, and other chemicals.

Paints, stains, varnishes, carpet dyes, fibers, glues, adhesives and sealants, wood preservatives, and several popular building products have all been shown to release them. Formaldehyde, which is released by particleboard, interior grade plywood, foam insulation, carpet, and fabrics, is the most well-known (VOC).

Particulates are thought to be harmful to one's health. Smoke, dust, and pollen are examples of particulates. Lead poisoning from paint chips is a persistent concern especially prevalent in housing complexes and hazardous to youngsters who consume deteriorated paint. In fireplaces, wood stoves, unvented gas or kerosene heaters, and tobacco products, combustion sources release carbon monoxide, nitrogen dioxide, sulfur dioxide, and respirable particulates. “Figure 7”

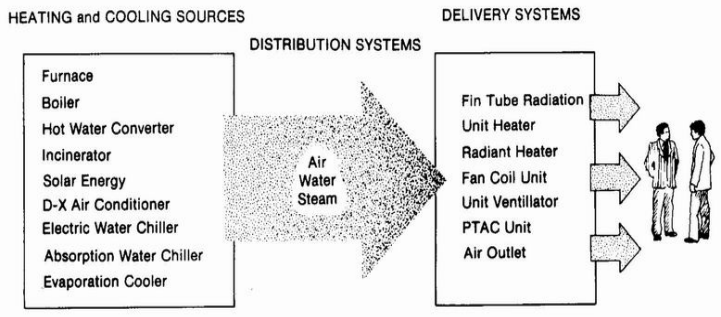


Figure 7. Basic elements of HVAC systems

Radon is a by-product of the decay of Uranium-238, which can be found in soil and bedrock. Radon gases are suctioned into building walls and floor slabs from the soil and rock through fissures and holes.Tobacco smoke contains more than 3,800 compounds, many of which are carcinogenic or mutagens. A substance that causes cancer is referred to as a carcinogen. A mutagen is a chemical that causes mutations in live cells' genes and chromosomes. The results of a survey conducted by (NIOSH) (11) in 2012 based on occupant complaints were documented in the following rankings Table 1. .(Ishteeaque, 2005)

Table 1. Building components Percentages

| | |
|---|---|
| **Inadequate ventilation** | **53%** |
| **Inside contamination** | **15%** |
| **Outside contamination n** | **10%** |
| **Microbiological contamination** | **5%** |
| **Building material and contamination** | **4%** |
| **Unknown.** | **13%** |

The majority of IAQ concerns in the facilities studied were caused by insufficient ventilation. As a result, in 2004, (ASHRAE) suggested a threefold increase in the minimum ventilation standards for commercial office buildings, from 5 to 15 cubic feet per person. As a result of this alteration, previously constructed structures are now deemed poorly ventilated. Plenums for return air might be troublesome. On the other hand, these plenums are unquestionably cost-effective since they eliminate the need for return air ductwork from the occupied space to the air handling units. Even yet, the plenums, which are above-ceiling portions of a building, are never clean or well-maintained.“Figure 8”

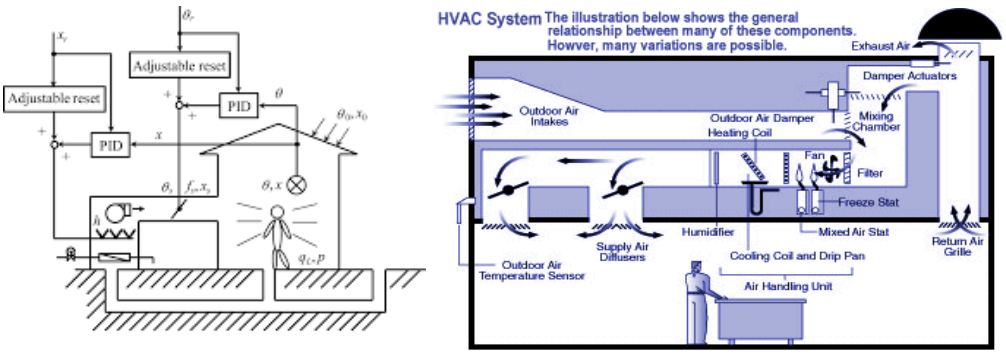


Figure 8. HVAC System, The diagram depicts the overall link between many of these elements.

Plenum spaces, which are located above the ceiling of a building, are seldom clean or properly maintained.
Office equipment, such as wet- and dry-copying machines, computers, and laser printers, emit various VOCs while in use. Therefore, this equipment should be kept isolated from the rest of the building's occupants, preferably in well-ventilated rooms with separate exhaust systems. This characteristic is usually missed in our familiar working environment.

Most Americans spend up to 90% of their time indoors, and many of them spend the majority of their time in an office setting. Because indoor air quality can affect occupants' health, comfort, wellness, and productivity, it is crucial for building managers, renters, and employees. As a result, the necessity for an employee to step outside for a breath of fresh air indicates that the IAQ is poor.

According to evidence, less-frequented public locations are more responsible for indoor air quality problems than heavily-trafficked areas. Structures that contribute to piles of papers act as a storage facility for pollutants. Architects should consider eliminating cubicles, keeping workplaces open, and avoiding confined spaces when designing for accessibility. (Ren and Cao, 2020)

### 4.5 The Following common alterations can be considered as new IAQ problems.

Changes in occupant load: As occupant density rises, heat, humidity, and volatile organic compounds (VOCs). Converting an executive office to a smaller one is expected, resulting in an increase in the number of occupants from one to several, and the air quality degrades as a result “Figure 9”.

Figure 9. change the design for interior office to reduce the number of occupants

Changes in occupant activities: Converting an office area into an aerobics class increases activity levels, which affects metabolic rates and, as a result, the rate at which people produce carbon dioxide. Increased equipment load: Adding copiers and computers increases the amount of heat and VOCs emitted, as well as the risk of airborne particulates. A new dedicated exhaust system may be required due to this alteration, which is commonly ignored.

Changes to the electrical or lighting systems and the addition of special equipment are frequently made to general office space to create a break room, print shop, smoking lounge, copy center, or laboratory “Figure 10”. The pressure relationships between the specific usage zones and the surrounding areas could be harmed. As a result, extra capacity or local exhaust may be required.

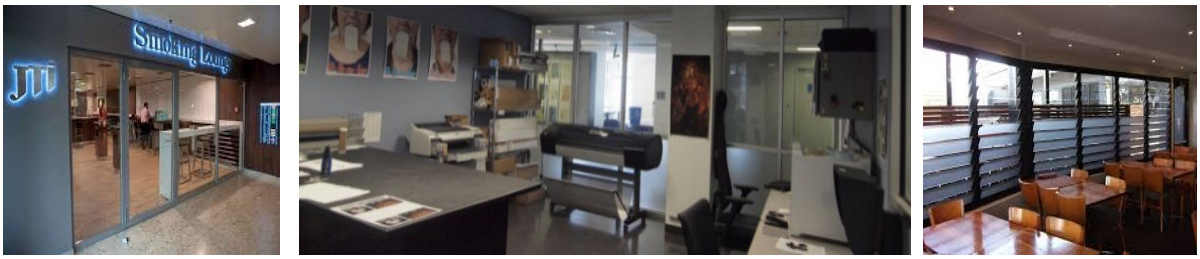


Figure 10. one office changed to a break room

Changes in the interior layout: Rearranging workstations, significantly when partitions must be moved, can change the airflow and air distribution patterns. Unfortunately, after a few years of use, this is a common occurrence in facilities, and the impact of such changes is generally underestimated.

## 5. Results and Discussion

The concept of dwelling was the focus of theoretical inquiry. The effect of window openings on the building's shape: The architect is in charge of the quality of the internal environment as the design team leader “Figure 11”.

Figure 11. Misr University for Science and Technology (MUST) is located in Giza, Egypt, on the 6th of October. The architect is Prof. Dr. Ahmed Abdin.

When creating more modern structures in the future and restoring existing buildings, the architect will require a thorough understanding of the myriad aspects that affect the quality of the indoor environment and excellent working knowledge of them. In addition, when examining the inside environment, the skilled architect must keep in mind that the requirements for various building types differ. For example, the indoor climate in schools, with its varied functions, high occupant load, and frequently poor maintenance, necessitates a different approach than the indoor climate in hospitals, which has numerous pollutant sources. Similarly, there are distinct criteria for households, offices, conference rooms, daycare facilities, cafes, nursing homes, and indoor sports complexes. All facility occupants can contribute to indoor air quality by being aware of indoor air issues: To avoid an unbalanced HVAC system, unblock vents and return air grilles, for example.

Airflow may obstruct furniture, boxes, and other items near supply vents or return air grilles. Maintain proper housekeeping standards by keeping places clean, swiftly disposing of waste, correctly storing food (food attracts bugs), and reporting overly hot, chilly, stuffy, or drafty conditions to management. To keep nonsmokers safe from secondhand smoke, follow the workplace and create smoking regulations. Water spills should be cleaned as soon as possible, office plants should be hydrated and cared for correctly, and water leaks should be notified immediately. Notify your building or facility manager straight away if you suspect an IAQ concern.

While dealing with indoor environmental challenges, have a healthy working relationship with building management. Consider the air circulation, temperature regulation, and pollutant removal capabilities of the HVAC system while placing office furniture, walls, and equipment, for example.

Avoid any procedures or products that have the potential to cause problems. For example, many shared office supplies, such as solvents, adhesives, cleaners, insecticides, and office equipment, such as photographic film development, copiers, printers, and fax machines, can produce pollutants and odors. As a result, adequate and occasionally separate ventilation is required if any of these products are used in the office. (Ishteeaque, 2005)

To assist in resolving indoor air quality issues, keep note of reported health complaints from building users and renters. Appoint a qualified indoor air quality representative who will be accountable for the quality of the indoor environment and will serve as a point of contact for any indoor environmental issues. Educate the building employees by providing opportunities for them to get training. Maintain and operate the building and ventilation system to guarantee good interior air quality. Before you rebuild or renovate, make sure you have clear policies in place for any changes to the area. Investigate options with building management and the architect to decrease occupant exposure to pollutants while ensuring that the air distribution system is not interrupted. Finally, encourage the building's administration to create a proactive interior air quality management program rather than a reactive one. Combining three basic approaches for managing indoor air quality is essential.” Figure 12”

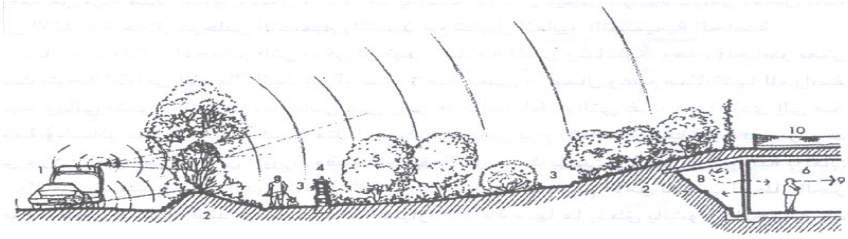

Figure 12. Green built to prevent noise, dust & more from being drawn back into the building.

Manage polluting sources by removing them from the building or separating them from humans by physical barriers, air pressure relationships, or usage schedules. Second, to dilute and remove toxins from the structure, use ventilation. Finally, to eliminate toxins from the air, utilize filtration. “Figure 13”

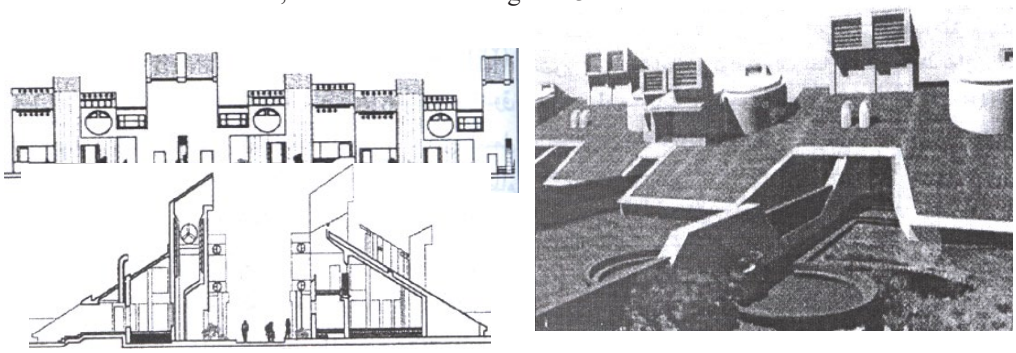

Figure 13. Green architect in TOSHKA

## 6. Conclusion

This study looked into the viability of addressing Sick Building that describes and studies indoor and outdoor air contaminants and analyses of factors and causes affecting the indoor environment in office buildings. As well as the typical changes and problems that occur there; and third, an empirical study of factors and causes affecting the indoor environment in office buildings. The study's findings are provided in a condensed and concentrated style to make them easier to grasp, apply, and serve as the tip of the iceberg of facts and studies that have allowed the researcher to achieve this brevity.

Indoor and outdoor studies in office buildings should be stratified to understand better and maximize the casual interactions between ventilation, indoor air humidity, and temperature. In addition, research is needed to find the ideal temperature range in various climate zones.

Volatile Organic Compounds (VOCs) may be released by building materials, office equipment, and most office equipment (VOCs). These toxins can linger for an extended period, emphasizing the urgency of this potentially dangerous issue. As a result, there was a strong link between the concentration of these chemicals and an increased occurrence of Sick Building Syndrome in other investigations (SBS).

Workplace discontent and high levels of Volatile Organic Compounds (VOCs), primarily due to poor workroom ventilation, were significant causes. However, the majority of the microbial pollutants found were from the body's normal flora. Due to a lack of disinfection, sufficient room cleaning, and internal natural ventilation.

Appropriate ventilation settings for infection control should be investigated, as should maintaining an optimal temperature and air humidity for human health. The mediating components in work performance research have been temperature, ventilation (CO2), and emission sources. The impact of indoor air humidity on job performance and the possible benefits of alternative ventilation scenarios and odor characteristics should be investigated.

When dealing with interior environmental challenges, have a positive working relationship with building management. Consider the air circulation, temperature regulation, and pollutant removal capabilities of the HVAC system while placing office furniture, walls, and equipment, for example.

Control polluting sources by removing them from the building or separating them from humans by physical barriers, air pressure relationships, or usage schedules. Second, to dilute and remove toxins from the structure, use ventilation. Finally, to eliminate toxins from the air, utilize filtration.

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