PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 5 No. 1 (2024) 635-645
https://publisher.uthm.edu.my/periodicals/index.php/peat

# Study on Indoor Air Quality (IAQ) level and Sick Building Syndrome (SBS) at Dato' Muhamad Salleh Perang Office Building

**Mohammad Hamirul Helmie Johari[1], Mohd Fahmi Abdul Rahman[1*]**

[1] *Department of Civil Engineering Technology, Faculty of Engineering Technology, University Tun Hussein Onn Malaysia (UTHM), Pagoh, 84600, MALAYSIA*

*Corresponding Author: mohdfahmi@uthm.edu.my
DOI: https://doi.org/10.30880/peat.2024.05.01.068

**Article Info**

Received: 28 December 2023
Accepted: 18 January 2024
Available online: 15 June 2024

**Keywords**

Indoor Air Quality, Sick building Syndrome, Indoor Health, IAQ Assessmemt, SBS Symptoms

**Abstract**

This study focuses the significant impact of poor Indoor Air Quality (IAQ) on the health and productivity of office building occupants, particularly in relation to Sick Building Syndrome (SBS), emphasizing the need for comprehensive research, adherence to IAQ regulations, and a focus on multiple IAQ parameters to create healthier work environments. This study aimed to assess Indoor Air Quality (IAQ) in the Dato' Muhamad Salleh Perang Building, identifying Sick Building Syndrome (SBS) symptoms, measuring IAQ parameters, and proposing practical solutions for a healthier office environment. The study employs quantitative methods, including IAQ measurements and SBS questionnaires, to thoroughly assess Indoor Air Quality (IAQ) and determine the prevalence of Sick Building Syndrome (SBS) symptoms among occupants in the Dato' Muhamad Salleh Perang Office Building. The findings showed that temperatures and RH were generally within acceptable ranges, air velocity and gaseous pollutants remained within permissible limits in all offices with low frequency of SBS-related symptoms. These symptoms were categorized into General discomfort, Throat and Chest problems, Nose problems, Skin complications, and Eye-related concerns. However, SBS symptoms highlighted the need for continuous monitoring and improvement efforts. Overall, this study contributes to the understanding of IAQ and SBS issues, offering insights that can inform practices for creating comfortable, safe, and productive workspaces. Future research recommendations include exploring additional IAQ parameters, assessing climate change impacts, and incorporating advanced monitoring tools for more accurate results.

## 1. Introduction

The issue of Poor Indoor Air Quality (IAQ) has become a significant concern for general health, particularly in developed nations, with limited studies conducted on the IAQ-health relationship compared to advanced countries. The quality of indoor air is crucial, significantly impacting the health, well-being, and productivity of individuals within office buildings. Poor IAQ, linked to Sick Building Syndrome (SBS) and other health problems, can lead to vague symptoms such as headaches, exhaustion, and inflammation of the eyes, nose, or throat, causing discomfort and reduced productivity for affected occupants [1]. To address IAQ concerns, Malaysia implemented the Malaysian Industrial Code of Practice on Indoor Air Quality (MICOP IAQ), specifying parameters and allowable limits. The publication of MICOP IAQ has improved occupants' understanding of IAQ and emphasized the necessity to maintain good air quality through elements like sufficient air conditioning, managing airborne pollutants, and maintaining a comfortable temperature and relative humidity in buildings [2]. SBS, a widely recognized environmental health issue caused by inadequate IAQ, manifests in symptoms such as eye, nose, throat, and skin irritation, respiratory problems, headaches, dizziness, and confusion. Up to 1.2 million commercial buildings are estimated to exhibit SBS symptoms, emphasizing the prevalence and significance of the issue [3].

This study is conducted with the intention of evaluating IAQ parameters and analyzing worker health in relation to SBS symptoms in office-style environments. SBS, characterized by discomfort and serious health impacts on office workers, has become a daily occurrence in office buildings globally. The research underscores the need to consider the relationships among various IAQ parameters and their impact on building occupants [4]. Escalating concerns about IAQ within office buildings and its potential influence on SBS symptoms necessitate systematic investigations to assess IAQ levels and the prevalence of SBS symptoms among building occupants [5]. Increased levels of indoor pollutants can result from factors such as building occupant density and various activities, impacting both the organization and its occupants. Acknowledging the limited research on the relationship between IAQ and health in developing nations, the study emphasizes the significance of IAQ in creating healthier and more effective indoor environments. Sick Building Syndrome (SBS) is highlighted as a consequence of poor IAQ, leading to vague symptoms such as headaches and irritation among occupants [6].

Therefore, the objective of this study is to measure key IAQ parameters, including temperature, humidity, air velocity, and concentrations of carbon dioxide ($CO_2$) and carbon monoxide (CO), identifying symptoms related to Sick Building Syndrome (SBS) commonly experienced by occupants and provide actionable recommendations for enhancing IAQ and mitigating SBS symptoms. The study's significance lies in its potential to provide valuable insights into current IAQ and SBS in Malaysian office buildings, serving as a catalyst for increased awareness among stakeholders and policymakers.

## 2. Literature Review

### 2.1 Indoor Air Quality and Sick Building Syndrome

The issue of Indoor Air Quality (IAQ) has gained prominence globally, particularly in developed nations, where the impact of poor IAQ on health and well-being is extensively studied. The quality of indoor air, encompassing factors like temperature, humidity, ventilation, and the presence of pollutants, significantly affects the health, happiness, and productivity of individuals in office buildings. Sick Building Syndrome (SBS) is a well-known consequence of poor IAQ, leading to vague symptoms such as headaches, exhaustion, and irritation of eyes, nose, or throat among office occupants [7]. The Department of Occupational Safety and Health Malaysia notes that complaints about IAQ-related discomfort may lead to a condition known as Sick Building Syndrome (SBS), characterized by various symptoms without a specific diagnosis [2]. IAQ issues arise from a complex interplay of construction materials, activities, climate, and occupants, with biological, chemical, particle, and aerosol pollutants being key contributors. Given that people spend a significant portion of their time indoors, addressing IAQ in offices and educational institutions is vital for both comfort and the health of occupants [8].

Research on IAQ and its relationship to SBS is crucial for creating healthier indoor environments, and the symptoms associated with SBS, including headaches and lightheadedness, are commonly experienced by affected occupants. Malaysia has established regulations like MICOP IAQ, but the attention given to IAQ is still less compared to developed nations, possibly due to a lack of comprehensive studies [9]. IAQ parameters encompass various factors crucial for assessing and ensuring air quality in enclosed spaces, influencing the comfort, health, and well-being of occupants. Gaseous pollutant parameters, including carbon dioxide ($CO_2$) and carbon monoxide (CO), play a significant role. High levels of $CO_2$ indicate insufficient ventilation, while CO levels, though not inherently harmful, can impact occupant comfort. Physical environment parameters like temperature, relative humidity, and air velocity further contribute to IAQ [10]. SBS, a prevalent issue globally, particularly in office buildings, is linked to IAQ, and its symptoms, such as headaches and respiratory problems, are prevalent among office workers. Psychosocial factors, building design, and maintenance also influence SBS [11].

### 2.2 Prevalence of SBS

Prevalence of SBS symptoms is influenced by factors like IAQ, with poor ventilation, pollutants, and contaminants contributing to the development of symptoms. The impacts of IAQ and SBS on health and productivity are significant, causing respiratory problems, discomfort, and potential long-term health effects [12]. Standard guidelines, including those from DOSH in Malaysia and international organizations like WHO, OSHA, and ASHRAE, establish acceptable ranges for IAQ parameters. It is crucial to proactively address IAQ and

SBS through measures such as ventilation, air filtration, and maintenance to ensure the well-being of building occupants [13].

Gaseous indoor air pollutants such as $CO_2$ and CO have been proven in other studies to be major indoor air contaminants due to the lack of ventilation. SBS can be caused by insufficient ventilation per person and increased levels of indoor chemical pollution [5]. Indoor $CO_2$ concentrations could be used as a surrogate for occupant-generated pollution and indoor ventilation parameters [14]. However, few studies have been conducted on the assessment of IAQ and SBS among office workers, resulting in difficulty in IAQ monitoring and management. Identifying and controlling factors related to SBS is crucial for improving worker health and efficiency.

The indoor environmental factors of temperature, relative humidity, air velocity, carbon dioxide ($CO_2$), and carbon monoxide (CO) play a crucial role in determining Indoor Air Quality (IAQ) and influencing the occurrence of symptoms associated with Sick Building Syndrome (SBS) [14]. Studies emphasize that suboptimal indoor conditions may lead to discomfort and health issues among building occupants. Incorrect temperature regulation, whether too high or too low, has been linked to skin irritation and dryness [14]. Notably, inadequate ventilation and elevated $CO_2$ levels, prevalent in poorly ventilated environments, contribute to key SBS symptoms like headaches and difficulty concentrating. This underscores the importance of maintaining ideal indoor environmental parameters to ensure occupant well-being and prevent the onset of SBS symptoms [15].

## 2.3 Standard and Guidelines for Indoor Air Quality

In Malaysia, the Department of Safety and Health (DOSH) is in charge of regulating the legal fulfilment of the law. The Industry Code of Practice on IAQ, which was approved by the Minister on 30 August 2010, was used by DOSH to establish the practice of IAQ assessment. The goal of the Industry Code of Practice on IAQ is to safeguard workers and building occupants from inadequate IAQ, which could have a negative impact on their health and welfare [2]. Table 1 below shows the Malaysian Industrial Code of Practice on Indoor Air Quality (MICOP IAQ) sets parameters and limits for IAQ, emphasizing the need to maintain acceptable standards.

**Table 1** *Standard and Guidelines on IAQ in Malaysia*

| Indoor Air Quality Parameters | Acceptable Range |
|---|---|
| Temperature | 23 - 26 °C |
| Relative Humidity | 4 0- 70 % |
| Air Movement | 0.15 - 0.50 m/s |
| Carbon Dioxide | 1000 ppm |
| Carbon Monoxide | 10 ppm |

## 3. Methodology

The study uses a descriptive approach to explore Indoor Air Quality (IAQ) and Sick Building Syndrome (SBS) prevalence at Dato' Muhamad Salleh Perang Office Building. Office occupants are chosen through convenience sampling. IAQ, measured with calibrated sensors, includes CO2, CO, humidity, air velocity and temperature. Participants also fill out a standard questionnaire for SBS symptoms. Analysis involves descriptive stats for IAQ and frequency stats for SBS symptoms. The study timeline follows systematic procedures for IAQ assessment, SBS questionnaire distribution, and analysis to provide a clear picture of IAQ and SBS at the office building.

## 3.1 Study Design

To determine the relationship between the IAQ and other variables in order, cross-sectional research will be conducted of 3 different locations of selected offices in Dato' Muhamad Salleh Perang Building and the prevalence of SBS symptoms. The selected offices are the Perbadanan Taman Negara Johor, Pejabat Tanah dan Galian Negeri Johor dan Jabatan Perancang Bandar dan Desa Negeri Johor. Study population consisting of the number of employees in the specified office with 49 people, 58 people and 65 people working at the Perbadanan Taman Negara Johor, Pejabat Tanah dan Galian Negeri Johor dan Jabatan Perancang Bandar dan Desa Negeri Johor, respectively. The research area was chosen by office department to measure the exposure level from indoor air pollutants. In this research, the surrounding indoor air was observed both in real-time as well as over an extended period.

Following that, this method will be used to determine the specific points of data collecting. Depending on the floor size of each of the 3 offices in the Dato' Muhamad Salleh Perang Building, 3 sampling point will be used for the collection of data samples for this study. To measure the level of air quality within the office in the worked area, measurements were taken at three separate points. Offices 1 and 3 would also use the same procedure as shown in Fig. 1. All offices in the Dato' Muhamad Salleh Perang Building operate from 8 a.m. to 5 p.m., with a total of 49 employees for Office 1, 58 for Office 2, and 65 for Office 3.

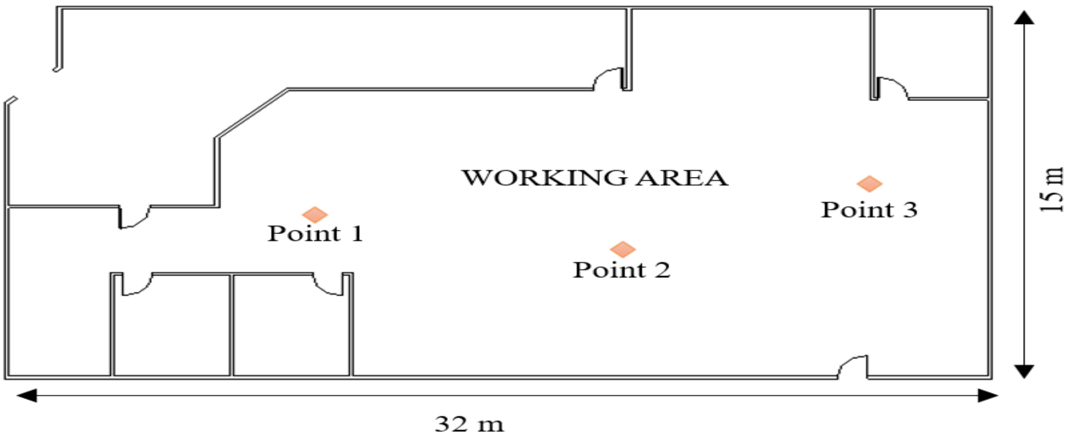


**Fig1.** *Layout Plan for Sample Points for IAQ Measurement (Office 2)*

## 3.2 Indoor Air Quality Assessment

The study evaluates the indoor air quality (IAQ) in three selected offices within a building, employing the Industrial Code of Practice (ICOP) from 2010 as the guideline. Air contaminants in the building are assessed using air monitoring equipment to measure IAQ parameters, identify contaminant sources, and model their dispersion. The IAQ evaluation utilizes a 4 in 1 Environmental Meter Kit and Hotwire Thermo-Anemometer for monitoring air velocity, temperature, and relative humidity, while the Indoor Air Quality Meter tests for carbon dioxide ($CO_2$) and carbon monoxide (CO) levels. Equipment sensitivity is ensured through validation to prevent errors during data collection. The study compares the evaluation results with acceptable limits specified in the ICOP on Indoor Air Quality, outlining ranges for physical environment parameters such as air temperature, relative humidity, and air movement, as well as gaseous pollutant parameters including carbon monoxide (CO) and carbon dioxide ($CO_2$) concentrations [2]. Sampling points are determined based on practical considerations, taking into account the working environment and office operation patterns during morning and evening time slots. The study follows the recommendations of the MICOP IAQ 2010 guidelines for determining the minimum number of sampling points, ensuring comprehensive coverage for different ranges of total floor area [2].

## 3.3 Questionnaire Survey

The study employed a questionnaire survey to assess sociodemographic and psychological aspects, utilizing the Malaysian Industry Code of Practice (ICOP) on Indoor Air Quality to formulate questions related to Sick Building Syndrome (SBS) symptoms. Binary data were used to categorize responses, considering an office worker experiencing at least one SBS symptom weekly as indicative of SBS. The sample size was determined using Krejcie and Morgan's table, justifying the distribution of over 50 questionnaires in each office, aligned with Roscoe's guidelines on adequate sample size [16]. The questionnaire encompassed demographic data (Section A), workplace conditions (Section B), and SBS symptoms experienced in the offices (Section C). Table 2 below shows a Likert scale with five response options that gauged the frequency of SBS symptoms and related conditions, allowing for a nuanced understanding of occupants' experiences. The study also introduced a classification system based on average mean scores to interpret the Likert scale responses, offering a structured approach to evaluating workplace conditions and SBS symptoms [17]. The study introduced a classification system to make sense of Likert scale responses, providing a structured way to assess workplace conditions and Sick Building Syndrome (SBS) symptoms. The Likert scale, which gauges respondents' agreement or disagreement with statements, was applied to evaluate the frequency and intensity of various factors. The classification system categorizes the average mean scores into groups like "Not Often" or "Moderately," simplifying the interpretation of survey data. This approach helps in understanding the impact of workplace conditions on occupants and allows for comparisons between different offices within the Dato' Muhamad Salleh Perang Office Building. In essence, the classification system adds clarity to the analysis, making it easier to comprehend and compare the reported experiences of occupants.

**Table 2** *Likert Scale for Classification of the Mean Index*

| Scale | Mean scale interval |
|---|---|
| Never | 1.00 – 1.50 |
| Not Often | 1.50 – 2.50 |
| Moderately | 2.50 – 3.50 |
| Often | 3.50 – 4.50 |
| Very Often | 4.50 – 5.00 |

## 4. Result and Discussion

The study investigates Indoor Air Quality (IAQ) and Sick Building Syndrome (SBS) at Dato' Muhamad Salleh Perang Office Building. Results of IAQ measurements, including temperature, humidity, air velocity, and gaseous pollutants, align with acceptable standards. The respondent characteristics reveal demographic information and workplace details. The prevalence of SBS symptoms, categorized by discomfort, respiratory issues, and skin and eye-related problems, varies among offices. The study also explores the effects of SBS, indicating a minor impact on work absences. These findings underscore the need for comprehensive strategies to address IAQ and mitigate SBS symptoms in the specific office environment.

### 4.1 Indoor Air Quality Measurements

The result of IAQ parameters measurements indicated in Table 3. The monitored parameters, including temperature, relative humidity (RH), air velocity, carbon dioxide ($CO_2$), and carbon monoxide (CO), were compared to the acceptable ranges outlined in the Industry Code of Practice on Indoor Air Quality (MICOP IAQ 2010). The results indicate that the temperature in Offices 1 (23.9 °C) and 2 (24.2 °C) fell within the acceptable range, while Office 3 (21.6 °C) was below the specified limit. RH values for all offices were within the permissible range of 40-70%, meeting IAQ standards. Air velocity in all offices conformed to the acceptable range of 0.15 to 0.50 m/s. Notably, gaseous pollutants, $CO_2$, and CO were well below the specified limits, demonstrating good indoor air quality. However, it does not prove that these office buildings are safe from SBS.

**Table 3** *IAQ Measurements in Office Buildings*

| Parameters | Office 1 | Office 2 | Office 3 | Mean | Standard Deviation | Acceptable Range (MICOP IAQ 2010) |
|---|---|---|---|---|---|---|
| Temperature (°C) | 23.9 (22.9 – 24.8) | 24.2 (23.5 – 25.0) | 21.6 (21.0 – 22.4) | 23.2 | 1.4 | 23 - 26 |
| RH (%) | 62.5 (56.2 – 67.2) | 63.0 (59.7 - 65.8) | 68.2 (64.4 – 70.5) | 64.6 | 3.2 | 40 - 70 |
| Air Velocity (m/s) | 0.16 (0.12 – 0.23) | 0.20 (0.12 – 0.33) | 0.16 (0.12 – 0.24) | 0.17 | 0.023 | 0.15 - 0.50 |
| Carbon Dioxide (ppm) | 706 (646 – 741) | 677 (624 – 704) | 507 (453 – 545) | 630 | 108 | 1000 |
| Carbon Monoxide (ppm) | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 10 |

### 4.2 Respondent Characteristics

The study conducted a questionnaire survey among employees from three offices in the Dato' Muhamad Salleh Perang Building to assess their overall well-being and symptoms related to Indoor Air Quality (IAQ) issues. A total of 142 questionnaires were collected, with 42 from Office 1, 49 from Office 2, and 51 from Office 3.

Table 4 below shows the survey included demographic information in Section A, revealing insights into the characteristics of respondents. Office 3 had the highest number of respondents (51 individuals), with 59% male and 41% female, followed by Office 2 (49 individuals) with 39% male and 61% female, and Office 1 (42 individuals) with 48% male and 52% female. The majority of respondents in Offices 1 and 3 were aged between

25-35 years, while Office 2 had a higher percentage in the 35-45 years age range. The study found that over 80% of respondents across all offices were non-smokers.

**Table 4** *Characteristics of respondents*

| Variables | | | Office 1 | Office 2 | Office 3 |
|---|---|---|---|---|---|
| Gender | Male | f (%) | 20 (48%) | 19 (39%) | 21 (41%) |
| | Female | f (%) | 22 (52%) | 30 (61%) | 30 (59%) |
| | Total | f (%) | 42 (100%) | 49 (100%) | 51 (100%) |
| Age | <25yrs | f (%) | 4 (10%) | 1 (2%) | 2 (4%) |
| | 25-35yrs | f (%) | 21 (50%) | 20 (41%) | 22 43%) |
| | 35-45yrs | f (%) | 15 (36%) | 23 (47%) | 17 (33%) |
| | >45yrs | f (%) | 2 (5%) | 5 (10%) | 10 (20%) |
| Do You Smoke? | Yes | f (%) | 8 (19%) | 6 (12%) | 8 (16%) |
| | No | f (%) | 34 (81%) | 43 (88%) | 43 (84%) |

## 4.3 Nature of Occupation Respondents

Table 5 below show s data on the nature of occupation for respondents in the Dato' Muhamad Salleh Perang's Building, focusing on factors such as the duration of employment, daily hours spent at the workstation, and the type of workstation. In terms of the duration of employment, a higher percentage of employees in Office 1 reported 1-5 years of employment (48%), while Offices 2 and 3 had a smaller percentage in the same category. However, Offices 2 and 3 had a higher percentage of workers with more than 15 years of employment, indicating a more experienced workforce. The average number of years worked varied within each office, demonstrating the diversity in employment distribution.

Regarding daily hours spent at the workstation, the majority of employees across all offices spent 4-8 hours a day, with small standard deviations indicating a regular pattern of working hours. In terms of workstation type, an open concept was predominant in all offices (86%, 86%, and 92% for Offices 1, 2, and 3, respectively), fostering a cooperative and open working atmosphere. However, a notable percentage of employees in Office 1 (14%) worked in enclosed rooms, possibly due to differences in workspace design or job nature. The presence of a central unit providing air conditioning to every workstation in all three offices ensures consistency in the surrounding environment.

**Table 5** *Nature of Occupation of Respondents*

| Variables | | | Office 1 | Office 2 | Office 3 |
|---|---|---|---|---|---|
| How long you have been at your present place of work? | 1-5yrs | f (%) | 20 (48%) | 16 (33%) | 22 (43%) |
| | 5-10yrs | f (%) | 5 (12%) | 8 (16%) | 5 (10%) |
| | 10-15yrs | f (%) | 9 (21%) | 12 (24%) | 8 (16%) |
| | 15-20yrs | f (%) | 3 7(%) | 9 (18%) | 12 (24%) |
| | >20yrs | f (%) | 5 (12%) | 4 (8%) | 4 (8%) |
| No. of hours spent per day at workstation? | 1-4hrs | f (%) | 1 (2%) | 1 (2%) | 1 (2%) |
| | 4-8hrs | f (%) | 24 (57%) | 23 (47%) | 30 (59%) |
| | 8-12hrs | f (%) | 16 (38%) | 25 (51%) | 20 (39%) |
| | >12hrs | f (%) | 1 (2%) | 0 (0%) | 0 (0%) |
| Type of Workstation | Enclosed Room | f (%) | 6 (14%) | 7 (14%) | 4 (8%) |

| | | | | | |
|---|---|---|---|---|---|
| | Open Concept | f (%) | 36 (86%) | 42 (86%) | 47 (92%) |
| Area Air-Conditioned | Central Unit | f (%) | 42 (100%) | 49 (100%) | 51 (100%) |

## 4.4 The Condition of the Workplace

The workplace's indoor air quality (IAQ) and the occurrence of Sick Building Syndrome (SBS) played a crucial role in influencing the well-being and productivity of employees. The data revealed that all three offices in the Dato' Muhamad Salleh Perang's Building employed a centralized air conditioning system, ensuring a uniform approach to environmental control. While this centralized approach aimed to maintain consistent conditions, it became imperative to assess its effectiveness in enhancing IAQ and mitigating SBS symptoms. The evaluation of this system's performance would provide valuable insights into the overall indoor environmental conditions, shedding light on potential areas for improvement to ensure a healthier and more conducive workplace.

Table 6 below shows the mean values for various environmental factors affecting indoor air quality (IAQ) were assessed through a questionnaire distributed among employees in three offices (Office 1, Office 2, and Office 3) within the Dato' Muhamad Salleh Perang's Building. The mean values for each factor provide insights into the perceived IAQ conditions. Overall, the respondents in Office 1 reported mean values suggesting that they experience these factors "Not Often" with an average mean of 2.24. In Office 2, the mean values were slightly higher, indicating a "Moderately" frequency of occurrence, with an average mean of 2.51. Office 3 respondents reported mean values that suggest conditions are "Not Often" with an average mean of 2.35. These mean values provide a qualitative understanding of the employees' experiences with environmental factors related to IAQ, helping to identify areas for potential improvement in the indoor environment.

**Table 6** *Condition of the Workplace in Office Buildings*

| Variables | Office 1 (42) | Office 2 (49) | Office 3 (51) |
|---|---|---|---|
| Draught | 2.02 | 2.31 | 2.10 |
| Room temperature too high | 2.52 | 2.80 | 2.90 |
| Varying room temperature | 2.55 | 2.82 | 2.63 |
| Room temperature too low | 2.55 | 2.76 | 2.47 |
| Stuffy "bad" air | 2.10 | 2.47 | 2.24 |
| Dry air | 2.07 | 2.37 | 2.29 |
| Unpleasant odour | 2.14 | 2.31 | 2.12 |
| Passive smoking | 2.07 | 2.31 | 2.04 |
| Dust and dirt | 2.10 | 2.45 | 2.37 |
| Total | 2.24 (Not Often) | 2.51 (Moderately) | 2.35 (Not Often) |

## 4.5 Prevalence of Symptoms of Sick Building Syndrome (SBS)

Table 7 below shows the survey of symptoms related to Sick Building Syndrome (SBS) across three different offices within the Dato' Muhamad Salleh Perang's Building revealed notable variations in reported health issues among employees. The symptoms were categorized into general discomfort, throat and chest-related problems, nasal issues, skin conditions, and eye-related discomfort.

In comparing the prevalence of Sick Building Syndrome (SBS) symptoms across the three offices within the Dato' Muhamad Salleh Perang's Building, distinct patterns and variations emerge. Office 1 generally reported lower mean values for symptoms in all categories compared to Offices 2 and 3. This suggests that employees in Office 1 experienced, on average, milder SBS symptoms. Notably, Office 1 displayed lower mean values for general discomfort symptoms such as headache and dizziness. In contrast, Office 2 reported slightly higher mean values for these general discomfort symptoms, indicating a comparatively higher frequency of occurrence.

For throat and chest-related symptoms, such as sore throat/cough, Office 2 had the highest mean values, reflecting a higher reported frequency of these symptoms among its employees. Office 3, on the other hand, showed slightly lower mean values for throat and chest symptoms compared to Office 2 but higher than those in Office 1. Nasal symptoms, including irritated or running nose, displayed consistent mean values across all offices, with Office 2 reporting the highest values.

Skin-related symptoms demonstrated a similar pattern, with Office 2 having higher mean values compared to Offices 1 and 3. Eyes-related discomfort also showed variations, with Office 2 reporting higher mean values for itching/irritated eyes, dry eyes, watering eyes, and eye strain.

**Table 7** *Prevalence of SBS symptoms of three Offices*

| Symptoms | Office 1 (42) | Office 2 (49) | Office 3 (51) |
|---|---|---|---|
| **GENERAL** | **1.86 (Not Often)** | **2.09 (Not Often)** | **2.03 (Not Often)** |
| Headache | 1.90 | 2.24 | 2.14 |
| Feeling heavy-headed | 1.86 | 2.08 | 1.96 |
| Fatigue/ lethargy | 1.86 | 1.96 | 1.96 |
| Drowsiness | 1.79 | 2.04 | 2.02 |
| Dizziness | 1.88 | 2.14 | 2.06 |
| **THROAT AND CHEST** | **1.66 (Not Often)** | **1.9 (Not Often)** | **1.84 (Not Often)** |
| Sore throat/cough | 2.10 | 2.33 | 2.29 |
| Hoarse, dry throat | 1.67 | 1.96 | 1.90 |
| Irritated throat | 1.55 | 1.90 | 1.84 |
| Breathing difficulty | 1.45 | 1.69 | 1.55 |
| Chest tightness | 1.52 | 1.80 | 1.63 |
| **NOSE** | **1.83 (Not Often)** | **2.24 (Not Often)** | **2.04 (Not Often)** |
| Irritated, running nose | 1.83 | 2.24 | 2.02 |
| Blocked or stuffy nose | 1.83 | 2.24 | 2.06 |
| **SKIN** | **1.57 (Not Often)** | **2.01 (Not Often)** | **1.80 (Not Often)** |
| Skin rash/ itchiness | 1.60 | 2.04 | 1.86 |
| Itching face without rash | 1.67 | 2.10 | 1.80 |
| Scaling/itching scalp or ears | 1.45 | 1.90 | 1.73 |
| **EYES** | **1.60 (Not Often)** | **1.85 (Not Often)** | **1.70 (Not Often)** |
| Itching/irritated eyes | 1.60 | 1.86 | 1.61 |
| Dry eyes | 1.60 | 1.88 | 1.78 |
| Watering eyes | 1.67 | 1.88 | 1.71 |
| Eyes strain | 1.52 | 1.80 | 1.71 |

These variations in SBS symptoms among the offices underscore the importance of considering specific workplace conditions, environmental factors, and perhaps individual differences that contribute to employees' health experiences. Factors such as ventilation, air quality, and ergonomic considerations may play a role in the observed differences [18]. A more detailed investigation into the workplace environments of each office and individual susceptibility factors could provide valuable insights into mitigating SBS symptoms and improving overall indoor air quality.

The analysis of SBS symptoms demonstrated a prevalence of generic discomfort, with headaches, fatigue, and nasal issues being commonly reported across offices. Notably, the most prevalent SBS symptom reported was an itchy, stuffy, or runny nose, aligning with findings from prior research [19]. The research revealed a lack of significant differences in SBS symptoms among the offices, emphasizing the uniformity of discomfort experienced by occupants throughout the building. The consistency in reported symptoms underscores the need for comprehensive strategies to address indoor air quality issues, including targeted measures to reduce pollutant sources and improve ventilation systems [20].

## 4.6 The Effects of SBS Experienced by Respondents

Table 8 below shows the study survey data on the effects of Sick Building Syndrome (SBS) experienced by respondents in three different offices within the Dato' Muhamad Salleh Perang's Building. The average number of days absent from work due to symptoms was relatively low across all offices, suggesting a minor impact on work absences. Respondents reported experiencing symptoms most often in the evening, with variations possibly linked to differences in work activities, ventilation systems, or office environments. The duration of symptom relief upon leaving the premises varied, with respondents in Offices 1 and 2 feeling relieved, while respondents in Office 3 found no noticeable relief. These discrepancies underscore the multifaceted nature of SBS, where factors like indoor air quality, ventilation, and individual vulnerability play pivotal roles.

**Table 8** *The Effects of SBS Experienced by Respondents*

| Questions | Offices | N | Mean | Std. Deviation | Classification |
|---|---|---|---|---|---|
| No. of days in the past one (1) month that you had to take off work because of these symptoms. | Office 1 | 42 | 1.14 | 0.35 | 1 Day |
| | Office 2 | 49 | 1.14 | 0.35 | 1 Day |
| | Office 3 | 51 | 1.20 | 0.40 | 1 Day |
| When do these symptoms occur? | Office 1 | 42 | 1.71 | 0.60 | Evening |
| | Office 2 | 49 | 1.76 | 0.72 | Evening |
| | Office 3 | 51 | 2.04 | 0.85 | Evening |
| When do you experience relief from these symptoms? | Office 1 | 42 | 2.07 | 0.75 | After leave building |
| | Office 2 | 49 | 1.96 | 0.82 | After leave building |
| | Office 3 | 51 | 2.37 | 0.77 | No Noticeable |

## 4.7 Recommendations for Improving IAQ And Preventing SBS Symptoms

To enhance Indoor Air Quality (IAQ) and mitigate Sick Building Syndrome (SBS) in Malaysian buildings, a multifaceted approach encompassing various crucial factors is essential. The management of temperature, relative humidity, air velocity, carbon dioxide ($CO_2$), and carbon monoxide (CO) emerges as critical components in ensuring occupant comfort and well-being [21]. Optimal temperature and humidity levels should be maintained, facilitated by efficient air conditioning systems and proper ventilation strategies. Air velocity control through well-designed ventilation systems is equally vital to avoid discomfort. Monitoring and regulating CO2 levels, employing indoor plants, and ensuring the safety of gas appliances are integral measures for IAQ improvement [22]. Additionally, effective source management, including minimizing VOCs and adopting green construction strategies, contributes to reducing indoor pollutants [23].

In preventing SBS, a comprehensive strategy should address factors influencing IAQ, including pollution control, ventilation, building design, and occupant awareness. Improving ventilation systems is crucial for reducing pollutant concentrations linked to respiratory symptoms, and the use of modern technologies, such as energy recovery ventilation, enhances efficiency [24]. Controlling indoor humidity levels is essential for minimizing skin and eye problems, with the implementation of humidity-regulating equipment and proper moisture control. Ergonomic designs, comfortable workplace equipment, and optimal lighting conditions contribute to reducing symptoms like tiredness and headaches [25]. Occupant awareness and education, promoting appropriate office behaviour and reporting IAQ concerns promptly, are vital aspects of SBS prevention [26].

## 5. Conclusion

In conclusion, this study successfully achieved its objectives by identifying the symptoms of Sick Building Syndrome (SBS) prevalent among occupants, measuring key Indoor Air Quality (IAQ) parameters within the Dato' Muhamad Salleh Perang Building, and providing practical recommendations for IAQ improvement and SBS prevention. The IAQ parameter measurements provided crucial insights into the working conditions and environmental factors influencing occupant well-being. The study's practical recommendations, encompassing ventilation improvement, pollution management, and employee education, serve as a valuable guide for building managers and policymakers to enhance indoor environments and mitigate the risk of SBS.

While the study concludes that the occupants' workspaces in the Dato' Muhamad Salleh Perang Building are generally safe for long-term occupancy, it highlights the need for continuous monitoring and adherence to recommended IAQ parameters. The study concludes by emphasizing the significance of ongoing research and dedication to IAQ measures in creating sustainable, healthier, and more productive indoor environments. Additionally, the conclusion provides recommendations for future research, including the exploration of additional IAQ variables, the assessment of climate change impacts on SBS and IAQ, and the utilization of advanced IAQ monitoring tools for more precise analysis. Overall, this study contributes to the understanding of IAQ and SBS issues, offering insights that can inform practices for creating comfortable, safe, and productive workspaces.

## Acknowledgement

The author would like to thank the Department of Civil Engineering Technology, the Faculty of Engineering Technology (FTK) of Universiti Tun Hussein Onn Malaysia (UTHM), and the Dato' Muhamad Salleh Perang Building, Iskandar Puteri, Johor, the management and staff and all the respondents who participated in this research and provided support in the research project.

## References

[1] Wargocki, P., Wyon, D. P., Baik, Y. K., Clausen, G., & Fanger, P. O. (2004). Perceived air quality, sick building syndrome (SBS) symptoms, and productivity in an office with two different pollution loads. Indoor Air, 14(1), 7-16.
[2] DOSH. (2010). Industry code of practice on indoor air quality. Minist. Hum. Resour. Dep. Occup. Saf. Heal., 1-50.
[3] Arzahar, A. A. B., & majid, Z. B. A. (2021). Factor that Affects Sick Building Syndrome in The Building. http://repository.psa.edu.my/handle/123456789/3234
[4] Mendell, M. J., Fisk, W. J., Kreiss, K., Levin, H., Alexander, D., Cain, W. S., ... & Milton, D. K. (2016). Improving the health of workers in indoor environments: Priority research needs for a national occupational research agenda. American Journal of Public Health, 106(6), 1010-1017.
[5] Zainal, Z. A., Hashim, Z., Jalaludin, J., Lee, L. F., & Hashim, J. H. (2019). Sick building syndrome among office workers in relation to office environment and indoor air pollutant at an academic institution, Malaysia. Malays. J. Med. Health Sci, 15, 126-134
[6] Nur Fadilah, R., & Juliana, J. (2012). Indoor air quality (IAQ) and sick building syndrome (SBS) among office workers in new and old buildings in universities Putra Malaysia, Serdang. Health and the Environmental Journal, 3(2), 98–109.
[7] Magnavita, N. (2013). Work-related symptoms in indoor environments: A puzzling problem for the occupational physician. Occupational and Environmental Health 88(2), 185- 196.
[8] Tebbe, H. M. (2017). Evaluation of Indoor Air Quality in Four Nursing Home Facilities in Northwest Ohio [Master's thesis, University of Toledo]. Ohio LINK Electronic Theses and Dissertations Center. http://rave.ohiolink.edu/etdc/view?acc_num=toledo1493411129998087
[9] Nag, P. K. (2018). Sick building syndrome and other building-related illnesses. In Office Buildings: Health, Safety and Environment (pp. 53-103). Singapore: Springer Singapore.
[10] Persily, A. K. (2015). Indoor air quality in sustainable, energy-efficient buildings. HVAC&R Research, 21(1), 122-131. doi:10.1080/10789669.2014.971309
[11] Mendell, M. J. (2017). Indoor residential chemical emissions as risk factors for respiratory and allergic effects in children: A review. Indoor Air, 27(2), 277-287. doi:10.1111/ina.12301
[12] Fahad Alomirah, H., & Moda, H. M. (2020). Assessment of Indoor Air Quality and Users Perception of a Renovated Office Building in Manchester. International Journal of Environmental Research and Public Health, 17(6), 1972. https://doi.org/10.3390/ijerph17061972

[13] World Health Organization (WHO). (2010). WHO guidelines for indoor air quality: selected pollutants. Retrieved from https://www.who.int/airpollution/guidelines/indoor-air-quality-pollutants/en/

[14] Tran, V. V., Park, D., & Lee, Y. C. (2020). Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality. International journal of environmental research and public health, 17(8), 2927. https://doi.org/10.3390/ijerph17082927

[15] Persily, A. (2015). Challenges in developing ventilation and indoor air quality standards: The story of ASHRAE Standard 62. Building and Environment, 91, 61-69.

[16] Scheepers, P. T. J., Van Wel, L., Beckmann, G., & Anzion, R. B. M. (2017). Chemical Characterization of the Indoor Air Quality of a University Hospital: Penetration of Outdoor Air Pollutants. International journal of environmental research and public health, 14(5), 497. https://doi.org/10.3390/ijerph14050497

[17] Bukhari, Syed Abdul. (2021). Sample Size Determination Using Krejcie and Morgan Table. 10.13140/RG.2.2.11445.19687

[18] Sullivan, G. M., & Artino, A. R., Jr (2013). Analyzing and interpreting data from likert-type scales. Journal of graduate medical education, 5(4), 541–542. https://doi.org/10.4300/JGME-5-4-18

[19] Mendell, M. J., & Heath, G. A. (2005). Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. Indoor Air, 15(1), 27-52. doi:10.1111/j.1600-0668.2004.00320.

[20] Zuliza, M. S., Irniza, R. & Emilia, Z. A. (2016). Indoor air quality and prevalence of sick building syndrome among university laboratory workers. International Journal of Sciences: Basic and Applied Research (IJSBAR), 29(2), 130-140.

[21] Nur Fadilah, R., & Juliana, J. (2012). Indoor air quality (IAQ) and sick building syndrome (SBS) among office workers in new and old buildings in universities Putra Malaysia, Serdang. Health and the Environmental Journal, 3(2), 98–109.

[22] Zaini, M. A. A., Sapian, R., & Zaki, S. A. (2021). Sustainable Building Design and Indoor Environmental Quality in Malaysia. In Green Building for a Sustainable Environment (pp. 97-115). Springer.

[23] Zaidi, M. A. M., Zaini, M. A. A., Ahmad, M. N., Abdullah, S. M., & Supian, N. (2019). An overview of indoor air quality in Malaysia. Procedia Environmental Sciences, 17, 18-28.

[24] Kadir, W. M. A. W. A., Bin Zaini, M. A. A., Razak, A. A., & Othman, M. H. (2017). A review of volatile organic compounds in the indoor environment. Indoor Environmental Quality, 2(1), 13-25.

[25] Hashim, Z., Nor, R. M., & Yusoff, N. A. (2020). Review on Sick Building Syndrome (SBS) in Malaysia. In E3S Web of Conferences (Vol. 156, p. 00002). EDP Sciences.

[26] Mendell, M. J., & Kumagai, K. (2017). Observation-based metrics for residential dampness and mold with dose-response relationships to health: A review. Indoor Air, 27(3), 506-517

[27] UNEP (United Nations Environment Programme). (2021). Indoor Air Quality Guidelines. Retrieved from https://www.epa.gov/sites/production/files/2014-08/documents/iaq-guidelines.pdf