

# Assessment of Indoor Air Quality Performance in a Building at Kemaman, Terengganu

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## Abstract

Violations of IAQ regulations can lead to sick building syndrome (SBS), which manifests as symptoms like respiratory difficulties, eye irritation, skin issues, and headaches. Monitoring IAQ is crucial for ensuring the well-being of occupants and preventing health issues and reduced productivity. Compliance with IAQ regulations is necessary to avoid legal concerns and penalties. The study aims to evaluate IAQ in accordance with the Department of Occupational Safety and Health (DOSH) Malaysia's Industry Code of Practice on Indoor Air Quality (ICOP 2010), which provides guidelines and acceptable limits for physical and chemical contaminants on the impact on occupants' health and comfort in Bangunan Persekutuan Kemaman, a government office building in Terengganu, Malaysia. Objective and subjective measurements were collected to assess physical parameters, chemical contaminants, and ventilation performance indicators. The data revealed that the airflow, relative humidity, and light intensity in the building did not meet the ICOP 2010 standards, indicating the need for repair and maintenance of the mechanical ventilation and air-conditioning (MVAC) system. The subjective survey completed by occupants indicated symptoms such as drowsiness, fatigue, and headaches, which are associated with poor IAQ. The study concludes that improvements are necessary to ensure compliance with IAQ regulations and recommends further research on the relationship between air temperature, relative humidity, and older building designs..

## 1. Introduction

A Indoor air quality (IAQ) refers to the state of the air within structures, such as houses, workplaces, schools, and other enclosed areas, in terms of its impact on inhabitants' health and comfort [1]. It encompasses various factors that can affect the quality of the air that people breathe indoors. There are several factors that can contribute to indoor air quality, such as airborne pollutants such as dust, pollen, pet dander, mold spores, and other allergens [2]. Inadequate ventilation can result in the accumulation of pollutants and stale air, whereas optimal ventilation helps to dilute and eliminate pollutants [3]. Moreover, high humidity promotes the growth of mold and mildew,

extreme temperatures also affect the comfort and air quality if the Heating, Ventilation, and Air Conditioning (HVAC) systems are poorly maintained [4]-[5].

Indoor air quality can also be compromised by gases (such as carbon monoxide, radon, and volatile organic compounds), particles, microbiological contaminants (mould, bacteria), and any mass or energy stressor that can produce significant health repercussions [6]. In the majority of buildings, the fundamental methods for improving indoor air quality are source control, filtration, and ventilation to dilute pollutants [7].

If this issue is left uncontrolled, even minor causes can impact negatively on IAQ. As a result, numerous national authorities and global effect bodies, like the World Health Organization (WHO), have developed regulations and guidelines targeted at limiting human exposure to specific breathing air contaminants. Carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), formaldehyde (HCHO), nitrogen dioxide (NO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>), and total volatile organic compounds are all common air pollutants that contribute to poor IAQ [8]. IAQ parameters such as air temperature, velocity, and humidity are also linked to the thermal comfort zone. The indoor environment's eventual state as an effect of violating rules and regulations may result in sick building syndrome (SBS).

SBS refers to a range of symptoms experienced by individuals who occupy a particular building or indoor space. These symptoms are typically linked to time spent indoors and tend to improve or resolve when the affected individuals leave the building [9]. Respiratory difficulties such as coughing, wheezing, chest tightness, shortness of breath, and nasal congestion are associated symptoms of SBS [10]. SBS also can cause eye irritation such as dry or itchy eyes [11]. Some individuals may experience skin rashes, itching, or dryness when in the building. They can also experience recurring headaches or migraines [12].

Relevant to the relationship between IAQ and SBS, monitoring of IAQ helps ensure the health and well-being of employees and other occupants. Poor indoor air quality can contribute to various health issues, including respiratory problems, allergies, headaches, fatigue, and reduced productivity. Consequently, IAQ monitoring can identify and treat potential air quality issues, promoting a healthier workplace [13]. There are legislation and guidelines in existence in numerous jurisdictions that stipulate minimum criteria for indoor air quality in business buildings. Regular monitoring of IAQ aids in ensuring compliance with these requirements, so avoiding any legal concerns and penalties [14]-[16].

The IAQ evaluation in this study is conducted in compliance with the Department of Occupational Safety and Health (DOSH) Malaysia 2010 Industry Code of Practice on Indoor Air Quality (ICOP 2010). It serves as a primary reference. ICOP 2010 specifies minimum requirements for a variety of indoor characteristics and offers suggestions for enhancing IAQ and preventing discomfort or adverse health impacts among building occupants in enclosed settings with mechanical ventilation and air conditioning (MVAC) systems. In this particular study, the ICOP's acceptable limiting values for physical and chemical contaminants served as a guidance. Table 1 and Table 2 shows the acceptable range for specific physical parameters and list of indoor air contaminants and the acceptable limits referring to ICOP 2010 that was set by DOSH Malaysia.

**Table 1** Acceptable range for specific physical parameters

Item	Parameter	Acceptable Range
1	Air temperature	23-26°C
2	Relative Humidity	40-70%
3	Air Movement	0.15-0.50m/s

**Table 2** List of indoor air contaminants and the acceptable limits

Item	Parameter	Acceptable Range
1	Carbon Monoxide	10ppm
2	Formaldehyde	0.1ppm
3	Ozone	0.05ppm
4	Respirable particulates	0.15mg/m <sup>3</sup>
5	Total Volatile Organic Compounds (TVOC)	3ppm
6	Total bacterial counts	500cfu/m <sup>3</sup>
7	Total fungal counts	1000cfu/m <sup>3</sup>
8	Carbon Dioxide	1000ppm

## 2. Materials and Methodologies

The collection of data will consist of two distinct components: objective measurement and subjective measurement. For objective measurement, physical parameters consisting of air temperature, air velocity, relative humidity, chemical contaminants such as formaldehyde (HCHO), carbon monoxide (CO), total volatile organic compound (TVOC), and particulate matter (PM), and ventilation performance indicator carbon dioxide (CO<sub>2</sub>) are measured (CO<sub>2</sub>) adhering to the previous studies [17]-[18]. Additional information includes oxygen (O<sub>2</sub>) and light intensity (Lux) [19]. As for subjective measurement, residents' questionnaire survey is implemented. From these two acquired data measurements, the data's interpretation can be derived. On the basis of the result's analysis, the conclusion can be drawn.

## 2.1 Location

Bangunan Persekutuan Kemaman, located in Terengganu and constructed in 1994, is a four-story government office building that houses 14 administrative departments and a multipurpose hall on the fifth floor. The entire floor area is 5671.425 square metres. The following Table 3 provides a summary of department offices by floor (wing) and respective Air Handling Unit (AHU) and area.

**Table 3** Department offices information based on floor (wings) with respective AHUs and size area

Floor	AHU	Department	Working Area (m <sup>2</sup> )	Total Area (m <sup>2</sup> )
Ground	AHU 1 (Left wing)	Bangunan Lindungan Sdn Bhd	80.32	322.064
		Jabatan RELA	55.825	
		Jabatan Pendaftaran Negara	185.919	
	AHU 2 (Right wing)	Jabatan Imigresen	286.967	286.967
First	AHU 3 (Left wing)	Jabatan Kemas	616.906	616.906
	AHU 4 (Right wing)	Jabatan Kebajikan Masyarakat	616.906	616.906
Second	AHU 5 (Left wing)	Jabatan Tenaga Kerja	409.056	409.056
	AHU 6 (Right Wing)	Jabatan PPH	261.68	471.74
		Jabatan Perhilitan	210.06	
Third	AHU 7 (Left wing)	Jabatan Pertanian	525.831	525.831
		Jabatan KPDNHEP		
	AHU 8 (Right wing)	Jabatan Laut Malaysia	585.782	713.26
		Jabatan Alam Sekitar		
		Jabatan AADK		

## 2.2 Equipment

Fig. 1 shows the equipment for HCHO, TVOC, and PM measurement. It can measure accurately the chemical contaminant elements of HCHO for measuring range of 0.000mg/m<sup>3</sup> to 1.999mg/m<sup>3</sup>, TVOC measuring range of 0.000mg/m<sup>3</sup> to 9.999mg/m<sup>3</sup>, and PM<sub>2.5</sub>, PM<sub>1.0</sub>, PM<sub>10</sub>. This device uses semiconductors for HCHO and TVOC testing. Whereas for PM, it uses the concentration (per liter) for its test method.

Fig. 2 presents the CO and O<sub>2</sub> measuring device. This AS8900 multi-gas monitor is a portable and handheld instrument that is capable to use continuously and simultaneously monitoring 4 gases: Oxygen, Combustible gas, Carbon Monoxide and Hydrogen Sulphide. Every gas reading shows in one LCD display. The unit also provide user to configure high and low alarm as well as Twa and Stel alarms. The unit will be audio and visual alarm once the alarm condition is exceeded. Fig. 3(a) displays the CO<sub>2</sub> measurement apparatus that is proficient to measure parameter of CO<sub>2</sub> in measuring range of 350ppm – 2000ppm. It is powered with one built-in lithium battery of capacity 1800mAh.

Fig. 3(b) depicts the physical parameters of air temperature, air velocity, and relative humidity measuring instrument that can accurately measure the physical parameters of air temperature for measuring ranges of 0oC to 40oC, air velocity of 0.10-30.00m/s, and relative humidity of 0 percent to 90 percent. Air velocity flow sensor-angled vane arms with bearings are utilised for testing by this device. The device is powered by three 1.5V AAA(LR03) batteries and will shut off automatically after 10 minutes of inactivity. Fig. 3 depicts the light intensity reading equipment that may be used to measure both artificial and natural light and provides a quick and straightforward method for determining lighting conditions.



**Fig. 1** HCHO, TVOC, and PM measurement devices



**Fig. 2** Smart Sensor Multi Gas Monitor (Model AS8900) for CO and O2 measurements



(a)



(b)

**Fig. 3** (a) Multifunctional Air Quality Tester CO2 measuring device (Model JD-3002); (b) Handheld Digital Anemometer for air temperature, movement, and relative humidity



**Fig. 4** (a) Testo 540 light intensity measuring device

### 2.3 Data Collection

The minimal number of sampling points proposed by ICOP in 2010 is shown in Table 4. In this study, up to three sampling points are chosen for each office department of Bangunan Persekutuan Kemaman. For sampling position, the sampling is carried out at least 0.5 m away from corners, windows, walls, partitions, and other vertical surfaces (such as file cabinets), not in direct contact with air supply diffusers, induction units, floor fans, or heaters, or the operator's exhaled breath, not under direct sunlight that will impact instrumentation, at least 1 metre away from localized sources such as photocopiers and printers, not inside a 2-meter radius of doors, and sampler inlets should be placed at a height of 75 to 120 cm from the floor, ideally 110 cm, depending on the occupant working position.

Other than that, the sampling period are taken on office hours from 8:00AM to 5:00PM for the 4 floors building within 5 days. All measurements are taken with a calibrated instrument/equipment, and the calibration is done according to the manufacturer's requirements.

Due to each floor are served by 2 AHUs, the data collections are divided into 2 wings (left and right) for each floor respectively. Average values are calculated and indicated for the parameters measured. The ICOP 2010

standard and guidelines are referred while conducting the assessment. For the questionnaire survey, a total of 42 questionnaires are collected. These 42 questionnaires are obtained from the 14 departments comprises of 3 representatives from each respective department. These questionnaires investigate on the symptoms at workplace for the past three months.

**Table 4** Minimum number of sampling points recommended (ICOP 2010)

Total floor area (served by MVAC system) (m <sup>2</sup> )	Minimum number of sampling points
< 3,000	1 per 500m <sup>2</sup>
3,000 - < 5,000	8
5,000 - < 10,000	12
10,000 - < 15,000	15
15,000 - < 20,000	18
20,000 - < 30,000	21
≥ 30,000	1 per 1,200m <sup>2</sup>

### 3. Results and Discussion

#### 3.1 Parameters Average Data for Respective Floor by Wings

Table 5 to Table 12 depicts the average data obtained for each level by wing and compliance with ICOP 2010 standards. The tables provide a detailed analysis of the average parameters for Air Handling Units (AHUs) located across different floors and wings of a building, with a focus on compliance with the Industry Code of Practice 2010 (ICOP 2010). This discussion systematically evaluates the compliance of each AHU based on the parameters outlined in the ICOP 2010.

Starting with AHU 1 located on the Ground Floor of the Left Wing, the assessment reveals mixed results regarding compliance. While the average air temperature falls within the recommended range of 23 to 26 Celsius, indicating compliance, the relative humidity and air movement parameters fall short of meeting the standards. The elevated relative humidity of 85.14% and suboptimal air movement velocity of 0.14 m/s indicate areas requiring improvement to align with ICOP 2010 guidelines. However, other parameters such as carbon monoxide, carbon dioxide, oxygen levels, formaldehyde concentration, and particulate matter (PM) levels all meet the prescribed limits, demonstrating compliance. Moving to AHU 2 situated on the Ground Floor of the Right Wing, the assessment shows better overall compliance. The air temperature, carbon monoxide, carbon dioxide, oxygen, formaldehyde concentration, and PM levels all meet the ICOP 2010 standards. Although the relative humidity falls slightly outside the recommended range at 84.23%, the air movement velocity meets the criteria, indicating compliance with most parameters.

**Table 5** Average parameters for AHU 1 ground floor (Left wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	24.96	Yes
Relative Humidity (40% - 70%)	85.14	No
Air Movement (0.15m/s - 0.50m/s)	0.14	No
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	399.73	Yes
Oxygen (Min 19.5%)	20.98	Yes
Fomaldehyde (Max 0.1ppm)	0.002	Yes
PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.03	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.02	Yes

**Table 6** Average parameters for AHU 2 ground floor (Right wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	25.18	Yes
Relative Humidity (40% - 70%)	84.23	No
Air Movement (0.15m/s - 0.50m/s)	0.16	Yes
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	429.67	Yes
Oxygen (Min 19.5%)	21.05	Yes
Fomaldehyde (Max 0.1ppm)	0.0078	Yes
PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.025	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.025	Yes

**Table 7** Average parameters for AHU 3 first floor (Left wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	24.69	Yes
Relative Humidity (40% - 70%)	76.56	No
Air Movement (0.15m/s - 0.50m/s)	0.16	Yes
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	394.47	Yes
Oxygen (Min 19.5%)	21.04	Yes
Fomaldehyde (Max 0.1ppm)	0.001	Yes
PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.025	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.025	Yes

**Table 8** Average parameters for AHU 4 first floor (Right wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	23.42	Yes
Relative Humidity (40% - 70%)	79.17	No
Air Movement (0.15m/s - 0.50m/s)	0.16	Yes
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	436.93	Yes
Oxygen (Min 19.5%)	21.03	Yes
Fomaldehyde (Max 0.1ppm)	0.009	Yes
PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.03	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.03	Yes

AHU 3 and AHU 4 on the First-Floor exhibit similar compliance trends. Both AHUs meet the standards for air temperature, carbon monoxide, carbon dioxide, oxygen, formaldehyde, and PM levels. However, they both struggle with relative humidity, with values below the lower limit of 40%. This deviation highlights the need for humidity control measures to ensure compliance with ICOP 2010. On the Second Floor, AHU 5 and AHU 6 also demonstrate satisfactory compliance with ICOP 2010 standards for most parameters. While AHU 5 complies with all parameters, AHU 6 exhibits non-compliance in air movement velocity, with a value of 0.14 m/s falling below the recommended range. Lastly, AHU 7 and AHU 8 on the Third Floor showcase similar patterns of compliance and non-compliance. Both AHUs meet the standards for air temperature, carbon monoxide, carbon dioxide, oxygen, formaldehyde, and PM levels. However, they both fall short in relative humidity and air movement velocity, indicating areas requiring attention to ensure full compliance with ICOP 2010.

**Table 9** Average parameters for AHU 5 second floor (Left wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	24.61	Yes
Relative Humidity (40% - 70%)	79.47	No
Air Movement (0.15m/s - 0.50m/s)	0.15	Yes
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	424.2	Yes
Oxygen (Min 19.5%)	21.05	Yes
Fomaldehyde (Max 0.1ppm)	0.007	Yes
PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.033	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.033	Yes

**Table 10** Average parameters for AHU 6 second floor (Right wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	25.35	Yes
Relative Humidity (40% - 70%)	79.06	No
Air Movement (0.15m/s - 0.50m/s)	0.14	No
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	400	Yes
Oxygen (Min 19.5%)	21.01	Yes
Fomaldehyde (Max 0.1ppm)	0.0025	Yes
PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.037	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.037	Yes

**Table 11** Average parameters for AHU 7 third floor (Left wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	25.31	Yes
Relative Humidity (40% - 70%)	79.88	No
Air Movement (0.15m/s - 0.50m/s)	0.15	Yes
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	398.67	Yes
Oxygen (Min 19.5%)	21	Yes
Fomaldehyde (Max 0.1ppm)	0.0019	Yes
PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.037	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.037	Yes

**Table 12** Average parameters for AHU 8 third floor (Right wing)

Parameters	Average	Compliance
Air Temperature (23 Celsius - 26 Celsius)	24.58	Yes
Relative Humidity (40% - 70%)	77.65	No
Air Movement (0.15m/s - 0.50m/s)	0.14	No
Carbon Monoxide (Max 10ppm)	0	Yes
Carbon Dioxide (Max 1000ppm)	421.4	Yes
Oxygen (Min 19.5%)	21	Yes
Fomaldehyde (Max 0.1ppm)	0.0062	Yes

PM 2.5 (Max 0.15mg/m <sup>3</sup> )	0.062	Yes
PM 10 (Max 0.15mg/m <sup>3</sup> )	0.063	Yes

In conclusion, while most AHUs demonstrate compliance with most parameters outlined in ICOP 2010, deviations in relative humidity and air movement velocity highlight areas for improvement. Addressing these deviations through appropriate measures will ensure optimal indoor air quality and alignment with industry standards. According to Tables 5 through 12, the airflow and relative humidity in the Bangunan Persekutuan Kemaman workplace do not meet the 2010 Industry Code of Practice for Indoor Air Quality. This is due to a shortage of repair and maintenance jobs and malfunctioning mechanical ventilation and air-conditioning (MVAC) system equipment. In addition, a high degree of humidity indicates an inadequate air-cooling mechanism, which hinders the intake air from dehumidifying. Inadequate reheating allows air with high levels of humidity to pass past the reheat coils without considerably increasing the temperature, hence inadequate reheating systems may also be the cause of this problem. As a result, the air supplied to the workplace has a high level of relative humidity. In addition, the light intensity does not conform to the norm. This issue can be resolved if the building administration performs maintenance or enhancement work on the lighting.

### 3.2 Questionnaire Survey

Fig. 3 shows the total number of symptoms encountered by 42 inhabitants who were surveyed. The figure presents a comprehensive overview of the symptoms experienced by 42 surveyed occupants in a given environment. Each symptom is accompanied by the number of respondents who reported experiencing it, shedding light on potential issues related to indoor air quality, comfort, and overall well-being. Firstly, symptoms related to physical discomfort and irritation are prevalent among the surveyed occupants. Irritation of the eyes, reported by 16 respondents, suggests potential concerns regarding environmental factors such as air quality, dust, or irritants present in the surroundings. Similarly, complaints of hoarse or dry throat (reported by 20 respondents) and irritated, stuffy nose (reported by 22 respondents) indicate possible respiratory irritations or sensitivities to allergens, pollutants, or dry air. These symptoms collectively point towards potential issues with ventilation, air filtration, or the presence of indoor pollutants, which may require further investigation and remediation to ensure occupant health and comfort.

Furthermore, symptoms such as skin rash/itchiness (reported by 13 respondents) and scaling/itching scalp or ears (reported by 14 respondents) suggest potential allergic reactions or sensitivities to substances present in the environment. These symptoms underscore the importance of assessing and mitigating potential sources of allergens or irritants within the surveyed space, such as chemical contaminants, dust mites, or mold spores, to create a healthier indoor environment for occupants.

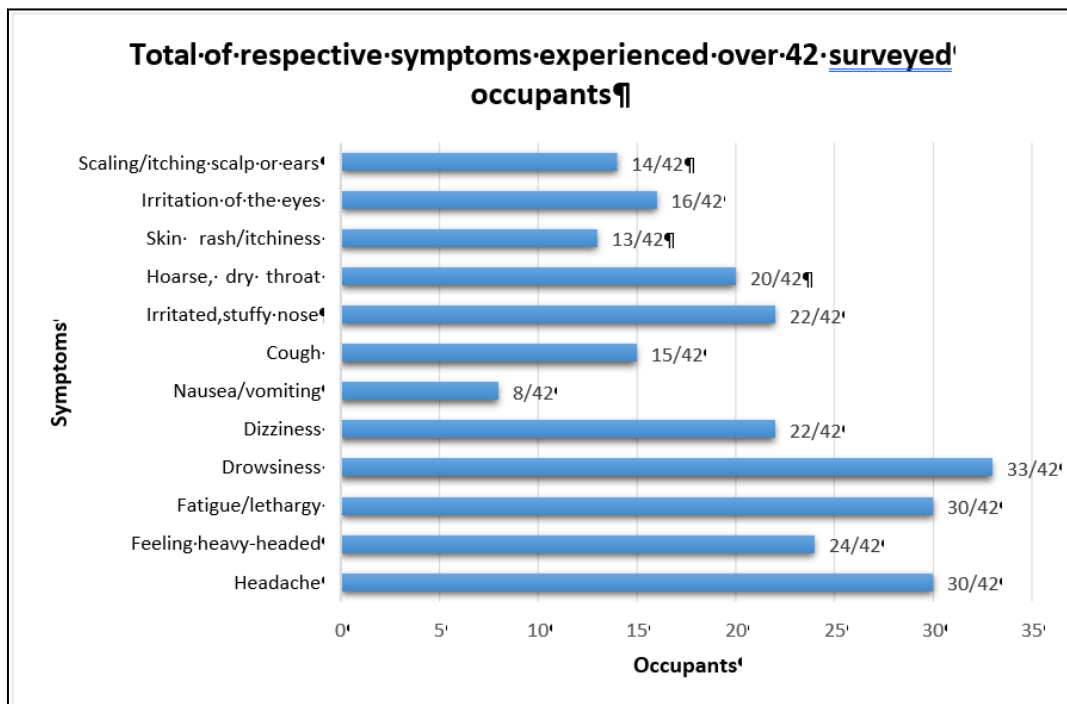


Fig. 3 Total of respective symptoms experienced over 42 surveyed occupants

Moreover, symptoms related to physiological discomfort and fatigue are also prominent among the surveyed occupants. Drowsiness, reported by 33 respondents, and fatigue/lethargy, reported by 30 respondents, may indicate issues with indoor air quality, thermal comfort, lighting, or ergonomics that could contribute to decreased productivity and well-being. Similarly, complaints of feeling heavy-headed (reported by 24 respondents) and headaches (reported by 30 respondents) suggest potential discomfort or stressors within the environment that may impact occupant concentration, cognitive function, and overall satisfaction.

Additionally, symptoms such as nausea/vomiting (reported by 8 respondents) and dizziness (reported by 22 respondents) warrant attention due to their potential health implications. While these symptoms may not be directly related to indoor environmental factors, their presence among surveyed occupants underscores the importance of considering broader health and safety concerns within the surveyed space, such as exposure to toxins, pathogens, or other hazards.

#### 4. Conclusion

In conclusion, it is determined that the working circumstances at Bangunan Persekutuan Kemaman do not match the ICOP 2010 permissible range for air flow and relative humidity, as well as the extra criterion of light intensity. The remaining parameters are compliant with ICOP 2010 regulations. The results from the detailed analysis of the Air Handling Units (AHUs) across different floors and wings, as outlined in Tables 5 through 12, indicate both compliance and non-compliance with the ICOP 2010. While many parameters such as air temperature, carbon monoxide levels, carbon dioxide levels, oxygen levels, formaldehyde concentration, and particulate matter (PM) levels generally meet the prescribed standards, deviations in relative humidity and air movement velocity highlight areas for improvement. The deviations observed, particularly in relative humidity and air movement, could potentially impact indoor air quality, occupant comfort, and overall well-being. The presence of elevated relative humidity levels suggests a need for enhanced humidity control measures, while suboptimal air movement velocity indicates potential issues with ventilation effectiveness. Addressing these deviations through appropriate maintenance, repair, and enhancement of mechanical ventilation and air-conditioning (MVAC) system equipment can contribute to optimal indoor air quality and alignment with industry standards. Furthermore, the comprehensive overview of symptoms experienced by surveyed occupants underscores the potential health implications of indoor environmental factors. Symptoms such as eye irritation, respiratory discomfort, skin rash/itchiness, fatigue, headaches, and dizziness reported by occupants indicate possible concerns related to indoor air quality, allergens, pollutants, thermal comfort, and lighting. These symptoms emphasize the importance of prioritizing occupant health and well-being by implementing measures to address indoor environmental issues and create a healthier, more comfortable work environment. Moving forward, proactive measures such as regular maintenance, repair, and enhancement of HVAC systems, effective ventilation strategies, air quality monitoring, and occupant feedback mechanisms are essential for maintaining optimal indoor environmental conditions and ensuring occupant health, comfort, and productivity. By addressing compliance deviations and mitigating indoor environmental concerns, stakeholders can create safer, healthier, and more conducive indoor environments for occupants in the Bangunan Persekutuan Kemaman workplace and beyond.

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#### Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

#### Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

*The authors confirm contribution to the paper as follows: **study conception and design:** Mohd Azahari Razali, Winardi Sani; **data collection:** Stewart Sumping Semang; **analysis and interpretation of results:** Juntakan Taweekun; **draft manuscript preparation:** Mohd Azahari Razali, Stewart Sumping Semang. All authors reviewed the results and approved the final version of the manuscript.*

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