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Study of Indoor Air Quality and Ventilation Rate at Pagoh Residental College

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Abstract: Indoor air quality issues are not new in Malaysia. According to the President of the Allergy and Immunology Association Malaysia, Dr. Amir Hamzah Abdul Latiff, 30 – 40% of Malaysian suffer from sinusitis allergy because of poor indoor air quality [1]. IAQ, which is frequently related to Sick Building Syndrome, has increasingly become a concern for building occupants globally. IAQ continues to be an important issue affecting occupants' health, comfort, satisfaction, and productivity [2]. The main research objectives of this study are to compare the IAQ parameters and ventilation rate with standards. The IAQ parameter will be measured and recorded in the data and the location chosen was UTHM Pagoh Residental College, where a selected room was in the students' house. The comparison of standards is made based on the appropriate standard used in Malaysia for IAQ and Air Change Rate which are (Industry Code of Practice on Indoor Air Quality 2010 and ASHRAE Standard 62.2-2019). Hence, the result shows that not all parameters comply with the IAQ while the Air Change Rate was good in fully utilized of openings. In summary, for better ventilation, the occupants may open the window at least three times daily to 'dilute' the contaminated air and ensure the furniture layout promotes ventilation.

Keywords: IAQ, Air change rate,

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1. Introduction

Indoor air quality refers to how the air inside a building affects a person's health, comfort, and work performance [3]. The study said, low IAQ results in unwanted health conditions, including death in the worst-case scenarios [4]. Indoor Air Quality (IAQ) was affected by a wide range of parameters, including temperature, relative humidity, air movement, chemical pollutants, and the quality of external air delivered into the buildings. Ventilation also should be recognized as a parameter to reduce airborne transmission [5].

IAQ is defined as the characteristic of the indoor air inside a building that consists of pollutants and thermal (which is temperature and relative humidity) concentration that can give affect towards health, comfort, and performance of the building [6]. There are three most frequent causes of unacceptable IAQ [7]. Firstly, inadequate design or maintenance of heating, ventilation, and air-conditioning (HVAC) systems. Secondly, a shortage of fresh air intake in buildings, and finally, a lack of humidity control [8].

Indoor air contaminants can be divided into three different categories; chemical, physical, and biological. Sources of chemical pollutants include tobacco smoke, emissions from products used in the building (e.g., office equipment; furniture, wall and floor coverings; and cleaning and consumer products) accidental spill of chemicals, formaldehyde, volatile compound, and gasses such as carbon monoxide, and carbon dioxide [9]. Physical parameters are air temperature, relative humidity, and air movement. Biological parameters consist of the total bacteria and fungi counts. Inadequate ventilation, high temperature, and humidity can increase the concentrations of some indoor pollutants [10].

2. Materials and Methods

This research only requires specific locations to be studied. The location chosen was UTHM Pagoh Residental College where a selected room was in the students' house. The observation data of reading is compared with the Industry Code of Practice on Indoor Air Quality 2010. The data collected will be analyzed and a comparison will be made with the standards; (1) Industry Code of Practice on Indoor Air Quality 2010 and (2) ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Building.

2.1 Collection data by measuring IAQ parameters

There are two parameters being considered in measuring the indoor air quality in the building. Each of the parameters has specific equipment to use. The physical parameters such as temperature, air movement, and relative humidity are measured using Multi-Function Environmental Meter. The chemical parameters such as carbon dioxide, carbon monoxide, and Total Volatile Organic Compound (TVOC) are being measured using Air- Quality Monitor. The data is collected three times a day and the observations are carried out for two days. The data is collected in the morning, evening, and night to get average data.

2.2 Experiment of Decay Method

This experiment's decay method used humans as sources of Carbon Dioxide in the room. The total number of occupants in the room is ten students. Using an IAQ monitor, the goal is to estimate incoming outdoor air flow in the unoccupied room that coed in two conditions which are closed windows and open windows.

2.3 Comparison with standards

The IAQ parameters are compared with the Industry Code of Practice on Indoor Air Quality 2010 while the air change rate is compared with ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Building.

2.3 Equations

As the result of the decay method, the data collected was applied by the following formula to calculate (ACH) air change rate:

$$\text{ACH} = \frac{-1 * ln\left(\frac{C_{end} - C_{ambient}}{C_{start} - C_{ambient}}\right)}{t_{end} - t_{ambient}} \quad Eq.\ 1$$

3. Results and Discussions

3.1 Result of IAQ

All the results gained from measurement explained in the methodology will be discussed. The parameters involved in these results and discussions are physical and chemical in the room.

3.2 Physical parameter

The physical parameter has been measured are temperature, relative humidity, and air movement. The data is collected three times a day and the observations are carried out for two days. The data is collected in the morning, evening, and night to get average data.

3.2.1 Air Temperature

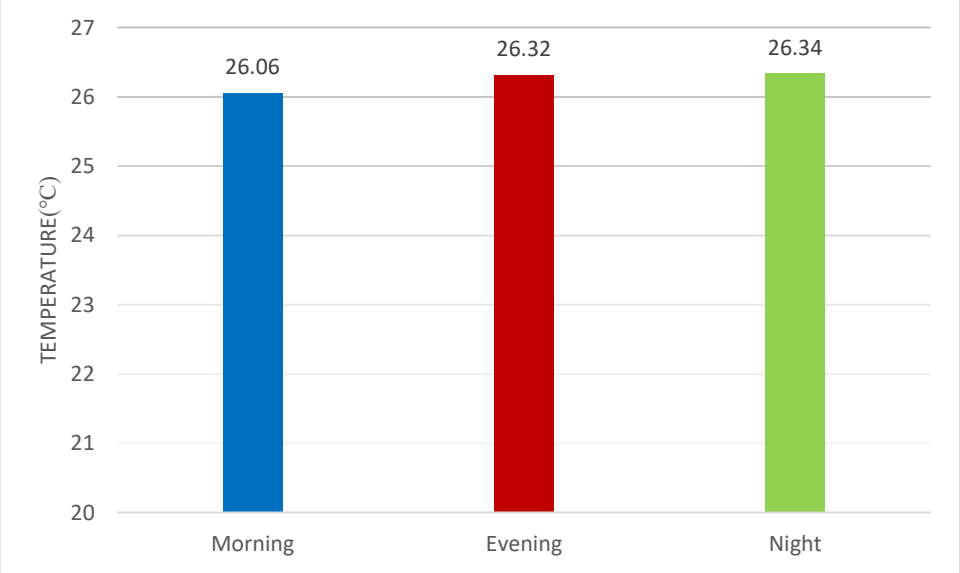

Figure 1: Average temperature in the room

Figure 1 shows the temperature obtained in the morning, evening, and night in the selected room. The recommended range for acceptable indoor air quality is 23 -26 ℃. The highest temperature reading recorded was 26.34 ℃ at night. The lowest temperature reading recorded was 26.06 ℃ in the morning. The temperature in the room in the evening was 26.3 which had minor differences from the temperature during the night.

3.2.2 Relative humidity

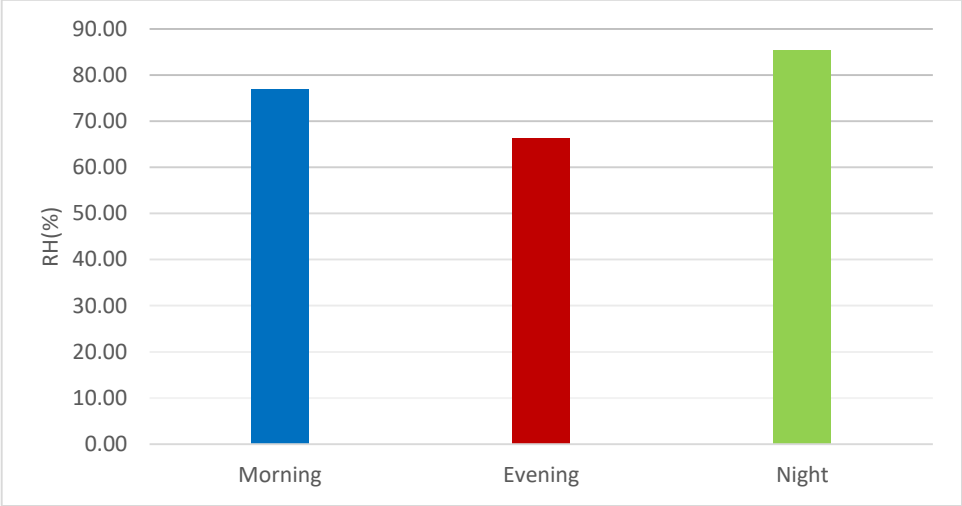

Figure 2: Average relative humidity in the room

For relative humidity, the recommended range of IAQ Standard is 40 – 70% as shown in Figure 2. The data shows that relative humidity in the morning and night has exceeded the maximum recommended level of 76.97 % and 85.43 % respectively. Based on the data only relative humidity in the evening achieved the standard.

3.2.3 Air movement

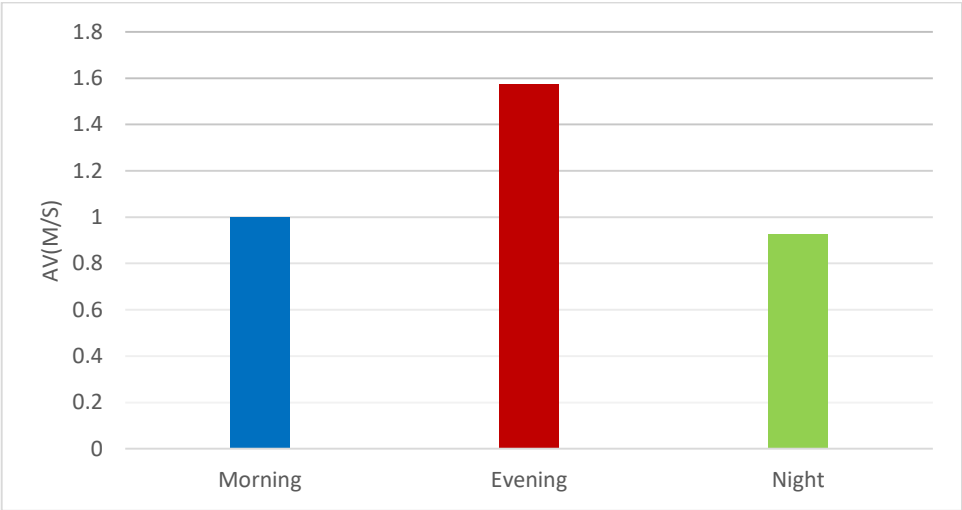

Figure 3: Average Air movement in the room

Figure 3 shows there is a significant reading of air movement in the room. This is because of all of the well-functioning natural ventilation systems. There was good ventilation in the room but unfortunately do not meet the recommended standard range of IAQ standard 0.5- 0.15 m/s.

3.3 Chemical parameter

The chemical parameters that have been measured are carbon dioxide (CO_2), Carbon monoxide (CO), and Total Volatile Organic Compound (TVOC) for every selected reading area. The data is collected three times a day and the observations are carried out for two days. Within two days, the data is collected in the morning, afternoon, and evening to get an average of data.

3.3.1 Carbon dioxide

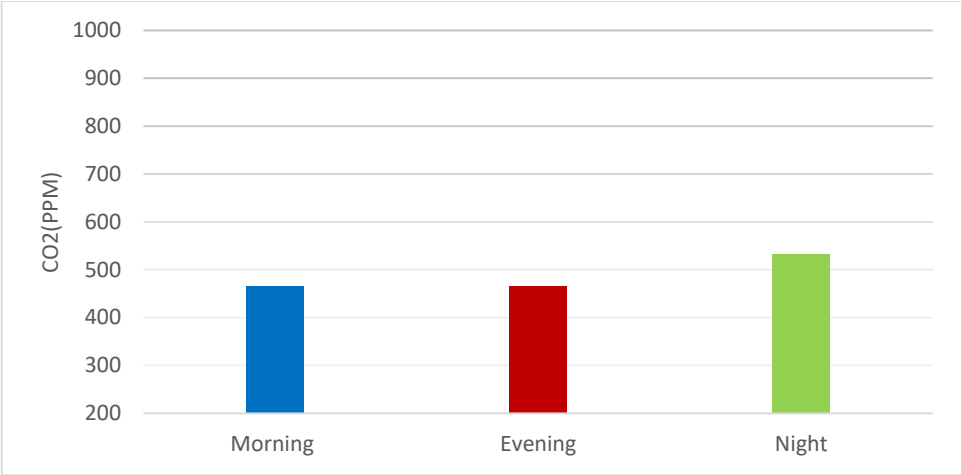

Figure 4: Average Carbon Dioxide in the room

Based on Figure 4, the reading of Carbon Dioxide in the room in the morning and evening was at the same value but the highest reading was recorded at night which is 531.84 ppm. This is because most students spend their time resting in their rooms at night. The amount of Carbon dioxide (CO_2) present indoors is influenced by the number of individuals present and the amount of metabolic activity performed within the air space.

3.3.2 Carbon Monoxide

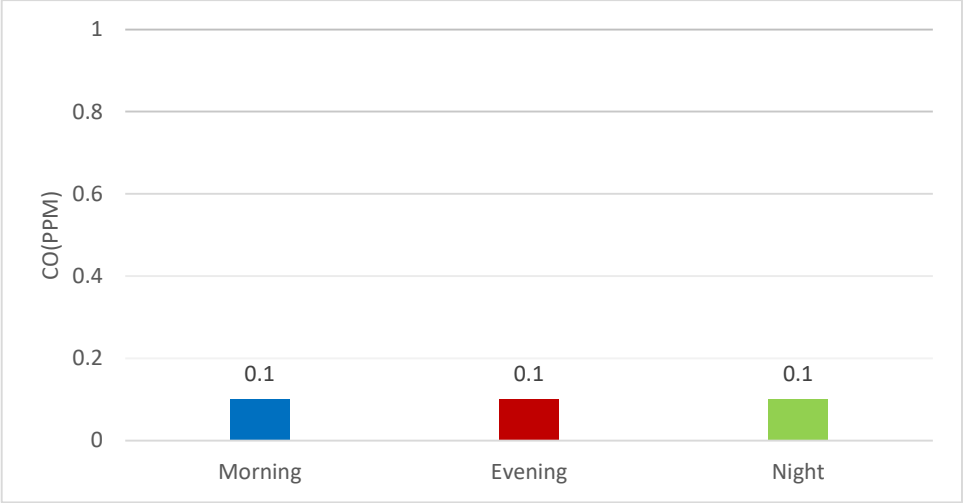

Figure 5: Average Carbon Monoxide in the room

Based on Figure 5, all the reading recorded in the morning, evening, and night was constantly 0.1. The reading was very low because there are insufficient sources of Carbon Monoxide such as clothes dryers, cigarette smokers, gas stoves, and motor vehicles.

3.3.3 Total Volatile Organic Compound

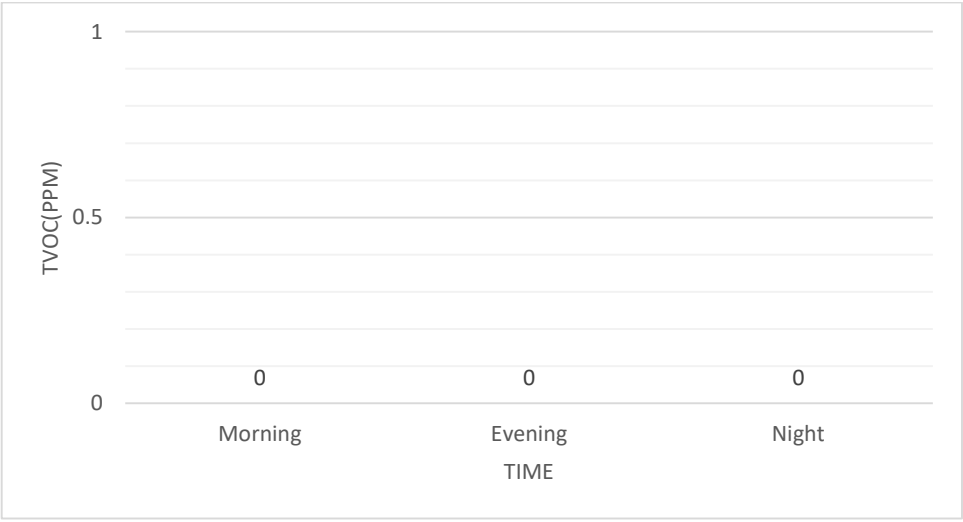

Figure 6: Average (TVOC) in the room

From the data obtained from Figure 6, there are no (TVOC) readings during the days. (VOCs) are chemicals that are applied in the manufacture and maintenance of building materials, interior decorations, cleaning goods, and personal care items.

3.3 Comparison with standard

All the data obtained are analyzed using Microsoft Excel. The figure and tables such as graphs or charts are used to describe the data collection after fieldwork. Then, all the data for IAQ parameters are compared with the Industry Code of Practice on Indoor Air Quality 2010.

The decay method for this experiment room is to estimate the incoming outdoor air flow in the unoccupied room using an IAQ monitor or the Air Change Rate. The value of the carbon dioxide content is recorded using the IAQ monitor to calculate the air change rate during the carbon dioxide decay process.

Table 1: Comparison between the results obtained with the Industry Code of Practice on Indoor Air Quality 2010.

Indoor Air Quality	Ranges	Industry Code of Practice on Indoor Air Quality 2010	Result
Physical Parameters			
Temperature (°C)	26.06 -26.34	23-26	✖
Relative Humidity (%)	76.97 – 85.43	30-70	✖
Air movement (m/s)	1-1.5	0.15-0.5	✖
Chemical Parameters			
Carbon Dioxide, Co2 (ppm)	466.11 – 531.84	1000	✓
Carbon Monoxide, CO (ppm)	0-0.1	10	✓
Total Volatile Organic Compound, TVOC (ppm)	0	3	✓

Table 2: Comparison of Air Change Rate between the ASHRAE Standard 62.2-2019 Ventilation and Acceptable Indoor Air Quality in Residential Buildings

Decay method	ACH	Result
Closed windows	1.6	<3 = Low
Open windows	4.1	4-5 = Good

3.3 Discussions

Based on the data analysis and decay method conducted in UTHM Pagoh Residental College, the Indoor Air Quality in the room has not achieved the IAQ standard but compiles chemically with the standard according to the Industry Code of Practice on Indoor Air Quality 2010 based on parameters stated.

The Air Change Rate in UTHM Pagoh Residental College is in good condition based on the ASHRAE standard 62.2 - 2019 and still needs more efforts in achieving the ideal air change rate to make a healthier living environment with adequate ventilation.

4. Conclusion

In conclusion, the comparison made between the standards responded to the objectives of this study which are to measure the indoor air quality in the selected room in the UTHM Pagoh Residental College, conduct an experiment using the decay method to determine the air change rate and compare the IAQ parameter reading and the ventilation rate with the standards.

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