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A CASE STUDY OF CONTROLLING HUMIDITY IN MALAYSIAN OFFICE BUILDINGS

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ABSTRACT

Microbial growth in buildings is a significant problem in tropical climates, where consistently high humidity levels create ideal conditions for its development. Some office buildings in tropical climates suffered with humidity problems for so many years. Microbial can cause significant health problems, damage to building structures, and discomfort for inhabitants. This case study explores the effectiveness of using air flow controlling method and installing heating coils as a method to control indoor humidity and prevent microbial growth in buildings. The study was conducted in administrative office building, where persistent humidity leads to frequent microbial infestations. The first method, total actual air flow was analysed using cooling load software to set the exact accurate air flow in the building. While the second method, heating coils were installed in the building to regulate temperature and humidity levels. The system was monitored over a period of a month of July 2024 and data was collected through humidity sensors, temperature readings, and visual inspections for microbial growth. The results indicated that both methods effectively reduced indoor humidity levels by increasing air temperature and reducing air flow rate, thereby reducing moisture levels and preventing the conditions conducive to microbial growth. Additionally, the system proved to be energy-efficient when combined with adequate ventilation. The study concludes that controlling humidity is a viable and cost-effective solution to combat microbial growth in tropical climates, although factors like energy consumption and maintenance need careful consideration. Further research is recommended to explore the optimal integration of heating coils with other building systems.

1. Introduction

The high value readings in humidity and in moisture have been happening over many years exist particularly in commercial buildings. This problem has occurred all over the world including Malaysia due to its location is near the equator line. The root causes of these issues can be intricate and encompass a wide range of building design, construction, and maintenance elements (Harriman et al., 1997). It happens when improper humidity control inside a building led to occupant discomfort. High humidity is directly linked to increased risks of microbial growth in buildings. According to (Zhang et al., 2020), indoor relative humidity (RH) levels above 60% can lead to condensation, mold growth, and indoor air quality (IAQ) degradation. ASHRAE Standard 62.1 recommends indoor RH levels be maintained between 30–60% for optimal comfort and health. However, in tropical climates like Malaysia's, external RH often exceeds 80%, complicating HVAC design.

An administration office building situated in negeri Perak is an office space, with a total floor area approximately 1,889.2 ft^2. The office was served by a constant air volume air handling unit (AHU) which had no heater coil that produced 850,000 BTU/hr with airflow rate of 16,400 cfm. A complaint report has been issued regarding the aggressive mold growing in almost occupied space due to its fast-growing period that caused occupants' health effects which led to these top three symptoms: asthma, allergy reactions tend to eyes irritation and skin irritation. Of all the symptoms, it is important to look for indoor areas where moisture and humid problems occur. On the other hand, mold growth on building envelope surfaces can result from moisture accumulation (Chen & Garcia, 2004; Zhang et al., 2020).

A heating, ventilation and air conditioning (HVAC) company has assigned Politeknik Ungku Omar to collaborate and to conduct a field survey and study to address the issue. This kind of collaboration suggests that the company is seeking viable solutions based on research and data collection to the humidity problem. The primary purpose of this study was to improve the high humidity conditions of the office area with an emphasis on improved indoor air quality. Observation and study were being made by performing IAQ experiments to investigate the issue.

It is easy to identify and avoid numerous issues that result in mold growth and poor humidity control. To classify the sources of humidity problems, a four-criteria system will be provided along with instances of administrative office buildings. Many of these buildings had some form of mold development, so it's also critical to know what mold is, how it behaves, and how to avoid or get rid of it.

1.1 Causes of Humidity

Indoor air humidity plays a crucial role determining thermal comfort and indoor air quality as RH to be considered as an important parameter (Al Horr et al., 2016). This thermal comfort will affect productivity, work quality and human health. However, its condition depends on season, building style and ventilation. Furthermore, there are several elements that influence thermal comfort in the space, such as the low wind flow rate, underutilized building openings, inadequate landscaping, hot indoor temperatures, and so forth. To address this issue, air conditioning is used in most buildings.

An air conditioning system supplies cool air into various types of buildings, ranging from large-scale commercial spaces to smaller residential units in different equipment and designed to regulate temperature and humidity independently or in a more integrated manner, depending on specific requirements of the building and its usage (Wolkoff, 2018). Its excellent work to promote thermal comfort and indoor air quality is certain if heat load calculations are made correctly. For a typical centralized air conditioning system, cool air circulates through a supply ducting system and registers or diffusers into occupied rooms and mixes with room air and becomes cool, then it flows back to air handling unit through grilles and return air ducts. Air conditioning systems works to dehumidify the air to improve to comfort and enhance cooling efficiency (Xu et al., 2018). By removing excess moisture from the air, air conditioners help lower the humidity levels in a space, making it feel cooler and more comfortable. Additionally, lower humidity can prevent the growth of mold and reduce the potential for allergens, creating a healthier indoor environment. Meanwhile, high humidity can make the air feel warmer than it is, and by reducing moisture, air conditioners allow the body to cool down more effectively through sweat evaporation. The allowable relative humidity for the office buildings of between 40 and 60 percent.

Criteria 1: Heating, Ventilation and Air Conditioning (HVAC) Design Considerations

HVAC design represents one of the primary areas where engineers exert the greatest level of control in ensuring indoor environmental quality. A well-designed building must create a comfortable and functional environment that supports the occupants in performing their tasks effectively. This includes the careful selection and integration of suitable heating and cooling equipment to maintain optimal indoor temperatures. Furthermore, maintaining a positive differential pressure relative to the outdoor atmosphere is critical. Negative pressure can lead to the uncontrolled infiltration of unconditioned air, which undermines efforts to regulate humidity levels.

A comprehensive evaluation of both the original design parameters of the air handling unit (AHU) and the actual measured air conditions reveals a critical performance gap: while the system delivers sufficient cooling capacity and airflow volume to meet the sensible heat load, it fails to effectively manage the latent heat load associated with moisture removal. It can be identified when some area and rooms had experience high relative humidity levels and people were upset with the room conditions because some of them experiencing allergies and sickness.

The design phase of this intervention prioritized a holistic approach that integrated both thermal comfort and microbial mitigation. A detailed load analysis was conducted using specialized HVAC simulation software to model and adjust the total actual air flow within the building zones. To minimize moisture growth in high-risk regions without sacrificing ventilation efficiency, the system's supply and return air flow rates were adjusted. Concurrently, the air handling units were designed to include electric heating coils to increase the air temperature above the dew point and reduce the relative humidity. The location of the coils and the heat output were carefully chosen in accordance with the existing ducting arrangements, consumption patterns, and building layout.

Criteria 2: Poor Construction

In addition, the building occasionally had construction flaws that allowed moisture to retain, such as poorly sealed duct joints, inadequate insulation that resulted in unwelcome condensation, the use of low-grade vapor barriers in the envelope, and incorrect slope and drainage design in the facade and rooftop elements. Uncontrolled indoor humidity levels were a result of these defects, which made the HVAC system work harder and frequently inefficiently.

Criteria 3: Retrofit Strategy

A retrofit approach was used instead of a complete system replacement because of the building's age and the constraints of the current HVAC system. The project minimized downtime, cut capital costs, and prevented disruptions to regular office activities by using a retrofit concept. Real-time monitoring is achieved with humidity sensors and Building Management Systems (BMS).

Criteria 4: Maintenance

The success of any HVAC-based humidity control system is heavily dependent on ongoing maintenance and operational oversight. These maintenance tasks were scheduled to coincide with existing service routines to avoid added labor costs and ensure consistency.

2. Methodology

This study was conducted inside one of the administrative office buildings in the North Peninsular Malaysia. There were 15 office workers are doing the administrative work in this office until 8 hours/day. The office shows that humidity level is high can cause of microbial growth around 80% humidity. High RH level with more than 75%, can lead to mold growth which can give an effect human health such as exacerbating asthma or allergic triggered or inflammatory reactions (Jones et al., 2022). Thus, the assessment of Indoor Air Quality was conducted followed by The Malaysia Indoor Air Quality Code of Practice (IAQ, COP), published by the Department of Occupational Safety and Health (DOSH), Malaysia (2005) to investigate the course of problem.

2.1 Data Collection

The data was collected during office hours between 8.00am to 5.00pm such as relative humidity (RH), temperature and air flow. The size of each partition room and diffuser was measured to calculate cooling load and air flow rate. Temperature, RH, and air velocity were continuously monitored using hygro-thermometer, psychometer, anemometer and Psychometric Calc Application at multiple vertical and horizontal points throughout the office spaces. All the collected data will be analysed to measure total supply air flow rate of the office.

Then, return air flow rate also will be measured at air handling unit (AHU) room. In this process, the return air and fresh air are mixed before entering the AHU to generate cold air. Data of air velocity, entering area, and inlet temperature will be collected to calculate the total mixed air flow rate. This measurement aims to assess the AHU's performance in supplying cooled air to the office building. Additionally, the estimated cooling load or total air flow rate will be analysed using the *Hourly Analysis Programme* (HAP) to compare it with the calculated supply air flow rate.

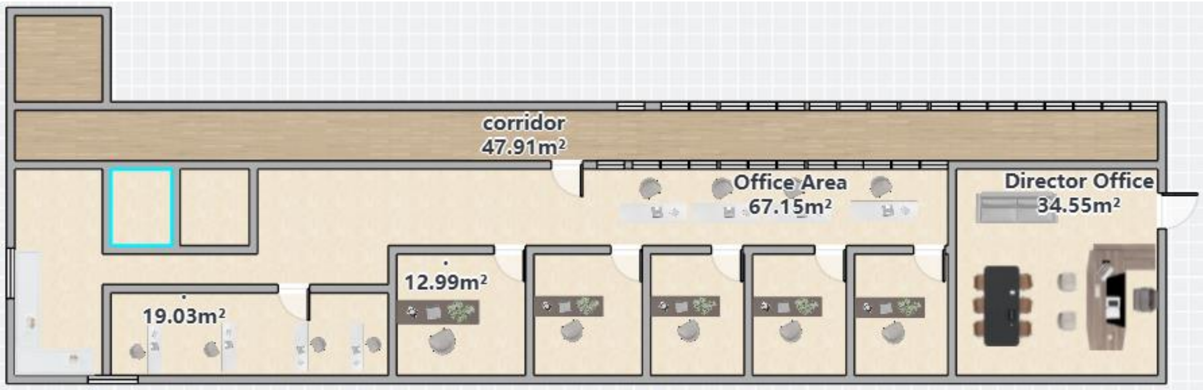

Figure 1. Administrative Office Floor Plan

2.2 Data Analysis

The analysis focuses on investigating the causes of high humidity in the office building. The expected causes based on early observation is extended office design and ventilation system. Apart from that, the data collected will be analysed to find out the definite causes.

- Relative Humidity Analysis

  Relative humidity (RH) levels will be continuously monitored in different room of the office building using digital hygro-thermometer. This data will help identify specific areas where humidity levels exceed the acceptable indoor range between 40% RH to 60% RH. A sling psychometer will be used periodically to manually verify the RH levels by digital monitoring. The sling psychrometer provides readings based on the difference between the wet bulb (WB) and dry bulb (DB) temperatures and the reading RH will analyse by Psychometric Calc Application that shown in Figure 2.

- Total Supply Air Flow Rate

  Air flow measurements will be taken at supply diffusers and the AHU (Air Handling Unit) to calculate the total volume of air delivered into the office spaces. Using equation (1) with put data air velocity and diffuser cross-sectional area, the actual supply air flow rate will be computed. Inadequate airflow can result in poor air distribution, insufficient dehumidification, and stagnant air pockets, all of which contribute to elevated humidity levels. By evaluating whether the supply air flow meets the designed requirements, potential ventilation insufficiencies can be identified.

$$Air\ flow\ rate, Q = A \times V \tag{1}$$

where, Q is air flow rate (CFM), A is cross-sectional area (ft^2), and V is air velocity (ft/min).

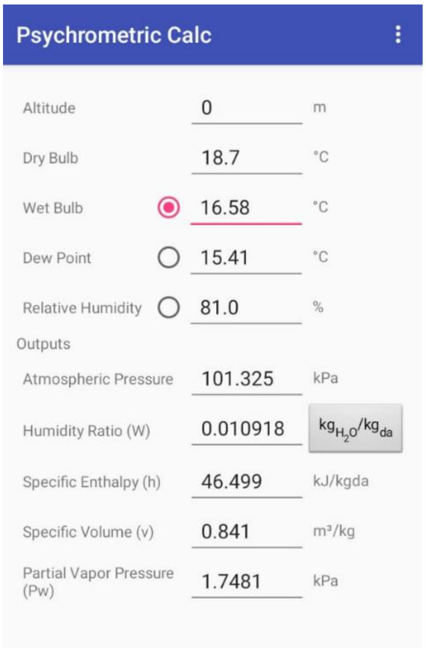

Figure 2. Psychrometric Calc Application

- The Actual Cooling Load by HAP software

  The Hourly Analysis Program (HAP) software will be used to simulate and calculate the estimated cooling load of the building based on number of occupancies, internal heat gains, lighting loads, equipment usage, and outdoor weather data. This analysis will provide a baseline of the cooling demand versus the current system's performance. If the cooling capacity is undersized or poorly distributed relative to the building's actual load, it may lead to inadequate moisture removal, which is a common cause of high indoor humidity.

- Total Supply Air Flow Rate After Improvement

  The data will be analysed after several system improvements have been implemented. These improvements include the installation of heater coils in the AHU, application of antimicrobial paint, thorough duct cleaning, replacement of the AHU filter, and installation of a new water flow actuator. Each enhancement is aimed at improving indoor air quality and overall system performance before evaluating the impact on humidity and cooling efficiency.

3. Results

The study revealed several contributing factors to the high humidity levels observed in the office building. Data collected from digital hygrometers showed that relative humidity (RH) levels in multiple zones frequently exceeded the recommended indoor range of 40%–60%, with some areas recording values as high as 78.22% during peak office hours. Manual verification using a sling psychrometer supported the digital measurements, with calculated RH values showing an average deviation of less than ±2%, indicating a high level of data accuracy.

Table 1. Average deviation reading between digital and manual measurement

Location Room	RH (%) – using digital hygrometer	RH (%) – using sling psychrometer	Average deviation
A	77.5	76.8 (WB- 17.57^{o}C, DB- 20.3^{o}C)	±2%
E	77.4	79.0 (WB- 16.9^{o}C, DB- 19.3^{o}C)	
G	81.3	81.0 (WB- 16.58^{o}C, DB- 18.7^{o}C)	
J	76.0	78.0 (WB- 20.05^{o}C, DB- 22.8^{o}C)	

Figure 3 shows the reading of humidity for three scenarios such as actual reading by collected data, estimated reading by HAP analysis and modified reading after system improvement. According to the graph, the actual reading is exceeded range of ASHRAE Standard 62.1. But, after modified in several improvement, the humidity looks in the recommended range but need high total supply air flow rate to stabilize the supply temperature.

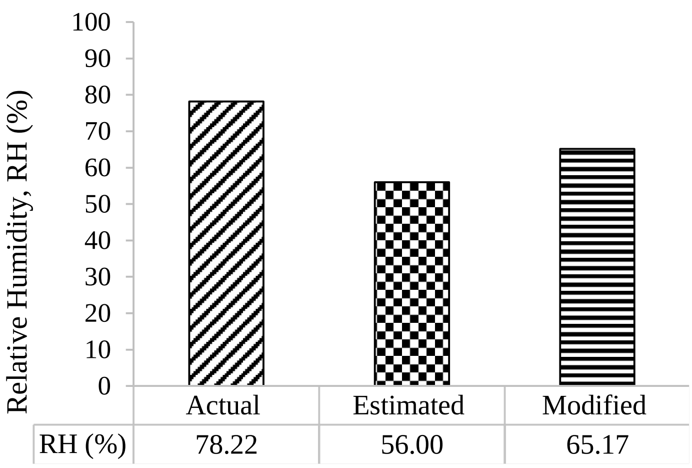

Figure 3. Relative humidity for 3 scenarios

The graph illustrates the comparison of total airflow rate across three different scenarios that are shown in Figure 4. The actual reading is 7668.56 cfm, whereas the estimated airflow rate is significantly lower at 3419.00 cfm. After implementing modifications, the airflow rate increased to 9554.28 cfm, indicating an improvement over both the estimated and actual values. The actual flow rate was notably higher than the HAP-estimated baseline, suggesting that the existing system was working beyond its design expectations, potentially to compensate for thermal and humidity imbalances in the building. However, despite this higher airflow, initial humidity readings exceeded the ASHRAE Standard 62.1 limit by 78.22%, indicating inefficient dehumidification (ASHRAE, 2019). Following the implementation of targeted improvements on humidity level including heater coil installation, duct cleaning, antimicrobial treatment, and actuator and filter replacement meanwhile, the modified system showed a significantly increased airflow. This corresponds with a 65.17% improvement in maintaining humidity within recommended levels.

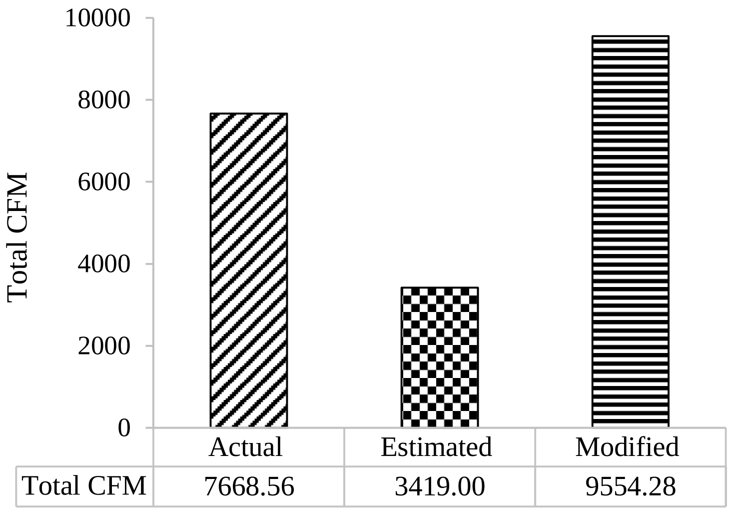

Figure 4 Total CFM for 3 scenarios

4. Discussion

Based on the floor plan, HAP analysis demonstrate that the airflow rate is lower than the actual. It is due to extended office and partition-rooms. At this point, the supply air shifted of each room because of the partitions blocked the airflow. The modified system value demonstrates the success of interventions or upgrades, likely involving changes in ductwork, fan capacity, or control systems, aligning with research emphasizing the positive impact of ventilation system modifications on airflow efficiency. The modified airflow not only exceeds the initial estimate but also surpasses the original actual performance, highlighting how strategic improvements can optimize system output. These findings underscore the necessity of dynamic system evaluations and the adoption of predictive control to ensure effective building airflow management.

However, the analysis also highlighted that achieving stable RH levels within the ASHRAE-recommended range required a substantially higher total supply air flow rate. This suggests that while the improved system effectively dehumidifies, it places a higher demand on airflow to maintain target temperatures. Optimized air distribution and flow rate are crucial for ensuring thermal comfort and consistent humidity control in commercial buildings (Buonocore et al., 2020).

An additional recommendation for improving indoor humidity control is the implementation of damper controllers to regulate air flow volume more precisely throughout the ventilation system. While increased air flow can enhance cooling performance, excessive volume without proper control may lead to raised humidity percentage due to insufficient latent heat removal, especially in humid climates. By integrating automated damper systems, the HVAC system can dynamically adjust air flow based on zone-specific humidity and temperature requirements, improving both energy efficiency and moisture management.

Lastly, installing UV lighting within the HVAC system is a proven and effective strategy to prevent mold growth and improve indoor air quality. UV lamps are typically installed near the cooling coils and inside the ductwork, where microbial contaminants such as mold, bacteria, and viruses are most likely to thrive due to moisture accumulation. The ultraviolet radiation disrupts the DNA of these microorganisms, rendering them inactive and unable to reproduce. This helps maintain cleaner coils, improves system efficiency, and reduces the spread of airborne microbials. Especially in humid environments, UV lighting plays a vital role in minimizing health risks and prolonging HVAC lifespan.

5. Conclusion

In conclusion, implementing several modifications the level of humidity has successfully reduced in ASHRAE recommended range. The implementation of targeted HVAC system improvements has effectively addressed the problem of high indoor humidity in the office building. These improvements include the installation of heater coils, duct cleaning, filter and actuator replacement, airflow regulation using damper controllers, and UV lighting to prevent microbial growth. As a result, relative humidity levels were successfully reduced and maintained within the acceptable range set by ASHRAE Standard 62.1. Additionally, these interventions improved indoor air quality, enhanced system performance, and minimized the risk of mold formation. Overall, the findings demonstrate that the objective of the study is achieving better humidity control and ensuring a healthier, more energy-efficient indoor environment.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the author(s) used OpenAI's ChatGPT to assist in improving the readability and language of the text. All content generated by ChatGPT was subject to thorough review, editing, and revision by the author(s) to ensure its accuracy, completeness, and alignment with the research objectives. The author(s) take full responsibility for the integrity and content of the published work. This declaration complies with ICGESD 2025 guidelines on the use of generative AI in scientific writing.

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