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INFLUENCES OF VEGETATION STRUCTURE (VS) ON METEOROLOGICAL PARAMETERS IN BUILT ENVIRONMENT; A FIELDWORK STUDY

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Abstract:

Vegetation plays a crucial role in establishing a comfortable thermal environment by regulating temperature, humidity, and wind velocity. It is a well-documented that the Vegetation Structure (VS) variables, including height, density, leaf colour and size, canopy, density can have a significant impact on the microclimate inside and around the plants. However, the correlation between the different vegetation structures around residential buildings and the meteorological conditions inside and outside remains unclear. In this paper, an experimental investigation was carried out to determine the effect of VS on residential buildings' microclimate. Parameters of meteorological were measured in and around two Case Study (CS1 & CS2) which are single story buildings located in Perak, Malaysia. Five days of meteorological data were collected using a Thermal Microclimate Datalogger (HD32.1 Delta Ohm) and an Indoor Air Quality Datalogger (HD37AB1347 Delta Ohm) to measure temperature (ºC), relative humidity (%), and air velocity (m/s). Both case study's VS variables were measured and then thoroughly examined to determine the potential of VS in generating a pleasant thermal environment. This research compares and discusses VS and meteorological parameters measured within and outside of the case study buildings. The results were analyzed in three Quartile: Q1 from 7:30 a.m. to 11:00 a.m., Q2 from 11.15 a.m. to 2:30 p.m., and Q3 from 2:45 p.m. to 6:00

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p.m. In Q1, CS1 shows the highest outdoor-indoor temperature difference of 2.31℃ compared to 2.02ºC for CS2. In contrast, CS2 recorded the highest ambient temperature differences of 1.35℃ and 2.73ºC in Q2 and Q3, respectively compared to CS1; 1.27ºC and 1.19℃. Overall, vegetation structure can have a significant impact on meteorological parameters, which can in turn influence indoor and outdoor thermal performance.

Keywords:

Vegetation Structure, Meteorological Parameters, Thermal Performance

Introduction

More than half of the world's population now resides in urban areas, and this percentage is expected to rise, especially in developing countries.(United Nations., 2008). Diversity and ecosystem functions, as well as local and regional climate and quality of life, are all significantly impacted by urbanisation. The urban heat island (UHI) effect is one of the unintended ecological consequences of urbanisation, causing cities to be warmer than their surrounding suburban and rural environs (Li et al., 2011). By 2050, the temperature in cities is projected to rise by another 2°C. Approximately 60% of the world's urban population is presently experiencing twice as much warming as the global average (Johnston, 2017). As a result, mitigating UHI effects is critical for promoting urban sustainability, particularly in the context of climate change (Akbari et al., 2001).

Vegetation is a natural cooling solution for cities. In general, more greenery has a greater cooling effect in cities (Fu et al., 2022). Adaptation strategies at the city level to mitigate UHI have significant economic and environmental benefits for the majority of the world's cities. Vegetation planting in urban areas is one of the most widely used practises (Yu et al., 2018). In the meantime, urban greening strategies, particularly in residential areas, are the simplest and least expensive way to reduce the local air temperature. Good landscape design has the potential to reduce the amount of sunlight that enters a building and, as a result, creates comfortable temperatures for indoor and outdoor environments (Kamarulzaman et al., 2016). Furthermore, the structure of vegetation affects temperature by mediating water vapour transport, shading effect, and wind speed and direction, all of which operate both directly and indirectly. The horizontal and vertical structure of vegetation are the two primary aspects of plant architecture. Vegetation cover, crown size, and crown shape are all aspects of horizontal vegetation structure that influence evaporative fraction and turbulent fluxes (Su et al., 2001). Water vapour transport and convergence, wind speed, and shading area are all significantly impacted by vegetation height, another major attribute of vegetation structure and a primary determinant of surface roughness (Yu et al., 2018).

Therefore, precise approaches to managing urban greenspace that reduce the UHI effect would benefit from knowledge of how the structure of vegetation affects UHI. The *primary objective of this study was to investigate how different types of vegetation structure affected the local weather and climate in suburban settings.*

Literature Review; *Relationships of Vegetation and Meteorological Parameters*

The term "vegetation" refers to a region's plant life. Plants do not exist in isolation, instead plant communities are formed by groups of plants that live in the same area. The number of vertical height layers of plants is related to vegetation structure. The natural tropical rainforest

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ecosystem is an example of a fully developed vegetation structure (Misni, 2012). In addition, Vegetation Structure (VS) refers to the physical characteristics of plants and their arrangement in a particular environment. It includes the height, width, shape, density of plants, leaf area index, canopy, colour as well as the spatial arrangement of individuals within a population.

Vegetation structure is also determined by a combination of genetic, environmental, and ecological factors. The shape and size of a plant are predetermined by its genes, and whilst environmental factors such as solar radiation, temperature, and soil nutrients can affect its development. The composition of plant communities can also be influenced by ecological interactions like competition for resources and predation. The structural characteristics of plants vary between species. Forests, for instance, typically feature a layered structure, with tall canopy trees towering over smaller understory trees and shrubs, while grasslands feature more uniform height and density of vegetation. Furthermore, as in a rainforest, trees have four layers of vertical stratification, according to Micheal (2001). These layers are depicted in **Figure 1** as emergent (A), upper canopy (B), understorey (C), and forest floor (D).

Figure 1 : A Sketch Profile of a Fruit Forest in West Sumatra, Indonesia, Illustrating The Vegetation's Complex, Forest-Like Structure (adapted from Michon, G., Foresta, H. d., Levang, P., & Verdeaux, 2007)

Meanwhile, the meteorological parameters refer to atmospheric conditions such as temperature, humidity, solar radiation, wind velocity, and precipitation. Numerous studies have shown that vegetation structure can have a significant impact on local meteorological parameters. For example, tall vegetation such as trees can provide shade, reducing the amount of solar radiation that reaches the ground and lowering air temperatures. Vegetation can also affect local wind patterns, with dense forests creating areas of calm air, while open grasslands allow for more air movement.

In addition to their aesthetic value, vegetations in an urban environment's existing fabric serve many purposes, including modifying the microclimate as shown in **Figure 2**, lowering air and noise pollution, and providing a habitat for urban wildlife (Lin BS, 2010). The influence of vegetation on meteorological parameters can have far-reaching consequences for a variety of ecological and human activities. The cooling effects of trees and other vegetation, for example, can help to mitigate the urban heat island effect. According to research conducted by Karakounos I. and Dimoudi A. (2018), it was found that vegetation has an impact on outdoor thermal comfort due to the evapotranspiration process as well as the different property values (solar reflectance, infrared emissivity, heat capacity, etc.) compared to other materials of the built environment. Humidity in the air rises due to water evaporation, which in turn causes a

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rise in latent cooling. Further, the urban environment's shading is determined by the geometric characteristics of plants (tree height, tree crown width, leafage shape and density, etc.).

Whether they are planted singly or in clusters, vegetations always provide the best mechanism for urban cooling due to their evapotranspiration process and morphological characteristics. Vegetations are a fantastic climate moderator, and they can help in many ways, including by providing shade, cooling the ground and air, reducing solar infiltration, increasing ventilation, and decreasing glare from reflection (Thani et al., 2012). Vegetation's cooling effect and its ability to reduce ambient air temperatures is primarily the result of evaporative cooling and passive shading (Misni, 2012). Even though a single tree can moderate its immediate microclimate, a group of trees, such as an urban forest, can extend its temperature-moderating effects over a larger area (Vaz et al., 2016).

Heisler has stated that trees are effective for cooling because they absorb 70–85% of the heat from solar radiation by transpiration (cited in Akbari, H.,& Taha, 1992). Since leaves are typically dark and coarse, they reflect little light and are therefore ideal absorbers and regulators of solar radiation. Leaves absorb approximately fifty percent of the sun's total energy (Taiz, L., & Zeiger, 2006). In general, when exposed to sunlight, leaves can reflect 10% of the visible energy and 50% of the solar infrared, while transmitting 10% of the visible energy and 30% of the solar infrared (Kong et al., 2017). Shahidan et al., (2007), illustrated the ability of leaves to respond to incoming shortwave radiation via reflection and transmission, as shown in **Figure 3**. According to Berry et al., (2013), multiple layers of leaves can reduce transmission even more. For example, in hot summer months, a dense and tall tree canopy can reduce surface temperature significantly by shading.

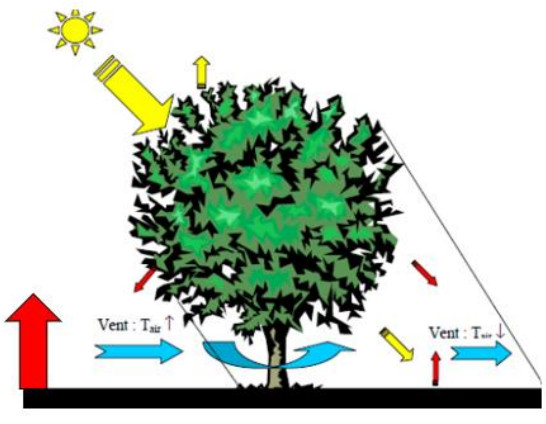

Figure 2 : Modification of Heat Transfer Around a Tree (Gherraz et al., 2018)

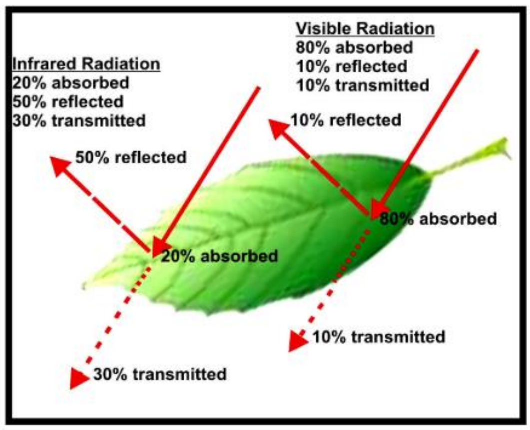

Figure 3 : The Ability of a Single Layer Leaf to Respond to Solar Radiation Absorption, Transmission, and Reflection (Shahidan et al., 2007)

Several studies have also monitored surface temperature to demonstrate the possible cooling effect of urban trees (Lin BS, 2010, Park et al., 2012, Mónica Ballinas, 2016), as tree canopy tends to lower surface temperatures in the shade, it reduces heat storage and convection (Armson, D., Rahman, M. A., & Ennos, 2013). Research conducted by Lee et al. (2009) revealed that park with a dense canopy can reduce the amount of solar radiation that reaches

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the ground, which can lower surface temperatures, as illustrated in **Figure 4.** In addition to its ability to modify air temperature, other studies also discovered that vegetation could affect meteorological factors such as relative humidity by regulating the amount of water vapor that is released into the air through transpiration. Plants with large leaves and a high leaf area index can release large amounts of water vapor, increasing humidity levels. Other than that, the presence of vegetation can cause turbulence and thus change the direction and velocity of blowing winds. Wind speed is typically lower in open grasslands with short vegetation and is typically higher in forests with tall trees because of the barrier they create. **Figure 5** shown the study result by Thani et al., (2013) in Putrajaya, Malaysia, lends credence to these claims. The results of this study show that relative to urban areas, water areas, and the ground, green spaces have consistently cooler air temperatures and higher relative humidity.

Therefore, the United States Department of Energy suggests that if every household planted three trees, the urban heat island effect could be mitigated by as much as 5°C Celsius (Kamarulzaman et al., 2016). Meanwhile, Simpson, J.R., McPherson (1996)found that two trees shading the west-facing exposure of a residence and one tree shading the east-facing exposure can reduce annual cooling energy use by 10 to 50% and peak electrical use by up to 23%.

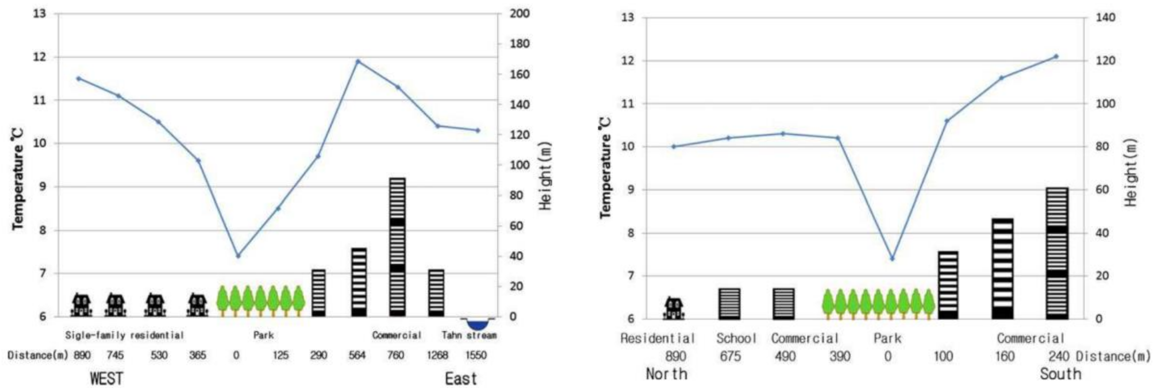

Figure 4: Influences of Horizontal Temperature Distribution of South-North and West-East Around Seolleung Park, Korea (Lee et al., 2009)

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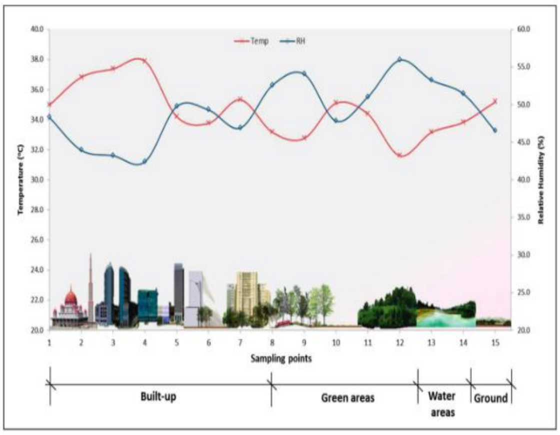

Figure 5: Variations in Meteorological Parameters Within Various Urban Landscape Morphologies in Putrajaya, Malaysia (Thani et al., 2013)

Research Methodology

Study Area

Malaysia, a country in Southeast Asia with a tropical climate, consists of two distinct regions: Peninsular Malaysia and East Malaysia (located on the island of Borneo). The country has a diverse landscape, with mountainous regions, coastal plains, tropical rainforests and experienced high temperatures and humidity year-round. Peninsular Malaysia is bordered by Thailand to the north and Singapore to the south, while East Malaysia is bordered by Brunei and Indonesia. The country has a coastline stretching for over 4,800km (2,980mi), which includes the South China Sea and the Straits of Malacca as shown in **Figure 6.**

The research study focused on a region of the northern Malaysian state of Perak, specifically the Perak Tengah District with latitude 4ºN and 100ºE Longitude. This area was selected because it is one of the three states in Malaysia with the warmest tropical climates. The average annual temperature in the district is around 27°C, according to data from the weather station in Ipoh, which is located near Perak Tengah. Throughout the year, the temperature remains relatively consistent, with average monthly temperatures ranging from 26°C in December and January to 28°C in April and May. March and April are typically the hottest months of the year, with average daily temperatures reaching 31°C.

There are two distinct monsoon seasons in Perak Tengah. The northeast monsoon, which lasts from November to March, brings heavy rain to the district's east coast. The average monthly rainfall during this time period ranges from 150mm in January to 300mm in December. The southwest monsoon, which lasts from May to September, brings heavy rain to the district's west coast. The average monthly rainfall during this time period ranges from 200mm in July to 350mm in November. The monsoon transitional period, which occurs between April and October, is typically drier than the monsoon seasons, with average monthly rainfall ranging from 100mm to 200mm.

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Figure 6: The Map Depicts the Location of the Research Area, Perak Tengah District, Perak Malaysia.

Research Process And Data Collecting

Firstly, the case study area was identified by choosing one residential area in Perak Tengah District, Perak. Using snowball techniques, two semi-detached houses were selected as Case Study 1 (CS1) and Case Study 2 (CS2). This research used a Qualitative data collection where the fieldwork data measurements were taken during the rainy season in October and November of 2018. This period is chosen to maximise the impact of green and lush landscapes on the surrounding plants. Because of the infrequent rainfall and slightly higher air temperatures during the dry season, the surrounding vegetation is less fertile. Meteorological parameters including air temperature(^{o}C), relative humidity (%), and wind velocity (m/s) were measured for the exterior and interior of both case studies. In addition, throughout the duration of each measurement, information was gathered on the vegetation present at each case study site.

Both case studies demonstrate modern and contemporary approaches to architecture and landscaping for medium-sized homes in Malaysia. As control variables, similar building designs, ages, and construction methods were chosen. The vegetations structure, density, and maturity of the surrounding vegetation in the area of the case study are different **(refer Figure 7 & 8)**.

Figure 7 : Case Study 1

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Figure 8 : Case Study 2

Two units of the Microclimate Monitoring system (HD32.1), which are portable meteorological instruments, were installed on the exterior of the case study building. In the meantime, one Indoor Air Monitoring System instrument (HD37AB1347) was installed within the building. The installation of exterior instruments is performed daily in the early morning hours, and the data logger begins at 7.30 am and runs until 6 pm. Exterior instruments are positioned at a height of 1 metre above the ground and approximately 3 metres away from the exterior wall. At the same height, the interior instrument was set up for 24 hours and operated for the duration of the seven-day measurement period. The sampling interval was determined to be 30 minutes per hour. The exterior and interior instruments of both case studies as shown in **Figure 9** are placed in positions as similar as possible. Periodic inspections of the study area have been conducted to ensure that the instruments are in working order and that all weather events have been recorded throughout the measurement period. Due to a technical error with the instruments, the field measurement results of both case studies were compared and analyzed for only five days.

Figure 9 : Instruments for On-Site Measurement Used For Both Case Studies

Data Collection and Analysis

The following table and graphs summarise the data collected over a five-day period that examined the effects of different vegetation structures on various meteorological parameters. As shown in **Figure 10**, the outdoor ambient temperature for CS1 over a five-day period show an inconsistent pattern, particularly on days two and three, whereas the indoor temperature shows a small difference. During the monitoring period, the outdoor air temperature ranged from 23°C to 37°C, peaking at 36.5ºC at 3 o'clock on the first day. On day two, between around

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9:00 and 9:30 in the morning, a temperature differential of 4.25ºC was measured in the outdoor environment. From 7:30 a.m. onwards, except for days 4 and 5, the average indoor ambient temperature in the building was 31℃. The temperature ranged from 29 ° c to 33ºC. The highest indoor air temperature of 33.3℃ being recorded at 3:30 p.m. on day one. The maximum indoor temperature difference of 0.60ºC was recorded on day one, approximately between 2:30 p.m. and 3:00 p.m.

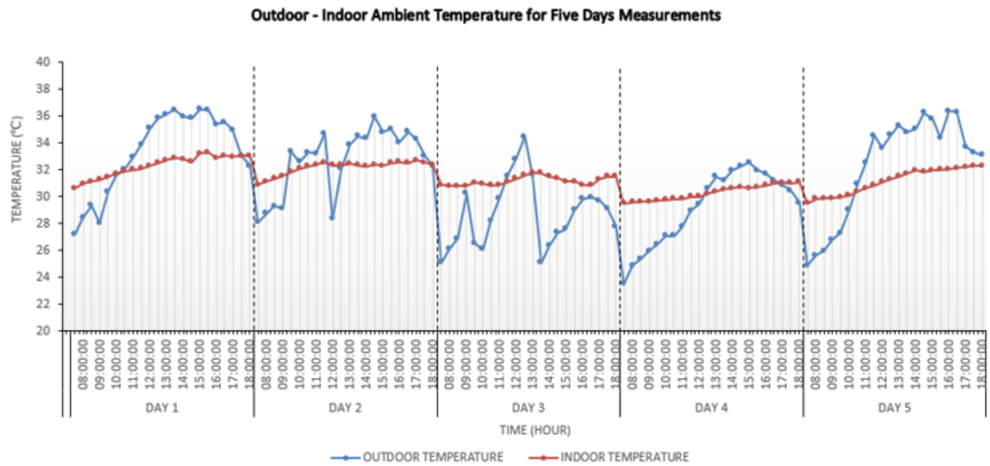

Figure 10: Outdoor-Indoor Ambient Temperature Readings for the CS1

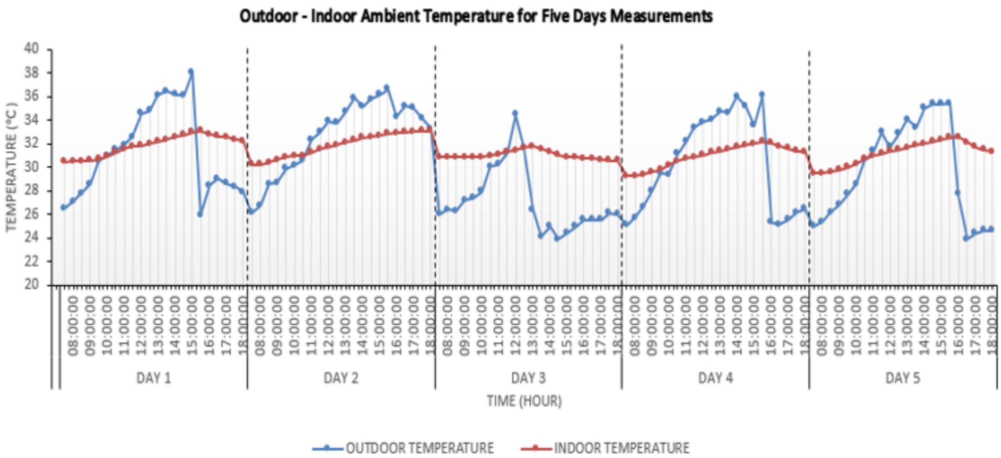

Figure 11: Outdoor-Indoor Ambient Temperature Readings for the CS2

The five-day trend in CS2's outdoor ambient temperature data is similarly irregular, except on day two. The contrast with indoor temperatures is drastic, as shown in **Figure 11**. During the monitoring period, the outdoor air temperature ranged from 24℃ to 38℃, peaking at 38.1℃ at 3 o'clock on the first day. Meanwhile, the indoor ambient temperature ranged from 29 to 33℃, with an average of 31℃. When there were temperature disparities between the interior and exterior, the building's concrete roof and brick walls absorbed the heat from the sun and transferred it inside. On both days, at 3:30 and 5:30 pm, the indoor air temperature reached a peak of 33.1°C.

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Figure 12 displays the five-day measurements of outdoor-indoor relative humidity percentage monitored at CS1. In general, an inconsistent fluctuating pattern of RH was observed throughout the week especially on the day two and three of monitoring period due to the variation of weather condition. The outdoor relative humidity measured ranged from 36% to 96%. The highest percentages of humidity were observed generally in the mornings and late evenings, with the highest value of 96.85 percent recorded around 3:30 p.m. on day three. Meanwhile, RH inside the building remained relatively constant at a percentage anywhere from 58% to 78%. On day one, at 3:00 p.m., the RH inside was at its lowest, at 58.2%, with the highest RH recorded on day five, at 9:00 a.m., at 78.3%.

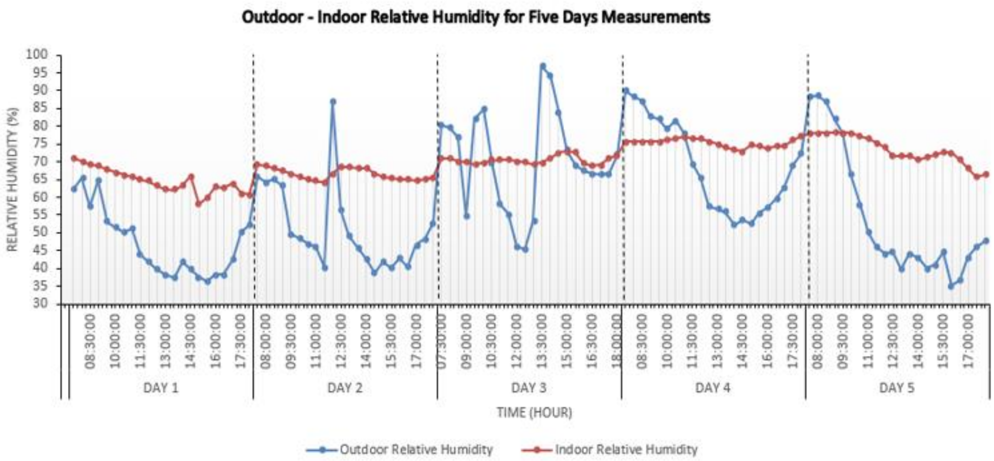

Figure 12: Outdoor-Indoor Relative Humidity Pattern for the CS1

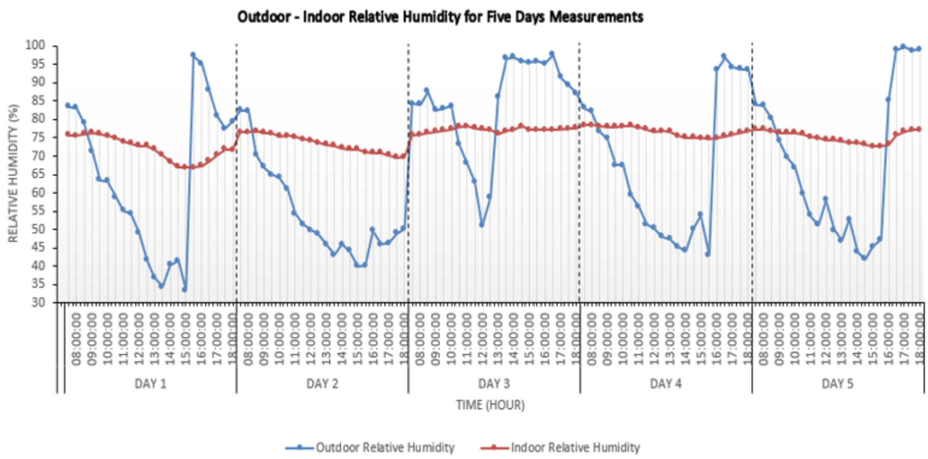

Figure 13: Outdoor-Indoor Relative Humidity Pattern for the CS2

Outdoor relative humidity for CS2 showed a generally irregular pattern as shown in **Figure 13**, with large swings in the RH reading throughout the surveillance period, except on day 2. The outdoor RH measured ranged from 33% to up to 99%. On the day five of observation, the humidity peaked at 99.7% around 5 p.m., as is typically on the mornings and late evenings. Meanwhile, the lowest values were observed on day one at 3:00 p.m., at 33.4%. However, during the surveillance period, a consistent pattern of indoor RH was observed, with only a modest range of variation from 66% to 78%. According to the data, the RH inside was 66.6 %

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at 3:00 and 3:30 on the first day. On day four of the monitoring period, between 7:30 and 8:00 a.m., the RH was at its highest indoor level of 78.5%.

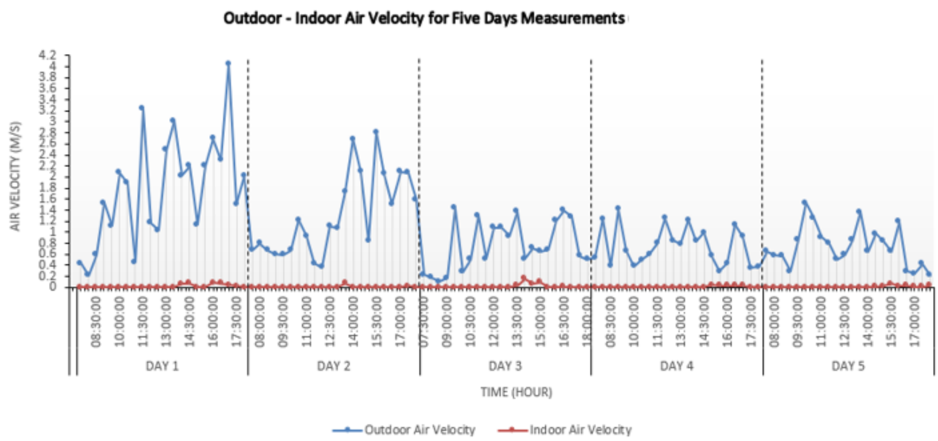

Figure 14: Outdoor-Indoor Air Velocity Readings for the CS1

Outdoor air velocity fluctuated much more than indoor air velocity throughout the week for CS1(refer **Figure 14**). Outdoor air velocity was 0.11–4.05 m/s. On day one, 5:00 p.m. air velocity reached the maximum value of 4.05 m/s. Meanwhile, the minimum value of 0.11 m/s being observed at 8:30 a.m. on day three of monitoring period. In contrast, the measured velocities of the air inside buildings show a horizontal pattern, from 0.00 to 0.16 m/s. When compared to the minimum limit set by ASHREA of 0.25 m/s of air movement and the requirement set by MS 1525 of 0.15 to 0.50 m/s of good air velocity, these results were quite low. Analyses of air velocity data of CS2 **(Figure 15)** shows that on day five, at 4.00 p.m., the outdoor air velocity peaked at 2.68m/s. Meanwhile, the lowest value of 0.16m/s was recorded at 9:30 a.m. on the first day of the monitoring period. Meanwhile, the indoor air velocity data exhibits a horizontal pattern throughout the entire observation week, averaging 0.00 m/s. The case study building had no occupants and no open windows or doors during the monitoring period, which could explain the lack of air circulation.

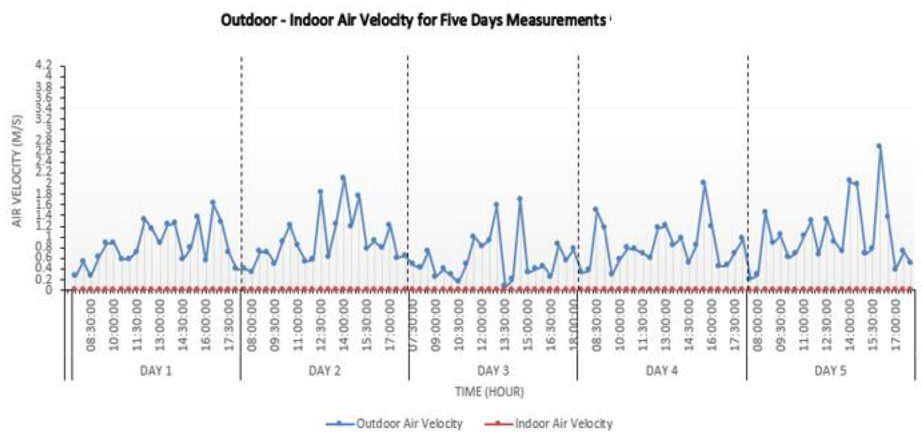

Figure 15: Outdoor-Indoor Air Velocity Readings for the CS2

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Comparison of Data Analysis

Details observation of all meteorological parameters measured for the 5-day analysis acquired for each case study monitored is average and summarised in **Table 1**. Data analyses on minimum, maximum, average values, and outdoor-indoor temperature different for five-day measurements were tabulated below.

Table 1: Summary of Average 5 Days Analyses of Meteorological Parameters Collected for CS1 and CS2.

Criteria	(1) Temp (°C)		(1) RH (%)		(1) Air Vel. (m/s)	
	CS1	CS2	CS1	CS2	CS1	CS2
Max Avg.	33.7	34.2	77.3	83.3	1.74	1.31
Min Avg.	25.8	26.0	47.5	49.4	0.46	0.34
Avg.	31.3	30.4	58.2	67.3	1.07	0.84
Criteria	(2) Temp (°C)		(2) RH (%)		(2) Air Vel. (m/s)	
	CS1	CS2	CS1	CS2	CS1	CS2
Max Avg.	32.1	32.2	73.5	76.3	0.04	0.00
Min Avg.	30.3	30.2	69.1	66.8	0.00	0.00
Avg.	31.4	31.4	71.5	72.0	0.01	0.00
Quartile	(1)-(2) Temp diff.		(1)-(2) RH diff.		(1)-(2) Air Vel. diff.	
Q1	2.31°C	2.02°C	6.11%	7.40%	0.78m/s	0.63m/s
Q2	1.27°C	1.35°C	18.95%	16.97%	1.22m/s	1.04m/s
Q3	1.19°C	2.73°C	18.39%	8.88%	1.21m/s	0.88m/s

**(1) : Outdoor* **(2) : Indoor*
**Temp : Temperature* **RH : Relative Humidity* **Air Vel. : Air Velocity*

Conclusion

In conclusion, the analyses of the effects of VC on the meteorological parameters showed that the outdoor-indoor ambient temperature was highest in CS2 at 11:00 a.m., in Quartile 1, compared to CS1.According to the findings, CS1 and CS2 have a minimal difference in the lowest average indoor ambient temperature of 25.8°C and 26°C, respectively. In addition, CS2 had the lowest indoor temperature recorded when compared to CS2 in similar Quartile 1. From 11:15 a.m. to 2:30 p.m., the average outdoor temperature trend was different in Quartile 2, with CS1 continuing to show the highest value when compared to CS2 at 1.00 p.m. Similarly, in Quartile 2, CS1 had the lowest average indoor temperature values when compared to CS2. From 2:45 p.m. to 6:00 p.m. in Quartile 3, CS1 still had the highest outdoor temperature in the early Quartile, followed by CS2. When the temperature dropped rapidly in the evening due to sunset, the scenario remained constant, with CS1 recording the highest outdoor temperature at 6:00 pm. Meanwhile, CS2 recorded the lowest outdoor ambient temperature at the time. Analyses of the difference in outdoor and indoor ambient temperature for each case study revealed that in Quartile 1, CS1 has the greatest outdoor-indoor ambient temperature difference of 2.31°C, while CS2 has the smallest difference of 2.02°C. The CS1 had the smallest outdoor-

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indoor temperature difference, which was 1.97°C. In Quartiles 2 and 3, CS2 recorded the highest ambient temperature differences of 1.35°C and 2.73ºC, respectively.

Overall, CS2 recorded the higher outdoor relative humidity in Quartile 1 for the average five-day surveillance period, particularly at 11:00 a.m., at 83.3%, compared to 77.3 for CS1. In terms of indoor relative humidity percentage, CS2 had the highest value in Quartile 1 when compared to CS2 RH readings in the same Quartile. While CS2 had the lowest reading of 66.8%, which was the same as the outdoor relative humidity reading. From 11:15 a.m. to 2:30 p.m., we saw a consistent upward trend in the average outdoor relative humidity; however, at 1.00 pm., CS2 recorded the highest relative humidity compared to CS1. Indoor relative humidity showed a similar trend, with CS2 having the highest readings compared to CS1 in Quartile 2. Even in Quartile 3, from 2:45 to 6:00 p.m., CS1 still had the highest relative humidity. As the evening temperature dropped precipitously, CS1's relative humidity readings gradually increased, peaking at 6:00 pm. The lowest outdoor relative humidity was recorded by CS2 at 66.8. Overall, for RH readings the CS2 recorded the highest outdoor relative humidity for the average five days of observation, compared to CS1. The CS2 also demonstrated a similar trend in indoor relative humidity, with highest readings of 72.0%.

For analyses of the effect of VC on air velocity, it is evident that CS1 had a higher average outdoor air velocity reading of 0.51 m/s at 7:30 a.m., Quartile 1, than CS2. The highest outdoor air velocity over a typical five-day surveillance period was also recorded by CS1 at 11:00 a.m. In contrast, in Quartile 1 of the analysis of indoor air velocity, no air velocity readings were found in either case study. Similarly, Quartile 2 saw CS1 continue to show the highest air velocity readings compared to other CS2 from 11:15 a.m. to 2:30 p.m., with a peak at 1:30 p.m. and a reading of 1.39 m/s. In Quartile 3 from 2:45 p.m. to 6:00 p.m., CS1 still showed the highest outdoor air velocity, peaking at 5:00 p.m. with a reading of 1.72 m/s. Quartile 2 and 3 had the slowest average indoor air velocities across all case studies, at just 0.01 m/s to 0.02 m/s. When comparing the CS1 and CS2, the average air velocity over the course of five days was 1.07 m/s for the CS1. CS1 has a greater outdoor-indoor air velocity difference of 0.78m/s in Quartile 1 than CS2 does of 0.63m/s. CS1 also had the highest air velocity differences (1.22m/s in Quartile 2 and 1.21m/s in Quartile 3) in both of those quartiles. These results indicate that outdoor air velocity has a significant effect on VCC differences for each case study. The analysis clearly showed that CS1 with the least vegetation density recorded the highest outdoor air velocity readings for the surveillance period compared to CS2.

Finally, as a conclusion, from the data analysis that has been carried out, this study has achieved the objective of the study which clearly shows that the difference in vegetation structure does not really affect the environmental climate of an area. This may be due to other factors such as vegetation density and landscape configuration such as the distance of plants from the house, the design and arrangement of the vegetations. further research should be conducted by taking samples from other case studies with a variety of vegetation structure types. the variety of vegetation structures indirectly has the potential to provide better research results. this is because past studies clearly show that vegetation has a major impact on global climate regulation because it modifies the transfer of heat and moisture, provides a cooling effect, and decreases the ambient temperature of the atmosphere. A ecosystem's local climate is largely determined by the structure of its vegetation, which is regulated by meteorological factors. Vegetation's height, shape, density of plants, leaf area index, canopy colour, and so on all have their own unique impact on the weather.

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