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ASPECT OF TREE FOR CONTROLLING OUTDOOR MICROCLIMATE: A CASE STUDY IN IIUM

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ABSTRACT

Trees have been known for their potential in controlling the microclimate. Trees can be differentiated based on species and their physical aspect or character. This aspect has certain influence in the screening potential of trees on solar radiation from reaching the ground. Identifying the characteristic of tree capable in controlling the environmental problem at most is going to be the choice in designing outdoor landscape with green element inside of it. Tree functioning to mitigate environmental problem is highly needed to improve the air quality and make a proper shelter to protect from direct sunlight heat. Understanding the tree is difficult as tree even between the same species have their own variable strength level that is able to influence changes to the environment microclimate. Many factors needed to be concern regarding the health of trees, shape, and size and planting method required to make an effective impact. Other factors that will be also considered are wind speed, wind direction, air temperature and relative air humidity in order to precisely describe the actual site microclimate qualities. Observation and data collection in this study can help appropriately assess the environmental benefits provided by green trees and useful inputs in designing landscape spaces to attain the result for sustainable design. This paper will suggest the crucial aspect of tree that able to control outdoor microclimate as future design guideline in proposing a park design.

Keywords: tree physical aspect, solar radiation, microclimate, urban heat island, sustainable design.

INTRODUCTION

A tree generally known as green element, softscape material or vegetation which meant for human being as landscape resource that hold major influence in many particular aspect of human life cycle. This research paper focuses on the aspect of suitable tree for controlling outdoor microclimate. The approach is to understand the crucial relationship of existing tree planted and microclimate surrounding the IIUM campus. Research data collected include the information on the physical characteristic of tree, spatial microclimate pattern, implication of landscape ecology and softscape elements of IIUM campus.

Research for aspect of tree refers as a study to the physical form and characteristic of tree, its species and the tree interaction to the environment that change over a period of time and how the tree can be applied to make use of the tree function in real time situation. It is to determine the norm and oddities of the tree in different perspective that may help in providing beneficial impact at its best.

By understanding the possible aspect of tree, it helps to create guideline for the best practice in using soft material to be applied for designing outdoor open space both directly and indirectly. Each approach will have countermeasure consideration for the tree to improve a landscape environment from problems regarding relative humidity

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level, temperature, wind buffer and solar radiation shelter. Eliminating these problems require a significant aspect of soft material to ensure high success rate in controlling outdoor microclimate parameter especially in IIUM campus as it located at the earth equator with high temperature every year. It can be something for educational and work purposes as it explains the importance for people to appreciate the value and acknowledge the respectful benefits it has to offer.

AIM AND OBJECTIVES

For the sake of achieving the goal of this research paper, a number of objectives were used to guide the research in making the steps required are properly arranged in the right order. Each objective derived from the identification of surfacing research problems and research questions from the investigated site. The objectives determine the pattern of findings and conclusions which is predicted to get at the end of the data collection.

The study is to understand the type and physical characteristic of a certain tree found on site that capable of being the factor in changing outdoor microclimate. Data gathered may help in making a clearer reason in order to understand a tree which act as the base to further expand the possible relation with other aspect either with people, environment or even with the other green element. Core data of tree help to examine the relationship of tree and the outdoor microclimate. Verifying this may lead towards narrowing down the point of searching the data which give significant influence of tree to the environment. The interaction will affect each other in specific factor that include relative humidity, air temperature, solar radiation and wind speed and its direction. The data collected will be arranged accordingly to see the changes of data in a period of time with other factors.

This research requires quantitative method which relies on measurable type of data (Burn, 2000). Quantitative data provide data which use integrated devices since it able to precisely measure data using numerical digit. Such data strengthen the reasons of certain reading as statistic evaluation is accurate and near perfect since it is based solely on raw data reading. The collected raw data is to be sorted to build a comprehensive understanding of these elements that may influence the value of a certain outdoor environment.

TREE PHYSICAL CHARACTERISTIC AND OUTDOOR MICROCLIMATE PATTERN

Tree physical form, fitness and size are varying from each other and depend on how much the tree consume for nutrient in growing process. For actively growing trees, in photosynthesis process a tree will eventually remodeled into carbon containing compounds which make up the part of tree trunks, stems, foliage, and roots by referred to Starr et al. (2009). A tree type or species that have a bigger growth form have a better and higher impact to the environment. Such tree could offer a well-made shelter to block solar radiation from reaching the earth surface.

However, a number of trees and the exact type and species are required to maintain a long sustainable low temperature. As mentioned by Hui (2006), the balance of proposing right quantity of softscape and hardscape elements is still a bit off, thus exceed the maximum load of carrying capacity of an area. Overload of hardscape material could lead to the existence of urban heat island (UHI). Such environmental problem could happen as hardscape element trapped moisture from

undergo the process of evaporation. Moisture is required to be released from the soil to cool down the air temperature.

Humidity is a measure of the amount of water vapor in the air (Ahrens, 2007). As long as heat present, the heat energy will be absorbed by moisture and released to the air in exchange for the use of heat energy. When heat ratio is overload on humidity rate, surrounding air temperature will rise significantly due to lack of humidity rate that is capable to handle the heat amount. From this research study, the finding from the data should be able to show the value of relative humidity rate of certain is required to handle heat from outdoor microclimate. Plus, the data is expected to track the best and possible method to control air temperature to the considerable level.

SITE INVESTIGATION

IIUM campus in Gombak area is chosen as the site study. The reason of choosing this site because this area is located at suburban area surrounded with trees. As this area have many hardscape material, some green landscape may be affected with the heat produced by hardscape material such as concrete buildings and paved soil surface. With current setting, research may be conducted to differentiate microclimate parameter between an area with lot of trees and area with lot of hardscape material constructed. This will also help to generate idea on how a tree is capable on controlling outdoor microclimate to an extreme condition.

Four sites in IIUM campus that represent Mahallah Ameenah open space, river side between Kulliyyah of Architecture and Environmental Design (KAED) and second gate guard post, IIUM square parade or helipad and rector residential area are where the research study was conducted during the research process. River side and rector house area considered to be more on the green covered site type while the other two are more toward hardscape material site type. There are two categories of data resource collected which are primary data and secondary data. Primary data collection had been conducted through real time situation by doing on site observation. Meanwhile, secondary data are reviewed through relevant studies and the previous researchers whose had been studying about the site to improve understanding and gain basic knowledge of tree characteristic, definition of outdoor microclimate, interaction of tree and outdoor microclimate and evaluate the impact to the environment.

Research study had been carried out by basing on both type of quantitative data and qualitative data collection. The observation techniques used to retrieve data collection were through the books, articles, journal, laboratory's reading equipment, basic stationary tools and photographic survey.

RESEARCH METHODOLOGY

The aim of this study is to identify the influence of the tree aspects on solar radiation penetration to the ground with focus on typical trees that can be found in Malaysia. Four case study sites at the International Islamic University Malaysia (IIUM) were identified and selected in conducting this study refer figure 1.The four sites were categorized into two types of open spaces: green and exposed, as shown in Table 1.

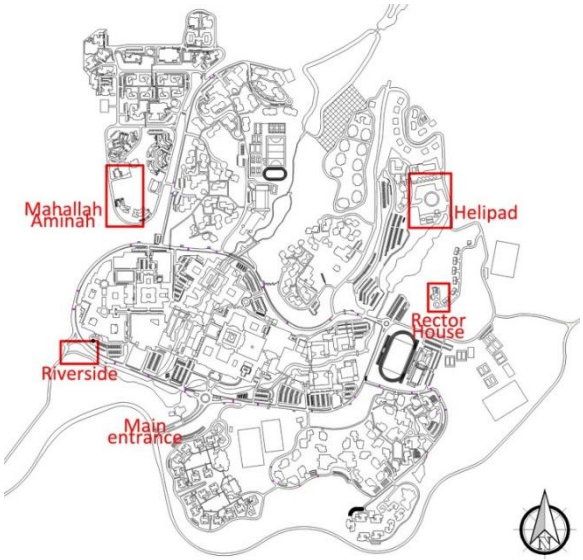

Figure 1: The layout of IIUM indicating the location of the four sites

Table 1: The four sites for research case study in the IIUM and their categorization

Category	Test sites	Specific site criteria
Green space (GS)	Riverside (RS)	Plenty of trees and shrubs with a stream flowing within the site
	Rector's house (RC)	On a hill top, surrounded with greeneries and plenty of trees
Exposed space (ES)	Mahallah Aminah (MA)	Wide turfed open field with small amount of trees, and partially surrounded by buildings
	Helipad (HP)	Wide tarmac area with small number of trees at the perimeter

The process of data collection was conducted within the month of Marchand April 2014 where the position of the sun is considered high in the Kuala Lumpur's sky – refer to figure 2, which was identified using the online tools www.sunearthtools.com. This is also the time where a haze occurred during the research and data collection.

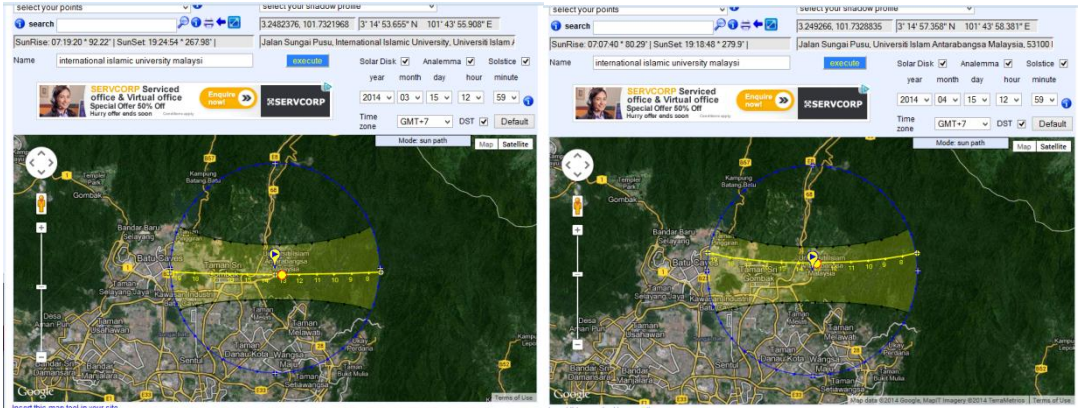

Figure 2: The sun position in the Kuala Lumpur sky in March (left) and April(right) 2014

Identification of area of study

The investigated trees are located at the four test sites as mentioned previously. These sites were identified based on two general categories which are green space and

exposed space. “Green space” is referring to space with a lot of big and mature trees as well as being well turfed, while “exposed space” reflected a space that has small amount of trees which caused it to be exposed directly to the sun. Besides that, the ground surface materials are also taken as among the factors considered in selecting the sites for that research (Abu Bakar, et al, 2013).

Trees selection and the process of inventory

Basically all trees within the four sites were identified by their common and scientific names with total up to 139 trees with 19 different tree species. Mature trees with trunk height not less than 1.5 meter were identified. The trees were examined, measured and inventoried in advanced prior to measuring the solar radiation underneath the tree canopy. The aspects of trees that were measured and inventoried are the trunk height (**TH**), crown height (**CH**), diameter of the canopy (**CD**), foliage density (**FD**), single leaf size (**LS**), twig (**T**) and branching structure (**BS**).Whenever the trees were higher than the staff used (more than five meters) – approximation by ratio method was applied. Figure 3 shows the equipment used in the process of the measurement (100 meter measuring tape and staff).

Figure 3: the process and equipment used to measure in the inventory the tree height

(1) (2) (3)

Figure 4: types of foliage density: (1) loose density, (2) medium density & (3) dense Top - side view/elevation and below - canopy view from underneath

Based on field observation and adoption of the Likert scale, generally the foliage density can be categorized into three which are loose density, medium density and dense, and these categories are numbered as (1), (2) and (3) accordingly for the purpose of analysis. Figure 2 shows the examples of trees and their foliage densities of these three classifications.

Leaf size (LS), twigs (T) and branching structure (BS) are seen as important tree aspects that influence the solar radiation screening potential of trees. For each species, mature trees were selected to measure their single leaf size (length and width – refer figure Y). Twig and branching structure were observed and upon identification, they were classified and recorded based on categories such as side-by-side and one-by-one, and picturesque, conical, rounded and irregular, respectively.

Environmental parameter and solar radiation reading process

In measuring and recording solar radiation and environmental parameters, two sites are identified for a day – refer table 2.

Date	Site	API value:
3March2014	Helipad, Rectory, Riverside, Mahallah Ameenah	105
4March2014		110
5March2014		80
8March2014		59
9March2014		103
10March2014		107
14March2014		176
15March2014		121
16March2014		170

Table 2: the dates and sites for solar radiation and environmental parameter measurement for research

Other environmental parameter measured is air temperature (ºC), relative humidity (%), wind speed (m/s) and wind direction (º). Two types of solar radiations reading were measured which are direct solar radiation and solar radiation under the tree canopies, for the purpose of comparing the screening potential of each tree. Hence, two units of solar meter model ISO-TECH ISM 410 were used – refer Figure 4.The accuracy level is ±5%. One unit was located stationary under the direct sunlight. The exposed solar radiation data was manually recorded after gathering the data by each tree. While the other unit was hand-held to measure solar radiation underneath tree canopy with time allocated for complete reading for each tree is 2minutes. 30 second for each spot with three different measurements. Reading started from North side, then East side, next is West side and last would be South side of a tree. After the reading under a tree canopy, next will be exposed or direct solar radiation reading from the sun.It was run at open space which is used to know the exact amount of each tree able to screen solar radiation using it canopy.

Figure5: the solar meter used and the process to measure solar radiation (two images on left) and the outdoor HOBO and Kestrel 4500 (two images on right)

In measuring the air temperature and relative humidity, four units of outdoor HOBO were used where two units were allocated per site, and two units of Kestrel 4500 portable pocket weather station were used where one unit was allocated per site – refer figure 4. These HOBO devices were stationed at shaded area (indicated as red circle) and exposed area (indicated as red square) within the site – refer figure 8, while each Kestrel 4500 was located at exposed area next to the HOBO. These two types of devices were installed at sites for six days in different location between 8:00 a.m. to 6:00 p.m. respectively. Hence, measurement was taken for three days in total for each of the four sites.

Figure 6: locations of equipment for each site (indicated in red spots) where the square shape meant for both Kestrel and Hobo while circle shape for under a tree shade

No	Equipment	Readings measured	Unit	No. of unit utilized
1	Solar radiation meter	solar radiation	W/m^2	2
2	Kestrel portable pocket weather station	wind speed	m/s	2
		wind direction	°	
3	Outdoor HOBO data logger	air temperature	°C	4
		relative humidity	%	

Table 3: Equipment used and unit of readings

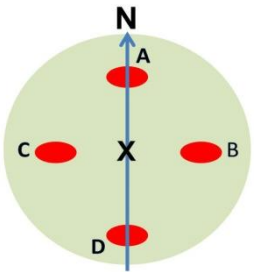

Figure 7: A person must be standing under one tree canopy with body facing the north when taking the solar radiation reading

Following the analysis on daily mean solar radiation data for Kuala Lumpur obtained from the Meteorology Department, Malaysia (Abu Bakar, 2007), the process of solar radiation measurement were decided to be conducted between 12noon until 2pm due to the high reading of solar radiation observed with an average reading beyond 400 Wh/m^2 (1 year data).The height of the equipment to record the reading for the solar radiation underneath the tree canopy is set at human level of 1.5 meter from the ground at taken at three points done consecutively – A, B, C and D (refer figure 7)

The equipment is positioned well to allow its sensor to capture the solar radiation reading while allowing the reading to be read and recorded. Three readings were recorded manually three times at each point with the interval of five seconds, and averaged. Between points, the interval is about one minute. These readings were then averaged, and further compared with those taken under the direct sunlight. These data were then keyed-in the Microsoft Excel for analysis. The rest of the environmental parameter was recorded from 8am until 6pm. Four units of outdoor HOBO were used to record data.

Each site has different number of trees where RC has the biggest number followed by MA, RS and HP, hence it affects the period of recording the data. Haze was experienced for several days as indicated in the said table and it affected the solar radiation as well as other environmental parameter measurement.

Monitoring equipment was used to record the reading of microclimate data. Such data would be the relative humidity and air temperature using HOBO data logger and wind speed with the direction using Kestrel meter that record data automatically on site depending on the time interval.

DATA ANALYSIS

Based on the methodology applied in the research, a number of data has been analyzed and able to achieve the result to fulfill the aim and objectives of the research study which is to verify the relationship between tree and outdoor microclimate. The research has reached the understanding of how the interactions occur and the possible significant changes between the two.

Each part of plants has their own specific factor that affects the capability rate of that plant to absorb and reflect solar radiation. Commonly most factors are found in tree crown and they are tree form leaf size, branching structure, twig formation, and crown height.

During research we found that, the branching structure of the plant influence the most solar radiation filtering capability of any plant involve in the study. For example, spreading branching structure of *Samanea saman* tree give the plant wider coverage of canopy but lower density of crown. While *Cinnamomum verum* which have more up straight branching formation have smaller coverage of canopy but denser crown. The tree branching structure also determines the whole overall form of trees. For example; *Filicium decipiens* which have the same branching structure as *Cinnamomum verum* have the same columnar form of tree. There are also other plant forms that were found during the research which are: picturesque *(Plumeria rubra*), conical (*Calleryaatro purpurea*), and irregular (*Cocos nucifera*).

Second most influential factor of trees that affect the tree's solar radiation filtering capability is the twig formation. There are two types of twig formation that have been identified o research subject which are side by side and one by one:

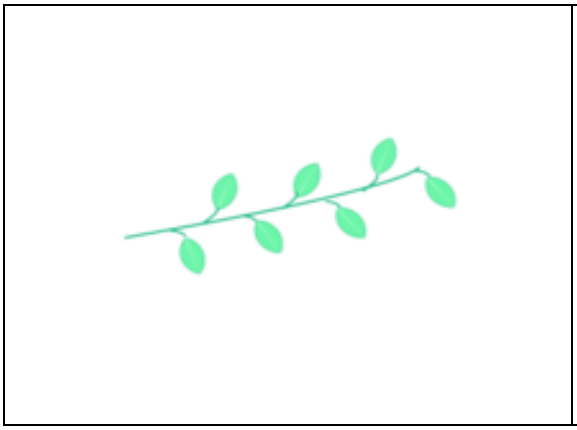

Figure 8: one by one leaf formation

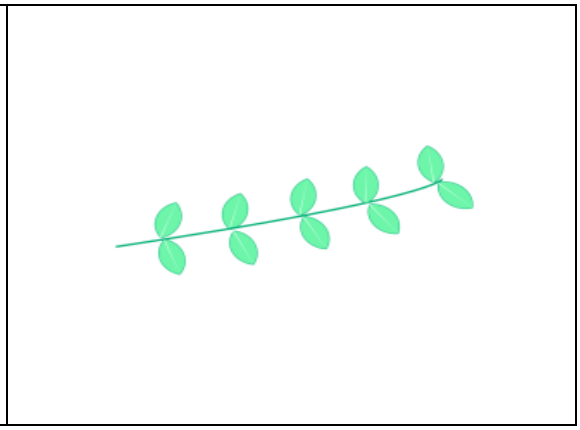

Figure 9: side by side leaf formation

The plant which having side by side twig formation has the denser leaves development. This is because this type of twig formation allows the plant to grow more leaves compared to the plant that have one by one twig formation. One by one leaf formation was disadvantageous to form a denser foliage as the space beside has no leaf to cover the other side. Meanwhile, type of tree with side by side leaf

formation is able to cover both sides of twig at the same time. However, depending on twig formation alone is still not enough.

Thirdly the height of crown from the ground surface also act as the affecting factor that permit the trees solar radiation capability to filter solar radiation especially the solar radiation that diffuse from other landscape element from all site of the trees. The trees that have dense foliage but have too high trunk height cannot filter the solar radiation well compared to the shorter trees that have same density of foliage. For examples; *Albizia falcate* tree that grow at the riverside and the other same species & condition of trees but shorter height that grow at the Helipad area.

Figure 10: dense and shorter *Albiziafalcata* left and dense and higher *Albiziafalcata*

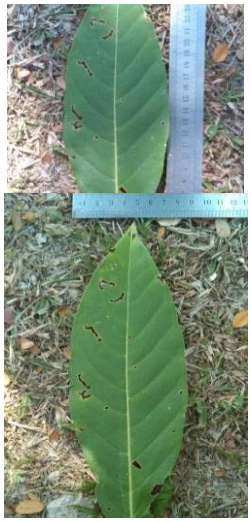

Figure 11: measuring the total surface area of leaf through width and length

Fourthly, the factor that basically known for its function as solar radiation filtering agent, is the leaf total surface area. Leaves also act as one indicator for researcher to know the current health condition of tree and the most important thing is leaf of tree sustains the tree. In congestion with this research the data about the actual total surface area of tree is essential to help us investigate the amount of solar radiation that can be filtered by the tree. *Mangifera indica* and *Lagerstroemia indica* both have a big size and shape of leaf. These trees leaf form is different with *Hopea odorata* and *Acacia mangium* that have rather smaller size leaf. Below is the table of plant suitability and efficiency to filter the solar radiation according to the species. To get this data we take the average of highest exposed solar radiation for every place as 100% percent of solar radiation that will be experience by the tree. Than they are ranks from the best solar radiation filtering capability.

No	Botanical Name	Common Name	Qty.	Site location	Tree code	SR reading under tree canopy (W/m2)	Screened SR by tree (%)	SR reading under direct sunlight (W/m2)
1	Samanea saman	Rain tree	18	Helipad	3	Maximum: 207.1	6%	219.7
2				Mahallah	1	Minimum: 60.3	95%	1130.7
3	Delonix regia	Red flame	4	Rectory	8	Maximum: 140.1	81%	751
4				Rectory	6	Minimum: 96.8	90%	1010.7
5	Filicium decipiens	Fern tree	1	Rectory	10	Maximum: 53.3	90%	536
6						Minimum: 53.3		
7	Hopea odorata	Cengal pasir	24	Rectory	31	Maximum: 229.4	43%	404
8				Rectory	46	Minimum: 58.2	89%	509
9	Cocos nucifera	Coconut tree	10	Rectory	57	Maximum: 86.3	80%	430
10				Rectory	58	Minimum: 57.5	90%	578.7
11	Plumeria rubra	Red frangipani	4	Rectory	66	Maximum: 81.9	77%	348.7
12				Rectory	64	Minimum: 66.4	86%	468
13	Jacaranda filicifolia	Jacaranda	1	Rectory	52	Maximum: 211.5	51%	433.7
14						Minimum: 211.5		
15	Caesalpinia ferrea	Leopard tree	4	Mahallah	8	Maximum: 275.5	41%	466
16				Mahallah	6	Minimum: 59.6	86%	425
17	Livistonia rotundifolia	Serdang	4	Mahallah	43	Maximum: 62.8	90%	657
18				Mahallah	41	Minimum: 48.8	92%	639
19	Lagerstroemia speciosa	Pride of India	10	Riverside	5	Maximum: 366.1	56%	835
20				Riverside	1	Minimum: 253.4	75%	1009
21	Albizia falcata	Silk tree	8	Helipad	6	Maximum: 360.3	59%	882
22				Rectory	27	Minimum: 145.2	70%	485
23	Acacia mangium	Mangium	5	Rectory	4	Maximum: 319.3	61%	818.7
24				Mahallah	44	Minimum: 159.8	63%	434.7
25	Cinnamomum verum	Cinamomum	17	Mahallah	13	Maximum: 158.0	62%	421
26				Rectory	17	Minimum: 139.7	74%	539
27	Artocarpus odoratissimus	Terap	1	Riverside	18	Maximum: 322.2	63%	861
28						Minimum: 322.2		
29	Callerya atropurpurea / Melia indica	Purple Melia	4	Helipad	8	Maximum: 494.2	41%	835.7
30				Rectory	68	Minimum: 168.8	69%	536.7
31	Ficus benjamina	Weeping fig	3	Mahallah	16	Maximum: 244.7	65%	689.3
32				Mahallah	17	Minimum: 242.3	67%	730.7
33	Dillenia indica	Elephant apple	2	Mahallah	20	Maximum: 273.8	63%	732
34				Mahallah	19	Minimum: 257.0	65%	744.7
35	Mangifera indica	Mango	7	Mahallah	22	Maximum: 158.8	78%	723
36				Mahallah	26	Minimum: 125.5	83%	734.7
37	Phoenix roebelenii	Dwarf date palm	12	Mahallah	39	Maximum: 360.8	48%	696.3
38				Mahallah	28	Minimum: 310.1	59%	758.3
	Total species and tree	19	139					

Table 4: Table of solar radiation reading for each species and both minimum and maximum measurement of tree to screen solar radiation

LEGEND (for table 4):

Sp. = Species
Qty. = Quantity
SR = Solar Radiation

There are also other environmental factors that influences the microclimate condition of site which are wind direction, wind speed, air temperature and relative air humidity. Wind direction of this area is greatly affected by the geographical factor of this region which is hilly. It is identified by the reading of Kestrel that shows the wind blow toward the north point of the earth during the morning till 12. During the evening till 1800 more fluctuation in data is recorded but it still blowing toward the North and slightly to the North West. The cycle of the fluctuation is completed each 30 minutes for all sites.

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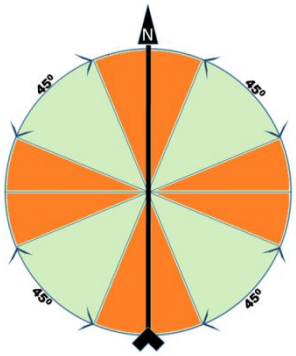

Figure 12: The division of angular data that represent wind direction. Each section cover about 45° and the 0°start at the North point of the

Wind speed is a phenomenon where the molecule of air moving to a place to replace existing air molecule there. This phenomenon generally occurs because of the energy (heat) transfer between hot to cold or cold to hot place. Wind speed help in balancing the air temperature and relative air humidity as when air travels it bring the element with them. Below is graph that show the overall pattern of wind speed at all the site throughout the research

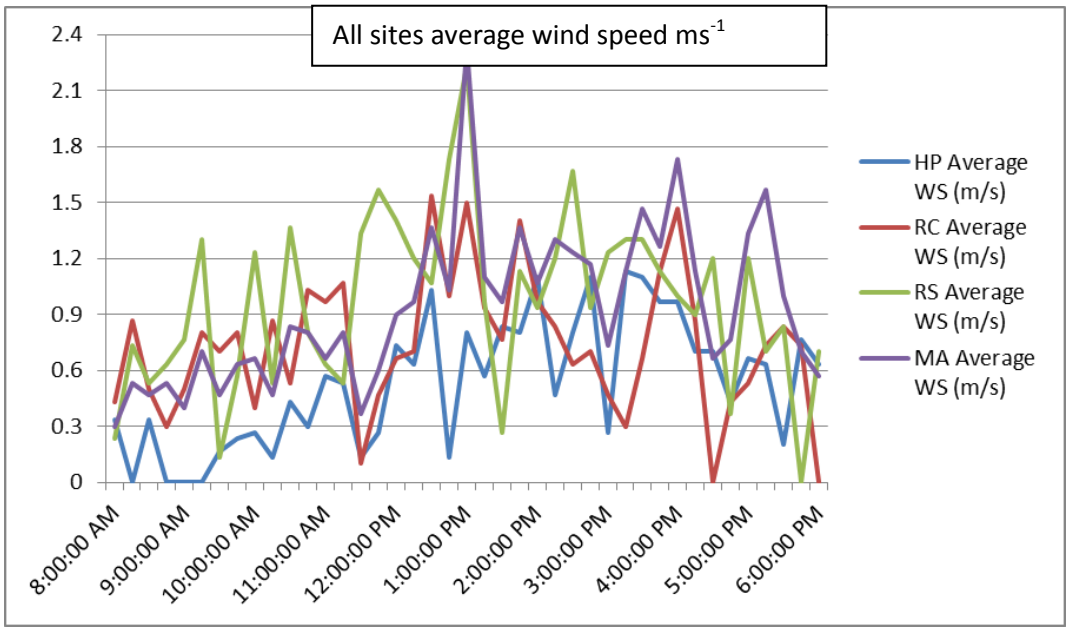

Figure 13: Graph of average wind speed measured for each site

	Helipad	Rectory Residential	Riverside KAED	Mahallah Aminah
Max Wind Speed (average) ms^{-1}	1.633	1.533	2.767	1.789
Time 0000	1715	1230	1600	1715
Date DD,MM,2014	3,15,16 / March / 2014	2,4,16 / March / 2014	5,14,15 / March / 2014	8,9,14 / March / 2014

Table 5: table of Kestrel 4500 data on maximum wind speed at each site

Air temperature plays very important role to sustain human activity in a particular space. During the research, air temperature measurement was held in the

most extreme possible condition where it was 'summer' in this region so that the data is reliable to be use during other season. We also found that, air temperature of surrounding is directly related to the percentage of relative water humidity in the air where; "The higher air temperature, the higher the loss of relative humidity of air".

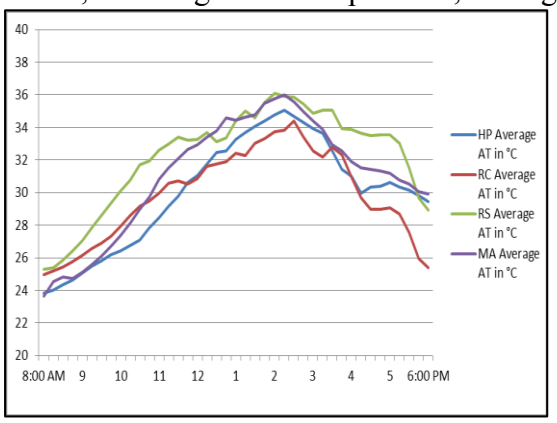

Figure 14:average air temperature reading recorded on an exposed area

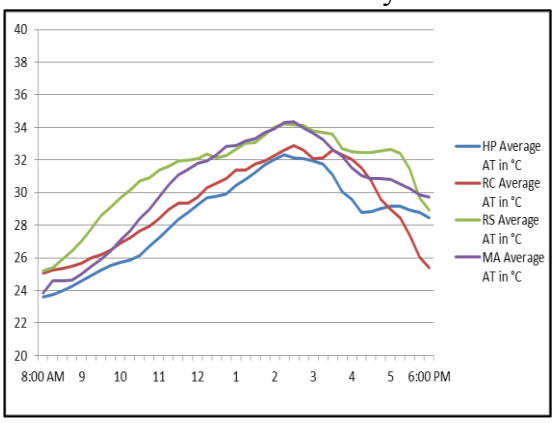

Figure 15: average air temperature reading record under ashade of tree

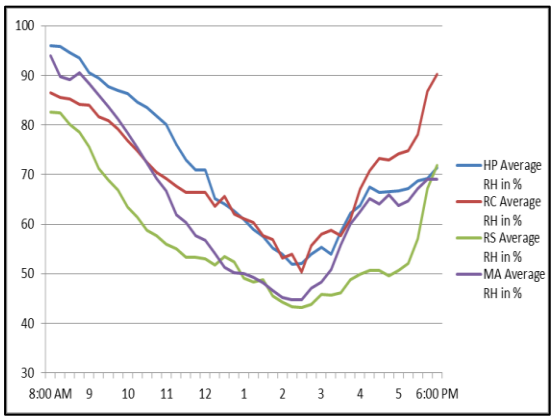

Figure 16: average relative humidity reading recorded on an exposed area

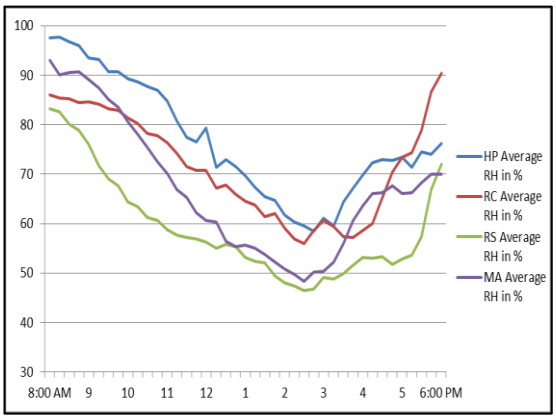

Figure 17: average relative humidity reading recorded under a shade of tree

LEGEND (for figure14, 15, 16, 17):

AT	=	Air temperature	MA	=	Mahallah Ameenah
RH	=	Relative humidity	RC	=	Rector House
HP	=	Helipad	RS	=	Riverside

An analysis of data from Hobo data logger has shown a practical idea and understanding as interaction occurs between different outdoor microclimate parameter. The data also prove that a green shade from tree could make changes to the surrounding air temperature. Tree shade also seems to be able to retain a lower air temperature for a long time. Maintaining low temperature would require a lot amount of moisture in the air. As heat from sunlight prevent moisture from evaporating is blocked by tree foliage, air temperature will response by lowering air temperature.

At peak, the differences of air temperature may reach from 1°C to 2°C higher at open space rather than the shaded area under a tree. During this time, the amount of relative humidity was also different between open space and tree shaded area. A different value from 3% up to 6% may be achieved.

From the analyzed data collected, it can be also concluded that form, size and characteristic of tree offer prominent feature that capable in changing the outdoor microclimate which should also be affecting value of relative humidity, air temperature and solar radiation penetration. This practice would be successful as the use of soft material is in balance properly.

CONCLUSION

Based on this research there are indeed significant value of tree according to species that can be propose in any new or existing development on land. Each part of plant that made up the tree has its own capability in absorbing and reflecting the solar radiation from the sun. Each plant has their own specialty in controlling outdoor microclimate in certain spaces and condition of surrounding. This study also tells us there is also some need of the plant in order for them to survive and serve well. Robustness of plant is closely related to biotic and abiotic factor in environment which they live. Human activities such as open burning have affected the reading of microclimate on the early of March because it also directly affects the quality of air. This worsens the increase of temperature of surrounding involved area. This annual phenomenon also increases the health problem among local people. Some other environmental factor such as wind speed, wind direction, air temperature and relative air humidity are actually working together in providing sustainable local microclimate as what Allah had already imprinted to that place. It is our responsibility to maintain the good environment for our child.

RECOMMENDATION

In order to improve the current microclimatic condition of area of studied sites the local authority should be more concern about functional aspect of the plant species rather than aesthetic value of plant. In designing landscape, the type of trees that will be chosen must appropriate following several guideline to ensure its optimum efficiency in fulfilling its intended function. Such tree would be *Samanea saman*, *Mangifera indica* and *Cinnamomum verum* as these trees were found to have an excel performance in reducing air temperature for a cooler area. For palm tree, it should be *Cocos nucifera dwarf* as it capable to make an area with extreme high temperature for tropical region to have more comfortable area to do outdoor activity.

For example in Mahallah Aminah they planted palm that have low trunk and crown height, and low density of foliage in the middle of the green space where people not even used that particular space that is *Phoenix roebelenii*. Instead of planting this palm, it is better to plant *Cocos nucifera dwarf* which provide a better shelter from sunlight and wider foliage form that allow people to stay under it during the day. The medium height of palm tree also make the foliage closer to earth surface which prevent the palm shade from moving to other side that may happen due to time lapse and earth rotation during the day.

Maintenance of planted trees must also be brought to higher level. As during the field observation there are many trees from *Samanea saman* and *Albizia falcata* which were planted along the pedestrian walkway have brittle branches as they are infected by parasite organism. The fertilizing process must also be done not according to already made schedule but according to the need. For example, a plant that planted at the slope may need more fertilizer than plant that planted at flat ground. For

example, *Samanea saman* species at the Helipad border, they have small leaves and lower density of branch compared to the *Samanea saman* at the flat riverside area.

To avoid worse microclimate factor become worsen like what happen when there is haze, all individual or any party should work together to prevent and avoid open burning whether it big or small. Government as the body that have power on engaging this situation should be more agile and aggressive in performing their duty as the protector of people.

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