Editor

Aida Bulucea

Recent Advances in Environment, Ecosystems and Development

Proceedings of the 13th International Conference on Environment, Ecosystems and Development (EED '15)

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Preface

This year the 13th International Conference on Environment, Ecosystems and Development (EED '15) was held in Kuala Lumpur, Malaysia, April 23-25, 2015. The conference provided a platform to discuss environmental protection, pollution control, quality of water, waste water treatment and management, urban development, ecology, cleaner energy systems, renewable energy systems, biodiversity, waste management etc. with participants from all over the world, both from academia and from industry.

Its success is reflected in the papers received, with participants coming from several countries, allowing a real multinational multicultural exchange of experiences and ideas.

The accepted papers of this conferences are published in this Book that will be sent to international indexes. They will be also available in the E-Library of the WSEAS. Extended versions of the best papers will be promoted to many Journals for further evaluation.

Conferences such as this can only succeed as a team effort, so the Editors want to thank the International Scientific Committee and the Reviewers for their excellent work in reviewing the papers as well as their invaluable input and advice.

The Editors

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Assessing The Microclimate of Green and Less-Green Tropical Landscape Environment

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Abstract: - Landscape settings shape the microclimate or thermal performance of the outdoor environment with vegetation and ground surface materials as among the affecting variables. This paper presents the microclimatic impact of landscape settings of two sites with different landscape environment during the wet and dry monsoon seasons of the tropical environment of Malaysia. The study involves field measurement of air temperature, relative humidity and wind environment from 0800hr to 1700hr, conducted on several days of the said monsoon regimes. The results show significant results in terms of the magnitude of air temperature differences between the studied sites, with similar patterns observed on the relative humidity. The wind environment seems to be also affected by the landscape settings.

Key-Words: -ground surfaces, microclimate, vegetation

1 Introduction

The process of urbanization which involved changes in the natural landscape where more hard surfaces were introduced has led to the urban heat island (UHI) phenomenon among others. This is observed particularly in cities in developing countries, and the majority of these cities lay close to the equatorial line of tropical climates. The UHI further exaggerates the already hot environment of a tropical environment. The role of vegetation in modifying the climate particularly in urban areas is acknowledged following its cooling effect on the evaporation process [1]. Hence, two sites with different landscape setting – green and less-green were identified in this study to see the impact of their landscape component on the microclimate.

2 Urbanization and microclimate modification

In hot-humid climate, the people are struggling to live comfortably due to the increment of air temperature that is further exaggerated by the UHI effect where significantly high air temperature in densely built environment is observed as compared to rural temperatures. Significant reduction of natural surfaces including the vegetated surfaces is commonly found in cities following the urbanization. This is among the factors that contributes to the UHI.

2.1 Characteristics of tropical climate of Malaysia

There are two main monsoon regimes in Malaysia. The South-West monsoon (dry season) starts from late May or early June, and ends in September. The North-East monsoon (wet season) starts in early November and ends in March. It is observed that high dry bulb temperature and less rain are observed during the dry season, while, on the contrary, low dry bulb temperature, solar radiation and high relative humidity and rainfall are observed during the wet season. In between these two monsoons, which is the inter-season, high solar radiation and low relative humidity is observed. Particularly for Kuala Lumpur, when analysed by the hour, high dry bulb temperature (≥31°C), high solar radiation (594.4 – 625Wh/m^2) and low relative humidity (≤65%) is observed between 1100hr to 1300hr [2].

2.1.1 Wind environment for tropical regions

Wind is an important asset in hot-humid regions. It is needed all year round to cool the streets by removing excess heat, and it is also seen as a potential source to cool the building via cross-

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ventilation [3]. Air flows from areas of high pressure to areas of low pressure as a heated up area by solar radiation shall reduce its pressure, and air has a relatively lower pressure when its temperature is higher [3]. In improving outdoor comfort, air movement plays an important role [1]. Ventilation is an essential factor for a hot-humid climate city as it helps to reduce temperature within the urban environment [4]. Hence, good air flow is crucially needed by cities in the hot-humid region. It was also agreed that ventilation plays an important role in minimizing the heat island effects by flushing out the pollutants [5][6]. The following table 1 is adapted from the meteorology office of the United Kingdom website [7], defines the wind speed together with the descriptions.

Table 1: The Beufort wind scale

Beufort wind scale	Mean wind speed (m/s)	Limits of wind speed (m/s)	Wind descriptive terms
0	0	<1	Calm
1	1	1-2	Light air
2	3	2-3	Light breeze
3	5	4-5	Gentle breeze
4	7	6-8	Moderate breeze
5	10	9-11	Fresh breeze
6	12	11-14	Strong breeze
7	15	14-17	Near gale
8	19	17-21	Gale
9	23	21-24	Strong gale
10	27	25-28	storm
11	31	29-32	Violent storm
12	-	33+	hurricane

3 Methodology of the research

The International Islamic University Malaysia (IIUM) is located in the Klang Valley, lies at latitude 3.2528° N and longitude 101.7375° E. The helipad (HP) and compound of the rector's house (RC) of IIUM were identified as the sites for this study as they have distinguished landscape settings for microclimate comparison. The majority of the ground surface of HP is tarmac (grey in color) with fewer trees surrounding it, whereas RC has more turf (green in color) covering its soil and surrounded with greeneries – refer to fig. 1. The site inventory and analysis of ground surface materials, and types and physical aspect of trees were conducted prior to collection of environmental data.

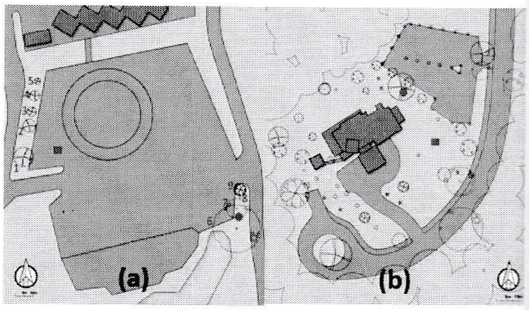

Fig. 1: Layout of HP (a) and RC (b)

A two-days reading of air temperature (°C) and relative humidity (%) with the interval of ten minutes from 0900hr until 1400hr were recorded during the dry season (twice) and the wet season (once) as shown in the following table 2. The wind environment of these two sites were also studied by recording the wind speed (m/s) with the interval of five minutes on the very same days. Five minutes interval would give a better reflection of the wind environment as the wind environment is more volatile compared to air temperature and relative humidity.

Table 2: Dates of field work measurement

day	date	season	monsoon
1	17/7/2013	Dry	South-west
2	31/7/2013		
3	10/7/2014		
4	23/7/2014		
5	24/12/2013	Wet	North-east
6	28/12/2013		

As these two monsoons significantly characterized the tropical climate with 'extreme' weather conditions, these two seasons were identified to conduct the field work and record the environmental data (air temperature and relative humidity).

Four units of the HOBO Pro V2 (U23-002) outdoor data logger were used to record the air temperature and relative humidity where two units were located at each site – one unit under the direct sunlight (exposed) and the other one under a mature tree (shaded) of the sites – refer fig. 2. The locations of these equipment are indicated as red square (exposed) and red circle (shaded) in fig. 1. Two units of Kestrel®4500 pocket weather station were also used to measure the wind environment of these sites and they were positioned beside the HOBO Pro V2 that were located in the direct sunlight as to allow free flows of winds.

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4 Analyses and Results

The presentation of the analysis starts with the physical description of the two sites, followed by the analysis of the environmental data. The Excel 2013 software is used to analyze the environmental data recorded for this study. The hypothesis applied to guide and strategize the analysis is "less-green area (HP) is hotter than green area (RC)".The environmental data analysis starts first with the discussion on the air temperature, follow by the relative humidity, and then the wind environment of the studied sites.

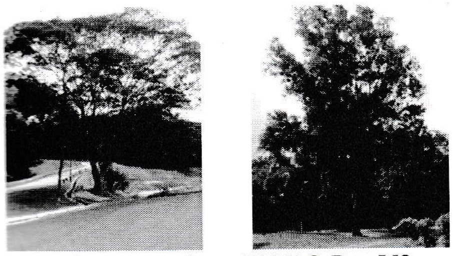

Fig. 2: The trees where HOBO Pro V2 were located (HP – left, and RC – right)

4.1 Landscape settings and physical character of the studied sites: HP and RC

The following table 3 and 4 describe the two investigated sites. The area size of HP is about 1.5 times bigger than RC. HP is covered by tarmac by 62% and 32% green area, considering that 24% and 72% for RC. RC has about 7.6 times more trees than HP with the majority of them (84%) with the canopy diameter in between one meter to less than seven meter. These criteria exhibit that RC is physically greener than HP.

Table 3: Size and percentage of ground surface types HP and RC

	HP		RC	
elements	(m^2)	%	(m^2)	%
turfed/vegetated	7460	32	11300	72
tarmac	14467	62	3767	24
water	771	3	0	0
building	608	3	625	4
total site area	23306	100	15692	100

Table 4: Quantity and percentage of tree canopy diameter

	HP		RC	
Canopy diameter (CD)	nos	%	nos	%
1m to <7m	4	44	57	84
7m to <14m	4	44	7	10
14m to <19m	0	0	3	4
≥19m	1	12	1	2
total	9	100	68	100

4.2 Temperature differences of HP and RC

In analyzing the impact of different landscape setting – between green landscape setting (RC) and less-green landscape setting (HP), the magnitude of difference of air temperature and relative humidity readings recorded at exposed area and the shaded area of both sites are studied. This approach is applied as it would be difficult to quantify the magnitude of differences between these two sites when trying to compare directly the differences of the air temperature and relative humidity of exposed and shaded area of these two sites (refer fig.3).

Referring to fig. 4, when the difference between the temperature reading of exposed area of HP and RC (HPt – RCt) is compared, the positive value (>0°C) indicates HP is hotter than RC, 0°C indicates similar air temperature reading, and the negative value (<0°C) indicates HP is cooler than RC at a given time. The following table 5 shows the amount and percentage of positive values obtained from the difference between HP and RC. The positive values seem to be giving high percentage. Hence, it can be said that the exposed area of HP is experiencing hotter environment than RC with the maximum difference of above 1.5°C (refer fig. 4).

Table 5: Percentage of positive values of temperature difference between HP and RC (exposed area)

	17/7/2013	31/7/2013	10/7/2014	23/7/2014	24/12/2013	28/12/2013
Nos. of positive value	85	82	85	51	70	83
% of positive value	100	96.5	100	60	82.4	97.6
Note: Total nos of reading is 85/day						

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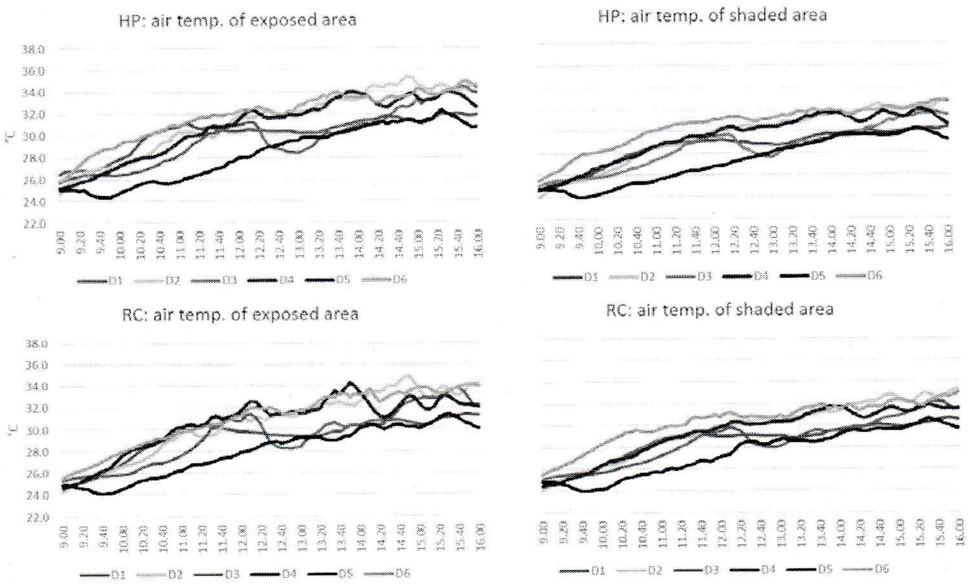

Fig. 3: Air temperature of HP and RC (exposed and shaded areas)

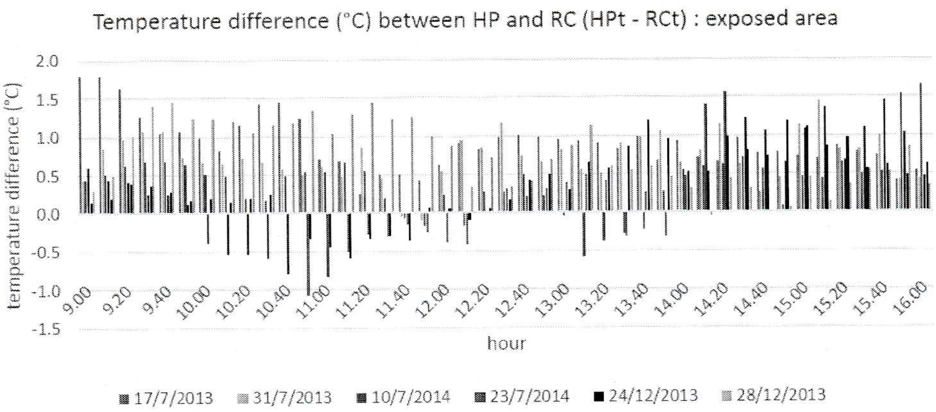

Fig. 4: Analysis on the air temperature difference of HP and RC (exposed area)

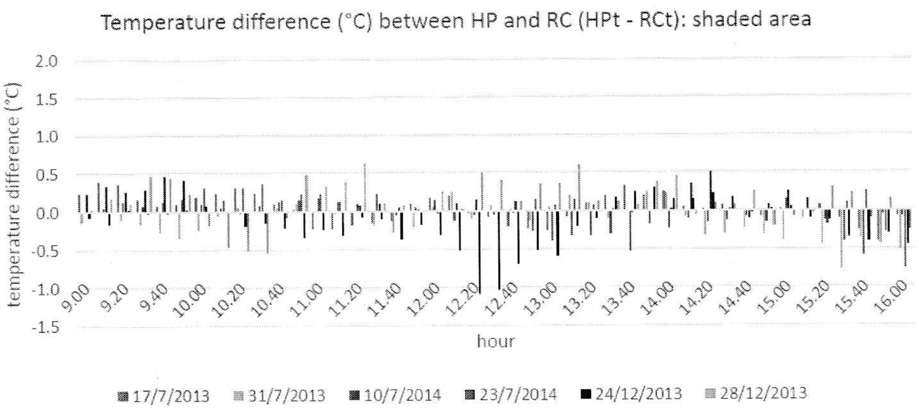

Fig. 5: Analysis on the air temperature difference of HP and RC (shaded area)

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Similar analysis is conducted for the shaded area (fig. 5). Unlike the exposed area, it can be observed that the percentage of positive values is lower for the shaded area, with two days reading (31/7/2013 and 24/12/2013) showing less than 50% (Table 6).

Table 6: Percentage of positive values of temperature difference between HP and RC (shaded area)

	1/7/2013	31/7/2013	10/7/2014	23/7/2014	24/12/2013	28/12/2013
Nos. of positive value	54	38	47	77	33	67
% of positive value	63.5	**44.7**	55.3	90.6	**38.8**	78.8
Note: Total nos of reading is 85/day						

Another observation is the range of difference between these exposed and shaded areas. As for the exposed area (fig. 4), the maximum range is more than 1.5°C since it is slightly above 1.0°C for the shaded area (fig. 5). This could be due to the effect of the trees (fig. 2) that helped to moderate the air temperature underneath their canopies, resulting in less air temperature volatility. Hence, it can be suggested that the shaded area of HP still demonstrates hotter environment than RC. From these two observations, it can be said that on the overall, HP is experiencing hotter environment than RC that could be due to the influence of their physical landscape settings as explained earlier.

4.3 Identifying the magnitude of air temperature difference of HP and RC

It is also interesting to further analyse the magnitude or intensity of air temperature difference between HP and RC following the differences of their landscape setting. This is done by looking at the percentage of magnitude of air temperature differences between the exposed and shaded areas (Table 7) according to the identified ranges. Based on the analysis, it was found that the range is as follows:

- Exposed area: between -1.1°C to 1.8°C (2.9°C range value),
- Shaded area: between -1.1 to 0.6°C (1.7°C range value).

The difference in the range value could be due to the moderation effect of trees as mentioned before.

Table 7: Analysis on the percentage of magnitude of air temperature difference for HP and RC

	Exposed area									Shaded area								
Range of air temperature difference*	17/7/2013	31/7/2013	10/7/2014	23/7/2014	24/12/2013	28/12/2013	Total nos.	%		17/7/2013	31/7/2013	10/7/2014	23/7/2014	24/12/2013	28/12/2013	Total nos.	%	
	nos									nos								
-1.1 to -1.5°C	0	0	0	1	0	0	1	**0.4**	13.2%	0	0	0	0	1	0	1	**0.4**	39.1%
-0.6 to - 1.0°C	0	0	1	3	1	0	5	**1.9**		0	1	1	1	3	0	6	**2.3**	
-0.1 to -0.5°C	0	2	7	12	6	1	28	**10.9**		15	23	20	3	23	10	94	**36.4**	
0°C	0	0	0	1	1	1	3	**1.2**	1.2%	6	10	7	8	7	4	42	**16.3**	16.3%
0.1 to 0.5°C	6	10	21	14	20	17	88	**34.1**	**85.6%**	22	9	15	31	9	27	113	**43.8**	**44.6%**
0.6 to 1.0°C	27	24	12	4	12	11	90	**34.9**		0	0	0	0	0	2	2	**0.8**	
1.1 to 1.5°C	7	7	1	7	3	13	38	**14.7**		0	0	0	0	0	0	0	**0.0**	
1.6 to 2.0°C	3	0	1	1	0	0	5	**1.9**		0	0	0	0	0	0	0	**0.0**	
Sub-total	43	43	43	43	43	43	258	**100.0**		43	43	43	43	43	43	258	**100.0**	

[*Note: the positive value (>0°C) indicates HP is hotter than RC, 0°C indicates similar air temperature reading, and the negative value (<0°C) indicates HP is cooler than RC at a given time.]

Referring to Table 7, following the ten minutes interval, 43 air temperature readings were recorded a day from 0900hr until 1600hr, 258 readings within six days per area, and a total of 516 readings for both areas. When accumulated and transformed into percentage, the influence of landscape setting on the air temperature can be significantly seen as HP is hotter than RC by 85.6% of the studied period for the exposed area. The majority of the magnitude of the difference is between 0.1°C to 1.0°C totalling up to 69.0%. It is also interesting to see that the difference can also be up until 2.0°C. As for the shaded area, as mentioned before, trees seem to moderate the air temperature readings. However, a similar pattern is observed here although HP is hotter than RC by only 44.6%. It is interesting to see how trees significantly moderate the air temperature underneath their canopies where the range hardly goes beyond 1.1°C be it within the positive or negative ranges.

On the overall when the reading of these two areas are combined (516 nos of readings), the positive ranges scored 65.1% (336 nos), whereas the negative ranges scored 26.2% (135 nos of readings) and again this reflects HP is hotter than RC.

4.4 Relative humidity differences of HP and RC

Relative humidity is having negative association with the air temperature where relative humidity decreases as air temperature increases. Similar to the

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analysis of the air temperature, the differences between relative humidity between HP and RC of both exposed and shaded areas are analysed (fig. 6 and fig. 7).

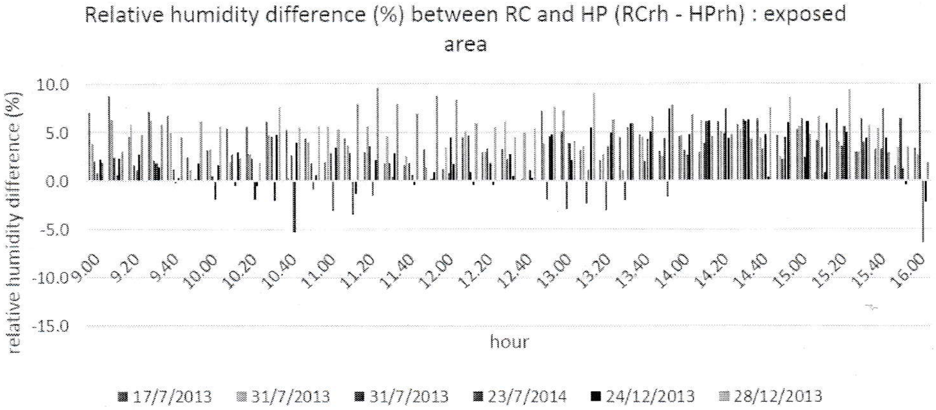

Fig. 6: Analysis on the relative humidity difference of HP and RC (exposed area)

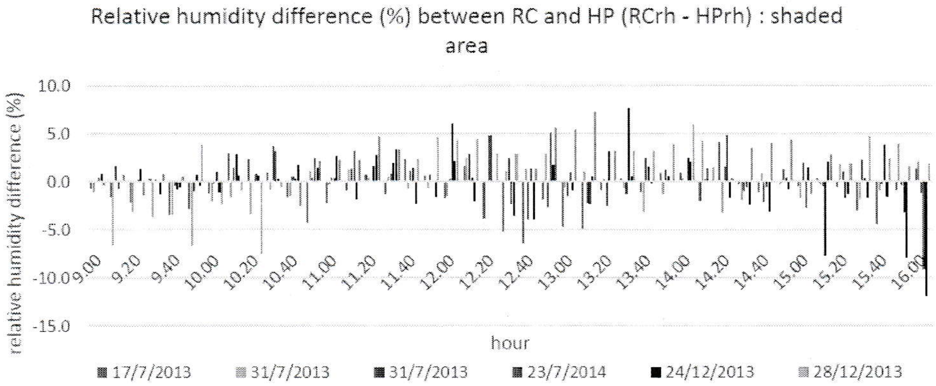

Fig. 7: Analysis on the relative humidity difference of HP and RC (shaded area)

Following the co-relationship and negative association with air temperature, a similar pattern (refer fig. 4 and 5) is observed on the differences of relative humidity as well as their magnitude for both exposed and shaded area. Hence, focus is more concentrated on the air temperature analysis

4.5 Wind environment of HP and RC

Air movement of wind is crucially needed in a hot-humid tropical region as it gives comfort to the people even as mild as 0.1m/s [2]. In other words, stagnant wind environment is unfavorable. Wind environment can be very dynamic and challenging to be studied. For this research, the wind environment recorded are between stagnant (0m/s) to the maximum of less than 4m/s. Hence, the analysis of stagnant wind condition of HP and RC is done first (fig. 8).

From the fig. 8, it can be seen that RC is experiencing more stagnant wind condition than HP, with the highest stagnant condition of 67.1% on 17/7/2013. Hence, HP can be said having more dynamic wind environment with the lowest stagnant wind condition of 14.1% on 28/12/2013. HP is observed as experiencing hotter environment than RC that leads to low pressure that induce dynamic wind environment. However, the dynamic wind environment does not seem to help much in reducing the ambient air temperature of HP as analysis on the air temperature is showing HP experiencing hotter environment that RC. This suggests that the effect of ground surface materials (tarmac in the case of HP) seems to influence the ambient air temperature more than the wind environment.

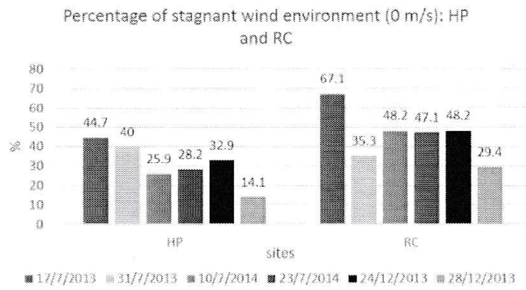

Fig. 8: Analysis on stagnant wind environment of HP and RC

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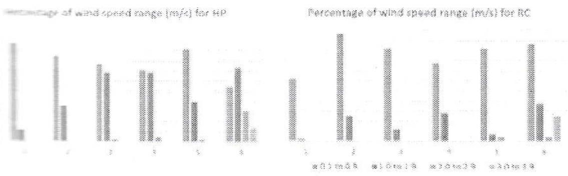

Fig. 9: Percentage of wind speed range by site

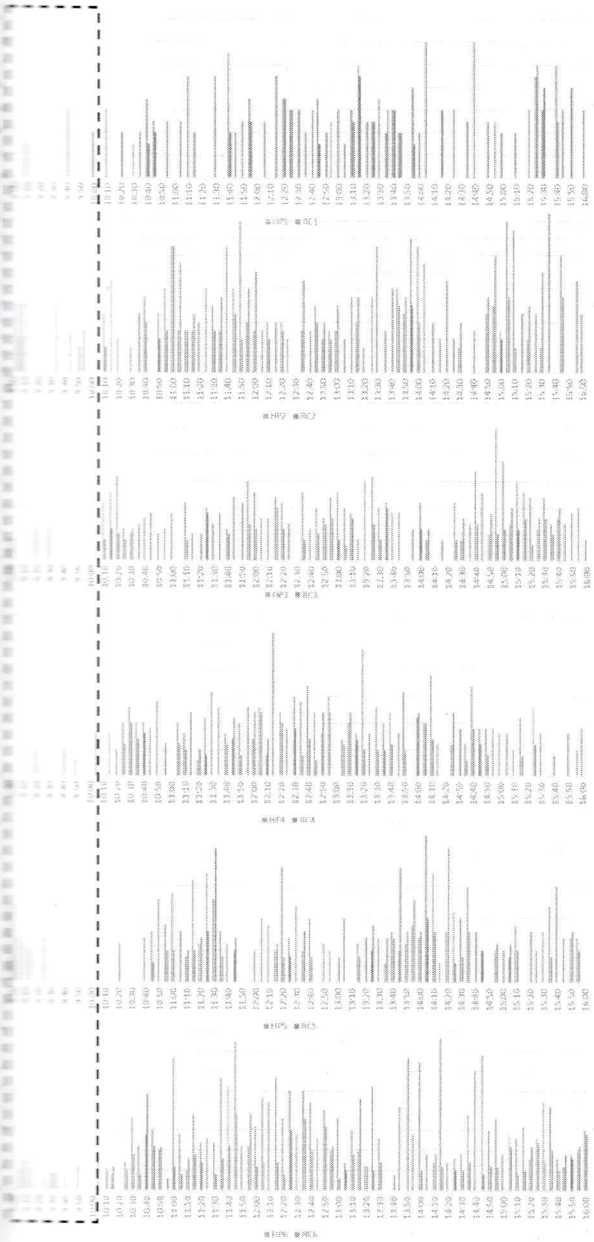

Fig 10: Wind environment between 0900hr to 1000hr

The range of wind speed of both studied sites for all six days is also analysed by looking at the percentage (fig. 9). Generally it can be said that the wind speed is between the range of calm to light breeze with the range between 0.1 to 0.9 m/s is experienced by both sites mostly, followed by the speed range of 1.0 to 1.9 m/s. The maximum wind speed range of 3.0 to 3.9 m/s is observed only on the sixth day (28/12/2013) on both sites (also refer Table II from the date of each day).

Referring to fig. 10, when compared between HP and RC on these six days, the wind environment between 0900hr and 1000hr can be generally suggested as the least dynamic – with significant stagnant and low range of wind speed. This could be because there is not much different in terms of pressure following the low air temperature readings recorded (<30°C) for both HP and RC and their two categories of spaces (exposed and shaded) on those six days of investigations – refer fig. 3.

4 Conclusions

The study has given some empirical evidences that landscape settings indeed influence the microclimate of the outdoor environment. High vegetation coverage – with more mature trees, turf and fewer hard surfaces covering the ground helped to make the ambient air temperature of RC cooler. Wide tarmac covering the ground surfaces with very little trees could enhance the urban heat island effect as observed at HP. The difference in air temperature ranging in between 0.1°C to 1.5°C is observed in this study suggested that properly chosen vegetation and ground surface material could lead to even lower ambient temperature towards sustainable outdoor environment. There were also times where the air temperature difference reached in between the range of 1.6°C to 2.0°C (refer Table 7). Hence, if attention is given to good quality trees that provide better shades with less solar radiation penetration to the ground, and surface materials that absorb and reradiate less heat to the environment, there is a possibility to further reduce the ambient air temperature, resulting to significantly cooler tropical environment.

Looking at the relatively high readings of air temperature, relative humidity, and the light wind with stagnant wind condition from time to time, it is understandable that the people is trying to 'avoid' from prolonging their stay in the outdoor environment of hot-humid tropical region. However, staying indoors could lead to people doing more sedentary activity. Therefore, by understanding the effect of landscape setting, it is hoped that the outdoor designer particularly, could play significant roles in modifying the thermal performance of the outdoor environment through the effect of landscape elements on the microclimate, hoping that thermally comfortable outdoor environment would attract people to spend more time outdoor doing active activity leading towards healthy lifestyles.

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