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1. INTRODUCTION

However the intensity and magnitude of the urban heat island varies from city to another, it could be simply defined by the difference in temperature measured between urban and rural areas, Streutker (2003). The urban heat island has been described as a pillow of warm air above the city. The most typical and recorded index of the urban heat island is the increase of air temperature, Valazquez (2002). Therefore, the comparison between urban and rural climates is the most used approach to analyze the urban heat island.

Large urbanized regions have been shown to physically alter their climates in the form of elevated temperatures relative to rural areas at their periphery. Comparing the elevation of temperature cause by global warming phenomenon and that cause by the urban heat island, global warming forecasts predict a rise in temperature of 3.5 to 6°F over the next century, while large urbanized regions are measured to be 6 to 8 °F warmer than surrounding rural regions, Brain (2001). Increasing at a rate of 0.25 to 2 °F per decade, the heat island effect within urban cores of rapidly growing metropolitan regions may double within 50 years, Brain (2001).

The effect of metropolitan regions is not only confined to horizontal temperatures but also to those in the vertical direction with far-reaching consequences, studies have shown that the thermal influence of a large city commonly extends up to 200-300 m and even to 500 m and more, Sham (1990/91) . His studies at Universiti Kebangsaan Malaysia over 12 year's period indicate that the commercial centers of Kuala Lumpur are usually several degrees warmer than the surrounding countryside, phenomenon known as the heat island. Which is another type of atmospheric pollution comes in the form of excess urban heat or the urban heat island. As many city residents can tell you, cities can be very hot places during the summer. On warm summer days, the air in a city can be 6-8°F hotter than its surrounding areas. Scientists call these hot cities "Urban Heat Islands."

The 1996 Environmental Quality Report (DOE, Malaysia) notes that almost all aspects of the environment have been affected by development activities ranging from deforestation to erosion, hazardous & toxic wastes to water & air pollution and creation of heat islands.

Heat island is one of the many areas of deterioration of the environment due to development. The intensity of such Urban Heat Island (UHI) in the order of 4°C-6°C influences air pollution dispersion and energy demand for cooling in urban areas, especially in Kuala Lumpur and the Klang Valley conurbation, Sham (1990/91).

The study focuses on the urban heat island of the city Kuala Lumpur, which is the largest metropolitan city in Malaysia. It investigates the recent situation of the UHI of the city in terms of its intensity, number and location of cool and heat islands, and the location of the nucleus of this UHI. Moreover, the study compares this UHI situation to that latest previous similar study done in 1985.

2. METHODOLOGY

Two methodologies are used for the data collected in this study. The Weather Station Networks, and an intensive fields work done with the collaboration of a number of assistants and field observers from College of Engineering and College of Architecture and Environmental Design, International Islamic University Malaysia. Alternative methodologies are combined and used to study and measure the intensity of the urban heat island of the city of Kuala Lumpur.

2.1. Measuring the Urban Heat Island through Weather Station Networks

Two weather station networks cover the City of Kuala Lumpur and its periphery; governmental weather station network and another private one. The governmental network is under Malaysian Ministry of Science and Environment and called the Malaysian Meteorological Services.

According to the case study, a specific number of stations are selected to be involved in the study. Concerning the first weather station network, the stations selected are Kuala Lumpur International Airport (KLIA), Petaling Jaya, Subang, Sungai Besi, and University Malaya. While for the private weather station network, the stations selected are Gombak, Shah Alam, Cheras, Country Height, Klang, Nilai, and Petaling Jaya.

2.2. Measuring the Urban Heat Island through Traverses Surveys Method

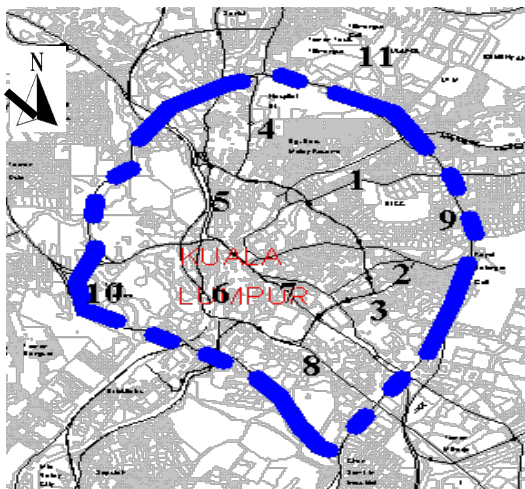
The traverses Surveys Method is used in a specific confined area within the study area. This methodology is used for the city center of Kuala Lumpur city and four major gardens within Kuala Lumpur and its periphery, and that because of the lack of weather station in those areas and the need for micro measurement among those areas.

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Because of the difficulty of making simultaneous measurements, a number of eighteen observers took measurements and readings. They are senior undergraduate students from Faculty of Architecture and Environmental Design and faculty of Engineering, International Islamic University Malaysia. With the help of those observers, intensive traverse surveys were carried out for measuring the air temperature from 20th to 26th of December 2004, for one-hour duration per day from 21:00-22:00 Local Malaysian Time (LMT). The area covered using Traverse Surveys Method has been divided into several sectors (stations). Each sector is assigned to one, two or three observers according to the area and complexity of sector referring to the aim of the study. The total number of stations is 12 four of them are parks and gardens. The city center of Kuala Lumpur city has been divided into 10 sectors two of them are parks (see Table 1 and Map 1 below).

| Sector No. | Name of sector | No. Of readings |
|--------------|------------------------|-----------------|
| 1- | KLCC | 168 |
| 2- | Bukit Bentang | 126 |
| 3- | Time Square | 126 |
| 4- | Chow kit | 126 |
| 5- | Sogo | 126 |
| 6- | Central Market | 126 |
| 7- | Puduraya | 126 |
| 8- | Hang Tuah | 140 |
| 9- | KLCC Park | 168 |
| 10 | Main Lake Garden | 252 |
| 11 | Titiwangsa Lake Garden | 238 |
| 12 | National Zoo | 196 |
| Total | | Total |
| 12 | | 1918 |

Table 1: Stations used for the Traverses Surveys Method



Map 1: Location of the Stations with the City Center of Kuala Lumpur

3. RESULTS AND ANALYSIS

3.1 Nucleus of the UHI of the City of Kuala Lumpur

The nucleus of the UHI of the city of Kuala Lumpur is located within the city center of the city. The hottest, hotter and hot sectors within the city centre area in different days of the week are depicted in table 2 below.

| Day | Extremely Hot (Hottest) | | Very Hot (Hotter) | | Hot | |
|-------|--------------------------|----------|----------------------|----------|---------------------|-------------|
| | Name of Sector | Temp. °C | Name of Sector | Temp. °C | Name of Sector | Temp. °C |
| Mon. | Puduraya | 29.2 | Chow Kit | 28.7 | Times Square | 28.6 |
| Tues. | Puduraya & Bukit Bintang | 28 | KLCC | 27.7 | Chow Kit | 27.4 |
| Wed. | Bukit Bintang | 27.9 | KLCC | 27.8 | Chow Kit & Puduraya | 27.5 & 27.4 |
| Thur. | Puduraya | 28.4 | KLCC | 28.2 | Chow Kit | 28.0 |
| Fri. | Puduraya & KLCC | 28 | Bukit Bintang | 27.5 | Chow Kit | 27.2 |
| Sat. | Bukit Bintang | 28.2 | KLCC | 27.9 | Puduraya | 27.5 |
| Sun. | Puduraya | 28.6 | Bukit Bintang & KLCC | 28.3 | Chow Kit | 27.7 |

Table 2 Hottest, hotter and hot sectors within the city centre of the city of Kuala Lumpur

Puduraya Sector is the hottest sector on Monday, Tuesday, Thursday, Friday and Sunday. While on Tuesday, Bukit Bintang sector has the same temperature as puduraya sector. Moreover, Bukit Bintang is the hottest sector on Wednesday and Saturday. On Friday, although Puduraya sector register the hottest record, KLCC sector have the same temperature.

The nucleus of the UHI of the city of Kuala Lumpur during five days of the week is located in Sector No. 7, Puduraya sector, while it is located in sector 2, Bukit Bintang for three days of the week. Moreover, one of these three days is shared by Puduraya sector. On the other hand KLCC sector is the nucleus of the UHI for only one day of the week and has the same temperature as Puduraya sector.

The nucleus of the city of Kuala Lumpur is almost located in Puduraya area for the whole period of the survey. Therefore, it concluded that, Puduraya Sector is the Nucleus of the urban heat island of the city of Kuala Lumpur.

3.2 Intensity of the UHI of the City of Kuala Lumpur

Table 3 below summarizes the intensity of the UHI of the city and the names of the highest and lowest stations by temperature records, in addition to the values of temperatures for these stations.

| Day of the week | UHI Intensity (°C) | Highest Temperature (HT °C) | Name of Station for HT | Lowest Temperature (LT °C) | Name of Station for LT | Lower Temperature (LT °C) | Name of station for LT |
|------------------|--------------------|-----------------------------|--------------------------|----------------------------|--------------------------------|---------------------------|-------------------------|
| Mon. 20/12/2004 | 4.7 | 29.2 | Puduraya | 24.5 | Country Height & Petaling Jaya | 24.6 | Gombak |
| Tues. 21/12/2004 | 3.9 | 28 | Puduraya & Bukit Bintang | 24.1 | Petaling Jaya | 24.8 | Gombak & Country Height |
| Wed. 22/12/2004 | 4.2 | 27.9 | Bukit Bintang | 23.7 | Petaling Jaya | 24.3 | Gombak & Country Height |
| Thur. 23/12/2004 | 5.1 | 28.4 | Puduraya | 23.3 | Petaling Jaya | 23.8 | Country Height |
| Fri. 24/12/2004 | 5.4 | 28 | Puduraya & KLCC | 22.6 | Petaling Jaya | 22.9 | Country Height |
| Sat. 25/12/2004 | 4.3 | 28.2 | Bukit Bintang | 23.9 | Petaling Jaya | 24.7 | Gombak & Country Height |
| Sun. 26/12/2004 | 5.5 | 28.6 | Puduraya | 23.1 | Petaling Jaya | 24.1 | Nilai |

Table 3 Hottest, hotter and hot sectors within the city centre of the city

On Monday 20 December 2004, the intensity of the UHI is 4.7°C, while it is 3.9°C on Tuesday and 4.2°C on Wednesday. It is 5.1°C, 5.4°C, 4.3°C and 5.5°C on Thursday, Friday Saturday and Sunday respectively.

The intensity of the UHI of the city varies from 3.9 to 5.5. The lowest value of this intensity is recorded on Tuesday, while the highest amount is recorded on Sunday 26 December 2004. Although the differences between the urban and rural temperature values are very big in Sunday, the highest value of temperature is recorded in Monday. Monday is the hottest day with the highest temperature during the survey. Therefore, both Sunday and Monday are extraordinary days in terms of temperature. Monday is the first working day of the week with dense traffic and human activities, while on Sunday people (recruits) is usually heading from the fringes of KL to reach in a suitable time before the first working day of the week started. That is a direct reflection of the traffic and human activities, Elsayed and Che (2006), on

the city due to the increased levels of urbanization.

3.3 Temperature Records in Different Days of the Survey

The temperatures recorded during 20-26 December 2004 varies from station to another and from day to another. Fig. 1 below shows the records of temperature at all stations during the week of survey (20-26) Dec 2004.

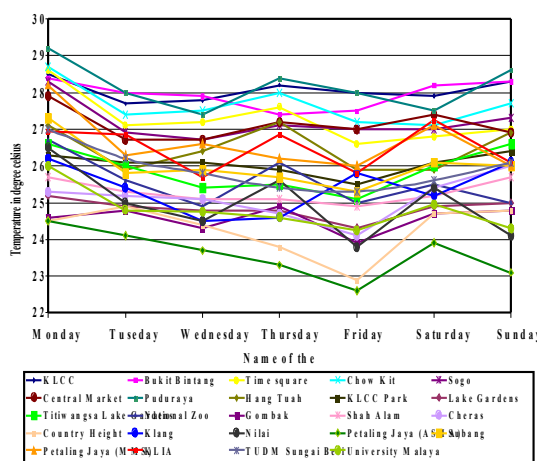


Fig. 1: Records of temperature for all stations, during the survey (20-26) Dec 2004.

Monday 20 December 2004 (the first working day of the week) registers the highest records of temperature for all stations excluding Cheras station. On the other hand, Friday 24 December 2004 registers the lowest records of temperature for most of the stations excluding Klang, Puduraya, Central Market, Sogo and KLCC stations. While for those excluded stations Wednesday is the day during which the lowest temperature records are registered. Puduraya, Central Market, Sogo and KLCC stations are recognized as busiest points located within the city centre of the city; moreover the 24 December is the Christmas Eve.

It is also recognized that the highest records of temperatures for all of the days of the week is registered at Puduraya station. Although Sunday is a non working day in the city, Puduraya station recorded the second highest temperature during the survey during that Sunday. Furthermore, it is the hottest day registered during the survey at Cheras station and never is the coolest day at any stations inside or outside the city. In converse to Sunday is Saturday, which is a holiday too. The records of temperature during Saturday for all stations located within the city center of the city are relatively low, while the records for the rest of stations are of medium values excluding KLIA stations. Moreover, the study finds that, the temperature is clearly varies from a work-day to a nonworking-day in the city generally. The working days are relatively hot compare to non working days, while in the city centre and more specifically at Puduraya station this statement is not true. At Puduraya station, even Sunday is very hot, and that could be because of

the location of the station. Puduraya is one of the busiest points in the city with very high traffic intensity where the main and largest national and international bus station, Puduraya Bus Station, is located there.

3.4 Number of Cool and Heat Islands

The study finds that there are clear differences when comparing this study to previous similar work done in 1985 by Sham in terms of number and location of cool and heat island, nucleus, and intensity of the UHI of the city.

The number of cool islands in this study has decreased compared to that in 1985, while the number of heat islands increased. Previously there were many cool islands located inside the city center, but by now, the study shows that, there is only one recognized cool island inside the city center and it is located in a park (Main Lake Garden sector).

The study shows that, the recent number of heat islands increased. The heat islands inside the city center become five recognized heat islands. Previously Chow Kit was the hottest island within the city centre, now in addition to Chow Kit sector there are Puduraya Sector, Bukit Bintang Sector, Times Square sector, and KLCC sector.

Such finding is due to continuous human activity and development within the city centre of KL. In the last two decades, the city centre of KL experienced rapid changes in concentration of commercial activities and in the re-location of population. Multi stories and tall buildings now occupy it. These multi-storied buildings found in the city centers dominate the skyline, and have a dramatic effect on the microclimates of the city centre. Man, through his constant constructions, has affected the exchange of energy and moisture within the system by altering the physical qualities and materials of the earth's surface within the city centre. He has continually replaced vegetation and greenery with buildings. Furthermore, he has become a primary source of heat production from his transportation systems, industrial plants, and HVAC systems.

3.5 The Location of the Nucleus of the UHI

The nucleus of the UHI of the city in the previous studies was located within the city center of the city; the study shows that, it is also located within the city center. Nevertheless, the location of the nucleus has shifted. It was previously in Chow Kit area, the study shows that, it is located in Puduraya area. The second hottest area within the city center is Bukit Bintang, then KLCC and the fourth one is Chow Kit. Therefore, Chow Kit area is no more the nucleus of the UHI of the city of Kuala Lumpur.

Such occurrence is due to the changes happening in terms of land use and human activity, Elsayed (2009). Although the land use in Puduraya, Bukit Bintang, KLCC and Chow Kit are all of

commercial land use, the type of human activity varies. Chow Kit is a collection of old commercial buildings compared to those buildings in Puduraya, Bukit Bintang and KLCC. The buildings are completely different in terms of their height, building materials and utilization of HVAC systems. Moreover, the human activities in Chow Kit area usually stopped by the closing of shops at 21:00 LMT. In Puduraya, Bukit Bintang and KLCC human activity stops either late night or not at all, particularly in Puduraya area, a national and international bus station with very dense traffic intensity.

4. CONCLUSION

The study shows that the nucleus of the UHI of the city of Kuala Lumpur is located within the city center of the city. The nucleus of the UHI of the city during five days of the week is located in Sector 7, Puduraya sector, while it is located in sector 2, Bukit Bintang for three days of the week. Moreover, one of these three days is shared by Puduraya sector. On the other hand KLCC sector is the nucleus of the UHI for only one day of the week and has the same temperature as Puduraya sector. Therefore, Puduraya Sector is the Nucleus of the UHI of the city of Kuala Lumpur.

The results gained from this study show that, the intensity of the UHI of the city of Kuala Lumpur is most severe during Sunday. The intensity varies from 3.9 to 5.5 °C. The lowest value of this intensity is recorded on Tuesday, while the highest value is recorded on Sunday. On Monday the intensity of the UHI is 4.7 °C, while it is 3.9 °C on Tuesday and 4.2 °C on Wednesday. It is 5.1 °C, 5.4 °C, 4.3 °C and 5.5 °C on Thursday, Friday Saturday and Sunday respectively. Comparing these values to that showed in the previous latest study, 1985, the intensity increased from 4 °C to 5.5 °C. Thus, the study concludes that, the increase in the intensity of the UHI of the city of Kuala Lumpur is more than one degree Celsius (1.5 °C), which is a recognized value whenever the human health and comfort are the concern.

5. ACKNOWLEDGEMENT

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