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Nocturnal Air Temperature Traverses across the City of Jakarta, Indonesia

Rosmini Maru*, Faculty of Mathematic and Environmental Studies, University Negeri Makassar, Makassar, Indonesia.

Shaharuddin Ahmad, Development and Environmental Studies, Faculty of Social and Humanities Universitiy Kebangsaan, Malaysia.

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Abstract

The increase of urban air temperature is a common phenomenon experiences by many cities in the world including Jakarta, Indonesia. One method to trace out this temperature increased is temperature traverse across different land use types in an urban area. For this study, observation was carried out for six months; starting from October 2011 to March 2012 and a total of 26 and 20 stations were created along the north-south and the east-west traverses, respectively. The results showed that the average monthly temperature of 28.3°C was calculated for a north-south traverse during the night, with the highest temperature of 29.0°C was recorded at the Jembatan Merah bus station point and the Swiss Hotel point. Meanwhile, the lowest temperature of 26.9°C was recorded at the Pintu Gerbang Universitas Indonsia point station. On a monthly basis, February was recorded the lowest temperature (27.4°C), while October was recorded the highest temperature (29.4°C). For the east-west traverse, the monthly average temperature was 28.3°C where the highest temperature of 29.2°C was recorded at the Taman Kota Pondok Kopi station; meanwhile the lowest temperature of 27.6°C was recorded at the Flay over Ciledug station. In addition, October was recorded the highest temperature (29.5°C), while February was observed the lowest temperature (27.3°C). Based on these temperature traverses, the average value of the urban heat island intensity during the nighttime was calculated at 2.1°C for the north-south traverse; meanwhile the value of UHII of 1.6°C was calculated for the east-west traverse during the nighttime. These high temperatures across various land uses in the city of Jakarta have definitely affects the thermal discomfort feeling among the urban dwellers of the Jakarta City.

* ADDRESS FOR CORRESPONDENCE: **Rosmini Maru,** Faculty of Mathematic and Environmental Studies, University Negeri Makassar, Makassar, Indonesia, *E-mail address*: rosminimaru@yahoo.com

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1. Introduction

The Urban Heat Island (UHI) phenomenon was first investigated and described by Luke Howard in the 1810s, although he was not the one to name the phenomenon (Sham, 1980; Tursilowati, 2005). The term 'urban heat island' describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1–3°C warmer than its surroundings. In the evening, the difference can be as high as 12°C, and is most apparent when winds are weak. In a cross section diagram, the form of UHI phenomenon is like an island whereby the highest temperature established in the middle and lowest temperature occurred within the surrounding areas (Effendi, 2007). Urban heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water quality.

Each city's urban heat island varies based on the city structure and thus the range of temperatures within the island varies as well. Parks and greenbelts reduce temperatures while the Central Business District (CBD), commercial areas, and even suburban housing tracts are areas of warmer temperatures. Every house, building, and road changes the microclimate around it, contributing to the urban heat islands of our cities. The situation is becoming more pronounced with the increase of anthropogenic activities that occur in urban areas (Shaharuddin & Noorazuan, 2010; Purnomohadi, 1995). In addition, heat island phenomenon depends on the stability and the amount of hot wind velocity (Oke, 1982).

In the near future it is expected that the global rate of urbanization will increase by 70% of the present world urban population by 2030 (Arrau & Pena 2013; Anon, 2013). As a result, urbanization has a negatively impact on the environment mainly by the production of pollution, the modification of the physical and chemical properties of the atmosphere, and the covering of the soil surface. This is also a common phenomenon in Jakarta, Indonesia nowadays whereby urbanization rate increases up to 20.4 % from the 1970s census (Lubis, 2010). It is expected that the population density of Jakarta now is about 661.52 km2. Jakarta urban development has expended to other parts of Jakarta that is Bogor, Depok, Tanggeran and Bekasi and known as 'Jabodetabek which accommodate around 23 million people. Based on this figure, therefore, Jakarta is the sixth city in the world with highest population density. As a consequent, more human activities take places in the urban areas whereby it will definitely alter the physical urban environment, especially urban microclimate. On this note, therefore, this study attempts to monitor and analyse temperature differences according to different land uses in Jakarta, especially night temperature.

2. Method Of Study

This study was carried out within the city of Jakarta, Indonesia. There are several methods that can be used in order to study the UHI phenomenon and one of them is temperature traverse (Iswanto, 2008). In this study, two traverses were formed across the Jakarta area that is the north-south and east-west traverses. The north-south traverse was about 22 km long started at Ancol, northern part of Jakarta right through the Jakarta area and end up at Gerbang Universitas Indonesia, in the south area. There was 26 stations were created to measure temperatures of different land use types along this traverse such as built-up area, housing area, green park, and open space and so on. Meanwhile, the east-west traverse was about 24 km long and it started at gerbang Universitas Budi Mulia in the east and end up at sawah Jembatan Keranji in the west. There were 20 stations along this traverse to measure temperatures of different land use types.

Temperature measurement was carried out for about six months that was started in October 2011 and end up in March 2012. The nocturnal temperature measurements were taken at around 21:00 –

23:00 hours West Indonesian Time (WIT). Every week two different days were chosen to carry out the measurement that was working days as well as week-end and public holidays. Data from these measurements were then tabulated and analyzed by using excel program. The results of this analyze were then transformed into cross section diagram to create the temperature traverses across the Jakarta area.

3. Results and Discussion

Figure 1 shows the nocturnal temperature measurements for the north-south traverse across the Jakarta area. This is the mean temperature measurements for the six months period taken at night (21:00 – 23:00 hours WIT). The result showed that the average nocturnal temperature was about 28.3°C with the Coefficient of Variation of 2.3. The highest average temperature was recorded at about 29.0°C at the Jembatan merah bus station and at the station Swiss Hotel. Meanwhile, while the lowest average temperature of 26.9°C was recorded at the University of Indonesia Gateway station. On a monthly basis, the low average temperature of 27.4°C was calculated for February 2012; meanwhile the average high temperature of 29.4°C was observed in October 2011.

Further analysis was carried out in determining the average temperature differences across the north-south traverse for the six months period. The result showed that a small temperature variation was observed along the traverse that was confirmed by the small value of coefficient of variation (1.7). Month to month temperature differences along the traverse displayed a small variation except for March whereby the temperature difference i.e. between the highest and the lowest or the Urban Heat Island Intensity (UHII) was calculated at about 2.7°C. The other months displayed a moderate UHII across this traverse. Therefore the average UHII for the north-south traverse was calculated at around 2.1°C.

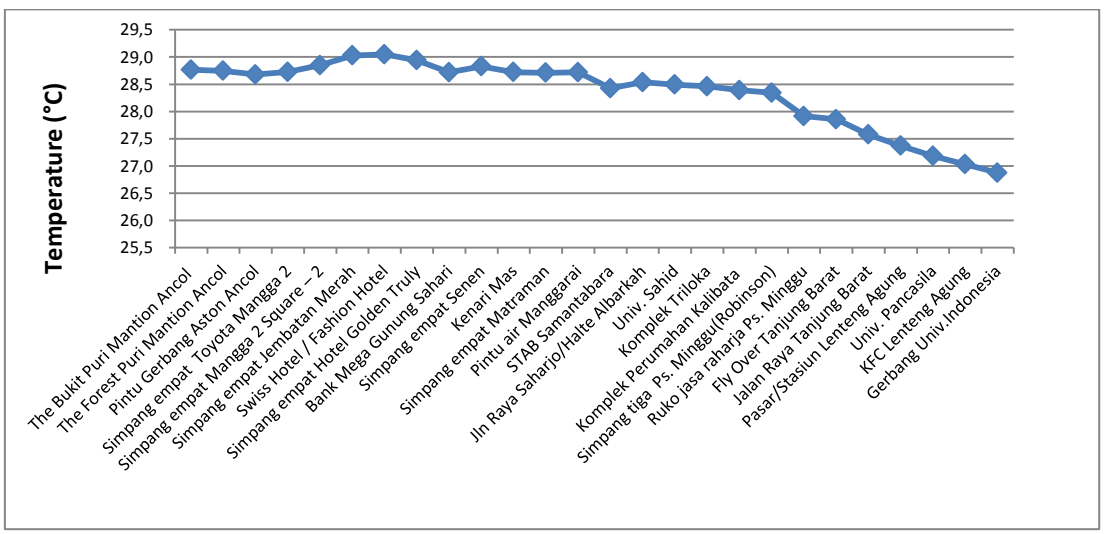

Figure 1. Average nighttime temperature for the north-south traverse

Another temperature traverse was carried out that was the east-west temperature traverse (October 2011 - March 2012). The result of the study is shown in Figure 2. The average monthly temperature for the traverse was calculated at about 28.3°C with the value of coefficient of variation of 1.7. The highest average temperature was observed at Taman Kota Pondok station i.e. 29.2°C; meanwhile the lowest average temperature of 27.6°C was observed at Fly over of Ciledug station. On a monthly basis, the study found that October 2011 was recorded the highest temperature of 29.5°C and the lowest temperature of 27.3°C was recorded in February 2012. Based on this finding,

therefore, the temperature differences across the traverse were small for February 2012 as compared with the month of October 2011.

During the month of October 2011, the highest temperature of 30.6°C was recorded at three stations i.e. the Fly over of Pondok Kopi, Rumah Susun Pondok Kopi and McD Buaran; meanwhile the lowest was recorded at the Universitas Budi Mulia station (27.9°C). Thus, the October Urban Heat Island Intensity (UHII) was calculated at about 2.7°C. For the other months, UHIIs were calculated at the moderate to small values. Therefore, the average UHII for the east-west traverse was calculated at about 1.6°C.

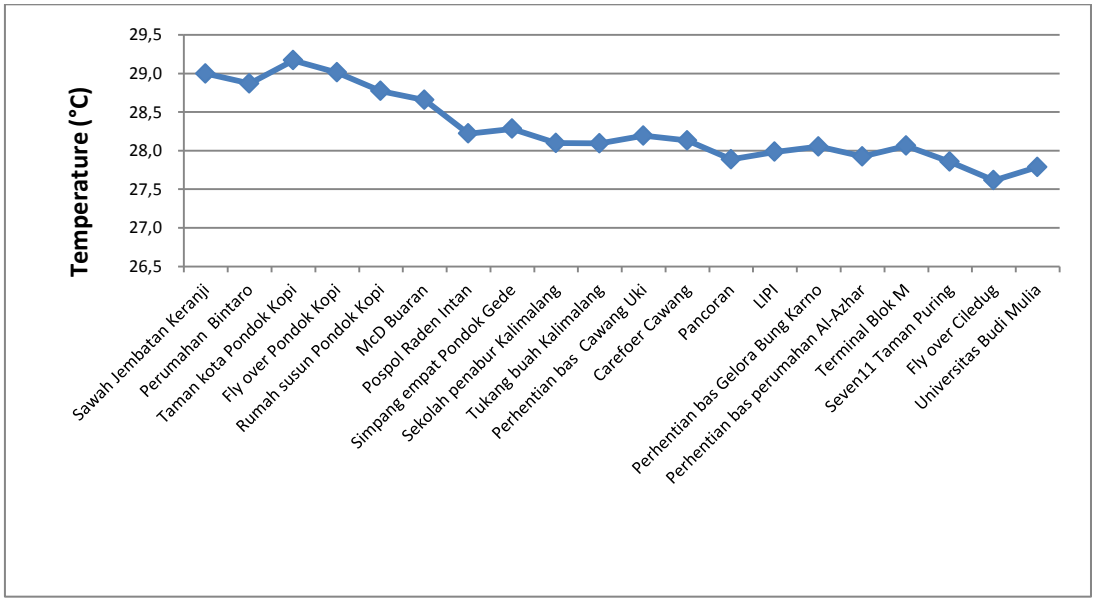

Figure 2. Average nighttime temperature for the east-west traverse

4. Planning Implication

The UHI in an urban area such as in the city of Jakarta is a common urban climate phenomenon due to rapid urban development that causes natural physical environment turn to man-made environment. The presence of UHI will definitely create more thermal discomfort among urban dwellers. This is due to the fact that, in general this phenomenon creates high temperature, less humid condition and more polluted air. In any urban area, urban design factors such as urban geometry, street canyon, sky view factor and landscape play an important role in modifying the urban microclimate. Besides, anthropogenic factors like economic and industrial activities are also contributing to the changes of urban microclimate significantly. Even though the UHII in the Jakarta area is not as high as other parts of the world, especially in the temperate areas, it needs to be measured and mitigated in order to reduce and enhance the comfortability of the urban dwellers in the future. The establishment of green area in an urban area has been proven to be a part of the cooling effect of urban areas. Jakarta is an area with a very high population density, therefore it is quite impossible to find open space to create green area. Thus, it is good for the Jakarta authority to mitigate the UHI phenomenon by adopting green technology extensively. Programs such as green roof technology, roof garden and energy saving use more light color for building materials, car park and other buildings can reduce heat storage during the day; instead will increase surface albedo significantly. Therefore, it will reduce latent heat release during nighttime and as a consequent will reduce high nocturnal urban temperature.

Even though, Jakarta authority has been implemented the use of public transport during the day for urban dwellers, the implementation must be followed by strictly enforcement. This is one way of reducing high traffic volume on the road during the day or else can contributing to high urban air pollution. If the program can be implemented significantly then the release of CO^2 to the environment can be reduced, hence will reduce greenhouse effect.

5. Conclusion

This study has reaffirmed the establishment of urban heat island in the city of Jakarta even though its intensity was not as high as observed in other part of the world. The different urban land uses has been observed playing significant roles in determining the temperature differences. The temperature measurement near the green areas, open spaces and padi fields consistently experienced low temperature rather than areas with less vegetation or more build-up areas. This situation was observed for both of the traverses.

Even though the UHII is small in magnitude, it is good enough to warn and inform the right authority such as the city of Jakarta authority that certain mitigation measures should be carried out in order to reduce the effect of urban heat island on urban dwellers in future, thus create more comfort environment condition. It was thought that the suitable mitigating approach is by utilization of landscape design knowledge particularly on the efforts of urban greenery in order to address the problem and thus enhance the comfortability of the urban dwellers.

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