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Research paper

Microclimate Field Measurments in Melaka Waterbodies

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Abstract

This research will help to develop an understanding of the existing waterbodies environmental conditions in Melaka Town. There are 2 necessary tests that need to be conducted to comprehend the characteristics of the Melaka River and the sea and their impact to the surrounding microclimate. The climate data includes air temperature (Ta), relative humidity (RH) and wind velocity (v), which were all continuously measured within the Melaka water body area. The study measures the microclimate condition within a number of stations, quantified by their respective distances within the sea and the river area respectively. This measurement activity seeks to provide an understanding in the field of climatic urban design, and the potential of utilizing water bodies (water cooling effects), as an urban design tool, with regard to minimise the profound effects of extreme climate condition on human comfort levels under hot and humid condition in Melaka Town. On a clear day, temperatures in surrounding area increase by 0.25 to 0.30 °C approximately 25 meters away from the water bodies. The findings could be used to determine how the surroundings near the water bodies affect the water bodies' cooling effect performance.

Keywords: *Technical and Vocational Education and Training (TVET), Job Satisfaction, Retention, Motivation.*

1. Introduction

Due to the growth of an urban-based economy and the associated large local and foreign labor migrations to the Melaka City, there was an emergence to adopt a new urban design approach to accommodate the increasing demand for new residential units and the ever-increasing number of automobiles in the city. The urban reclaimed development scenario took place in the south part of the city, which signaled a departure from the traditional urban pattern of Melaka, to accommodate the modern urban pattern [1].

The modest efforts of adopting climatic considerations and human dimension during the design process has exacerbated the severity of the microclimate conditions in such tropical water body region. Indeed, this increases the reliance on the active cooling systems in outdoor spaces to overcome such degradation in the environmental quality of indoor spaces. Water body as one of the essential components of underlying surface, is an important part of urban residential environment, and plays a assured regulating effect on microclimate environment of residential district in summer [2]. The temperature mitigating capability of water bodies in urban surroundings can potentially moderate energy consumption, enhance outdoor thermal comfort and mitigate the Urban Heat Island (UHI) effect [3]

A field study, by Remaz, investigated the existence, intensity, and magnitude of the urban heat islands in the Melaka has shown that such climatic phenomenon does exist in the city and is more evident during the nighttime. It is concluded that more attention should be given to minimize the severity of urban microclimate conditions in the Melaka City. Rapid development and the lack of trees are turning these cities into urban heat islands (UHI) that are warm even at night [4, 5].

Additionally, outdoor urban spaces are the major outdoor places for people to walk on or engage in recreation and social activities. An environment that is comfortable is crucial vis-à-vis enjoyment of the outdoors. In countries like Malaysia, where tourism is an important source of income and outdoor activity is expected in most places of attractions, thermal comfort within urban dwellings is imperative [6]. Therefore, it is important for outdoor spaces to be properly designed. As one of the difficult fundamental surfaces, the urban waterfront areas often developed the most attractive site, due to its variety water scene and the same time, the rivers, lakes and artificial water body not only realized their ecological purposes but also enhanced the native thermal climate in the neighboring area of the waterfront, particularly on water vapor circulation and temperature [7]. This facts elucidates the need for using the full advantages of cooling effect features of water bodies in urban designing [8].

The water bodies operate as a cooling source on the microclimate of the surrounding area. Air temperature near or over bodies of water is much different from that over land due to differences in the way water heats and cools. The increased availability of water usually enhances evaporation, and the associated uptake of latent heat provides a daytime cooling effect. Many other researchers have argued that evaporative cooling from water bodies or water features is one of the most efficient ways to ensure the passive cooling of building and urban spaces.

The study concentrated on the waterbody area in Melaka town Malaysia. The final outcome of the study contributes toward creating comfortable outdoor spaces in hot and humid contexts to enhance the quality of outdoor life in similar cities.

2. Background of the study

Many studies have shown that the mitigation of temperature measures, such as increasing the quantity of vegetation cover, might alter the severe impact of urbanization. The vegetation provides a cooling effect, mainly through its shadowing effect and evapotranspiration process. The process is basically a natural mechanism in which heat is removed by changing the heat from sensible heat to latent heat. Additionally studies proposed the presence of water body can minimize the UHI effect of an urban area by creating water body cooling island [9, 10, 11]. A similar process like green space is happening over water bodies with the help of solar radiation. This process is known as evaporative cooling. When solar radiation from the sun reaches the water's surface, the water will vaporize and remove the heat, thereby cooling the surrounding air.

Water features within an urban area have a positive effect on the microclimate of the surrounding areas when natural cooling from the evaporative process is needed on hot sunny days. The increased availability of water usually enhances evaporation, and the related uptake of latent heat provides an additional daytime cooling effect. The air temperature near or over bodies of water is much different from that over land due to differences in the way water heats and cools. Water bodies are noted to be about the best absorbers of radiation; on the other hand, they exhibit very little thermal response. Many other researchers have argued that evaporative cooling from water bodies or water features is one of the most efficient ways to passively cool building and urban spaces. However, evaporative cooling might not work optimally in a hot, humid tropical country as it has high relative humidity [12]. Although studies have also mentioned that having more water surfaces could improve the urban heat island effect, this possibility has received comparatively less attention [8].

A study by Murakawa (1991) showed a difference of approximately 3–5°C in air temperature between the river and the city area in Japan. The water bodies of the river operate as a cooling source on the microclimate of the surrounding area. Many other researchers have argued that evaporative cooling from water bodies or water features is one of the most efficient ways to provide passive cooling for building and urban spaces [13]. Thus, the current study examines this evaporative cooling performance of water bodies for the surrounding microclimate of Singapore. Ambient air temperatures are measured to make a clear distinction of the influence of cooling from the water bodies horizontally [14].

3. Methods

3.1. Study site location

This study was conducted in Melaka town, which has a population of 860,000. It is situated on the west coast of Peninsular Malaysia, at the mouth of the Straits of Melaka, and is 147 km south of Kuala Lumpur (Figure 1). In terms of size, Melaka is one of the smallest states in the Peninsular. UNESCO listed its capital, Melaka town, as a world heritage site since 7th July 2008.

Melaka Tengah has become the main city and capital of Melaka State. The situation shows that rapid development has taken place in the state of Malacca, which has not only attracted the attention of all levels of society in providing jobs, but also provided an opportunity to engage in business in the tourism industry in Malacca State.

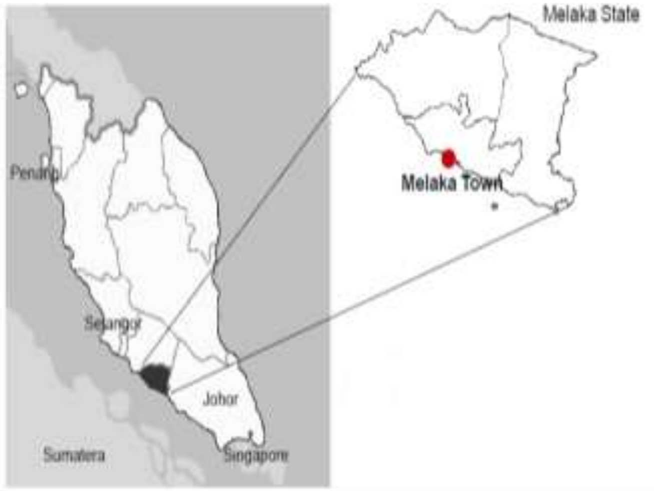


Fig. 1: The location of Melaka Town in Malaysia, Source: drawn by the author from different sources

The Melaka river passes through the city of Melaka for north to south of the city (Figure 2). The impact of the construction and beautification of the Melaka river bank on the layout structure refers to the restructuring arrangements for business and residential area along Sungai Melaka. The findings indicated that the linear existence of this waterfront project had possibly influenced the structural layout of the rows of shops. The layout of the building and beautification of existing buildings also provide a landscape that is attractive to visitors.

Fig. 2: Melaka River, source: Melaka town and country planning department, 2012

3.2. Field measurement program

Twenty (15) units of Data loggers HOBO U12 4-External Channel and HOBO U12 were used in conjunction with each other. This unit was selected due to its purported accuracy vis-à-vis air temperature and relative humidity. They are self-monitoring recorders that can measure and operate automatically without manual supervision. Both operates within -20 to 70°C (-4° to 158°F) and 0 to 95% RH. The HOBO determined the relative humidity and ambient temperature for designated location. For increased accuracy in relation to ambient air temperature and relative humidity, the loggers were cased within a well-insulated PVC tube with a silver wrap, which helps it eschew precipitation and direct heat radiation while encouraging the free flow of air. This combination is installed 2 m above ground, on lamp posts. The loggers were pre-coded to collect data every 10 minutes continuously. A handheld climate meter (4-in-1 Environmental Meter, Model 45170) was used to measure the wind velocity.

4. Study the effect of the sea to the study area

Due to the proposed preliminary study, the effect of the sea upon the area being studied was analyzed. As long as the end part of the selected zones for the study meets the big sea, or any large body of water, it can be surmised that the selected zones might fall under the influence of the cooling effects from this large(r) body of water (in this case, the sea), as opposed to a river (or any smaller body of water). In order to confirmed this theory, 10 points were selected every 200 meters, within 2km alongside the river, beginning at the bay point, and monitored the average temperature of the selected points within whole month of June 2014 for 24 hours (Figure 3).

Fig. 3: Ten measure stations alongside the Melaka River started from RS1 as the bay point

Figure 4 shows the maximum, average and minimum air temperature that was mainly taken from the continuous measurements in 10 weather stations recording the data at every 5 minutes' interval, and was installed alongside the Melaka River in June 2014. The figure shows fluctuation among the points, however, this happens as we move further way from the sea, which was unexpected.

In fact, the minimum temperature is 28.77 on the riverside 1(RS 1), which might affect the river's cooling performance, as sea breeze could cool the air of the surroundings. The sea breeze could also theoretically cool the air around rivers; however, this effect is not expected to last as long as RS2. Some points are hotter than other, but this might be due to their respective surroundings as opposed to any influence of the surroundings, such as that demonstrated by point RS6.

The average temperature ranges from 28.77°C to 29.55°C, representing a difference of about 1.0°C. Conversely, it can be perceived that the maximum temperature difference at different locations is not very significant. The maximum difference is about 0.8°C between the two locations of RS1 and RS6. As mentioned earlier, the maximum temperature is of significant importance in the tropics, since it determines the outdoor comfort level and energy use in buildings in urban areas [15, 16]. Thus, the large differences of maximum temperature need to be reduced in order to mitigate the heat stress in the Melaka water body. This verifies the importance of this study in maximizing the cooling effect in this area so as to mitigate the actual UHI condition in the Melaka town

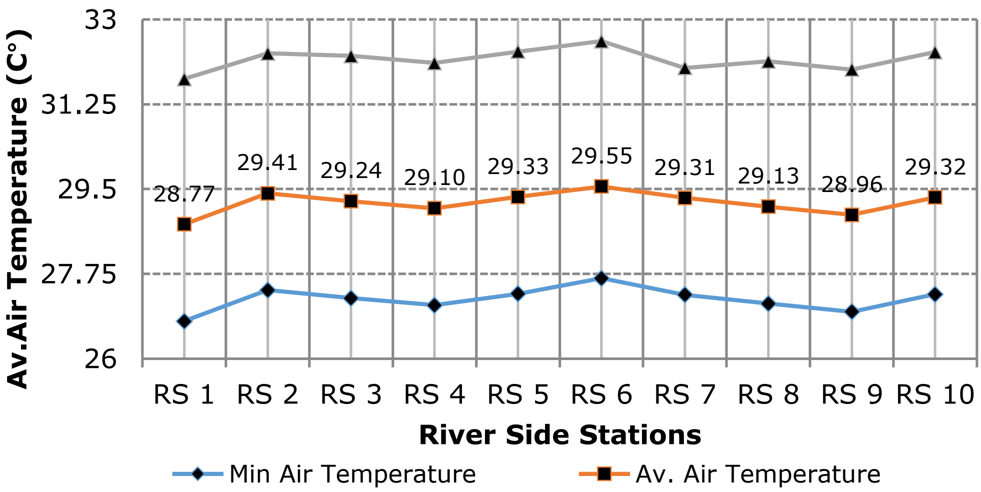


Fig. 4: Average air temperatures from the 10 weather station located alongside the Melaka River.

5. Comparison of day time average temperature of points in along the Melaka river

The second preliminary test intends to analyses the levels that the water bodies cool its respective surroundings. One of the streets (Jalan Tukang Besi) that open up to the river in a perpendicular manner was selected. If the street remains open to the water body and it is not obstructed, it can be assumed that the river can cool it. For the purpose of this study, the same days were selected (June 2014), for 24 hours to examine the influence of distance. The point nearest to the waterways in the study case areas (point 1) was used as a reference point to determine temperature reductions, as shown in Figures 5 and 6.

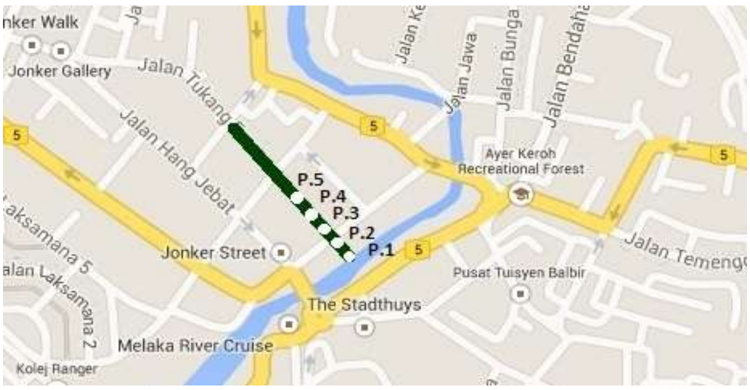


Fig. 5. Five chosen points in Jalan Tukang Besi

5.1. Comparison of day time average temperature of points in along the Melaka river

The influence of river on the air temperature in the aforementioned microclimate is analyzed via the collection and normalization of the data and comparing it with the reference point stipulated in the river body. The air temperature data was collected at every 5 minutes' interval with the help of HOBO data loggers. The measuring points (Point 1, Point 2, Point 3, Point 4 and Point 5) were selected in order to verify the cooling effect propagated from nearby bodies. Five measurement points that were 25 m apart from one another was selected, starting from the side of the river as the reference point (Figure 5).

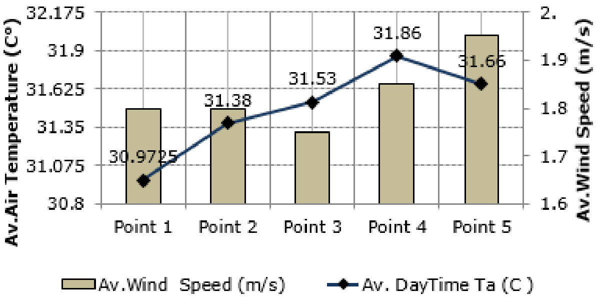


Fig. 6: Average air temperatures from 5 points with 25 meters difference from each other in Jalan Tukang Besi

Figure 6 shows that generally, in the five waterways, the average temperature near the water bodies in a tropical area is quite high, at about 30.97- 31.86°C. As can be seen, the five waterways showed an increase at Point. 2, which is located 25 m away from the river body. This basically implies that during daytime, measurements that are closer to the waterway will result in cooler temperatures, suggesting that temperature variations are functions of distance. The diurnal difference in the average temperature from the reference point and P.1 was confirmed to increase the average temperature by 0.4 °C. It can be surmised that the temperature of the measured points (P.1- P.5), might be influenced by the wind velocity. In order to confirm this statement, the wind velocity values are presented in the same graph with temperature. Overall, there is no obvious relation between velocity and temperature, but very notable in comparison between P.1 and P.2, where they have the same amount of velocity but their temperature value is different. It is concluded the wind in the study area is very static and not strong. In order to the points be influenced by the wind, a really high wind velocity at least above 3 m/s is needed.
Point P3, which is located 25 m beyond P.2 (about 50 m away from the water bodies), also showed an increase. In this study, the first three points are the most likely to be the only points that demonstrate a reasonable evaporative cooling effect from the waterway. The average temperature is directly proportional to the distance of the points; the further away it is, the higher the average temperature of the waterway. Point P.5, which is the measurement point that is furthest from the waterway, was 31.66 °C, which was lower than the average temperature of P.4.
The average temperature difference between the points is approximated to be 0.25-0.30 °C for each point further from the reservoir, where maximum solar radiation occurs. These findings suggest that evaporative cooling from water bodies could produce cooler air for the surrounding area, based on the distance, in a hot and humid climate.
The data collected from Jalan Tukang Besi revealed that air temperature increases the further one moves from the reference points; hence, one can expect the water bodies to bring about a possible cooling effect in hot and humid climates, and with enough solar radiation for the evaporation process, the air temperature is expected to be cooler when moving closer to the waterways.

5.2. Distance effect with polynomial regression

The correlation and regression analyses were conducted in order to determine the increase of air temperature as a function of distance. This study determines to what extent they can enable bodies of water to cool their surroundings. The data suggest that this approach has the potential to address the research objective of reducing temperatures at a distance from water bodies.

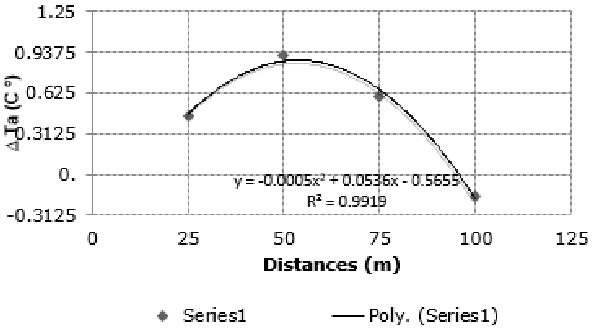
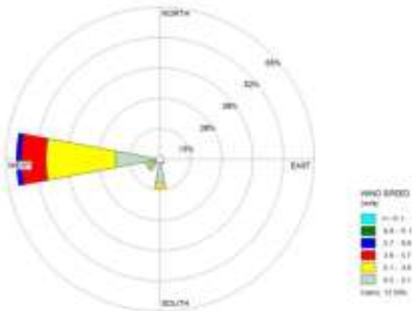


Fig. 7: Correlation between temperature reduction and distance at Jalan Tukang Besi

For the regression at Jalan Tukang Besi (Figure 7), a simple mathematical calculation was used to suggest that this reduction is prevalent within the range of 0.25 - 0.3°C at every 25 m from the waterway. This number is however only true for a bright and sunny day.
The polynomial regression is shown in Figure 7. In Jalan Tukang Besi, the maximum cooling effect extends to ~50 m away from the body of water. Beyond that distance, the cooling effect is less dominant; however, its effect extends up to ~95 m, albeit at greatly reduced effectiveness. Coincidentally, Jalan Tukang Besi had very few trees, which might have affected the performance of water cooling, suggesting that trees adjacent to water bodies are effective in extending its cooling performance.

5.3. Wind characteristics (v)

Figures 8 and 9, show the increase of June wind (distribution of wind speeds and directions) during the study period in Melaka, based on 24-hours of wind data. This shows that the winds in Melaka in June originated predominantly from the west. In fact, the three spokes nearest west (S and SW) comprise of more than 80 % of all hourly wind directions. This also implies that the wind rarely blows from the north or the east. Examining the winds from the west (the longest spoke), one can determine that the wind blows from the west, south-west, or south at speeds between 0.5 and 2.1 m s-1, which is approximately 41.7% of the time in June in Melaka. Similarly, these winds blow at speeds between 2.1 and 3.6 m s-1 ~33.3 % of the time, and at speeds greater than 3.6 m s-1, ~12.5 % of the time from the west. The mean speed of these winds is 3.14 m s-1, with the highest average wind speed of 6.3 m s-1at 16:00 - 17:00, and the lowest at 0.2 m s-1at 00:00 (Figure 10).



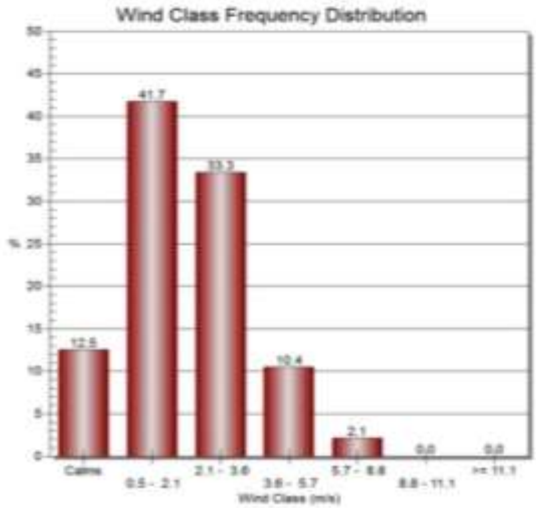


Fig. 8 & 9: June wind rose in Melaka study area

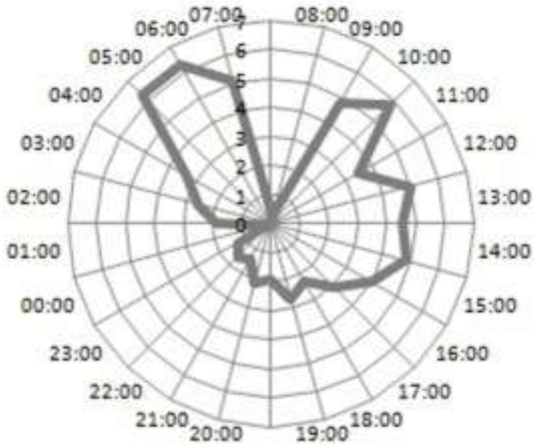


Fig. 10: Hourly average wind speed for the study area

6. Conclusion of the overall field measurement findings from preliminary tests

Based on the data collected and analysed from the field measurements, water bodies can lower the air temperatures in nearby environments. The presence of water bodies obviously improves the thermal environment on hot sunny days via air cooling over a distance. The temperature decreases by ~0.25-0.30 °C for every 25 m away from the water bodies. However, the cooling effect is limited to its immediate surroundings. The regression results suggested that the water bodies' cooling effect could extend to approximately 90 m to its surroundings. Water bodies absorb the heat from their surroundings when they evaporate to instigate a cooling effect. Then, the water molecules evaporate and leave the surface of the water bodies. The results from the preliminary tests will be used to further measure and analyse the water bodies.

Acknowledgements

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