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THE EFFECT OF VEGETATION AND WATER BODY ON THERMAL COMFORT IN BANTENG CITY PARK, JAKARTA

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Abstract

City park plays significant role for city green area and accommodating the social outdoor activities for urban dwellers. Jakarta has initiated the enhancement of its' city parks to provide the comfortable outdoor public area. This study examines the effects of vegetation and water body on the microclimate and thermal comfort in Banteng City Park, Central Jakarta. This study uses Envi-Met 3.1 urban simulation. The result present that the vegetation reduces the air temperature (Ta) and prevent the concrete pavement from the solar radiation exposure, while water body is functions as the cooling agent as it increases the relative humidity. The finding this study is recommend for urban planners and decision makers in designing and strategizing the city parks to achieve the better thermal comfort in the tropical open spaces.

Keywords*:* city park, vegetation, water body, Envi-met simulation

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INTRODUCTION

City park is crucial to maintain a balance of environmental feature in a developed urban area, as it plays the important functions related to ecological, socio-cultural, and aesthetic aspects (Imansari dan Khadiyanta, 2015). Ecologically, city park function as climate controllers, namely as oxygen producers, noise control, as well as visual control through the shadowing affects from the the reflection of sunlight. City park reduce the urban air temperature rise and urban heat island (Ulfiasari and Yola, 2022a; Ulfiasari and Yola, 2022b). Socio-culturally, city park accommodates space for social interaction for urban dwellers. Aside from social space, it also facilitates a recreation, sports, educational facility, or culinary activity center. City park also encourage the pedestrian walkability and the promotion of public transportation (Purwoko et al., 2022; Arif and Yola, 2022; Ashri and Yola, 2022; Marpaung and Yola, 2022) Furthermore, city park increases thermal comfort, beautify the city environment and stimulate the creativity or productivity of city dwellers.

Outdoor thermal comfort is one of the key factors to encourage outdoor social activities of urban dwellers (Ashari and Yola, 2023; Chen, 2012; Effendy and Aprihatmoko, 2018; Hidayah et al., 2020) especially in hot and humid region (Yola and Siong, 2016; Gupta 1984), therefore the consideration of strategizing the maximum level of thermal environment in the process of structuring and designing a city park is important. Thermal comfort can be understood as the way people react to the air temperature around them through their sense of taste (Karyono, 2001). The consideration of the use of various hard scape and soft scape elements is needed in the arrangement and design of city parks (Sastrawan, et al 2018). Therefore, studies (Yola et al., 2023; Erell et al., 2011; Givoni, 1998; Ng, 2010; Oke, 1997; Oke 1979) have highlighted range of strategies in maximizing the role of city parks through the sustainable and climatically responsive urban design and urban planning (Yola et al., 2020)

Jakarta as a high dense metropolitan area, experiences the critical issue of lacking the public open green space due to the rapid development (Hidayah et al., 2020). It brings the problem of increase of air temperature, environmental degradation and lacking of public open spaces in the city. Thus, Jakarta local city authority seeks to strategies in enhancing the existing public open spaces especially the big city parks. Banteng City Park is no exception. As one of the city parks in Central Jakarta, Banteng City Park has social benefits for the community as a place to play, exercise, gather, socialize, rest and enjoying the fresh air in the city center. Banteng City Park has been going through great process of revitalization which has been open again for public in 2018 (Figure 1). In general, Banteng City Park is categorized into three zones for public use. The first zone is the sports zone which is located on the north side, the second zone is the conservation/main zone which is located in the middle of the Banteng City Park, and the third zone is the urban forest or green zone which is located on the south side. Generally, there are variations in land cover in Banteng City Park , in the sports zone it is covered by grass, in the conservation/main zone it is covered by concrete pavement, and in the urban forest zone, it is a combination of concrete pavement and grass.

Figure 1: Site Situation of Banteng City Park in Jakarta

Though the social mobility was restricted during the pandemic, Jakarta urban dwellers were encouraged to visit the public open spaces with some health protocols (Mogot et al., 2021). Technically, the Banteng City Park visitors tends to be more focused on the conservation/main zone with more tree area, meanwhile other sides tend to have less used by visitor. As Banteng City Park is one of Jakarta local authority's priority and main concerned city parks, this issue was the background of furthering the empirical research on the effect of land cover and vegetation on thermal comfort in Banteng City Park. The finding of this study is expected to be great recommendation for urban planners and designers, as well as the Jakarta local authority in strategizing, managing and designing the Banteng City Park to support sustainable and climatically responsive urban environment.

LITERATURE REVIEW

This study investigates the thermal performance of land cover materials and vegetation. Susanti et al (2006) emphasized that each surface material has a different albedo, in this case changing the fraction of solar radiation that is reflected or absorbed by the surface. The albedo of urban areas ranges from 10-15% (snow albedo is higher than 80%), this can also mean that the greater the incoming solar energy absorbed by a city. On the other hand, building materials used in urban construction are generally synonymous with high heat capacity and conductivity. The combination of low albedo with high heat capacity is an anthropogenic factor that produces a special character in the atmospheric conditions above urban areas.

Vegetation in urban areas provides many benefits such as reducing the urban heat island effect, reducing air conditioning costs in buildings, improving air quality, and providing a psychologically superior setting for human activities (Zhao et al., 2018). The presence of trees in urban areas can affect air temperature at a range of spatial scales, from individual roads to urban scale modifications. Trees reduce not only solar radiation intensity in the urban surface, but also longwave radiation from the ground, building surfaces, and the sky (Erell, 2011).

Vegetation also influences surface temperature. Vegetation is one of the natural components that can cause the comfort level of air to remain comfortable (Susanti et al, 2006). When a city promotes green open space, the temperature in the city can be reduced by 0.2°C to 0.5°C (Effendy, 2007).

According to Erell (2011), there is a strong relationship between temperature variations, vegetation cover, and thermal stress. Erell (2011) illustrates the potential of urban vegetation to moderate thermal stress. It was further explained that the yard covered with earth or grass or concrete paving is planted with shade trees (mesquite and rosewood), allowing for reduction of daytime thermal stress.

According to Gomez et al. (2004), there is a relationship between temperature variation, vegetation cover, and thermal comfort. It is further emphasized that the vegetation zone affects the albedo and the amount of solar radiation reaching the metropolitan area significantly. There is a favorable relationship between human comfort and comfort index.

RESEARCH METHODOLOGY

The method used in this study is an experimental and simulation method using the Envi-Met 3.1 computer application. Earlier studies stress the urban simulation is a reliable approach to investigate the micro urban microclimate and thermal comfort (Yola et al., 2022; Elnabawi et al 2013). In this research will be divided into three stages of research. The first data collection on the existing conditions of the microclimate in the existing site, as well as additional data covering the condition of vegetation and land cover in the study area. The second stage is to carry out the Envi-met 3.1 simulation on the existing site conditions on January 18, 2023, from 07.00 a.m to 06.00 a.m next day. Third, carry out the simulation data extraction and analysis using the existing site configuration data and microclimate that has been obtained with the receptor height at the average height of the Indonesian pedestrian, and the location of the receptors or observation locations in the simulation is in the pavement circulation area without vegetation shade, pavement circulation area with shade vegetation, as well as in the amphitheater area adjacent to the water pool. Observations and measurements of the microclimate and thermal comfort data in the Banteng City Park were carried out at two times, namely at 10.00 and 16.00 western Indonesian time, as at these particular times the solar radiation were high and the density of visitors were maximum.

ANALYSIS AND DISCUSSION

To simulate the existing conditions in the Banteng City Park, the data needed include pavement typology, building height, type, and density of vegetation. As a basis for the simulation, data on microclimatic conditions are needed. The microclimate data needed includes data on air temperature, air humidity, and wind speed. In this study, the configuration microclimate data was referred from the National Climatic Data Center (NCDC) data at the BMKG Kemayoran station or from the Central Statistics Agency (BPS).

This simulation was carried out for 24 hours using ENVI-met 3.1 to determine the effect of vegetation and water on air temperature or thermal comfort in Banteng City Park site (Figure 2). The urban configuration simulation was held on 18 January 2023. The ENVI-met configuration editor data includes the physical and climate data, as follows:

- Windspeed: 3 m/s
- Wind direction: 220°
- Relative Humidity: 66%
- Initial temperature atmosphere: 304,15° K

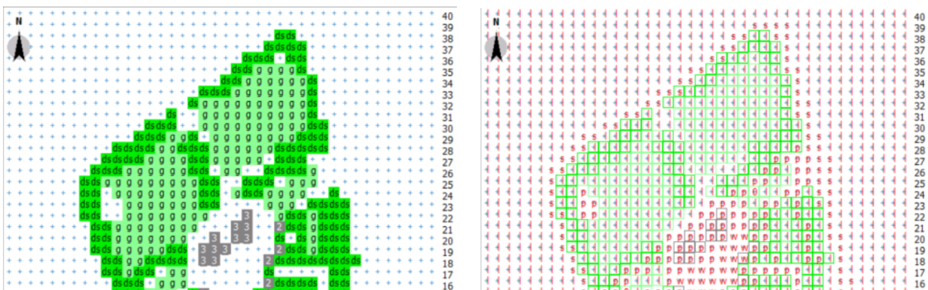

Figure 2: Site Domain in Envi-Met Model

The wind speed felt at the receptors located in the pavement circulation area with vegetation shade is higher (1.22 m/s) compared to the pavement circulation area without vegetation (0.64 m/s) and the pavement circulation area adjacent to water (0.97 m/s). Pavement circulation areas with shaded vegetation have higher wind speeds, especially in the west area. This condition is due to the corridor of this area has an orientation close to the same direction as the inlet wind direction. Whereas on the east side or pavement circulation areas without vegetation tend to have low wind speeds due to the blocking of surrounding dense buildings.

Relative humidity (qrel) in the pavement circulation area with vegetation shade is higher (73.26%) compared to the pavement circulation area without vegetation (71.98%) and the pavement circulation area adjacent to water (72.56%). Relatively low humidity is found in the pavement concrete circulation area without vegetation shade, this occurs because the heat generated by the road material affects the temperature value to be higher and causes water vapor to decrease. Circulation areas that have vegetation have higher relative humidity due to the evaporation process from the evapotranspiration of vegetation by solar radiation, increasing relative humidity.

The temperature (Ta) felt by receptors located in the circulation area of the pavement with vegetation shade is lower (22.23°C) compared to the circulation area of the pavement without vegetation (22.37°C) and the circulation area of the pavement adjacent to water (22. 31°C). The air temperature in the pavement circulation area with vegetation tends to be lower because it is covered in shadows due to the vegetation canopy. Vegetation plays a role in reducing the absorption of pavement concrete material (road material that is directly exposed to solar radiation). There is a shadowing condition from the vegetation canopy touching each other, resulting in lower heat absorption. Vegetation also helps reflect solar radiation, so the surface material beneath absorbs little solar radiation. Figure 3 presents the mapping of the air temperature distribution at 10.00 and 4.00 by using Leonardo 2D graphic.

The mean Radiant Temperature (Tmrt), in the pavement concrete circulation area, reaches a high value because the area's pavement material is exposed to direct solar radiation. Based on pavement material, the circulation area with pavement concrete material type land cover has the highest MRT value, namely 14.18 – 14.62 °C, while pavement concrete with vegetation shade and pavement concrete adjacent to water has a lower MRT value of 13.08 – 13.30 °C. Areas with vegetation tend to have lower values because they are covered in shadows due to the vegetation canopy. It can be further explained that the presence of the water element as part of the outdoor space element can be useful as a cooling element during hot weather because water can increase humidity and the larger the water area, the greater the impact that may occur on the microclimate (Laurie, 1986). Figure 4 presents the mapping of the mean Radiant Temperature distribution at 10.00 and 4.00 by using Leonardo 2D graphic.

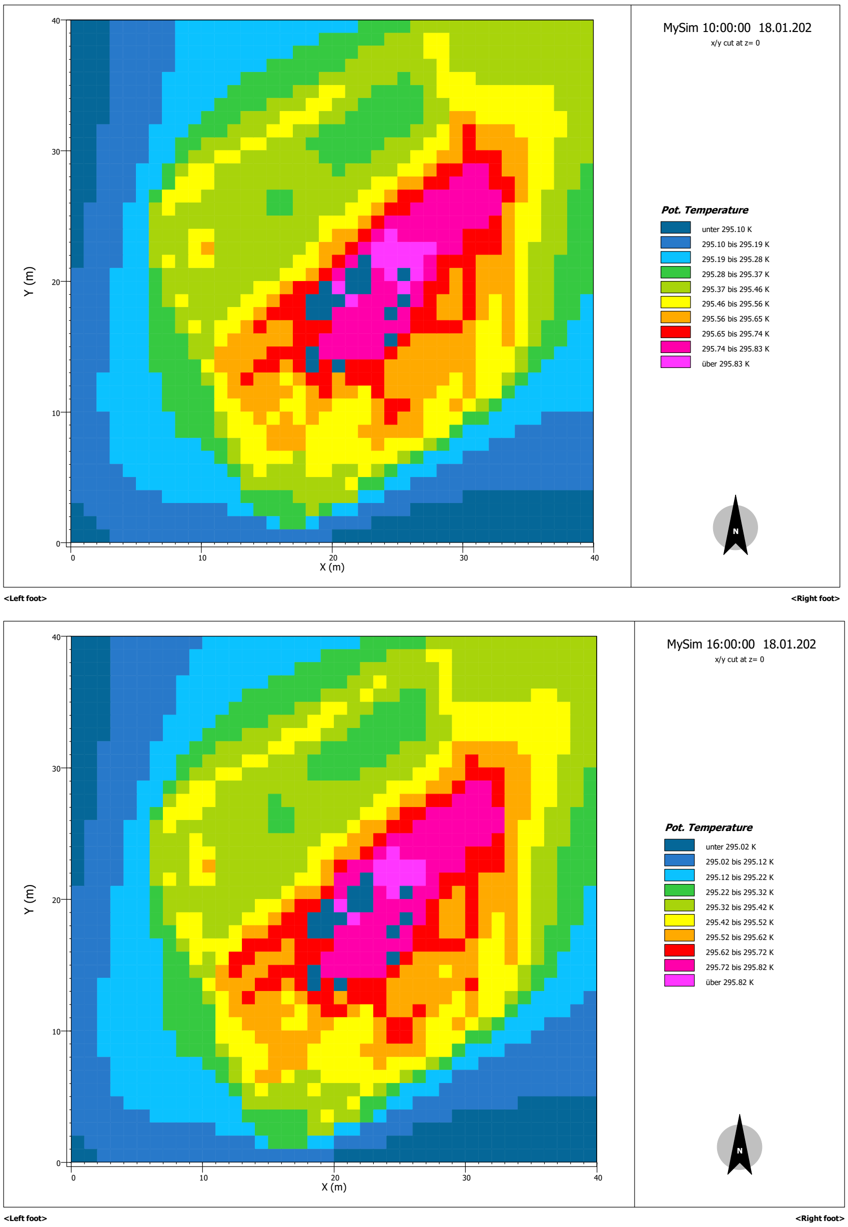

Figure 3: Mapping of the air temperature distribution at 10.00 a.m (top) and 4.00 p.m (buttom)

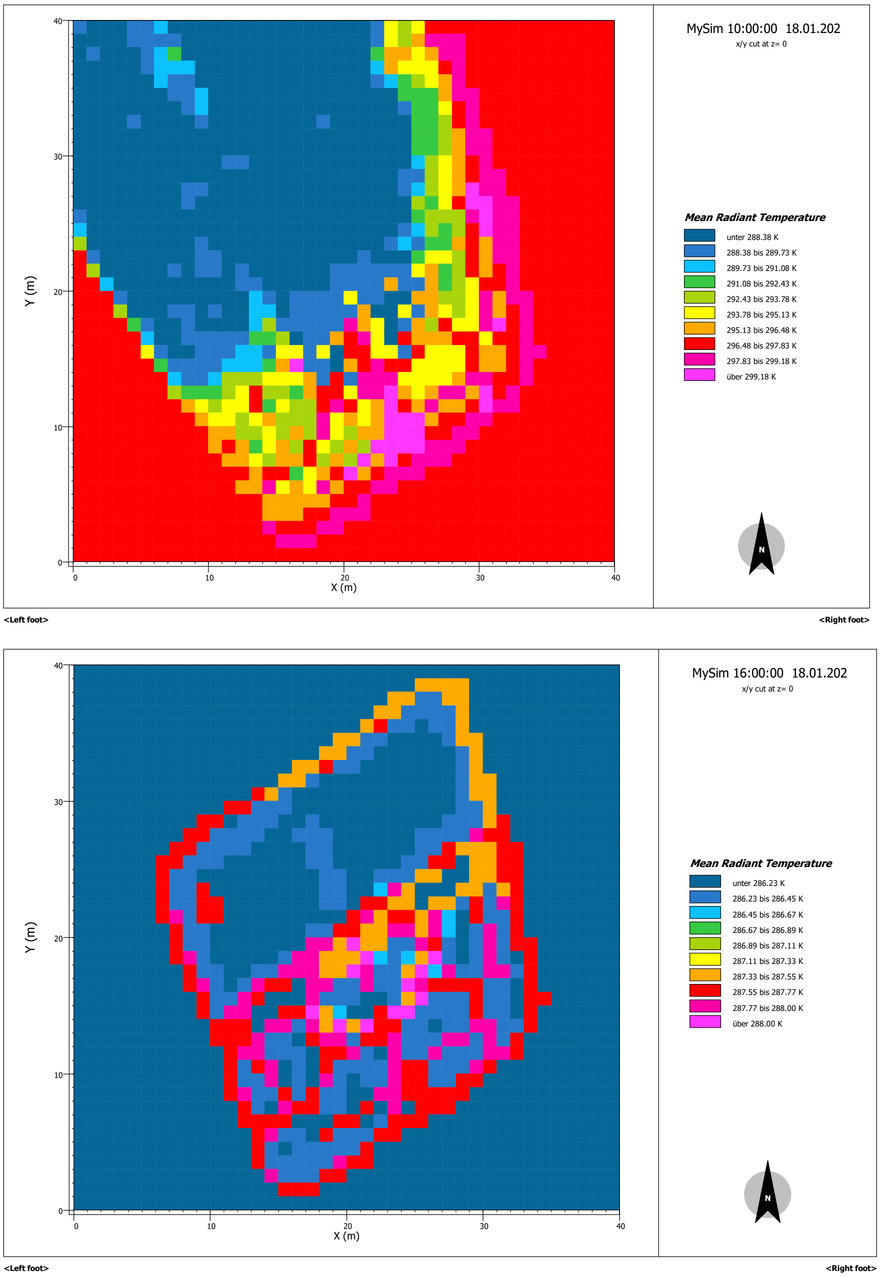

Figure 4: The mapping of the mean Radiant Temperature distribution at 10.00 (top) and 4.00 (buttom) by using Leonardo 2D graphic

According to Lippsmeier (1997), to obtain thermal comfort in the context of a microclimate in a humid tropical climate is determined by three parameters, namely:

a. Air Temperature: standard criteria for thermal are divided into comfortable cool (20.5°C – 22.8°C), optimal comfort (22.8°C – 25.8°C), and comfortably warm (25.8 °C – 27.1°C).
b. Air Humidity: comfort criteria range from 40% to 70%.
c. Wind Direction and Speed: ranges from 0.1 m/s to 0.5 m/s

Referring to the parameters put forward by Lippsmeir (1997), it is known that the entire area of Banteng City Park (the pavement circulation area with vegetation, the pavement circulation area without vegetation, the pavement circulation area adjacent to water) is classified as comfortable cool.

CONCLUSION

Public green open space plays a crucial role in balancing the ecology and environmental character of dense urban area. This study raises the urgent need for maximizing the great role of public green open spaces by strategizing the microclimate and thermal comfort to accommodates the climatically responsive urban design by considering both green and social concern. The simulation finding of this study present that in Banteng City Park, the promotion of vegetation was able to reduce air temperature (Ta) and reduce exposure to pavement concrete from solar radiation as the source of the outdoor heat stress. Meanwhile the water body functions strongly as a cooling element during hot weather as it increases the humidity. The finding of this study and the strategy on vegetation and water body applied in Banteng city park master plan is recommended for urban planners or designers as well as decision maker in strategising a climatically and sustainable city parks in Jakarta or a hot and humid city context.

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