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Original article

Potential of important vegetation in Vatulemo Green Open Space

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Abstract

Green Open Space is a space that is fully arranged with various plants. The expansion of green open space in Palu City is designed to meet the minimum minimum area of greeneries at 30% of the city area. Landscape areas with different types of vegetation have different abilities to provide thermal comfort. This research aims to analyze the vegetation structure and the ability of vegetation to reduce air temperature in Vatulemo's green open space. This research method are analysis of the vegetation structure in Vatulemo City Park's green open space based on the types of vegetation components that comprise the green open space and exploratory analysis of the ability of vegetation with the highest importance value (IVI) to reduce air temperatures that provide thermal comfort for various living things. The results showed a codominance between the vegetation was found, for instance, *Cuphea* sp, *Samanea saman*, *Cynodon dactylon*, *Terminalia mantaly* and *Tabernaemontana divaricata*. The average temperature under and outside the canopy of the vegetation was quite different. The temperature under the canopy is lower than outside the canopy. The difference in surface temperature under and outside the canopy is influenced by the primary factor of shading arising from the thickness of each vegetation's canopy. As a result, according to SNI 03-6572-2001, temperature under canopy vegetation with the highest importance are classified as comfortable warm standard temperature. In Vatulemo Park, planting canopy trees remains extremely scarce. Each vegetation has a different ability to create thermal comfort.

Keywords: Green Open Space, Important Value Index, Vatulemo Park, Temperature, Thermal Comfort, Vegetation

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Introduction

The expansion of green open space is designed to meet the minimum requirement of greeneries in urban areas. According to Law no. 26 of 2007, urban areas are required to include a plan for the provision and utilization of green open space (BPK, 2022) and sets the minimum area of greeneries at 30% of the city area, accounting of 10% private and 20% public green open space.

The development of urban areas necessitates a greater focus on wildlife habitat and life in land use changes. The existence of various fauna in urban ecosystems is an essential features of ecological cycle (Smail & Lewis, 2009). Changes in land use can cause habitat fragmentation from the city center to outskirts, resulting in the formation of habitat pockets or patches (Handoyo et al., 2016). The identification of plant species and their ability to reduce air temperature can an overview of the potential of urban vegetation to provide thermal comfort. As a results, it is expected that the urban environment will become more acceptable for animal habitat. The achievement of sustainable green open space is also driven by its ability to meet the germplasm need (biodiversity) (Kusmana, 2015).

In previous studies, various thermal comfort indicators have been studied (Bandaso & Widjajanti, 2016; Rejeki, 2017; Wahid *et al*., 2021). Of these factors, people visit city parks for the perceived outdoor thermal comfort of the role of urban green open spaces, indicating that different types of vegetation exert different abilities providing thermal comfort in landscape areas. In addition other studies' findings, such as the selection of tree species such as *Machilus nanmu, Ginko biloba,* and *Sabal pallmeto* attributing with crowns, intersecting leaves, and dense planting patterns, serve as a model for optimizing outdoor thermal comfort in urban areas (Zhang et al., 2020). The presence of high albedo concrete in green spaces casts a shadow. Trees composing broad canopies, as well as the use of water in green spaces, are ideal solutions for dealing with summer heat (Gachkar et al., 2021). Urban Heat Island has a significant impact, particularly on outdoor thermal comfort. Building high cliffs that form a canopy to model the urban landscape is a step toward providing thermal comfort by lowering ambient air temperatures (Deng & Wong, 2020).

In this scenario, this study was carried out in the city park of Vatulemo Palu, which have not studied yet. The green open space was quite wide, and a more in-depth study was associated with the ability of vegetation for thermal comfort that would support the activities of living organism, especially the people of Palu City. According to Meteorological and Climatological Agency (2022) records, the average temperature around the Vatulemo city park is approximately 32°C, which is above thermal comfort. As a result, it is necessary to improve the function of critical vegetation. The most widely known plants in the garden, providing thermal

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comfort not only for humans but also for other living things such as fauna, are referred to as critical vegetation. Thermal comfort refers to the sensation of heat or cold as a form of temperature stimulation of the body (Hoppe, 2002). The presence of vegetation contributes to cooling the air near green spaces, which are driven by evapotranspiration. The morphology of each type of vegetation, especially the roots, affects the evapotranspiration process. Since there is a process of soil water absorption, water evaporates when heat energy is absorbed. The evaporation of water creates moisture and has a cooling effect on the air temperature around the vegetation (Pudjowati, 2018). It is expected that the development of Green Open Space in Palu City can be more optimal to overcome the problem of urban heat in the future. According to the corresponding problem above, this research aims to analyze the vegetation structure and the ability of vegetation to reduce air temperature in Vatulemo's green open space.

Methods

This research was conducted at the Vatulemo City Park green space, Palu City, Central Sulawesi (0°54′1″S, 119°48′320.9″E) (Figure 1). The Vatulemo Park area is located in South Palu District, Mantikulore. The Vatulemo City Park covers an area of 206.8 km^2. This study was perfomed in two stages of research, including analysis of structure vegetation and exploratory analysis of the vegetation. Firstly, the Analysis of the vegetation structure in Vatulemo City Park's green open space based on the types of vegetation components that comprise the green open space. Secondly, exploratory analysis of the ability of vegetation with the highest importance value (IVI) to reduce air temperatures that provide thermal comfort for various living things (Table 1) (Hidayat, 2018). Temperatures were measured under and outside the vegetation canopy using a mercury thermometer, 1.5 m from the ground. The measurement time was carried out for five days, with the times 05.00 am (morning), 13.00 pm (noon), 17.00 pm (afternoon), and 20.00 pm (evening) local time (GMT+8).

Figure 1. Vatulemo Green Open Space

Measurement of the structure and composition of vegetation using the line transect method was adopted from the previous study with minor modifications (Mueller Dumbois & Ellenberg, 1974). In the measurement, vegetation structure parameters are measured based on density, relative density, frequency, relative frequency, cover or basal area, and relative basal area for all types of vegetation to obtain an important value index. The transect method is a narrow path that crosses the land to be investigated by forming a line. This method employs a line that determines the sample point, approximately 50 m from the park's right or left edge, and then draws a transect with a size that is adjusted to the path that the vegetation follows. After establishing the transect line, measurements are taken by walking along it (Sari et al., 2019). The Importance Value Index (IVI) (Table 1) indicates the importance of each plant in the City Park based on its values (Arisoesiloningsih et al., 2018). Vegetation with the highest importance from various types of vegetation of trees, shrubs, and grasses will be observed to determine its role in lowering air temperature, providing thermal comfort in urban parks. The value of temperature will be measured under the canopy and outside the canopy of vegetation. The thermal measurement outputs are compared to the SNI 03-6572-2001 thermal comfort index (National, 2001). According to previous study (Karyono, 2004; Kusumawati, 2011; Tuhari 2014), the thermal comfort index SNI 03-6572-2001 for Indonesians is valued about 20.5-22.8 °C for comfortable cool temperature, 22.9-25.8 °C for neutral or comfortable, and 25.9-27.1 °C for comfortable heat.

Analysis

Vegetation data was analyzed both qualitatively and quantitatively. Plant species that constitute urban green spaces were described using qualitative analysis. Identification books and other supporting applications assisted in the identification of vegetation. Quantitative analyses were conducted to describe the structure or form of plant composition of the Vatulemo City green open space, as well as the level of importance of each species in the City Park. Microsoft Excel calculations were used to calculate density, cover or basal area, frequency, and Importance Value Index (IVI) (Table 1) (Hidayat, 2018). The hourly average temperature data will be displayed in a fluctuation graph/image showing the maximum and minimum average temperature values. If the observed value exceeds the threshold of comfortable warmth, then recommendations or suggestions will be given as improvements and efforts to overcome the problem of hot city temperatures.

Table 1. Equations to calculate Important value index (IVI) of species

Index	Equation
Importance value index (IVI)	Relative density + Relative frequency + Relative dominance
Relative density	$\frac{\text{Density of a species}}{\text{Total density of all species}} \times 100\%$
Relative frequency	$\frac{\text{Frequency of a species}}{\text{Total Frequency of all species}} \times 100\%$
Relative dominance	$\frac{\text{Dominance of a species}}{\text{Total Dominance of all species}} \times 100\%$
Density	$\frac{\text{Number of a species}}{\text{Total area sampled}}$
Frequency	$\frac{\text{Area of plots in which a species occurs}}{\text{Total area sampled}}$
Dominance	$\frac{\text{Total basal area of species}}{\text{Total area sampled}}$

Results

Vegetation structure of Vatulemo Green Open Space

Based on important value index (IVI) data, the vegetation structure in Vatulemo consists of various types, including trees, shrubs, and herbs. The vegetation structure of urban green open spaces shows IVI values in the range of 4.5-27.7%. Based on this data, a codominance between the vegetation was found, for instance, *Cuphea* sp with an importance value of 27.72%, *Samanea saman* 26.51%, *Cynodon dactylon* 25.96%, *Terminalia mantaly* 25.49% and *Tabernaemontana divaricata* 22.25% (Figure 2).

The ability of Vatulemo's vegetation to lower air temperature

The average temperature under and outside the canopy of the *T. mantaly* tree differed at the afternoon and evening (Figure 3a). The maximum temperature under and outside the canopy is 30.3°C and 31.3°C in the noon, respectively, resulting in the differences temperature about 1°C. However, no difference in temperature was observed in each cardinal directions. In the afternoon, the temperature under and outside the canopy was 27.1°C and 27.5°C. Based on SNI 03-6572-2001, noon and evening temperatures are classified as the comfortable warm standard temperature.

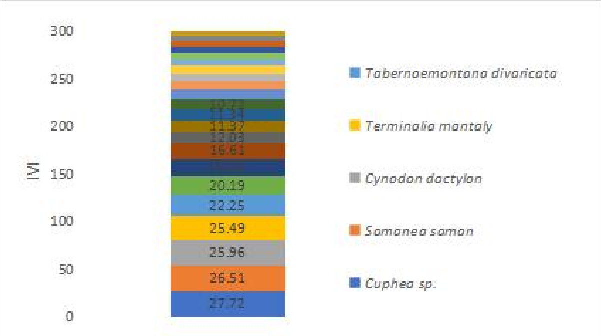

Figure 2. Important Value Index of Vegetation in Vatulemo Green Open Space

The average temperature under and outside the canopy of *S. saman* revealed different in different time (morning, noon, afternoon, and evening (Figure 3b). However, the temperature is still relatively warm in the morning and evening, falling below 27°C under and outside the canopy. At maximum temperature (13.00 p.m.), the surface temperatures under and outside the *S. saman* canopy are 29,2°C and 30,6°C, respectively, revealing about 14°C differences. The temperature rose above 27,1°C in the evening. According to SNI 03-6572-2001, the temperature was classified as the warm comfortable standard temperature.

The average temperature under and outside the canopy of the *T. divaricata* small was quite different. The temperature under the canopy is lower than outside the canopy. The difference in surface temperature under and outside the canopy is influenced by the primary factor of shading arising from the thickness of each vegetation's canopy. In addition, the increase in air temperature in green open spaces was affected by the presence of pavement media such as unshaded paving (Figure 3E). The temperature under the canopy was between 29,5-29,8°C (Figure 3c), while the temperature outside the canopy reaches 31°C. As a result, according to SNI 03-6572-2001, temperature under of *T. divaricata* is classified as comfortable warm standard temperature.

The temperature under the canopy of *Cuphea* sp in the morning is warmer than outside the canopy. While, the temperature outside the canopy is higher than the surface of the plant in noon, afternoon, and evening. The maximum different temperature under and outside the canopy was considerably different. The surface temperature under and outside the canopy of *Cuphea* sp were 30°C and 31°C, respectively, which classified as the comfortable warm standard (Figure 3d). The temperature on the grass surface reaches 31°C, which is lower than the surrounding temperature, while the temperature above the paving surface reaches 31,8°C (Figure 3e). This suggests the role of grass in reducing temperature when compared to the surrounding area of paving.

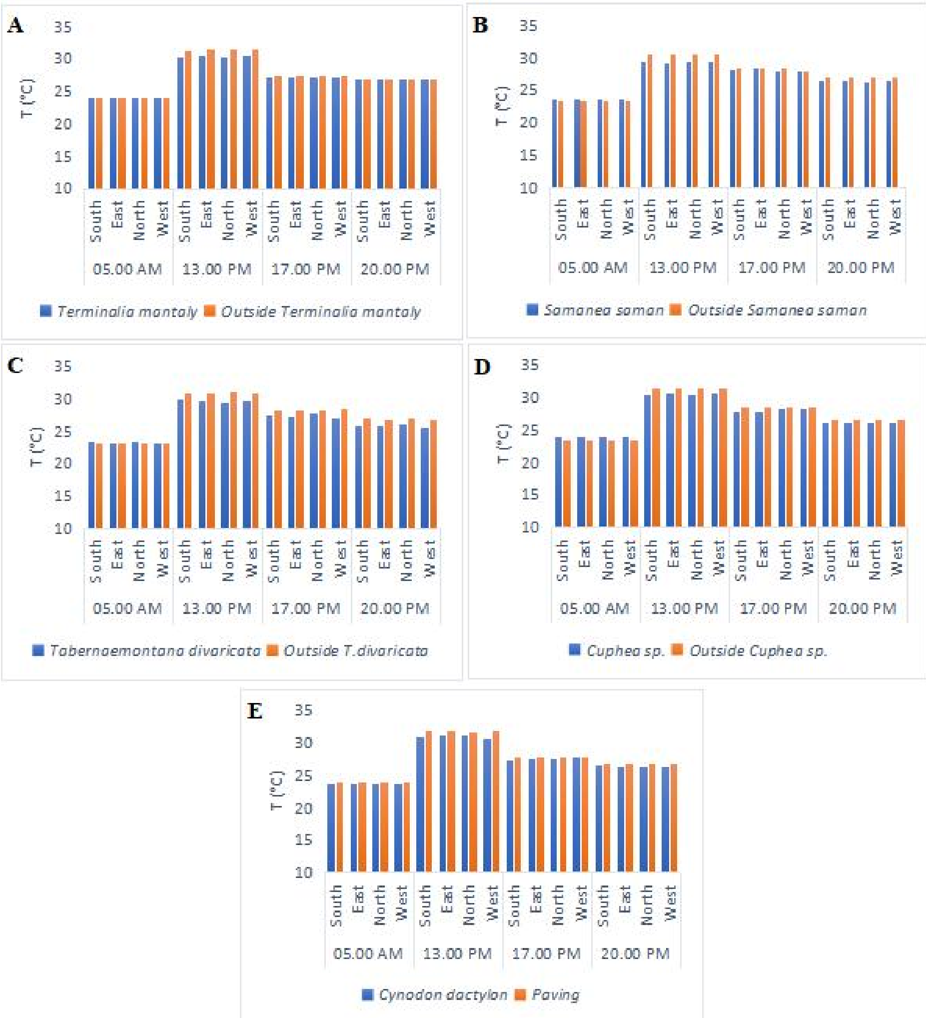

Figure 3. Vegetation surface air temperature: A=*T. mantaly*, B=*S. saman*, C= *T. divaricata*, D=*Cuphea* sp E=*C. dactylon*

Discussion

Various types of vegetation of Vatulemo Park

Vegetation types, including shrubs or undergrowth, had the highest abundance of species in green city Vatulemo compared to trees, where *Cuphea* sp is the most commonly found as shrub. *Cuphea* sp. was planted to provide greenery to the ground area of Vatulemo's Green Open Space. It was often used to enhance the appearance of the garden. The growth of this shrub requires extra maintenance to achieve maximum shape and shade. However, *Cuphea* sp. is known resistant against pest attacks (Housing and Cipta Karya Office, 2021).

The canopy of S. saman is considered to have a cooling effect. The use of *S. saman* in urban parks and urban forests is very common due to its optimum role as a canopy. The shape of the *S. saman* canopy shapes an umbrella, resulting in a canopy tree (Afrianto et al., 2021). In addition, *T. divaricate* is one of the composing vegetation of Vatulemo gardens with lots of small tree species. Its role as an ornamental plant is driven by its attractive and highly decorative flower morphology. Visitors are attracted to the city park because of this flower. In addition, this plant is an evergreen plant (Kukde et all., 2018). Following that, *C. dactylon* exhibited the highest density in the Vatulemo garden. This grass is easily planted in the garden area. Its ability to thrive on barren land and lack of water is widely recognized as a ground cover (Yulifrianti et al., 2015). *T. mantaly* is regarded as a canopy plant planted as a building block of the garden. Its crown is composed of shady leaves which provide a comfortable atmosphere underneath (Makmur, 2019).

The capability of vegetation canopy as canopy creates thermal comfort

S. saman has a freely spreading canopy making it very appropriate when used as canopy vegetation, due to the fact that plants with a wide canopy have a 76% more effective evapotranspiration process, including water evaporation and cooling processes supported by planting media in the form of soil or grass (Ow et al., 2019). *S. saman*'s ability to reduce temperature reached 4.2%. The abundance of *S. saman* that predominated in Vatulemo Park was highly favourable to the soil medium. In addition to *S. saman*, trees with crowns and foliage that satisfy the assessment criteria as crown vegetation for tree species such as spreading, wide, and umbrella-shaped crowns are strongly encouraged as park trees (Ihsan et al, 2020). The tree canopy is a critically significant element contributing to modifying the local microclimate as it lowers solar radiation and controls wind speed. (Vieira De Abreu-Harbich et al., 2012).

According to Mastaba (2018), the canopy of *T. mantaly* decreases the temperature that falls under the discomfort index by 6%. In this study, *T. mantaly* can reduce the uncomfortable temperature by 3.1%. This is due to the number of leaves on *T. mantaly* in Vatulemo Park is still less dense. The growth of this tree is considered low to medium and therefore its ability remains limited. *T. divaricata* has a crown shape that is less umbrella-shaped but has a densely packed leaf mass. The dense leaf mass plays a role in decreasing the ambient air temperature. Its ability to improve thermal comfort by lowering the temperature reached 3.8%. Planting plants with dense leaf shapes is highly recommended to modify the local microclimate to increase thermal comfort (EPA, 2022). The function of grass or shrubs serving as ground cover plants is evident in reducing the ambient air temperature when pavement materials such as paving are located outside the plants. Pavement materials such as paving could elevate the ambient air temperature up to 10°C compared to the surrounding temperature (Anupam et al., 2021). Thus, it is desirable for ground cover plants for covering garden areas compared to larger areas of pavement such as asphalt roads, concrete, or paving. However, when compared to trees and shrubs, the ability of ground cover plants are less optimal to reduce ambient air temperature. In this study, ground cover plants such as grass, shrubs, and *Cuphea* sp did not play an optimal role in modifying the local microclimate.

Thermal comfort can be achieved when the vegetation in the park is dense. The role of canopy vegetation is considered to function optimally if the canopy of each tree with the subsequent trees in close contact with each other. The addition of vegetation types in the form of trees with characteristics as canopy vegetation is essential to the optimisation of the role of green open spaces providing thermal comfort. The process of decreasing the temperature around vegetation is triggered when vegetation converts water into water vapour through the transpiration process, where the temperature of the leaves and the surrounding air can decrease. (Lai et al., 2019). The effectiveness in reducing air temperature, facilitating thermal comfort, can be optimised by trees rather than ground cover plants or canopy-less plants such as grass (Lee et al., 2016). The cooling effect induced by the presence of vegetation in the form of trees having a wide canopy will be even greater, twice as high during hot and sunny weather than during overcast (Wang et al., 2015). The effect of the cooling arising from the presence of vegetation, especially trees in green open spaces and parks, is highly desirable in tackling the city's heat issue.

In conclusion, the vegetation composing the Vatulemo park as a green open space is composed of many types, including trees, small trees, shrubs with diverse morphological characteristics. The vegetation serves as ornamental plants and a canopy. Trees and ornamental plants are the predominant plants in Vatulemo Park. The ability of vegetation to function as a canopy plant is wide canopy trees. This wide canopy can be utilised to increase thermal comfort. In Vatulemo Park, planting canopy trees remains extremely scarce. Each vegetation has a different ability to create thermal comfort.

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