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RESEARCH ARTICLE

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The Urban Forests Affecting the Environmental Parameters in Makassar City, Indonesia

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ABSTRACT

The urban forests in every city are very important to creating comfortable urban conditions for the community. The existence of urban forests, such as city parks, urban forests, and fields, can provide a sense of comfort to the community both thermally and visually. In addition, urban forests also act as microclimate ameliorators and noise reducers. The importance of this research is that it is expected to provide additional information and reference materials to identify the factors that contribute to thermal comfort in green open spaces in Makassar City. This study aims to analyze the thermal comfort of some green open spaces in Makassar City. The methodology of this research involves a field survey that measures climate factors such as temperature, humidity, sunlight intensity, noise, and wind speed. Thus, it can be concluded that if increasing the urban forest area in urban areas will have a positive impact on comfort, improve air quality, water, soil, and biodiversity, as well as enhance public health and welfare. Enhancing urban forests requires an approach that involves good urban planning, supportive policies, community participation, and the adoption of green technologies across the board, particularly in Makassar City.

Introduction

Urban forests are an essential element of environmental sustainability in urban areas that must be considered. Green space (urban forest) can exist in compact or clustered areas or along longitudinal or circular paths with more relaxed use, where plants grow naturally or intentionally cultivated. Increasing urban development, population growth, the number of vehicles, and various urban activities lead to a decrease in environmental quality, causing changes in ecosystems, such as temperature, humidity, sunlight intensity, noise, and wind speed. One of the steps to improve and preserve the Earth is addressing these issues [1]. Increasing urban growth and human activity in urban forests is needed to help absorb carbon through photosynthesis, which can only be achieved by increasing the area of plants. This explains that urban forests function as regulators of environmental parameters and provide shade.

Urban forests play an important role in improving the quality of the urban environment because they combine natural and human systems and are part of the spatial arrangement of urban areas with a large amount of vegetation. Urban forests, such as parks, forests, and green lanes, with vegetation as a component, can improve the quality of life in many ways [2]. The large amount of vegetation in an urban forest plays a vital role in controlling the parameters of the urban environment, which shows that vegetation has a positive impact on handling environmental parameters through the absorption and reflection of solar radiation, as well as through leaves and twigs that block solar radiation, slow wind speed, and control noise [3]. This is important because the more vegetation planted in the middle of a city, the greater the benefits for improving the quality of the city's environment. Therefore, it is necessary to measure environmental parameters at

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three urban forest locations in Makassar City to determine the influence of urban forests on environmental parameters in Makassar City.

Materials and Methods

Study Area

The study was conducted in Makassar, specifically in Pakui Sayang Park, the UNHAS (*Universitas Hasanuddin*) Tamalanrea Campus, and Karebosi Fields. The study was carried out from March to May 2023, over a period of three months, with measurements taken for seven days, divided into four different time slots each day: 06.00–07.00 AM, 09.00–10.00 AM, 12.00–01.00 PM, and 03.00–04.00 PM. Measurements were taken both inside and outside the urban forest, where the measurements were carried out simultaneously inside the urban forest and outside the urban forest, with data collected simultaneously at each location every day, assuming sunny weather conditions during the measurement period.

Data Processing and Analysis Methods

This research method is a field survey that involves climate measurements of temperature, humidity, sunlight intensity, noise, and wind speed. The data collection procedure involves determining the measurement points, preparing and installing research tools at the measurement locations, and then conducting measurements with the following details. The microclimate (temperature and humidity), sunlight intensity, wind speed, and noise were measured using a Mastech MS6300 tool. For each location, two sampling points were selected: one inside the urban forest and one outside the urban forest. Therefore, across the three research locations, the total number of sampling points is six. The sampling points were positioned using the Mastech MS6300 tool, placed at a height of 160 cm, both inside and outside the urban forest simultaneously at each research location.

The data analysis used was a correlation analysis conducted with the IBM SPSS Statistics 26 application and tested using ANOVA, which showed a value of α < Sig. A value of 0.005 indicates a significant difference between the inside and outside of urban forests. Figure 1 shows maps of the research location illustrating the specific areas where data collection and observations were conducted. The map provides a detailed representation of the park's geographical features, including pathways, vegetation zones, and key landmarks relevant to the study. This visual aid helps understand the spatial distribution of the research sites and their significance to the study objectives.

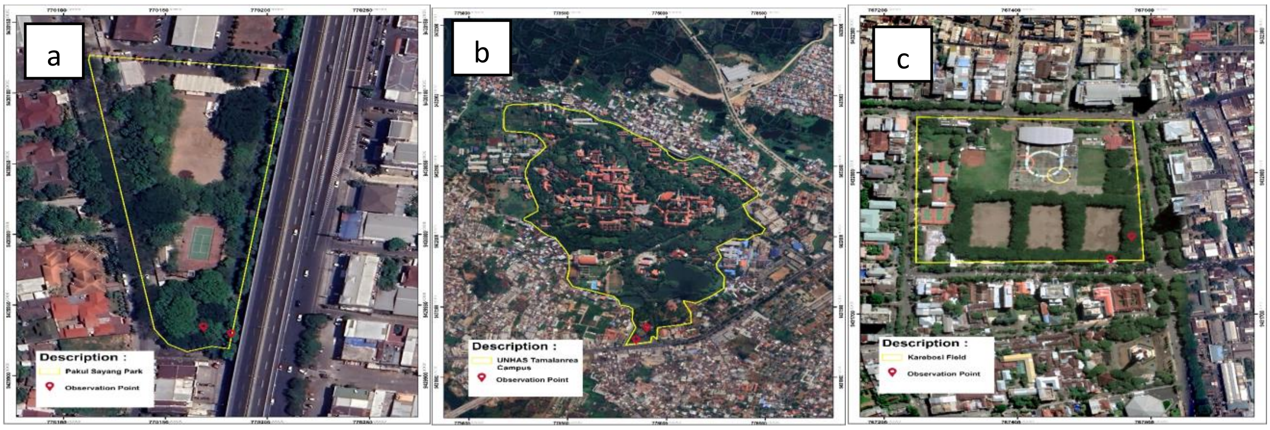


Figure 1. Map of the research location at (a) Pakui Sayang Park, (b) UNHAS Tamalanrea Campus, and (c) Karebosi Field.

Table 1 presents the research data detailing the locations of urban forests studied, including Pakui Sayang Park, UNHAS Tamalanrea Campus, and Karebosi Field. The table includes information on the village and sub-district where each urban forest is located and coordinate points inside and outside the urban forest areas. Altitude measurements ranging from 0 to 8 meters are also provided, offering insights into the topographical variations across the research sites.

Table 1. Research data.

No.	Name of urban forest	Village and sub-district	Coordinate point Inside urban forest	 Outside urban forest	Altitude (meter)
1.	Pakui Sayang Park	Masale Village and Panakkukang Subdistrict	X: 770167 Y: 9429930	X: 770182 Y: 9429924	0–5
2.	UNHAS Tamalanrea Campus	Tamalanrea Village and Tamalanrea Subdistrict	X: 775928 Y: 9431324	X: 775844 Y: 9431236	0–8
3.	Karebosi Field	Pisang Utara Village and Ujung Pandang Subdistrict	X: 767572 Y: 9431869	X: 767539 Y: 9431802	0–2

Figure 2 provides an overview of the research procedure, outlining the systematic steps undertaken in the study. It illustrates the sequence of activities, from site selection and data collection to analysis and interpretation. This visual representation helps understand the methodology used, ensuring clarity in the research process. By depicting each stage, Figure 2 serves as a guide for replicating the study and validating the findings.

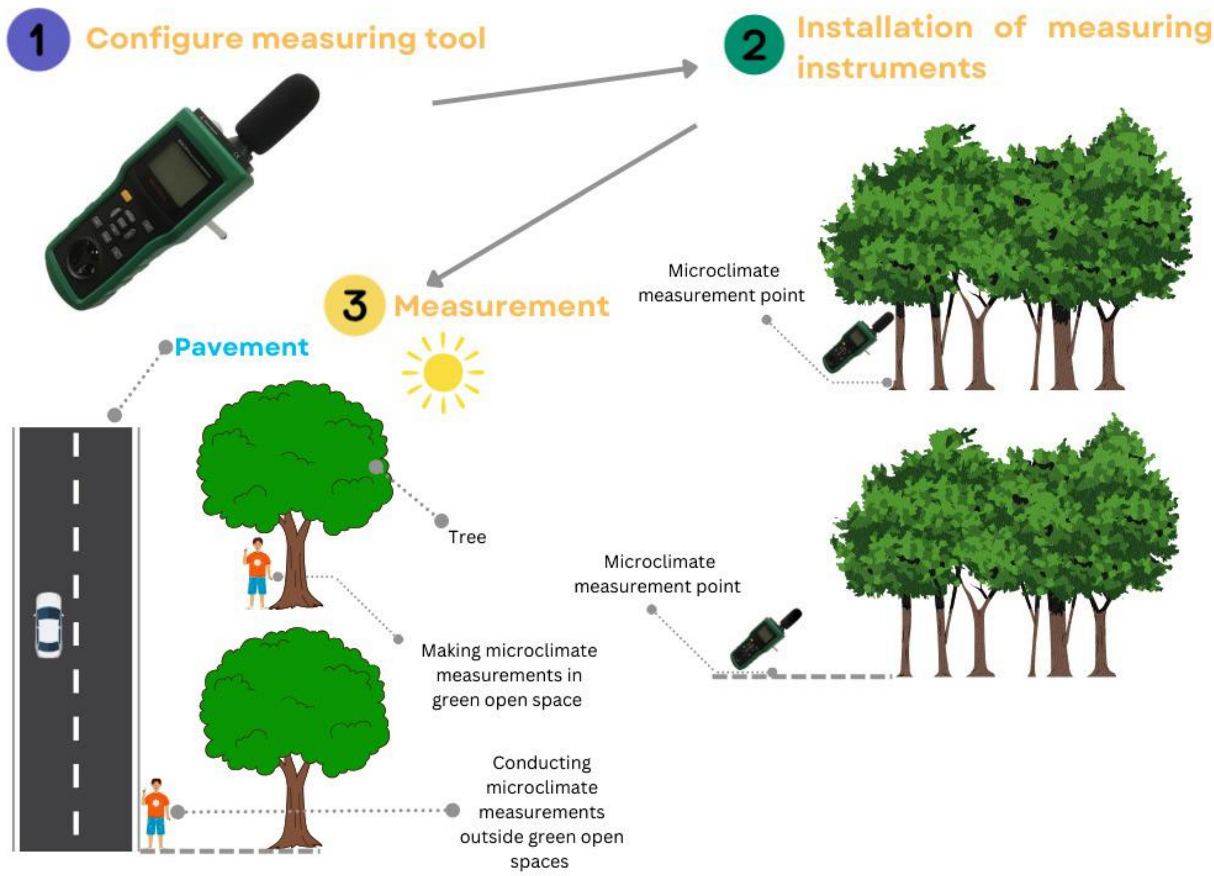


Figure 2. The overview of the research procedure.

Results

Temperature Test Results Inside and Outside Urban Forest

The results of the data obtained directly from the field showed that temperature data inside and outside the urban forest, collected at three urban forest locations in Makassar City-namely, Pakui Sayang Park, UNHAS Tamalanrea Campus, and Karebosi field from March to May, were significantly different from the results presented in Figures 3, 4, and 5. The temperature inside the urban forest at the two locations was lower than the temperature outside the urban forest, which was higher because the urban forest inside receives less solar radiation [4].

Figure 3 shows that the average temperature in the urban forest at the three sites was statistically insignificant (0.282) < α (0.05). This means that the temperatures in the urban forest at all three sites at each time point were the same. If the significance value of t > 0.05, H_0 is accepted, meaning that there is no significant effect between the independent variable that can reduce solar radiation energy.

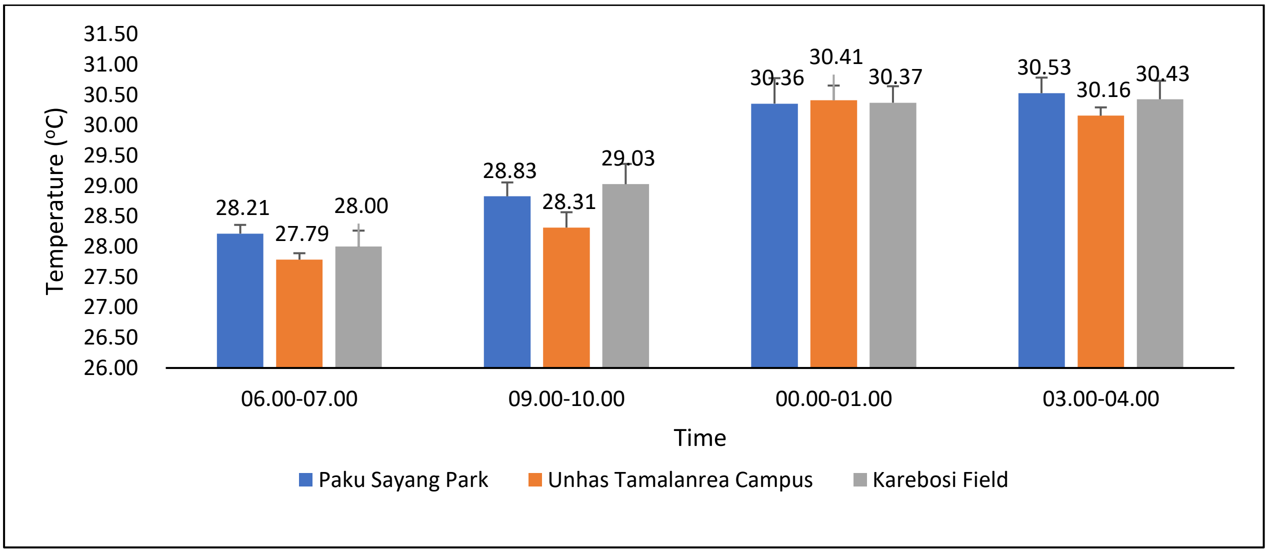


Figure 3. Temperature inside the urban forest.

Figure 4 shows that the difference is not statistically significant (0.033) < α (0.05). This means that the temperature outside the urban forest in Makassar City is not significantly different across the three locations at each time, indicating that the absence of vegetation (trees) outside the urban forest contributes to the higher temperatures. If the significance value of t < 0.05, H_0 is rejected, meaning a significant effect exists between the independent variables and the dependent variable.

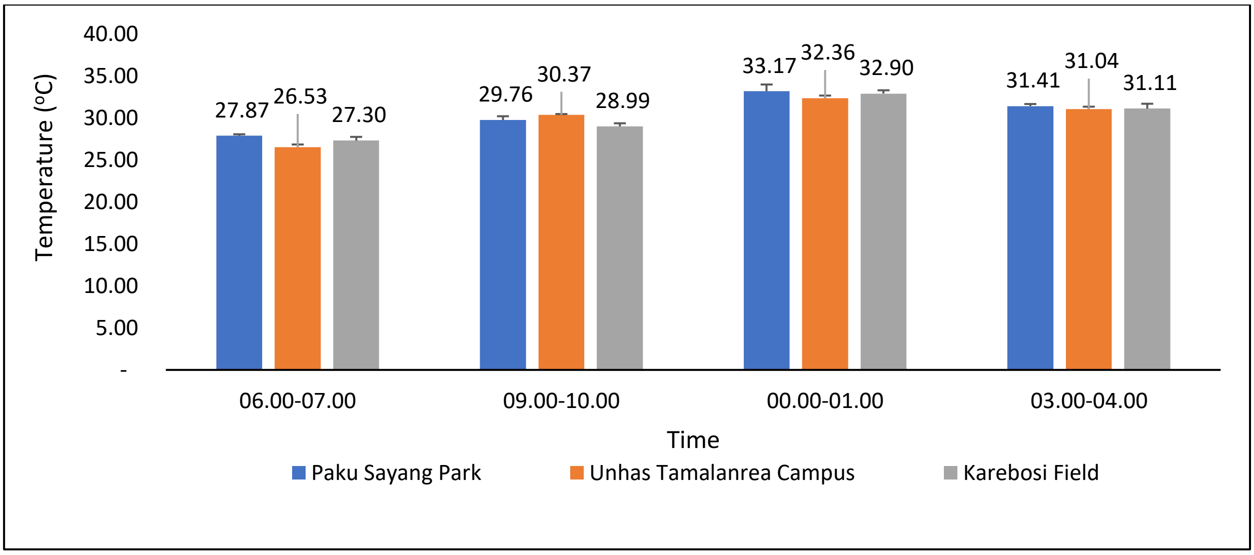
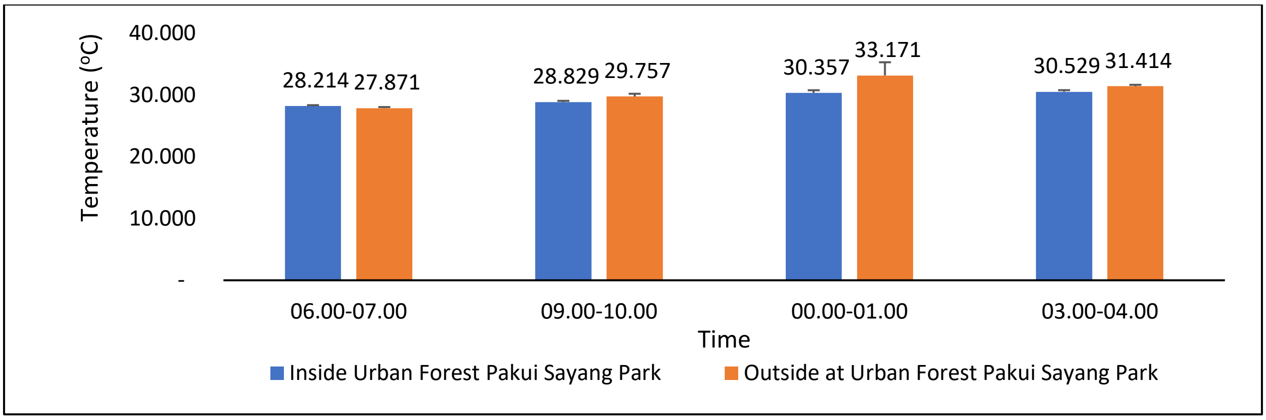


Figure 4. Outside temperature the urban forest.

The comparison of temperatures inside and outside the urban forest presented in Figure 5 shows that the temperature at the three urban forest locations is statistically significant (0.000) < α (0.05); in other words, there is a difference 25.4 °C between the temperature inside and outside the urban forest, with the temperature outside being higher. If the significance value of t < 0.05, H_0 is rejected, meaning that an independent variable significantly influences the dependent variable. This is due to factors such as the location on the highway, lack of vegetation (trees), dense buildings, high vehicle density, and a dense population.



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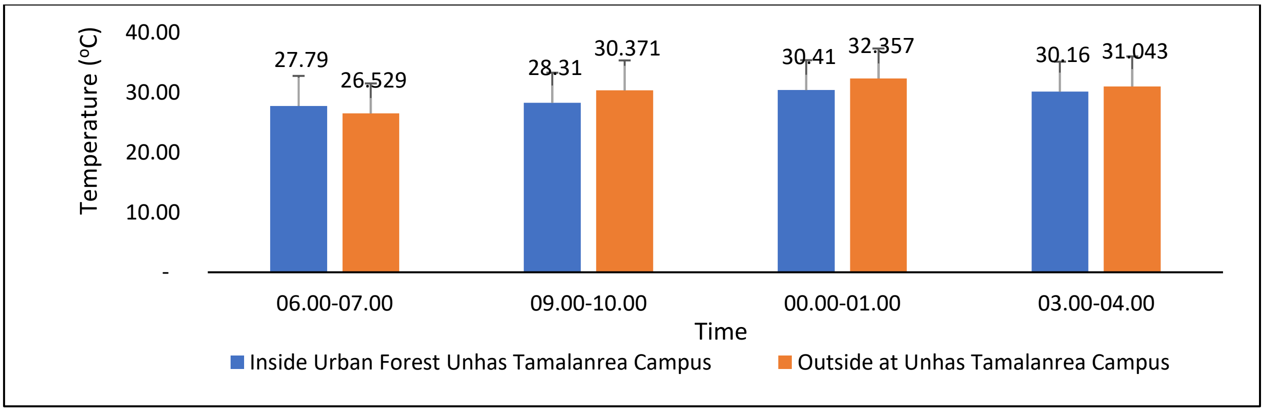

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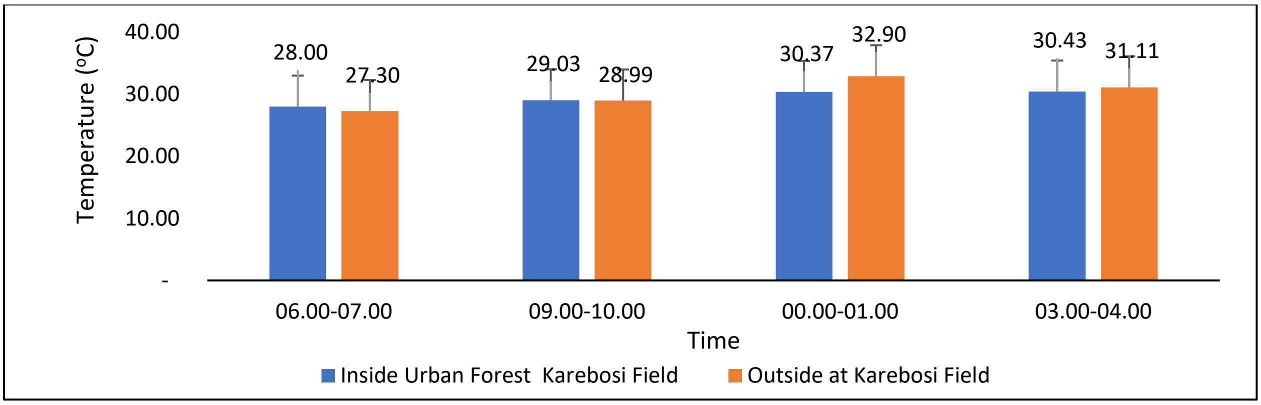


(c)

Figure 5. Temperature comparison between inside and outside urban forest of (a) Pakui Sayang Park Makassar City, (b) UNHAS Tamalanrea Campus Makassar City, and (c) Karebosi Field Makassar City.

Test Results Humidity Inside and Outside Urban Forest

The results of data obtained directly from the field showed that temperature data inside and outside the urban forest, collected at three urban forest locations in Makassar City-namely, Pakui Sayang Park, UNHAS Tamalanrea Campus, and Karebosi Field from March to May, were significantly different from the average calculation results presented in figures 6, 7, and 8. Figure 6 shows that humidity in the urban forest was statistically insignificant (0.350) < α (0.05). If the significance value of t < 0.05, H_0 is rejected, meaning there is a significant effect between the independent variable and the dependent variable, indicating that the humidity inside the urban forest at each location is the same. The condition of tree vegetation can affect moisture levels because the tree canopy can block solar radiation, which directly affect humidity conditions in a location. This suggests that urban forest vegetation is highly influential in creating moisture.

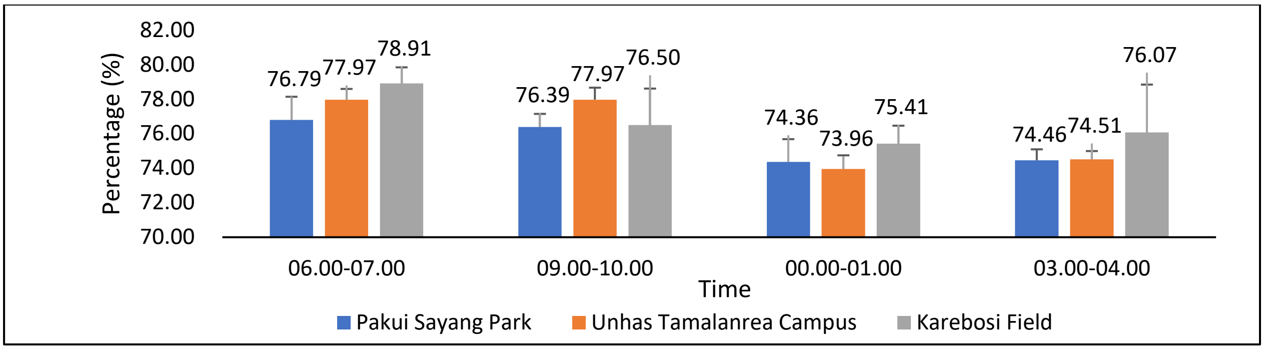


Figure 6. Humidity inside the urban forest.

Figure 7 shows that the humidity outside the urban forest at the three urban forest sites is statistically significant (0.000) < α (0.05). If the significance value of t < 0.05, H_0 is rejected, meaning a significant effect exists between one independent and dependent variable. This shows that the lowest humidity in the afternoon and the highest humidity in the morning affect the solar radiation at the three locations, thus affecting humidity conditions. Tree structure also affects the humidity of urban forests; if tree stands do not dominate an urban forest, the humidity will be much lower. Grass segments with 50% canopy cover, less dense vegetation placement, and small canopy areas have less effect on increasing relative humidity. The pavement segment without a canopy cover is an area dominated by concrete pavement. Various factors, including the availability of vaporizers, air temperature, and solar radiation, influence the relative air humidity [5].

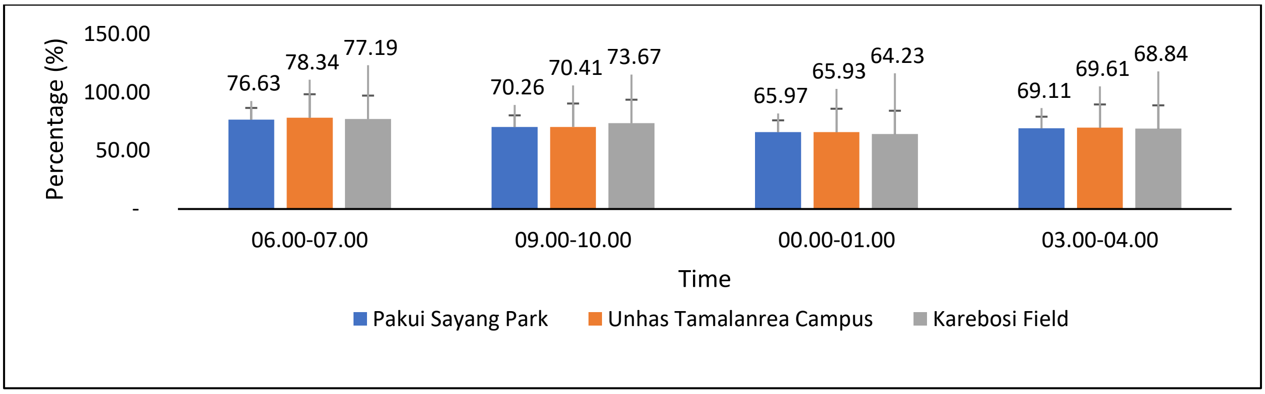
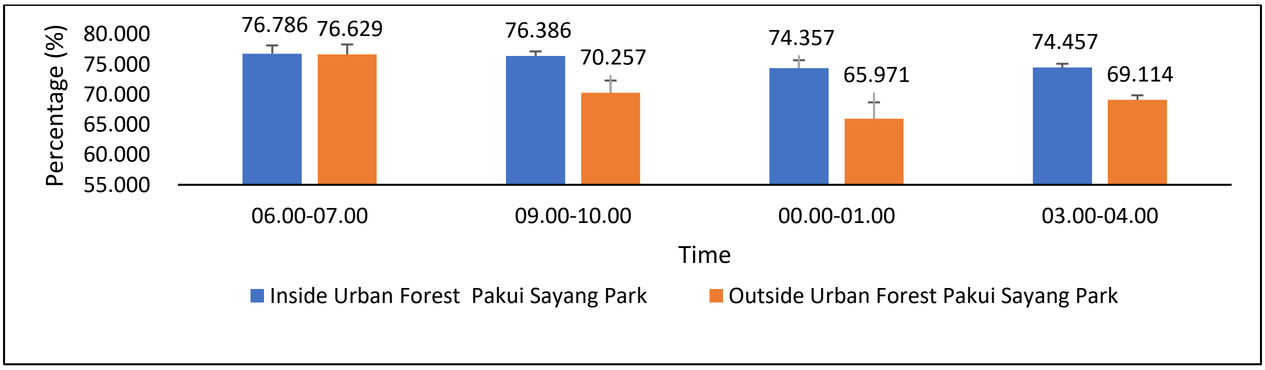


Figure 7. Humidity outside the urban forest.

The results shown in Figure 8 indicate that the average humidity values inside and outside the urban forest are statistically highly significant (0.000) < α (0.05). In other words, there was a 5% difference in humidity between the urban forest and outside, with lower humidity outside the urban forest. In comparison, humidity inside the urban forest was higher. When the significance value was t < 0.05, H_0 was rejected, indicating a significant effect between one independent variable and the dependent variable. Humidity inside the urban forest at all three study sites was higher than outside the urban forest.



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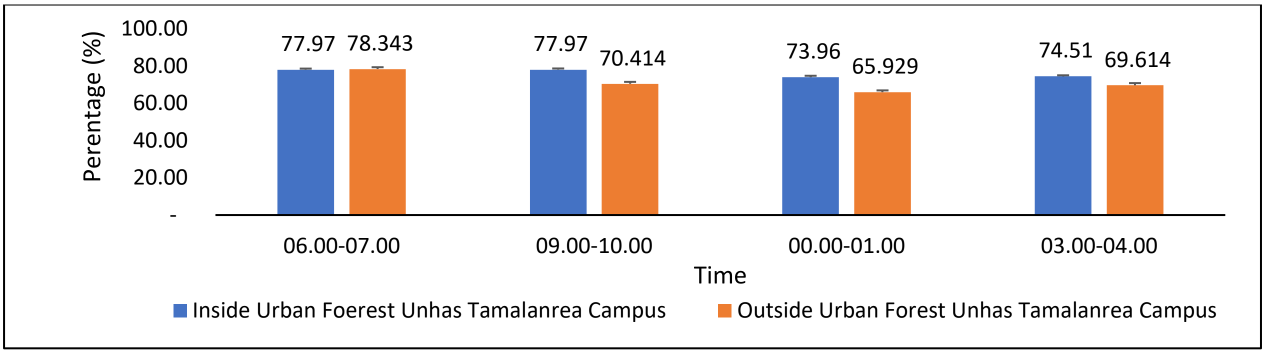

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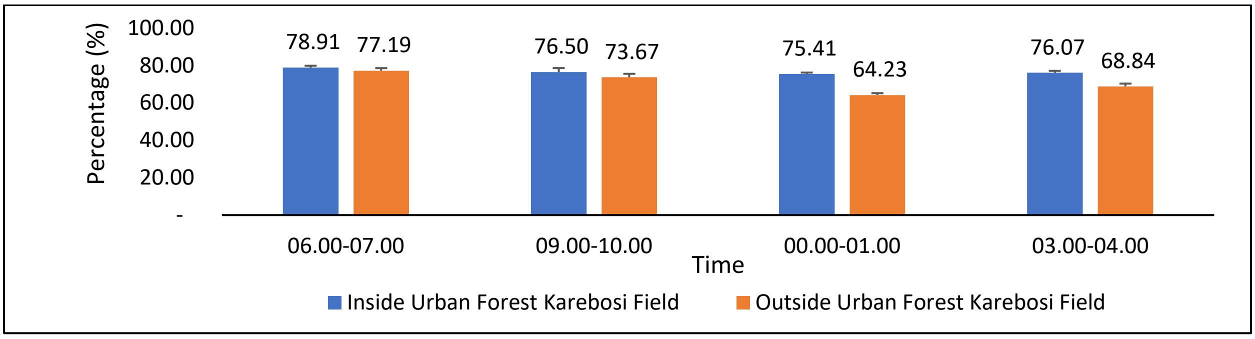

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Figure 8. Comparison of humidity between inside and outside urban forests of (a) Pakui Sayang Park Makassar City; (b) UNHAS Tamalanrea Campus Makassar City; and (c) Karebosi Field Makassar City.

Sunlight Intensity Test Results Inside and Outside Urban Forest

The results of data obtained directly from the field showed that temperature data inside and outside the urban forest, collected at three urban forest locations in Makassar City, namely Pakui Sayang Park, UNHAS Tamalanrea Campus, and Karebosi Field from March to May, were significantly different from the average calculation results presented in Figures 9, 10, and 11. Solar radiation intensity inside the canopy is lower than outside the canopy due to shading. Areas overgrown with shade trees provide the effect of a tree canopy that resists direct solar radiation so that the temperature under the shade will be lower than in open space [6]. Figure 9 shows that sunlight intensity in the three locations is statistically insignificant (0.077) > α (0.05); if the significance value of t > 0.05, then H_0 is accepted, meaning that there is no significant effect between one independent variable and the dependent variable, which means there is no difference (they are the same). This is because the canopy is a collection of several canopies that can affect the intensity of sunlight, causing shade. Vegetation (trees) undoubtedly provides more shade, making the area cooler and moister. Moreover, most solar radiation does not directly penetrate the plant canopy, thus reducing the influx of sunlight to the surface.

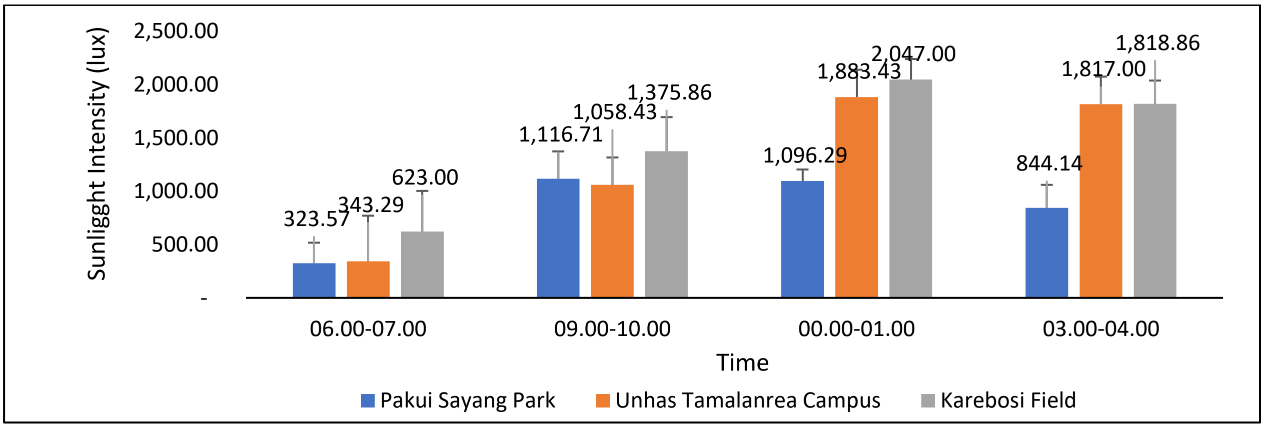


Figure 9. Sunlight intensity inside the urban forest.

Figure 10 shows that the measurement results of sunlight intensity at each time point are statistically insignificant (0.217) > α (0.05). If the significance value of t > 0.05, H_0 is accepted, meaning there is no significant effect between the independent and dependent variables, and the intensity at the three locations is the same each time. This indicates that conditions outside the urban forest, which lack vegetation, result in direct sunlight hitting the ground surface without shade to reduce the sun's intensity. The density of vehicles and the influence of motor vehicle pollution, especially near toll roads, also play a role.

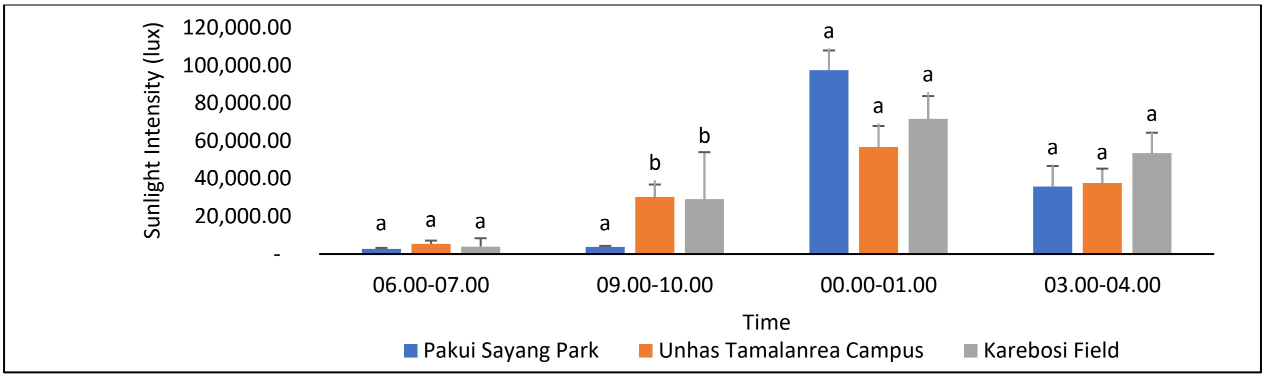
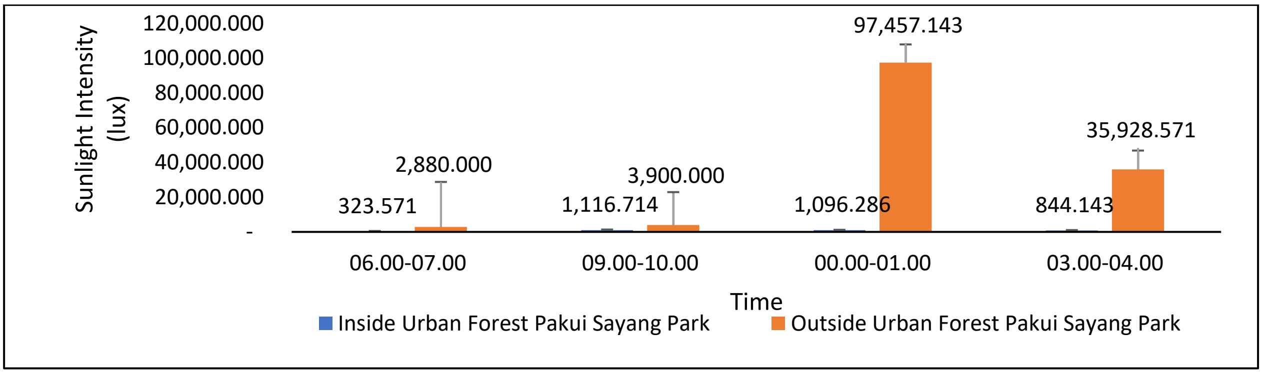


Figure 10. Sunlight intensity outside the urban forest.

Figure 11 shows that in the three urban forest locations, there is a statistically significant effect (0.000) < α (0.05). In other words, there is a difference in the magnitude of sunlight intensity inside the urban forest and outside, with a difference of 31,327 lux, where the intensity of sunlight outside the urban forest was higher, and inside the forest, it was lower. If the significance value is t < 0.05, H_0 is rejected, indicating a significant effect between the independent and dependent variables. This means there is a difference in sunlight intensity inside and outside the urban forest, with the intensity being lower inside due to the canopy's shade. Areas covered with trees that provide shade block direct solar radiation, so the intensity of sunlight outside the urban forest is higher than that inside. Additionally, solar radiation finds it difficult to penetrate areas with a high tree canopy density.



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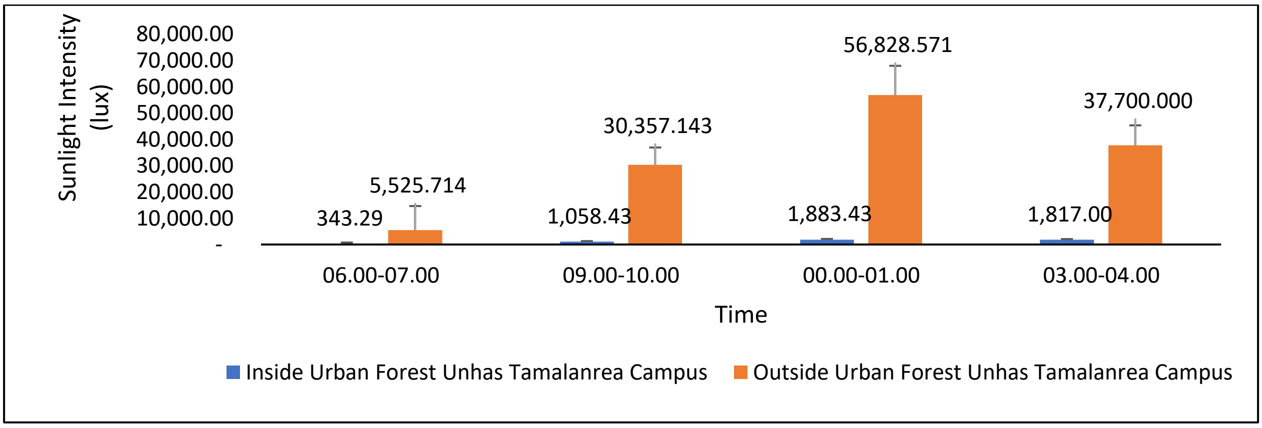

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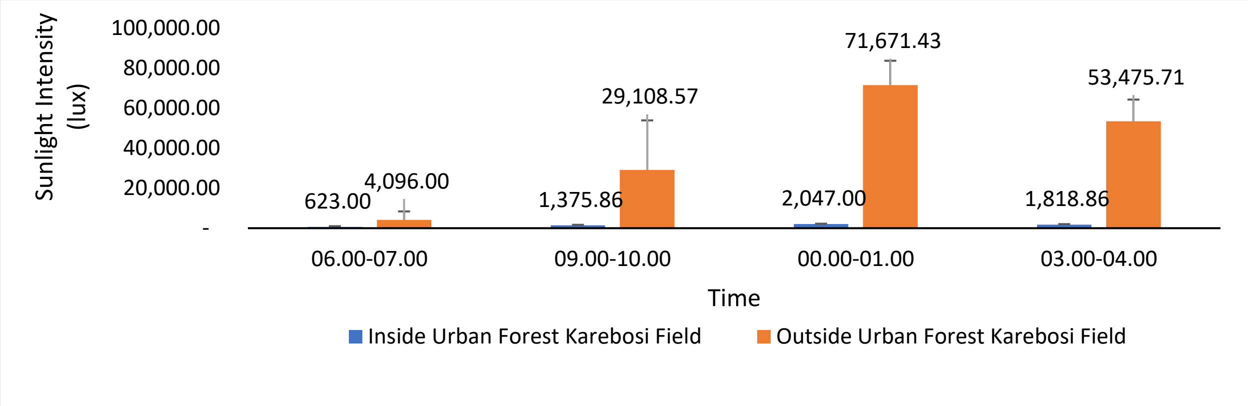


(c)

Figure 11. Comparison of sunlight intensity between inside and outside urban forest of (a) Pakui Sayang Park Makassar City; (b) UNHAS Tamalanrea Campus Makassar City; and (c) Karebosi Field Makassar City.

Noise Test Results Inside and Outside Urban Forest

The data obtained directly from the field showed that temperature measurements inside and outside the urban forest, collected at three urban forest locations in Makassar City-namely, Pakui Sayang Park, UNHAS Tamalanrea Campus, and Karebosi Field from March to May, were significantly different from the average calculation results presented in figures 12, 13, and 14. The urban forest area designed to reduce noise is one surrounded by tall trees, which function to minimize noise levels originating from residential or vehicle activities [7]. From figure 12, the noise in the urban forest is statistically insignificant (0.000) > α (0.05), and when the significance value of t < 0.05, H_0 is rejected, indicating that there is a significant effect between the independent and dependent variables. This suggests that the noise level in Pakui Sayang Park is always higher than in other urban forests. This could be due to the location's proximity to toll roads, such as Pakui Sayang Park. However, since vegetation (trees) act as a barrier or absorbent material, the noise level decreases after passing through the trees. The larger the vegetation (trees) with dense, shady crowns, the greater the noise reduction.

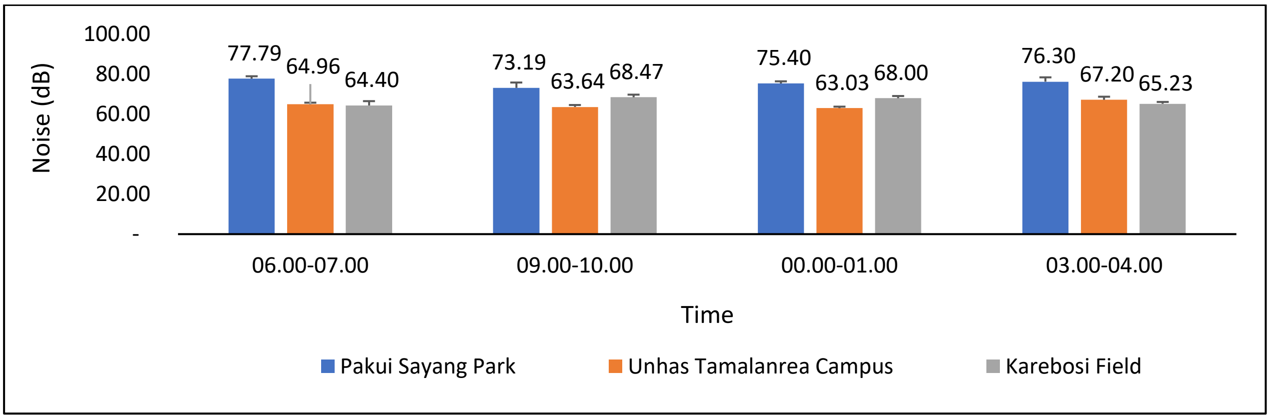


Figure 12. Noise inside the urban forest.

Figure 13 statistically shows a significance value (0.007) > α 0.005. If the significance value of t > 0.05, H_0 is rejected, meaning there is a significant effect between the independent and dependent variables related to the highest daily noise levels. This is due to road conditions that are crowded with private and public vehicles, which increase noise, and other causes such as vehicle queues in traffic light areas, the behavior of motorists driving at high speeds, particularly dominated by students and workers in the morning and evening, and the tendency of motorists to honk in the traffic light area, all of which can affect the noise levels in urban forests.

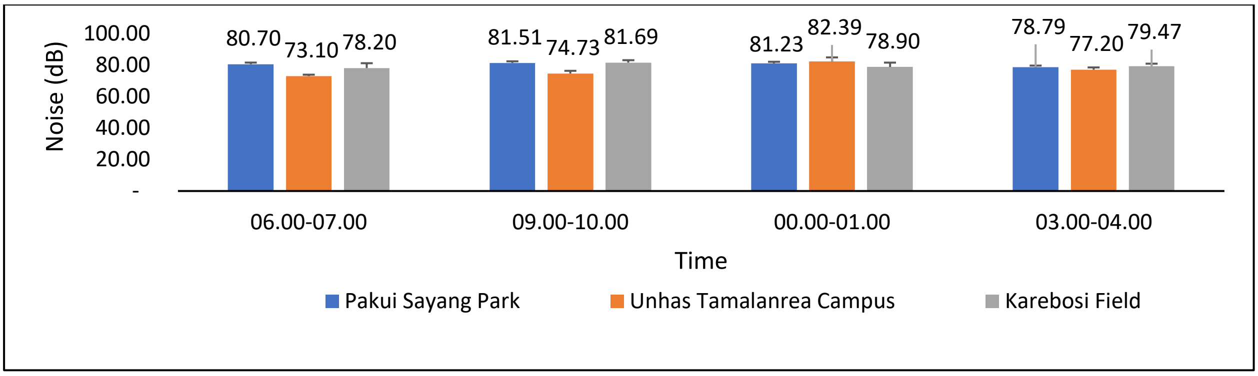
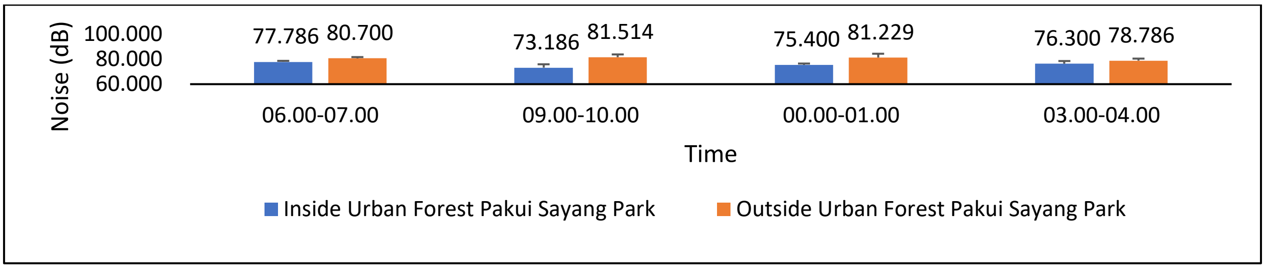


Figure 13. Noise outside the urban forest.

Figure 14 shows a statistically significant effect (0.000) < α 0.05, indicating a difference in the magnitude of the noise level between the three urban forests and the area outside the urban forest, with a difference of 12 dB. This means that the noise level outside the urban forest is higher due to the proximity to the noise source from road activity. If the significance value is t < 0.05, H_0 is rejected, indicating a significant influence between the independent and dependent variables. This is thought to be because work activities lead to a high volume of vehicle traffic in the morning and evening, whereas the noise level is lower inside the urban forest.



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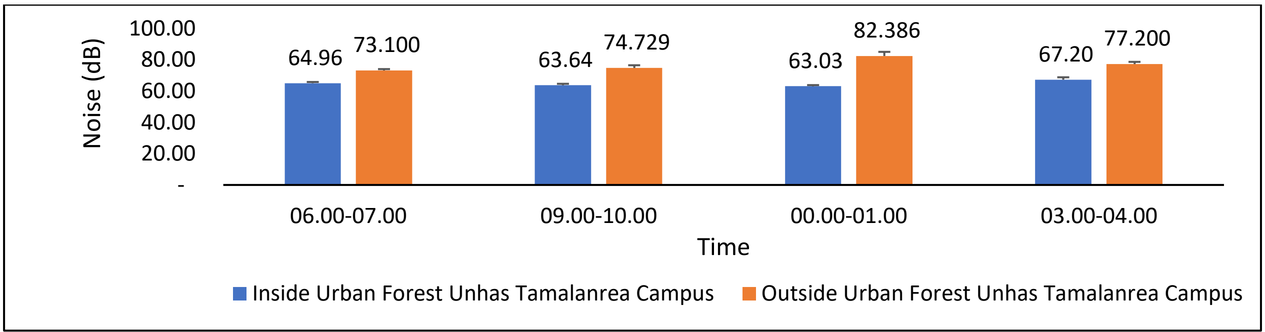

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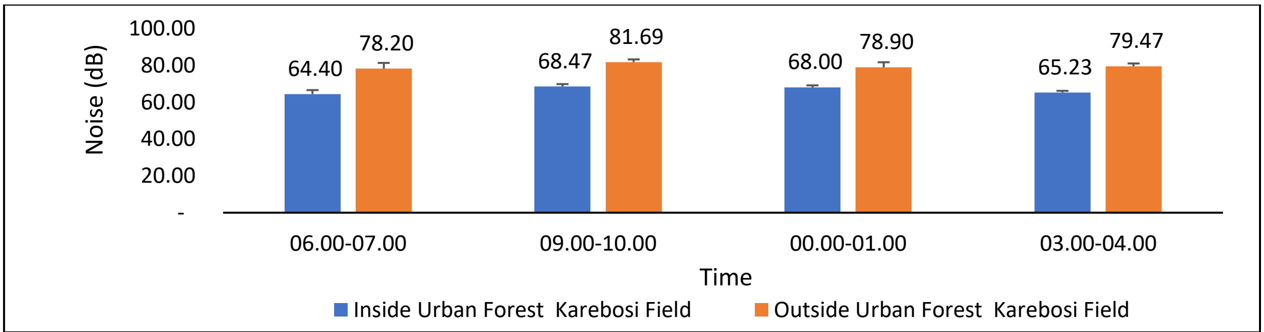

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Figure 14. Noise Comparison Between Inside and Outside Urban Forest of (a) Pakui Sayang Park Makassar City; (b) UNHAS Tamalanrea Campus Makassar City; And (c), Karebosi Field Makassar City.

Wind Speed Test Results Inside and Outside the Urban Forest

The results of data obtained directly from the field showed that temperature data inside and outside the urban forest, collected at three urban forest locations in Makassar City-namely Pakui Sayang Park, UNHAS Tamalanrea Campus, and Karebosi Field from March to May, were significantly different from the average calculation results presented in Figures 15, 16 and 17. The wind speed under the canopy is slower than the wind speed in open urban areas because diverse tree canopies can reduce wind speed, and wind will also carry cooler air from under the shade to the surrounding environment, causing the air temperature and humidity under the shade to remain stable [6]. Figure 15 shows the measurement results at the three study sites, with a statistically significant result (0.000) < α 0.005. If the significance value of t < 0.05, H_0 is rejected, meaning a significant effect exists between one independent and dependent variable. This means wind speeds in the urban forest tend to decrease significantly in the morning. Because the vegetation (trees) is planted relatively close, the wind cannot blow freely, and the wider the canopy, the lower the wind speed.

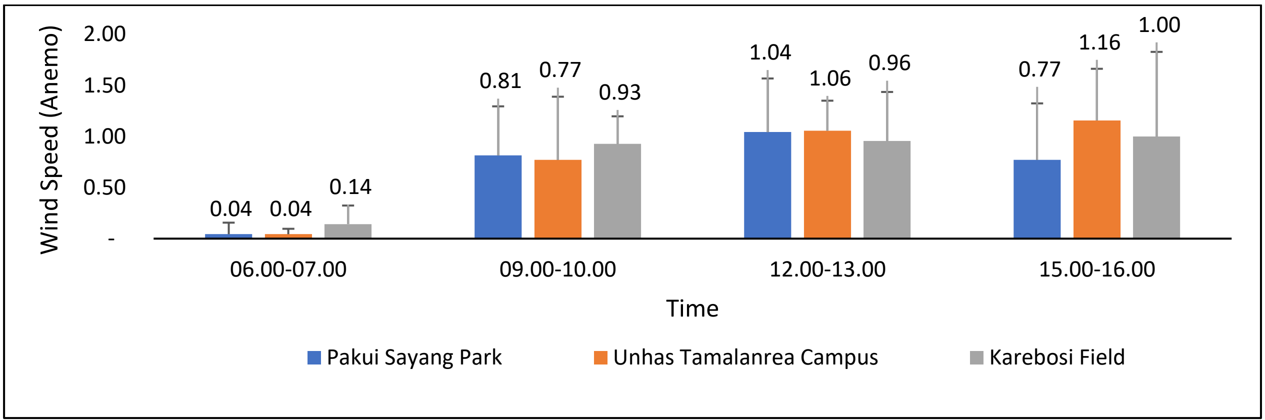


Figure 15. Wind speed inside the urban forest.

Figure 16 shows a significant value (0.89) > α 0.05, which means that the wind speed outside the urban forest was the highest during the day. If the significance value of t > 0.05, H_0 is accepted, meaning no significant effect exists between one independent and dependent variable. This indicates that the absence of tree canopies and leaf shapes that block wind outside the urban forest can increase wind speed. Trees can act as windbreaks that reduce wind speed.

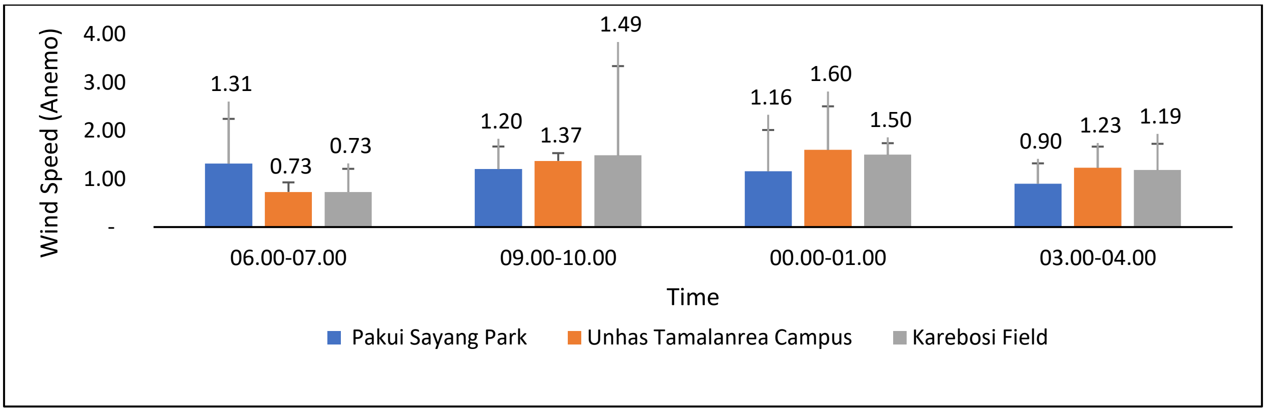
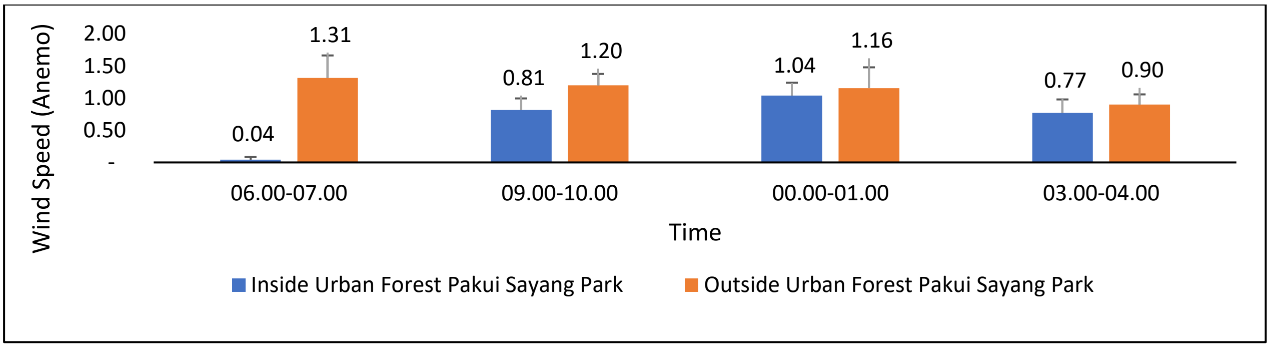


Figure 16. Wind speed outside the urban forest.

Figure 17 shows the result of a significant value of 0.000 < α (0.05), which indicates that there is a difference in the magnitude of the difference between inside the urban forest and outside the urban forest of 0.5 Anemo. The wind speed inside the urban forest was slower than that outside the urban forest. If the significance value of t < 0.05, H_0 is rejected, meaning a significant influence exists between one independent variable and the dependent variable. Diverse tree canopies can slow the wind speed, and the wind carries cold vapor from the shade to the surrounding environment.



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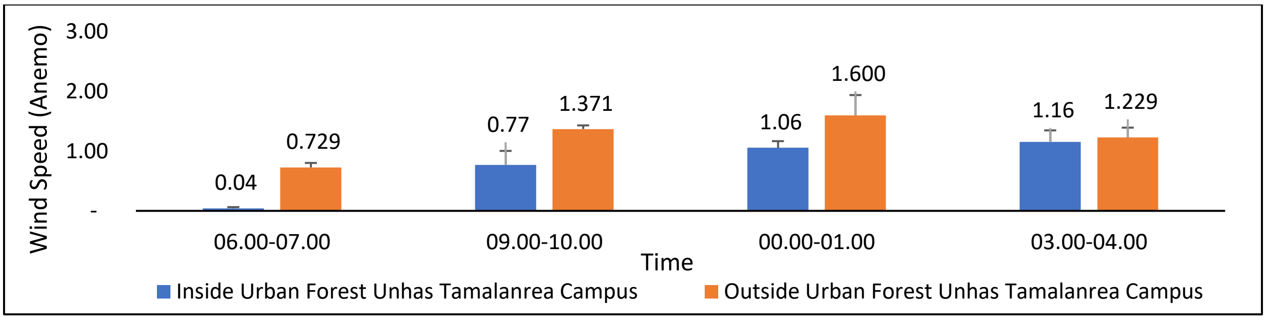

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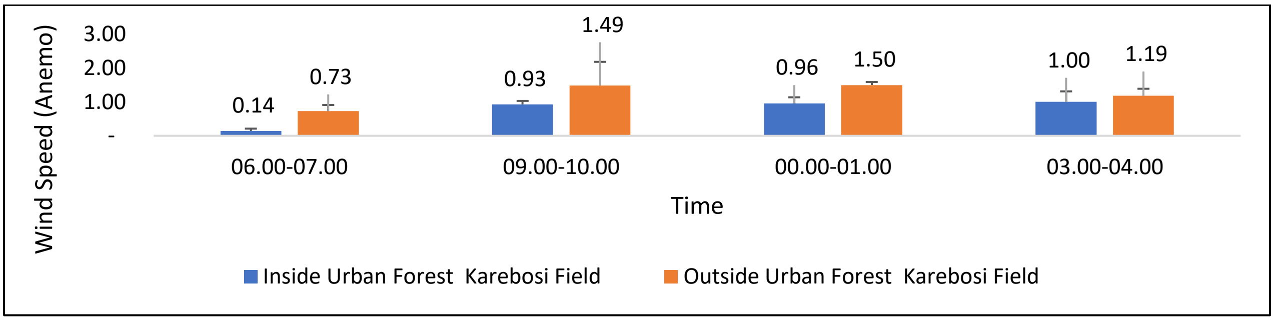

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Figure 17. Comparison of wind speed between inside and outside the urban forest of (a) Pakui Sayang Park Makassar City; (b) Tamalanrea Campus Makassar City; and (c) Karebosi Field Makassar City.

Discussion

Urban Forest Affecting the Environmental Temperature

Urban forest areas shaded by vegetation (trees) with high tree density can reduce solar radiation energy. The lowest temperature is around the parking area because it is surrounded by trees and a relatively dense vegetation canopy, which relatively blocks the heat radiated by sunlight and the ground surface [8]. Radiant energy will be absorbed, reflected, or emitted by the presence of the canopy, creating temperatures in the lower urban forest area and forming a microclimate [9]. The shape of the canopy, with relatively dense leaves, shaded areas, and tightly vegetation, can influence the amelioration of the urban forest microclimate because it can minimize the amplitude of air temperature variations [10]. The Canopy's soil exposure, along with its shade, absorbs and blocks solar radiation, protecting the ground below the canopy [11].

The location is on the side of the road where there is pavement, such as asphalt, which is dominated by lanes for large vehicles and is not blocked by tree canopies, allowing solar radiation to directly hit non-urban forest floors, causing an increase in environmental temperature. Areas not shaded by trees receive much solar radiation, resulting in higher temperatures [12]. Areas without urban forests will directly receive solar radiation on their surface because there is no barrier to block it. The air temperature can also increase by 50% due to reflections from paved roads, buildings, and other hardened surfaces in the area [13]. The average air temperature in open areas was higher than in areas shaded by vegetation. Urban forest areas with tree canopy cover will provide shade that blocks incoming solar radiation, resulting in lower air temperatures at the site [14].

The presence of urban forests in an area can affect the pattern of air temperature changes. The lower temperature in vegetated areas is caused by the latent heat used for plant physiological processes, including evapotranspiration, which is relatively greater than the sensible heat [15]. Tree vegetation structures are more effective in shading factors that reduce air temperature. Both trees with rounded crowns and denser branching patterns also affect the pattern of air temperature changes above the land surface. Medium-height trees, between 6 to 10 m, are more effective in providing shade and increasing comfort in the surrounding area. Therefore, vegetated structures are needed for microclimate control, especially to create comfortable air conditions [16]. According to Susianti et al. [14], the tree structure can absorb more incoming sunlight energy, increase the ability to absorb CO_2, provide shade, and carry out the process of water movement in the plant body, releasing water vapor into the atmosphere, thereby lowering the temperature inside the urban forest [17].

The functions of vegetation (trees) include suppressing air pollution, absorbing dust, reducing odors, dampening noise, and preventing soil erosion, as well as acting as windbreaks and regulating rainfall. They thoroughly protect the existence of urban protected areas, control pollution and damage to soil, water, air, germplasm, and biodiversity, and manage water resources. Vegetation is planted using a mixture of small, medium-sized, and large size tree species, half-tree shrubs, shrubs, and ground/surface cover plants [18].

Urban Forest Affecting Environmental Humidity

The temperature and humidity of the air at the two locations were different. The humidity inside the urban forest was higher than that outside the forest. Urban forest areas, shaded by tree vegetation, receive less solar radiation and create higher humidity. In contrast, areas not shaded by trees receive a large amount of solar radiation, resulting in lower humidity [14]. The presence of vegetation can alter temperature and humidity. Humidity measurements carried out in an urban forest are influenced by increases or decreases in air temperature. A reduction in temperature occurs because of the large amount of land cover that can block and absorb sunlight energy, thereby reducing the temperature in the area. A decrease in temperature leads to a reduction in water vapor pressure, which lowers the capacity to hold water vapor and causes an increase in air humidity [19].

The higher the tree density, the more difficult it is for sunlight to penetrate the soil surface. This can cause a decrease in temperature, which in turn causes humidity to increase. Various vegetation types in urban forests can absorb solar energy and CO_2, and evapotranspiration leads to high air humidity and low temperatures [20]. A high relative humidity value indicates the presence of many water particles in the air at the time and location of the urban forest, resulting in high humidity around the urban forest area. This is consistent with the conditions in the study area, where urban forests with dense vegetation have low temperatures and high humidity [21]. The UNHAS Tamalanrea Campus urban forest, which has a higher stand density than other urban forests, also has a lower temperature and higher humidity than the other urban forests.

Trees carry out evaporation/transpiration, thereby participating in increasing the content of water vapor in the air, which determines air humidity. The high and low humidity of air in a place highly depends on several factors: temperature, air pressure, wind movement, the quantity and quality of irradiation, vegetation, and water availability in an area (groundwater, waters). This means that the greater the amount of vegetation in urban forests, the more sunlight energy will be absorbed, and the more CO_2 will be absorbed as well, which can reduce humidity [22]. High humidity results in lower air temperatures, while low humidity values measured outside the urban forest are due to population activity, pavement in the form of asphalt and concrete, which are less effective at absorbing solar radiation, and trade centers, which prevent an increase in humidity outside the urban forest.

High density causes evapotranspiration and high air masses; thus, more water vapor is in the air, increasing air humidity. A large number of trees increases the ability to absorb CO_2 from population activities or public transportation, which helps to reduce the effects of climate change in the form of increased air temperature [23]. Trees are closely related to the microclimate because vegetation affects the heating effect when solar radiation becomes hot. That tree function can absorb CO_2, decrease the temperature, reduce pollution in urban areas, provide shade with a broad canopy shape and low porosity, provide soil protection from direct stormwater runoff, reduce carbon dioxide levels in the atmosphere, reduce the rate of global warming, and protect from sunlight and wind gusts [4].

Urban Forest Affecting the Environmental Sunlight

The existence of urban forests with more shady trees affects the intensity of sunlight that reaches areas blocked by the canopy of shady vegetation. The thickness of the leaves on vegetation blocks sunlight, while thinner leaves filter sunlight. This shows that more vegetation in urban forests will positively impact the microclimate, supporting the lives of all living things. Shade directly affects the condition of urban forests in urban areas; therefore, the presence of shade makes urban forests quite cool and comfortable [23]. It is stated that vegetation density in urban forests significantly affects the intensity of sunlight and air temperature. The role of vegetation in reducing the air temperature in urban forests is achieved through photosynthetic processes in plants. Plants and vegetation are needed in cities because green plants capture CO_2 and remove O_2 from the air through photosynthesis. The influence of vegetation structure and header shape on environmental parameters can act as a barrier or filter of sunlight intensity [24].

Factors that affect microclimate conditions, such as temperature and humidity, include land cover and differences in the characteristics of each type of land cover in absorbing and reflecting radiation, which can create temperature and humidity. The increase in temperature due to the absorption of solar radiation occurs as a result of changes in land cover, population growth, and activities related to the lives of urban communities, as air warming originates from surface heating [25]. The high temperature in an area is caused by the absence of a canopy that can absorb sunlight, as leaves are very effective in absorbing sunlight. The canopy can gradually lower the temperature through plant evapotranspiration. The position of the tree affects the intensity of sunlight. Tree crowns block sunlight directly hitting the ground, causing microclimate variables to differ. This difference is characterized by the sunlight intensity inside the urban forest, which is overgrown with shade trees, giving the effect of tree canopies that block solar radiation. In contrast, the highest intensity of sunlight is outside the urban [26].

According to Jabbar et al. [27], The formation of microclimate cannot be separated from the role of vegetation in the urban forest. The more vegetation there is, the better the microclimate will be, unlike land with little vegetation, where the microclimate formed will be different. The higher the temperature, the lower the humidity; therefore, vegetation functions as climate control for human comfort [28]. In urban forests, vegetation controls the radiation of sunlight, temperature, and wind [29]. The role of vegetation is very important in forming the microclimate; in the forest, much sunlight is blocked by canopy closure, resulting in lower light intensity. Open land receives direct sunlight without any protection, while comfort still requires shade. Shade directly affects the intensity of light that reaches the ground surface [30].

Urban Forest Affecting the Environmental Noise

Urban forests are essential for urban areas; the presence of urban forests can help overcome urban environmental problems, especially in reducing noise levels and air pollution [31]. A large amount of vegetation plays a vital role in reducing noise. Noise sources include public transportation, motorcycles, cars, trucks, human voices, music, and building tools and machinery [4]. The influence of noise levels on urban forest areas mostly comes from vehicle activity, so a significant amount of vegetation is needed to control this [32]. Vegetation is one of the elements that can affect noise suppression / control; the level of noise reduction in the park can be as much as 10.5 dB compared to areas outside the park [33]. The level of vegetation canopy cover is quite effective in reducing noise levels, and distance also reduces noise levels; the greater the distance between the sound source, the smaller the noise level. The ability of vegetation to reduce noise is significant. The higher the vegetation density, the more effective the noise cancellation. An area overgrown with many trees helps to minimize noise [34].

Urban Forest Affecting the Environment Wind Speed

The condition of vegetation, high vegetation density, and land cover materials in city parks inhibit the flow of wind from outside the area because it is blocked by vegetation, which continues to maintain its direction of movement until it encounters an obstacle. The greater the number and structure of tree vegetation in an urban forest, the better it is at the withstanding wind, and the shape of the canopy, with a higher amount of vegetation, can block in the wind [35]. The wind speed tends to be relatively high because the area outside the urban forest is quite open and directly adjacent to the highway; therefore, there is no barrier to the wind blowing from the direction of the road. The vegetation structure influences this, and vegetation in the urban forest area can withstand wind forces. The higher the availability of vegetation, the lower the wind speed [36].

The influence of vegetation's availability and structure and the canopy's shape on wind speed is significant. The greater the number and arrangement of tree and shrub vegetation, the more an environment can withstand the wind, and the shape of the canopy, the higher the amount of vegetation with a canopy shape that can block the wind, and the greater the ability of the environment to withstand wind [37]. It was revealed that the amount of vegetation covering the entire area causes wind reduction or wind dampening due to being restrained by surrounding plants planted in the urban forest area [38]. The vegetation structure that can obstruct, direct, and filter the wind is the type of vegetation with a tree or shrub structure with a height above 1 m. Vegetation affects the climate and comfort of a city because it can dampen sunlight even though it does not directly reduce air temperature. Vegetation absorbs sunlight for photosynthesis and shading effects and can also block surface heating under vegetation. The function of vegetation is to provide shading effects and dampen sunlight; it can also act as a wind barrier that can reduce wind speed [39].

Conclusions

Urban and non-urban forest areas showed significant differences in environmental parameters at the three observation sites in Makassar City-namely, between inside and outside urban forests. In summer, the three observation sites inside the tree-covered area showed a decrease in the average significance value of t < 0.05 compared to the surrounding built-up land or areas without vegetation (trees). The potential of the urban forest UNHAS Tamalanrea Campus has better green open space. One of the factors reviewed from the condition of environmental parameters to improve user comfort is with a temperature of 29 ^{o}C, humidity of 76%, sunlight intensity of 1,275 lux, noise of 65 dB, and wind speed of 0.8 anemometers compared to other urban forests. The UNHAS Tamalanrea Campus urban forest provides the most dominating tree vegetation combined with shrubs and grasses to balance and harmonize between buildings and a healthy environment. It also has aesthetic value. This difference occurred because of the amount of vegetation, the selection of appropriate tree species, and the extent of tree crowns built inside the urban forest, which are different from those outside the urban forest with no vegetation, resulting in lower air humidity in Makassar City. Overall, these findings contribute to understanding the role of trees in reducing environmental parameters and differences in the cooling intensity of trees across climate zones.

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