COMFORT LEVEL OF GREEN OPEN SPACE IN BANDAR LAMPUNG BASED ON CLIMATE AND HUMIDITY

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ABSTRACT

Green open space is used as microclimate control in the cities besides its function as a recreational and sports facility for communities. The existence of green open space needed by the community to control and integrity and quality of the environment especially in the city. There was very little research and assessment on green open spaces in Bandar Lampung. The latest research conducted in 2015 about green open spaces showed that only 2,121 ha left in Bandar Lampung. The study aimed to determine the temperature and humidity in the three most visited green open spaces in Bandar Lampung contained Taman Dipangga, Taman Gajah, and Taman Kalpataru. The data were taken in 2019 using the Temperature Humidity Index formula. The results showed that the highest temperature was found in Taman Gajah (34,39 $^{\circ}$C), and the lowest was in Taman Kalpataru (27,47 $^{\circ}$C). The high temperature in Taman Gajah was due to the lack of shade vegetation in the park. Based on the function of green open space to fill the need of ecological functions, Taman Gajah needs to be improved by adding vegetation with a dense type of canopy density and a variety of cropping patterns to withstand temperature and humidity.

***Keywords:** humidity, temperature, city park*

INTRODUCTION

One of the city's supporting capacities that are useful for the people of Bandar Lampung is the Green Open Space. The existence of green open space needed by the community to control and integrity and quality of the environment (Balitbangda, 2016). Keeping the integrity and quality of the urban environment aims to maintain the benefits of green open space, namely as ecological support and extrinsic support as an architectural function. The trend of comfort is obtained from the closure of the canopy by trees to provide a cool effect (Irwan and Kharuddin, 2012). As supported by Annisa et al. (2015), the ecological function of the existence of vegetation functions to reduce sunlight, regulate temperature, humidity, and wind speed.

However, one of the problems in urban areas is characterized by the conversion of green open space which causes environmental quality problems (Annisa et al., 2015). Based on the description of green open space area in Bandar Lampung, Law no. 10 of 2011 concerning Spatial Planning states that the existence of green open space in urban areas is at least 30% of

the city area, consisting of 20% public green open space and 10% private green open space until 2015, there was a decrease in green open space in Bandar Lampung by 64.37 ha from the previous 2,489.80 ha to 2,121.22 ha (11% of city area) (Ikhsanuddin and Satriana, 2015). According to Balitbangda (2016), the planning requirements for a green open space area are a location with a minimum area of 5000 m^2 or two locations connected by a green connecting corridor. The ratio of the composition of green space (softscape) to the pavement (hardscape) is a minimum of 70%: a maximum of 30%, in the form of materials that are friendly to the environment. The increase in pavement area is one of the reasons for the increase in air temperature which increases the decrease in environmental comfort (Saputra et al., 2010). Green open space area development can also be done by developing its ecological function. Based on the research of Yanti et al. (2018), ecological functions are included in supporting the comfort factor in green open space. This is because the ideal conditions in a public green open space are the factors that determine the comfort, safety, and ease of use of public spaces.

The development of green open space in an ecological function is the existence of vegetation that functions to reduce sunlight, regulate temperature, humidity, and wind speed (Annisa et al., 2015). Supported by research by Livesley et al. (2016) and also Pharisee et al. (2017), trees in green open space are used to reduce the impact of air pollution and can distort carbon stocks. Vegetation that can regulate some of the things previously mentioned depends on the type and purpose of vegetation being planted. Shady vegetation can regulate temperature, humidity, and wind speed better than vegetation which serves to beautify the environment (Paulina, 2018). While shady vegetation able to regulate temperature better (Paulina, 2018), built-in surfaces have a higher temperature than areas dominated by vegetation (Achsan et al., 2019).

In this case study, three green open spaces in Bandar Lampung will be taken. Green open spaces that will be carried out as research locations are Taman Gajah, Taman Dipangga, and Taman Kalpataru. These three green open spaces needed to be assessed because it is located in the city center and directly adjacent to city road and paving block which potentially increase the city's air temperature (Choirunnisa, 2017). Taman Gajah is a destination for the people of Bandar Lampung to have recreation and exercise in the city center (Balitbangda, 2016). In line with the functions of Taman Gajah, Dipangga and Kalpataru are also recreations and sports centers because they are dominated by mahogany trees that surround the football field (Choirunnisa, 2017).

Based on data from the Central Statistics Agency (2017), the average air temperature in Bandar Lampung City is 26.91^{o}C with 80% humidity. One of the negative impacts of city development is an increase in environmental problems (Zahra et al., 2014). The environmental problem that arises is air pollution by motorized vehicles (Tursilowati, 2007). The existence of green open space in city development is a guardian of the stability of the surrounding air temperature due to the physiological processes of Masruroh (2013). Based on research, vegetation in the form of trees can reduce the impact of air pollution (Livesley et al., 2016) and is also a store of carbon stocks (Farisi et al., 2017). Therefore, there is a need for research on the comfort level of Bandar Lampung based using temperature and humidity index to see the role of green open space in supporting urban development.

METHOD

The research was conducted in Taman Gajah, Taman Dipangga, and Taman Kalpataru Bandar Lampung in January 2020. The data used in this study were tree species, temperature, and humidity. Tree species identification was carried out by identification all the trees in three

observation locations. The tree species results were then analyzed with literature studies regarding their ability to support comfort at the research location.
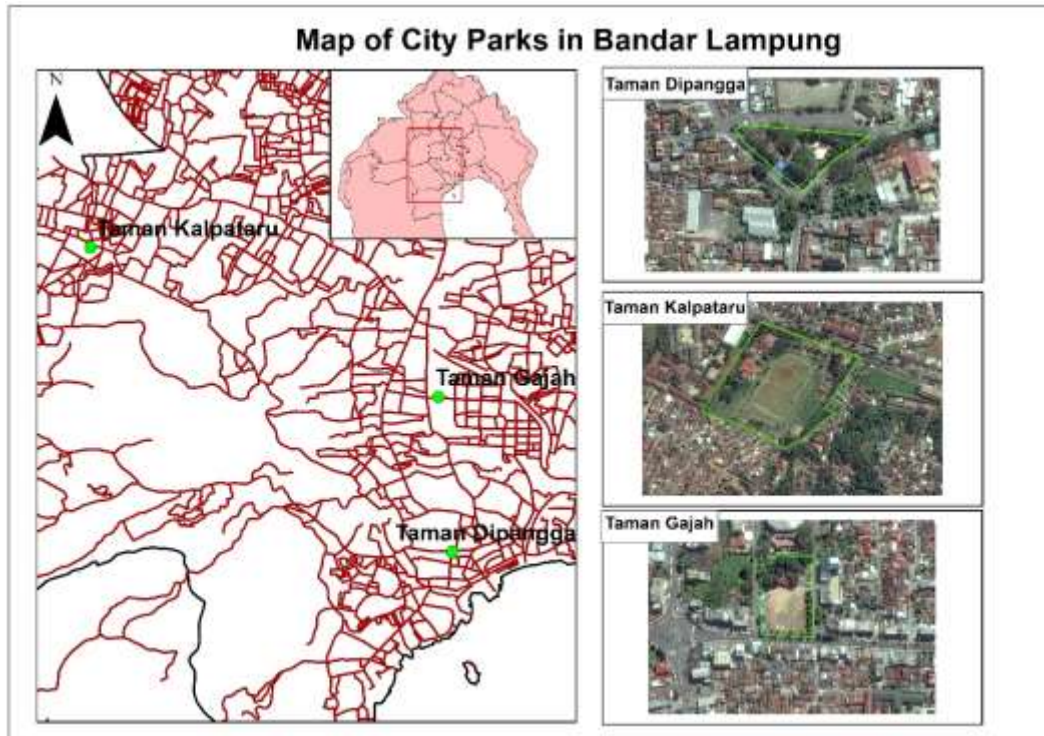

Figure 1. Map Location of Bandar Lampung City Parks

Temperature and humidity variables were supporting factors for comfort in an area (Zahra et al., 2014). The temperature and humidity data were taken using a thermohygrometer as high as 1.5 meters from the ground at three-time intervals. Sample determination was carried out based on morning time intervals (07.00 WIB - 09 WIB), afternoon (12.00 WIB - 14.00 WIB), and evening (16.00 WIB - 18.00 WIB) on sunny days to determine the level of comfort index (Temperature Humidity Index) (Choirunnisa et al., 2017). The three-time intervals were done aimed to know the minimum and maximum temperature which was 03.00 WIB and 15.30 WIB (Mustika, 2001).

The temperature and relative humidity values were analyzed using the Temperature Humidity Index (THI) formula to determine the level of comfort (Choirunnisa et al., 2017). The formula for THI was obtained from 0,8 multiply temperature (T) plus the multiplier from relative humidity (RH) and temperature divided by 500.

$$THI = \frac{0,8T + (RH \times T)}{500}$$

Temperature Humidity Index (THI) comfort level criteria are classified into three, namely comfortable (21-24), moderate (25-26), and uncomfortable (THI> 26).

RESULTS AND DISCUSSION

This study was using air temperature and relative humidity to maintain the thermal comfort of three green open spaces in Bandar Lampung. Air temperature is the state of hot air caused by the heat of the sun. The state of the air temperature somewhere on earth will be determined by factors of vegetation and buildings (Mannan, 2007). Air humidity is the amount of moisture in the air. Water evaporates into the air more during the day than in the afternoon and early morning. Air humidity figures range from 0% - 100% (Choirunnisa et al., 2017). Thermal comfort, as defined by the ISO (International Standard Organization) 7730 standard, is the complex relationship between air temperature, air humidity, and airflow velocity, coupled with the type of clothing and activity and the occupant's metabolic rate that represents an expression of feelings of fullness. to air conditions in an environment. Thermal comfort is a subjective statement about human satisfaction that depends on each individual and other factors. Comfort conditions are also defined as thermal neutrality, which means that a person feels neither too cold nor too hot (Rahim et al., 2016).

A. Air Temperature

City parks are green open spaces that have a function for aesthetics and social interaction between communities (Irwan, 2005). Apart from social and aesthetic functions, city parks also support environmental conservation functions (Zoer'aini, 2005). The function of environmental preservation can be in the form of ecological and hydrological functions (Atmojo, 2007). Based on the Minister of Home Affairs Instruction No. 14 of 1988 regarding the arrangement of green open space in urban areas, green open space is an area or city space that has various functions. The function referred to can be a green urban garden area, an urban forest area, a green city recreation area, a green area for sports activities, a green area for cemeteries, an agricultural area, a green belt area, and also a yard area. Primarily, green open space has both intrinsic (ecological) and additional (extrinsic) functions (Permen PU, 2008). Green open space areas can be natural or artificial with crops, gardening, or plantation crops.

The existence of green open space and the existence of plants in it makes the environment more comfortable (Setyowati, 2008). Green open space has tree-like vegetation that has various functions, one of which is as a barrier to sunlight intensity and a microclimate regulator (humidity, temperature, and wind) (Ramadhani et al., 2019). One of the main elements that influence the calculation of the comfort index is air temperature (Hadi et al., 2012). Local factors that influence micro-climatic conditions such as temperature and humidity are land cover. Differences in the characteristics of each type of soil cover in absorbing and reflecting radiation can create differences in temperature and humidity (Kaka, 2013).

Table 1. Trees Inventory

Taman Kalpataru			
No.	Local Name	Scientific Name	Amount
1.	Cempaka	*Magnolia champaca*	17
2.	Mahoni	*Swietenia mahagoni*	50
3.	Flamboyan	*Delonix regia*	23
4.	Sonokeling	*Dalbergia latifolia*	3
5.	Ketapang	*Terminalia catappa*	1
6.	Jabon	*Anthocephalus cadamba*	1

7.	Akasia	*Acacia auriculiformis*	1
8.	Nangka	*Artocarpus heterophyllus*	1
Total			97

Taman Dipangga

No.	Local Name	Scientific Name	Amount
1.	Lamtoro	*Leucaena leucecophala*	15
2.	Palem Raja	*Roystonea regia*	6
3.	Bungur	*Lagerstroemia speciosa*	4
4.	Mahoni	*Swietenia mahagoni*	3
5.	Glodokan	*Polyalthia longifolia*	1
6.	Johar	*Cassia seamea*	8
7.	Trembesi	*Albizia saman*	2
8.	Cemara Laut	*Casuarina equisetifolia*	1
9.	Mangga	*Mangifera indica*	2
10.	Jambu Air	*Syzgium Aqueum*	1
Total			43

Taman Gajah

No.	Local Name	Scientific Name	Amount
1	Ketapang Kencana	*Terminalia mantaly*	15
2	Kurma	*Phoenix dactylifera*	30
3	Mahoni	*Swietenia mahagoni*	11
Total			56

Source: Primary Data (2019)

In this study, three green open spaces in Bandar Lampung were researched, namely Taman Gajah, Taman Dipangga, and Taman Kalpataru. The three green open spaces have different levels of comfort. The comfort caused by the existence of green open space has the role of vegetation which can reduce the temperature. Temperature or temperature is the degree of heat from molecular activity in the atmosphere (Surmi et al., 2016). This is evidenced in the research of Choirunnisa, et al. (2016) which states that there is a difference in air temperature inside city parks and outside city parks. This is because the comfort caused by plants is associated with the role of plants being able to reduce solar radiation to provide a microclimate (Sanger et al., 2016).
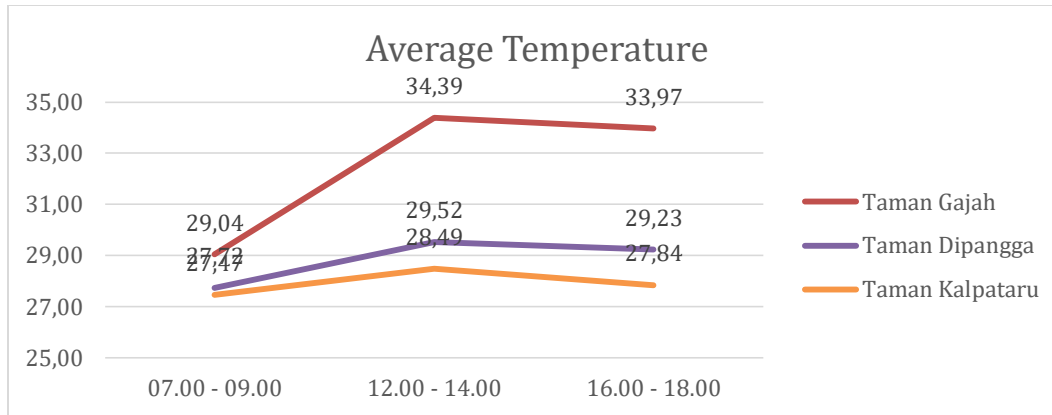
Figure 2. The Average Temperature at Bandar Lampung City Parks

It can be seen in Figure 1. Taman Dipangga and Taman Kalpataru have lower temperatures than Taman Gajah. This is because the role of vegetation in Taman Dipangga and Taman Kalpataru is more than in Taman Elephant. Supported by research Sapariyanto, et al. (2016), the resulting air temperature on vegetated land is lower than on non-vegetated land. The temperature that comes from solar radiation does not directly touch the ground but is obstructed by vegetation canopies (Lakit, 2002). Land that has vegetation can release O2 as a result of photosynthesis, absorbs carbon dioxide, and can produce water vapor in the air through transpiration to maintain moisture stability (Taufiq et al., 2019).

The highest temperature is in Taman Gajah (34,39 ^{o}C) at 12.00 WIB - 14.00 WIB. The high temperature in Taman Gajah is caused by the absence of a canopy that can absorb sunlight because the leaves can absorb sunlight most effectively. The canopy or canopy can slowly lower the temperature through the plant evapotranspiration process (Taufiq et al., 2019). Apart from the dense canopy, the temperature is also influenced by the shape of the vegetation canopy (Femy et al., 2014). The effectiveness of absorption and transmission of sunlight depends on the characteristics of each vegetation species, such as branching, many leaves, or density (Sanger et al., 2016). Sunlight will decrease when it passes through the top canopy, then slowly decreases to the lowest vegetation. The green open space area should be filled with plants that have extensive protective and shade functions because the area is used for socialization activities so that it requires cool and comfortable conditions (Sanger et al., 2016).

B. Air Humidity

The results of the study in Figure 2 show that the highest humidity is obtained in the morning and the lowest during the day. Of the three green open spaces, the highest humidity (56%) is in Taman Kalpataru at 07.00 WIB - 09.00 WIB and the lowest is in Taman Kalpataru (17%) at 12.00 WIB - 14.00 WIB.
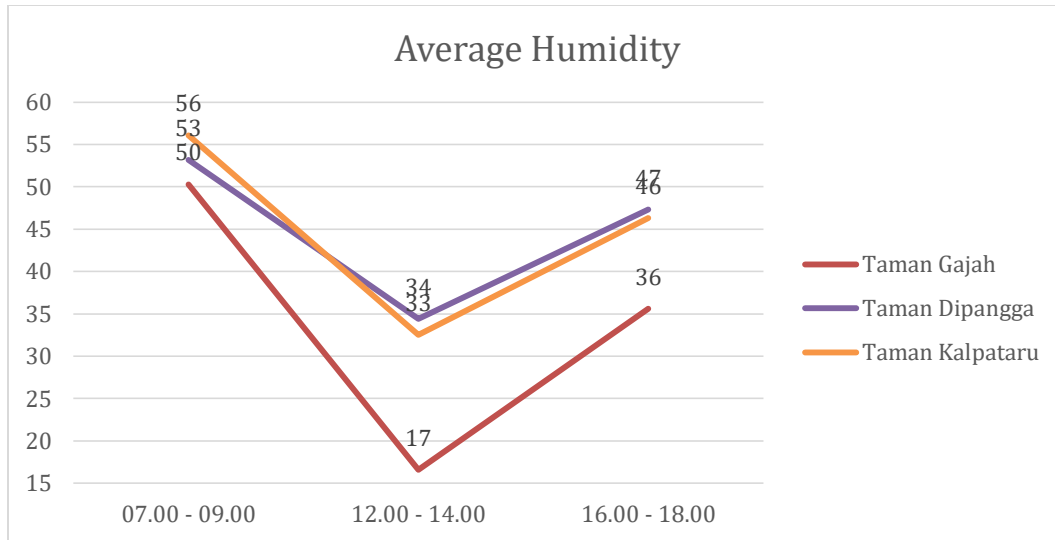
Figure 3. The Average Humidity at Bandar Lampung City Parks

The highest humidity is obtained at 07.00 WIB - 09.00 WIB due to the influence of solar radiation, where when the sun sets to sunrise, the temperature will decrease and the humidity increases (Sanger et al., 2016). During the day, the humidity will decrease, as the temperature increases. Following the opinion of Fandheli and Muhammad (2009), air humidity will be higher when the air temperature decreases and vice versa.

The lower humidity in Taman Gajah compared to the other two green open spaces is caused by the lack of vegetation in the green open space which can be seen in Table 1. Indriyanto (2006) stated that vegetation is a component of nature that can control climate through controlling fluctuations or changes in elements. climatic elements that exist around it such as temperature, wind humidity, and rainfall thus determine local climatic conditions. In Taman Kalpataru and Taman Dipangga, there is a lot of vegetation with wide canopies such as *Delonix regia*, *Terminalia catappa*, *Anthocephalus cadamba*, and *Swietenia mahagoni*. Unlike the Taman Gajah which has a small number of species and a small canopy such as dates. Following the research of Kleerekoper et al. (2012), the role of trees is to cool the environment through the evapotranspiration process and passively protect the surface by the canopy which can reduce short waves of solar radiation. Following the opinion of Sanger et al. (2016), trees are more effective than other forms in increasing air humidity and lowering the temperature. Air humidity is influenced by air temperature which is caused by a decrease in water vapor pressure so that the air capacity to accommodate water vapor decreases and causes an increase in air humidity (Prasetya et al. 2017).

C. Temperature Humidity Index

Thermal comfort is a type of human comfort commonly found in green open spaces (Karyono, 2005). Various levels of human thermal comfort come from the climate, namely air temperature, air humidity, solar radiation, and wind speed (Choirunnisa et al., 2017). The use of THI calculations is for planning the development of green and environmentally friendly urban planning (Wati and Fatkhuroyan, 2017). One of the factors that affect the level of THI is the rate of urbanization development in urban areas (Wati and Fatkhuroyan, 2017). The comfort index is one of the indicators in the design of a building for a workplace to facilitate reorganization activities, changes, or strategies for placing new tools and for increasing the comfort of workers in the workplace (Talaia, 2013). Taking the Temperature Humidity Index (THI) to determine the

level of comfort in a place daily to help support the development of comfortable and environmentally friendly urban planning.

Table 2. Temperature Humidity Index

Temperature Humidity Index			
	07.00 - 09.00	12.00 - 14.00	16.00 - 18.00
Taman Gajah	Uncomfortable	Uncomfortable	Uncomfortable
Taman Dipangga	Moderate	Moderate	Uncomfortable
Taman Kalpataru	Moderate	Moderate	Moderate

Sumber: Primary Data (2019)

Temperature and humidity data were collected at three-time intervals because the minimum air temperature occurred at 03.00 and the maximum air temperature was at 15.30 (Mustika, 2001). Based on the research results, Taman Gajah has an uncomfortable index value three times. It is different from Taman Dipangga which only has an uncomfortable index in the afternoon, and the others are at a moderate level. This is related to the vegetation planted in Taman Gajah based on Table 1. where planting is carried out with trees with vegetation structures with non-dense canopies such as date palm vegetation. Following the research of Santi et al. (2019), the high temperature in city parks is due to the absence of surrounding vegetation so that it is unable to create a comfortable microclimate. The role of trees planted with high density can reduce high air temperatures during the day (Setyowati, 2008). Sapariyanto et al. (2016) explained that the absorption of solar energy by the plant canopy system will encourage growth to increase its transparency rate. In the process of transpiration, plants will use most of the water that has been absorbed from the soil. Plants will transpire faster if the air temperature is high because rising temperatures will increase the vapor pressure inside and outside the leaves. The increase in vapor pressure is different on the inside and outside of the leaves, thereby increasing the amount of water vapor in the air.

The most effective vegetation structures in reducing temperature and increasing air humidity are trees because they can evapotranspiration with a dense canopy (Choirunnisa et al., 2017). Supported by the opinion of Lakit (2002), trees will make the air beneath them feel shadier because most of the sunlight intensity is blocked by the tree canopy. Stable air temperature and humidity under the tree are stable due to cold steam from under the tree which is carried by the wind to the surrounding environment (Annisa, 2015).

Taman Gajah has a smaller area of trees than other pavements so that a lot of sunlight is converted into heat energy so that the temperature increases (Zahra et al., 2014). If a land cover is converted from vegetated land to non-vegetation areas such as buildings, it will cause the expansion of hot and dry areas and lead to a reduced level of comfort to become uncomfortable (Kalfuadi, 2009). To reduce the temperature in Taman Gajah, tree vegetation can be planted on the land cover such as concrete and cement. Supported by the research of Hadi et al. (2012) stated that land cover causes high temperatures in a place, but can be reduced by trees because land cover other than tree cover does not affect the comfort index if it is covered by tree cover.

Unlike the Taman Gajah, Taman Dipangga, and Taman Kalpataru are planted with various types of trees that have a wide canopy. The width of the canopy planted in the two areas made the two locations have an average THI in the medium category. Under the research

of Ujwala et al. (2018), areas that have an uncomfortable index, are usually dominated by tree cover that is smaller than the dominance of other land covers.

To improve thermal comfort in Taman Gajah, we can plant shade plants and bodies of water (Hayati et al., 2013) and can plant shade tree species with branches of more than two meters (Department of Public Works, 1996). As evidenced by the research of Prasetya et al. (2017), differences in vegetation determine the microclimate conditions at each location. In line with Setyowati's (2008) research, a group of trees with a dense density can reduce the air temperature, especially during the day. The density level is based on the ratio of the total area to the area overgrown with vegetation (Choirunnisa et al., 2017).

D. Comfort Level

The comfort of City Parks is an important aspect of a city. The emergence of comfort in City Parks is a form of psychological response from humans to their environment (Siregar and Kusuma, 2015). Comfort can arise because of the role of city parks in reducing air temperature, reducing solar radiation, producing clean air, filtering air pollution, and others (Ochoa and Marincic, 2005).

The poor level of comfort in city parks can lead to an increase in land surface air temperature (Hidayat, 2016). Based on Hidayat's research (2016), there has been an increase in land surface temperature (SPD) that occurred in Jakarta from 31.82 $^{\circ}$C to 37.40 $^{\circ}$C. The increase in SPD was directly proportional to the decrease in the percentage of green vegetation (PKV) in Jakarta from 2005 to 2006 by 1.60% from 10.19% to 8.59%.

Siregar and Kusuma's research (2015) shows that of the various elements of comfort in city parks, the element with the highest frequency mentioned is vegetation. The vegetation element in question is a lot of trees and plant diversity in a city park because it can provide comfort in the form of a microclimate. In line with Obi's (2014) opinion, vegetation is an important element in the urban microclimate control strategy. Supported by the opinion of Prasetya et al., (2017), the quality of green open space is generally related to a large number of shady trees. The more shade trees, the better the quality of green open space. Vegetation has a good effect in reducing temperature increases through absorption and reflection of solar radiation. This is based on the increasing number of vegetation in a place, the lower the temperature is due to the process of transpiration and the interception of sunlight intensity by the tree canopy (Annisa, 2015). According to Sapariyanto et al. (2016), the characteristics of tree structures can affect the microclimate, including the shape of the canopy, planting, plant size, and crown density.

Table 1. shows that the most abundant vegetation is in Kalpataru City Park with 97 trees and the lowest is in Taman Dipangga with 43. However, Taman Dipangga has a better THI value than Taman Gajah. This is because, in Taman Gajah, the vegetation species planted are vegetation that has a less frequent canopy density than in Taman Dipangga. The difference in temperature and humidity between Taman Dipangga and Taman Gajah was very visible in the measurement at 12.00. The average temperature in Taman Dipangga is 29.52 $^{\circ}$C, while in Taman Gajah it is 34.39 $^{\circ}$C. The denser of plant canopy in an area, the more stable the environment is (Erly et al., 2019). Following the research of Femi et al. (2014), a denser canopy shape such as *Polyalthia longifolia* compared to the dome and columnar crowns affects air temperature and humidity.

Another case with vegetation, the existence of the Taman Gajah form which is dominated by concrete is the cause of the high temperature during the day. The fluctuation in

the average temperature in the morning from 29.04 ℃ to 34.39 ℃ during the day is caused by the ability of concrete to release cold air and is quickly replaced by hot air (Hidayat, 2016). In line with Putritama and Sufianto's research (2018), building forms that can infiltrate vegetation can reduce temperature better than building forms in the form of clay and concrete. Also, material that is not shaded has a higher temperature than material that is shaded by vegetation and other buildings (Rusyda et al., 2017).

Another criterion of comfort level in a city park according to Siregar (2015) is pollution-free. Vegetation in the form of trees can absorb air pollutants such as aerosol particles, Pb, gas, and dust particles (Chaudhry and Panwar, 2016). The pollution-free criterion is based on the fact that pollutants such as dust can reduce comfort levels because they harm humans. The negative effect given by dust particle pollutants is lung function disorders (Hamidi et al., 2013).

Besides being able to absorb air pollutants, planting tree vegetation is also able to provide clean air (Ramadhani et al., 2019). Supported by Djuangsih and Siringoringo (2000), plants can absorb and accumulate pollutants which are determined by leaf morphological characteristics. Leaves that have hair or leaves with a rough surface have a higher absorption ability than leaves that have a smoother and flatter surface (Hendrasarie, 2007).

The vegetation of trees that can absorb dust well according to research by Ramadhani et al. (2019) is *Artocarpus heterophyllus* and *Polyalthia longifolia*. *Artocarpus heterophyllus* and *Polyalthia longifolia* can be found in Taman Kalpataru and Taman Dipangga. This is because *Artocarpus heterophyllus* can absorb dust due to the rough and hairy shape of the leaves, so it can absorb more particles. *Swietenia mahagoni* has a smooth leaf shape making it difficult to absorb dust. In contrast to *Swietenia mahagoni*, *Polyalthia longifolia* has two sides of shiny leaf surfaces so that dust will be difficult to stick to the leaves but the columnar canopy form and branches that droop down and tightly from one leaf to another, make the dust around the tree stick to it. in the wind.

CONCLUSIONS AND RECOMMENDATIONS

The highest average temperature was recorded at 12.00 in Taman Gajah with a temperature of 34.39°C and the lowest temperature was recorded at 07.00 - 09.00 WIB in Taman Kalpataru with a temperature of 27.47°C. The highest humidity is in Taman Kalpataru at 56 and the lowest is in Taman Gajah at 17. Based on the Temperature Humidity Index (THI), Taman Gajah has an uncomfortable value from 07.00 WIB to 18.00, while Taman Kalpataru has a moderate THI value from 07.00 WIB to 18.00 WIB. The difference in temperature and humidity in the three City Parks in Bandar Lampung is caused by different types of vegetation that can reduce temperature and increase humidity.

It is necessary to add vegetation with a dense type of canopy density with a variety of cropping patterns to withstand temperature and humidity. Vegetation planting with a variety of cropping patterns can increase the level of comfort level in three City Parks in Bandar Lampung.

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