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International
Journal
Of Modern Engineering Research (IJMER)

# Comparative study of different methodology of microclimateassesment on public open spaces in Kendari

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***ABSTRACT***:*The availability of open space in urban areas becomes one of the most important things in developing urban population. An ideal open space must accommodate the surrounding community activities and be able to function as an urban forest.This article aims to compare the results of micro climate data collection both collected by direct methods in the field and simulations using ENVI-Met. the results obtained also compared the impact on the two study sites. Both research locations, namely the City Park and Tugu Religi court have different dimensions and composition of vegetation cover. the calculated composition of vegetation in the City Park is 64% while the Tugu Religious court is 33%. T-Test Paired statistic test was conducted to investigate the differences in the results of several microclimate variables used to identify the thermal comfort of public open spaces. The result shows the different for wind speed were 0,2 m/s and 0,3 m/s; for temperature were 4,2 $^{o}$C and 2,6$^{o}$C; also for relative humidity were 26,7% and 18,6%.*

***KEY WORDS:****green open space, ENVI-met, wind speed, temperature, relatuve humidity, thermal comfort*

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Date of Submission:15-09-2019 Date of acceptance: 03-10-2019

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## I. INTRODUCTION

The urban heat island phenomenon has occurred in almost cities in the world. Several studies on the phenomenon of increasing air temperaturein Indonesia have been carried out over the past few years. most of the research was carried out in big cities in western part of Indonesia, including Wulandari (2017) in Surakarta[1], Sobirin, et al (2015) in Surabaya[2], Husna, V. N. (2018)in Yogyakarta[3], and Limas A.V., et al (2014) in Jakarta [4]. In general, research shows that most of the major cities in Indonesia experience the phenomenon of rising temperatures compared to the sub urban area, this is in accordance with what was stated by Voogt thatthe conditions where the air temperature becomes higher is generally known as the ‘urban heat island’ effect[5]. This term refers to the observed temperature difference between urban and environments and the surrounding areas. The air temperatures are higher due to the urban heat island (UHI) effect and the wind speeds are lower due to wind sheltering by buildings[6].This condition on the outdoor causes energy demand for cooling space in the building to increase significantly. Therefore it can be concluded that the urban microclimate affects the energy consumption of the city.

Several factors causesUHI condition to be described by Lazzarinin Noro, M. as follows: the structure of urban canyons that affect the shortwave radiation heat exchange capacity of the urban surface towards the sky; the typically low albedo of the urban surfaces that increase the heat absorber by buildings, pavements, roads, and roofs; the anthropogenic heat produced by heat engines of the motorcars and chillers condensation heat; the greenhouse effect that is amplified by the higher pollutant concentration in the urban atmosphere; and the shortage of green areas that increases the heat exchange with air and decreases the evaporative cooling effect due to the lack of evapotranspiration of trees and grass[7].

Basicallythedeterminationofthevalueofmicroclimateiscarried out throughdirectmeasurement. However, over the past few years the method has been changed by prediction using numerical simulation. The numerical model uses a numerical procedure to solve the conservation equations that govern airflow and heat transfer in an open space. It is a very powerful and efficient methodology of investigating temperature, flow fields, and comfort indices in outdoor urban spaces where many parameters are involved.The use of numerical simulations should still be combined with direct measurements in the field to compensate the accuracy of the data obtained from both methods. Therefore, the most precise way to calculate or assess the impact of changes is through numerical methods, although there already are several models that can deal with the complexity of urban structures and even take into account human thermal comfort[7]. This complex thermal environment is relevant to human well-being and health due to a close relationship between thermoregulatory mechanism and circulatory system[8]. A complete application of thermal indices of the energy balance in the human body gives detailed information on the effect of the thermal environment on humans (VDI 1998).

Microclimate is a climatic condition in a space that is very limited to a limit of approximately two meters above ground level. Microclimate is a climate in a small space that is influenced by several factors, such as forests, swamps, lakes, and human activities[9].One of the problems of microclimate in urban areas faced by urban planners is the condition of thermal comfort in the outdoor.

In tropical climates, one of the characteristics is the discomfort felt during the daytime. It is very important to know the handling of the microclimate in oudoor area, including how to create a cooling effect through the use of elements of outdoor. Basically there are six factors that must be considered in the adaptive planning of microclimate conditions, namely environmental factors consisting of air temperature; relative humidity, wind speed, mean radiant temperature and personal factors in humans which include clothing insulation and type of activity.Environmental influences on microclimate for example on air temperature, soil temperature, wind direction speed, radiation intensity received by a surface, and air humidity (Holton, 2004).

There are several studies that identify and compare the results of microclimate indicators through field measurement methods and ENVI-met simulations including research by Elnabawi et al which evaluates the use of measurement methods and model simulations in two regional forms in Cairo. One of the results of the study referred to the use of ENVI-met as an alternative method in gathering outdoor meteorology information in an area to support measurement methods in the field[10].

This study aims to examine the use of two methods in micro climate data collection in two regions that have different characteristics of vegetation in Kendari. In this paper the simulation uses ENVI-met simulation in open space model to obtain micro-climate indicator values which will then be investigated for comparation with results obtained through field measurements.Calibration of these predictive models is necessary to verify their applicability in outdoor spaces. Usually, the calibration method adopted is experimental inductive (i.e., field research of microclimatic variables and subjective answers), and deductive with simulation of predictive models [11].

## II. MATERIAL AND METHODS

### 2.1 Description of Study Area

The study was conducted in Kendari, the capital of province of Southeast Sulawesi, Indonesia. Kendari astronomically located at the southern part of the equator is between 30 54` 30``-40 3`11`` South Latitude and stretches from west to east between 1220 23`-1220 39` East Longitude. As in other regions in Indonesia, Kendari is an area with a tropical climate that experiences two seasons, dry season and rainy season. According to data obtained from the Kendari Maritime Station's Meteorology, Climatology and Geophysics Agency Station in 2017 the maximum air temperature is at 33$^{o}$C and the minimum air temperature is 23.1$^{o}$C, the average air humidity is 83.67%. Meanwhile, the average wind speed in the same year reached 4.86 knots.Several preliminary studies reveal that Kendari has an upward trend in the temperature condition over the past few years. In 2010, the average air temperature in Kendari was recorded at 24$^{o}$C while in 2016 increase at 28$^{o}$C. In compared to sub urban where minimal infrastructure is built, cities and suburbs can show different air temperatures. The average air temperature in Kendari suburbs in 2017 is 27$^{o}$C or lower by 1$^{o}$C. This is in line with statements about the UHI phenomenon in urban areas where the air temperature in urban areas will be higher than the surrounding areas.

Nowadays, Kendari residents have only 11 public open space areas that are commonly used for outdoor activities, this public open space is spread out at several districs in Kendari.The object of the study is two public open space areas in Kendari, City Park and the square of City Monument Although the two locations are next to each other, the management of these public spaces is different. The City Park is managed by the Kendari City government, while the City Monument court is managed by the Southeast Sulawesi Provincial government.


**Figure 1:**Study area: A (City Park), B (square of City Monument)

Based on data processing from Google Earth, the City Park area reaches ± 6 hectares. Meanwhile the the area in the square of City Monument is limited to ±7 hectares because some parts inside the square are converted into road accessthat are often traversed by vehicles and not used by people for outdoor activities, so that some of these areas are not counted into the area of the area under study.The types of land cover are for example: impervious materials (tiles, asphalt and concrete), pervious material (paving blocks) and natural cover (soil and grass). These types of land cover allow different rates of permeability for underlying soil, affecting the temperature of the ground.Research data from field assesment was collected from several measuring instruments. Microclimate data such as ambient temperature, relative humidity, and wind speedwere obtained by usingmeasuring instrument.

**2.2 Microclimate Field Measurement**

The research was carried out in 4 stages. First, empirical measurements to determine the existing microclimate conditions at the research location. Data collection is carried out using measuring instruments to measure wind speed, air temperature and relative humidity. The tools used are several multi-environment meter units. Data collection was carried out on October 4, 2018. On that day, the sky condition was clear (clear sky). The timing of microclimate data retrieval in October was based on the results of weather data analysis from the Meteorology and Geophysics Agency of Kendari City in the past few years, the results showed that the hot months were around September and October. In addition, the data collection time is carried out during the day around 12:30 to 14:00 puku. these times are the times when solar radiation reaches its peak. From some of these considerations, it can be obtained the value of microclimate in extreme summer weather conditions.The data was measured from 1.5 m above the surface and at least 1.5 m from the material's perimeter (Asaeda, Ca, &Wake, 1996).

In addition to micro climate data, data on components of public open space landscapes is also needed. These data include the first: the type and order of vegetation that grows, including the distance between vegetation, type of vegetation (height and density of leaves); both types of ground cover material, including types of natural and artificial materials, area of material cover; the three types and dimensions of buildings that are inside the research location. Landscape component data is needed for making simulation models at the next stage.

**2.3 Microclimate ENVI-Met Simulation**

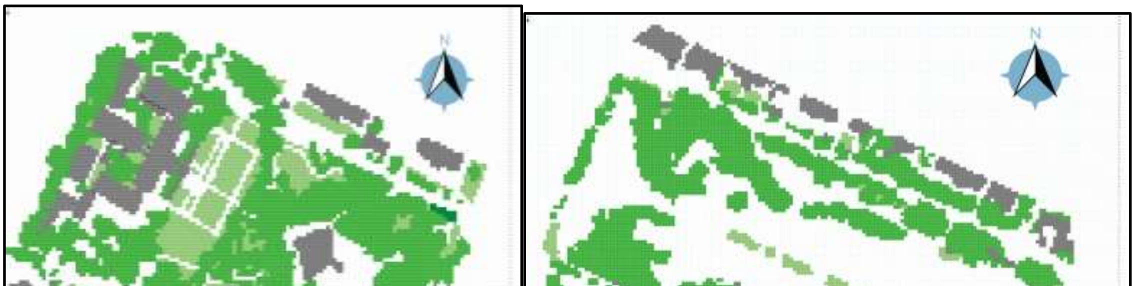


**Figure 2**: Envi-MET lanscape model data input

The second stage is a simulation using ENVI-Met software to determine the arrangement of landscape elements to micro-climate components. In this article the author conducted a simulation using the ENVImet model to obtain microclimate data as a comparison of data collection conducted in the field. to accurately simulate meteorological conditions in the boundary layer on the surface of the earth, modeling software must meet the following requirements[12]:

- grid size from the simulated model area must be small enough to fit the size of the building, eg The grid size is not more than 10 m;
- regional models must apply energy balance to all types of area surfaces;
- data regarding the physical and physiological properties of plants must be included;
- calculation of atmospheric processes must be prognostic and transient.

Due to the limitations of the latest opensource version of ENVI-Met software (v4) to analyze areas in a large grid, this study still uses the previous version of ENVI-Met (v3). The three components of the microclimate are the same as those measured directly at the field research, namely air temperature, wind speed, and relative humidity. The objectives of this research is to compare the data result obtained between field measurements and simulation model. Basically the method with ENVI-Met model simulation is one way to describe the real conditions of the elements of the microclimate incertain region, therefore it is necessary to have a complete picture of the existing conditions to be simulated, i.e vegetation, building, surface material, and diurnal atmosphere data. The simulation is preceded by making a landscape model along with soft and hard material according to the identification carried out in the field. Furthermore, entering data that can be seen in the table, for example simulation time data, location coordinates, and some weather data.

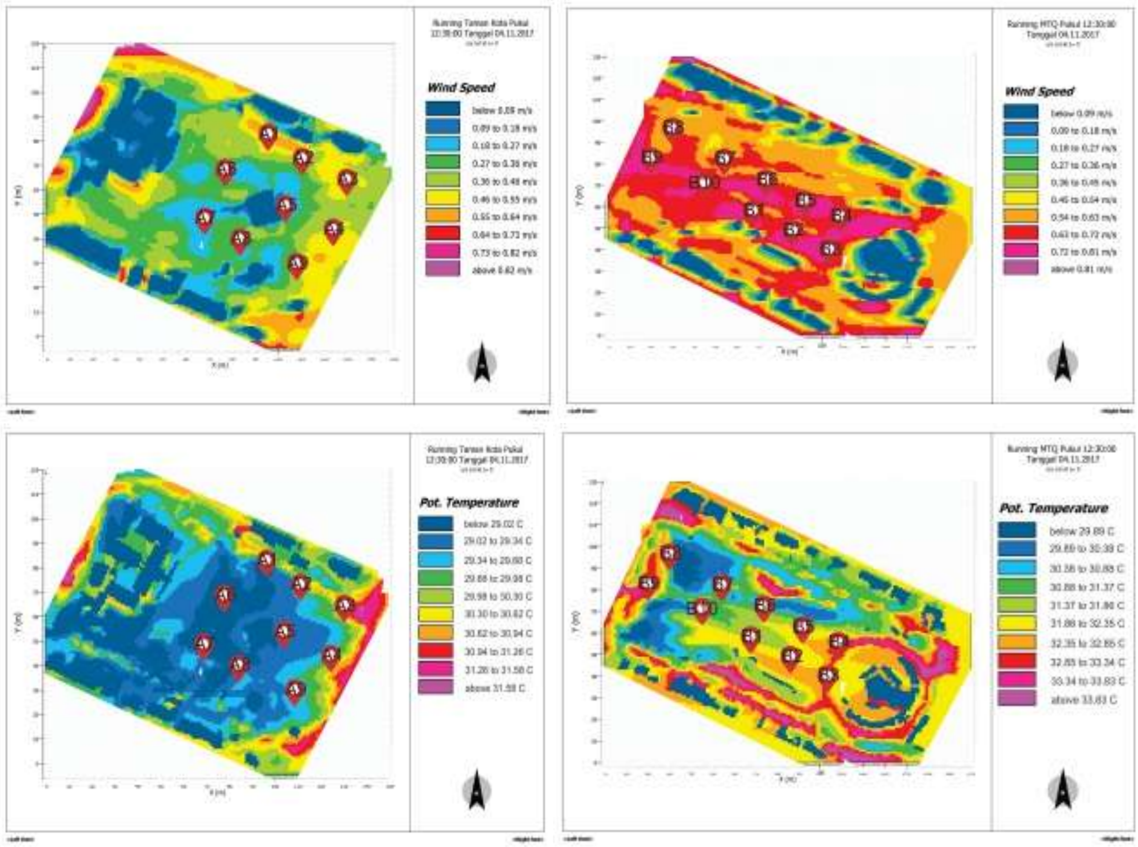
**Table1:** Envi-MET secondary data input

| Parameter | Value |
|---|---|
| Temperature | daytime: 32 ºC |
| Relative humidity | daytime: 50 %Rh |
| Wind speed and direction | daytime: 1,5 m/s |
| Date of model simulation | 4th October 2017 |
| Coordinat location | $3^0$ 54` 30``-$4^0$ 3`11`` South Latitude dan $122^0$ 23`-$122^0$ 39` West Longitude. |

### 2.4 Comparative microclimate result

The fourth stage is to look for differences in the results obtained from field measurements and ENVI-Met simulations. Statistical software, namely SPSS with Paired T-Test is used for testing. The results of this comparison are used as a comparison in the development of the next outer spatial design.

## III. RESULTS AND DISCUSSIONS



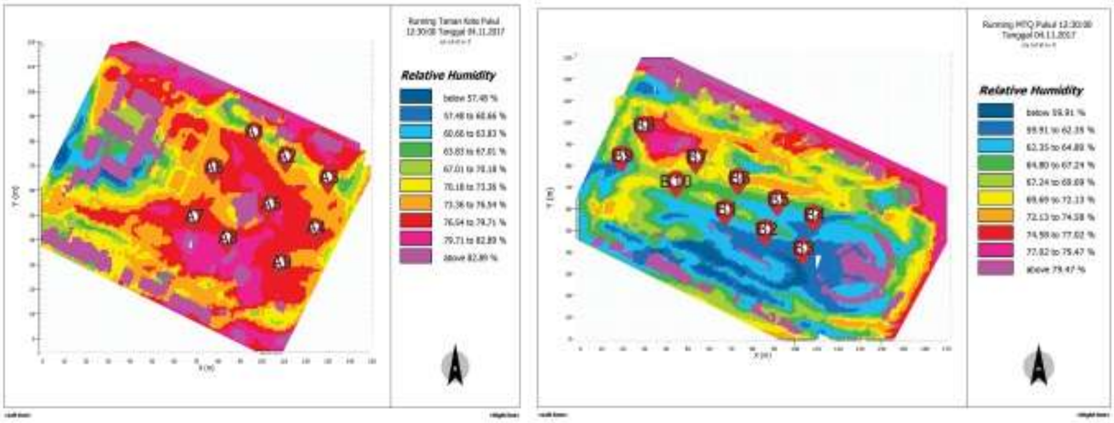



**Figure 3:** ENVI-Met simulation result

Figure 3 is the result obtained in the model simulation method. If the results of the two methods are compared, generally the pattern shown between the two is quite the same, this is shown in table 2. The difference in the method used lies in the value obtained. In the ENVI-Met model simulation method, the parameters of wind speed and temperature show lower results than the field measurement method, whereas in the relative humidity variable, the model simulation method shows higher results than the field measurements. The following is a further explanation of the results obtained in both locations and the two methods of microclimate data collection.

**Table2:** Result of Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confd. Interval of the Difference: Lower | Upper | | | |
| **Paired Samples Test City Park** | | | | | | | | | |
| Pair 1 | measurement - simulation(temperature) | 4,20 | 1,01 | ,33 | 3,42 | 4,99 | 12,39 | 8 | ,000 |
| Pair 2 | Measurement-simulation (wind speed) | ,23 | ,20 | ,06 | ,08 | ,39 | 3,57 | 8 | ,007 |
| Pair 3 | Measurement-simulation (rel. Humidity) | -26,76 | 4,57 | 1,52 | -30,28 | -23,24 | -17,55 | 8 | ,000 |
| **Paired Samples Test square of City Monument** | | | | | | | | | |
| Pair 1 | measurement - simulation(temperature) | 2,60 | 1,36 | ,43 | 1,63 | 3,58 | 6,05 | 9 | ,000 |
| Pair 2 | Measurement-simulation (wind speed) | ,34 | ,46 | ,14 | ,00 | ,67 | 2,30 | 9 | ,046 |
| Pair 3 | Measurement-simulation (rel. Humidity) | -18,66 | 4,87 | 1,54 | -22,15 | -15,18 | -12,10 | 9 | ,000 |

Based on the results of data collection wind speed obtained the average wind speed is higher on the square of City Monument than City Park, both based on data obtained from the field and through simulation models. the highest and lowest wind speeds in a row at City Park were 1.06 m/s and 0.34 m/s for field measurements while the highest and lowest simulation model wind speeds were 0.55 and 0.27 m/s. at the square of City Monument, the lowest and highest wind speeds for field measurements are 1.83 m/s and 0.4 m/s and for the lowest and highest wind speed simulation models are 0.63 m/s and 0.81 m/s.

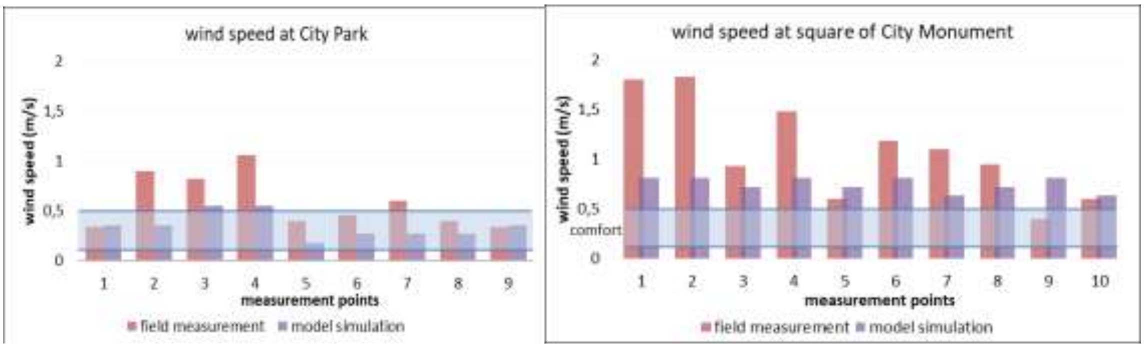



**Figure 4:** windspeedcomparison graph

This condition is supported by testing Paired T-Test in both locations and the two methods applied are field measurement and model simulation.Comparison between wind speed in the existing condition and model simulation can be seen from the probability / p value of the T Paired test which results in 0.007. This means that there are differences between the results of field measurements and simulations. At City Park theresultshows with an average difference of 0.238, the value is positive, meaning that the wind velocity tendency in the Envi-MET simulation method is lower by 0.238 m/s. Meanwhile, at square of City Monument the result shows an average value of a difference of 0.34, the value is positive, meaning that there is a lower tendency of wind speed in the Envi-MET simulation method of 0.34 m/s.

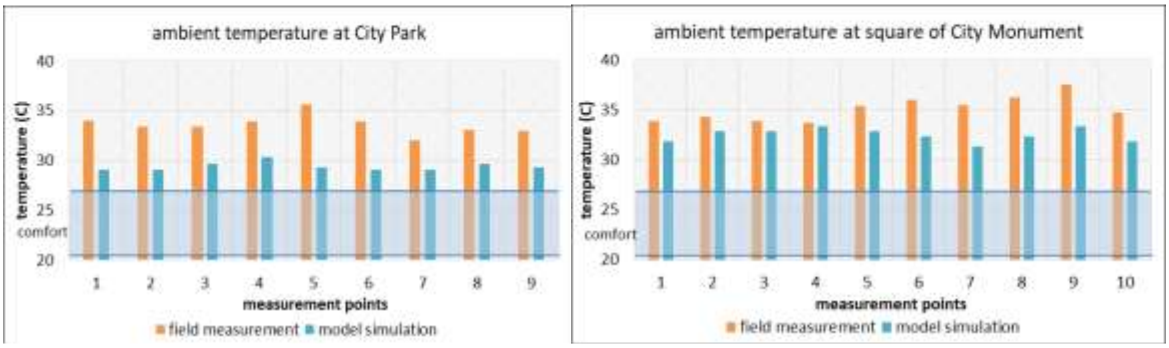



**Figure 5:** ambienttemperaturecomparison graph

The results obtained in the air temperature parameters indicate values that are far from the thermal comfort standard. Of the two locations studied, none of the values from the measurement point were within the threshold of comfortable value. Based on the results of field measurements, the lowest air temperature at the City Park location was recorded at 32.06$^{o}$C and the highest was 33.9$^{o}$C. While in the simulation results the lowest air temperature is 29.02$^{o}$Cwhich is constant at some measuring points and the highest is 30.03$^{o}$C. The similar pattern is shown in the results obtained at the square location of City Monument, the value of the simulation results is lower, the lowest temperature is 31.86$^{o}$C, while the value of the field measurement is 33.7$^{o}$C.

The comparison between the temperature in the existing condition and the model simulation can be seen from the probability/p value of the T Paired test which results in 0,000. This means that there are differences between the results of field measurements and simulations. At City Park theresultshows with an average difference of 4.208, the value is positive, meaning that there is a lower temperature tendency in the Envi-MET simulation method, which is lower by 4.208$^{o}$C. Meanwhile, at square of City Monument the result shows with an average value of difference of 2.609, this value is positive, meaning that the temperature decreasing tendency in the Envi-MET simulation method is lower by 2.609$^{o}$C.

However, on average, the air temperature in both data collection methods shows that the air temperature at the location of the square of City Monument is higher than that of City Park. City Park itself is an area with a higher percentage of vegetation than the square area of City Monument.

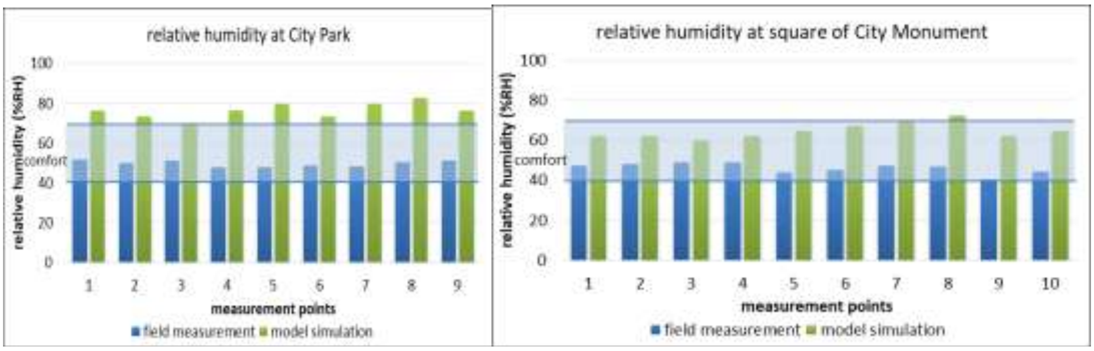



**Figure6:** relative humiditycomparisongraph

same as the previous two parameters, there is a difference in the results obtained from both field measurements and model simulations on the relative humidity microclimate indicator.Comparison between relative humidity in the existing condition and model simulation can be seen from the probability / p value of the T Paired test with the result of 0,000. This means that there are differences between the results of field measurements and simulations. With an average difference of 26.765, the value is negative, meaning that the tendency of relative humidity in the Envi-MET simulation method is higher by 26.765%. Furthermore the paired result at  can be seen from the probability / p value of the T Paired test which results in 0,000. This means that there are differences between the results of field measurements and simulations. With an average difference of 18,669, this value is negative, meaning that the tendency of relative humidity in the Envi-MET simulation method is higher by 18.666%.

Relative humidity results from the model simulation method look quite high at the City Park location. This is in line with the theory that areas with dense vegetation make the water content in the air more and more so that the relative humidity will be higher. this contrasts with the results of the square of City Monument where the results of the simulation show a drier air condition due to lower relative humidity. this is due to the lack of vegetation in this location.

## IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, it was concluded that the values of climate parameters obtained on all distributions of ENVI-Met simulation points had a pattern distribution which tended to be the same as the results of field measurements. The distribution of the results of climate parameters in both methods also shows that the more naturally an area is, the closer to the thermal comfort standard. These results indicate that the ENVI-Met simulation results can capture variations in the components of air temperature, wind speed and air humidity and provide good predictive performance from the composition of vegetation and surface material. However, from the results of the statistical test, it shows the difference from the average value, for example higher and lower between methods. Based on the results of field assessment and simulations on the components of the open space microclimate, several recommendations were formulated as follows:

1. There are differences in microclimate parameter values namely air temperature, relative humidity and wind speed obtained through field measurements and model simulations
2. The statistical analysis shows there are differences result between ENVI-Mets model simulation and field measurements on some measuring points on both open space. The result of ambient air temperature and wind speed shows higher in field measurement than the simulation. Otherwise in relative humidity parameter, the result on field measurement shows lower than simulation model.
3. The differences in the results of microclimate parameters between field measurement methods and model simulations are smaller in the public space with a more natural landscape arrangement, in this case the study area located at City Park.
4. It is highly recommended for further research to identify and validate Envi-met simulation results based on environmental conditions at different locations.

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Santi" Comparative study of different methodology of microclimateassesment on public open spaces in Kendari" International Journal of Modern Engineering Research (IJMER), vol. 09, no. 5, 2019, pp 01-08