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Analysis of Air Changes per Hour on Ventilation of Laboratory in a Tropical Rain Forests Area

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ABSTRACT

The existence of ventilation in the laboratory in a humid tropical forest environment affects comfort. Ventilation requirements are measured in Air Change Per Hour (ACH) which consists of fresh air availability, air circulation quality, heat loss, and unwanted gases in the room. This study was conducted to determine the ACH and to analyze the ventilation system at four locations, consisted of the main laboratory, head of the laboratory, assistant, and equipment rooms at the Computational Physics and Modelling Laboratory of the Faculty of Mathematics and Natural Sciences, Mulawarman University. The ACH values were determined through three stages, i.e., measurement, calculation and analysis. At the measurement stage, the parameters measured were wind speed, cross-sectional area, and room volume. The calculation step was carried out by entering the measured parameters into the ACH equation. The last stage, the analysis was carried out to compare the ACH values based on the ASHRAE recommendations. Based on the results, the average value of ACH for the main laboratory room was 6.78334 x/hour, the laboratory head room was 62.3082 x/hour, the assistant room was 52.7314 x/hour, and the equipment room was 4.36885 x/hour. Only the main laboratory room has met the ASHRAE recommendations with the ACH of the Laboratory room ranging from 6 to 12 x/hour. It can be concluded that wind speed, cross-sectional area, and room volume affect the amount of air exchange per hour.

I. Introduction

Borneo is an island surrounded by tropical rain forests with hot and humid weather. It is because the island of Borneo is crossed by the equator. The hot and humid weather affects the human working climate in the exchange of air in the room. Air exchange of workers in the room, one of which is in the laboratory room. The laboratory is a place to conduct scientific researches, experiments, measurements, or scientific trainings using various materials and special instrumentation by students, lecturers, researchers, and so on [1]. A good laboratory must be equipped with special facilities and public facilities. Special facilities in the form of equipment, such as practicum tables, teacher/lecturer desks, chairs, blackboards, and others. Public facilities in the laboratory can be used by the public in the form of lighting, electricity, gas and ventilation [2].

Ventilation is an important facility in the laboratory which is useful for the process of air exchange and avoiding the room becoming stuffy. It is done to maintain the air quality in the room. Ventilation is divided into two parts, namely natural ventilation and artificial ventilation. Natural ventilation, such as windows, serves as natural air circulation. Artificial ventilation, such as air conditioners (AC), also functions as air circulation with mechanical and electrical assistance.

The results of the study [3] stated that a safe and healthy ventilation system in the mining area was measured using AutoCAD 2014 software simulation with reference to KEPMEN No. 555.K/26/M.PE/1995. The research of [4] also conducted the same research in the mining area, but used a Ventsim Visual software simulation with reference to KEPMEN No. 555.K/26/M.PE/1995. Research on ventilation systems is interesting to study. Therefore, in this study, it was intended to

find out how the air changes per hour is in the tropical rain forest area. In this case, the laboratory used is the laboratory of the Samarinda Occupational Safety and Health Center. It aims to create optimal laboratory conditions by using a ventilation system.

II. Method

This study used prospective data collection techniques. The data used were derived from direct measurements in a computer laboratory in a tropical rain forest area. It used the TESTO 425 anemometer to measure wind speed, a digital meter to measure the volume of the room and the cross-sectional area of the ventilation, a Lutron-ABH 4225 to measure temperature and humidity in the room, and a laptop to process the data.

The data collection procedure was as follows:

1. Prepared research tools in advance,
2. Measured wind speed at three points on each surface of the vent by directing the tip of the anemometer measuring instrument to the vent with a total of 10 data taken at each point,
3. Measured the cross-sectional area of ventilation and room volume using a digital meter, temperature and humidity in the room using a Lutron-ABH 4225,
4. Entered the measurement results of wind speed, room volume and ventilation cross-sectional area into the following equation

$$ACH = \frac{v \, x \, A \, x \, 3600}{V} \quad (1)$$

with,

v = wind speed

A = cross-sectional area

V = room volume of laboratory

This equation is used to find the air changes per hour (ACH) [5],

5. The results obtained were recorded.

The research procedure carried out is presented in a flow chart as shown in Figure 1.

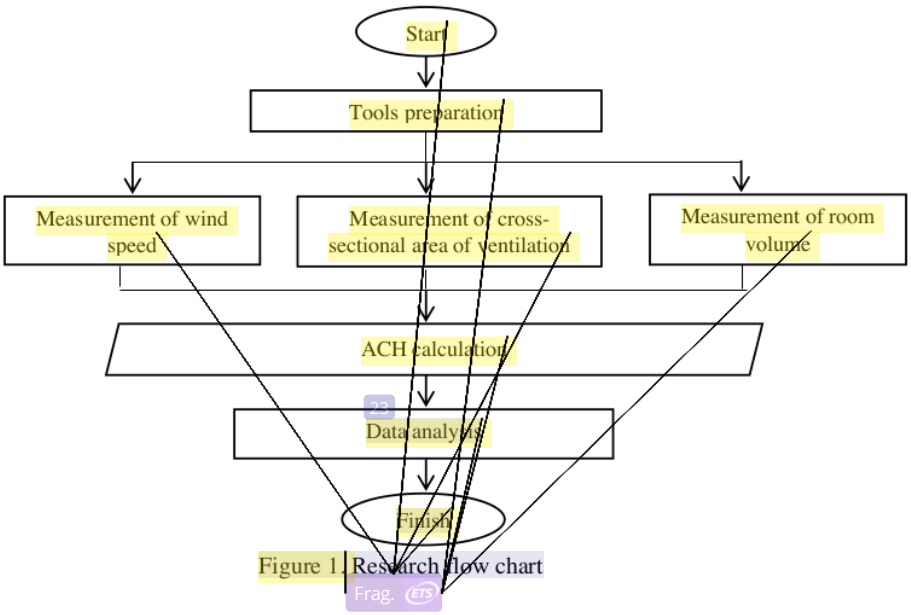

Figure 1. Research flow chart

Air changes per hour, abbreviated as ACH or air exchange rate is the number of changes in all air in the room with fresh air from outside every hour. The greater the potential for air pollution in a room (such as laboratories, workshops, toilets and kitchens), the higher the hourly air changes required. The benchmark for determining the quality of air exchange in laboratories is based on the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE recommended ACH for a safe and healthy environment can be seen in Table 1.

Table 1. Air changes per hour by ASHRAE

Room	ACH
Office	8-10
Laboratory	6-12
Class	3-4
Public auditorium	12-14

[6].

III. Result and Discussion

The results of measurements and calculations using Equation 1 are presented in Table 2.

Tabel 2. Hourly air exchange the morning day

No.	Location	Wind speed (m/s)	Luas Cross-sectional area (m^2)	Room volume (m^3)	ACH (x/hour)	Temperature (^{0}C)	Humidity (%)
1	Main Laboratory Room	5,3857	0,1	318,1108	6,07585	22,8	57,5
2	Head Laboratory Room	3,3932	0,1	20,1781	60,5384	24,2	57,9
3	Laboratory and Assistant Room	3,4034	0,1	23,5605	52,0031	24,8	58,2
4	Tool Room	0,1574	0,72	18,5937	2,19418	27,9	64,2

Seen in Table 2 is the hourly air exchange (ACH) in the morning from 08.00 to 09.00 WITA, the data is obtained from the measurement of wind speed, cross-sectional area and room volume which is substituted into equation 1. Calculation of hourly air exchange (ACH)) in the morning from 08.00 to 09.00 WITA carried out in various locations such as the main laboratory room at 6.07585 x/hour, with the ACH value meeting the ASHRAE (2011) recommendation. The head of the laboratory is 60.5384 x/hour, with the ACH value not meeting the ASHRAE (2011) recommendation. The laboratory and assistant rooms are 52.0031 x/hour, where the ACH value does not meet the ASHRAE (2011) recommendation. The tool room is 2.19418 x/hour, with the ACH value not meeting the ASHRAE (2011) recommendation [7]. The room temperature value indicates the optimal comfort range, except in the tool room. Air humidity is included in relative humidity, except for the tool room based on SNI 03-6572-2001 [8].

Tabel 3. Hourly air exchange during the day

No.	Location	Wind speed (m/s)	Cross-sectional area (m^2)	Room volume (m^3)	ACH (x/hour)	Temperature (^{0}C)	Humidity (%)
1	Main Laboratory Room	6,3275	0,1	318,108	7,13833	20,9	58,1
2	Head Laboratory Room	3,5334	0,1	20,1781	63,0397	23,6	58,9
3	Laboratory and Assistant Room	3,461	0,1	23,5605	52,8832	23,7	58,8
4	Tool Room	0,379	0,72	18,5937	5,28333	26,2	64,8

In Table 3, the calculation of hourly air exchange (ACH) during the day from 12.30 to 13.30 WITA is carried out in various locations such as the main laboratory room of 7.13833 x/hour, with the ACH value meeting the ASHRAE (2011) recommendation. The head of the laboratory is 63.0397 x/hour, with the ACH value not meeting the ASHRAE (2011) recommendation. The laboratory and assistant rooms are 52.8832 x/hour, where the ACH value does not meet the ASHRAE (2011) recommendation. The tool room is 5.28333 x/hour, with the ACH value not meeting, but not far from the ASHRAE (2011) recommendation [7]. Room temperature values indicate the optimal comfort range, except for the main laboratory room. Air humidity is included in relative humidity, except for the tool room based on SNI 03-6572-2001 [8].

Tabel 4. Hourly air exchange in the afternoon

No.	Location	Wind speed (m/s)	Cross-sectional area (m^2)	Room volume (m^3)	ACH (x/hour)	Temperature (^{0}C)	Humidity (%)
1	Main Laboratory Room	6,3292	0,1	318,108	7,13585	17,8	58,9
2	Head Laboratory Room	3,5584	0,1	20,1781	63,3466	23,4	59,6
3	Laboratory and Assistant Room	3,5202	0,1	23,5605	53,308	23,5	59,4
4	Tool Room	0,4046	0,72	18,5937	5,62904	25,4	63,3

Table 4 is the calculation of hourly air exchange (ACH) in the afternoon from 15.00 to 16.00 WITA carried out in various locations such as the main laboratory room of 7.13585 x/hour, with the ACH value meeting the ASHRAE (2011) recommendation. The head of the laboratory is 63.3466 x/hour, with the ACH value not meeting the ASHRAE (2011) recommendation. The laboratory and assistant rooms are 53.308 x/hour, where the ACH value does not meet the ASHRAE (2011) recommendation. The tool room is 5.62904 x/hour, with the ACH value not meeting, but not far from the ASHRAE (2011) recommendation [7]. Room temperature values

indicate the optimal comfort range, except in the main laboratory room. Air humidity is included in relative humidity, except for the tool room based on SNI 03-6572-2001 [8].

Table 5. Air changes per hour in laboratory in a tropical rain forest area

No	Location	ACH (x/hour)			Mean
		Pagi	Siang	Sore	
1	Main Laboratory Room	6,07585	7,13833	7,13585	6,78334
2	Head Laboratory Room	60,5384	63,0397	63,3466	63,3082
3	Laboratory and Assistant Room	52,0031	52,8832	53,3080	52,7314
4	Tool Room	2,19418	5,28333	5,62904	4,36885

In Table 4.16 are the results of hourly air exchange (ACH) from various locations and times in the Computational Physics and Modeling Laboratory, such as in the main laboratory room there are 2 ACs, namely AC 1 and AC 2, where for data collection the morning ventilation is 6 0.07585 x/hour, 7.13833 x/hour during the day and 7.13585 x/hour in the afternoon with an average hourly air exchange rate (ACH) of 6.78334 x/hour. In the head of the laboratory room there is 1 air conditioner where for ventilation data collection in the morning is 60.5384 x/hour, during the day is 63.0397 x/hour and in the afternoon is 63.3466 x/hour with an average air exchange value per hour. hourly (ACH) of 62.3082 x/hour. In the laboratory and assistant room there is 1 air conditioner where for ventilation data collection in the morning is 52.0031 x/hour, during the day is 52.8832 x/hour and in the afternoon is 53.3080 x/hour with an average air exchange value per hour (ACH) of 52.7314 x/hour. In the tool room there is 1 window where for data collection ventilation in the morning is 2.19418 x/hour, during the day is 5.28333 x/hour and in the afternoon is 5.62904 x/hour with an average air exchange rate per hour. (ACH) of 4.36885 x/hour. The value of air exchange per hour (ACH) is obtained from data on wind speed, room volume, and cross-sectional area.

Based on the measured parameters, the results of the calculation of the air flow rate in natural ventilation in the tool room are obtained. The parameters are wind speed, cross-sectional area and effectiveness of the opening of the cross-sectional area [8]. Figure 2 is a diagram of the results of the air flow rate in 1 day in the tool room.

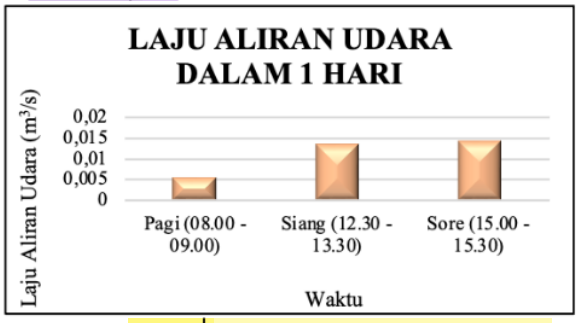

Figure 2. Airflow rate chart in 1 day in the tool room

In Figure 2 is the result of the air flow rate in 1 day obtained from the measured parameters, then substituted into equation (2). It appears that the value of the air flow rate in the morning from 08.00 to 09.00 has a low value because the conditions in the morning are not windy so the measured wind speed is low. Meanwhile, during the day from 12.30 to 13.30 and in the afternoon from 15.00 to 16.00 it has a fairly high speed value caused by strong winds that produce high wind speeds.

In the measured parameters, the calculation of the entropy value in the tool room is obtained. The parameters measured were wind speed, cross-sectional area, room temperature and outdoor temperature [9]. Figure 3 is a graph of the entropy value in 1 day in a tool room with natural ventilation, namely windows.

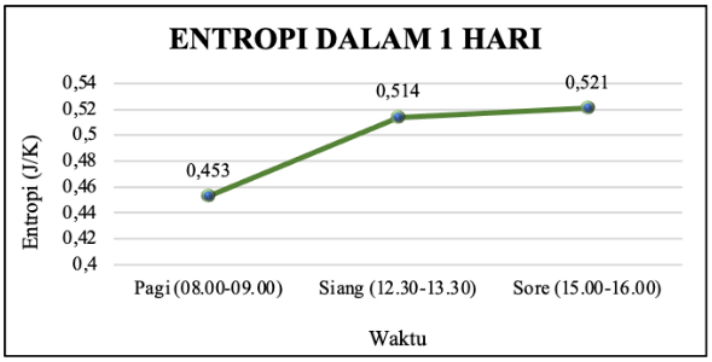

Figure 3. The value of entropy in 1 day in a tool room with natural ventilation

In Figure 3 is the result of entropy in half a day obtained from the parameters measured in the tool room, then substituted into equation 2.15 and equation 2.16. It can be seen that the entropy value in the morning from 08.00 to 09.00 has a low entropy value of 0.453 J/K because the weather was slightly cloudy in the morning and the window had just been opened, resulting in a low temperature being measured. During the day from 12.30 to 13.30 the entropy is 0.514 J/K and in the afternoon from 15.00 to 16.00 is 0.521 J/K has a fairly high speed value caused by sunny weather conditions and the windows have been opened in the morning, resulting in high temperatures.

The process of exchanging air in the tool room uses natural ventilation, namely windows. The exchange process is obtained from outside air that enters the tool room through a window with a cross-sectional area that has been used. Wind speed and temperature from outside affect the result of entropy which stabilizes wind speed and indoor temperature based on the second law of thermodynamics in the concept of entropy says "a natural process that starts in one equilibrium state and ends in one other equilibrium state will move in the opposite direction. causes the entropy of the system and its surroundings to increase"[10]

IV. Conclusion

Based on the results obtained, the average value of air exchange per hour (ACH) for the Computational Physics and Modeling Laboratory in the main laboratory room is 6.78334 x/hour, in the laboratory head room is 62.3082 x/hour, in the laboratory room laboratory assistant and assistant is 52.7314 x/hour, and in the tool room is 4.36885 x/hour. It can be concluded that wind speed, cross-sectional area and room volume affect the amount of air exchange per hour.

The ventilation system in each room in the Computational Physics Laboratory has not fully met the ASHRAE (2011) recommendations from the four laboratory rooms that were measured, namely the main laboratory room, the head of the laboratory room, the laboratory and assistant rooms, and the tool room, there were only 1 a laboratory room that has met the ASHRAE (2011) recommendation for a good ventilation system, namely in the main laboratory room.

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