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Research Paper

Indoor Air Quality of Physical and Microbiological in Universitas Muhammadiyah Kalimantan Timur, Indonesia

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Abstract
Indoor air quality is important for mental health and comfortable environment inside the rooms. Poor indoor air quality has impact to the sick building syndrome to occupant in the rooms. Physical and microbiological are factors influence the indoor air quality. Purpose of this study is measure indoor air temperature, humidity and microbiological in Universitas Muhammadiyah Kalimantan Timur in the morning and afternoon. Method used field measurement, microbiological laboratory analysis and regression test by SPSS. High temperature and microbiology occur in the afternoon, humidity is not significant between morning and afternoon. Temperature and humidity were influenced by ventilation and use of air conditioner in the rooms. Ventilation, efficiency air circulation, building type, maintenance air conditioner and occupant density are factors getting clean and health indoor air quality for keep comfortable environment. Statistical analysis result temperature and humidity has not affected the indoor air microbiological increase.

Keywords
Microbiological Content, Humidity, Temperature, Indoor Air

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1. INTRODUCTION

The result of available research of indoor air quality, include temperature, humidity and inefficient ventilation have harmful to the person in the building (Bragoszewska et al., 2020). People often have more indoor activities during the day than outdoor. It will be high impact to exposed indoor air contaminant as physical, chemical and microbiological. Physical and microbiological Indoor air quality is very important on mental health for people in the building and improved learning performance of the students (Wargocki et al., 2020). Especially in the university rooms, there are students and lectures have activity in there. They need comfortable atmosphere to have focus and concentration for learning. Need attention to control the physical factor in indoor air to avoid growth microbiology for keep healthy the people in the school (Andualem et al., 2019). Temperature and humidity is physical parameters that affect growth the microbiological content in the indoor air (Bragoszewska et al., 2020; Andualem et al., 2019).

Previous result show the lowest microbiological content in school is 450.67 CFU/m^3 and highest is 7740.57 CFU/m^3 (Andualem et al., 2019). Almost microbiological indoor air content is pathogen and effect to allergenic (Stryjakowska-Sekulska et al., 2007; Fsadni et al., 2017). Poor indoor air quality has impact to sick building syndrome (SBS) to the people in the buildings. Microbiological as fungi can be hazardous for health and can breed allergies, sick building syndrome because of irritation, bad physical condition, tiredness, dermatosis, asthma, and cancer (Stryjakowska-Sekulska et al., 2007). High contaminant of bacteriology in indoor air causing sick building syndromes, allergy rhinitis asthma and conjunctivitis (Hayleeyesus and Manaye, 2014). Indoor air quality is affected by specific classroom, room cleaning processes, and maintenance. Rooms have ventilation and air conditioning (AC) need maintenance continually and the ventilation should follow the standard that the rooms have nice of air circulation control for health. It is impact to the temperature, humidity and the microbiological growth in the indoor air. The great maintenance, cleaning and nice air circulation would give nice indoor air quality (Fsadni et al., 2017). It is depend on the characteristic building and weather in each country in the world.

Factors that affect to the indoor quality not only physical, chemical parameters but also microbiological. Physical as

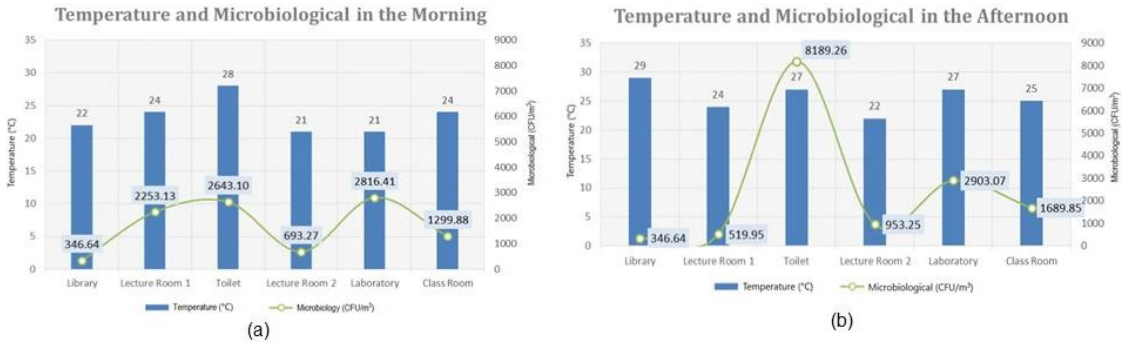

Figure 1. Indoor Air Temperature and Microbiology: (a) In The Morning and (b) Afternoon

temperature, humidity; chemical as concentration of carbon dioxide (CO_2) and microbiological as fungi and bacteria. Improving indoor air quality also affected number of people in the rooms, more ventilation are better to decrease carbon dioxide (CO_2) concentration and total microorganism in the air (Rejc et al., 2020). Poor indoor air qualities give impact to the mental health and physical health occupants in the rooms that it disturbing the concentration. Mechanical ventilation selection and keep environmental sustainability needed to produce healthy environment especially for indoor air quality. Energy cost for effective and best ventilation is possible to obtain healthy indoor air quality, reduce energy consumption and environmental sustainability as guarantee for occupant's health, safety and wellbeing (Balocco and Leoncini, 2020).

Because of the importance indoor air quality for human health inside the rooms, this study was measured. The objective of this study is analysis how the indoor air quality in the university rooms especially for temperature, humidity and microbiological.

2. EXPERIMENTAL SECTION

2.1 Methods

Measurement was conducted at 6 rooms in Universitas Muhammadiyah Kalimantan Timur and measure in different time. Bacteria sampling procedure refers to the previous researchers. The media prepare in laboratory and measure to the fields. Physic parameters collected are temperature and humidity, those are measure used hygrometer. Overalls will analysis follow standard and continues to evidence by statistical analysis. The steps are normality data test, multiple linear regression test and partial regression test.

2.2 Location and Time for Sampling

This study was organized in Universitas Muhammadiyah Kalimantan Timur, Indonesia. Location of measurement was chosen by purposive sampling considering the high activity in the rooms. That locations are library, lecture room 1, toilet, lecture room 2, laboratory and classroom. Time for measure of the parameter is twice in a day, in the morning (at 8.30 AM) and afternoon (at 02.00 PM) that the location, Indonesia is a tropical region.

2.3 Bacteria Sampling Procedure

Temperature and humidity measure in each room immediately at the same time in the morning and afternoon using thermo hygrometer. Microbiological sampling and measurement using settle plate method: open petri dishes include the same media then isolated in 24h at 37°C with 9 cm diameter petri dishes (Hayleeyesus and Manaye, 2014). After that, identify process by microscopic to calculate Colony Forming Units (CFU) in laboratory (Bragoszewska et al., 2020; Stryjakowska-Sekulska et al., 2007; Hayleeyesus and Manaye, 2014; Basinska et al., 2019). Calculation of CFU following equation below (Hayleeyesus and Manaye, 2014).

$$N = 5a \text{ x} 10^4 (bt)^{-1}$$

Where:

N = Indoor Air Microbiology (CFU/m^3)
a = Number of Colonies per Petri Dish
b = Dish Surface (cm^2)
t = Exposure Time (min)

3. RESULTS AND DISCUSSION

3.1 Temperature and Microbiology

Result of indoor air temperature and microbiological in the morning and afternoon is presented in Figure 1. Highest temperature occurs in toilet, highest microbiological content in laboratory. It measured in the morning that a lot activities the students practice material in laboratory. Highest temperature in toilet was depended on field temperature compare with another rooms use air conditioning. Indoor temperature and humidity be affected by outdoor temperature and efficiency of ventilation system (Baures et al., 2018; Wolkoff, 2018).

Indoor air temperature and microbiological content in some rooms in the afternoon was higher than morning. It caused that afternoon high occupant with several activities

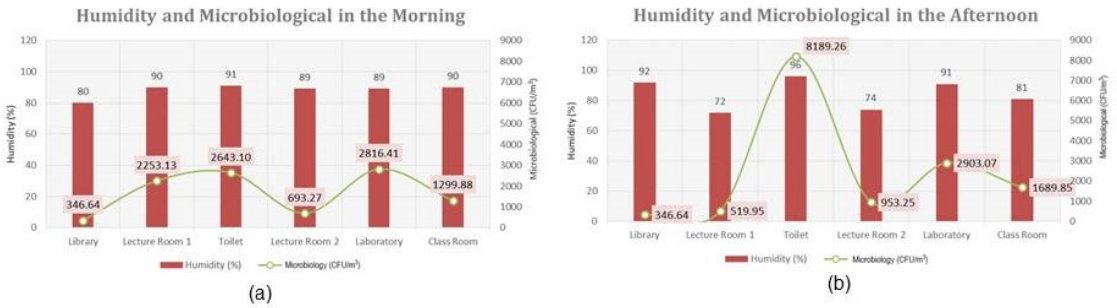

Figure 2. Indoor Air Humidity and Microbiology: (a) In The Morning and (b) Afternoon

in rooms. Indoor air temperature exceeded 25°C, which favors of fungi growth increase (Zender-Swiercz et al., 2019). Surviving of the microbiological growth is depend on some environment factors as temperature and humidity but also their type, kind of species and physic, chemical properties (Wolkoff, 2018). The accumulation of dust on air conditioning filter and floor surface contribute as source of indoor air bacteria and fungi (Osman et al., 2018). Great maintenance, cleaning the rooms, nice circulation and ventilation system give the benefit for nice indoor air quality (Fsadni et al., 2017).

The amount of microbiology in all rooms also fluctuates, but almost all the rooms the number of microbiology increases during the day because the activity of occupants was increase. Temperature and humidity affect to the microbiological growth. Both low and high humidity favors transmission and survival of influenza virus but the relationship between temperature, humidity and virus depend on the virus type and its physical and chemical properties (Wolkoff, 2018). Carpets are source of chemical indoor air pollutant and on the low humidity support microbial growth (Haines et al., 2020). Microbiological indoor air quality in a building is depends on ventilation system and individual occupant health condition.

3.2 Humidity and Microbiology

Indoor air temperature and humidity is influenced the weather, outdoor temperature, air conditioning and ventilation. Highest humidity occurs in toilet for morning and afternoon is presented Figure 2. Humidity in some rooms in the morning was higher than the afternoon. It was difference with toilet, temperature and humidity in the morning and afternoon just a little bit deviation. Because only in toilet without air conditioning, windows but use exhaust fan for air circulation. Beside that ventilation, air flow and density of occupants also affect it. Indoor humidity in some locations depends on the weather, building design and ventilation (Wolkoff, 2018). A lot of study said that ventilation system and design give impact to the indoor air quality (Hayleeyesus and Manaye, 2014; Wolkoff, 2018; Enitan et al., 2017; Rejc et al., 2020).

The room had highest humidity also had highest microbiological. Almost the rooms show increasing humidity was followed increasing microbiological content except library. It is means high humidity is not more support microbiological growth as same as high temperature also. But compare indoor air temperature and humidity show increasing humidity more support microbiological increase than increasing temperature. There is an analysis presented humidity has relationship with number of bacteria and fungi is compared with temperature (Bjelic et al., 2020). Microbiological growth was affected by their type, physic and chemical properties (Wolkoff, 2018). But in difference case that already known the type of microbiological as studied in Malaysia, SARS-CoV-2 can still spread in higher humidity and temperature (Suhaimi et al., 2020). It means the type and properties of microbiological are suitable to growth and survive in that environment.

3.3 Microbiology, Temperature and Humidity in-The Morning and Afternoon

Microbiological, temperature and humidity content in in the morning and afternoon from all rooms was measured is presented in Figure 3 . Highest microbiological showed in the toilet in afternoon, the second in the laboratory and third in the classrooms. Almost rooms had higher microbiological content in the afternoon than morning. Microbiological contents increase significantly in the toilet. It happened because of increasing people density and increasing humidity in the afternoon. Many activities and increasing occupants in the rooms give impact to increasing microbiological. Occupants usually increase in the afternoon. It is mean total microbiological content influenced by density of the activities occupants in a room. Reduction of the occupants in the rooms are recommended to keep healthy indoor air quality (Rejc et al., 2020; Grisoli et al., 2019; Zender-Swiercz et al., 2019).

There are air conditioners in the rooms except toilet use blower. All rooms had higher temperature in the afternoon than morning except toilet. It happened because of the ventilation system and the environment inside the toilet. Indoor air humidity in the library, toilet and laboratory was higher in afternoon than morning. Indoor air humidity was not affected morning and afternoon temperature. High indoor air humidity occurs in library, toilet, laboratory in

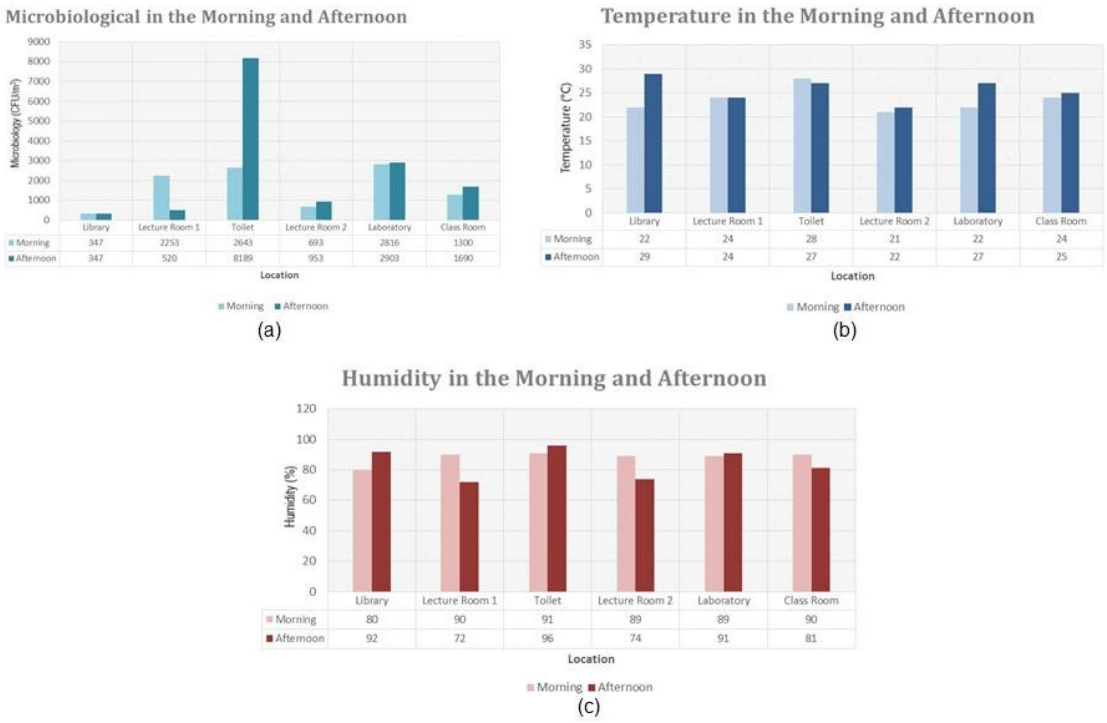

Figure 3. Indoor Quality in The Morning and Afternoon: (a) Indoor Air Microbiology (b) Indoor Air Temperature (c) Indoor Air Humidity

Table 1. Measurement Result Compare The Standard

Parameter	Measurement Results	Standard	Information
Temperature (°C)	21.5 - 27.5	23 - 26	Meet the standards
Humidity (%)	81 - 93.5	40 - 60	Exceeded standards
Microbiology (CFU/m^3)	346.640 - 5416.180	700	Exceeded standards, except library

afternoon and lecture room 1, classroom, lecture room 2 in the morning. The highest occurs in toilet in afternoon.

Temperature and humidity also influenced by ventilation system, bad air circulation and water contact continually. Building design and ventilation influence indoor air temperature and humidity (Wolkoff, 2018). Great maintenance, cleaning and nice air circulation are factors nice indoor air quality (Fsadni et al., 2017). High temperature occurs in library and laboratory in the afternoon affected by density of the occupants, air circulation, air conditioning and ventilation. There was increasing people activities read the books, learning and laboratory practical. Temperature and humidity are affect to the indoor air quality and human health inside the rooms (Wolkoff, 2018; Zender-Swiercz et al., 2019; Pitarma et al., 2017). Both low and high indoor air humidity support influenza virus life in many studies, but relationship between temperature, humidity and virus and aerosol dynamics is complex, finally depend on individual virus type and its physical and chemical properties (Wolkoff, 2018).

Microbiological, temperature and humidity measurement of indoor air is very important identification for determine indoor air quality. It is very important to protect the health and comfort of the people in the rooms. The result of microbiological, temperature and humidity measurements were compared with standard. Indoor air quality standard in office according to the regulation of Minister of Health of the Republik Indonesia No. 48 year 2016 (Indonesia Minister of Health, 2016) is presented in Table 1. Almost all location of measurement exceeded standard for microbiology except library 346.64 CFU/m^3. Temperature in the rooms still meet the standard and the humidity exceeded standards for all location of measurement. The other research presented the mean result of the study about microbiological in the schools show 4378.82 CFU/m^3 (Enitan et al., 2017).

Table 2. Data Distribution

N	Standard Deviation	Significancy
6	981. 153	0.992

Indoor air quality monitoring is very important to maintain the health and comfort of its occupants. Evaluation of Global Index of Microbiological (GIM/m^3), Index of Mesophilic Bacterial Contamination (IMC) and the Amplification Index (AI) are indices that calculate contaminant factor of indoor and outdoor microbial, efficiency of ventilation system and density level in the building (Grisoli et al., 2019). Indoor air quality is affected by outdoor air quality beside of material building, ventilation system and density of the occupants. Beside that used active Air Purifiers (APs) can reduce particles less than 3.3 μm and bacteria by 16% (Bragoszewska et al., 2019).

Type of ventilation, efficient and regularly maintenance of air conditioners are important factors to keep better hygienic indoor air quality (Bragoszewska et al., 2018). Healthy quality of indoor air in the building can be improved by avoid overcrowding and good design ventilation system (Hayleeyesus and Manaye, 2014). Overcrowding in the rooms caused poor indoor air quality especially for temperature, humidity and carbon dioxide (Zender-Swiercz et al., 2019). Improved indoor air quality can be done by used a good ventilation design and carefully select the construction material for building (Idris et al., 2020). Monitoring indoor air quality is needed to reduce sick building syndrome especially for parameters: temperature, humidity, carbon monoxide, carbon dioxide and luminosity (Pitarma et al., 2017). High concentration of indoor bacterial aerosol needs kindly attention to avoid risk exposure to the children health (Enitan et al., 2017). Carpet and rugs currently often used in building and schools. Carpet can influence our exposures to particles and volatile compounds in the indoor air. Good Cleaning process of the carpet could be optimized to minimize negative impact for human health (Haines et al., 2020). Various solutions to obtain healthy school environment is needed effective and efficiency energy and choose the best ventilation design for improve indoor air quality (Balocco and Leoncini, 2020).

Indoor air quality is an important factor affecting to the human health. People are more activity indoors during the day than outdoors. It is will be high risk to exposed indoor air pollutants in physical, chemical and biological contaminants. Risk of exposed poor indoor air quality is allergies, sick building syndrome because of irritation, bad physical condition, tiredness, dermatosis, asthma, and cancer (Stryjakowska-Sekulska et al., 2007). Relevant risk of bio aerosol exposures are respiratory dieses, including coughing, irritated eyes or throat, allergic rhinitis, aggravation of asthma and some infectious diseases (Jiayu et al., 2019). The other effect is allergy and lung inflammation because of exposure PM 2.5 and NO_2 (Isa et al., 2020). Outdoor air quality of Particle Number Concentration (PNC) have effected on Microvascular Function (MVF) and indoor air quality of PM 2.5 and bio-aerosols causing inflammation and lung cell integrity (Karottki et al., 2015). Bio aerosols exposures can entry to the human body by inhalation, ingestion and dermal contact (Jiayu et al., 2019). Concentration of PM 10, PM 2.5 and microbiological in an university in Poland exceeded the standard and can affect to the significant health risk (Wolny-Koladka et al., 2019). Those are some risks of human health was affected poor indoor air quality.

3.4 Statistical Analysis

Based on data analysis obtained normal data with a significance value of 0.992, greater than 0.05, presented in Table 2. Further the data analysis continued to proceed with multiple linear regression test, presented in Table 3. Significant value when the independent variables (temperature and humidity) were tested simultaneously on the number of microbes, the F value 3.841 or sig value 0.149 was obtained. This shows $0.149 > 0.05$, then there is no effect between temperature and humidity simultaneously on the number of microbes.

Then regarding a partial regression test, the temperature variable on the number of microbes is obtained the value of t (1.629) or sig value 0.179, presented in Table 4. This shows $0.179 > 0.050$, there is no effect between temperature partially on the number of microbes. Variable humidity partially to the number of microbes, obtained the value of t (3.200) or sig value 0.033. This shows $0.033 < 0.050$, so there is simultaneous effect of humidity on the number of microbes.

There are some factors influence the number of indoor air microbes as temperature, humidity but also their type and properties, kind of species and physic, chemical properties (Wolkoff, 2018). But in this study gets result just from partial analysis that temperature not effects the number of microbes. Its difference result from multiple regression test that temperature and humidity not effect to the number of microbes.

4. CONCLUSIONS

Factors have effect to the indoor air quality are physical, chemical and microbiology. Result of this study overall showed that the highest temperature occurs in library, highest humidity and microbiological occurs in toilet in the afternoon. Base on the result for all rooms, indoor air temperature and humidity does not affect to the microbiological content. It shows in statistical analysis that independent variables (temperature and humidity) simultaneously have no effect on the dependent variable (number of microbes). Except, result of partially test there is no effect of temperature but humidity effect the number of microbes. Perhaps there are kinds of microbiological does not suitable with the humidity then die. The others still living cause suitable with the environment, it is depend on type and property of the microbiological.

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Table 3. Multiple Linear Regression Test

Dependent Variable	Independent Variable	Mean	F	Significancy
Microbiology	Humidity Temperature	6162978	3.841	0.149

Table 4. Partial Test by Independence Variable Temperature and Humidity

Dependent Variable	Independent Variable	t	Significancy
Microbiology	Temperature	1.629	0.179
Microbiology	Humidity	3.2	0.033

helped to measure and analysis the microbiology.

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