Evaluation of air quality in office rooms (case study: the rector’s office building of Syiah Kuala University)

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Abstract. The Rector's Office Building of Syiah Kuala University is the administrative headquarters at Syiah Kuala University which has a high density schedule. Employees in the building, work for 8 hours a day in the building. Staying in a room for an extended period of time can lead to disease, particularly Sick Building Syndrome (SBS). Poor air quality as a result of air pollution and poor air exchange is the primary cause of SBS. Therefore, it is important to evaluate the air quality in the room to prevent SBS. This research was conducted with a quantitative approach by measuring the physical and chemical quality of the indoor air. The study was conducted on two sample rooms, namely the administration room and the student affairs office. The method of collecting data is descriptive by evaluating based on the regulations of the minister of health and SNI. Air quality is also seen based on the results of room simulations using ANSYS 2019 R3. Based on the results of field measurements, the air quality in the room is not good. Thus, 60% of the employees in the Administration Room and 64.71% of the employees in the Student Affairs Office were infected with SBS.

1. Introduction

In 466 buildings in the United States, the United States Occupational Safety and Healthy Agency (NIOSH) found that there were six sources of air pollution in buildings. 52% of pollution due to inadequate ventilation, 17% of pollution from equipment and furniture, 11% of pollution from indoor and outdoor pollution, 3% of pollution from chemical compounds in building materials, 5% of microbial pollution, 12% of other pollution. [1]-[2] Indoor air quality is related to the comfort and health conditions of the occupants of the room. [3]. Indoor pollution has a very high risk to human health and comfort. Indoor conditions are 2-5 times worse than outdoor air. [4] So it can be possible that air quality is very influential on SBS. Air quality in Indonesia is regulated in the Regulation of the Minister of Health of the Republic of Indonesia Number 1077/MENKES/PER/V/201.

Adjustment of indoor air quality can be done with the help of some device. Generally, office buildings are equipped with air conditioners (AC) which can lower the room temperature and circulate air in the room. This cooling system is designed and operated not only for cooling, but also for adequate air exchange in the room. Problems arise as a result of the cooling system’s inability to exchange air which causes poor indoor air quality [11]. The age of the building can cause several
diseases [5]. This can occur as a result of weathering, peeling, and other. Some materials also emit chemical compounds which are very bad for human health, so these substances must be removed from the room by exchanging air into the room.

In this study, the object of research was the Rector's Office of Syiah Kuala University, this building is located in Kopelma Darussalam, Syiah Kuala, Banda Aceh. This building was taken as the object of research because this building is the administrative center of Syiah Kuala University. The building of the Rector's Office of Syiah Kuala University is 26 years old since it was built in 1995. The architect as a person who designs a building mass, must design the building so that users can be comfortable while in the building. Therefore, the focus of this research was on evaluating the air quality of the office space as a means of prevention of sick building syndrome, which has a negative impact on user productivity, and as well as meeting the criteria for healthy building.

2. Methods

2.1. Types of research
This research is a quantitative research with a descriptive approach. The research was conducted by measuring temperature, humidity, air velocity, amount of formaldehyde (HCHO), amount of volatile organic compound (HVOC), and amount of carbon dioxide (CO₂).

2.2. Location and Time Research
The location of the research was carried out at the Rector's Office of Syiah Kuala University, which was located on street Teuku Nyak Arief No. 441, Kopelma Darussalam, Syiah Kuala, Banda Aceh, Aceh. In the building, two room samples were taken. field research will be conducted in March 2021, to be precise on 30-31 May 2021. The research is conducted during working hours, i.e. 08.00 – 17.00 WIB. The duration of the measurement in the study was 30 minutes due to limited device. There was a range time 10 minutes between rooms, this was due to the distance was quite far between rooms and different floors.

2.3. Research variable
2.3.1. Physical quality
On the physical quality, which is reviewed in the room is the temperature and humidity. In measuring the physical quality conditions in the room, data were obtained using the EL-USB-2.

![EL-USB-2](image)

**Figure 1. EL-USB-2**

2.3.2. Chemical quality
In the chemical quality, which is reviewed in the room there are carbon dioxide (CO₂), volatile organic compound (VOC), and formladehyde (HCHO) in the room. In measuring the condition of the chemical quality in the room obtained data using the Air Quality Tester. The unit in the tool for CO₂ is parts per millions (ppm) while for HCHO and HVOC it is milligrams per cubic meter (mg/m³).
2.3.3. Air velocity

Air velocity is used as one of the components that affect the movement of air in space and the distribution of air in space. In measuring the air velocity data obtained by using the Hot Wire Anemometer.

2.3.4 Sick building-syndrome

Sick Building Syndrome (SBS) is a complex health effect with non-specific causes that can attack building occupants and can disappear as soon as the patient leaves the building [6]. The biggest influence of SBS is bad condition of the air quality in the building, it is sourced from indoor air pollution. SBS can be considered if the complaints related to SBS in one room are more than 20% [7]-[8]. In knowing the condition of SBS in the room, it can be done by questionnaires to employees while in the room by asking several questions about symptoms that may occur in the room such as eye irritation, nose irritation, throat irritation, skin irritation, dry lips, dry skin, itchy skin, headaches, difficulty concentrating, tired easily, coughing, runny nose, earache, sore throat.

2.4. Data analysis technique

The data that has been measured is collected in a table which is then analyzed descriptively how the condition of the room exists. Furthermore, field data from physical quality and chemical quality are compared with standards that have been obtained from the Regulation of the Minister of Health of the Republic of Indonesia Number 1077/MENKES/PER/V/2011 to see the condition of indoor air quality.

To determine the distribution of indoor air using the formula Air Change per Hour (ACH). The results of the calculations will be compared with the standards obtained from SNI 03-6572-2001. A good exchange of air is carried out for an office space of at least 6 air exchanges within 1 hour. The results of air velocity measurements will be simulated to see the movement and the direction of air distribution in the room. The simulation was carried out with the help of the ANSYS 2019 R3 software.

SBS conditions were evaluated based on the number of employees who experienced symptoms while in the building. This symptom is associated with air quality conditions that affect the room and also room conditions such as the space patterns or furniture in the room.
3. Results and discussion

3.1. Location description

3.1.1. Location analysis

This measurement was carried out at the Rector's Office of Syiah Kuala University. In the building there are four building masses, namely Buildings A, B, C, D which have different orientations which can be seen in Figure 4. In this study, Buildings A and B were taken with one room sample taken from each building.

![Building Masses](image)

**Figure 4.** 1st floor, 2nd floor, and 3rd floor plan of the Rector's Office of Syiah Kuala University (Source: USK Planning Office, 2011)

In building A, the Administrative room is taken which has a floor area of approximately 263 m² with the direction of the building facing north-south. This room has 7 rooms in it with a total of 45 employees. In Building B, the Student Office room is taken with a floor area of approximately 190 m² with the direction of the building facing west-east. This room has 6 rooms in it with a total of 17 employees. Both rooms use mechanical ventilation in the form of air conditioner (AC) with the number of each unit in the room amounting to 5 and 7 respectively.

3.1.2. Measuring point

The placement of the tools is positioned based on the position of the employee working. The position of the tool is at a height of one meter from the floor.

![Room Plan](image)

**Figure 5.** Room plan (Source: USK Planning Office, 2011)
3.2. Measurement results

3.2.1 Air temperature, humidity and air Velocity

The condition of the room with mechanical ventilation that can condition the air in the room is certainly the right choice for a room. Maintenance, position, and requirement for ventilation in the room are an obstacle where ventilation is required to be able to easily change air.

![Figure 6. The results of temperature and humidity measurements in both rooms](image)

Based on Figure 6, it can be seen the value of the measurement results on temperature and humidity. Based on the measurement results, it can be seen that the air temperature is at an average of 26 °C in both rooms, this is of course very inversely with the outdoor temperature conditions which reach an average of 28 °C. The difference in air temperature levels is strongly influenced by the air conditioner (AC) in the room, the role of the air conditioner is very large in lowering the temperature in the room. Because the room uses AC as the main ventilation, the two rooms is sealed so the cold air from the AC does not come out of the room. The air speed of the air conditioner in each unit is around 2 m/s.

Based on the measurement results, the humidity level inside the two rooms are very different from the outdoor conditions. It can be seen that the indoor humidity level is higher than the outdoor air humidity. The humidity level outdoors has an average of 63%, while indoor air humidity reaches an average of 73%. The difference in humidity levels is influenced by the lack of circulation in the room. Although in both rooms there are windows, the conditions in the room only use the AC as an exchange of air circulation so that the air cannot be replaced optimally.

3.2.2 Amount of volatile organic compound (HVOC) and formaldehyde (HCHO)

Chemical compounds are not very good for the human body, so they must be removed from the room by changing the air in the room. Compounds that are too long in the room can settle and worsen the air quality in the room.

![Figure 7. HVOC and HCHO measurement results in both rooms](image)
In Figure 7 it can be seen that the levels of HVOC and HCHO increased in the number of compounds at certain hours. The increase in these two compounds is due to the volatile compounds that can easily affect with the air quality in the room. These compounds are very easy to find on factory processed such as paint, furniture, air freshener, and others. In addition, office goods such as printer ink or photocopiers also contribute to increasing the number of these compounds.

3.2.3 Amount of carbon dioxide (CO₂)
Like other chemical compounds, CO₂ can also worsen air quality. These compounds are very easy to find in the air such as vehicle fumes, respiration of the human body, and others.

![Figure 8. CO2 measurement results in both rooms](image)

It can be seen in Figure 8, it can be seen the amount of CO₂ in the room is in accordance with the standard, but there are times when the intensity of the compound is quite high at 10:00-12:00 WIB. The level of CO₂ in the room should be attempted to be less than 1000 ppm. If the CO₂ level exceeds this limit, it can be indicated that the amount of fresh air flowing through the ventilation system is insufficient [8]. The difference in the number of employees and guests who come is the main factor in the high intensity of this compound.

3.3 Discussion
3.3.1. Government standard
Regulation of the Minister of Health of the Republic of Indonesia Number 1077/MENKES/PTR/V/2011 a good air temperature for the room is 18-30 °C with a humidity percentage of around 40-60% Rh. Based on the measurement results, the air temperature level in the two rooms is between 18-30 °C, this indicates that the air temperature in the room is relatively normal and good for body. Unlike the air temperature, the percentage of air humidity in the two rooms is above the standard, which is 65-74% Rh. High humidity greatly affects the health of body, where there is a possibility that microbial organism can multiply so that it can damage air quality.

According to regulations, carbon dioxide (CO₂) has a standard of 1000 ppm every 8 hours, volatile organic compound (VOC) has a standard of 3 ppm every 8 hours or 0.246 mg/m³ every 1 hour, and formaldehyde (HCHO) has a standard of 0.1 ppm. every 30 minutes or 0.123 mg/m³ every 30 minutes. Based on the measurement results, the amount of the three compounds has an average according to the standard. However, the three compounds have a high intensity at a certain time at 10.00-14.00 WIB, which is a very busy working hour and also many workers and guests are in one room.

3.3.2. Wind movement simulation
Simulation of air movement is carried out with ANSYS 2019 R3 software, the simulation is carried out by entering air velocity data and determining wind entry and exit routes. the most comfortable air velocity at 0.25-0.5 m/s [9].
The simulation results in Figure 9 show that in the administrative room, there are many areas of turbulence due to the space being too large with many corners of the room and there are walls that block it. The Student Affairs Office itself has an elongated shape so that air can flow more easily. However, in the Student Affairs Office room there is an area of turbulence due to the position of the air conditioner facing each other so that the air in the room is uneven.

Based on the simulation results of the air conditioner which has an air speed of 2 m/s, it can be seen that the air velocity flowing in the room is at 0.1-0.5 m/s so it can be said that the air flowing in the two rooms is very comfortable. If the indoor air velocity is included in the ACH formula, then the results obtained in the Administrative Room have 4 air exchanges in one hour, while the Student Affairs Office Room has 6 air exchanges in one hour. So it can be concluded that the air exchange in the Administrative Room is still far from the standard of SNI 03-6572-2001 [10].

3.3.3 Evaluation of Sick Building Syndrome
Based on the results of the questionnaire to 45 employees in the Administration Room and 17 employees in the Student Affairs Office. In the Administration room, the most common symptoms in the employee's body were 26.67% experiencing nasal irritation, 35.56% experiencing headaches, 35.56% having difficulty concentrating, and 35.56% experiencing sneezing. Based on the results of a questionnaire to 45 employees, 60% of employees experience SBS, which is characterized by employees experiencing two or more illnesses in the room.

In the Student Affairs Office Room, the most common symptoms in the employee's body were 35.29% experiencing nasal irritation, 29.41% having difficulty concentrating, 47.06% experiencing runny nose, and 41.18% experiencing sneezing. Based on the results of a questionnaire to 17 employees, 64.71% of employees experienced SBS.

4. Conclusions
Based on the results of measurements and analysis of conditions in the field, the building of the Rector's Office of Syiah Kuala University can be indicated to cause SBS. This can be seen from the condition of the Administration room and the Student Affairs Office room which has humidity in the room which is still far from standard, and there are also certain times when the level of chemical compounds is higher. The two sample rooms also still have uneven air distribution so that the air in the room cannot move evenly. Poor air exchange can result in indoor air not being exchanged properly so that polluted air in the room not being replaced, which can induce disease symptoms. Based on the
results of the questionnaire, 60% of employees in Administration Room and 64.71% of employees experienced SBS.

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