Air quality and comfort level assessment: a case of Faculty of Geography, Universitas Gadjah Mada, Indonesia

U Suarma¹, E Nurjani¹, M P Hadi¹, K A Cahyono¹, W H Permatasari², and R D Amalia²
¹Laboratory of Hydrology and Environmental Climatology, Department of Environmental Geography, Faculty of Geography, Universitas Gadjah Mada, Yogyakarta, Indonesia
²Research Assistant, Department of Environmental Geography, Faculty of Geography, Universitas Gadjah Mada, Yogyakarta, Indonesia
utiasuarma@ugm.ac.id

Abstract. The aim of this research is to better understand the conditions of air quality, thermal, and audial comfort level in the Faculty of Geography. The measurement of ambient air quality conducted to determine the level of CO (Carbon monoxide) from motors vehicle. Thermal comfort measurement data obtained by measuring parameters of microclimate i.e. temperature, and air humidity, whereas the audible comfort uses noises-parameters. Sample points used to building in the Faculty of Geography. This measurement conducted on 3 days-working hours consecutively from 8 AM until 4 PM during the student orientation week. The result showed that the condition of air quality within the study area based on CO measurement is classified as good air-quality because it fulfills the level standard on all points of measurement. Thermal comfort conditions based on the Thermal Heat Index (HTI) belongs to a less comfortable level and the medium-comfort. The condition of audial comfort strongly affected by the activity on those specific days and also must be considered with the source of noise disturbances from the road (vehicle engine). Therefore, during working days observation there are several sample points that exceed the standard level of noise-standard-quality.

1. Introduction
Indonesia is a tropical climate country which has characteristic of high temperature and humidity along the year. This condition needs adaptations which creates comfort even indoor or outdoor zone. The comfort level both locations is very important to maintain the health and also support people productivity. The comfortable environment must be built everywhere, and one of them could be within Faculty of Geography, where the comfortable campus should be a place of study, discuss and live dully to students, lectures, staffs, and others in order to make people feel more comfortable.

The comfortable level of the campus environment could be built by doing adaptations on microclimate condition. Factors of climate which affects comfort level namely temperature, humidity, wind velocity, and solar radiation. Comfort in relation to buildings can be defined as a situation where it can provide a comfortable and pleasant feeling for its occupants. At least four types of human comfort for a building are known, namely spatial comfort, visual comfort, thermal comfort, and audial comfort [1]. The comfort index tries to summarize, in a single number, the description, and perception of the user.
related to aspects of building performance. This index is based on major environmental factors such as lighting, noise, temperature and air quality [2].

providing a comfortable microclimate in a place of education is needed to improve the spirit of students for study. thermal comfort is a condition of the human mind that shows satisfaction with the thermal environment [3]. Factors that affect thermal comfort are air temperature, air humidity, wind speed, clothing insulation, and activity. Providing a thermally comfortable environment is crucial for people well-being and productivity [4]. Thermal comfort is usually created practically by installed Air Conditioning (AC) device, ventilation settings, and lighting arrangements. However, the provision of AC is considered to be too cost-effective, so it needs an effective way to minimize the number of AC but can create comfort in learning [5].

Noise disturbance is also an important aspect for comfort improvement. There is a positive correlation between the noise level and the disruption of learning activities due to noise disturbance around the campus. The higher the noise levels, the higher the level of learning disturbance. Therefore it is very important to do noise disturbance mapping to know the environmental impact caused [6].

2. Research Methods

2.1. Measurement of air quality
Air quality data collected by measuring levels of CO at several points within the area. Sample points location consist of the parking area in the basement of D building, parking area in the north of D Building, parking area in the east of E Building, the corridor between D and E Building, and corridor between B and C Building. Furthermore, after the data collected then it will be analyzed quantitatively (Figure 1). The result of data analysis then compared to the Standart Quality of Ambient Air Quality [7].

2.2. Measurement of thermal comfort
Thermal comfort data obtained by measured indoor temperature and humidity. Sample points for this measurement purpose namely Merapi Auditorium, library, corridor in front of chosen classroom, lecturer room and academic-staff room. The result of temperature and humidity parameters measurement then calculate using thermal comfort index Temperature Humidity Index (THI). Classification of comfort index from THI basic standard is 21-24 (comfortable), 25-27 (less comfortable), and >27 (uncomfortable). As for the equations used as follows [8]:

\[
THI = (0.5 \times Ta) + (RH \times 1)
\] (1)
Ta = Temperature (°C), RH = Air Humidity (%) 

Figure 2. Thermal comfort measurement

2.3. Measurement of audible comfort

In most cases, data used to analyze the noise level at Faculty of Geography was classified into primary data and secondary data. Primary data is the data obtained directly from the result of observation measurement at the site location.

Noise level data measured by using Sound Level Meter on each sample location the measurement time during working hour particularly at noon because of some teaching and learning activity in the class could be considerate as high. Moreover, data analytic technique was completed by using the method of descriptive quantitative based on the result from measurement at noise level and Standart Quality of Noise Level [9].

Figure 3. Audible comfort measurement.
3. Discussion

3.1. Air quality during final exam period

The advantage of CO concentration level in Faculty of Geography UGM has been fluctuating but not significantly. The range of CO concentration for three days measurement was 2.50–4.50 PPM. The highest level of CO has been known at the portal site and the lowest has been in front of Building D. The result of different CO levels at each location are affected by the activity and the characteristic of the place. In front of Hall D and Hall-B are classroom lecture and library. measurements were made during the Final-Exam period so it could be assumed that there were some activities. Meanwhile, for the measurement in front of Merapi Auditorium, Basement Hall-D, East of E Building and Faculty Portal at measurement time, there were activities such as construction that took place in the basement area of Hall-D, the main entrance of campus, and also some non-permanent activities.

The effect of CO gas existence of the health is harmful gas for our body because the binding capacity of CO to Hb on chemical reaction is 240 times bigger than CO bonding to O2. If the CO gas on blood (HbCO) is high enough, it will cause symptoms such as a headache (HbCO 10%), nausea, and shortness of breath (HbCO 20%), impaired vision and sagging concentration (HbCO 30%), unconscious (HbCo 40-50%) and if it continues, it will cause casualty. the chronic exposure in years will show symptoms of neurological disorders, brain infarction, cardiac infarction and infant death in the womb. High of CO gas level in the blood can come from cigarettes and smoke from motor vehicles. In the indoor room, air environment especially CO gas can also be a gas that causes building associated illnesses, with complaints of a headache, nausea, and vomiting.

The CO quality standard for ambient air was 26.19 PPM. When it was compared CO quality standards for ambient air, then at all measurement locations have met the ambient air quality standard for the parameter CO. this case because the results of measurement of the highest CO level was only 4.55 PPM. It was on the Geography portal. The condition was caused by the number of vehicles that enter the science cluster so which means achieve the highest result of CO levels among other measurement points.

![Figure 4. Graphic of average CO at the Faculty of Geography during final exam period](image)

3.2. Audibility comfort during final exam period

If averaged in one day, the highest level of the noise level in the Faculty of Geography was on the 2nd floor of Building B was equal to 65.64 dB. This was influenced by the sound source of the Diploma students who often gather in the 2nd-floor aisle. Figure 5 also showed that the lowest noise level was in front of the Hydrology and Environmental Climatology Laboratory of 47.46 dB.

The standard quality of noise level for the educational environment was 55dB so that if noise level > 55 dB has exceeded the quality standard. When it was compared with the standard of noise quality
for the educational environment, then the room in accordance with the quality standards, was in Building E Building that includes Laboratory of Hydrology and environmental Climatology, 1st Floor and 3rd Floor and 2nd Floor of Hall-D (Department of Environmental Geography). In addition, in Hall-A, the academic room was also still met the quality standard of noise.

The rooms that exceeded the quality of noise was in Building D, It covered the 1st floor room, such like D105 and D112, while Library, 2nd and 3rd-floor rooms in Building B show have exceeded the quality standard for noise. The noise level in front of Merapi auditorium has also exceeded the quality standard of noise.

![Graph of average noise during the final exam period](Image)

**Figure 5.** Graph of average noise during the final exam period

### 3.3. Air quality during student orientation week (PPSMB)

The condition at the time of measurement was sunny-day, the lecture activity is not running due to the semester holiday period, but there is a series of activities of new students in the Student Orientation Week activity in the Faculty of Geography. Measurements on Thursday and Friday were calculated on average CO levels in the morning, afternoon, and evening then result in graph of CO in the environment of the Faculty of Geography. CO pattern was generally similar in every measurement area with the rising pattern from morning to evening. The increasing of CO level content based on the graph which has been measured in the east of E Building. That result was because at the east of E Building which is the road to the parking lot of motorcycle. Furthermore, motorcycle produces CO gas through fuel combustion and release through the exhaust.

When compared between the measurement results with the ambient air CO quality standard, all the measurement sites have met the quality standard. The reason is that the highest CO measurement result was 5.05 PM (Figure 6). It is located at the east of the E Building in the afternoon. These results indicated that the dominant CO gas source was from vehicles passing through Kaliurang Street with high traffic density. In addition, the high CO levels are also caused by the east of E Building functioned as a motorcycle parking area for students at Faculty of Geography. The presence of traffic lights on the Kaliurang Street beside the Faculty of Geography causes decreasing on vehicle speed and its impact was Co levels accumulation increasingly. In addition, the measurement time in the afternoon caused CO levels
3.4. Audible comfort during student orientation week (PPSMB)

Based on the measurement result, the average level of noise during PPSMB event showed that the highest noise level was at Merapi Auditorium. While it was measured as 60.47 dB, and then lowest of noise level was in Laboratory of Hydrology and Environmental Climatology as 47.66 dB. The result of this measurement showed an equation with the current measurement on Final Exam, it was the Laboratory of Hydrology and Environmental Climatology, which was the lowest noise level. However, there is a difference in the highest noise level because at the time of Final Exam and the highest noise level was on the 2nd floor of Hall-B.

When compared with standard quality of noise level for educational environment during the event, the result corresponds with the standard quality includes Laboratory of Hydrology and Environmental Climatology at E building; 1st floor (Hall-D105 and Hall-D112) and 2nd floor (Department of Environmental Geography) in Hall-D; 3rd floor of Hall-B; as well as in front of Academic Hall-A. The rooms have exceeded of noise standard when PPSM event was at E Building on 1st and 3rd floor, 3rd floor on Hall-B, and in front of Merapi Auditorium at Hall-A. the noise level of each measurement location is influenced by different sources of noise.

The source of noise at the E Building strongly influenced by the presence of Kaliurang Street in the east as a busy street every time, especially in the morning, and afternoon. The source of noise in Hall-A is strongly influenced by the existence of the entrance to the gate of mostly science major causing high noise. In addition, the noise disturbance source of Hall-A cause by student activity who discussed or just gathered in the lobby. The noise source in Hall-B is heavily influenced by the PJ SIG Diploma students who often gather on the 2nd floor, while the noise source in D Building is heavily influenced by the presence of local road and because of new parking are construction.
3.5. Thermal comfort

The determination of thermal comfort in the Faculty of Geography was done by using the comfort index of Temperature Humidity Index (THI) and SNI T-14-1993-03 standard. The measurements of air temperature and humidity to determine the thermal comfort in the Faculty of Geography are carried out in Hall-A, Hall-B, E Building, and Hall-D. Measurements are conducted for five days with details 3 days to represent normal condition on working days, and 2 days to represent of the working day with increasing productivity due to the PPSMB event. According to the THI thermal comfort index, the comfortable scale is divided into three levels, there are comfortable (THI 21-24), moderate (THI 25-27), and uncomfortable (THI >27).

Based on the measurement results on three-normal-working-days was conducted in several rooms in Hall-A, Hall-B, E Building and Hall-D that showed of comfort level in the location which is included in the uncomfortable class according to THI index (Figure 8). Uncomfortable conditions occurred in the morning, afternoon and evening. That is influenced by the wheater conditions when the measurement and the room cooling did not reach the location of the measurement point; while the measurement results on PPSM (orientation week) showed THI index value was different from THI value during normal workday measurement. THI on PPSMB event showed, which some rooms in Hall-A, Hall-B, E Building, and Hall-D are included into "Quite-comfortable-class" in the morning, while in the noon and late afternoon the comfort is decreasing. However, there are exceptions in some spaces such as in front of Merapi auditorium, E Building basement, 1st and 3rd floor E Building, 2nd and 3rd floor in Hall-B, Secretariat of Department of Environmental Geography, Room 112 and Room 105 in Hall-D that have included in the middle comfortable class during the afternoon. Based on the daily average of THI value is compared between each room in the buildings at the Faculty of Geography, those could be seen that each room has an average daily of THI index over 27. It shows that each room has a value of "comfort" onto an uncomfortable class based on THI index. The conditions are influenced by the high average of air temperature. High relative humidity does not provide significant comfort because according to the THI formula that the temperature has a proportion of 80% in determining the comfort level. In contrast to the measurement results on normal business days, the daily THI measurements when the PPSMB in each room to be included in the middle-comfortable class because it has THI of 25-27. The highest level of comfort is in the E Building, it is influenced by the presence of laboratories that always using air conditioner continuously to ensure laboratory conditions has a stable temperature.
Figure 8. Comparison of average temperature, humidity, and THI Comfort Index during final exam period and student orientation week

4. Conclusions
The condition of air quality at Faculty of Geography based on measurement showed that all sample point locations including basement of Hall-D, in front of D Building, at the east of E Building, in front of B Building as well as campus portal correlated with the standard quality so that those would be included good air quality. The condition of thermal comfort based on THI index which included on uncomfortable-class and middle-comfort-class. Generally, the lower temperature and high humidity at each sample point especially in the morning result in high-comfort condition measured only in the morning. That condition was affected by many factors including building condition, usage of Air Conditioner, and the weather condition during the measurement period

Acknowledgment
This research was funded by Faculty of Geography and conducted by the Laboratory of Hydrology and Environmental Climatology. Air quality and comfort level data around the campus area collected by students who participate in Environmental Management Course in 2017

References
[1] Karyono T H 2001 Penelitian Kenyamanan Termis di Jakarta sebagai Acuan Suhu Nyaman Manusia di Indonesia. Jurnal Dimensi Teknik Arsitektur 29 (1)
[2] Baird G 2010 Sustainable Buildings in Practice What The Users Think. (Abingdon: Routledge).
[3] Nugroho M A 2011 A Preliminary Study of Thermal Environment in Malaysia’s Terraced Houses, Journal and Economic Engineering 2(1): 25-28.
[4] Park C S Augenbroe G 2008 Normative Thermal Comfort Assessment. Indoor and Built Environment 17: 324-333.
[5] Zaki S A Damiati S A Rijal H B Hagashima A and Razak A A 2017 Adaptive thermal comfort
in university classrooms in Malaysia and Japan. *Building and Environment* **122**: 294-306.

[6] Zannin P H T, Engel M S, Fiedler P E K, and Bunn F 2013 Characterization of environmental noise based on noise measurements, noise mapping and interviews: A case study at a university campus in Brazil. *Cities* **31**: 317-327.

[7] Regulation of the Minister of Environment No. 12 of 2010 on the Implementation of Air Pollution Control in the Region.

[8] Nieuwolt S 1975 Tropical Climatology, An Introduction to the Climates of the Low Latitudes. (New York: John Wiley & Sons).

[9] Ministry of State of the Environment (1996). Standard Quality of Noise Level, Decree of the Minister of State Number: Kep. 48 / MENLH / XI / 1996, dated 25 November 1996, Jakarta: Ministry of State of The Environment.