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Outdoor traffic noise effect in indoor sound distribution

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Abstract. Noise mapping is one of the common acoustic project done, especially in urban environment. Researchers have used different location, studied the usability area, and used simulation with numerical analysis as well as variety of data collecting techniques. However, information about noise distribution in an area that considers the sound distribution inside a building is still limited, since the indoor acoustics are mostly discussed in the field of room acoustics. Meanwhile, people tend to spend more time indoor than outdoor and therefore, such information above is considered important. This research propose a specific study about traffic noise effect to the indoor sound level distributions. Locations of this study are Faculty of Law (FH UGM) and Department of Electrical And Informatics Engineering Vocational College Universitas Gadjah Mada (DTEDI SV UGM). Selected based on interview results with the building management. The discussions are zoning of data collection points, identification of traffic noise from inside the building, analysis of sound wave attenuation, then the data are visualized via software that based on Geographic Information System or GIS. The identified traffic noise using simultaneous recording is categorized as continuous noise and intermittent noise such as police’s whistle, modified exhaust, and honking. Police siren is categorized as an outlier with the highest sound pressure. The study proved that the external sound sources do produce noise that affect the distribution of sound level inside the building. Detailed results and possible recommendations for this issue have been submitted to FH UGM and DTE DI SV UGM.

1. Background

Previous research about noise mapping in some area of Universitas Gadjah Mada (UGM) by Dian et al., found that there are high noise sources in several street intersections such as at the shopping center, main road, and food court intersections[1]. This condition is estimated to effect the indoor noise distribution inside the academic buildings that are Faculty of Law building (FH) in food court area, Department of Electrical And Informatics Engineering Vocational College building (DTEDI SV) in shopping center area, and Magister of Management building (MM) in main road area inside Universitas Gadjah Mada (UGM). Discussion with the building management for each location was also held, where it can be concluded that the indoor space of MM building is not affected by external noise because of the structure of the building itself is designed for isolating external noise But the different result is found in FH and DTE DI, that in some parts of FH and DTE DI building there are external noises that are affecting the indoor sound distribution.

Given the result of the preliminary study above, the purpose of this research is to observe issues related with the external noise in these two locations and to provide some possible recommendation to reduce the external noise.
Many researches discussed about traffic noise but only few that studied on how the traffic noise affected indoor sound level distribution. Study on traffic noise is the domain area of environmental acoustic, focuses on outdoor noise. However, people tend to spend their time inside buildings where the acoustics quality is observed through room acoustics area of study[2]. How human perceive the differences of sound pressure level (SPL) is also related with the study on noise. The lowest SPL differences that a human can sense is around 1 dBA, although they are more confident with 3 dBA differences [3].

Noise level is using the unit of dBA since the frequency weighted of A-weighting function is representing the human’s ear sensitivity. The noise distribution data is generated using Geographic Information System (GIS) as what have been done in the previous research about noise mapping[1], [4]–[6].

2. Method

2.1. Data collection

Acoustics data was collected using recorder since information about the dynamic condition in each point can be re-played by having this recorded sound. Other information about identification type of noise and noise source can be provided using notes that were taken during recording.

The location used for this research is in the UGM area specifically FH UGM and DTEDI SV UGM. Selected based on the result from discussion with the building management. Point data assessment is determined based on adaptive sampling that considers the difference of location for each point, inside and outside building. By knowing the different acoustics conditions of the indoor and outdoor locations, thus the data collection are grouped into three zones. First is the outdoor zone near street area, indoor zone is area inside the building, then transition zone is zone between street and building. Total points for FH UGM area are 27 points as shown in Figure 1. Then for DTEDI SV UGM are 25 points as shown in Figure 2.

Figure 1. Location and point data assessment at FH UGM.

The locations of each point inside the building is only in the first floor for this research with the detail information shown in Table 1. Point locations of the data collection in building area are located in the first floor. Because in these two building, the first floor is already used for academic activities.
Before performing the actual data collection, preliminary field review in the area was performed. Results from the preliminary survey has identified several noise sources coming from street, which are police’s whistle, honk, and modified exhaust. The dominant noise sources inside the building are chatter and steps. Considering the transition zone, the dominant noise source is moving vehicles that are heading to the parking lot. After knowing the condition in this area, the recorders were prepared. At least two recorders were for simultaneously recording.

To get the information needed, recording time is limited to two conditions. First is when the building was empty and second is when there were activities inside the building. Therefore, the two conditions were divided into two recording-time, 06.00 – 07.15 AM (morning time) and 09.30 – 11.00 AM (daily activity time). These two conditions are expected to cover the information needed.

### 2.2. Result analysis

The first analysis to see whether the traffic noise is affecting the indoor noise distribution or not, with the absolute value of difference between two times condition. Sound wave attenuation from outdoor zone and transition zone is then performed to show the actual condition of the parking lot route. After that, the identification of specific noise to prove the statement of each building management about the part of the building where there is external noise.

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**Figure 2.** Location and point data assessment at DTEDI SV UGM.

**Table 1.** Detailed indoor point data locations

| Detailed point locations inside building (FH UGM) | Point Assessment |
|--------------------------------------------------|------------------|
| Hallway                                          | 1                |
| Office lobby                                     | 2                |
| Porch                                            | 3, 5, 7, 8, A    |
| Court                                            | 4, 6             |

| Detailed point locations inside building (DTEDI SV UGM) | Point Assessment |
|--------------------------------------------------------|------------------|
| Lobby                                                  | 1                |
| Student’s waiting room                                 | RT               |
| Porch                                                  | 2, 3, 4U, 4S, 5, 6, 12 |

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3. Result and discussion

The first result is the difference noise level in each points within two measurement time. This result will shows the effect of traffic noise to the changes in the noise level distribution inside the building. Each locations show that there is no correlation between the changes of noise level inside building with the traffic noise, as shown in Figure 3. In the road area the blue colour shows that there is only a little difference between two measurement times, but inside the building area the colour began turn into yellowish and reddish to show that there are many changes of noise level. This yellow and red colour indicate that the noise level has different value in the two measurement times.

![Figure 3. Result of absolute value of difference.](image)

Even though there is no correlation between the changes of noise level inside building from the effect of traffic noise, it is still depicted that there is still contribution from the external noise such as moving vehicle. This condition is showed by the outcome of comparison between calculated sound pressure level and recorded sound pressure level with the outdoor zone as $L_1$ and transition zone as $L_2$ as in Table 2.

From Table 2 with the tolerance difference $\pm 3$ dBA, it can be concluded that the actual sound pressure level is higher than the calculated ones. This condition shows that the transition zone is contributing external noise as the vehicles are moving into parking lot in each area of study.

But there is a problem with the occurrence of police siren when point DTEDI 7 daily activity time was being recorded, because of the limitation of this research, the DTEDI 7 is considered as an outlier and it makes the calculated noise level higher than the actual noise level. Therefore, it can be neglected.
Table 2. Comparison between calculated sound pressure level and recorded sound pressure level

| Outdoor Zone Points | $L_1$ (dBA) | $r_1$ (meter) | $r_2$ (meter) | Calculated $L_2$ (dBA) | Transition Zone Points | Recorded $L_2$ (dBA) | Difference (dBA) |
|---------------------|--------------|---------------|---------------|------------------------|------------------------|----------------------|-----------------|
| FH 9                | 73.7         | 1.5           | 23.3          | 61.8                   | FH T2                  | 67.8                 | 6.0             |
| FH 13               | 74.7         | 1.5           | 17.7          | 64.0                   | FH T3                  | 65.5                 | 1.5             |
| FH 12               | 71.1         | 1.5           | 16.9          | 60.6                   | FH T1                  | 64.8                 | 4.2             |
| FH UGM daily activity |             |               |               |                        |                        |                      |                 |
| FH 9                | 72.7         | 1.5           | 23.3          | 60.8                   | FH T2                  | 63.1                 | 2.3             |
| FH 13               | 71.7         | 1.5           | 17.7          | 61.0                   | FH T3                  | 62.8                 | 1.8             |
| FH 12               | 71.1         | 1.5           | 16.9          | 60.6                   | FH T1                  | 59.4                 | -1.2            |
| DTEDI SV UGM morning time |         |               |               |                        |                        |                      |                 |
| DTEDI 9             | 71.1         | 1.5           | 26.9          | 58.6                   | DTEDI 15               | 62.4                 | 3.8             |
| DTEDI 8             | 72.9         | 1.5           | 14.9          | 62.9                   | DTEDI 16               | 64.7                 | 1.8             |
| DTEDI 7             | 75.3         | 1.5           | 22.8          | 63.5                   | DTEDI 17               | 66.8                 | 3.3             |
| DTEDI SV UGM daily activity |         |               |               |                        |                        |                      |                 |
| DTEDI 9             | 72.8         | 1.5           | 26.3          | 60.4                   | DTEDI 15               | 61.5                 | 1.1             |
| DTEDI 8             | 71.9         | 1.5           | 14.9          | 61.9                   | DTEDI 16               | 62.1                 | 0.2             |
| DTEDI 7             | 79.9         | 1.5           | 22.8          | 68.1                   | DTEDI 17               | 61.8                 | -6.3            |

With the result as in Table 2, transition zone is contributing the increase of noise level outside the building, and the dominance of specific noise in this zone are moving vehicle and its components. The identified noise that is moving vehicle, being generated to be noise mapping as shown in Figure 4. Figure 4 shows the specific noise in each area when the daily activity time is being recorded. Each area shows that there is actually identified vehicle noise in the building area. Even though the dominance of occurrence and level is low to mid, it is indicated that the external noise (vehicle and its components) are affecting the indoor sound distribution, especially from transition zone because of the parking lot route being used by vehicles. Then this issue needs to be controlled.

Specifically speaking, the condition in FH building is better than DTEDI SV, but in some points inside FH building area indicated that there is another sound source that dominating in these points, which is people chattering as part of the human activity (shown in white color Figure 4 (i)). Because this area is used as people to get together and have discussion.

![Figure 4. Identified distribution vehicle (i)](image-url)
It cannot be said whether this condition is bothering or not for people who are actually inside the building. Because it needs next study about sound perception in this area. The recommendation is to improve the acoustics quality in these two areas by changing the parking lot route and regulation about the modified exhaust. Both were easily identified through analyzing the recorded audio during the play-back process.

4. Conclusion

This research found that there is no correlation between the effects of traffic noise with the changes of indoor noise level. But there are still contribution from traffic noise as specific noise like intermittent noise and continuous noise that is identified as moving vehicle in indoor area along with noise caused by human activities inside building. The noise issue is caused by modified exhaust vehicle and parking route in the surrounding building area. Thus, the recommendation is to reduce this noise issue by changing the parking lot route and regulation about modified exhaust, with the consideration being returned to building management of each locations.

References

[1] D. D. Avorelli, S. S. Utami, K. Zakiya, dan H. Sutanta, “SOUND LEVEL MAPPING USING GEOGRAPHIC INFORMATION SYSTEM (GIS) TO OPTIMIZE A GREEN CAMPUS ENVIRONMENT QUALITY,” vol. 11, no. 6, hal. 4058–4064, 2016.

[2] N. Maisonneuve, M. Stevens, M. E. Niessen, dan L. Steels, “NoiseTube: Measuring and mapping noise pollution with mobile phones,” Environ. Sci. Eng. (Subseries Environ. Sci., hal. 215–228, 2009.

[3] Bruel&Kjaer Sound & Vibration Measurement A/S, “Environmental Noise,” 2000.

[4] P. Tao, Y. Chen, dan L. Tong, “GIS-based city noise mapping research and development,” Int. Geosci. Remote Sens. Symp., hal. 6729–6732, 2012.

[5] M. Cai, J. Zou, J. Xie, dan X. Ma, “Road traffic noise mapping in Guangzhou using GIS and GPS,” Appl. Acoust., vol. 87, hal. 94–102, 2015.

[6] A. Schindler, G. Information, dan S. Gis, “Soundscape Mapping : Spatial Variability of Sound at Furman University,” 2016.