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Methods to reduce noise level due to environmental changes: A case study in Universitas Gadjah Mada

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Abstract. A sound level mapping in Universitas Gadjah Mada (UGM) was done in 2015. At the end of 2016, there were changes in UGM’s infrastructure and operational management at several areas. This research aims to find the effect of environmental changes toward sound level through sound level mapping. Sound level was recorded by H6 Zoom Recorder at three allocated times, in the morning (6 - 8 AM), at noon (11 AM – 1 PM), and in the afternoon (4 – 6 PM). The sound level mapping in 2017 has shown a decrease of sound level within the range of 2 dBA to 12 dBA. This decrease is indicated in the noise map by the dominance of blue color in the color gradation. The conclusion refers to examples of significant infrastructure and management changes that can reduce sound level such as the usage of ticket or identity card and arrangement of parking area and public space.

Keywords: sound level mapping, sound level, infrastructure, management

1. Introduction

Based on the theory of city growth, Spiro Kostof (1991) proposed that the analogy of element of city shaper is human body organ, where free space refers to lung, city center as the heart, and streets as the arterial tissue in the body. The high population growth leads to the change of city shaper elements, as what is currently happening in Yogyakarta. The changes of city shaper element can be observed through both visual and auditory perception. The changes can be visualized directly from the building shape and streets transformation. The changes of element can also be observed as audio-related changes of vehicle’s noise.

Sound level mapping can be used to indicate the effect of changes of city shaper element towards the auditory perception. Sound level mapping is a map with color gradation based on the noise level distribution of an area. The same sound levels are described in contour lines and the overall sound level contour map will describe the areas of different sound levels [1]. Studies about sound level mapping have been developed worldwide. Sukru Dursun et al. (2006) conducted a sound level mapping in Konya, Turkey [2], Kang-Ting Tsai et al. (2009) created sound level mapping in Taiwan [3], while Tara P McAlexander et al. (2015) made sound level mapping in New York City [4]. The
sound level maps are also have been built in other areas such as in China [5], Korea [6], Brazil [7], [8], and Hong Kong [9]. Our previous sound level mapping in Universitas Gadjah Mada (UGM), conducted in 2015, is an example of similar study in Indonesia. Sound level mapping in UGM was created to find the distribution of sound level from traffic noise in a university area [10].

At the end of 2016 until early 2017, street infrastructure and operational management has changed in several areas of UGM which caused changes in the number and type of vehicles in this area as compared to the previous year. A different sound level and sound level mapping is expected to happen. The paper provides a description of such changes and further analysis of its impact to the sound level distribution in the campus area. The paper also provides several ideas that can reduce the sound level due to traffic.

2. Research Methodology

2.1. Research Location

The environmental changes and sound level distribution from the condition in 2015 to 2017 of three different areas in UGM were observed. The first location was the area of UGM Mosque and its surrounding. In the past two years this area has gone through significant changes, mostly changes of the environmental elements. Therefore, the traffic pattern also changed. Data were collected at 17 measurement points. The second location was the surrounding of an outdoor food park that has undergone some management changes with 14 measurement points. Seventeen measurement points were taken at the third location, which is the area around the university hospital, RSUP Dr. Sardjito.

2.2. Interpretation of Sound Level in Sound Level Map

The acoustic data recorded by the measurement tool, H6 Zoom Recorder positioned at a height of 1.5 m above the ground referring to a human ear level [2], [3], [11], were processed to obtain sound level in the unit of dB(A). Sound levels for each point are plotted as contour lines using Surfer 11 software, creating a sound level map. This sound level map display color gradation, which describes sound level distribution of the area.

3. Result and Discussion

3.1. Changes of Infrastructure and Management

There are three case-studies discussed in this paper based on the selected locations within UGM that have gone through infrastructure and management changes. The first discussion is the area of UGM Mosque. The main changes of this area from the condition in 2015 to the current condition in 2017 are in the street elements. In 2015, there existed a street divider in front of the UGM Mosque, which created a narrow street and therefore, only limited vehicle could pass this area. Other elements were vegetation on the side of the street positioned close to the building’s gate or the mosque main entrance gate. In 2017, the vegetation was removed and their plantation area was replaced by a side-walk for pedestrians and bicyclists. The street divider was also removed, which made the street seems slightly wider even though this is not true.
The second case studied applied managerial changes, which took place in the surrounding of the food park area. The managerial changes included utilization of ticket to enter the university property. This entrance system had not been applied in 2015. This entrance system involves the use of identity card as a pass clearance for faculty members, staff, or students as. If identity card is not available, ticket would be used as the pass clearance.

The area around the RSUP Dr. Sardjito hospital is the last location selected as the case study. The different environment condition between 2015 and 2017 in this location involves physical and managerial changes. In 2015, the walkway and street side in front of the hospital is used as a street market for street sellers and as parking area for motorbikes. It is considered a crowded street especially from 6 AM to 6 PM. A market was built to relocate the street sellers and the side walk is now officially used for pedestrians. A street divider is also employed to avoid sudden turn and prevent the use of the street side as parking area.

3.2. Comparison of Sound Level Mapping in 2015 and 2017
A recent sound level mapping created in 2017 is used as a comparison to the sound level mapping created in 2015. The previous research in 2015 has shown a sound level map that classified to three zones. However in this paper we only discuss on sound level map not sound zoning. Further analysis on this comparison of the sound level distributions enables to see the changes that already occurred in the past two years due to physical and managerial changes.

3.2.1. Physical Changes. The physical changes of the street elements lead to the change of sound level distribution in area of UGM Mosque. The detail of sound level distribution differences between 2015 and 2017 for this location is shown in figure 3.

There is a dominance of bluish color in the sound level mapping of 2017, where blue indicates a lower sound level within the range of around 45 – 55 dBA for dark blue, 56 – 59 dBA for blue, and 60 – 64 dBA for light blue. Meanwhile, a wider area of yellowish to orange color is shown in the 2015 sound level mapping, indicating a larger area of a higher sound level of around 65 – 75 dBA. For all the three measurement times, in the morning, noon, and afternoon, nearly all of the sound level value of each measurement point decreased by 2-10 dB from 2015 to 2017.

The changes of the street infrastructure also caused the type of vehicle passing through this street to differ from those passing in the previous year. In 2015, buses were seen passing this street, while in 2017 there is nearly no bus passing through this street. In addition, because of the divider, the streets become narrower and for some way it led to less number of vehicles passing by.
3.2.2. Managerial Changes. The significant sound level mapping changes between 2015 and 2017 is due to management changes is in the area where pass clearance is applied by employing ticket or identity card. Description of the changes is provided in figure 4.

Figure 4 shows that the sound levels in the food park area decreased when compared to the 2015 measurement, especially in the morning. The majority of the sound level mapping contains bluish color, indicating a lower sound level in the morning. Even the range of the lowest sound level in the morning in 2015 and 2017 reached 12 dB. Similar condition is occurring at noon where the range of the lowest and highest sound level in 2015 and 2017 reached 5 dB and 7 dB, respectively. However, in the afternoon, the lowest sound level in 2015 is higher than the sound level in 2017, although the sound level mapping is still dominated by blue color.

![Figure 3](image_url)
Figure 4. Sound level mapping in food park area due to managerial changes.

The operational management changes made it hard for mass transportation to enter the college area so there have been no bus passing through this street.

3.2.3. Physical and Managerial Changes. The area where a combination of physical and managerial changes was applied is in the area near the hospital. The street infrastructure changes and relocation of street sellers and parking area led to the change in noise level from 2015 to 2017 (see figure 5).

Figure 5 shows that the sound level mapping in 2017 significantly changed with the domination of blue color indicating a lower sound level distribution in most of this area. The range of the lowest to highest sound level changes in 2015 and 2017 for three measurement times varied from 3 dB to 10 dB. The street infrastructure change did not affect the mass transportation route in this area. The relocation of street sellers and parking area is a policy that created significant changes since the street is not as crowded as it was in 2015. Visually the street also looks neater and people walking through the street especially heading to the hospital are more comfortable to use the walkway.
Based on three of case studies, the result of sound level mapping in 2017 has shown a decrease of sound level within the range of 2 dB(A) to 12 dB(A). This decrease is indicated in the sound level map by the dominance of blue color in the color gradation.

4. Conclusion

Physical and managerial changes applied on an area will affect the sound level distribution of the area and can be identified through sound level mapping. Sound level mapping were conducted in 2015 and 2017 which shows that the sound level decreased in 2017 within the range of 2 dB to 12dB.

From the calculation, the most impact of sound level decrease is resulted from the use of pass clearance to enter the university by ticketing or identity card. This can be claimed as the most effective strategy to reduce noise level in an area since public transportation will have only limited access to enter this area. The transmission loss value due to the combination of physical and managerial changes of the surrounding area of the hospital near university has resulted in a decrease in the sound level. However, public transportation, particularly bus, is still passing through the narrower street given the street divider and therefore it remains still a street with a high density of vehicle.

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