Noise Variation Between Days and Hours in an Urban Areas

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Abstract. Noise disturbance quality standards which refer to Indonesian Government Decree number 22 of 2021 concerning Environmental Management in the future will be drawn up. This possibility has prompted several local governments to measure and map noise in their respective areas. The commonly used pattern in noise studies is taking grab samples and processing the test sample data using extrapolation techniques in order to obtain long-term noise levels. The approach requires a sufficient literature base. This study analyzed noise based on daily data at three different locations in the City of Jakarta, Indonesia. The three locations were construction site, industrial area and along inner-city toll road. Analysis of ANOVA variance at daily and hourly levels for 42 LA eq was presented in this study. Statistical results showed significant differences between hourly and daily periods, so further attention is needed on the extrapolation approach that represents long-term noise levels. The longer the noise analysis period in an area, the more accurate the characterization of noise in the study area will be.

1 Introduction

The Indonesian government has various regulations that conduct noise threshold levels in every specific area or zone. One of the regulations is the Decree of the Minister of the Environment Number 48 of 1996 concerning Quality Standard of Noise Level (The Decree Number 48/1996). It administers the maximum noise level allowed to be discharged into the environment from activities. Furthermore, the noise disturbances to human health and surroundings will be reduced.

The Decree Number 48/1996 divides eight categories of measurement area and three activities such as housing area, a trading area, office area, green open space, industrial area, government areas and public facilities, recreation, and special area (airport, train station, port, cultural heritage). Those three activities consist of hospitals, schools, and places of worship. The noise threshold standard in this regulation is 55 dBA to 70 dBA depending on area category. The newest regulation, Indonesian Government Decree number 22 of 2021 concerning Environmental Protection and Management, has defined noise as a form of disturbance that must be controlled and the quality standard must be set. The quality standard itself was revised from the previous regulation. Simultaneous noise measurement and grab sampling are useful methods for determining the noise level then noise mapping can be

carried out [1]. If the noise measurement is done by grab sampling, then prediction efforts can be made to complete the mapping in an area [2].

Massive noise measurement efforts have been carried out in developed countries in the European Union [3,4]. Noise mapping for the entire region in Indonesia itself is not yet mandatory unless the area is subject to environmental impact analysis. The obstacles that arise are the unavailability of fixed stations for noise in cities, the unavailability of policy regarding reliable mapping methods, and limited resources in mapping techniques. Noise measurement methods in Indonesia have used the methods that stated in the Decree of the Minister of the Environment Number 48 of 1996 or SNI (Indonesian National Standard) Number 7231:2009 entitled Measuring Noise Intensity Method in Workplace. The stated method was to analyze the measurement results using the sound level meter, so the value can be compared with recent regulations. In Indonesia, the measurement data obtained are generally by grab sampling and then analyzed using the interpolation method then the mapping points are complete [5,6]. Based on Geraghty and O'Mahony [1], the noise measurement gap occurs if the measurement is based on grab sampling only or the deviation is large if the measurements are not carried out simultaneously.

Based on the problems above, this study was made to describe the differences in daily and hourly measurement variations on specific sources of industry, highways, and construction areas in Jakarta, Bogor, and Bekasi, Indonesia. This study focused on weekly and monthly measurements that can be applied in environmental impact analysis studies where the results will be better than grab sampling. This study hypothesized that there were variations in measurements between weekdays and holidays, there were also variations in measurement between day and night. If the hypothesis was not proven, simultaneous monthly and annual noise measurements are recommended to obtain background data for environmental monitoring purposes.

2 Methodology

2.1 Noise Level Measurement

The measurement area consists of three areas, i.e. industrial area, ring road, and construction area (Fig. 1). The reasons for choosing the areas are currently under construction or development, so noise monitoring needs to be carried out as a condition for compliance. Those data measurements were conducted for 24 hours in the same month using several instruments of sound level meters. The name of the instrument is Lutron brand type SL-4001, GM1351, and IEC 651 TYPE 2. They have specifications measurement distance divided into three range selectors, namely 30-80 dB, 50-100dB, and 80-130 dB.

Measurements were also assisted with a tripod and a GPS to determine the coordinates of the sampling point. Position of the tool was at a height 120 cm to 150 cm from the ground, with a minimum of 3.5 meters far from buildings or trees. Noise level measurement was done in two ways (SNI Number 7231:2009):

1) Noise mapping method
   The method must be done by 2 people as shown in Fig. 2, one person observed the time and gave the clue instantaneously to read noise level per 5 seconds in 10 minutes. The other recorded the instantaneous noise level reading from a sound level meter. Noise measurements were made at several points (7 points for industrial area, 4 points for ring road, and 4 points for construction area) from the noise source on each location using a sound level meter equipped with a windscreen and not in rainy conditions.

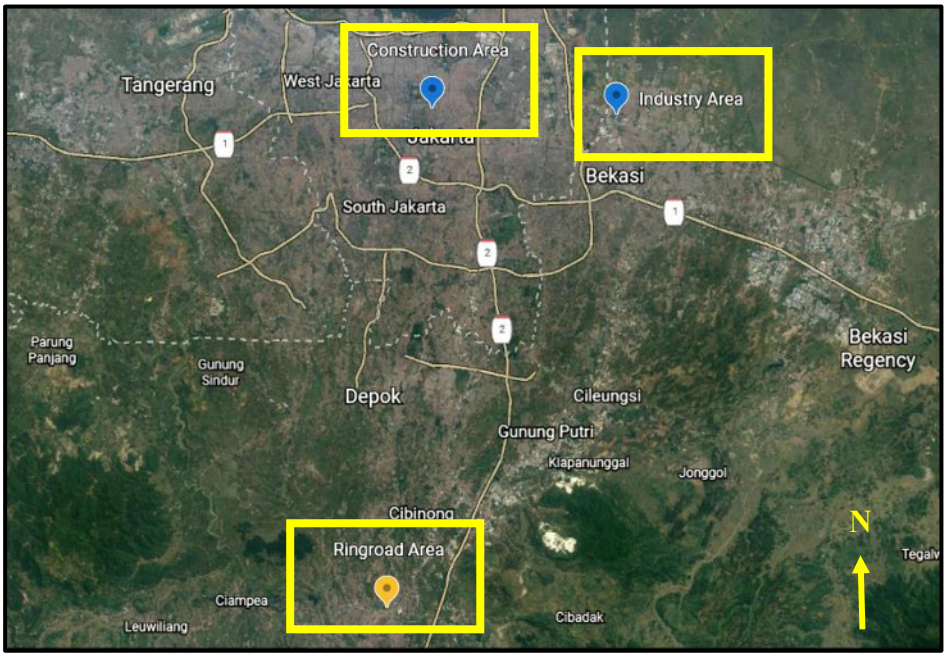


Fig. 1 Three location of measurement named as Site 1-3

The sound level meter is used to measure the pressure level of transitory sound dB(A) for 10 minutes for each measurement. As a result, the surveyor obtains up to 200 pieces of data which represent certain time intervals.

Fig. 2. The first method of measurement

2) Noise variance collection method
The method was carried out with the integrating sound level meter having L_{TM5} measurement facilities, namely Leq with measuring time every 5 seconds, recorded automatically for 10 (ten) minutes. By the instrument, Leq and T have been obtained and read autonomously on the sound level meter. Noise measurements were made at one point which represents the entire area.

2.2 Analysis

The variance was obtained by analysis of variance (ANOVA) and the results were tabulated in post hoc form for one month of observation. Temporal analysis was performed based on a daily rate and hourly rate. If a significance value of <0.05 is obtained and homogeneous, then post hoc visualization is carried out based on the Tukey method. If the homogeneity of variance is not proven, then post hoc visualization is carried out based on the Games Howell method. After the analysis of variance is carried out, the data obtained from noise mapping are calculated to obtain constant levels based on the formula (Minister of Environment Decree No. 48/1996):

$$Leq = 10 \log \{f_1 \times 10^{0,1L1} + f_2 \times 10^{0,1L2} + \ldots f_n \times 10^{0,1Ln}\} \text{ dBA} \quad (1)$$

Leq is the equivalent of constant levels, f are the fractions of time that occur when the shift is 8/24, L is the calculated levels in the time interval of each shift (n). The obtained Leq values were then mapped and visualized using Surfer GIS version 10.

3 Result and Discussion

3.1 Daily Variance

The post hoc ANOVA test (Table 1) was compared to obtain significant results and the results were similar to those of [1,7]. Site 1 is a ring road, site 2 is a construction area and site 3 is an industrial area. Based on Table 1, site 2 and site 3 variations on holidays and weekdays have the same pattern. Site 1 variations are not visible on holidays and weekdays. This is possible because, on the ring road, noise sources come from various sources. The ring road also includes open areas [3] so those daily variations cannot be interpreted directly. Longer observations such as monthly in the span of one year are needed then daily variations are more reliable.

3.2 Hourly Variance

The variation between day and night for site 2 and site 3 has similarities between industrial and construction areas. Site 2 is significant for working hours outside the shift change hours of employees, this also happens for site 3. Both have 3 times shift changes with different times, 05.00-06.00 am; at noon; and 06.00-07.00 pm for site 2 and 07.00; 3 pm; 11.00 pm for site 3. The effect of employee rotation and length of working hours is similar to research [4].

The hourly pattern for site 1 is different from the others (Table 2), this is because the location is a project with an open-source noise. The hourly pattern at this location is the same as the daily pattern, where the rush hour pattern occurs starting at 05.00-10.00 pm. The noise started to decrease in the early hours of the morning, even though the project implemented a 2 shift employee system. Noise level cannot be determined using analysis of variance, but temporally, this analysis of variance can be used to make policy [1].

Table 1. Post hoc statistical significance indication for between day comparisons of Leq for Site 1-3

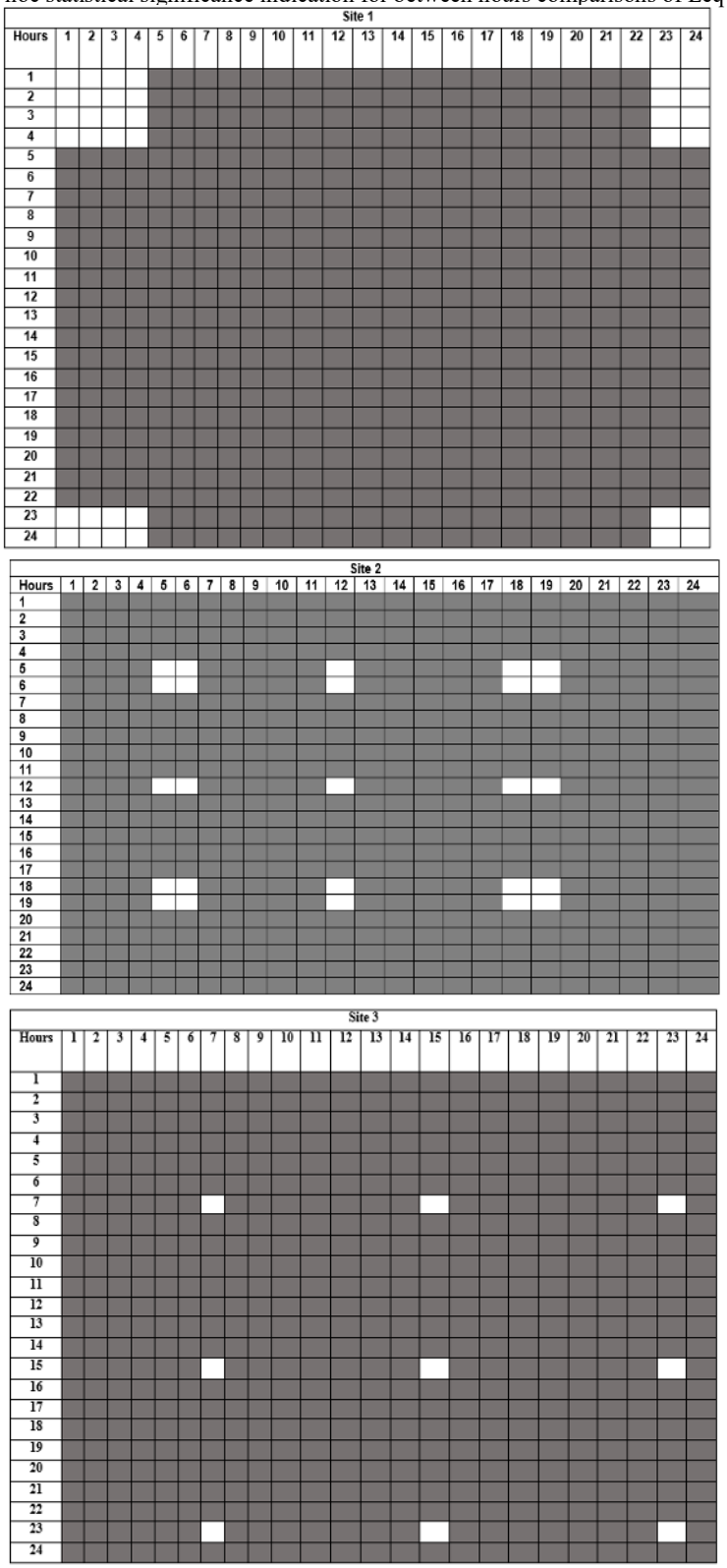
Site 1							
	Mon	**Tues**	**Wed**	**Thurs**	**Fri**	**Sat**	**Sun**
Mon							
Tues							
Wed							
Thurs							
Fri							
Sat							
Sun							

Site 2							
	Mon	**Tues**	**Wed**	**Thurs**	**Fri**	**Sat**	**Sun**
Mon							
Tues							
Wed							
Thurs							
Fri							
Sat							
Sun							

Site 3							
	Mon	**Tues**	**Wed**	**Thurs**	**Fri**	**Sat**	**Sun**
Mon							
Tues							
Wed							
Thurs							
Fri							
Sat							
Sun							

Based on the analysis of daily and hourly variations, noise measurements with significant variance can be applied for at least one day, but it is recommended that there are previous observation data for one year. Especially in areas with open noise sources, the measurement time may be longer because the noise level is more difficult to estimate. To fulfill environmental compliance and reduce errors, it is better if noise measurements are based on direct measurements.

Table 2. Post hoc statistical significance indication for between hours comparisons of Leq for Site 1-3



3.3 Noise Mapping

The noise level of each site (Fig. 3) was visualized using a noise map. The red contour represents the high noise area, the yellow contour represents the medium noise area and the green contour represents the low noise area. The noise measurement refers to direct measurements, sampling points represent construction sites and nearby residential areas. Spatial noise analysis needs to be complemented by temporal noise analysis, this is in line with the statement of [1,4,8].

According to the quality standard for noise levels in the work area and the environment (Regulation of the Minister of Manpower and Transmigration Number 13/Men/X/2011 concerning Threshold Values for Physical and Chemical Factors in the Workplace), noise at site 1 is still below the threshold value or below 85 dBA. The noise level at site 2 is dominated by an area with noise levels above the quality standard, which is 86 – 90 dBA. Workers entering the area are required to wear personal protective equipment/ earmuffs. The construction area or site 3 has a high concentration of noise throughout the structural work process. High noise levels are managed by business owners through substitution efforts, engineering control, and administration [6].

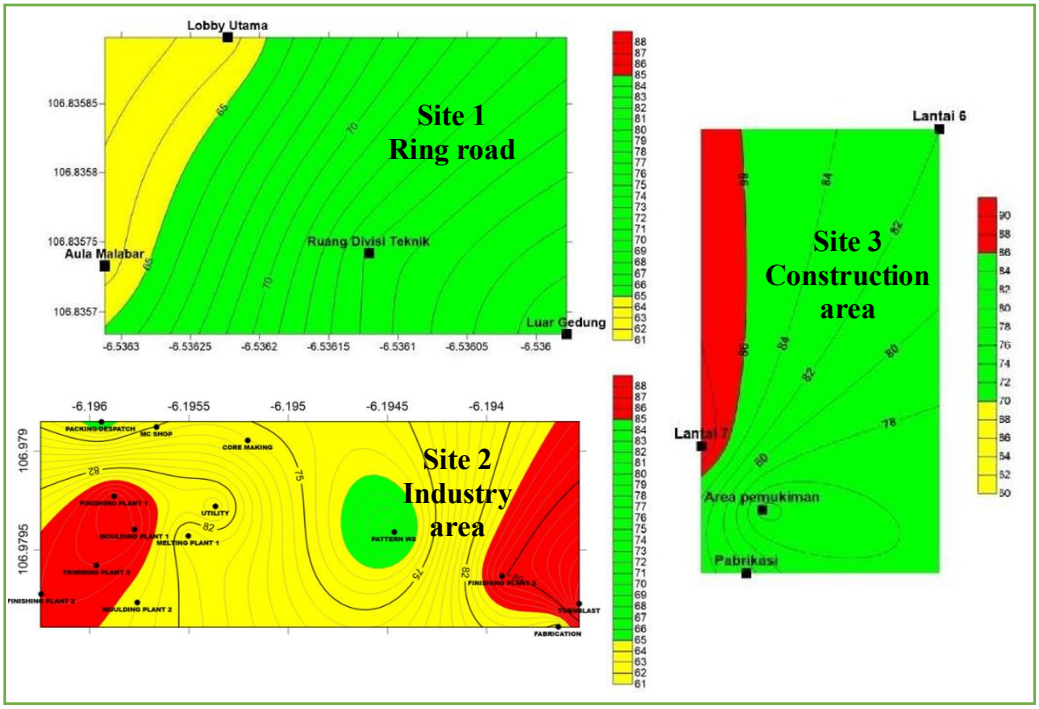


Fig. 3. Noise mapping of site 1 to site

4 Conclusion

Significant measurement variations exist at sites 2 and 3, both daily and hourly. Especially for site 1, the open condition causes the need for a longer noise monitoring effort. Both sites 1, 2, and 3 have noise measurement points that already represent noise mapping. Moreover, to comply with environmental regulations and obtain background data, it is necessary to measure simultaneously with a longer period.

References

[1] D. Geraghty and M. O'Mahony, Int. J. Sustain. Built Environ. **5**, 34 (2016)
[2] W. Wei, T. Van Renterghem, B. De Coensel, and D. Botteldooren, Appl. Acoust. **101**, 127 (2016)
[3] E. Murphy and E. A. King, in Environmental Noise Pollution (Elsevier, 2014), pp. 173–201
[4] P. Aumond, L. Jacquesson, and A. Can, Appl. Acoust. **139**, 34 (2018)
[5] O. P. Rosmala, T. Budi Santoso, and M. Huda, in 2019 International Electronics Symposium (IES) (2019), pp. 148–153
[6] Susanto, D. O. Setyawan, F. Setiabudi, Y. M. Savira, A. Listiarini, E. K. Putro, A. F. Muhamad, J. C. Wilmot, D. Zulfakar, P. Kara, I. Shofwati, S. Sodikin, and M. Tejamaya, Noise Mapping **8**, 1 (2021)
[7] U. Hernandez-Jayo and A. Goñi, Sensors **21**, (2021)
[8] Benocci, Bellucci, Peruzzi, Bisceglie, Angelini, Confalonieri, and Zambon, Environments **6**, 79 (2019)