Model of Noise Propagation in Urban Area
A Case Study in Jakarta

Sandi Prasetyo [a], Haryoto Kusnoputranto [b], Hadi S.Alikodra [c] Raldi Hendro Koestoer [d]

[a] Postgraduate Program on Environmental Science, University of Indonesia, Indonesia.

[b] Department of Environmental Health, Faculty of Public Health and Postgraduate Program on Environmental Science, University of Indonesia, Indonesia.

[c] Department of Silviculture, Faculty of Forestry, Bogor Agricultural University, Indonesia

[d] Ministry of Economic Affairs, Republic of Indonesia.

Corresponding authour: dj_voltus@yahoo.com

OIDA International Journal of Sustainable Development, Ontario International Development Agency, Canada
ISSN 1923-6654 (print) ISSN 1923-6662 (online)
Available at http://www.ssrn.com/link/OIDA-Intl-Journal-Sustainable-Dev.html

Abstract: One of the most developed cities nowadays is Jakarta. Jakarta as the capital city of the Republic of Indonesia is a metropolitan region with a population of more than 9.9 million people (BPS, 2013). One of the environmental impacts is noise problem. The problem in urban areas is an urgent matter because it has direct impact on health of inhabitants. Motor vehicles are major sources of noise (Doelle, 1993). According to Satriyo (2008), the overall noise level in the city of Jakarta is very high. For example, the noise in the Semanggi area measured to 68.7 - 69.5 dB (A). Another measurement (Martono et al., 2004) stated at the Sudirman areas, it demonstrates the value of 66.95 - 71.28 dB (A). Values that have passed the standard noise level for residential areas, based on the Regulation of the Indonesian Minister of Environment (1996), which amounted to 55 dB (A). The quality standard is used for residential areas, because until now there is no noise quality standard for urban areas. While the quality standard for office area is 70 dB (A). The objectives of this study are two folds: (a) to determine the noise source and level in Jakarta and (b) to create a model for propagation of noise. This study was conducted in August 2013 to August 2014 in the heart of the city, especially along Sudirman road, of Jakarta. The area chosen not only it is a major area, but also it has concentrations of offices, housing, green areas and industrial activities. This area is the central business in Jakarta. Noise level measurements carried out at 64 points affecting Sudirman street. A model of noise propagation built using inverse square law approach to the type of point source, involving excess attunuation which includes the atmosphere, soil condition and barrier. This study uses an analytical approach that space needs to be supported by the method of the Geographic Information System, which is a method to demonstrate the ability of spatial information, and can display visually. The instrument used was ArcView 3.2 program. This method serves to provide the following information: (a) The area being affected spatially or spread of noise distribution; (b) The most noisy location along the Sudirman. The closer the lines contained in the noise contour maps, the more noisy. The highest noise was in the middle of junction location between North-South and East-West; (c) contour map which is converted to dB (A) can provide information about the locations that have noise level of more than 85 dB (A) for the 8-hour exposure period. This location is catagorized as not healthy places for people who are staying in these areas; and (d) noise contour map gives information about a particular location with spatially gradual noise levels. According to the noise measurement result, Semanggi areas is the highest level of ambient noise with the range of 64.3 dB (A) – 72.8 dB (A). The area with the lowest noise level is around Istana Negara (National Palace) with 52 dB(A) – 56.3 dB(A). Meanwhile, the propagation of noise due to calculated model reduces from south to north of Sudirman line, and for west of Sudirman street the level remains high.

Keywords: Jakarta, model of noise propagation, noise, noise measurement, urban area.

Introduction

Motor vehicles, is a major source of noise (Doelle, 1993). Causes of noisy among others came from the hooter when vehicles want to precede the road, when the traffic lights are not functioning, mechanical friction between the tire with the road during emergency braking and high speed and exhaust noise due to compression of the gas pedal excessively or exhaust imitation. Other causes include at the time of crash among vehicles, as well as the frequency of vehicle mobility, both in quantity and speed (Ikron, 2007). Noise is a variety of sound. It means any unwanted sound. Noise pollution affects both heath and behavior.

Indonesian Ministry of Environment (KEP-48/ MENLH/ 11/1996) on Standards of Noise for the measurement ambient noise, set a maximum limit noise in an office area is 65 dB(A). However, currently it is difficult to obtain data about noise in Jakarta. Data on noise levels and the spread of noise are very limited. While, overall noise level in Jakarta is very high (Satriyo, 2008). For example, the noise in Semanggi area measured to 68.7 - 69.5 dB(A). Another measurement (Martono et al., 2004) stated that at the Sudirman areas demonstrated the value of 66.95-71.28dB(A). Therefore, the objectives of this study are two folds: (a) to determine the noise source and level in Jakarta and (b) to create a model for propagation of noise.

Methods

Noise measurement performed by the method sampling the ambient noise (Soedomo, 2001). Noise measurement was conducted by sampling the ambient noise. Noise sampling conducted in 8 (eight) areas, which is Istana Negara[1], Bundaran HI[2], Rasuna Said[3], Semanggi[4], SCBD[5], Patung Pemuda[6], Patung Dirgantara[7], and Slipi[8]. At each location measurements taken 8 (eight) points each measurement with a radius of 500 meters upright from the source.

Measurements were taken at the time of the activity which is taken place in 3 periods: in the morning, noon and night. Measurement points taken especially in locations experiencing exposure. At each point measured noise levels and be repeated in a different time of days. While for the source sampling is done at a distance of 1 (one) to 100meters. At each point of measurement is made three (3) replicates for each measurement condition.

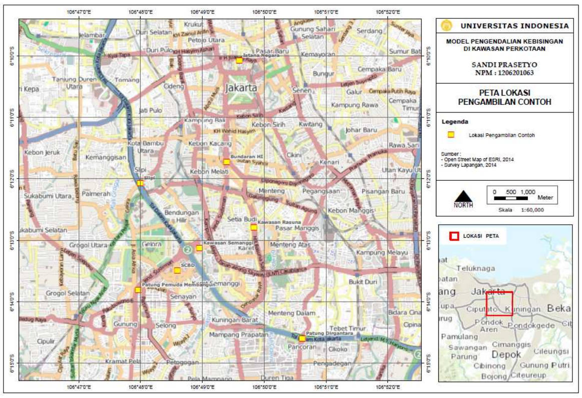

Figure 1. Sampling locations, set by authors

Noise level measurement conducted by measuring the maximum decibels or maximum A- weighted sound level or noise level weighted (weighted) A maximum hereinafter called dB (A). The tool used is a Sound Level Meter. Time measurements made during the 24-hour activity (LSM) by way of daytime activity levels were highest for 16 hours (LS) at the time of 6:00 to 22:00 and evening activities for 8 hours (LM) in 22:00 to 6:00. Each measurement represents a certain time interval with a set of at least 4 (four) time measurements during the day and at night at least three (3) time measurement.

LS $= 10 \log 1/16 \, (T1.10^{0.1*L1} + ... + T4.10^{0.1*L4})$ dB(A)
L**M** $= 10 \log 1/8 \, (T5.10^{0.1*L5} + ... + T7.10^{0.1*L7})$ dB(A)
L**SM** $= 10 \log 1/24 \, (16.10^{0.1*LS} + ... + 8.10^{0.1(LM+5)})$ dB(A)

For the assessment level of noise, the measurement results were compared to the quality standards applicable noise. The quality standard that is used according to the Indonesian Ministry of Environment (KEP-48/ MENLH/ 11/1996) on Standards of Noise for the measurement ambient noise.

The model used in this study is a model of noise propagation. Noise propagation models constructed using the approach of Inverse Square Law (ISL) for the type of point source (point source) involving excess attunuation (Ae) that includes atmospheric attenuation, attenuation of land and barrier attenuation (Iwan et al., 2005).

Lp2 (dB) = Lp1 – 20 Log (r2/r1) - Ae
Ae=Atmosfer + Barrier + Soil Atenuation
Atmosfer atenuation= $\mathbf{A_{abs}} = \alpha r/100$
$F_{r,O} = 2.4+4.04x10^4$ h [(0.02 + h)/(0.391+h)], *oxygen relaxation frequency*, Hz
$F_{r,N} = (T/T_0)^{-1/2}$ [9+280 $he^{\{-4.17\ (T/T0)\ -1\}}$], *nitrogen relaxation frequency*, Hz
$\alpha = 869\ xf^2\ \{1.84\ x\ 10^{-11}\ (T/T_0)^{1/2} + (T/T_0)^{-5/2}\ [0.01275\ (e^{-2239.1/T})$
$/(F_{r,O} + f^2/F_{r,O}) + 0.1068\ (e^{-3352/T})/(F_{r,N} + f^2/F_{r,N})]\}$
Barrier atenuation= $\mathbf{A_{barrier}} = (20 \log (m_s f)) - 48$
Soil atenuation=$A_{\mathbf{ground}} = G_s C_s + G_R C_R - 3M (1-G_p)$

Results and Discussion

Results

Table 1. Results of ambient noise measurements, units of dB(A)

Location	Point							
	1/U	2/T	3/S	4/B	5/U	6/T	7/S	8/B
1.	54.1	54.4	52.2	54.1	54.9	56.3	52.0	54.8
2.	64.1	62.1	65.7	64.2	65.3	61.4	66.1	64.4
3.	54.1	52.2	56.3	54.4	54.7	53.9	58.8	58.1
4.	69.6	67.6	72.8	69.6	69.7	65.9	69.9	64.3
5.	67.6	72.8	59.5	66.1	70.1	69.7	67.4	65.1
6.	65.1	66.4	54.1	57.6	60.1	59.5	53.8	56.1
7.	67.7	69.9	67.7	64.4	65.6	69.2	68.5	59.7
8.	71.2	72.3	72.5	73.1	67.5	69.6	69.2	70.5

Source: Field assessment by the authors

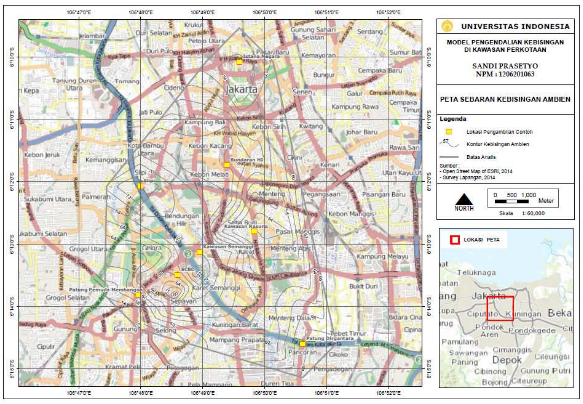

Figure 2. Distribution of noise; set by the authors

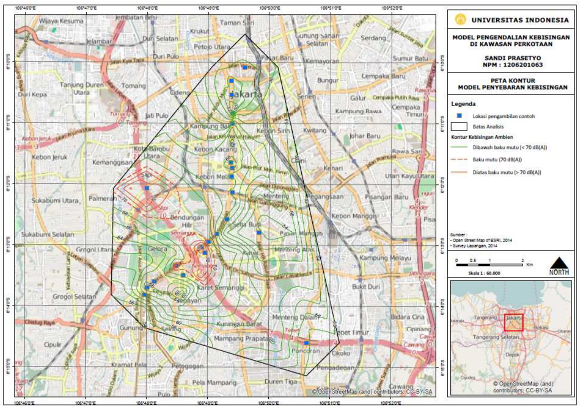

Figure 3. Distribution of noise by model of noise propagation; set by the authors

Discussion

From ambient measurement results as a whole, by combining the overall locations of observation, it was found that the most noisy location was along Sudirman line, especially at Semanggi area. In the measurement of ambient noise in the Semanggi area, for a radius of 50 meters is in the range 67.6 - 72.8 dB (A). For a 100 meter radius ambient noise range 64.3 - 69.9 dB (A). From the measurement results found in a radius of 50 meters and 100 meters, ambient noise mostly attaint over the quality standards set by the Indonesian Ministry of Environment (MENLH/ II/ 1996), which is 65 dB (A). This condition is possible because this location is seen from the types of vehicles that passed on through it, in contrast to other sampling locations. Semanggi area crossed by buses, trucks and other large vehicles are known to cause greater noise. This area is also known as the most frequent traffic jams and always crowded every day.

As for the istana negara area is the area with the lowest noise at Sudirman Street. The results of measurements at the Istana Negara area, showing the ambient noise in a radius of 50 meters range between 52.2 - 54.4 dB (A) with the direction of maximum noise into the southern part of the area. For a 100 meter radius ambient noise ranging between 52.0 - 56.3 dB (A), where the largest ambient noise also occurs in the southern part of the area. The distribution of the noise is found heading towards the south of the Bundaran HI area based in Semanggi area.

For the Slipi and Patung Dirgantara area, as a region known influence the distribution of noise in Sudirman street, found noise levels are already high enough. It eventually adds to the burden of noise located at Sudirman street. While for the Rasuna Said area, judging from the results of noise measurement were less affected.

From the calculation of noise dispersion modeling can be seen that the most noisy region in Sudirman Street is in the Semanggi area. The noise level is high because this area is an open area, with no plants that could have functioned as a barrier. In this area, the plant functions merely aesthetic, but various kinds of vehicles passing by. While for the areas with the lowest noise level is around Istana Negara area. Apart from the number of plants functioning as noise barrier, in congested area the most important thing is to re-set a number of vehicles passing by. Propagation of noise indicates the direction of the propagation of noise reduced the noise levels away to the west and to the north of Sudirman Street. In the Semanggi area, the noise level from the source transport activity remains very high. The noise level in the north is around 47.2 - 51.6 dB (A), much different than that of the Semanggi area where the highest at 74.4 dB (A). For the eastern region, based on model calculations was obtained value generated noise is under 60 dB (A); while to south varies between 63.9 - 67.9 dB (A).

Conclusion and Suggestion

Conclusion

The results of measurements ambient noise in Sudirman street sourced from motor vehicle activity show that in some areas have exceeded the permissible levels. The highest noise level is in Semanggi area and the lowest noise level contained in Istana Negara. Results of noise propagation modeling calculations show that the direction of the noise distribution centered on the Semanggi area gradually reduced toward the Istana Negara area (north) and Patung Pemuda area (west).

Suggestion

This research may be continued with building a model of noise control by observing the extent of green open spaces and the amount of mass transportation. Jakarta government is expected to set a policy about the restrictions a number of vehicles that pass through Sudirman street.

References

[1] Abolina, K. (2005). *Urban Sustainability Indicator Development Criteria*, Summary of Doctoral Dissertation in Environmental Science, University of latvia.
[2] Anonim. (1992). *Encycopledia of Occupational Health and Safety*, vol II, Mc. Graw Hill Book Company, New York.
[3] Anonim. (1993). *ISO 9613-1. Attenuation of Sound During Propagation Outdoors*, ISO, Switzerland.
[4] BPS Indonesia. (2014). *Hasil Sensus Penduduk*, Badan Pusat Statistik Indonesia.
[5] Campo, A.G.D. (2008). *Incorporating Spatial Data and GIS to Improve SEA of Land Uses Plans: Opportunities and Limitations: Case Studies in the Republic of Ireland*, Theses Ph.D, Dublin Institute of Technology, Faculty of Built Environment, Departement of Planning and Environment 27th November 2008.
[6] Canter, W.L. (1996). *Environmental Impact Assessment.* McGraw- Hill, Inc., New York.
[7] Ciriani, F da Giovanni Leonardi (2012). *Environmental Modelling for Traffic Noise in Urban Area*. American Journal of Environmental Science, 8(4), 345-351.
[8] Davis, MacKenzie and David A. Cornwell. (1991). *Introduction to Environmental Engineering.* McGraw- Hill, Inc., New York.
[9] Doelle, L. (1993). *Environmental Acoustic.* McGraw- Hill, Inc., New York.
[10] Griefahn, B., Anke Marks, Sibylle Robens (2006). *Noise emitted from road, rail and air traffic and their effects on sleep*, Institute for OcuppationalPhysiology at Dortmund University. Journal of Sound and Vibration 295 (2006) 129 – 140.
[11] Ikron. 2007. *Pengaruh Kebisingan Lalu Lintas Jalan Terhadap Gangguan Kesehatan Psikologis Anak SDN Cipinang Muara Kecamatan Jatinegara, Jakarta Timur*. Jurnal Makara, Departemen Kesehatan Lingkungan UI, Volume 11: 32-37.
[12] Iwan, P., I. B. Ardhana., I.G.N. Merthayasa dan J.D. Chandra. (2005). *Pemetaan Bising Berbasis Simulasi Komputer*, Jurnal Teknik Lingkungan 11: 25-32.
[13] JICA. (2004). *Studi/Kajian tentang Perbaikan Kualitas Udara Ditinjau dai Perbaikan Emisi Kendaran Bermotor*, PPSML UI, Jakarta.
[14] Keworthy, J. (2006). *The eco city: Ten Key Transport and Planning Dimensions for Sustainable City Development*, Environment and Urbanization, 2006, 18: 67.
[15] Keputusan Menteri Negara Lingkungan Hidup nomor 48 Tahun 1996 tentang Baku Tingkat Kebisingan.
[16] Miller, G. (2006). Environmental Science: working with the earth, elevent ed., Thomson Corporation, Belmont, USA.
[17] Mpofu, T. (2013). Environmental Challanges of Urbanization: A Case Study for Open Green Space Management. Research Journal of Agricultural and Environmental Management Vol. 2(4), pp. 105-110,
[18] Peraturan Menteri Dalam Negeri nomor 1 Tahun 2007 tentang Penataan Ruang Terbuka Hijau Kawasan Perkotaan.
[19] Satriyo, S. (2008). *Studi Kondisi Kimiawi Penyebaran Pb, Debu dan Kebisingan di Jakarta*, Ubhara Jaya, Jakarta.
[20] Sedigeth Lotfi, Kiomart Habibi, Mohammad Javad Koohsari. (2009). An Analysis of Urban Land Development Using Multi-Criteria Decision Model and GIS (A Case Study of Babolsar City), American Journal of Environmental
[21] Soedomo, M. (2001). *Kumpulan Karya Ilmiah Pencemaran Udara.* Penerbit ITB, Bandung.
[22] Undang- undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup.
[23] Williams, K. (2009). *Sustainable Cities: Research and Practice Challenges*, International Journal of Urban Sustainable Development, Vol 1, Nos 1-2, May-November 2009, 128-132.
[24] Zhao, P. (2011). *Car use, Commuting and Urban form in a rapidly growing city: evidence from Beijing,* Tranportation Planning and Technology, vol 34, no.6, August 2011, 509-527.