ISSN 2347 - 3983
Volume 8. No. 8, August 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter77882020.pdf
https://doi.org/10.30534/ijeter/2020/77882020

Noise Distribution Mapping and Ideal Settlement in the Airport Area

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ABSTRACT

In this study, measurements were conducted on the airport runway, which is analogous to a source of noise and also carried out in a residential area around Halim Perdanakusuma airport, Indonesia. The measurement distances are 500, 354, 250 and 50 meters. The distance used was obtained from the measurement of the nearest runway to the settlement point. The goal is to obtain an ideal settlement point based on noise levels, map out existing noise, and also analyze the noise level from the source. This study used WECPNL (continuous noise) and LDN (Day and Night) calculation methods as a contour map. The noise level is influenced by the distance of the settlement to the airport and the frequency of the number of flights with high and medium level. The sources on the runway were 92.8 to 95.17 dBA and in research, landing and take-off aircraft movements have a fixed movement, then BL and BT settlements were obtained 76.7 to 86.6 dBA and 84.6 to 88.9dBA respectively. In the CN (North) and CS (South) zone measurements, 65.8 to 70.65 dBA and 61.8 to 65.8 dBA. The recommended settlement area from the level of noise and the standards that apply to the government of the environment and aviation standards are CN or North C zone, and CS or South C zone, regarding the use of natural noise barriers, can reduce noise with a range of 9.45% to 36.01%.

Keywords: Noise Distribution, Mapping, Settlement, Airport, Aviation

1. INTRODUCTION

The growth in the number of flights in Indonesia in 2018 has increased along with economic growth. The increasing number of flights will indirectly have a negative impact on the quality of human life, air pollution which can be felt directly by humans, which refers to the noise felt in the settlements around the airport [1, 2]. According to experts, noise is sound that is not expected by listeners such as humans, animals and plants [3, 4]. According to international aviation standards, the level of dB emitted by aircraft jet engines, when taking off and landing, is in the range of 89 dBA up to 108 dBA, depending on engine and aircraft type [5, 6]. This is quite high, given the level of hearing comfort possessed by humans, there is only 85 dBA with a period of 8 hours. According to Fleuti [7], Halim Perdanakusuma Airport (HLP) itself has a location in the middle of the city with a geographical location North $106^{o}53'28$ "E and South $06^{o}15$ '59" S. The runway owned by Halim airport, has a runway length of 3 kilometres with approximately 7,400,000 times flights summarized in 2018, which was named the 8^{th} busiest airport in the Republic of Indonesia managed by the Indonesian National Army. Thus, research conducted to the level and spread of noise caused by flight activities at Jakarta's Halim International Airport.

2. RESEARCH METHODS

This study applies the concept of noise research which carried out a direct observation, measurement in the residential area closest to the airport and conduct an inspection of the runway analogous as a source [8-10]. The analysis results obtained from data retrieval are processed into a descriptive analysis. By using software that supports data, analysis obtained is valid, accurate and actual [11-13].

Determination of Data Collection Zones

The first measurement is carried out on the runway (Zone A), which is analogous to a noise source with 3 data collection points.

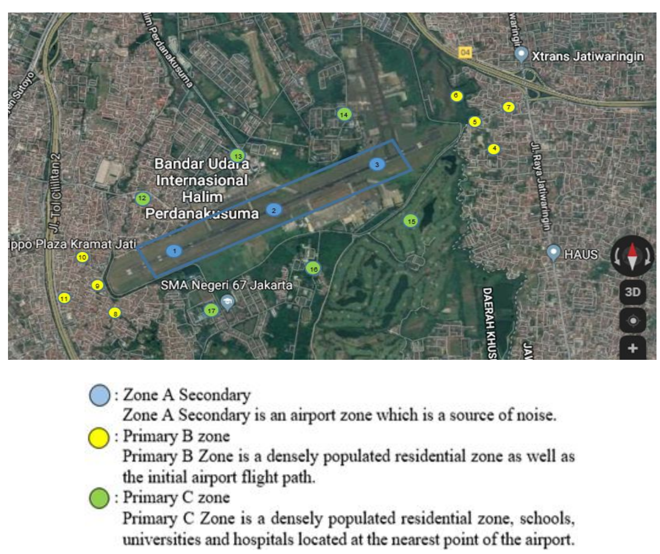


Figure 1: Point of measurement platform and settlement

The second measurement is carried out in a residential area around the Halim airport with 8 zone B and 6 zone C data collection points, with repetition in accordance with the number of flights within 24 hours, especially seen on the map in Figure 1. The zone was determined by the distance of airport as a source [14-16].

Measurements were made with EM.SLM (Environment Sound Level Meter) [17-23] at different time and settlement samples where measurements are made in the morning, starting at 08.00 and 10.00, which are considered to represent the time period of 06.00 and 12.00. Then, in the afternoon and evening with a measurement time of 13.00 and 16.00, which is considered to represent the time range of 12.00 until 18.00. In the evening, measurements are taken at 19.00 and 22.00, which can represent measurements during the period of 18.00 until 24.00. Measurements in this study took place in accordance with flight schedules obtained with the flight radar application and matched with flight data, obtained from Angkasa Pura.

Data Processing Analysis

Noise data that has been processed using methods under the rules of Minister of Environment Year 1996 and the Minister of Transportation Year 2010. The method used for mapping calculations and comparison charts use the WECPNL method according to the International Aviation standard of ICAO and the Minister of Transportation Year 2010. Equation (1) used to get noise intensification.

$$dB\ (A) = 10 \log \frac{10^{\frac{L1}{10}} + 10^{\frac{L2}{10}} + \cdots + 10^{\frac{Ln}{10}}}{n} \quad (1)$$

Equation (2) and (3) are used to get the number of flights for 24 hours, and to get the average noise index obtained in real-time measurements.

$$N = N_2 + 3N_3 + 10\ (N_1 + N_4) \quad (2)$$

$$WECPNL = dB\ (A) + 10 \log N - 27 \quad (3)$$

The method used for the calculation of distribution mapping and comparison mapping, using the L_{DN} method for settlements guided by the standard of Ministry of Environment Year 1996. L_{DN} is calculated by the Equation (4).

$$L_{DN} = 10 \log 1/24 \{16.10^{0,1.L}{}_S + \ldots + 8.10^{0,1(L}{}_M{}^{)}\} dB(A) \quad (4)$$

While, L_D (day time) and L_N (night time) are calculated with the Equation (5) and Equation (6).

$$L_D = 10 \log 1/16 \{T1.10^{0,1.L1} + \ldots + T4.10^{0,1.L}\}\ dB\ (A) \quad (5)$$

$$L_N = 10 \log 1/8 \{T5.10^{0,1.L5} + \ldots + T7.10^{0,1.L7}\}\ dB\ (A) \quad (6)$$

3. RESULTS AND DISCUSSION

Relationship of Noise Factors

This study found a relationship between noise level and settlement distance and with a large number of flights.

(a) Correlations

		Plane Frequency	Noise Level
Plane Frequency	Pearson Correlation	1	-.507*
	Sig. (2-tailed)		.038
	N	17	17
Noise Level	Pearson Correlation	-.507*	1
	Sig. (2-tailed)	.038	
	N	17	17

*. Correlation is significant at the 0.05 level (2-tailed).

(b) Correlations

		Measurement point distance	Noise level
Measurement point distance	Pearson Correlation	1	-.773**
	Sig. (2-tailed)		.000
	N	17	17
Noise level	Pearson Correlation	-.773**	1
	Sig. (2-tailed)	.000	
	N	17	17

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 2: Correlations between (a) noise level and frequency (b) noise level, frequency and distance of the settlement

Based on Figure 2, the noise level is influenced by the frequency of aircraft flight with moderate intensity, Based on Figure 3, besides being influenced by frequency, the noise level in settlements around the airport is also influenced by the distance of the settlement to the airport with a strong level. Aircraft noise level can be predicted and controlled thus was not exceed the threshold.

Noise Zone Coverage Level

Zone A Runway

In the average WECPNL calculation, the noise level from Figure 3 as 84.88 dBA is seen. The calculation uses WECPNL which also used by the 2017 CASR (Civil Aviation Safety Regulation) International Aviation Standard which guided by the Rules of Minister of Transportation Year 2010. This standard stated that the maximum level of noise emitted by aircraft on the runway recommended no more than 108 dBA.

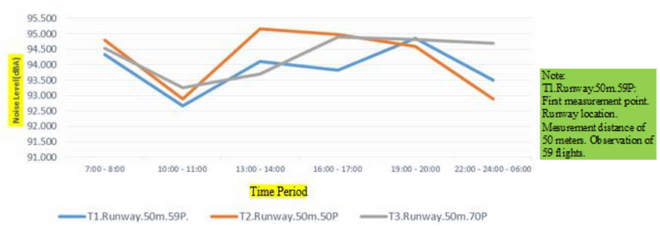


Figure 3: The noise level on the runway

Therefore, in this study, the data was successfully obtained had a decibel number that tended to be lower with a difference of 23.12 dBA or by a difference of 12.4% in the CASR standard. CASR arrange noise level on the safety outcome of air transport industry and airport.

Zone B Settlement

Noise level fluctuation graph obtained in the zone B area, presented in Figure 4.

Figure 4: Noise fluctuation in zone B
(a) landing, (b) take-off aircraft

The conditions in the noise fluctuation in Figure 4 (a) of the landing section was obtained from direct measurements with the type of intermittent noise from the aircraft. An average decibel time is 86.34 dBA. This study is guided by standards published by the Minister of the Environment in 1996. It is stated that the ideal noise level is 55dBA with a tolerance of 3 dBA in settlements. This indicates the area in the measurement is above the applicable guidelines with a difference of 36.3% or with a difference of 31.34 dBA decibel.

According to the data presented in Figure 4 (b) of the take-off section based on real-time data retrieval, the object being measured is an aeroplane with different intensity on each measurement with intermittent noise categories. Fluctuations obtained with an average of 87.46 dBA guided by the Standard of Minister of the Environment Year 1996, revealed that ideal settlements should have an average noise of 55 dBA. Refer to these standards, the area indicates that the quality of the settlement is not good with noise that is above the guidelines with a difference of 32.46 dBA decibel or at a percentage of 37.1%.

Zone C Settlement

According to the data presented in Figure 5 (a) obtained from real-time data retrieval, the object measured is an aeroplane with a different intensity at each measurement, with intermittent noise category. Fluctuations obtained with an average of 67.45 dBA guided by the Standard of Minister of the Environment Year 1996, revealed that ideal settlements should have an average noise of 55 dBA. Refer to these standards, the area indicates that settlement quality is not good with noise that is above the guidelines with a difference of 12.45 dBA decibel or at a percentage of 18.47%.

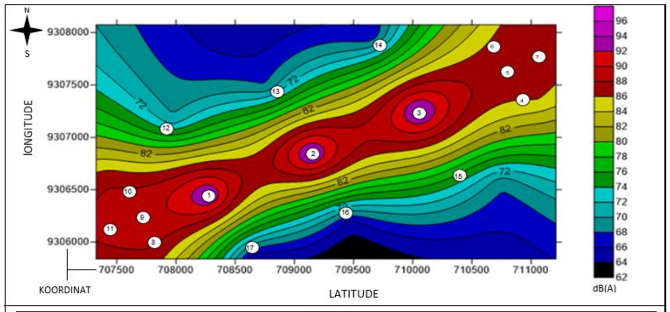
Figure 5: Noise fluctuation in zone
(a) CN (northern), (b) CS (southern)

The conditions in Figure 5 (b), noise fluctuation graph in the South obtained from direct measurements with the type of internal noise from the aircraft. An average decibel is 65.21 dBA. This study followed standards published by the Minister of the Environment Year 1996. It is stated that the ideal noise level is 55 dBA with a tolerance of 3 dBA in settlements. This indicates the area of measurement is above the applicable guidelines with a difference of 15.66% or with a difference of 10.22 dBA decibel.

Noise Distribution Mapping

Noise Distribution (LDN)

In Figure 6, the minimum decibel numbers are 62 dBA to 68 dBA, marked in dark blue contained in measurements T.13 and T.17. The next decibel number is in the measurement zone CN (Northern) and zone CS (Southern), i.e. in settlements T.12, T.14, T.15, T.16. The settlement is marked in blue tosca colour with 68 dBA to 74 dBA.



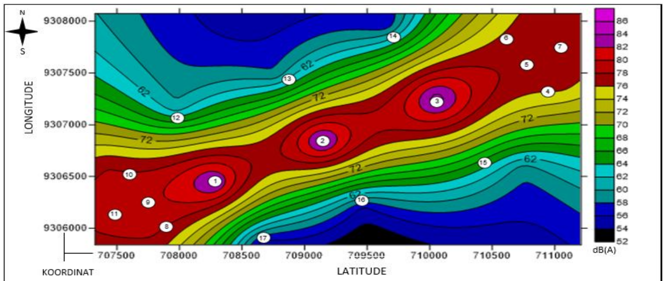
Categories											
Code	Settlement With Trees (PDP)			Code	Densely Populated Settlement (PPP)			Code	Open Settlement (PT)		
	Latitude	Longitude	Distance (m)		Latitude	Longitude	Distance (m)		Latitude	Longitude	Distance (m)
T4	711053.0	9307387	354	T6	710808.2	9308075	354	T5	710937.9	9307713	250
T13	708759.8	9307488	500	T8	707820.1	9305842	354	T7	711210.3	9307876	500
T14	709649.0	9307977	500	T10	707427.8	9306607	354	T9	707591.0	9306204	250
T15	710748.2	9306558	500	T12	707970.3	9307178	500	T11	707325.6	9306108	500
= Zone B Primary Landing and Takeoff								T16	709467.1	9306179	500
= North and South Primary C Zone								T17	708657.1	9305839	500

Figure 6: Noise Distribution (LDN)

There are settlements in T.4, T.5, T.6 and T.7 marked in dark red at 86 dBA – 88 dBA while settlement points T.8, T.9, T.10, and T.11, which describe the noise of 88.0 dBA to 92.0 dBA marked bright red.

Noise Distribution (WECPNL)

The WECPNL calculation in Figure 7 shows the minimum decibel number is 52 dBA to 58 dBA, marked in blue contained in T.16 and T.17 measurements. The next decibel number is in the measurement zone CN and CS that is in settlements T.12, T.14, T.15, T.16. The settlement is marked in blue tosca and bright green with 58 dBA - 70 dBA.



Code	Settlement With Trees (PDP)			Code	Densely Populated Settlement (PPP)			Code	Open Settlement (PT)		
	Latitude	Longitude	Distance (m)		Latitude	Longitude	Distance (m)		Latitude	Longitude	Distance (m)
T4	711053.0	9307387	354	T6	710808.2	9308075	354	T5	710937.9	9307713	250
T13	708759.8	9307488	500	T8	707820.1	9305842	354	T7	711210.3	9307876	500
T14	709649.0	9307977	500	T10	707427.8	9306607	354	T9	707591.0	9306204	250
T15	710748.2	9306558	500	T12	707970.3	9307178	500	T11	707325.6	9306108	500
	= Zone B Primary Landing and Takeoff							T16	709467.1	9306179	500
	= North and South Primary C Zone							T17	708657.1	9305839	500

Figure 7: Noise Distribution (WECPNL)

There are settlements in T.4, T.5, T.6, and T.7 at 76 dBA – 78 dBA which are marked in dark red while there are settlement points T.8, T.9, T.10, and T.11 marked bright red which describe the noise of 80.0 dBA to 82.0 dBA. The decibel value is indicated to make zone settlement T.16, and, T.17 are settlements with a good category.

Noise Difference in a Settlement with Source

The noise conditions in each settlement zone are marked in the accompanying Figure 8, based on the rules of Minister of the Environment for settlements Year 1996, that the decibels in a settlement should be equal to 55 dBA with the provisions of decibel tolerance with 3 dBA. In the scope of the research results obtained, settlements that have decibel that is close to the stipulated number, are in the settlements of the CS (South) and CN (North) zones.

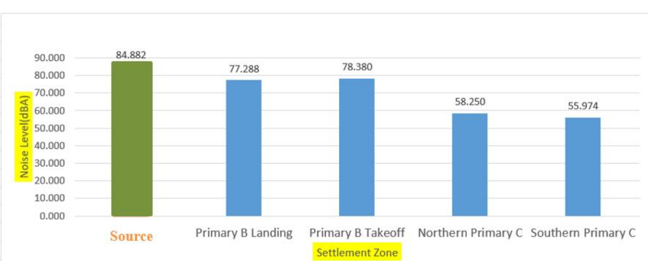


Figure 8: Noise differences between source and settlement

The undesirable distribution of decibel conditions in CN (North) zone are settlements that tend to approach the ideal stipulation rate of 58.25 dBA with a tolerance value of decibel 3 dBA by standard provisions. Meanwhile, CS (South) settlements, obtained at an average rate of 55.97 dBA. The data obtained from the processing results tend to be close to the standard assessment with 55 dBA issued by the category of good settlement conditions in the Minister of Environment Year 1996. The settlement area of the CS (South) zone is in a safe area from noise. The location of settlements in the southern part of the airport and the direction of the wind that carries the sound tends to lead to North and North East while the North zone settlement area obtained a decibel number that is not too high due to wind movement that tends to rarely move towards the North of the airport area, and also the condition of the area which is fairly average using natural barriers as a reduction and reduction of decibel, due to flight movements in the airport.

Noise Reduction Value

Based on the research, there was a decrease in the noise level obtained from the runway which is analogous to the airport noise source, to the following settlements in Table 1.

Table 1: Noise Reduction Value

Settlement	Before applying the barrier		Remarks
	Noise level (dBA)	Reduction effectiveness (%)	
	Primary landing zone B		
T4.PDP.354m	76.7	9.45	
T5.PT.250m	77.5	8.44	
T6.PPP.354m	77.2	8.80	
T7.PT.500m	77.7	8.27	
Average	77.3	8.74	
	Primary take-off zone B		
T8.PPP.354m	77.5	9.00	
T9. PT.250m	79.4	6.79	
T10. PPP.354m	78.0	8.41	PDP : Settlement with tree PT : Open settlement PPP : Dense population settlement
T11.PT.500m	78.7	7.51	
Average	78.4	7.93	
	Zone C North		
T12. PPP.500m	60.3	28.79	
T13. PDP.500m	58.4	31.36	
T14. PDP.500m	56.1	34.15	
Average	58.3	31.43	
	Zone C South		
T15.PDP.500M	54.5	36.01	
T16.PT.500M	58.4	31.39	
T17.PT.500M	55.1	34.95	
Average	56.0	34.12	

Noise Blocking Recommendations

In this study, the use of natural barriers in residential areas around the airport can reduce noise levels with a range of 9.45 % to 36.01 %. The use of artificial barriers in residential areas around the airport can reduce noise levels with a range of 8.41 % to 28.79 %. Thus, it can give a reference of appropriate decibel barrier to be applied in the residential area around the airport as a reflection. It also as a noise absorbent is by using a tree barrier that tends to have a natural character (Figure 9).

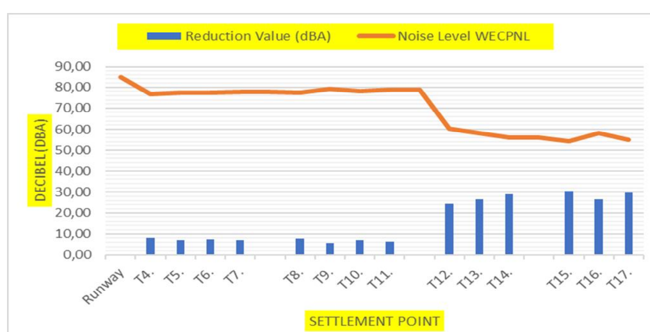


Figure 9: Noise level and zone coverage reduction value

Table 2: Settlement category

Category					
Code	Settlement	Distance (m)	Code	Settlement	Distance (m)
T4	Settlement with trees	354	T11	Open Settlement	500
T5	Open Settlement	250	T12	Dense Population Settlement	500
T6	Dense Population Settlement	354	T13	Settlement with trees	500
T7	Open Settlement	500	T14	Settlement with trees	500
T8	Dense Population Settlement	354	T15	Settlement with trees	500
T9	Open Settlement	250	T16	Open Settlement	500
T10	Dense Population Settlement	354	T17	Open Settlement	500

*The distance used is obtained from the measurement of the nearest runway to the settlement point

The result was guided by the provisions and the WECPNL method applied by the Minister of Transportation Year 2010. The results of this noise distribution study were obtained, the residential area T.1, T.2, T.3 is the decibel distribution area III, which is also the airside area of the aircraft. Zone settlement areas T.4, T.5, T.6, and T.7 are designated as decibel distribution areas II as landing areas of aircraft and residential areas zones T.8, T.9, T.10, and, T.11 is the take-off zone.

Figure 10: Application of Natural Barriers

The area of distribution area is decibel I, there is a measurement area in settlements T.12, T.13, T.14.T.15, T.16, and T.17 (Table 2). Data on previous relevant research uses natural category barriers in the airport area. Then the researchers provide a reference to the application of natural barriers in Figure 10.

Table 3: Noise level prediction with the application of natural barriers

Settlement	Before applying the barrier		After applying the barrier	
	Noise level (dBA)	Reduction effectiveness (%)	Noise level (dBA)	Reduction effectiveness (%)
Primary landing zone B				
T4.PDP.354m	76.7	9.45	61,99	26,81
T5.PT.250m	77.5	8.44	62.8	25.80
T6.PPP.354m	77.2	8.80	62.5	26.16
T7.PT.500m	77.7	8.27	63.0	25.63
Average	77.3	8.74	62.6	26.10
Primary take-off zone B				
T8.PPP.354m	77.5	9.00	62.8	26.27
T9. PT.250m	79.4	6.79	64.7	24.06
T10. PPP.354m	78.0	8.41	63.3	25.68
T11.PT.500m	78.7	7.51	64.0	24.78
Average	78.4	7.93	63.7	25.20
Zone C North				
T12. PPP.500m	60.3	28.79		
T13. PDP.500m	58.4	31.36		
T14. PDP.500m	56.1	34.15		
Average	58.3	31.43		
Zone C South				
T15.PDP.500M	54.5	36.01		
T16.PT.500M	58.4	31.39		
T17.PT.500M	55.1	34.95		
Average	56.0	34.12		

Based on the recommendation of the Public Works Department, natural barriers which have a reduced value of approval using the Bambusa sp (Pringgodani) tree which can reduce by 14.70 dBA. Prediction of the level of success made by the author, using the WECPNL calculation method with the calculated value of 14.70 dBA as the value of the natural barrier reduction.

The conditions revealed in Table 3, the occurrence of noise reduction in the application of natural barriers as a reference. The prediction of the application of the reference results of this study, the average decibel reduction of 25.66 % for the zone B settlement was obtained. In North and South zone, the researchers did not provide a reference to the application of the barrier. Based on the results of the study, the distribution of the level of decibel in the two regions, is still at a safe level, with the area of distribution of decibel airport.

4. CONCLUSION

Decibels of noise spread in residential areas around Halim Perdanakusuma airport, divided into four zones, i.e. CS (South) zone, CN (North), zone B landing, B take-off. The noise generated, occurs and affected by the number of flights every day with a moderate level of connection, and the distance of the location of settlements with the airport with a high level of connection. Settlement areas which are categorized into noise III areas are T.1, T.2, and, T.3 with the status of airside zoning. The category II decibel noise areas are T.4, T.5, T.6, T.7, which are landing zone B and T.8, T.9, T.10, T.11 which are take-off zone B. Noise zone I was found in settlements T.12, T.13, and T.16 which are settlements of CN (North) and CS (South) zones. In this study, it was found that the application of natural reducing as noise mitigation in settlements around the airport, can reduce noise levels with a percentage range of 9.45% to 36.01%. Good and ideal settlements as a reference found in settlements T.14, T.15, and T.17.

ACKNOWLEDGEMENT

Thank you for Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) Universitas Nasioal and my colleagues at Faculty of Engineering and Science, Universitas Nasional, Jakarta, Indonesia.

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