International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 4, Issue 2 (August 2014) PP: 13-19

Analysis of Noise Pollution on Airport Environment
(Case study of International Airport of Sam Ratulangi Manado, Indonesia)

Daniel Sondakh[1, 2], Maryunani[3], Soemarno[4], Budi Setiawan[5]
[1)]*Doctoral Program of Environmental Studies, PPS Brawijaya University, Malang, Indonesia*
[2)] *Faculty of Engineering, Tomohon Indonesia Christian University, Indonesia*
[3)] *Faculty of Economics and Business, Brawijaya University, Malang, Indonesia*
[4)] *Faculty of Agriculture, Brawijaya University, Malang, Indonesia*
[5)] *Faculty of Agriculture, Brawijaya University, Malang, Indonesia*

Abstract: *The purpose of this study is to measure and evaluate noise levels arising from operation of Sam Ratulangi International Airport of Manado to the surrounding environment, then proceed to make the imp ct restraint strategies. Environmental noise measurement method is done in accordance with the Regulation of the Environment State Minister of the Republic of Indonesia No. 48/1996 on Noise Level Treshold. By the measurement and the calculation of the level of noise during the night ($L_{DAY\text{-}NIGHT}$) at the locations of retrieved results: in Apron 87.4 dB (A); Koka village's 67.5 dB (A); Wusa village 73.1 dB (A); and Mapanget village 59.7 dB (A), which means all of the location occurs lending in excess of a threshold noise levels according to the threshold of noise Standards for residential areas is 55 dB (A), and the airport of 75 dB (A). While based on the perception of the people who live around the airport which is located in the village of Koka, Wusa and Mapanget about noise obtained information changes on the health of the body such as insomnia (58%), hearing loss (18%), declining environmental quality (13%) and disturbance on communication (11%), which means there is the influence of impact noise that occurs on the physical health of people living around the airport. Restraint and handling of the problem of noise at the airport can be arranged through Noise restraint at the source; Noise restraint on the transmission path; and Noise restraint on humans.*

Keywords: *Airport Environment Noise Pollution, Level of Noise Equivalent, Noise Level Treshold, Noise restraint at the source; Noise restraint on the transmission path; and Noise restraint on humans*.

I. Introduction

The noise is an unwanted sound that may cause some psychological and physical stress to the living and non-living objects exposed to it [17]. Noise level is a measure of the energy of sound which is expressed in units of decibels or dB. Noise threshold is the limit maximum noise level permitted dumped into the environment from the undertaking or activity so as not to cause disruption of human health and environmental comfort [22].

Many airports faced noise disturbance around an airport is caused by aircraft in the air; reverse thrust used by aircraft to slow down after landing; aircraft on the ground, including taxiing, engine testing and running on-board electrical generators; departing aircraft that stray from the Preferred Noise Routes (PNRs); road traffic to and from the airport [1]. In addition, operation and implementation of the airport and all its activities may cause impact on workers, communities, and the environment around the airport [14].

Sam Ratulangi International Airport of Manado as the gates of the North Sulawesi province, from year to year increase the number of flight traffic, which in 2013 is recorded as much as 718 international flights and domestic flights 23,989 enter and exit through the airport (Angkasa Pura, 2014). This resulted in increased operational noise happens and influential to the employees at the airport and also the people who live around the airport [10].

Noise is one of the environmental health problems in large cities [4]. There are 8–12% of the world population has suffered the impact of noise in various forms and estimated the figure will continue to rise, and in 2001 was estimated at 120 million population is experiencing hearing loss [20]. According to the Kompas newspaper, edition Saturday, January 23, 2010, the Indonesia Ministry of health survey conducted in collaboration with the Faculty of medicine University of Indonesia of 20,000 people in seven provinces in Indonesia found about 38 million people Indonesia is experiencing hearing loss. Furthermore several adverse effects have been associated with exposure to environmental traffic noise, where among the more commonly documented ones, sleep disturbances have been regarded as being the most serious. Both noise annoyance and sleep disturbance have been proposed as important mediators of the impact of noise on health [8].

Generally, the legislation that regulates noise pollution, especially around airports, varies by country and even between locations within countries. We use Indonesia legislation or regulation regarding noise pollution control at airport as an example of some of the problems that may arise. Those are Legislation of the

Republic of Indonesia No.32/2009 on Protection and Management of Environment; The Government Regulation of the Republic of Indonesia No. 40/2012 on the Airport Development and Environment Preservation; and The Environment State Minister Regulation of the Republic of Indonesia No. 48/1996 on Noise Level Treshold.

This research aims to measure and evaluate noise levels arising from operation of Sam Ratulangi International Airport of Manado, then proceeded to make the impact restrain strategy.

II. Methodology

2.1. Research Object

In this study, the noise pollution is used as a research object, it will be approached through combination of 2 (two) types of measurement are a standard measurement using Sound Level Meter (SLM) and measuring the perception of the people who live around airports using a questionnaire.

2.2. Research Location

Site selection or measurement points is chosen based on the noise prediction of the most high. They are Apron (50 m) from runway, residence areas located at Wusa (1800 m), Koka (1900 m) and Mapanget (2700 m) from runway.

2.3. Data Collecting and Sampling Method

Data collection techniques used in this research is a survey, observation and documentation in order to obtain the data and information required. Noise pollution measured data namely noise equivalent level (Leq) is retrieved by noise level measurement at selected locations and normal event time (no activities both take off and landing), take off event and landing event. The measurement results are collection of data samples namely Leq event-noise.

In addition on this research using public perception in order to obtain information related to exposure to noise pollution that had befallen him or her. The respondents were selected based on their knowledge and experiences about noise pollution and as permanent residents living in the vicinity of the airport. Then based on this selected 20 people from each village where the noise level measurement is carried out (the village of Wusa, Koka and Mapanget), totally are sixty persons that gives their perception through the questionnaire.

2.4. Research Variables

Variables are used in this research as follows:

1. Noise equivalent level (Leq) of day and night which is a model of the equivalent noise level is used to determine the level of event-noise in an area [22].
2. Public perception [9].

2.5. Research Instruments

The instruments used in this research is sound level meter with a measuring range 30–130 dB(A); portable weather meter and questionnaires for the public perception of noise experienced or perceived.

Whereas the instruments that are used to retrieve data is structured questionnaire (closed question), where the details of the questions developed from the research variables formed from previous studies and amount of related Legislation dan Regulation of Republic of Indonesia.

2.6. Method of Environment Noise Measurement

Equivalent Continuous Level (Leq) is the noise level of the fluctuating noise during a specific time interval is equivalent to the established (steady) noise levels in the same time interval, known as Leq event-noise [22]. Its unit is dB (A). The equation for the Leq event-noise written as:

$$Leq = 10\log\left[\frac{1}{n}\left(\sum_{i=1}^{n} 10^{0.1L_i}\right)\right] \quad (1)$$

Notes :

Leq = Level of equivalent noise; n = sample data number of noise measurement; L_i = Noise value on measurement time interval specified.

In order to measure the environmental noise level is done by a direct method, using the integrated sound level meter with Leq measurement facilities [22]. Event measurement is performed every 5 seconds for 10 minutes. The Interval time is set for 1 hour. Measuring instrument mounted on one of the houses for 24 hours non-stop so that it can be produced as many as 24 data consists of 16 data for day (06.00-22.00) and 8 data for

night measurement (22.00-06.00). After the data is retrieved then performed the calculation value of L_D (Leq day), L_N (Leq night) and L_{D-N} (Leq day-night). By using equation (1) that has been inserted value measurement assumptions above, then the equation (1) becomes as follows:

$$L_{day} = 10\log\left[\frac{1}{16}\left(10^{0.1L_1} + 10^{0.1L_2} + 10^{0.1L_3} + ... + 10^{0.1L_{16}}\right)\right] \quad (2)$$

and

$$L_{night} = 10\log\left[\frac{1}{8}\left(10^{0.1L_1} + 10^{0.1L_2} + 10^{0.1L_3} + ... + 10^{0.1L_8}\right)\right] \quad (3)$$

Notes :

L_{day} = Leq value for day (16 hours): 06.00-22.00; L_{night} = Leq value for night (8 hours): 22.00-06.00

L_1 to L_{24} = Leq value every hour

Next, Leq (day-night) value can be calculated by using equation:

$$L_{day\text{-}night} = 10\log\left[\frac{1}{24}\left(16.10^{0.1L_{day}} + 8.10^{0.1\left(L_{night}+5\right)}\right)\right] \quad (4)$$

Notes :

$L_{day\text{-}night}$ = Leq value during 24 hours; L_{day} = Leq value along day (16 hours); L_{night} = Leq value along night (8 hours); (L_{night}+5) states that measurement result at night should be added 5 dB(A) as a correction

III. Results And Discussion

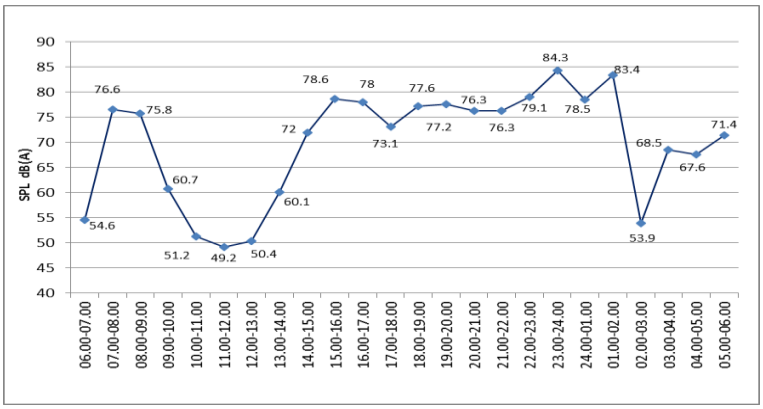
3.1. Data Acquisition (Sound level meter)

Based on identification of the noise carried out in the area around Sam Ratulangi International Airport of Manado covers 4 (four) point measurement, then it can be known to the average level of noise (Leq event-noise). See Table 1, below

Table 1. The Result of Event-Noise Level Measurement

i	Measurement Period	Leq - dB(A)			
		APRON	KOKA	WUSA	MAPANGET
1	06.00-07.00	55.1	60.4	51.8	55.9
2	07.00-08.00	77.3	58.2	48.1	57.9
3	08.00-09.00	76.5	58.3	56.9	49.8
4	09.00-10.00	61.2	57.8	54.6	52.9
5	10.00-11.00	51.7	52.9	42.8	60.8
6	11.00-12.00	49.6	48.6	51.3	56.9
7	12.00-13.00	50.9	47.1	46.9	58.3
8	13.00-14.00	60.6	46.2	46.9	55.9
9	14.00-15.00	72.6	49.8	48.5	69.0
10	15.00-16.00	79.3	54.3	55.4	55.3
11	16.00-17.00	78.7	56.4	64.7	59.1
12	17.00-18.00	73.8	56.3	61.8	49.9
13	18.00-19.00	77.9	55.0	65.9	57.4
14	19.00-20.00	78.3	55.4	44.3	49.4
15	20.00-21.00	77.0	57.7	52.0	51.7
16	21.00-22.00	77.0	57.1	66.3	53.7
17	22.00-23.00	79.8	55.0	68.1	52.7
18	23.00-24.00	85.1	55.3	67.5	52.3
19	24.00-01.00	79.2	55.7	71.6	45.2
20	01.00-02.00	84.2	52.3	64.2	40.6
21	02.00-03.00	54.4	58.9	51.4	40.9
22	03.00-04.00	69.1	55.3	47.0	40.7
23	04.00-05.00	68.2	64.6	53.9	45.7
24	05.00-06.00	72.0	64.4	55.4	46.8

Measurement results in Table 1 shows figures for noise level has exceeded a required threshold, especially in Koka village, Mapanget, and Wusa. Noise level occurs at those locations are not eligible for the housing/residence allocation, including the noise occurs on Apron caused by airport operations. Those locations are community residence located closest to the runway so that are those areas directly received noise exposure as well as its impact for residents. If compared to secondary data (retrieved from Airport Health Office) as Fig. 1. below, specifically describe the Apron highest noise level recorded by 84.3 dB (A) at 24.00-01.00. This figure is still required noise threshold excessive, particularly for the area of airports, regulated to 75 – 80 dB (A).



Source: Airport Health Office (2013)

Fig 1. Noise level at Apron

Furthermore, using equation (2), (3) and (4), then the results can be obtained Leq day, Leq night, and Leq day-night, as in table 2 below:

Table 2. Calculation of Leq day, Leq night dan Leq day-night

Measurement Period	Leq - dB(A)			
	APRON	KOKA	WUSA	MAPANGET
L_{DAY}	75.2	56.0	59.5	59.5
L_{NIGHT}	79.9	60.0	65.8	48.1
$L_{DAY-NIGHT}$	87.4	67.5	73.1	59.7

With increasing flight frequencies, especially night flights then the night noise impact also increased, for example in the period 21.00 – 02.00 a peak noise levels occurs at 24.00-01.00(see Table 1), as same as shown on Table 2 by value of L_{NIGHT} for each measurement point where the highest L_{NIGHT} occur in both residence locations and Apron, except Mapanget village. Likewise the morning measurement period of 06.00-09.00 shows noise threshold excessive (Apron, Koka village and Mapanget), as same as the period of 15.00 – 19.00 measurement. Thus, generally on those measurement locations does not meet the threshold requirements of the noise level, which is for residence areas is 55 dB (A), and the airport of 75 dB (A) [21].

3.2. Public Perception Who Live in the Vicinity of the Airport

To improve the results of the noise level measurement above, then made a measurement using questionnaires to the communities who lived in the vicinity of the airport, the residents of Wusa, Koka and Mapanget village. The purpose of this measurement is to obtain information of the socio-demographics of the area around the airport as the comparison of the above normative measurement results. With the acquired socio-demographics information, then expected in the strategy designed for tackling the noise problem can be more communities protective from noise happened exposure. After the data is tabulated, obtained some of the following information:

1. Resident (respondent) age are beetwen 20–30 years *(*22%); 30–40 years *(*38%); 40–50 years *(*23 %), and more than 50 years (17 %).
2. Living duration at this location are beetwen 0–5 years *(*31%); 5–10 years *(*24%); 10–15 years *(*17 %); 15–20 years *(*13%) and more than 20 years *(*15%).
3. There are noise impacts health: sleeping disturbance (58%), hearing degradation (18%), Quality of life degradation (13%) dan communication disturbance (11%).
4. Others information as show in Table 3 below

Table 3. Public Perception of Noise Pollution

No	Question	Know	Does Not Know
1	Knowing well about noise pollution	77%	23%
2	Noise impacts to the human health	87%	13%
3	Noise impacts to the human mental health	27%	73%
4	Knowledge of the noise protection device (ear muff)	61%	39%
5	The importance of using noise protection device (ear muff)	48%	52%
6	Reducing noise was close ears by hands	98%	2%

From Table 3 above, the community understands the noise pollution and its effects on health (physiological and psychological). It's just to do a protection on hearing a few still use ear protective equipment, but most just cover their ears with their hands when the planes pass by. Thus, generally, it can be concluded the happened noise has given impact on the sleeping disturbance, the baby is crying because of the shock and fear, degradation in hearing, Emotional instability and hypertension. When these findings confirmed to the PT Angkasa Pura as an Airport operator obtained information that what made the management of Angkasa Pura in dealing with various issues of this pollution is in compliance with the regulations in force, all of which have been published in the Periodic Report and Environmental Monitoring Plan of Sam Ratulangi Airport. It recognized the existence of excess of threshold on this noise problem. It's just that until now there has not been any complaints from the public relating to the question of the noise so that the management of PT. Angkasa Pura also considers there is no serious problem about this.

The literature on physiological effects of exposure to aircraft noise suggests there are several kinds of reflex responses that cause a stress reaction, such as emotional stress [17]. Noise can also interfere with communication in conversation and furthermore will interfere with the productivity and safety [9]. Physiological effects of noise can lead to decreased hearing ability and pain at a very high level [6], if exposed to noise more than 85 dB (A) at the airport are at risk of increased systolic blood pressure of 2.5 times and a diastolic of 2.1 times [10] and for those who are exposed to noise with an intensity of more than 85 dB (A) at the cement factory resulted an increasing of blood pressure (systolic 10.5 times and diastolic 7.6 times) [4].

Management of Angkasa Pura Airport's has made efforts to minimize the impact by planting trees along a fence bordering houses as residents. However the trees there are currently not enough effective in noise muffle, because those trees planted above ground flat (Figure 2) and interstellar density levels of the tree are also still quite porous so that there are wide enough fissures. The planting configuration like this not to absorb the noise.

Fig 2. Noise muffle plants.

3.3. Noise Restraint Strategy

In order to control noise at the airport more effectively it is necessary to make the strategy of handling the problems of noise pollution as an action plans periodic (annual). Thus the noise impact problems handling can be done all year round and is integrated with the management functions of the other, as follows:

- Identify the Airport noise problems
- Determine the level of noise that can be accepted by employees and residents around the airport
- Determine noise source.
- Make predictions based on current conditions, so that action plans can be made early to be used as guidelines for the handling of the noise problem. That in this case there is planning that is anticipatory, so it's not purely reactive only.
- Steps to make improvements and adjustments to the operational conditions through these approach: Techno-engineering, Bio-engineering dan Socio-engineering.
- To do evaluation dan monitoring periodically

At the operational level, noise control can be performed through reduction and control of noise levels which comprises 3 aspects, namely:

1. Restraint at source, consist of:
   a) Protection at equipments, structure and workers from noise impacts.
   b) Nois level Restrictions may be emitted from the source.

   Noise reduction at the source usually require modification or reduce of vibration causes as the noise source and equipment components reduction. Noise control at the source is relatively more efficient and practical as compared to control at the transmission path and the receiver. This can be performed routine maintenance on equipment such as hold speakers, Tow Bar and other ground handling equipment
2. Control of the transmission path. This is performed in between the source and the noise receiver. The principle is weakening the intensity of noise that transmitted from the source to the receiver by means of creating obstacles. There are two ways of controlling the noise in the transmission path in the outdoor and indoor noise control. For example, a certain type of tree planting (like pine) on top of embankment soil as high as ± 10 m parallel to the runway, thus giving a more significant influence in absorbing noise [13]. See Figure 3. below

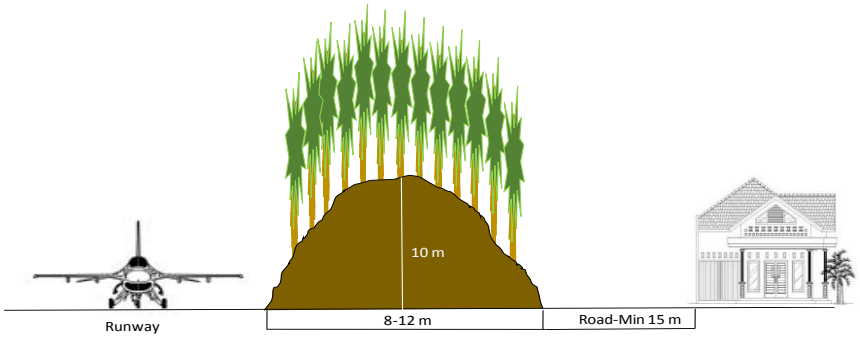


Fig. 3 Noise Mitigation Embankment (cross section)

   Tree planting can be used for comparison of embankment width and height is 1: 4 slope on both sides is 1: 2 with a distance of planting enough dense [12]. This way need to be followed by others that rearranged landscape, land use planning and the use of the building noise reducer. As for building noise silencers with dimensions height minimum of 2.75 m, and a wall thickness of at least 10 cm [27]. Other methods are quite effective in order to reduce the impact of this is making land use planning-empty land around the airport [11].
3. Noise Control in humans. This control is done to reduce the noise level received per day. This control is primarily aimed at people who every day receive noise, such as aircraft operator and others who receive noise. In the human ravages of noise received by hearing (inner ear) so his methods make use of the tools can reduce the level of noise entering the ear. This is done on a shift system for the enforcement of the operators of ground handling, maximum 5 (five) hours per day, including the necessity to use ear muff for workers in an Apron. As for the people who live around airports need mounting silencers designed programs in houses of residents with the help of funds from party PT. Angkasa Pura as the operators of Sam Ratulangi Airport in Manado, which it is also a form of CSR Angkasa Pura in harmonize surroundings.

IV. CONCLUSION

By the measurement and the calculation of the level of noise during the day and night ($L_{DAY-NIGHT}$) obtained resultas: Apron 87.4 dB(A); Koka village 67.5 dB(A); Wusa village 73.1 dB(A); and Mapanget village 59.7 dB(A), This means all the location happened excessive threshold, where for Residence area 55 dB(A), and Airport 75 dB(A).

Based on public perception who live around Airport, especially Koka, Wusa dan Mapanget village about noise, obtained information sleeping disturbance (58%), hearing degradation (18%), Quality of life degradation (13%) dan communication disturbance (11%).

Restraint and handling of the problem of noise at the airport can be arranged through Noise restraint at the source; Noise restraint on the transmission path; and Noise restraint on humans.

Recommendation for management of International Sam Ratulangi Airport of Manado can plant type of tree planting (like pine) on top of embankment soil as high as ± 10 m parallel to the runway, thus giving a more significant influence in absorbing noise.

REFERENCES

[1]. Adisasmita, S.A, Achmad Zubair, (2010). "Aircraft Noise Level Impact at Airport and Its Surroundings, (Case Study: Djalaluddin Airport, Gorontalo, Indonesia)"**,** Proceeding of Malaysian Universities Transportation Research Forum and Conferences 2010 (MUTRFC2010), 21 December 2010 Universiti Tenaga Nasional. ISBN 978-967-5770-08-1.

[2]. Ashford, Norman., Stanton H.P. Martin dan A. Moore Clifton, (1997), Airport.Operations, Second Edition, McGraw-Hill Inc. New York.

[3]. Ashraf, Jan, (2010). "Airport Systems: Planning, Design, and Management" American Planning Association. Journal of the American Planning Association·Autumn 2010; 70,4; ProQuest.

[4]. Babba J. (2007). Hubungan Antara Intensitas Kebisingan Di Lingkungan Kerja Dengan Peningkatan Tekanan Darah. Tesis. Universitas Diponegoro Semarang.

[5]. Berry, F, Sarah Gillhespy, Jean Rogers, (2008), "Airport Sustainability Practices-A Synthesis of Airport Practice", Transportation Research Board of The National Academies, Washington DC,© 2008 National Academy of Sciences. All rights reserved.

[6]. Black. D.A, John A. Black, Tharit Issarayangyun, Stephen E. Samuels (2007). Aircraft noise exposure and resident's stress and hypertension: A public health perspective for airport environmental management, Journal of Air Transport Management 13 (2007) 264–276

[7]. Francis, G., Humphreys, I., Fry, J, (2002), "The Benchmarking of Airport Performance". Journal of Air Transport Management 8, p 239-247, Elsevier Ltd.

[8]. Fyhri A. Gunn Marit Aasvang (2010). Noise, sleep and poor health: modelling the relationship between road traffic noise and cardiovascular problems. Sci Total Environ October 2010;408(21):4935–42.

[9]. Issarayangyun, T.Black, J. Black, D. Samuels, S, (2005), "Aircraft Noise and Methods for The Study of Community Health and Well-Being", Journal of The Eastern Asia Society for Transportation Studies, Vol.6, p.3293–3308.

[10]. Hastuti E. (2004) Pengaruh Bising Terhadap Kenaikan Tekanan Darah pada Pekerja di Bandara Ahmad Yani Semarang. Tesis. Semarang: Universitas Diponegoro.

[11]. Horonjeff, R & McKelvey, F.X., (1988), "Perencanaan dan Perancangan Bandar Udara". Penerbit Erlangga, Jakarta.

[12]. Lord. P, Duncan Templeton. (1996). Detailing for Acoustics. London E & F.N. Spon, ISBN 0419202102.

[13]. Narita International Airport Corporation (NAA), Narita International Airport Environment Report 2013

[14]. Rachman**,** R,M. (2007). Study of Environmental Management at Ahmad Yani Airport of Semarang, Thesis, Post Graduate, University of Diponegoro, Semarang, 2007

[15]. Sasongko D.P, Hadiyarto A, Sudharto P.H, Asmorohadi N, Subagyo A, (2000), "Kebisingan Lingkungan", Badan Penerbit Universitas Diponegoro, Semarang.

[16]. Singh, N., Davar, S.C. (2004), "Noise Pollution - Sources, Effects and Control", Journal of Human Ecology 16 (3), 181-187.

[17]. Singh.,V., Dev, P. (2010), "Environmental Impact of Noise Pollution, A Case Study in Ssaharanpur City, Western Uttar Pradesh , India", International Journal of Earth Science and Engineering, 3 (6), 869- 874.

[18]. Spreng, M., (2000). Possible health effects of noise induced cortisol increase. Noise and Health 2 (7), 59–64

[19]. Suwardjoko, W.P (1990). Merencanakan Sistem Perangkutan. Bandung, Penerbit ITB

[20]. Vogiatzis, Konstantinos, (2012), "Airport Environmental Noise Mapping and Land Use Management as an Environmental Protection Action Policy Tool-The Case of the Larnaka International Airport (Cyprus)", Science of the Total Environment, May 2012, Vol. 424, p162-173, 12p.

[21]. WHO. (2001). Occupational and Community Noise. Fact sheet no.258 Revised February 2001.

[22]. Legislation of the Republic of Indonesia No. 32/2009 on Protection and Management of Environment

[23]. Regulation of the Environment State Minister of the Republic of Indonesia No. 48/1996 On Noise Level Treshold

[24]. Regulation of the Transportation Minister of the Republic of Indonesia No. 11/2010 On National Airports Order.

[25]. Regulation of the Government of the Republic of Indonesia No. 40/2012 on the Airport Development and Environment Preservation.

[26]. Regulation of the Government of the Republic of Indonesia No. 70/2001 on the Airport.

[27]. Regulation of the Director-General of Bina Marga. No. 076/KPTS/Db/1999, on Guidelines for the Planning of Building Engineering Noise Reducer