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ANALYSIS OF NOISE LEVEL AND ITS EFFECTS ON WORKERS IN A CEMENT PLANT

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Noise is a problem that is often encountered many industrial workers today. The cement plant has production machines with high noise level. The noisy environment will arise risks on workers. The purpose of this study was to determined noise level and its effect on workers in a cement plant. The noise intensity was measured at three area of the plants; raw mill, cement mill, and sillo raw mix. There were 23 measuring points where considered as hazardous potential to workers. The measurement was carried out seven times during three days on each area. To found effects of noise exposure on workers by questionnaires. It used to found existing of physiological, psychological, and communication disturbs. The results indicated that all measured points exceeded the threshold limit value 85 dBA for 8 working hours. Raw mill and sillo raw mix have the highest equivalent noise level where each area reached 118,1 dBA and 119 dBA. The highest annoyance based on workers response was communication disturbs. Recommendations for reducting this negative effects had given technically, administratively, and control noise at receiver.
Keywords: *noise level, effects of noise exposure, cement plant*

1. BACKGROUND

Noise is an important factor that affects work environment, and consequently affects workers' healthy and efficiency. (Noweir et al., 2012) (Orkomi et, 2013). Prolonged exposure to noise may present significant demage for workers and those in the surroundings. In the work environment, the disturbing sounds not only affect the hearing of employees but also have physiological and phychological implications (Qiu and He, 2013). Hearing losses are the most common effects among the physiological ones. Blood pressure increases heartbeat accelerations, sleeping disorders may be considered among the other physiological effects. The psychological effects of noise are more common compared to the psychological ones and they can be seen in the forms of annoyance, stress, anger and concentration disorders as well as difficulties in resting and perception. (Atmaca, et al, 2005). Noise is also cause disturbs in communication. Noise can disrupts conversation thus impedes delivery of verbal information. (Saputra, 2007). A study indicated that noise at work area of power plant significantly affect the performance of workers. (Kholik and Krishna, 2012). A study found a fact where work environment with high intensity noise caused light deafness of some workers (Kusmindari, 2008).

Some countries have regulation about noise intensity in the industry. Indonesia government had issued Kep-51/MEN/1999, while in USA through NIOSH had made threshold of noise exposure to workers where noise level at 85 dBA for 8 hours of exposure time. This study aimed to determined noise level of some areas in a cement plant, to found effects of noise exposure on workers, and to made recommendation for reducting the effects.

2. THEORETICAL BACKGROUND

Noise is defined as annoying and unwanted sound. (Qiu and He, 2013). Sound is transmitted through the air by sound waves which are produced by vibrating objects. The vibrations cause a pressure wave which can be detected by a receiver, such as a microphone or the human ear. The ear may detect vibrations which vary from 20 to 20.000 (typically 50–16 000) cycles each second (or Hertz – Hz). Noise may be transmitted directly through the air,

by reflection from surrounding walls or buildings or through the structure of a floor or building. Sound intensity is measured by a unit known as a pascal (Pa – N/m^2). If noise was measured in this way, a large scale of numbers would be required ranging from 1 at one end to 1 million at the other. The sound pressure level (SPL) is a more convenient scale because it compresses the size of the scale by using a logarithmic scale to the base 10. It measures the ratio of the measured pressure, ρ, to a reference standard pressure, ρ_0, which is the pressure at the threshold of hearing (2×10^{-5} Pa).The unit is called a decibel (dB) and is defined as: (Hughes and Ferrett, 2007)

$SPL = 20 \log_{10}(\rho/ \rho_0)dB$

Sound pressure level is a measurement of the magnitude of the air pressure variations or fluctuations which make up a particular sound. dB(A) implies measurement of sound pressure level using the 'A' network of a sound pressure level meter. The 'A' network of such an instrument is the one which most closely follows the performance of the human ear. It should be appreciated that the decibel scale is a logarithmic scale (not a linear scale) and, on this basis, each increase in pressure of three dBA represents a doubling of the sound intensity. (Strank, 2008).

3. RESEARCH METHOD

This study was conducted at a cement plant that located in West Sumatera Province, Indonesia. The study is a descriptive research by analysis quantitatively. Sound level meter type SL-4030 (Figure 1) was used for measuring actual noise at three area of the plant. They were Raw Mill (9 points), Cement Mill (10 points), and Sillo Raw Mix (4 points). These area chosen due to considered their noise intensity are higher than others. Determining of measurement points based on position where workers doing their activity. Figure 2, 3, and 4 displays the noise measurement points of each area evaluated.

Figure 1. Sound Level Meter Type SL-4030

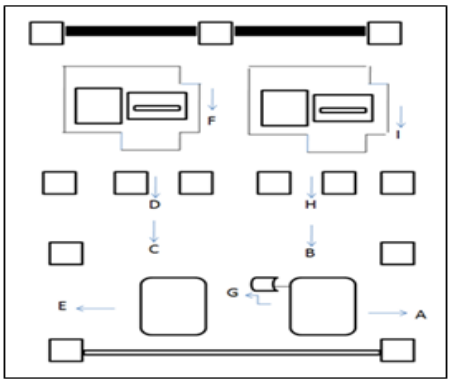

Figure 2. Measurement Points on Raw Mill

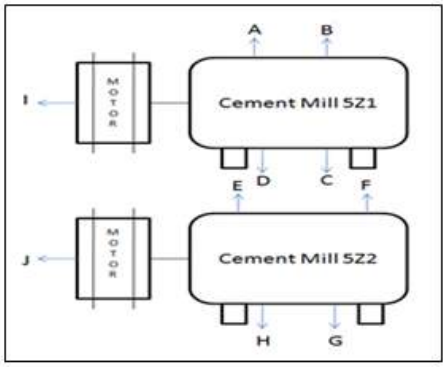

Figure 3. Measurement Points on Cement Mill

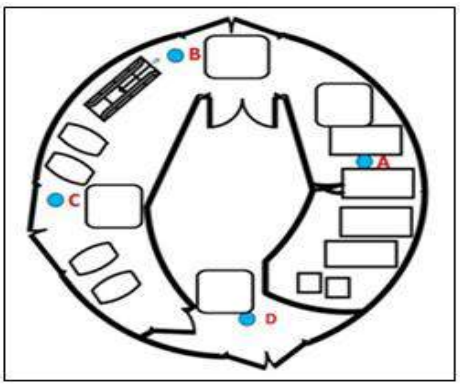

Figure 4. Measurement Points on Sillo Raw Mix

Noise intensity on each points were measured seven times in a day (07.30, 08.30, 09.30, 10.30, 11.30, 13.30, and 14.30) during three days consecutively. This measurement was done in April 2014. The measurement was only done on the first workshift due to time availability.

Noise intensity data was collected and then calculated the equivalent noise level (Leq) to represented noise level of three days using the formula : (Fredianta, 2013)

$$\text{Leq} = 10\,\text{Log}\{f_1\,10^{0,1L_1} + f_2\,10^{0,1L_1} + f_3 10^{0,1L_n}\}$$

Where : f = fraction of measurement, Ln = noise level on day-n (n = 3)

Next, calculating Leq to represented noise level of working duration (7 hours) with the same formula by setting n = 7.

The survey was carried out with the use of questionnaires to obtained effects of noise on workers subjectively. The questionnaire contained concise questions tailored towards getting reaction of workers about noise. The questionnaire was closed questions that related to physiological, psychological, and communication disturbs. The questionnaires are made based on (Kholik et al, 2012). Physiological aspect includes physicial disturbs, physicological aspect includes emotional, concentration disturbs, and communication aspect include annoyance in receiving information. The questionnaires were distributed to workers that work at three area. The results that obtained by questionnaires are collected to be analysed and made recommendation to reduced these effects.

4. RESULT AND DISCUSSION

4.1. Equivalent Noise Level

Having obtained the noise intensity data of each area for three days then done calculation to obtained the equivalent noise level to represented noise level of three days. As an example to point A of Raw Mill area at 07:30 WIB obtained intensity noise ; $L_{(day\text{-}1)}$= 119.3 dBA,$L_{(day\text{-}2)}$= 119.3 dBA, $L_{(day\text{-}3)}$=119.6 dBA. Then Leq can be calculated as follows:

$$\text{Leq} = 10\log\left\{\frac{1}{3}10^{0.1\text{x}119.3} + \frac{1}{3}10^{0.1\text{x}119.3} + \frac{1}{3}10^{0.1\text{x}119.6}\right\}$$

$$\text{Leq} = 119{,}4\ \text{dBA}$$

The summary of these equivalent noise level at Raw Mill, Cement Mill, and Sillo Raw Mix could be seen in Table 1, 2, and 3 below.

Table 1. Noise Equivalent Level on Raw Mill (Representing 3 Days)

Point	Equivalent Noise Level (dBA) at Time :						
	7:30	8:30	9:30	10:30	11:30	13:30	14:30
A	119.4	119.4	119.5	119.8	119.6	119.4	119.5
B	118.6	118.5	118.7	118.6	118.9	118.3	118.4
C	116.6	116.7	116.3	116.7	116.8	116.6	116.7
D	118.3	118.3	118.5	118.0	118.2	118.1	118.4
E	119.3	119.4	119.4	119.5	119.4	119.3	119.7
F	116.2	116.4	116.4	116.3	116.5	116.7	116.4
G	117.4	117.2	117.3	117.6	117.6	117.5	117.6
H	119.3	119.4	119.4	119.3	119.3	119.3	119.6
I	117.7	117.5	117.3	117.5	117.3	117.6	117.7

Table 2. Noise Equivalent Level on Cement Mill (Representing 3 Days)

Point	Equivalent Noise Level (dBA) at Time :						
	7:30	8:30	9:30	10:30	11:30	13:30	14:30
A	93.4	93.3	93.4	93.4	93.6	93.3	93.3
B	93.6	93.3	93.3	92.6	93.5	93.2	93.3
C	99.4	98.8	98.8	98.8	98.7	98.7	99.2
D	99.4	99.2	99.4	99.2	99.2	99.1	98.8
E	92.8	92.8	93.4	92.7	93.4	93.4	92.4
F	95.2	95.4	95.6	94.7	95.2	95.5	95.2
G	96.6	96.6	96.5	96.4	96.3	96.4	96.7
H	94.7	94.8	95.1	94.6	95.4	94.4	94.4
I	91.3	90.5	90.6	91.6	91.2	90.8	91.3
J	90.7	91.2	91.4	90.6	90.4	90.6	90.7

Table 3. Noise Equivalent Level on Sillo Raw Mix (Representing 3 Days)

Point	Equivalent Noise Level (dBA) at Time :						
	7:30	8:30	9:30	10:30	11:30	13:30	14:30
A	118.3	118.6	118.4	118.6	118.6	118.4	118.4
B	118.8	118.8	118.7	118.5	118.5	118.8	118.8
C	119.3	119.2	119.4	119.5	119.5	119.5	119.6
D	119.3	119.4	119.7	119.5	119.5	119.5	119.4

Next, the equivalent noise level was calculated to represented noise level of 7 working hours. As an example to point A of Raw Mill area had obtained : $Leq_{(07:30)}$ = 119.4 dBA, $Leq_{(08:30)}$ = 119.4 dBA, $Leq_{(09:30)}$ = 119.5 dBA, $Leq_{(10:30)}$ = 119.8 dBA, $Leq_{(11:30)}$ = 119.6 dBA, $Leq_{(13:30)}$ = 119.4 dBA, $Leq_{(14:30)}$ = 119.5 dBA. Then Leq can be calculated as follows :

$$\text{Leq} = 10\,\text{Log}\{f_1\,10^{0,1L_1} + f_2\,10^{0,1L_1} + .. f_7\,10^{0,1L_7}\}$$

Where :
F_1 = fraction of time 07:00-08:00 =1/7
F_2 = fraction of time 08:00-09:00 =1/7
F_3 = fraction of time 09:00-10:00 =1/7
F_4 = fraction of time 10:00-11:00 =1/7
F_5 = fraction of time 11:00-12:00 =1/7

F_6 = fraction of time 13:00-14:00 =1/7
F_7 = fraction of time 14:00-15:00 =1/7

$$\text{Leq} = 10\,\text{Log}\{\frac{1}{7}10^{0,1\text{x}119,4} + \ldots + \frac{1}{7}10^{0,1\text{x}119,5}\}$$
$$\text{Leq} = 119,5\ \text{dBA}$$

The summary of the equivalent noise level, threshold value limit (TVL), and reduction at Raw Mill, Cement Mill, and Sillo Raw Mix could be seen in Table 4, 5, and 6 below.

Table 4. Noise Equivalent Level on Raw Mill (Representing 7 Hours)

Point	Leq (dBA)	TVL (dBA)	Reduction(dBA)
A	119.5	85	34.5
B	118.6	85	33.6
C	116.6	85	31.6
D	118.3	85	33.3
E	119.4	85	34.4
F	116.4	85	31.4
G	117.5	85	32.5
H	119.4	85	34.4
I	117.5	85	32.5

Table 5. Noise Equivalent Level on Cement Mill (Representing 7 Hours)

Point	Leq (dBA)	TVL (dBA)	Reduction(dBA)
A	93.4	85	8.4
B	93.3	85	8.3
C	98.9	85	13.9
D	99.2	85	14.2
E	93.0	85	8.0
F	95.3	85	10.3
G	96.5	85	11.5
H	94.8	85	9.8
I	91.1	85	6.1
J	90.8	85	5.8

Table 6. Noise Equivalent Level on Sillo Raw Mix (Representing 7 Hours)

Point	Leq (dBA)	TVL (dBA)	Reduction(dBA)
A	118.5	85	33.5
B	118.7	85	33.7
C	119.4	85	34.4
D	119.5	85	34.5

The summary of average noise equivalent level dan reduction of all area could be seen in Table 7 below.

Table 7. Average Noise Level, TLV, and Reduction

Area	Leq (dBA)	TLV (dBA)	Reduction (dBA)
Raw Mill	118.1	85.0	33.1
Cement Mill	94.6	85.0	9.6
Sillo Raw Mix	119.0	85.0	34.0

As can be seen in Table 7 above, Raw mill and mix Sillo have the highest noise level. Overall, equivalent noise level of three area had exceeded Threshold Limit Value (TLV) of noise based are NIOSH Standard and Kep-51/MEN/1999 (85 dB for 8 hours exposure time). Look these standard in Table 8 below.

Tabel 8. Standard of Noise Level and Exposure Time

Exposure Level (dBA)	Duration	
	Hours	Minutes
85	8	0
86	6	21
87	5	2
88	4	0
89	3	10
90	2	31

Source : NIOSH 1998 and Kep-51/MEN/1999

As comparison to past researchs, (Orkomi et al, 2008) measured noise level at a cement plant in Iran where cement mill area reached (100.83 dBA) and raw mill area reached (99.15 dBA). (Atmaca, 2005) measured average noise level at cement plant in Turkey about 70 -106 dBA. It could concluded generally that cement plant had high noise level. Therefore need to be known effects of noise on workers.

4.2. Effects of Noise on Workers

The questionnaire forms were distributed to workers who will to filled the forms . The workers made of technicians and cleaning service personnels. There were 25 respondents at Raw Mill and Cement Mill, and 10 respondents at Sillo Raw Mix. Percentage of respondents to total workers on each area overs 50%. They have worked on these area at least 1 year. There were 5 questions that related to physiological disturbs, 3 questions related to psychological disturbs,, and 2 questions related to communication disturbs. Each question has three answer option (never, occasionally, and always). Point of concern was amount of answer ‘always’ due to it was indicated the presence of noise effects. Table 9 presented the summary questionnaire results.

Table 9. Summary of Questionnaire Results

Physiological	Raw Mill	Cement Mill	Sillo Raw Mix
Never	60.0%	28.0%	40.0%
Occasionally	16.0%	56.0%	48.0%
Always	24.0%	16.0%	12.0%
Psychological	Raw Mill	Cement Mill	Sillo Raw Mix
Never	60.0%	40.0%	60.0%
Occasionally	13.3%	40.0%	26.7%
Always	26.7%	20.0%	13.3%
Communication	Raw Mill	Cement Mill	Sillo Raw Mix
Never	10.0%	0.0%	0.0%
Occasionally	10.0%	40.0%	40.0%
Always	80.0%	60.0%	60.0%

To see distribution of noise effects on each area more clearly could see graph in Figure 5 below.

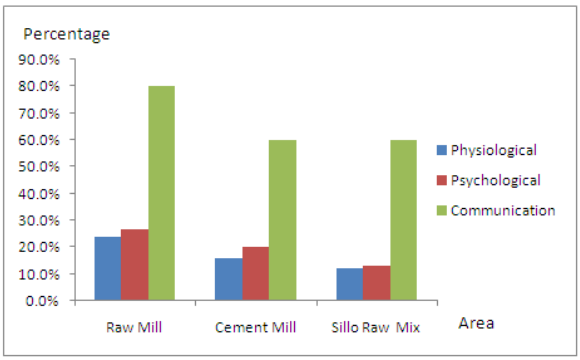

Figure 5. Noise Effects at Three Area

As could be seen in Figure 4 above, communication disturbs reached 60% to 80%, psychological disturbs reached 13,3% to 26,7%, and physiological disturbs reached 12 % to 24 %.

4.3. Recommendations to Reduce Effects of Noise

Based on the obtained results, noise level exceeded the standards and noise effects were exist on workers, it was needed efforts to reduce effect of noise exposure on workers. People who are exposed to noise in excess of 85 dBA on a continuous or intermittent basis stand the risk of going deaf, ie noise-induced hearing loss or occupational deafness. (Strank, 2008). For the average individual, no hearing loss will occur if the sound level is below 80 dBA. (Okoro, 2014).

Noise control efforts that can be done include control technically, administratively, and noise control at the receiver. (Bachtiar, et al., 2013). Technically, include installation of replacing or modifying noisy machines, maintenance of machines, isolating noise sourcesor vibration. (Noweir et al., 2012) Administratively, include rotation of workers from noisy area to quieter areas that means reduction of the time during which people are exposed to noise. (Stranks, 2008). Noise control at receivers means reduced the level of noise received by workers using earplug and earmuff hearing. Using earplugs can reduce noise of ± 30 dBA, while earmuff can reduce the noise a little bigger that between 40 dBA – 50 dBA. (Bin and Richardson 2010) (Fredianta, et al., 2013). Thus, noise exposure on the operator will be in a safe level. In fact the company has provided ear protective equipments and has included in Standard Operation Procedure (SOP) in the plant. However by observation, the workers were reluctant to use them. Therefore it is necessary to socialize the benefits of using ear protective equipments to workers.

However, using earplug and earmuff can make delivery of information delivery through auditory displays include voices, alarms become not effective. It was recommended to use visual display at noisy environment. It was recommended firstly to make technically efforts. Because, using of personal protection relies heavily on the exposed person using this equipment while exposed to the particular noise level and, as such, will never be a perfect solution to the problem. (Stranks, 2008).

5. CONCLUSIONS

The study found all measurement points at Rawmill, Cement Mill, and Sillo Raw Mix area exceeded threshold value. The dominant effect of noise exposure on workers is communication disturbs. The recommendations for reducting effects of noise had given technically, administratively, and control noise at receiver. The limitation of this study were not considered the noise level at night time as comparison. The research can be developed by noise mapping as the first step to solve noise technically.

6. ACKNOWLEDGEMENTS

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