Noise investigation in a small muffler industry in Purbalingga, Indonesia

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Abstract. Noise can occur in the work environment and as a factor of dissatisfaction in residential areas, therefore controlling noise is needed. The noise level generated by the muffler production process in a small muffler industry can exceeds the threshold standard at 85 dB of 8 hours work. This study identifies the value of noise at the points of the production process at the muffler industry process and location mapping. Noise assessment is carried out at 5 points different metal working task location. The loudest noise is at the measurement was the grinding points with a noise exposure of 102.04 dB, and the average noise in parallel process was 95.38 dB. The measurement shows the location near to the source of loud noise will increase the amount of noise level, which was the grinding machines increases the noise level for other processes. Overall the noise exposure of all sampling points in parallel process was above standard noise level Kepmenaker no. 5 of 2018, however in individual process only beatings plates and grinding task were exceeds.

1. Introduction
Noise is unwanted sounds by the ear which can interfere with concentration, communication, and for a long term can cause hearing damage [1]. Noise exposure is one of the most important environmental pollutants in many occupational and non-occupational setting [2]. Noise can be factor in dissatisfaction with the environment in residential areas [3]. Noise also can occurs in the work environment, as a global health problem especially among industrial workers [4],[5]. Occupational noise exposure associated with increased accident and injury risk, and also the cause of 16% of adult-onset hearing loss globally [2]. This led of policies on controlling noise and methods of assessing the impact of noise [3] and WHO uses evidence on the health effects of noise to identify the needs of vulnerable groups and to offer technical based recommendations on average environmental noise exposure [6].

There are three important aspects to determine the level of noise interference, which are the length of exposure, intensity, and frequency [1],[7]. Noise pollution that exceeds the recommended safe limit affecting comfort and health of operators and neighboring population [8]. Noise not only can affect human health but also people’s work activity [3-4]. Occupational noise exposure causes acute increases of noradrenaline and blood pressure. People who reported noise disturbances at work and at home show higher morbidity [10], with noise sensitivity as a prominent reaction modifier [11]. The results of various studies show that under conditions of excessive noise can cause health problems such as annoyance, decreasing performance, fatigue, sleep disturbance, stress, and noise induced hearing loss hearing loss, etc. [3],[9],[11-14]. Therefore, to consider the health, comfort and performance of worker, one of major key area to provide a better working environment is environmental ergonomics [15]
Small to medium-sized industry (SMEs) are a key sector in country’s economy [16]. To support and strengthening the regional superior products of small industry, policy scope reduced from city to districts policy [17]. Purbalingga District of Central Java province has superior local products in the form of the exhaust or muffler of a motorbike or a car and it has entered the global market. This study conducted at MMS K4471NE as a small muffler enterprise in Purbalingga has been established for 60 years. The average production reaching 10,000 units of muffler per month. The use of technology of the exhaust production is mostly using conventional technology [17]. The production process of MMS K4471NE muffler was done by semi-manually, with several processes using the production machine. The production process includes cutting plates, rolling plates with beatings, cutting with cutting grinders, welding and finishing with polishing machines.

The more the amount of production, the higher the environmental impact produced [18]. There is a need strategic noise mapping for noise investigation in the muffler industry as a preliminary study to control the impact of noise.

2. Research Methodology
Occupational health and safety (OHS) problem in SMEs are not different from larger industry [16]. This study identifies the value of noise at the points of the production process at the muffler industry location. The results obtained are then compared with the noise value of each process to get the engine source which causes the biggest noise impact. Noise investigation is carried out by measuring the noise level with sound level meter, processing noise data, and analyzing the data.

2.1. Noise measurement at each point of the muffler production process.
Noise assessment was carried out in each muffler production process (5 different metal working task location) for RX King Telo product using a environmental meter. In muffler industry, the workforce works for 8 hours with 6 working days. Noise is measured in two conditions; the first condition was including all machines working on parallel activities and the second condition was only one machine in operation activity (non-parallel). The method of measuring noise carried out refers to the study [19] where measurements were carried out for one minute with readings every 5 seconds, so that there were 12 data noise in each process. Figure 1 shows the production layout of the muffler with number 1 to 5 indicated the noise points to be measured and A to I as location in operation floor.

![Figure 1. The distribution of sampling point in process zone](image)
Noise measurement is carried out at a distance of 1 meter horizontal axis and 1.2 meters vertical axis from the noise source or process machine [5]. The 5 points of noise measurement are cutting plates, rolling plates with beatings, cutting with cutting grinders, welding and finishing with polishing machines. The sequence of the manufacturing process of the muffler is as Table 1 showed.

### Table 1 Muffler Manufacturing Process

| Process                  | Measurement Points | Sequences                                                                 |
|--------------------------|--------------------|---------------------------------------------------------------------------|
| 1                        | Cutting Plates     | Plate Cutting process using sitting scissors                               |
| 2                        | Beatings           | Beating process, the cutting plate will be rolling with beatings using a hammer. |
| 3                        | Cutting with Grinders | Grinding process, useful for smoothing the muffler parts that have been beatings before |
| 4                        | Welding            | Welding Process. using argon welding serves to connect the muffler parts   |
| 5                        | Finishing with Polishing Machines | Finishing process, using a polishing machine to smooth the finished muffler completely |

#### 2.2. Noise data processing

Commonly intensity is measured in decibels (dB) which shows the magnitude of the energy flow of broad unity [1]. The noise value from the next observation will be converted in the form of Leq. Leq is a certain value of noise from noise that fluctuates for a certain time and is equivalent to a fixed noise level at the same time interval [20]. Here is the equations of Leq [4]:

$$Leq = 10 \log \left\{ \frac{1}{N} \left[ \left(10^{\frac{L_{t1}}{10}}\right) + \left(10^{\frac{L_{t2}}{10}}\right) + \ldots \left(10^{\frac{L_{tn}}{10}}\right) \right] \right\} \quad (1)$$

Where Leq is equivalent continuous sound pressure level in decibels, $L_{t1}$ is sound pressure level in $t_1$ period, $L_{tn}$ is sound pressure level at $t_n$ period, and $N$ is the number of data. The Leq value per process will then be combined into a total noise level with equation 2 [21].

$$L_{total} = 10 \log \left( \sum_{i=1}^{n} 10^{\frac{Leq_i}{10}} \right) dB \quad (2)$$

#### 2.3. Comparing the measurement result

After getting the results of processing noise data, then the processing noise data are then analyzed. The analysis is done by charting and contouring maps based on coordinate data and noise values. Coordinate data is obtained by drawing layouts and contours map.

### 3. Result and Discussion

#### 3.1. Noise data processing

Noise is measured by sound level meters in two conditions, namely when all machines work (parallel) and only 1 machine works (non-parallel). Table 2 shows the results of noise measurements for both conditions based on equation (1) and equation (2).

### Table 2 Noise Measurement Result (Leq)

| Measurement points                  | Parallel condition (dB) | Non-parallel condition (dB) |
|-------------------------------------|-------------------------|-----------------------------|
| Cutting Plates                      | 96.71                    | 73.48                       |
| Beatings Rolling Plates             | 98.93                    | 98.97                       |
| Cutting with Grinders               | 101.03                   | 102.05                      |
| Welding                             | 86.09                    | 65.1                        |
| Finishing with Polishing Machines   | 94.16                    | 82.92                       |
Noise in grinding process has the greatest value for both parallel conditions and non-parallel conditions, namely 101.03 dB and 102.05 dB. The sequence of noise values for each measurement point with parallel condition is grinding process 101.03 dB, rolling plates with beatings 98.93 dB, cutting plates 96.71 dB, polishing 94.16 dB and welding 86.09 dB. While the results of noise value measurements for non-parallel conditions give the sequence of noise values as follows grinding process 102.05 dB, rolling plates with beatings 98.97 dB, polishing 82.92 dB, cutting plates 73.48 dB, and welding 65.01 dB. The Figure 2 and Figure 3 is a graph of the comparison of noise values with acceptable noise for parallel conditions and non-parallel conditions.

![Noise in Parallel Condition](image)

**Figure 2.** Noise measurement at parallel condition

The measurement results with parallel conditions in Figure 2, showed all the value of noise generated from the muffler production process exceeds the statutory occupational noise exposure limit of 85 dB by Ministry of Labor Indonesia (Kepmenaker) No. 5 of 2018 [22]. While Figure 3 showed a graph of the noise value generated from non-parallel conditions. The value of noise produced is still below the threshold, such as cutting plates, welding and finishing.

![Noise in Non-Parallel Condition](image)

**Figure 3** Noise measurement at non-parallel condition

The noise value from the cutting plate process point in the parallel condition becomes much louder than the non-parallel conditions because the cutting plates location near beating rolling plates area.
Likewise, welding and polishing processes located near the grinding process also influenced by increased intensity of noise.

3.2. Noise Mapping
Strategic noise mapping is a step to identify and evaluate the environmental impacts caused [23-24] and many industry have developed noise maps for identification and evaluating the effects of noise [13][25]. In this study, noise identification was also carried out by drawing noise contours. Figure 4 shows of noise measurement result where all the activity on processes parallell condition. The location with the loudest noise value was at the cutting point of the grinder machines at 101 dB. The red color indicates the area with the largest noise value. In Figure 4 this also shows the noise generated by the cutting process with the grinding being one of the centers of noise which has an impact on other processes. Cutting process location (D), which is close to rolling plates with beating process (H), causes the value of noise generated in some areas of H to be greater.

Figure 4. Contour map for noise distribution at muffler production

Contour distribution showed the noise spread in process floor of muffler production. Occurrence of noise because mechanical operations was common and usually unavoidable in production [26], on idling or in operation [27]. Working in machine in loud noise can make headache, sleeplessness and stressed [8]. Moreover, studies show that steady noises above 80 dB are capable of producing some change in auditory threshold, while the average noise exposure as low as 85 dB may elevate injury risk and this association appears independent of job-specific injury risk [2][9]. This investigation is to decide what need to do to ensure the health and safety of the workers. The type assessment will depend on scope and the extend problem of the work place, but all risk should be considered [15]. To reduce noise often a combination works best with control measures as: elimination or control of noise source, work layout arrangement and personal protective equipment [15][26], for example [27] reduce noise by scheduling plans while [16] suggest replacement of machinery with low noise technology and suitable ear muffs.

4. Conclusions
In this research, noise investigation on parallel and non-parallel production processes can identify the process that is the source of the noise that exceeds the acceptable noise i.e. cutting process with grinder and rolling plates with beating. This study also indicates the loudest noise based on first condition and
the location near to the source influenced by increased level of noise. Therefore, some policies to reduce noise impacts, i.e. redesign production layouts, production scheduling and technological changes in the muffler production process, can be a further research topic.

**References**

[1] Sutalaksana I Z, Anggawisastro R and Tjokroatmadja J H 2006 *Teknik Perancangan Sistem Kerja* (Indonesia: ITB Bandung)

[2] Cantley L F, Galusha D, Cullen M R, Dixon-Ernst C, Rabinowitz M and Neitzel R L 2015 Association between ambient noise exposure, hearing acuity, and risk of acute occupational injury *Scand. J. Work. Environ. Heal.* 41–1 pp 75–83

[3] de Kruif H and Stoter J 2003 Noise mapping and GIS: Optimising quality and efficiency of noise effect studies *Comput. Environ. Urban Syst.* 27–1 pp 85–102

[4] Scandari A 2018 Evaluation of Noise Pollution in Small Workshops in Qom, Iran; and Its Situation Compared to National Noise Standards *Arch. Hyg. Sci.* 7–3 pp 157–164

[5] Juliansyah H 2016 Penentuan Tingkat Kebisingan Pada Area Pengolahan Sekam Padi, Siltstone Crusher, Cooler Dan Power Plant Pada Pt Lafarge Cement Indonesia-Lhoknga Plant *J. Islam. Technol. 2*–2 pp 127–142

[6] Joseph W S 2009 Night noise guidelines for Europe *J. Am. Podiatr. Med. Assoc.* 100–5 pp 1–162

[7] Carolina M C 2016 *Analisis Potensi Bahaya Kebisingan Di Area Produksi P.T. Semen Bosowa Maros J.* (Indonesia: Tugas akhir Hasanuddin Univ.)

[8] Elias E, Majaja B A, Ibrahim S and Emmanuel G R 2014 Noise Pollution in Maize Milling SMEs *Tanzania J. Eng. Technol.* 35–1 pp 34–45

[9] Ward W D 1993 Developm ents in noise induced hearing loss during the last 25 years *Proc. 6th Int. Congr. Noise as a Public Heal. Probl. Institut Natl. Rech. Sur Les Transp. Leur Secur.* (France: INRETS)

[10] Hartmut I and Ekkehard R 1993 Comparison of Acute Reactionns and Long-Term Extra Aural Effect of Occupatinal and Environmental Noise Exposure *Proc. 6th Int. Congr. Noise as a Public Heal. Probl. Institut Natl. Rech. Sur Les Transp. Leur Secur.* (France: INRETS)

[11] Job R F S 1996 The influence of subjective reactions to noise on health effects of the noise *Environ. Int.* 22–1 pp 93–104

[12] Lercher P 1996 Environmental noise and health: An integrated research perspective *Environ. Int.* 22–1 pp 117–129

[13] Hebrani O, Madonna S and Nurseyowati P 2018 the Effect of Noise on Work Fatigue in an Oil and Gas Industry *Indones. J. Urban Environ. Technol.* 1–2 p 109

[14] Haron Z. 2015 A preliminary study of occupational noise exposure among leaf blower and grass cutter workers in public university *J. Tekno1.77–16 pp 153–159

[15] Qutubuddin S. M., Hebbal S S and Kumar A C S 2012 A Review on Effect of Industrial Noise on the Performance of Worker and Productivity (PDF Download Available) *Int. Rev. Appl. Eng. Res.* 2–1 pp 43–54

[16] Seneviratne M and Phoon W O 2006 Exposure Assessment in SMEs: A Low-Cost Approach to Bring OHS Services to Small-Scale Enterprises *Ind. Health* 44–1 pp 27–30

[17] Wijaya A A and Widiyanto D 2015 Analisis kesiapan industri knalpot Kelurahan Kembaran Kulon sebagai One Village One Product (OVOP) di Kabupaten Purbalingga Provinsi Jawa tengah *J. Bumi Indone1*s 1–4

[18] Masrurroh N 2011 Analisa Penjadwalan Produksi Dengan Menggunakan Metode Amphell Dudeck Smith, Palmer, Dan Dannenbring Di Pt.Loka Refraktoris Surabaya *Tekmapro 1–1 pp 158–171

[19] Metawati N, Busono T and Siswoyo S 2017 Evaluasi Pemenuhan Standar Tingkat Kebisingan Kelas Di Smnp 23 Bandung *Innov. Vocat. Technol. Educ.* 9–2 pp 145–156

[20] Rudini H P 2016 Analisa Kebisingan Akibat Aktivitas Transportasi Di Jalan Ahmad Yani Kota Sorong *J. Tek. Sipil Univ. Muhammediyah Sorong* 48 pp 1–9
[21] Kurnia M, Isya M and Zaki M 2018 Tingkat Kebisingan Yang Dihasilkan Dari Aktivitas Transportasi (Studi Kasus Pada Sebagian Ruas Jalan : Manek Roo, Sisingamangaraja Dan Gajah Mada Meulaboh) J. Arsip Rekayasa Sipil dan Perenc. 1–2 pp 1–9

[22] M. K. R. Indonesia 2018 Peraturan Menteri Ketenagakerjaan Republik Indonesia Nomor 5 Tahun 2018 Tentang Keselamatan Dan Kesehatan Kerja Lingkungan Kerja (Indonesia)

[23] Vogiatzis K 2012 Airport environmental noise mapping and land use management as an environmental protection action policy tool. The case of the Larnaka International Airport (Cyprus) Sci. Total Environ. 424 pp 162–173

[24] Murphy E and King E A 2014 Environmental Noise Pollution: Noise Mapping, Public Health, and Policy, Elsevier Inc. pp 81–121.

[25] Zajamsek B 2019 Experimental and numerical investigation of blade–tower interaction noise J. Sound Vib. 443 pp 362–375

[26] Kumar C V, Murthy C S and Vardhan H 2016 Noise Assessment in Mines – A Critical Review Concurr. Adv. Mech. Eng. 2–1 pp 6–11

[27] Yin L, Li X, Gao L, Lu C and Zhang Z 2017 Energy-efficient job shop scheduling problem with variable spindle speed using a novel multi-objective algorithm Adv. Mech. Eng. 9–4 pp 1–21