Real-time Noise Risk Assessment as Preventive Action to Occupational Disease in A Pharmaceutical Industry

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Abstract. Noise is a form of dangerous exposure that occurs around humans because of sound sources from industrial machines, work equipment, alarms, transportation equipment, etc. Continuous exposure to noise with noise levels higher than 85 dBA can lead to psychological and psychological health problems. The aim of this research is to identify the intensity of noise in the pharmaceutical industry and to map the noise to humans. Noise evaluation began by conducting a survey of conditions on the production floor by arranging a production floor layout accompanied by the location of machines and other work facilities. The next step was to determine the size and number of networks that would help in identifying interference measurement points. It took around 100 points to identify interference and then measurements were carried out using a noise meter with 6 repetitions per point. The equivalent continuous sound pressure level (Leq) was calculated first before being used as input to the Surfer software to obtain interference on the production floor. The research results showed that there were 100 points spread across 12 workstations in this drug manufacturing industry. The results showed that there were 19 points that received interference ≥ 85 dBA. The areas with the biggest disturbances were the EPM machine area, spooling machine, and slitting room.

1 Introduction

The production process in the manufacturing industry is required to be able to compete to meet demand targets and achieve the expected quality targets. These conditions lead to industry being designed to use machines to increase productivity and accuracy. In addition, machine operations are carried out 24 hours or continuously. Even though the production process is automated, it still involves humans as the controllers. Machinery in industry has a positive impact on increasing company productivity. Nevertheless, it also has a negative impact on workers’ health. Industrial machines that are in operation will make sounds or noises due to the work process between machine parts. Sounds that are not desired by
humans, such as the continuous sound of machinery, are known as noise. Several activities that have the potential to cause noise sources exceeding the threshold range from upstream industries such as open-pit coal mining (1), coal handling machines (2), natural stone processing industries (3), metal industry (4), to downstream industries such as the tissue paper industry (5).

Threshold Limit Value (TLV) is a standard of hazard factors in the workplace as the level/intensity of time weighted average that workers can accept without causing disease or health problems, which in daily work refers to a time not exceeding 8 hours a day or 40 hours a week. The TLV for noise is set at 85 decibels A (dBA) (6). Continuous noise exposure with noise levels higher than 85 dBA can result in negative physiological and psychological effects. The physiological effects may include hearing loss (7), increased heart rate (8), increased blood pressure (9,10), coronary heart disease (11), and vertigo (12). Meanwhile, the psychological effects of noise can be observed from repetitive stress injuries, impaired concentration (13), communication disorders (14), and sleep disorders (15).

Various studies described previously used direct measurements to obtain noise intensity values. On the other hand, there are also studies that describe noise exposure using noise mapping in an urban area in Greece (16) or a campus environment (17). However, there has been no research that utilizes noise mapping to describe noise exposure on the production floor. Noise mapping is a map of an area that is coloured based on the noise level of that area. Noise mapping not only shows the noise value at one point but can also show predictions of its distribution in an area. With this capability, noise mapping can be employed to determine machine noise exposure not only to the operator operating the machine, but also to operators in the surrounding area.

The number of pharmaceutical chemical industries (drugs or cosmetics) in Indonesia tends to increase from year to year. According to BPS data, there are 256 medium industries in this sector, one of which is factory A. The pharmaceutical industry, which is classified as a medium – large industry, uses various machines operated both automatically and semi-automatically. In factory A, there are 5 types of machines used to produce plaster products. Each machine produces sound that needs to be evaluated whether it poses a risk of noise exposure or not. In addition, the number of studies on noise using noise mapping in Indonesia is still limited. Therefore, this research has the potential to be developed.

From this description, this research will identify the noise points on the production floor and the noise values at these points by taking direct measurements. After that, a diagnosis will be carried out using noise mapping to determine the distribution of noise on the production floor. It is expected that this research will produce recommendations for reducing noise in the pharmaceutical industry, creating a safer and healthier work environment, and contributing to occupational health and safety science, especially on the topic of noise.

2 Methods

This research starts with calibrate the measurement tool. It used to measure noise in the work environment is a sound level meter (SLM). A sound level meter (SLM) consists of a reading display, microphone, amplifier, and electronic circuits. The microphone on the sound level meter is utilized to detect small air pressure variations associated with sound and turn them into electrical signals that will be processed by electronic circuit of the instrument. The
Measurement of noise in the work environment can be carried out by a sound level meter. There are three steps of measuring noise at work sites as follows:

1. Measurement with sampling points
   Measurements with sampling points are carried out when noise that exceeds the threshold value only occurs at one or a few locations. Measurements with sampling points are carried out to evaluate the noise caused by simple equipment, for example a compressor or generator. The measurement distance from the noise source must be stated, for example 3 meters from a height of 1 meter. In addition, the direction of the microphone of the measuring device used must be considered.

2. Measurement with grid
   Measuring with a grid is to create a sample of noise data at the desired measurement location. Sampling points are made at equal intervals throughout the measurement location. The measurement location is divided into several boxes of the same size and distance, for example: 10 x 10 m. In order make the identification of the boxes easier, they are marked with rows and columns. According to the Minister of Health of the Republic of Indonesia, noise level standards are the maximum limit of noise levels that are permitted to be released into the environment from businesses or activities so that they do not cause harm to human health and environmental comfort. In general, the environmental noise measurement used is the equivalent continuous sound pressure level ($L_{eq}$) with a reference time of 24 hours ($T = 24$).

   Hence, $L_{eq}$ (24 hours) can be calculated using the following formula:

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   L_{eq} \text{ (24 jam)} = L_{SM} = 10 \log_{10} \left[ \frac{1}{T} \left( \sum_{i=1}^{24} t_i \times 10^{L_i/10} \right) \right] \tag{1}
   \]

   In which:
   - $L_{SM}$ is the day-night noise level.
   - $L_i$ is the instantaneous sound pressure level in the time interval $t_i$.

3. Measurement with contour maps
   Measurements with contour maps are useful for determining an image of noise conditions in the coverage area. Measurements with contour maps are carried out by making an isopleth drawing on scaled paper that corresponds to the noise measurement to be carried out. On the contour map, to describe the noise situation, a colouring code is created, in which green is for noise levels with an intensity below 85 dBA, orange is for high intensity noise levels above 90 dBA, and yellow is for noise levels with an intensity between 85 - 90 dBA.

3 Result and Discussions

This research was carried out in one of the manufacturing industries in the field of medicines and cosmetics, with plaster (bandage) as one of the final products. The factory location has an area of more than 4 hectares, with facilities that include an office, two production factories, parking lots, roads, and rest areas. The company operates a Wastewater Management Installation to control liquid waste contamination in accordance with government regulations because the factory location is quite close to residential areas. There are ± 358 employees working in the company with a proportion of 229 permanent employees consisting of 128 people in the production department and 101 in other managerial roles.
departments and supported by 129 contract employees. Working hours at the factory last for 5 working days per week with 8.5 working hours per day.

The plaster production process begins with receiving raw materials in the form of rubber which is first weighed in the weighing room. Any rubber that complies with applicable regulations is taken to the granulator machine to be crushed, while inspection activities for defects resulting from the granulator machine are carried out. In the next process, the crushed rubber is taken to the mixing room to be mixed with other additional materials, to the coating room (restricted area), and then to the slitting room (A2) to be cut into mother roll according to the specified specifications. The results of the work in process product in the form of mother rolls are stored in room A3 for plaster products and room B13 for patch products. The mother rolls will be converted into 3 products, i.e., elastic plaster, roll plaster, and patch. To convert it into elastic plaster, the mother roll is processed using an EPM machine (A7). To be converted into plaster roll, the mother roll is processed with a spooling machine (A6). Meanwhile, to turn it into a patch, the mother roll is processed with a dressing machine (A5). The finished plaster products are taken to the manual packing (MP) section to be packaged into final products, while the patch products are taken to the patch packing room (B12).

The production floor layout that was drawn was then added with supporting lines in the form of a grid. The grid was created on the x-axis and y-axis with the same size scale so that matrices were produced in the layout. On the x-axis, 39 points were produced, and, on the y-axis, 14 points were produced with the same scale. These auxiliary lines will help when determining noise measurement points. Some of the results of adding a grid is depicted in Figure 8. In addition to the grid, noise measurement points were also determined which were spread across each workstation. There were 100 points (nodes) that were used as noise measurement points. More details regarding the layout image accompanied by a grid and noise measurement points can be obtained in the attachment section.

During the research, there were no additional machines and other tools that could increase the noise intensity, and the tools used for production operations were the same. Therefore, the noise intensity was not much different compared to each working day. The type of noise in the production section is a continuous type of noise caused using several machines, i.e., 6 EPM machines and 5 spooling machines. The 3 dressing machines and 1 techno machine are not activated. By using equation (1), the continuous sound pressure level obtained for the plaster and patch production area is as shown in Figure 1. These results are compared with the Noise Threshold Value according to government regulations, i.e., 85 dBA for 8 hours of work.

![Fig. 1. Noise exposure nodes value (dB)](image-url)
Noise Mapping is a method for measuring noise at each point to attain a representation of sound exposure in a certain area. Mapping in this regard is the mapping of sound pressure levels at the points being studied or points that are used as references. Noise mapping was created using Surfer software. To develop a noise mapping model, first enter the X and Y coordinate data. The X coordinate values were 0 to 39 which were filled with 40 nodes with spacing 1. Meanwhile the Y coordinate values were 0 to 14 which were filled with 15 nodes with spacing 1. Then the equivalent noise value was entered into the data and the run button was pressed to carry out the mapping process to produce a contour image as in Figure 2.

![Figure 2. Noise mapping of pharmacy shop floor (dB)](image)

Based on Figure 2, it is discovered that there are dark red areas, especially areas close to the EPM machine and spooling machine. The darker the red colour indicates an increase in noise intensity. The production floor area is mostly orange which still indicates a noise intensity of 60 dBA to 80 dBA. This occurs due to the exposure of machine noise to other rooms and there is no effective control mechanism to reduce this intensity.

Over exposure of noise to human could affect the human’s health and severe occupational disease. Implementing noise reduction measures need as preventive action, such as installing sound-absorbing materials, adjusting the layout of the shop floor, or using quieter equipment. It could also involve training staff on noise reduction techniques, such as minimizing unnecessary noise or using noise-reducing equipment. Monitoring and evaluating the effectiveness of noise reduction measures involve regularly monitoring the noise levels in the pharmacy shop floor and evaluating the effectiveness of the noise reduction measures implemented. This could include conducting regular noise assessments and adjusting as necessary. Management could also consult with experts to ensure that the noise reduction measures are effective and comply with relevant regulations and guidelines.

Studies on noise still have high potential for development. If humans still play a role in the production process using machines, there is a potential health and safety hazard to human life. However, creating a very safe workspace is difficult for companies since there is a trade-off between achieving production targets and human safety factors. However, if this is neglected, the risk of developing conditions of mental and physiological imbalance in workers will be even greater.

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References


