Temporal and Spatial Analysis of the Occupational Noise at Rice Mill in Kedah

A Abu Mansor1, S Abdullah2, M A Ahmad Nawawi2, A N Ahmed3,4, N N L Mohd Napi2 and M Ismail1,2*

1 Faculty of Science and Marine Environment, University Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.
2 Air Quality and Environment Research Group, Faculty of Ocean Engineering Technology and Informatics, University Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.
3 Institute of Engineering Infrastructures, University Tenaga Nasional, Bangi, Selangor, Malaysia.
4 Faculty Engineering, Universiti Tenaga National, 43650 Bangi, Selangor, Malaysia.
*Corresponding author: marzuki@umt.edu.my

Abstract. Noise or unwanted sound, is considered as occupational pollution, especially one that is loud or unpleasant or that causes disturbance to human and surroundings. Occupational noise is a noise emitted from various industries that effect the workers’ safety and health. A prolonged exposure towards noise can bring negative effects to the receptor, resulting in noise induced hearing loss (NIHL) diseases. The state of Kedah is known as the rice bowl of Malaysia, producing more than half of the country's home grown rice supply. Majority of the rice mill is situated in Kedah where the major occupational hazard for the workers is noise during the operation of various machines to convert paddy to rice. The aim of this study is to assess the noise risk assessment in the rice mill. The noise level was measured during working hours of 0900hrs – 1800hrs for three consecutive days using sound level meter. The evaluated daily noise level did not exceeded the limit enacted by the Occupational Safety and Health (Noise Exposure) Regulation, 2019 but there were occasions the reading surpassed the limit, ranging from 86.5 dBA to 90.3 dBA. Measurement of noise exposure at 1-meter distance for machineries located in the rice mill was also conducted and the most critical location in the rice mill is the Rice Huller machine. Noise sources from the machinery shows strong negative correlation with noise level (r = -0.97, p<0.05) (Air Blower), (r = -0.94, p<0.05) (Rice sieving), (r = -0.98, p<0.05) (Air Pump), (r = -0.95, p<0.05) (Rice Huller) and (r = -0.95, p<0.05) (Rice Polisher), correspondingly. The findings from this study is important for the company management team as abatement measures for the employees in providing a more conducive working environment and indirectly increases the productivity of the company.

1. Introduction
High exposure of noise experienced by industrial workers may cause both auditory and non-auditory harmful effects [1]. In Malaysia, to protect the workers from excessive exposure to noise, the Occupational Safety and Health (Noise Exposure) Regulation 2019 was introduce during hearing conservation program [2]. The employee shall not be exposed to noise level exceeding equivalent continuous A-weighted sound pressure level of 85 dB(A) or exceeding the limits specified in the First Schedule or exceeding daily dose of unity [3-5]. The recommended noise exposure limit for occupational noise based on United States National Institute of Occupational Safety and Health is 85...
dB(A) and if the level is at or above level, it is considered hazardous [6]. High level of occupational noise remain a problem in all regions of the world caused by motor vehicles and various type of industry [5]. In Asia, rice is a primary staple food where nearly 90% consumed it and in recent year, rice plantation has increases up to 154 million hectares [7]. Increasing rice plantation and high demand of rice, directly caused high demand for rice mills industry. In industrial and manufacturing environments, one of the most common occupational health hazard is noise pollution that comes from processing that involves machinery. Workers at rice mills industry must protect and maintain their healthy in terms physical and psychological [8]. The aim of this study is to assess the occupational noise at rice mills industry. The results of the noise exposure at the rice mill industry can be used as reference for workers and employer about the effects towards their health due to noise exposure at the workplace.

2. Materials and Methods

2.1. Site selection
This study is conducted at Jabi Rice Mill Sdn. Bhd, Pokok Sena Kedah Darul Aman, Malaysia (6°08’ 59.68” N; 100°28’ 20.54” E) (Figure 1). Jabi Rice Mill factory was divided into two part that involves processing machine area (S1) and packaging area (S2). S1 involves process such as drying, removal of husk, separation of rice grain, polishing of rice at place for subsequent collection at gunny bags and S2 contains packaging machine. The spatial noise measurement made at S1 with 38 sampling points and S2 involved 16 sampling points around paddy processing. Rice sieving, air pump, rice hülle and rice polisher were located at S1 area and consumed 3 days for each area. Sampling duration is with the interval of 5 minutes. S1 worker was selected randomly because the machinery area and process composed of various sources of noise and exposure noise can caused disease on "noise-related hearing impairment" [23]. The measurement period for both locations was conducted during working hours (0900 hours to 1800 hours). The parameters included are noise level and wind speed. Dataset was collected using sound level meter (SLM) model 407730 from EXTECH for noise level parameter and Kanomax Climomaster is used for monitoring the wind speed at the sampling points.

![Figure 1. Study area.](image-url)
2.2. Data Analysis

2.2.1. Environmental noise.
Equivalent continuous sound pressure level or receptors of the at factory were exposed to equivalent noise level \((L_{eq})\) calculated using equation (1).

\[
L_{eq} = 10 \log \sum_{i=1}^{n} \frac{L_i}{10^{10}} (t_i)
\]

Where \(n\) = total number of samples taken; \(L_i\) = noise level in dBA of the \(i\)th sample; \(t_i\) = fraction of total simple time

Daily noise exposure level for the effective duration of the working day calculated using equation (2) and (3):

\[
L_{EX,Bh} = L_{eq} + 10 \log \left( \frac{T_e}{T_0} \right) \text{ dBA}
\]

Where \(L_{eq,T_e}\) = A weighted equivalent continuous sound pressure level for effective duration of the working day; \(T_e\) = effective duration of working day; \(T_0\) = 8 hours.

Daily personal noise dose calculated using the following formula:

\[
Dose = 100 \times \frac{T_e}{8} \times 10 \log \frac{L_{eq,T_e}-85}{10}
\]

Where, \(T_e\) = effective duration working day; \(L_{eq,T_e}\) = A weighted equivalent continuous sound pressure level for effective duration of the working day.

Controlling noise exposure through distance calculated using equation (4)

\[
SPL_2 = SPL_1 - 20 \log \left( \frac{R_2}{R_1} \right)
\]

2.2.2. Correlation Analysis

Correlation analysis is the analysis that determine the degree of agreement between two variables. In this study, we used correlation analysis to establish relationship between machine and distance contributing towards noise level at the factory. The relationship between two parameters was measured by correlation coefficient \((r)\). The equation of \(r\) for sample defined as Equation (5):

\[
r = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n \sum x_i^2 - (\sum x_i)^2} \sqrt{n \sum y_i^2 - (\sum y_i)^2}}
\]

Where, \(n\) = total number of sample taken; \(x_i\) and \(y_i\) = the individual sample points indeed with \(i\)

3. Results and Discussion

Table 1 shows the maximum value that measured at 90 dBA (S1) and 72 dBA (S2). The machines in the mills created noise more than 90 dBA for eight hours of exposure per day [5]. Noise level of the machinery area at S1 exceeds OSH (Noise Exposure) Reg 6 (1) (a) that stated about noise level exposure cannot exceed 85 dBA. The noise level measurement shows that the minimum noise level occur at 83 dBA (min) (S1) while 64 dBA (S2) which are one of the maximum values for noise exposure exceeded
regulation and the most critical is S1, which is the area that contains almost the entire process at the rice mill factory. Noise mapping can determine to simulate the spread of noise due to the source of noise movement [22].

This study shows that the minimum noise exposed towards workers is 83 dBA (S1) and 64 dBA (S1), respectively during the break time, while the maximum noise of 90 dBA (S1) and 72 dBA (S2), respectively during the working time nearby machinery. High exposure to noise might cause several sensory neural hearing losses among workers [12-13]. The range of noise levels of the machines was in between 91.3 dBA and 100.7 dBA with the mean of 95.0 dBA which has been proved by Jaafar et al., [19]. There are many symptoms that can affect the workers which has been stated by [5] which is insomnia and disturbed sleep, besides stress reactions similar to other stressors caused by a relationship between daytime environmental noise and nighttime sleep disturbance [1, 20]. Panda et al., [13] stated that 33% of the individuals are annoyed during the daytime and 20% have disturbed sleep at night caused by noise exposure during daytime and this study revealed personal noise exposure encountered by the workers during workdays even though not exceed the limit a few step improvements for noise level need for workers healthy.

### Table 1. Descriptive statistic.

| Location | S1 | S2 |
|----------|----|----|
| Mean (dBA) | 87.25 | 67.69 |
| Min (dBA) | 83.00 | 64.00 |
| Max (dBA) | 90.00 | 72.00 |

The daily noise exposure for the measurement of noise level exposure towards them during working hours (0900 hours to 1800 hours) including the break time (1300 hours to 1400 hours). Analysis of Variance (ANOVA) was conducted to determine significance different of noise level exposure in the rice mills factory for three days [9]. Our null hypothesis is that, the noise level monitored is same for the three days [10-11]. Based on the ANOVA, (S1, p-value = 0.725; S2, p-value = 0.971), we accept the null hypothesis as there is no significant difference of the noise level during the three days of sampling. Thus, the worker was exposed with the same noise level during the working days. The evaluated $L_{eq}$ were 80.85 dBA (S1) and 60.28 dBA (S2). The calculated value $L_{eq}$ not exceeded the limit set in Occupational Safety and Health (Noise Exposure) Regulation 2019 of 85 dBA for overall area but there was certain point that has high noise level especially in S1.

Table 2 shows the calculation of sound level pressure for both location S1 and S2. Calculation for SPL$_2$ is conducted to compare with observed data at S1 and S2 area. Table 2 shows that predicted sound level pressure lower than observed sound pressure level. Effective, simple and inexpensive administrative control were the common ways for controlling noise exposure at the factory. Doubling distance between the source of noise and worker is one of the ways and the SPL$_2$ predicted decreased by 6dBA noise [26]. The predicted SLP was exclude-surrounding factors and this study proved that surrounding factors could cause increases SLR at the working area compared to predicted SLP range 5.62-2.82 dBA. This study proved that surrounding activity caused increasing noise level in that area, which caused increasing noise level pressure, compared to the calculated sound level pressure equation that been used.

### Table 2. Sound level pressure (SLP) predicted and observed.

| Mach/Distant | Air Blower (dBA) | Rice Sieving (dBA) | Air Pump (dBA) | Rice Huller (dBA) | Rice Polisher (dBA) |
|--------------|------------------|--------------------|---------------|------------------|---------------------|
|              | $SLP_{2o}$      | $SLP_{2p}$         | $SLP_{2o}$    | $SLP_{2p}$      | $SLP_{2o}$          | $SLP_{2p}$         |
| 2m           | 83.5             | 79.28              | 80.5          | 75.78            | 85.5                | 81.08              | 84.1                | 80.08              | 86.6                | 82.68              |
| 4m           | 81.6             | 77.48              | 80.1          | 74.48            | 82.3                | 79.48              | 81.9                | 78.08              | 84.9                | 80.58              |
Spearman correlation coefficient of relation between two parameters was conducted using Statistical Packages for Social Sciences (SPSS®) version 25 software. The analysis was to analyse the positive and negative correlation between noise level and distance of noise source (machinery) [15]. To correlate the distance sources with noise level, five machineries were taken as sources of noise which are air blower, rice sieving, air pump, rice huller and rice polisher. Table 3 shows the correlation between distance source and noise level. Strong correlation is between 0.5 and 1, while weak correlation is between 0 to 0.49. Results show that there exists strong significant correlation between the distance source of machineries and noise level for air blower (r=0.98, p<0.05), rice sieving (r=0.97, p<0.05), air pump (r=0.99, p<0.05), rice huller (r=0.97, p<0.05), and rice polisher (r=0.99, p<0.05). Mechanical noise was produce from a solid vibrating surface, driven or in contact with a prime mover which is this situation can radiate a sound of power (W in Watts) which is proportional to vibrating area S and the mean square vibrating velocity and [23] also stated that reduction of vibration velocity can produced sound power reduction up to 6dB by assume that the other parameter is constant. Motor and generators in the electric motor can cause noise because electric motor converts electrical energy to mechanical energy with the output of a useful torque at the motor shaft. Noise reduction in electric motors can achieve by the use of an absorptive silencer or by redesign of the cooling fan [23]-[24].

Employer need to conduct audiometric testing annually towards their workers and during audiometric testing an occupational health doctor must appoint to interpret audiogramme of the workers based on audiometric testing and medical examination must carried out on the workers because excessive noise can caused hearing injuries that can cause permanent hearing loss [25]-[26]. Daily noise levels above the subordinate action level of 80 dBA caused long term effect and may ultimately ground for noise induced hearing loss (NIHL)[18]Besides that employer shall provide personal hearing protector that suitable and efficient towards their workers to reduced noise level exposure and announce hearing protecting zone. Workers need to wear their personal hearing protection in that zone and all of committee in the factory must expose with OSH (Noise Exposure) regulation that can reduced noise exposure in the working environment.

Table 3. Correlation between distance source and noise level.

| Distance | Air Blower | Rice Sieving | Air Pump | Rice Huller | Rice Polisher |
|----------|------------|--------------|----------|-------------|---------------|
| Distance | 1.000      | -0.981**     | -0.972** | -0.996**    | -0.968**      |
| Air Blower | 1.000      | 0.994        | 0.974    | 0.940       | 0.978         |
| Rice Sieving | 1.000      | 0.964        | 0.942    | 0.966       | 0.993         |
| Air Pump | 1.000      | 0.966        | 0.966    | 1.000       | 0.963         |
| Rice Huller | 1.000      | 1.000        | 0.966    | 1.000       | 1.000         |

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

4. Conclusion

One of two area (S1) exceed the limit of 85 dBA based on Occupational Safety and Health (Noise Exposure) Regulation 2019 and employer must provide personal hearing protector for workers which has been stated in noise exposure Reg 7(1). High noise area was at paddy delivery area which exceeded the standard and needs more improvement to ensure the health of the workers. The correlation analyses revealed that the distance source and noise level have strong correlation and the main contributor of noise at the factory were rice polisher, rice huller, air pump, air blower and rice sieving.
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