ASSESSMENT OF NOISE POLLUTION EXPOSED TO WORKERS IN FURNITURE AND METAL FACTORY

EDY MUSTAQIM BIN MUHAMAD

SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2019

ASSESSMENT OF NOISE POLLUTION EXPOSED TO WORKERS IN FURNITURE AND METAL FACTORY

By

EDY MUSTAQIM BIN MUHAMAD

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)
(CIVIL ENGINEERING)

School of Civil Engineering,
Universiti Sains Malaysia

June 2019

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2018/2019

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title:

ASSESSMENT OF NOISE POLLUTION EXPOSED TO WORKERS IN FURNITURE AND METAL FACTORY

Name of Student: EDY MUSTAQIM BIN MUHAMAD

I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

Signature: Approved by:

_____ _____

(Signature of Supervisor)

Date : Name of Supervisor :

Date :

Approved by:

_____

(Signature of Examiner)

Name of Examiner

Date :

ACKNOWLEDGEMENT

Assalamualaikum w.b.t.

First and foremost, I praise Allah, the Almighty, for giving me this opportunity to complete my final year's project. I'd like to compliment the Civil Engineering School, USM for providing me with a wonderful educational experience and study experience and good facilities including resource centre, equipment, software and others.

Thanks in particular to Dr. Herni Halim, my project supervisor, and En. Abdul Hakim bin Salleh as co-supervisor of my project, who always provides guidance and supervision for the completion of the project. The progress of the project was achieved effortlessly through their advice and encouragement. Surely insight and experience were appreciated. This final year project would not have been successful without their support and valuable knowledge. Furthermore, I would like to express my deep appreciation for Dr. Herni Halim who help to correct my dissertation.

I want to express my deep appreciation to my family member Muhamad bin Ya'acob (father), Janah binti A Rahman (mother) and all my siblings who have always provided me with unfailing support and ongoing incentives over all my years of study. This achievement would not have been possible without them. Finally, I would like to express my appreciation to my friends who supported and encouraged this dissertation process so much.

ABSTRAK

Pencemaran bunyi adalah masalah utama di seluruh dunia terutama dari kawasan industri. Kajian ini dijalankan di industri yang merupakan perabot dan kilang logam kerana baru-baru ini tidak ada kajian tentang pendedahan bunyi di industri di Malaysia. Pada masa kini, kebisingan pada kesihatan pekerja sentiasa menjadi subjek perdebatan. Kajian ini memberi tumpuan untuk menentukan punca bunyi bising di tempat kerja. Kebisingan yang dihasilkan oleh hubungan antara mesin dan permukaan kerja. Mekanisme bunyi bergantung kepada operasi dan peralatan yang bising. Kebanyakan sumber bunyi dari kajian ini adalah dari jentera dan proses produk seperti mesin pemotong, mesin penggerudian dan operasi jentera. Kajian ini menyiasat tahap bunyi bising di tempat kerja yang terdedah kepada pekerja dengan menggunakan meter tahap bunyi jenis CR1710. Tahap bunyi dari industri kebanyakannya melampaui batas dan jelas mempengaruhi pendengaran pekerja. Berdasarkan objektif kajian ini, hasil kebisingan tertinggi dalam pemerhatian adalah 91.0 dB(A) yang berada dalam zona bahaya dan melebihi batas atas pendengaran bunyi dengan 85 dB selama 8 jam kerja sehari. Kemudian, tahap hingar paling rendah adalah 54.2 dB(A) dan ia dianggap sebagai zon selamat dan di bawah keadaan kawalan bunyi. Kajian ini bertujuan untuk mendapatkan peta tahap bunyi untuk membayangkan pengedaran pencemaran bunyi, yang boleh digabungkan dengan sistem maklumat geografi dan analisis sumbangan sumber bunyi yang berbeza.

ABSTRACT

Noise pollution is a major problem around the world especially come from industry area. This research was conducted at the industry which is furniture and metal factory because recently no or less studies on noise exposure at Pulau Pinang industry in Malaysia. Nowadays, noise on workers' health always a subject of debate. This study focuses on determine the source of noise at workplace. Noise produced by contact between the machine and the working surface. The mechanisms of noise depend on the noisy operation and equipment. Most of noise source from this study are from machinery and processes of product such as cutting machine, drilling machine and operation forklift. This study investigate the noise level in the workplace exposed to the workers and carried out the field work by using sound level meter type CR1710. Noise level from industry mostly exceeding the limits and obviously affects the hearing of the workers. Based on the objective of this study, the result of highest noise level in the observation is 91.0 dB(A) which is in danger zone and exceeding the upper limit for noise exposure with 85 dB for the duration 8 hours of work per day. Then, the lowest noise level is 54.2 dB(A) and it is considering as safe zone and under the control condition of noise. This study aims to obtain noise level map to visualize the distribution of noise pollution, which can be combined with geographical information system and different noise source contribution analysis.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

L_{10}	Noise level exceeded for 10% of the time.
L_{50}	Noise level that exceeded for 50% of the time.
L_{90}	Noise level exceeded for 90% of the time.
L_{Aeq}	Equivalent Continuous Sound Level.
L_{max}	Maximum Sound Level, that occurs during given time period.
L_{min}	Minimum Sound Level, that occurs during given time period.
dB(A)	Decibel A – Weighted A unit of measurement of sound level corrected to the A-weighted scale using a reference level of 20 micro Pascals.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Noise pollution, is the spread of noise that has a harmful effect on human or animal life activities. Environmental pollution is a secondary and unwanted product of various industrial activities that further threaten the environment (Mohammadizadeh et al., 2015). Therefore, the definition of noise pollution is open to debate and there is no clear border as to which sounds may constitute noise pollution (Reza et al., 2016). In the narrowest sense, sound is considered noise pollution if it adversely affects wildlife, human activity, or is capable of damaging physical structures on a regular, repeating basis. They further stated that in the broadest sense of the term, a sound may be considered as noise pollution if it disturbs any natural process or causes human harm, even if the sound does not occur on a regular basis (Reza et al., 2016).

Noise pollution implies an annoyance and restlessness caused to humans by unwanted high intensity sound (Reza et al., 2016). There are two sources of noise pollution namely industry and non-industry. Apart from air pollution, environmental noise pollution is one of the major health and well-being threat. The alarming of magnitude and severity of high noise level exposure area affected by population growth and urbanization (Hiral et al., 2017). Noise pollution cannot be seen, smelled or touched even it has harmful impacts on human, therefore it often underrated to all parties (Anizar et al., 2018). The World Health Organization (WHO) recognizes that noise pollution is the third dangerous threat to the world following water pollution and air pollution.

Industrial noises are commonly generated rotating, reciprocal or other types of machinery or high-pressure gases, liquids or vapors involved in industrial processes. One

of the contribution factor to high level noise exposure is industrial noise. One of the most important impacts of industrial noise is physiological and psychological effects (Saba et al., 2015). Industrial noise is a noise pollution, which annoys and disrupts the daily activities of workers (Berivan et al., 2014).

Steel industry is one of the most important industries of each country and noise pollution is one of the very annoying factors in this industry that causes various diseases (Farhad et al., 2015). In addition, machinery and equipment was used in the steel industry are considered as sources of annoying noise (Aliabadi et al., 2015). One of the unique features of the noise associated with wood machinery is the level of exposure and duration and equipment used in a wood factory can be extremely loud (Mayowa et al., 2016)

More than 60 million people in the world are exposed to excessive noise levels (> 85 dBA) in their work environments and they further stated that harmful effects of noise have been identified (Sajad et al., 2015). Noise exposure measurements are often expressed as dBA (Farhad et al., 2015). In this study, the noise level and source is studied and the results are represented in the form of noise map to give a better view of current noise level exposed in the factory.

1.2 Problem Statement

Machines, processes, and tasks in the iron and steel factories may produce noise levels that are harmful to hearing if not properly controlled (Israel et al., 2016). Due to the presence of noisy machines in the factory, workers are always exposed to noise level that exceeding the limits. The presence machines made a lot of noise and this noise obviously affects the hearing of the workers (Mohammadizadeh et al., 2015). Most industries have a plenty of devices and machines that considered as a source of noise

such as: rotors, cutting machines, motors, compressors, electrical machines, internal combustion engines, drilling, crushing, fans and transportation resources (Berivan et al. 2014).

Mohsin et al., (2014) studied the prevalence hearing loss among workers of the steel industries who had been exposed to noise levels between 83 and 102 dB. According to Robinson et al., (2014), noise readings were taken from five furniture factories and five saw mills. Hour-long LAeq values ranged from 71.2 to 93.3 dBA at the former and 74.9 to 93.9 dBA at the latter. For a number of years, the effect of industrial noise on workers' health has been a subject of debate among scientists (Berivan et al., 2014). Therefore many studies in industries discuss about the noise level problem or exposure.

The possible health effects of noise pollution are numerous, widespread, persistent and socially and medically important such as sleep disturbance, concentration of workers, communication skill and workers activities. They further stated that noise induces direct and cumulative adverse effects to health, social, working and learning environments correspond to economy (Hiral et al., 2017). Noise annoyance can result from interference with daily activities, feelings, thoughts, sleep, or rest, and may be accompanied by negative emotional responses, such as irritability, distress, exhaustion, a wish to escape the noise and other stress-related symptoms (Manfred et al., 2016). Therefore, exposure to noise can also lead to social and psychological problems such as bad tempered, stressful and nervousness.

Therefore, the assessment of noise exposure level at factory by noise map will be conducted in this study to trace the cause of high noise pressure levels and which is creating intensely high noise that may be willing to reduce the noise source. This study also gives an insight into the current level of noise exposure to the workers at factories.

1.3 Objectives

The aim of this study is to access noise level at factory areas in Nibong Tebal and Sungai Bakap, Penang. This study is carried out in order to achieve the following three main objectives:

1. To determine the sources of noise at workplace.
2. To investigate the noise level in the workplace exposed to the workers.
3. To produce noise map throughout study area.

1.4 Scope of Work

This scope of work focuses on monitoring noise level in factory at Nibong Tebal and Sungai Bakap, Penang which is investigate the current noise level that exposed to the workers. In addition, the sampling duration was only measured on 23rd January 2019 at Nibong Tebal while 24th January 2019 at Sungai Bakap. During each sampling period the data were measured three minutes with a sound level meter. The collection time was carried out during the working hour, so that noise level variations can be obtained. This study measures indoor and outdoor noise of the factory area.

The collection of noise data in the factory areas are presented in the form of noise map to give a better view of the noise level. The map can also be used to identify the source of noise location in the factory.

1.5 The Importance and Benefits of this Project

The primary aim of this study is to compare the noise levels in factory at Nibong Tebal and Sungai Bakap, Penang with World Health Organization (WHO) and Department of Environment (DOE). On the basis of the Planning Guidelines for Environmental Noise Limits and Control (DOE, 2007), the Maximum Permissible Level

of Sound (LAeq) is 70 dB (A) during the day and 60 dB (A) at night. Based on the data, mitigation measures for reducing noise exposure among workers can be suggested. At the same time, it could encourage all the staff about awareness of the noise pollution and the importance of work with good environment. In addition, from the result of noise level can be managed through engineering control approach, for instant changing the processing method, changing the material and using less noisy machines (DOE, 2007).

1.6 Dissertation Outline

The thesis has been categorized into specific chapters for better viewing and understanding of the study. This dissertation consists of five chapters.

Chapter 1: Introduction – Provide an overview on industrial noise pollution and noise pollution issue in industry. General description of the study, which includes an explanation of the problems, objectives to be achieved and scope of work.

Chapter 2: Literature Review - The content of this chapter discusses previous research in industrial areas relating to noise pollution. Explanation about industrial noise pollution, worldwide factory noise pollution, etc.

Chapter 3: Methodology - Explain all previous research steps. This chapter consists of the introduction to the sample analysis of the study area and its description.

Chapter 4: Results and Discussion - This chapter discusses the results of the study, including the level of assessment of noise measured in industrial areas and producing noise map.

Chapter 5: Conclusion and Recommendation - This chapter concludes the findings of this study and suggests that the environmental problem should be mitigated.

CHAPTER 2

LITERATURE REVIEW

2.1 Noise Pollution

Noise is seen by road traffic, railways, airports, industrial sites and domestic activities as an environmental stressor and nuisance. Noise pollution was synonymous with urban settlements, industrialisation, and rapid expansion of housing, population growth and technological developments. Environmental noise interferes with social behaviour and manifests through a variety of mechanisms in the form of psychological and physiological disorders. Exposure to a continuous noise of 85 - 90 dBA can lead to progressive hearing loss and threshold sensitivity changes. These annoyance reactions are related to the extent of daily activities in magnitude, variety and severity. Table 2.1 summarizes some frequently observed noise levels in everyday life, Foo (2014).

Table 2.1: Some noise levels commonly observed in the daily life (Foo, 2014)

Noise Level (dBA)	Activity
0	Threshold of hearing
38	Library
40	Living Room
58	Conversational speech
66	Business office
80	Average street traffic
100	Pneumatic chipper
125	Firecracker
140	Jet take of (25 m) and threshold of pain

In the meantime, offensive industrial noise is a disruptive sound pattern, which can generally be classified as continuous noise from machinery, repetitive high-speed actions, flow-induced noise and working tools associated with furnaces, generators and electromechanical devices in the working environment.

According to the World Health Organization (WHO), the irreversible noise-induced hearing impairment affects approximately 10 million adults and 5.2 million children in the United States, and 250 million people worldwide are exposed to dangerous levels of environmental noise every day (Foo, 2014). Although environmental noise interference is well documented, these complaints about noise levels have traditionally been taken for granted in developing countries, particularly in Malaysia. Human activities have appropriated nearly 80% of the Earth's land cover with industrial agriculture, resource extraction and sprawling urban areas (Clinton, 2015). Unwanted sound, as one of the most important physical factors in the majority of production units, imposes a great number of problems on industrial workers. They further stated that different studies have shown that 30 million individuals among the American workforce are exposed continually to high levels of noise (Khajenasiri et al., 2016).

2.2 Noise Level Measurement in Factory Worldwide

2.2.1 Noise Level Measurent in North Sumatera, Indonesia

According to Rizkya (2017), this research was carried out to investigate the level of noise in the rubber industry at the North Sumatra enumeration station, Indonesia. The noise level permitted in several industries, including the textile industry was approximately 75-99 dBA, the iron and steel industries 77-100 dBA, the cement industry was approximately 70-106 dBA, the concrete industry was approximately 80-107 dB(A)

(Rizkya et al., 2017). Many studies have been carried out to assess the level of noise from industrial activities, services and non-industrial activities.

Quantitative procedures were used in the study. Observations made using the equivalent noise level calculation method. Six measuring points were observed for three days for one shift and were carried out in an hour for the period of work (Rizkya et at., 2017). Table 2.2 shows the value Leq (equivalent noise level) on the production floor which is made in 6 measurement points. A sound level meter calibrated was used to measure noise levels. Measures were taken during one shift at six measurement points (Rizkya et at., 2017).

Table 2.2: Summary of Measurement in the Rubber Industry at North Sumatera, Indonesia (Rizkya et at., 2017)

Measuring Days	**Point 1 (dB)**	**Point 2 (dB)**	**Point 3 (dB)**	**Point 4 (dB)**	**Point 5 (dB)**	**Point 6 (dB)**
Day 1	101.4	101.4	101.5	102.3	102.3	102.4
Day 2	102.2	100.6	101.8	102.3	99.7	100.6
Day 3	103.6	102.3	102.6	99.8	102.5	102.5
Day 4	103.8	103.6	103.4	102.5	103.4	103.6
Day 5	102.4	100.6	101.7	103.6	101.7	101.7
Day 6	102.3	102.7	102.4	101.5	102.3	103.5
Day 7	101.4	101.4	102.8	101.4	102.5	102.3
Day 8	100.8	102.2	102.3	102.6	99.7	99.8
Day 9	102.6	103.6	100.8	102.8	102.8	102.5
Day 10	101.6	102.8	102.6	102.5	102.9	102.7
Leq	**102.21**	**102.12**	**102.19**	**102.13**	**101.98**	**102.16**

On the basis of the graph in Figure 2.1 shows that all of the measuring points on the production floor has the actual conditions that are above 85dB for 8 hours.

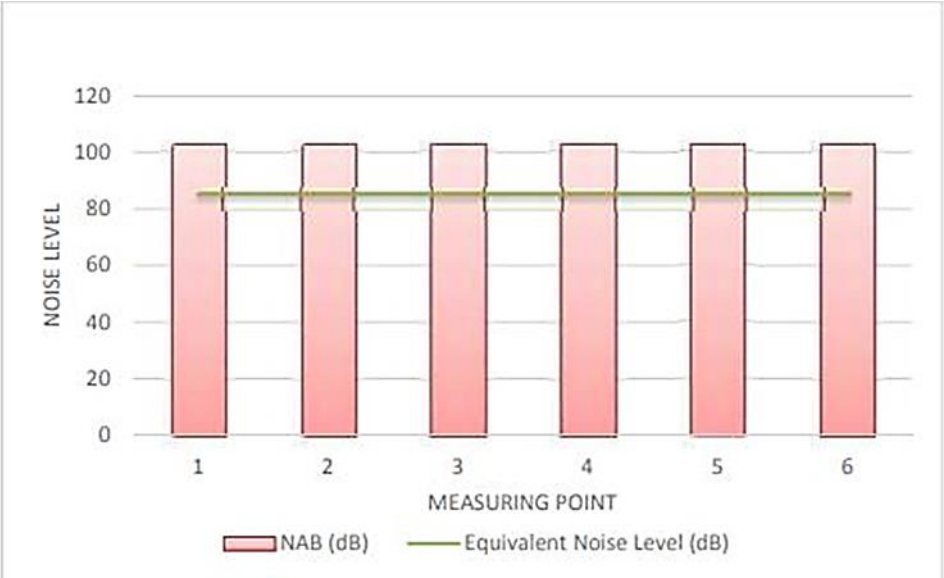

Figure 2.1: Graph of Actual Condition and Noise Standards Conditions Level in Enumeration Stations in the Rubber Industry (Rizkya et at., 2017)

In accordance with ISO 11690 - 1/1996, for the 8 hour work shift at industrial workplaces in the range of 75 to 85dB, maximum values for the sound pressure equivalent weighted A are accepted. Office routine work ranges from 45 to 55dB. The range of noise levels in a meeting room or task involving around 35 - 45dB. Noise level surveillance measurements within 1 hour.

The results show that the noise level is equal to 85 dBA/8 hours over the threshold limit. Based on the results of the measurement, the entire observation point was well above the threshold Limit Value (TLV). The highest equivalent noise level is in point 6 of the observation with a value of 102.21 dB. The noise level at the rubber industry enumeration station in the sixth measuring point exceeds the maximum permissible exposure levels.

Table 2.3 shows the value of noise above 85 dB indicates that the situation is very noisy.

Table 2.3: Maximum Permissible Exposure Levels

Noise Level dB(A)	Description
< 74	Good Conditions
75 – 80	Tolerable Conditions
81 -84	Noisy Conditions
85 – 87	Very Noisy Conditions
> 88	Intolerable Conditions

Conditions in enumeration station in the rubber industry as shown in Figure 2.1 shows that the noise value is above 100 dB. These values indicate an uncontrolled noise condition. Conditions uncontrolled noise can interfere workers' hearing. Noise level equivalent in enumeration station can be described within noise contour map. Contour noise on the production floor can be seen in Figure 2.2 with the whole point measurement (1, 2, 3, 4, 5 and 6) being in danger zone.

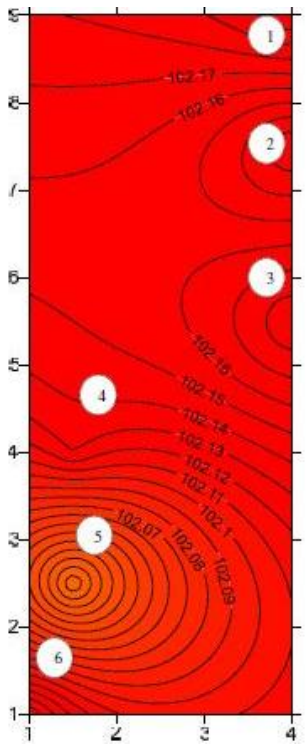

Figure 2.2: Contour Noise Mapping

Figure 2.2 shows the mapping of contour noise at 6 point of sources of noise using software suffer version 11. The mapping shows the picture of noise level in the rubber industry.

2.2.2 Noise Exposure for Operators in a Sugar Factory in Binjai, North Sumatera, Indonesia

Anizar et al., (2018) extended their analysis and revealed that most industries in developing countries face serious noise and vibration problems and are regarded as the most important problem in the working environment, in particular in industrial countries and developed countries. This research was conducted at grinding station in a sugar factory in Binjai, North Sumatera, Indonesia .Their study continues on the rotation of work in order to reduce the effect of noise exposure on sugar factory operators. This study investigates the noise level in a sugar factory at the grinding station by measuring the level of sound pressure. This study aims to obtain noise level map, so operators can regulate their working time accordingly. The level of noise is measured with a sound level meter for four days. Observation will take place at 9 points at 9:00, 11:00, 13:00 and 15:00. Table 2.3 shows noise level has exceeded upper safe limit recommended by Occupational Safety and Health (OSHA).

Table 2.4: Recapitulation of equivalent noise level at all point of measurement (Anizar et al., 2018)

Point of Measurement	Equivalent Noise Level (dB)			
	09.00	11.00	13.00	15.00
1	92.9	93.0	92.9	92.9
2	94.8	95.0	95.1	95.0
3	93.1	92.1	93.1	93.6
4	95.3	94.7	94.9	94.6
5	95.4	92.1	93.3	93.9
6	90.8	90.7	91.0	91.2

7	92.6	92.4	92.6	92.7
8	88.3	89.1	91.0	91.1
9	87.5	90.5	90.5	90.8

The noise level at the 1st until the 9th point of measurement is far above the safe limit allowed by Indonesian Government of Human Resource and Transmigration Decree No 13 The Year 2011 about 85 dB for 8 hours of work per day.

The number of measurement points is determined by contour mapping using a grid size of 3 m x 3 m. The pattern of noise distribution is obtained from surfer software v11.0. The results show that the Daily Noise Dose (DND) exceeds the Occupational Safety and Health (OSHA) standard. Each measuring point has a different noise level, which means this the maximum permitted exposure time is also different.

That suggests the problem can be solved for a different period of time at different stations by regulating the operators' working hours at each station operator's work.

Table 2.5: Calculation recapitulation of daily noise dose (Anizar et al., 2017)

Point of Measurement	**Noise Level in the Afternoon**	**Maximum Duration of Exposure**	**DND (%)**	**Explanation**
1	92.9	90.58	530	Unsafe
2	95.0	71.79	669	Unsafe
3	92.9	91.35	525	Unsafe
4	94.9	72.48	662	Unsafe
5	93.9	81.07	592	Unsafe
6	90.9	122.05	393	Unsafe
7	92.6	94.23	509	Unsafe
8	90.0	143.54	334	Unsafe
9	90.1	142.37	337	Unsafe
Average	**92.6**	**100.82**	**506**	Unsafe

Indonesian Government of Human Resource and Transmigration Decree No 13 The Year 2011 recommends that the allowed upper 8 for noise exposure is 85 dB for the duration of 8 hours of work per day (Anizar et al., 2017)

2.2.3 Industrial Noise Pollution and its Health Effect on Workers in Nairobi City, Kenya.

In non - formal metal and formal industries dealing with metal works, grain milling, plastic production and wood works, industrial noise pressure levels in the workplace, its perceived effects on workers and its progression beyond industrial borders were monitored. According to Gongi et al. (2016), this study was carried out in Nairobi City to assess the level of industrial noise and to assess the extent to which the industry complies with existing measures to control industrial noise pollution. Nairobi is not just Kenya's capital of commerce, industry and administration, it is also a leading business hub for East and Central Africa with the current population standing at about four (4) million people (Gongi et al., 2016). In addition, 56% of all formal medium-sized and large companies are based in Nairobi (Gongi et al., 2016). Figure 2.3 shows the health effects of industrial noise pollution among workers in industries.

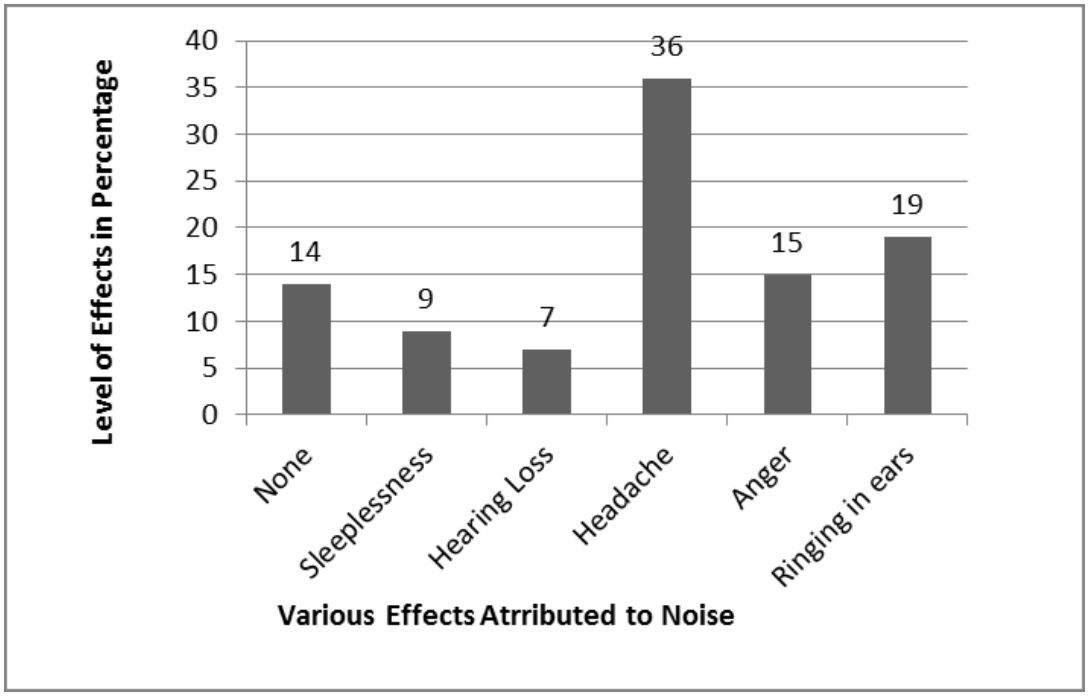

Figure 2.3: Perceived impacts of industrial noise on the health of workers (Gongi et al., 2016)

After 10 - 15 years of exposure, noise - induced hearing loss starts to manifest. The 7.0% manifestation of hearing loss is a large percentage (Gongi et al., 2016).

The evaluation was carried out using a digital integrated sound level meter, SLM (SVANTEK 971), in accordance with ISO 1996 - 2002. For determining the noise source coordinates a hand-held GPS receiver was used. Noise levels in the non-formal metal, formal metal and grain mill industries exceeded 90 dB (A), exceeding international guidelines (WHO, NIOSH,OSHA) and the local work place noise standards. The progression of noise levels into the streets adjacent to the industries was also above acceptable limits and contributed significantly to street noise in the background. The noise prevention and control programs required by the Environmental Management and Coordination Act of Kenya (EMCA) of 2009, Legal Notice No. 25, and the Factories and Other Places of Work Act of 2005, have not been enforced.

This study concludes that noise excessively pollutes not only working areas in industries, but also street noise on a normal working day exceeds acceptable limits. It is recommended that deliberate efforts be made to reduce noise levels in the workplace, raise awareness of their harmful effects and provide adequate protective equipment to workers.

In all regions of the world, high levels of occupational noise remain a problem and there is evidence of its increasing prevalence in the workplace (Gongi et al., 2016). For example, more than 30 million workers in the United States of America (USA) are exposed to hazardous noise exceeding 85dB (A). In Germany, 4-5 million people (12-15% of the workforce) are exposed to noise levels defined by the World Health Organization as hazardous. Data for developing countries are scarce, but there is evidence that average noise levels in many developing countries are well above the recommended standards, Mithanga (2013).

Studies in Egypt's various cities show that 70 percent of workers were exposed to hazardous noise levels (Ali, 2010). In Kenya, a study by Mithanga (2013) showed that 75.8% of employees work in production areas where noise levels were higher than standards and the majority of participants agreed to have problem working and concentrating when heavy and noisy machines were running.

2.2.4 Effect of Noise

The common effects of noise can be seen in forms of annoyance, speech interference, sleep quality, depression, anger, hearing loss, concentration disorders, hypertension and nervousness, Geravandi (2015). The most common reason for annoyance and permanent hearing loss is considered to be high noise levels, Elizabeth (2016). Gongi (2016) showed that almost half of the injuries were attributed to the risks

associated with noise and hearing loss together. Therefore, noise interferes with the efficiency of work by hindering communication between employees; it can also cause accidents by masking warning signals. In a study done in the manufacturing sector in Thika District in Kenya, most participants agreed that when heavy and noisy machines were running, problems were working and concentrating, Mithanga (2013). In the same study, Mithanga (2013), most employees indicated that high levels of professional noise in the manufacturing industry affect their work performance and communication.

2.2.5 Noise Limit

The U.S. Occupational Noise Exposure Regulation limits the noise levels of industrial workers at 90 dB (A) for a period of eight hours (USEPA, 1973). In Turkey, the maximum permissible noise is 75 dB (A) for a period of 7.5 hours (Republic of Turkey Ministry of Environment, 1986) while in Kenya, the maximum permissible work-place noise level is 90dB(A) for an eight hours duration. Generally 85-90 dB over an eight-hour work day is the level of noise allowed in most standards. Occupational Safety and Health Administration (OSHA) sets legal limits on noise exposure in the workplace. These limits are based on a worker's time weighted average over an 8 hour day. With noise, OSHA's permissible exposure limit (PEL) is 90 dBA for all workers for an 8 hour day (Occupational Safety and Health Administration – Occupational Noise Exposure 1910.95). The existing regulation in Kenya requires that there should be a noise control and hearing protection program in all of our workplaces (Legal Notice No. 25, the Factories and other places of work (Noise Prevention and Control, 2005); Gongi et al., 2016). Table 2.5 shows the measured data indicated that all the industries exceeded the maximum permissible occupational noise levels thus putting public health at very high risk.

Table 2.6: Effects of noise pollution on public health and welfare (Gongi et al., 2016)

Effect of noise	Protective noise limit (LAeq, 24h, dBA)	Duration of exposure (Years)	Measured noise level in various industries (LAeq, 8h, dBA)/Inference (level of risk)				
			Grain mills	Metal	Plastic	Wood	Non-formal Metal
Noise Induced Hearing Loss (NIHL)	70	20-40	94.4/Very High risk	90.2/Very High risk	83.2/High risk	82.1/High risk	92.2/Very High risk
Physiological Effects (Hypertension, Cardiovascular Disease, etc.)	65-70	30	94.4/Very High risk	90.2/Very High risk	83.2/High risk	82.1/High risk	92.2/Very High risk
Psychological/Mental Illness/Stress	70	ST-LT	94.4/Very High risk	90.2/High risk	83.2/High risk	82.1/High risk	92.2/Very High risk
Speech Interference (Indoors)	35	ST	94.4/Very High risk	90.2/Very High risk	83.2/High risk	82.1/High risk	92.2/Very High risk
Speech Interference (Outdoors)	55	ST	94.4/Very High risk	90.2/Very V High risk	83.2/High risk	82.1/High risk	92.2/Very High risk
Sleep Disturbance	30	ST	94.4/Very High risk	90.2/Very High risk	83.2/ High risk	82.1/ High risk	92.2/Very High risk
Activity Interference	45-55	ST	94.4/Very High risk	90.2/Very High risk	83.2/High risk	82.1/High risk	92.2/Very High risk
Annoyance/Social/Behavioural Effect	80	ST	94.4/Very High risk	90.2/Very High risk	83.2/High risk	82.1/High risk	.2/ Very High risk

2.3 Noise Level Measurement in Factory Malaysia

2.3.1 Occupational Noise Exposure in Manufacturer Industries in Malaysia

According to Tahir et al (2014), the manufacturing sector accounts for 18.1% of Malaysia's total workforce, which is known for the utilisation of noisy machinery to establish output. Although employers are obliged to notify the authority of any hearing loss cases annually, there is still a shortage of cases of professional hearing loss. In addition, their study aimed to estimate the total number of workers in Malaysia's manufacturing industries exposed to occupational noise.

In five states, Johor, Selangor, Pulau Pinang, Terengganu and Pahang, which recorded the highest noise - induced hearing loss (NIHL) cases in 2011, Tahir (2014), a field

survey was carried out in 26 selected industries. Safety and health professionals were interviewed in each industry and obtained information on industrial classification, noise management and worker exposure levels.

Industry levels of occupational noise exposure were 28% for 91 - 140 dBA and 72% for 86-90 dB(A), which showed that all workers were at high risk. In the metal industry, 2091 of workers exposed to noise at work were found to be the highest. Next, followed by textiles industry which is 631 of workers and food industry which is 439 of workers. The percentage of exposed workers in each industry ranged from 13.6% to 68.9%. Furthermore, 103,673 (39%) from total employment of 267,964 were estimated to be workers exposed to high risk noise.

This study shows that the majority of manufacturing workers have been exposed to high-risk occupational noise and an effective hearing conservation program for preventive measures must be implemented.

2.3.2 The Noise Exposed Factory Workers

In Kuala Lumpur based on a study conducted by Maisarah (1993), there are many industrial pollutants, but they are not as wide and common as noise. In Malaysia, the Noise Regulation came into force in early 1989. The Factories and Machinery (Noise Exposure) Regulation 1989, requires protection for all employees exposed to noise levels exceeding 85 dBA. The aim was to compare the prevalence of sensor-neural hearing loss among workers exposed to noise and non-noise. A total of 578 workers from 4 factories selected randomly were studied. They consisted of 488 noise exposed workers (noise level 90 dB Equivalent Continuous Sound Level [Leq] or more) and 90 workers working in 'quiet' environments (noise level less than 80 dBLeq). Each subject was interviewed

personally and subjected to otoscopic examination before performing pure tone audiometry.

Only 524 of 578 employees were included in the study. They consisted of 442 noise exposed and 82 non-noise exposed workers. Fifty four workers (46 from the noise exposed and 8 from the non - noise exposed groups) were excluded because they had either perforated drums, conductive loss or a history of diseases or conditions that could cause sensory - neural hearing loss. The age of workers in the group exposed to noise ranged from 18 to 52 years with an average age of 36.5 years and exposure to noise from 3 to 29 years. The non-noise exposed group were between 18 to 53 years, mean 33.2 years and with a working duration of 0.3 to 34 years. For both groups, in the ratio of 1:2.3 for exposed noise and 1:3.8 for exposed non - noise, males were more than females. Figure 2.4 compares the mean threshold level of the 2 groups. For each frequency tested, the noise exposed workers showed a significantly higher threshold of hearing ($p<0.0l$). Figure 2.5 compares the prevalence of hearing loss at various test frequencies. For all the test frequencies, the prevalence of hearing loss was significantly higher among the noise exposed group ($p<0.0l$).

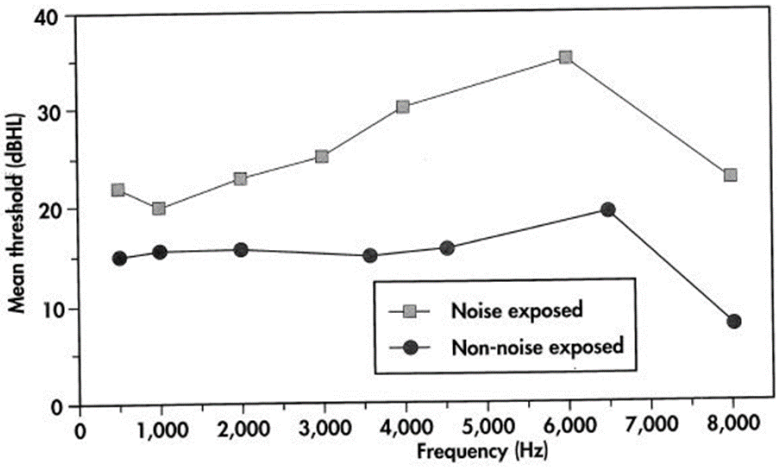

Figure 2.4: Mean Hearing Thresholds for the Noise Exposed and Non-Noise Exposed Groups (Maisarah, 1993)

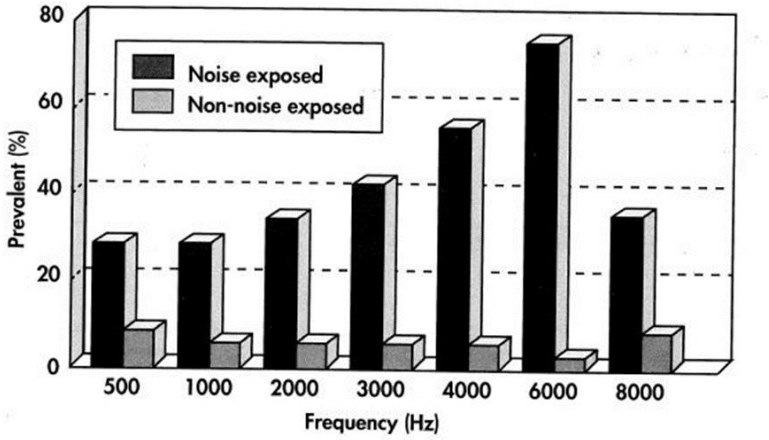

Figure 2.5: Prevalence of Hearing Loss across the Test Frequencies (Maisarah, 1993)

2.3.3 An Assessment of Noise and Chemical Solvent Exposure

In Malaysia, Noise-induced hearing loss (NIHL) prevention programs and legislation exist but poor implementation and enforcement (Masilamani et al., 2014). In addition, they further stated that NIHL has emerged as the biggest cause of occupational disease in recent years especially in industrialized country. Study was carried out by Ratnasingam et al. (2010), to evaluate the noise and chemical solvents exposure among workers in the wooden furniture industry in Malaysia. Hence, the findings could possibly help to identify measure that could mitigate noise and chemical exposure faced by workers in the Malaysian wooden furniture industry.

Hearing loss may lead to mental health problems and may affect workplace safety as affected workers to become less aware of their surroundings (Retneswari et al., 2014). Moreover, noise and chemical solvents are serious health and safety concern among workers in wooden furniture manufacturing (Ratnasingam et al., 2010). Previous studies have shown that industrial accident are closely related to the prevailing work environment such as prevailing environment which is noisy at workplace (Thanasegaran et al., 2011). One of the primary health and safety concerns of the workers in the wooden furniture manufacturing industry is noise (Bennet et al., 2010). The factories located

throughout Peninsular Malaysia, were selected on the basis of their reportedly safety records. This study conducted more than 1500 workers of large-sized wooden furniture-manufacturing factories (Ratnasingam et al., 2010).

There are many noise sources in the furniture manufacturing factories such as structural vibration of machine frames, aerodynamic turbulence of the rotating tools and dust and wood chips extraction system (Ratnasingam and Loras, 2010). Although, the factories and machinery (noise exposure) regulation of 1989 of Malaysia, stipulates that the maximum permitted noise exposure limit for workers in the woodworking industry should not exceed 90 dBA for 8 hours period, its effectiveness to provide adequate hearing protection to the workers remain debatable (Ratnasingam and Loras, 2010). The average noise-levels recorded in the Malaysian wooden furniture manufacturing industry is shown in Table 2.7.

Table 2.7: Average Noise Level in the Malaysian Furniture industry (Ratnasingam and Loras, 2010)

Section	**Percentage of Workers**	**Percentage of Workers Using Hearing Protection**	**Average Noise-Level (dBA)**	**Machine**	**Average Noise-Level (dBA)**
Rough Mill	43 (645 workers)	WP-27 HPDW-73	130	Moulder surface-planer thicknesser	150 125 115
Machine Shop	57 (855 workers)	WP-5 HPDW-3 DHP-92	67	Shaper narrow band-saw router mortise tenoner multi-borer	85 55 110 50 60 40

It is apparent that the highest noise-level of 130 dB(A) was recorded in the rough milling sections of the furniture factories, while in the machining section, only the high-speed router recorded noise-levels higher than the permissible 90 dB(A). The rough milling section, involving heavy-duty wood machining operations such as the moulding, ripping and planning are regarded as machines emitting high levels of noise (Ratnasingam and Loras, 2010).

The personal dosimeter results, expressed as percentage of 90 dBA/8 hour's dose, are shown in Table 2.8.

Table 2.8: Noise Induced Permanent Threshold Shift (NIPTS) Among Workers (Ratnasingam and Loras, 2010)

Percentage of workers	**NIPTS in 4-6 kHz band (dB)**	**Years at work**	**Hearing impairment**
8.9	>40	>10	Significant
25.8	30-40	3-10	Slight
65.3	<30	<3	Not significant

It is apparent that 25.8% of the workers in this study have a slight handicap with permanent threshold shift between 30 and 40 dB, while 8.9% of the workers have significant handicap with permanent threshold shift greater than 40 dB. The percentage of workers having no hearing handicap is 65.3% (Table 2.7). These results imply that the noise levels in the wooden furniture factories can significantly impair workers' hearing and hence, the use of hearing protection and job-rotation among the workers must be strictly implemented, in order to ensure a hearing conservation program within the industry.

The results of noise level exposure of workers showed that 43% of the workers involved in the study were exposed to higher dose than the permissible one, while the balance 57% were exposed to a less dose.

Compared to their counterparts in Europe and Scandinavian countries, the study revealed that workers in the Malaysian wooden furniture industry are exposed to higher noise and chemical solvents levels than the permissible standards (Ratnasingam and Loras, 2010) and without stricter enforcement of the existing occupational safety and health regulations in Malaysia

This study on the noise and chemical solvents exposured in the Malaysian wooden furniture industry reveals that the workers are exposed to levels higher than the Permissible Exposure Level (PEL). Thus, there is suggested that protective gadgets must be provided to all workers and its' wearing must be made compulsory to minimize exposure. It is also apparent that the existing occupational safety and health regulations must be implemented and enforced strictly to ensure compliance within the wooden furniture manufacturing industry, which it turn will boost labour productivity, thereby enhancing competitiveness.

Hearing conservation programs should be implemented as soon as one is employed to prevent progression to hearing loss. This requires acknowledgement from the management on the magnitude of the problem and their commitment to preventing NIHL among workers (Masilamani et al., 2014).

2.3.4 Prevalence of Hearing Loss and Hearing Impairment among Small and Medium Enterprise Workers

Noise induced hearing loss (NIHL) is undoubtedly prevalent in industrial countries (Reddy et al. 2012), with no exception for Malaysia as manufacturing industry is the major sector in this country. Factories and Machinery (Noise Exposure) Regulation 1989 always insist employer to protect workers from noise exposure ≥85 dB. Nevertheless, noise induced hearing loss (NIHL) has been the highest notifiable occupational health issue among Malaysian workers in 2014 (Sam et al., 2017). Hearing loss seems not to be taken serious by some of the workers because they feel that it is not a life-threatening injury and some even thought that it is curable (Sam et al., 2017).

In Malaysia, there were 2648 cases of occupational disease (OD) and poisoning cases in 2014, where 1563 cases of investigated occupational disease were of noise induced hearing loss (NIHL) which was the commonest occupational disease experienced by Malaysian workers (78.1%) as compared with other diseases (DOSH, 2014). According to a study on burden of NIHL among manufacturing workers in Malaysia, incidence risk of NIHL per 100,000 manufacturing workers projected to be 8% (139 cases). The highest risk and incidence was among the motor vehicle parts industry (32%), followed by tobacco industry (23%) and fabricated metal industry (23%) (Tahir et al. 2014). According to the estimates of World Health Organization (WHO) on the magnitude of disabling hearing loss, more than 250 million people around the world are affected in 2000 and has since increased to 360 million people in 2012 (WHO, 2012).

This study focuses the prevalence of hearing loss among 146 adult manufacturing workers with noise exposure ≥85 dB was carried out in Selangor. In this study, a validated questionnaire and pure tone audiometry were used to determine the hearing status.