JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

ENVIRONMENTAL ENGINEERING CHAIR

ASSESSMENT AND EVALUATION OF NOISE POLLUTION AND LEVELS OF SAFETY MEASURES IN A ROAD CONSTRUCTION PROJECT: THE CASE OF JIMMA TOWN ROAD CONSTRUCTION PROJECT, JIMMA, ETHIOPIA.

BY: WASYHUN DAMENE

A THESIS SUBMITTED TO JIMMA UNIVERSITY, JIMMA INSTITUTE OF TECHNOLOGY, FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING, ENVIRONMENTAL ENGINEERING CHAIR IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE INENVIRONMETAL ENGINEERING

OCTOBER, 2017

JIMMA, ETHIOPIA

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DECLARATION

I, Wasyhun Damene, hereby declare that the thesis, entitled "*Assessment and evaluation of noise pollution and levels of safety measures in a road construction project: The case of Jimma town road construction project, Jimma, Ethiopia*", is entirely my original work done for the award of MSc. degree in Environmental Engineering. To the best of my knowledge, the work has not been presented for the award of MSc. degree or any other degree either in Jimma University or any other Universities. Thorough acknowledgment has been given where reference has been made to the work of others.

Wasyhun Damene

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Name (Main advisor) Signature Date

Thesis has been submitted for examination with my approval as University co-supervisor.

Mamuye Busier (Assistant Prof.)

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Name (Co-supervisor) Signature Date

As chair Holder of Environmental Engineering, I approved the submission of the Thesis for examination

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Name (Chair Holder) Signature Date

ABSTRACT

Road construction necessitates the use of heavy machineries and equipment leading to construction workers to be exposed to high noise levels. Noise can also create stress and can be a safety hazard at workplaces, interfering with communication, acting as a distraction and making warnings harder to hear. When a problem has been identified but cannot be removed immediately, the extent and magnitude of the noise should be determined through a noise assessment by detailing the levels present, the items causing the most noise and the people affected by the noise in order to work-out noise control. However, there is no systemized recording and reporting of effect of noise resulted health problem in developing countries including Ethiopia. In this study attempts has been made to asses and evaluate the noise pollution levels and safety measures in place in road construction project of Jimma town. A study of noise characteristics in Jimma Road construction project machineries has been carried out from May 2016 to October 2016. The study involves physical measurement of the noise levels using digital sound level meter and a social survey was conducted using questionnaire.

Fourteen machineries and 187 construction workers who have exposure to the machineries were assessed. A structured questionnaire was used to collect data for the assessment and evaluate of health risk and safety measures among Jimma road construction workers. Field measurement was done on the noise levels generated by road construction machineries at 1m, 3m and 5m distance. From the existing system of operation noise level at average of 1m is about 2.6% to 20.8% higher than the standards prescribed by the OSHA which is 90 dB(A) and the noise level decrease as the distance increase from the source of the noise. Regarding the awareness of the respondent toward importance of personal protective equipment 98% of them are aware of its importance the rest 2% are not aware of PPE. From the respondents 90% of them are having exposure to excessive noise and 84.6% experience headache resulted from high noise level. All the average measured values at 1 meter are above the standard of OSHA which is 90 dB(A). These exposed workers suggested to have periodic audiometric testing in order to identify deterioration in their hearing ability as early as possible and the importance of noise control regulation, awareness creation and safety measures are recommended by the researcher (hearing protection).

Key words: *Construction Machineries, Decibel, Hearing loss, Noise Pollution, Personal Protective Equipment, Safety Measures, Sound level.*

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ACRONYMS

CDC	Centers for Disease Control and prevention
dB	Decibel
dB (A)	A-weighting Decibel
DALY	Daily adjusted years
EASH	European Agency for Safety and Health
FDRE	Federal Democratic Republic of Ethiopia
HCPs	Hearing Conservation Programs
HPD	Hearing Protection Device
ILO	International Labor Organization
JiT	Jimma Institute of Technology
JRCP	Jimma Road Construction Project
Km	Kilometer
Leq	Equivalent Continuous Sound Level
m	Meter
Max	Maximum
Min	Minimum
mm	Millimeter
NIOSH	National Institute for Occupational Safety and Health
OHS	Occupational Health and Safety
OHSA	Occupational Safety and Health Administration
PPD	Personal Protective Device
PPE	Personal Protective Equipment
SLM	Sound Level Meter
TWA	Time-Weighted Average
USA	United States of America
WHO	World Health Organization

CHAPTER ONE

1. INTRODUCTION

1.1. Background

1.1.1 Overview of Jimma road construction project

The Jimma road construction project would be a rehabilitation project that covers about 8 km in the vicinity of Jimma town. It is the main highway to connect the western part of Ethiopia. It enables easy accesses to Jimma zone as well as the neighboring zones including Jimma town. The project covers a total of 8 km road with the total costs of 55,000,000 (fifty five million) Birr. Jimma road project has started the construction during the first quarter of 2016 (February 2016).Construction of the road would require approximately 18 months. It would require up to 363 workers at peak construction time. The project area is southwester of the City of Jimma in Oromia National Regional State, Ethiopia. Either the final environmental impact report (EIR) approved by Federal Environmental Protection Authority (EPA) or Regional/local Environmental Protection Authority was not found for the project.

1.1.2 Noise Pollution

Noise is excessive or unwanted sound, which potentially results in annoyance and/or hearing loss; whereas sound is a pressure variation (wave) that travels through air and is detected by the human ear [36].

. Some countries such as Japan and the United States of American have specific legislations on noise pollution. In Ethiopia no law is governing noise pollution, however, noise is simply cited as a pollutant in the Environmental Impact Assessment "Proclamation NO. 299/2002". The Federal Environmental Protection Authority (EPA) of Ethiopia, as a government body has mandate to formulate policies, strategies and standard that specifies maximum tolerable noise levels. Accordingly, the EPA has set 75 decibels for industry areas, 65 and 55 decibels for construction and residential area. Noise standard vary from one place to another. Nevertheless, the EPA's effectiveness in bringing its own standard down to earth and enforcing them accordingly is far from satisfactory [33].

The highest percentages of overexposed workers occur in highway and street construction, carpentry and concrete work. Of the approximately 5 million construction workers in 1995, the total number exposed to noise levels of 85 dB (A) and above was about 754,000. Because National Institute for Occupational Safety and Health (NIOSH) sampled noise levels rather than exposures, these are not Time-Weighted Average (TWAs) and the actual numbers would be somewhat lower when using TWA, but these numbers are useful for ranking the extent of the hazard by trade and to estimate the upper bound of the total number exposed [9].

Current enforcement of these noise regulations is not rigorous, particularly in construction. Neither the noise reduction nor the hearing conservation provisions are well enforced in construction. For example, more than 18,000 federal construction inspections during fiscal year 1998, only 63 inspections were conducted for the noise regulations, resulting in a total of 79 citations [9]. Lack of enforcement characterizes state as well as federal programs. Even those states that have adopted the general industry noise regulation for construction, such as the state of Washington, have failed to enforce the hearing conservation provisions. Part of the problem has been a perceived lack of information about the noise exposures of construction workers, although several studies have been conducted over recent decades in the United States and Canada [9]. A more salient reason for the lack of activity in this area is the impracticality of the usual approaches to Hearing Conservation Programs (HCPs) in the construction arena. The mobility of construction workers of short periods of employment and the consequent record keeping difficulty present a daunting obstacle. This study attempts to address these issues and offer possible solutions.

Assessment and evaluation of road construction worker safety and health risk measures adopted on road construction worker as pre requisite to tackle occupational noise hazards. This kind of assessment is the basis of the interventions taken to alleviation of occupational hazards.

1.2. Statement of the Problem

It is estimated that worldwide more than one-half million construction workers are exposed to potentially hazardous level of noise [9] and many of these noise are unsafe for the construction worker as well as to the workers due to poor usage of hearing protection device [5]. Health effect of noise according to WHO deafness, hearing loss, and headaches there for exposure to excessive noise at any place increasing the health effect of human. Construction employment data (1995) and National Institute for Occupational Safety and Health (NIOSH) estimates (1981–1983) exposed above 85 dB A, in highway and street construction from 223 employees, 27% of them are exposed to greater than 85 dBA [9].

There are varieties of reasons for the poor occupational safety situation in developing countries. A real problem facing in developing countries is the importation of occupational hazards, without appropriate and adequate safeguards. Despite low cost, effective means of prevention, the occupational health of workers has not been prioritized. Since all road construction workers are essential to the provision of quality health care services and should be protected from occupational noise hazards. In addition, unsafe working condition contributes to global shortage of worker because of these workers working in this project may face different kinds of health problems depending on their working habits [7]. Occupational hazards exposure from this road project is mostly unwanted sound (noise). For this matter, engineers, vehicle driver, daily labor worker and motor maintenance worker are the most vulnerable groups [3].

Exposure to excessive noise more than recommended duration may result in loss of hearing, stress, high-blood pressure, loss of sleep, distraction affecting productivity, and a general reduction in the quality of life. The effects of noise are difficult to quantify because tolerance levels among different populace and types of noise vary considerably. There is a large amount of scientific literature written on the effects of noise on human beings. It may cause deafness, nervous breakdown, mental disorder, heart troubles, high blood pressure, dizziness and insomnia [19].

Jimma road construction project worker are always exposed to different risks and most of the time the safety measures adopted are not satisfactory to protect their health from the specially noise risks, during working time, at working site high noise level but they do not use personal noise control material (PPE) also worker do not communicated (interference to speech communication). The presence of minimal published document on road construction workers safety and health risk measurements and lack of guideline and standard for road construction machineries noise level in Ethiopia is the main reason for the initiation of this study.

1.3. Objective of the study

1.3.1. General Objective

The general objective of this study was to assess and evaluate noise pollution level of a road construction project in Jimma town, in order to ascertain the degree of impacts on road construction workers and the available safety measures.

1.3.2. Specific Objectives

1. To measure the amount of noise generated by construction machineries.
2. To evaluate safety measures implemented by the project. (To assess the personal protective equipment (PPE) availability and utilization pattern among workers.)
3. To measure the health effect of noise on the construction workers.
4. To design/determine the safe distance from noise source to workplace.

1.4. Research questions

1. How much is the highest noise level generated by construction machineries?
2. What safety measures are considered during the road construction?
3. What are the main sources and effects of noise in road construction processes?
4. How much is the safest distance from noise source?

1.5. Significance of the study

This study could be helpful for assessment and evaluation of road construction worker safety and health risk measurement adopted by road construction workers among road construction industry. It provides recommendation to road workers to protect themselves from unwanted sound or noise, the findings provide basic information that enables to minimize occupational noise hazards arising from this work place, determine the safest distance from noise source to working place. In addition, it may serve as preliminary study for further studies.

1.6. Scope of the Study

This research assessment and evaluation of noise pollution and levels of safety measures in a road construction project: the case of Jimma town road construction project, Jimma, Ethiopia. The study measures the standard of the safety and health practices in general. This is done from the perspective of employees of construction machineries and worker. It is based on opinion of all road site workers in the selected area. This study does not include the testing of hearing ability (audiometric test) of road construction workers.

Scope of this study is limited to evaluation of noise pollution in road construction machineries in Jimma, Oromia, Ethiopia. In this paper were include machineries noise and noise pollution problem in road construction workers in Jimma. All road construction site machineries are purposively included in this study. Data collected by performing noise measurement for machineries, checklist and workers questionnaire.

The scope of the research conducted based on the objectives was recording of noise levels recorded at different noise generating sources (construction machineries). A detailed study has been arrived and noise levels were recorded, compared. A comprehensive study has to be conducted with a view to understand the noise related problem. A collective measurement technique has to be adopted for the accurate determination of the acoustical environment of an area and source of noise generation. The noise levels are proposed to be recorded by conducting onsite measurements of noise levels using digital sound level meter. The noise levels are to be used for calculating sound noise level and compared with the OSHA and EASH standard. At places of study it was found that the noise levels measured were above the acceptable standards. Hence an urgent needs to control the noise pollution. The study also covers a review of the existing control measures and suggests improvement such as barrier provision to noise levels.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Introduction

The ability to make and detect sound provides humans with the ability to communicate with each other and to receive useful information from the environment. Sound can provide warning as in from the fire alarm and enjoyment as from music. In addition to such useful and pleasurable sounds, there is noise often defined, as unwanted sound that results from the various anthropogenic activities. Noise is an environmental pollutant generated in conjunction with various anthropogenic activities to which we are exposed before birth and throughout our life. We produce two general types of pollutants as waste products of our way of life. The first type of pollution is the mass residuals that remain in the environment for extended periods of time. The second general type of pollution is energy residuals such as the waste heat and sound waves that do not remain in the environment for extended periods of time. The total amount of sound energy dissipated throughout the earth is not large when compared with other forms of energy; it is only the extraordinary sensitivity of the ear that permits such a relatively small amount of energy to adversely affect [1, 5].

There are valid reasons why widespread recognition of noise as a significant environmental pollutant and potential hazard or as a minimum, a detractor from the quality of life, has been slow in coming. First the definition of noise as unwanted sound is a subjective experience. What is considered noise by one listener may be considered desirable by another. Secondly, noise has a short decay time and thus does not remain in the environment for extended periods, as do air and water pollution. By the time the average individual is spurred to action to abate, control, or, at least, complain about sporadic environmental noise, the noise may no longer exist. Thirdly, the physiological and psychological effects of noise on us are often subtle and insidious, appearing so gradually that it becomes difficult to associate cause with effect. Indeed, to those persons whose hearing may already have been affected by noise, it may not be considered a problem at all [3, 6].

Further, the typical citizen is proud of this nation's technological progress and is generally happy with the things that technology delivers, such as rapid transportation, labor saving devices and new recreational devices. Unfortunately, many technological advances have been associated with increased environmental noise and large segments of the population have tended to accept the additional noise as part of the price of progress.

Properties of Sound Waves

Sound waves result from the vibration of solid objects or the separation of fluids as they pass over, around or through holes in solid objects. The vibration and/or separation cause the surrounding air to undergo alternating compression and rarefaction. The compression of the air molecules causes an increase in local air density and pressure while the rarefaction causes a decrease in density and pressure. It is these alternating pressure changes that are detected as sound by human ears [2].

The rise and fall of pressure follow a cyclic or wave pattern over a “period” of time (Figure 2.1). The wave pattern is called sinusoidal. The time between successive peaks or between successive troughs of the oscillation is the period (*P*). The inverse of this, that is, the number of times a peak arrives in one second of oscillations, is the frequency (*f*) of sound, defined as the number of compressions and rarefaction per unit time. Units of frequency are hertz, which design at the number of cycles per second. Frequency is independent of the speed of sound in a given medium. All frequencies travel at the same speed. In air, at standard conditions, all frequencies travel at approximately 344 m/s. (Equation 1) defines the relationship between the speed of sound and the frequency:

$$\lambda = \frac{c}{f} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where C = speed of sound (m/s), λ= wavelength (m), f = frequency (Hz).

Since the pressure wave moves at a constant speed, the distance between equal pressure readings remain constant. Wavelength is defined as the distance a sound wave travels during one pressure cycle (1 compression and 1 rarefaction). The most important frequency for all acoustical measurements is 1000 Hz since this frequency is the reference frequency of the Phon scalier of equal loudness contours, as also it is the base for all series of preferred frequencies.

The relationship between the speed of sound and the frequency is defined by (Equation 2):

$$C = f\,(\lambda) \ldots\ldots\ldots (2)$$

Where Cis velocity of the sound (m/s), (λ) = wavelength (f) = frequency of sound

Period (p) and frequency (λ) are related according the following equation (Equation 2):

$$\mathbf{P} = \frac{\mathbf{1}}{\boldsymbol{f}} \ldots\ldots\ldots\ldots\ldots\ (3)$$

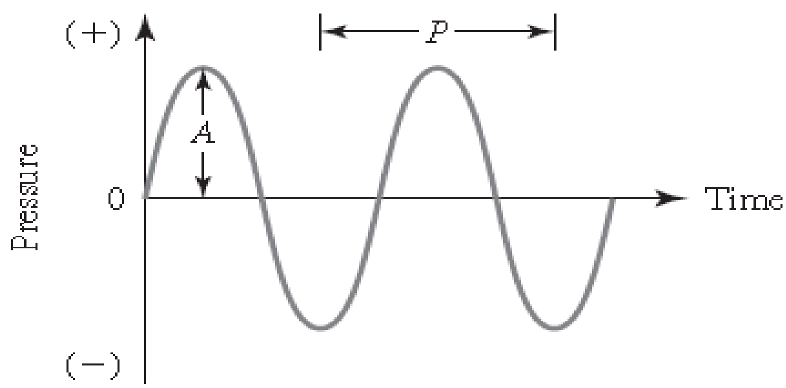

Figure 2.1. Alternating compression and rarefaction of air molecules results in sinusoidal wave (A = amplitude and P =period) [OSHA 1996].

The amplitude (A) of the wave is the height of the peak or depth of the trough measured from the zero pressure line [47].

Sound Power Level

Sound is the transfer of energy without transfer of mass. Sound pressure level and sound power are the magnitudes used to describe the energy of sound or noise. It is known that work is defined as the product of the magnitude of the displacement of a body and the component of force in the direction of the displacement. Thus, traveling waves of sound pressure transmit energy in the direction of propagation of the wave. Sound power is the total amount of sound energy emitted per second by a particular source. It is therefore a property of noise source and will not depend on the environment in which it is placed. The decibel counterpart of sound power is called sound power level (abbreviated to LW, SWL or PWL) and is the most useful quantity to use when one noise source is compared with another. Use of the term sound power level is preferred, since it characterizes the noise emitted by various types of machines and equipments that are essentially independent of the environments. Sound power level is derived using a reference level.

$$Lw = 10\log\frac{W1}{Wr}$$

Where Lw = sound power level (SWL), dB W_1 = power of source (watt), Wr = reference power 10^{-12} (watt), log = logarithm to base 10.

Where there are no reflections in sound and sound radiates equally in all directions, the sound propagation wave follows a spherical distribution. The surface area of a sphere, $4\pi r^2$, would be used to define the sphere surrounding a noise source. If sound intensity is multiplied by the surface area, a relationship between sound power and intensity is established as follow (Equation 3):

$$\boldsymbol{I} = \frac{\boldsymbol{W}}{\boldsymbol{A}} \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where W = sound power in watt, I= average sound intensity at a distance r from noise source, A = area of spherical, $4\pi r^2$ under free field conditions, of an imaginary shell surrounding a source at distance (r) in meter.

Sound Intensity

Sound intensity (I) is defined as the time-weighted average sound power per unit are a normal to the direction of propagation of the sound wave. Sound intensity is the amount of sound power flowing across a particular surface with an area of $1m^2$. It is measured in watts per square meter (W/m^2). Its decibel counterpart is sound intensity level. From equation 4, it is clear that the sound intensity will decrease with the square of the distance. The factor A is reduced as obstructions are introduced. Typically, only half of free field is approached, A is reduced to $2\pi r^2$ for hemispherical radiation. (For l/4 spherical radiation A = πr^2; for a spherical radiation A = $\pi r^2/2$.)The sound intensity, like sound pressure and sound power, also covers a large range of values. Sound intensity is expressed as a dB level described by the following relationship.

$$\text{LI} = 10\log\frac{I}{Ir} \ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Where LI = sound intensity level, dB; I = sound intensity at a given distance, Ir =reference sound intensity, $10^{-12} W/m^2$.

Relationship between SPL and SWL

For a given set of conditions, sound power and sound intensity can be defined in terms of sound pressure and vice versa.

$$I = \frac{(P)^2}{\rho c} \ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Where P = root mean square sound pressure (Pa), ρ = density of air at standard conditions 1.2 kg/m^3, I = intensityW/m^2, C = speed of sound in air, 344 m/s.

Equation 6 can be represented in terms of sound pressure as:

$$\text{Sound pressure} = P = (I\rho C)^{1/2} \text{ ……………… (6)}$$

Again Equation 6 can be described in terms of intensity.

$$\text{Sound power} = W = IA$$

Using the above equation, the additional relationships exist between sound pressure level and sound power level as:

$$Lw = Lp + 10 \log A \text{ ………….. (7)}$$

A is defined as the surface area of an imaginary shell at distance, r, where Lp would be the measured sound pressure level for any point on the shell.

Octave Bands

To completely characterize a noise, it is necessary to break it down into its frequency components. Normal practice is to consider 8 to 11 octave bands. The scale on both sides of the reference frequency is divided by fractions of octaves like 1/1 octave, 1/2 octave and 1/3 octave etc. Table 2.1 shows the standard octave bands and their geometric mean (centre band) frequencies. Octave analysis is performed with a combination precision sound level meter and an octave filter set. While octave band analysis is frequently satisfactory for community noise control (for identifying violators), more analysis that is refined is required for corrective action and design. One-third octave band analysis provides a slightly more refined picture of the noise source than the full octave band analysis. This improved resolution is usually sufficient for determining corrective action for community noise problems. Narrow band analysis is highly refined and may imply bandwidths down to2 Hz. This degree of refinement is only justified in product design and testing.

Table 2.1. Octave bands.

S.NO	Octave frequency range (Hz)	Geometric mean frequency (Hz)
1	22 - 44	31.5
2	44 - 88	63
3	88 - 175	125
4	175 - 350	250
5	350 - 700	500
6	700 - 1400	1000
7	1400 - 2800	2000
8	2800 - 5600	4000
9	5600 - 11200	8000
10	11200 – 22,400	16000
11	22,400 – 44,800	31500

In general, in octave band, the centre frequency (Fc) is related to lower (Fl) and upper (Fu) band frequency as per the following relation:

$$Fc = \sqrt{FlFu} \;\ldots\ldots\ldots\ldots(8)$$

Averaging Sound Pressure Levels

Because of the logarithmic nature of the dB, the average value of a collection of sound pressure level measurements cannot be computed in the normal fashion. Instead, the following equation must be used:

$$\overline{Lp} = 20 \log \frac{1}{N} \sum_{j=1}^{N} 10^{(Lj/20)} \ldots\ldots\ldots\ (9)$$

Where Lp= average sound pressure level, dB re: 20 _Pa

N = number of measurements

Lj= the jth sound pressure level, dB re: 20 _Pa

j = 1, 2, 3 . . . , N

This equation is equally applicable to sound levels in dB A. It may also be used to compute average sound power levels if the factors of 20 are replaced with 10s.

Noise Rating systems

An ideal noise-rating system is one that allows measurements by sound level meters or analyzers to be summarized succinctly and yet represent noise exposure in a meaningful way. Our response to sound is strongly dependent on the frequency of the sound. Furthermore, the type of noise (continuous, intermittent, or impulsive) and the time of day that it occurred (night being worse than day) are significant factors.Because environmental noise levels fluctuate over time, a time-averaged noise level in dB A is often used to characterize the acoustic environment at a given location. The average noise intensity over a given time is the energy equivalent noise level (Leq). The day-night equivalent noise level (Ldn) is a 24-hourLeq which is derived by adding a 10 dB A "penalty" to noise levels measured between 10 p.m. and 7 a.m.

Noise is customarily measured in decibels (dB), units related to the apparent loudness of sound. Weighted decibels (dBA) represent sound frequencies that are normally heard by the human ear. On this scale, the normal range of human hearing extends from about 3 dBA to 140 dBA. Table 1 shows the noise levels of different activities and the response criteria of various noise levels.

A logarithmic decibel scale is used to measure sound, because hearing sensation increases with the logarithm of the stimulus intensity. Each 10-dBA increase in the level of a continuous noise is a ten-fold increase in sound energy, but is judged by a listener as only a doubling of loudness. Each 3 dBA increase in sound is a doubling of sound energy, such as doubling the amount of traffic on a street, but is judged as only about a 20 percent increase in loudness, and is a just-noticeable difference to most people. Increases in average noise of about 5 dBA or more are noticeable to most people, and is the level required before any noticeable change in community response would be expected. A 10 dBA change would almost certainly cause an adverse change in community response.

Equal loudness counter and weighting networks

The ear is less sensitive to low frequencies than to high frequencies. Equal loudness contours (Figure 2.2) show that as sound levels increase, the ear becomes more uniformly sensitive to all frequencies. An equal-loudness contour is a measure of sound pressure (dB SPL), over the frequency spectrum, for which a listener perceives a constant loudness when presented with pure steady tones. The unit of measurement for loudness levels is the phon (sound pressure levels of the 1,000 Hz pure tone in dB) and is arrived at by reference to equal-loudness contours. Equal-loudness contours are often referred to as "Fletcher-Munson" curves, after the earliest experimenters who conducted a series of experiments to determine the relationship between frequency and loudness. The lowest contour (dashed line) represents the “threshold of hearing.”The actual threshold may vary by as much as ±10 dB between individuals with normal hearing [47].

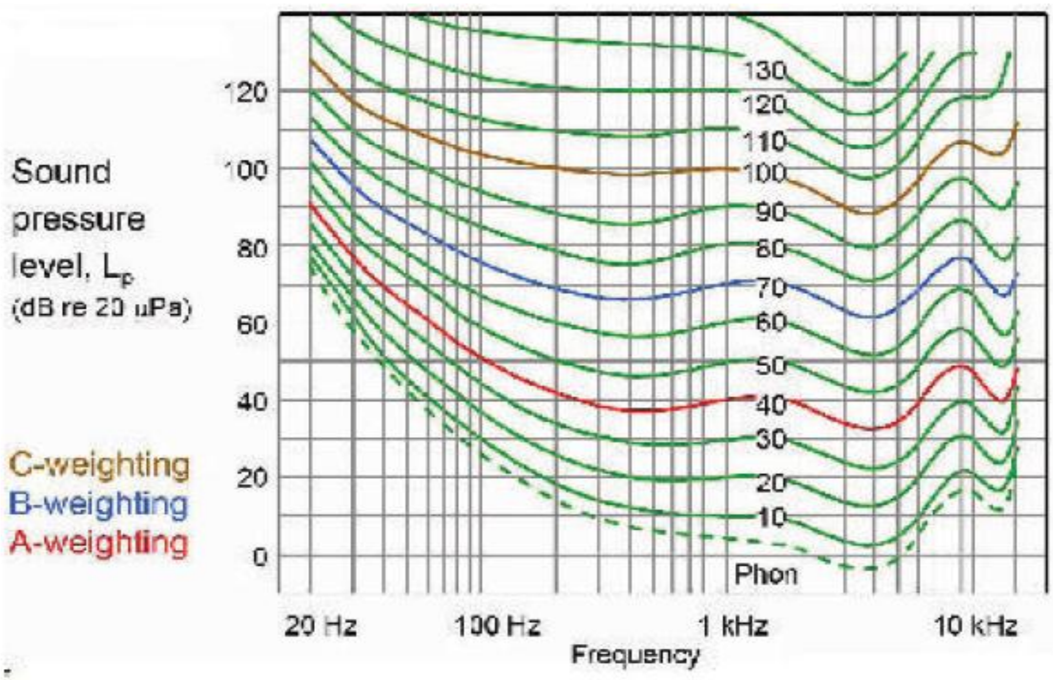

Figure 2.2. Fletcher-Munson equal-loudness counters [OSHA, 1996].

Weighting networks

Loudness of a sound (that is, the subjective response of the ear) varies with frequency as well as with sound pressure and the variation of loudness with frequency depends to some extent on the sound pressure. Sound-measuring instruments are designed to make allowances for this be have or of the ear by the use of electronic “weighting” networks. Weighting networks modify the frequency response of the instrument so that its indications simulate the ear’s sensitivity. The various standards organizations recommend the use of three weighting networks as well as a linear (un weighted) network for use in sound level meters. The A-weighting is designed to approximate the response of the human ear at low sound levels (near the 40 dB level). Similarly, B and C networks approximate the response of the ear at levels of 55-85 dB and above 85 dB values respectively. A fourth network, the D-weighting, has been proposed specifically for aircraft noise measurements. Figure2.3 shows the correction which must be added to a linear reading to obtain the weighted reading for a particular frequency. When even a weighting network proves desirable, in industrial locations, the A-weighting network was taken to measure noise. Table **1**represents the A- weighting corrections for different frequency bands.

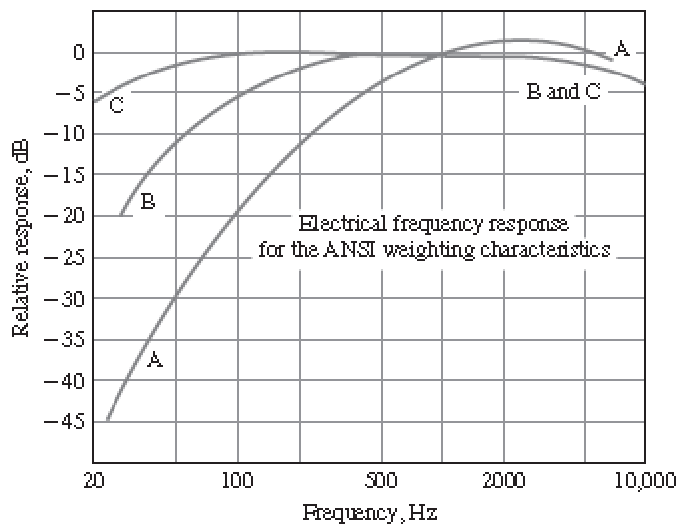

Figure 2.3. Response characteristics of the three standard weighting networks namely A, B, and C [David H.F. Liu 1999].

Noise Measurement

Acoustic instruments have been used for decades to quantify the physical properties of sound and classify them on the basis of physical parameters like amplitude and duration. These instruments include sound level meter, octave band analyzers, noise dose meter, noise average meter, noise survey meter, statistical analyzers, recorders (magnetic tape, cassette, and pen), acoustic calibrator and sound scope meter. Different weighting network A, B and C have been adopted in sound level meters. However, scales other than A are seldom used as they do not provide a good approximation to the human ear frequency response. Noise survey meter is used in the measurement and analysis of steady noise. Sound scope meter is a combination of both sound level meter and octave band analyzer in a small unit. Noise integrator is capable of measuring intermittent noise by giving an intermittent or average noise level when used in conjunction with a noise survey meter. Noise dose meter is used to integrate automatically the sound energy received with regard to its intensity and duration. They are used to assess total noise exposure at workplace. The dose may be expressed as a proportion of the maximum permitted 8 hours dose. Noise measuring instruments made by B & K are widely used with reliability and accuracy [1].

Sound Level Meter

The basic instrument for measuring noise levels is the sound level meter, sensitive to RMS sound pressures between about 20 and 20,000 Hz. It is equipped with weighting networks, fast and slow response, an attenuator with102 dB steps and an indicating meter which spans 16 dBs, from - 6 to +10 dB. It operates over a total range of about30 to 140 dB sound pressure level. The basic parts of most sound level meters include a microphone, amplifiers, weighting networks and a display indicating decibels. The microphone acts to convert the input acoustic signal (acoustic pressure) into an electrical signal (voltage). This signal is magnified as it passes through the electronic preamplifier. The weighting network to obtain the A-, B-, or C-weighted signal may then modify the amplified signal. This signal is digitize to drive the display meter, where the output is indicated in decibels. The display setting may be "fast" response, "slow" response, "impact" response or "peak" response. Unless interested in measuring rapid noise fluctuations, the "slow" response setting is usually used.

Most sound level meters have output terminals so that accessories such as impact-noise meters, octave-band and Ad octave-band filter sets, graphic recorders and the like can be attached. Self-contained analyzers are also available with all components housed in a single unit; these often have variable width settings. Based on the accuracy of the meter sound level meters are rated into the following categories,: (a) type 1, precision; (b) type 2, general-purpose; (c) type 3, survey and (d) special-purpose sound level meters.

The Effects of Noise

According to WHO (1990) the health significance of noise pollution can be classified depending upon the specific effects: noise-induced hearing impairment, interference with speech communication, disturbance of rest and sleep, psycho-physiological, mental health and performance effects, interference with intended activities, annoyance and effects on residential behavior [8].

Hearing Impairment

Hearing damage is related to duration and intensity of noise exposure and occurs at levels of 80 dB (A) or greater, which is equivalent to the noise of heavy truck traffic. Children seem to be more vulnerable than adults are.

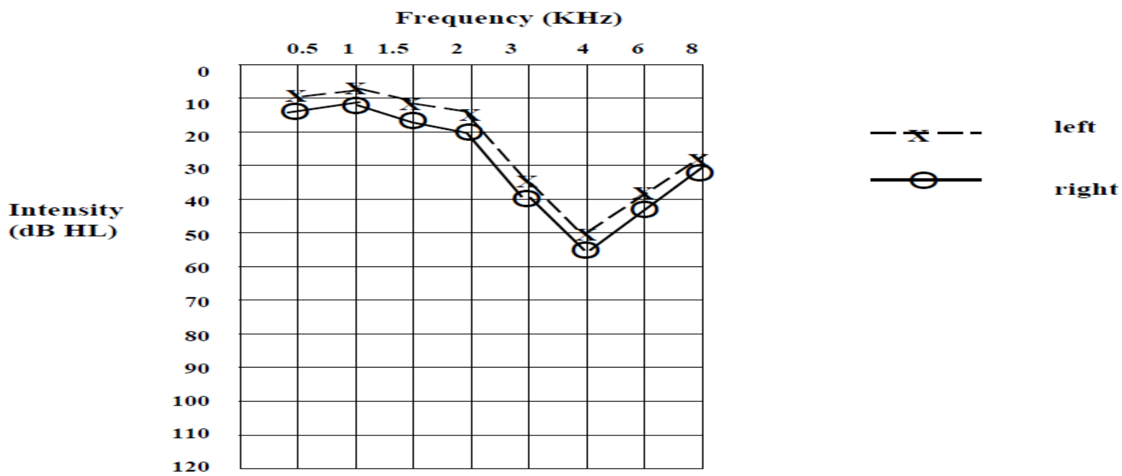

Figure 2.4**.** The shape of the noise induced hearing loss [Ashenafi Hailu, 2015].

Data collector was audiometric technician for audiometric reading and physician to do physical diagnosis and noise induced hearing loss was identified with physician trained on this area or otolaryngologist.

Table 2.2. Definition of hearing impairment (WHO, 1991)

Grade of hearing impairment	Audiometric ISO value	Performance
0:No impairment	<25 dB (better ear)	No, or very slight, hearing problems. Able to hear whispers.
1: Slight impairment	26−40 dB (better ear)	Able to hear and repeat words spoken in normal voice at 1 m.
2: Moderate impairment	41−60 dB (better ear)	Able to hear and repeat words using raised voice at 1 m.
3: Severe impairment	61−80 dB (better ear)	Able to hear some words when shouted into better ear.
4: Profound impairment,	>81 dB (better ear)	Unable to hear and understand even a

including deafness		shouted voice.

Speech Interference

Noise can interfere with our ability to communicate. Many noises that are not intense enough to cause hearing impairment can interfere with speech communication. The interference, or *masking,* effect is a complicated function of the distance between the speaker and listener and the frequency components of the spoken words. The Speech Interference Level (SIL) was developed as a measure of the difficulty in communication that could be expected with different background noise levels. It is now more convenient to talk in terms of A-weighted background noise levels and the quality of speech communication.

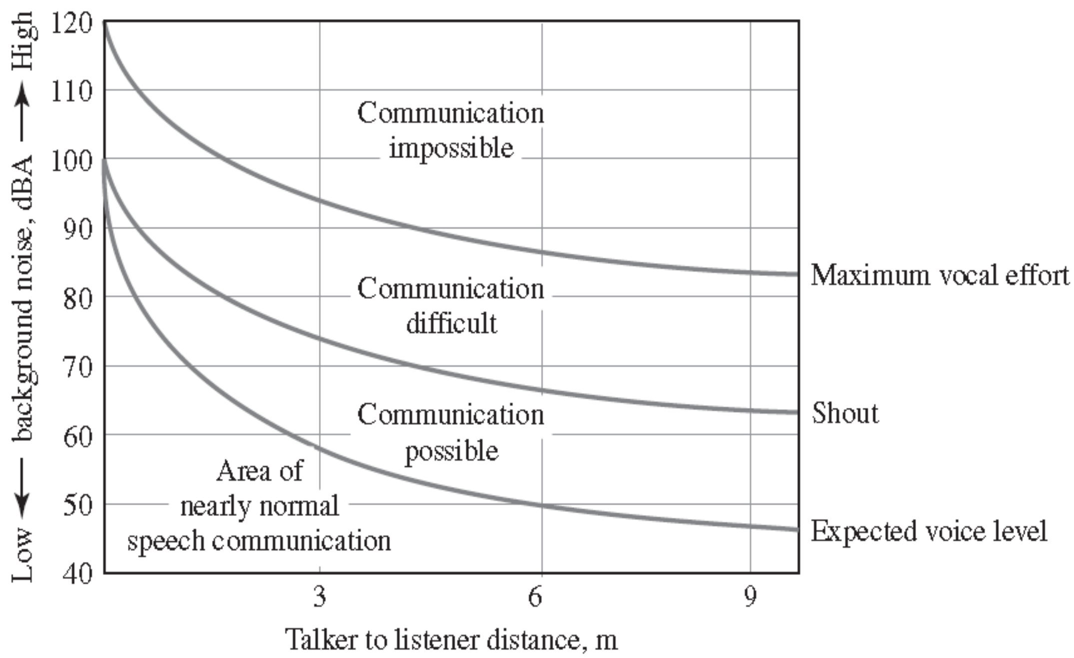

Figure 2.5. Quality of speech communication as a function of sound level and distance [David H.F. Liu 1999].

Uninterrupted sleep is known to be a prerequisite for good physiological and mental functioning in healthy persons. Noise pollution is a major cause of sleep disturbances. Apart from various effects on sleep itself, noise pollution during sleep causes increased blood pressure, increased heart rate, increased pulse amplitude, vasoconstriction, cardiac arrhythmias, and increased body movement. These effects do not decrease over time. Secondary effects include fatigue, depressed mood and well-being, and decreased performance. Combinations of noise and vibration have a significant detrimental effect on health, even at low sound pressure levels.

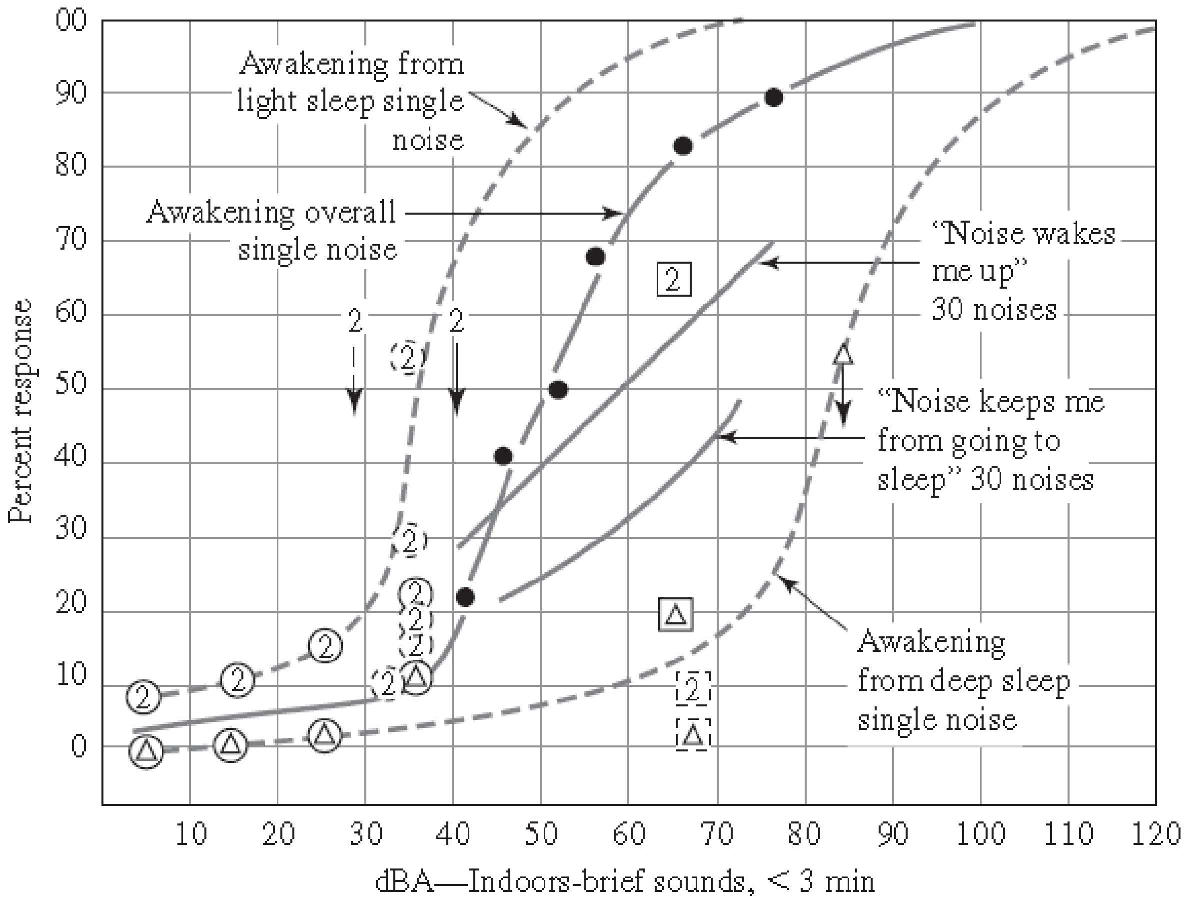

Figure 2:6. Effects of brief noise on sleep [David H.F. Liu 1999].

Effects on Performance

The effects of noise pollution on task performance have been well studied. When a task requires the use of auditory signals, noise at any intensity level is sufficient to mask task performance. However, where mental or motor tasks do not involve auditory signals, the effects of noise on performance have been difficult to assess. Steady noises without special meaning do not seem to interfere with human performance unless the A-weighted noise level exceeds about90 decibels. Irregular bursts of noise (intrusive noise) are more disruptive than steady noises. Even when the A-weighted sound levels of irregular bursts are below 90 decibels, they may sometimes interfere with performance of a task. High-frequency components of noise, above about 1,000–2,000 hertz, may produce more interference with performance than low-frequency components of noise. Noise is more likely to reduce the accuracy of work than to reduce the total quantity of work. Complex tasks are more likely to be adversely influenced by noise than are simple tasks.

Noise impairs task performance, increases errors, and decreases motivation. Reading attention, problem solving and memory are most strongly affected by noise.

Cardiovascular Disturbances

A growing body of evidence suggests that noise pollution may be a risk factor for cardiovascular disease. Acute exposure to noise activates nervous and hormonal responses, leading to increased blood pressure and heart rate and to vasoconstriction. If the exposure is of sufficient intensity, there is an increase in heart rate and peripheral resistance; an increase in blood pressure, and increased levels of stress hormones (epinephrine, nor epinephrine, and cortical).

Disturbances in Mental Health

Noise pollution is not believed to be a cause of mental illness, but it is assumed to accelerate & intensify the development of latent mental disorders. Noise pollution may cause or contribute to the following adverse effects: anxiety, stress, nervousness, nausea, headache, emotional instability, argumentativeness, & sexual impotence, changes in mood, increase in social conflicts, neurosis, hysteria, and psychosis. Children, the elderly and those decreases motivation,

Negative Social Behavior and Annoyance Reactions

Annoyance is defined as a feeling of displeasure associated with any agent or condition believed by an individual to adversely affect him or her. Annoyance increases significantly when noise is accompanied by vibration or by low frequency components. The term annoyance does not begin to cover the wide range of negative reactions associated with noise pollution; these include anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Social and behavioral effects are complex, subtle, and indirect. These effects include changes in everyday behaviors (closing windows and doors to eliminate outside noises), changes in social behavior (aggressiveness or disengagement), and changes in social indicators (residential mobility, hospital admissions, drug consumption, and accident rates), and changes in mood (increased reports of depression). Noise above 80 dB is consistently associated with decreased helping behavior and increased aggressiveness. The WHO guideline values for schools are summarized in Table 2.3.

Table 2.3. WHO Community Noise Guidance

Environment	Critical Health Effect	Sound Level dB (A)	Time (Hr.)
Outdoor living areas	Annoyance	50 - 55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	Sleep disturbance	30	8
School classrooms	Disturbance of communication	35	During class
Industrial, commercial & traffic areas	Hearing impairment	70	24
Music through earphones	Hearing impairment	85	1
Ceremonies and entertainment	Hearing impairment	100	4

2.2. Control of Noise

Essentially, there are three approaches to reduce and control noise: modifying the source, altering or controlling the transmission path and the environment and protecting the receiver. Source control can be achieved by careful consideration of noise control during the design of new products. This may mean using a quieter process instead of a noisy one, reducing the amount of metal-to-metal impact, treating radiating panels or using vibration isolation mountings. Regular maintenance is also important in reducing noise at source. A new course of action that has arisen recently is active noise/vibration control that attempts to reduce radiated sound levels by means of either injecting sound near the source to force destructive interference or modifying the radiation efficiency of the source. One variation of the source control theme is operation oriented, in that effective noise control may be achieved by introducing alternative methods of performing an operation. One can see that noisy operations at night incur the 10-dB penalty in the Ldn whereas the same operation performed during the day would not [52].

When the desired amount of noise reduction cannot always be achieved by source reduction, the next best solution is the modification or alteration of the noise path between the source and the receiver. Usually, the source control step coupled with path modification should result in an adequate noise reduction. However, noise levels may be high in spite of adequate controls. In such cases, the third approach to noise control is that of personal protection or control at the receiver. The individual's exposure to noise levels either must be limited to dosage levels by limiting time and dosage level, or by further protection through the wearing protective devices such as ear plugs or head phones.

Thus, noise is any sound, independent of loudness, that can produce an undesired physiological and/or psychological effect in an individual or group and that may interfere with the social ends of all human activities including communication, work performance, recreation and sleep [1].

Noise is an environmental pollutant that is increasing very rapidly because of improvement in commercial, industrial and social activities. The study of noise covers all fields of sound production, propagation and reception and is measured as sound pressure [2].

. Sound pressure level depends on the power output of the noise source and the environment. The ear has the remarkable ability to handle an enormous range of sound.

Much advancement made in many countries to improve working conditions and to develop worker safety and health, we still face a tremendous worldwide need for more effective measures in workers life. This is particularly the case in developing countries [4, 8].). Information of occupational accidents is not standardized worldwide. Especially, developing countries do not have reliable information on their occupational accidents due to lack of proper recording and notification systems.

More than one-half million construction workers are exposed to potentially hazardous level of noise every year. Yet federal and state Occupational Safety and Health Administration (OSHA) programs provide little incentive to protect them against noise-induced hearing loss. Construction noise regulations lack the specificity of general industry noise regulations [7].
According to ILO and who estimated every year more than 1.2 million people die of work related accidents and disease, more than 160 million workers fall in each year owing to work place hazards, the poorest, least protected in individuals, often women, the children and migrants are among those most affected. Several studies conducted in the 1960s and 1970s indicated that construction workers were over exposed ``for noise. In the early 1980s NIOSH estimated the numbers of workers in various occupations, including construction, exposed to noise levels above 85 dB (A). Although the percentages were derived in the early 1980s, the data on numbers of employees in the various trades has been updated to1995.The highest percentages of

overexposed workers occur in highway and street construction, carpentry, and concrete work. Of the approximately 5 million construction workers in 1995, the total number exposed to noise levels of 85 dB (A) and above was about 754,000.

Because NIOSH sampled noise levels rather than exposures, these are not time-weighted average (TWAs), and the actual numbers would be somewhat lower when using TWA, but these numbers are useful for ranking the extent of the hazard by trade and to estimate the upper bound of the total number exposed [9].

Meters measure sound pressure on the decibel dB (A) scale. 0dB is the threshold of human hearing, 50dB is around the level of a normal conversation and 120-140dB is the threshold of pain. A 3dB increase is equal to a doubling in sound pressure but, if the sound is steady, will only just be noticed by a human. A 10dB increase equates to a doubling in the perceived loudness. Standards for environmental noise use the 'A-weighted' decibel scale [dB (A)] which mimics the sensitivity of the ear to different frequencies. The environmental noise indicators used vary between countries and industries and depending upon the type of sound that is being measured. They include: the maximum sound level reached in a period of time; the average sound level over a period of time. If noisy events are intermittent, the average value may not reflect the actual disruption caused by each event; indicators that are weighted to account for sound at disruptive times of the day such as evening or night [13, 14].

2.3. Magnitude of occupational noise exposure level and its effect

Worldwide, 16% of the disabling hearing loss in adults (over 4 million DALYs) is attributed to occupational noise, ranging from 7% to 21% in the various sub regions. The effects of the exposure to occupational noise are larger for males than females in all sub regions and higher in the developing regions [17].

Long-term exposure to noise levels beyond 80 dB (A) carries an increased risk of hearing loss, which increases with the level and duration of noise exposure and ultimately this will lead to hearing impairment in some workers (20). WHO defined hearing impairment as a hearing loss of "at least 25 dB in the better hearing ear (average over the frequencies 0.5, 1, 2 and 4 kHz)" (38).

Since human conversation usually ranges between 0.5 to 2 KHz, a permanent threshold of more than 25 dB at frequencies between 0.5 to 2 kHz is considered to affect normal activities. Such level of hearing loss decreases the capacity to engage in conversation, in meetings or social activities, thus creating a significant barrier in establishing or maintaining emotional relationships and leading to isolation. Hearing loss due to chronic exposure to noise occurs by causing damage to the outer hair cells in the cochlea in the inner ear [39]. The damage is permanent with no effective cure [40, 41]. However, the risk of noise-induced hearing loss can be greatly minimized if noise exposure is reduced to below 80dBA [42].

Negative effects of noise on human beings are generally of a physiological and psychological nature. Hearing losses are the most common effects among the physiological ones. It is possible to classify the effects of noise on ears in three groups: acoustic trauma, temporary hearing losses and permanent hearing loss [43].

Noise also can related with blood pressure increases, heart beat accelerations, appearance of muscle reflexes, sleeping disorders may be considered among the other physiological effects. The psychological effects of noise are more common compared to the physiological ones and they can be seen in the forms of annoyance, stress, anger and concentration disorders as well as difficulties in resting and perception [44, 45].

These reviews will emphasis on all formations relating to environmental considerations for the occurrence of any noise pollution [35]. The highest unwanted sound risk exposure come from heavy cars and machinery, such as those used to access hearing, for example, dozer sound. Personal protective equipment’s considered to be the last line of defense against hazards in the workplace. Advocates for workers in high-risk occupations emphasize the continuing need to control or eliminate hazards, rather than require workers to protect themselves with personal protective equipment. For example, hearing protectors eliminate or reduce the chances of hearing loss (provided they fit, are appropriate, and are used properly), but they do not eliminate the hazard – in this case, noise [15].

PPE will, however, continue to be required in many work situations: must be used if occupational exposure remains after engineering work practice controls are estimated or it theirs controls are not feasible such equipment includes gloves, gowns, face shields or masks, eye protection and hear protector, personal protective equipment’s are considered appropriate if they does not permit blood, unwanted sound other potentially infection materials to pass through or reach employees it from punctured or contaminated or if its ability to function as a barrier is compromised [4]. Work practices must be assessed for officially so that protective practices can be reinforced an unsafe practices altered by hazarded control mechanism like, unwanted sound, containment, facility design safety equipment’s biological safety cabinet[2, 4].

World Health Organization (WHO) Guidelines for Community Noise (1999) provide community noise exposure recommendations (Table 2.3). Alternatively, a written record which includes dates and times during which the perceived noise nuisance occurred and/or a tape recording of the type of noise experienced, can provide important evidence which can be presented in Court (McGraw-Hill (1997).

2.4. Environmental Policy, Laws & Standards of Ethiopia

2.3.1 Environmental Policy of Ethiopia

The Government of the Federal Democratic Republic of Ethiopia (FDRE) has established a comprehensive environmental policy in 1997. The overall policy goal is aimed to improve and enhance the health and quality of life of all Ethiopians. The policy sets the following objectives and principles among others.

2.3.2 Specific Laws on Noise Pollution

Some countries have specific legislation on noise. For Instance, United States of America, noise control code 1972, Japan, Noise Control Laws 1968, in the case of Ethiopia, Noise Pollution is governed under the Environmental Pollution Control Proclamation 300/2002 and other laws.

2.3.3 Regulation of Noise Pollution under the Laws of Ethiopia

Articles 44 and 92, of Federal Democratic Republic of Ethiopia's Constitution (1995) deal with environmental rights and environmental objectives respectively, According to Article 44 "All persons have the right to clean and healthy environment". Despite the facts that environmental rights and environmental objectives are part of the Constitution there is no specific legislation emanating from these articles of the Constitution.

2.3.4 The Issues of Noise Pollution under the Environmental Pollution Control Proclamation No. 300/2002 and Other Laws.

Environmental Pollution Control Proclamation No.300/2002 is the General Law which covers all aspects of environmental pollutions including noise pollution. Noise is included in the list of pollutants under the definition part of the proclamation.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1.Description of Study area and period

The study area is Jimma road construction project (JRCP), located at an altitude of 1740 m above sea level. The instrument was mounted at a height of 1.5 m above the ground for all the 14 locations for consistency of measurement with the antenna pointing to the sound source. The instrument was set at the A-weighting network and the equivalent noise level (Leq) which is the constant noise level that expands the same amount of energy over the same period, was measured for the various locations. This measurement process was carried out for the 14 construction machineries locations at different times of the day.

This study was conducted in Jimma road construction project (JRCP), Jimma, Oromia, Ethiopia from May 2016 to October 2016. Jimma town is located 352 km southwest of Addis Ababa. The town has an estimated area of 4482 m^2 and is located at an altitude of 1740 m above sea level; its average annual rainfall is about 1465.7 mm, which makes it one of the wettest places in the country. The town is divided in to seventeen kebeles and 22,831 households with an average family size of 5.5 persons and also has estimated total of asphalt road coverage of 35.10 km.

Jimma Road construction project costs 55,000,000 Birr by which a total of 8 km length and 7m to 15 m width asphalt road is constructed. The project has employed 363 full and half time administrative and technical staffs of which 187 are full time field construction workers. The project used about 14 different types of machineries. Duration of the construction was from February 2016 to June 2017.

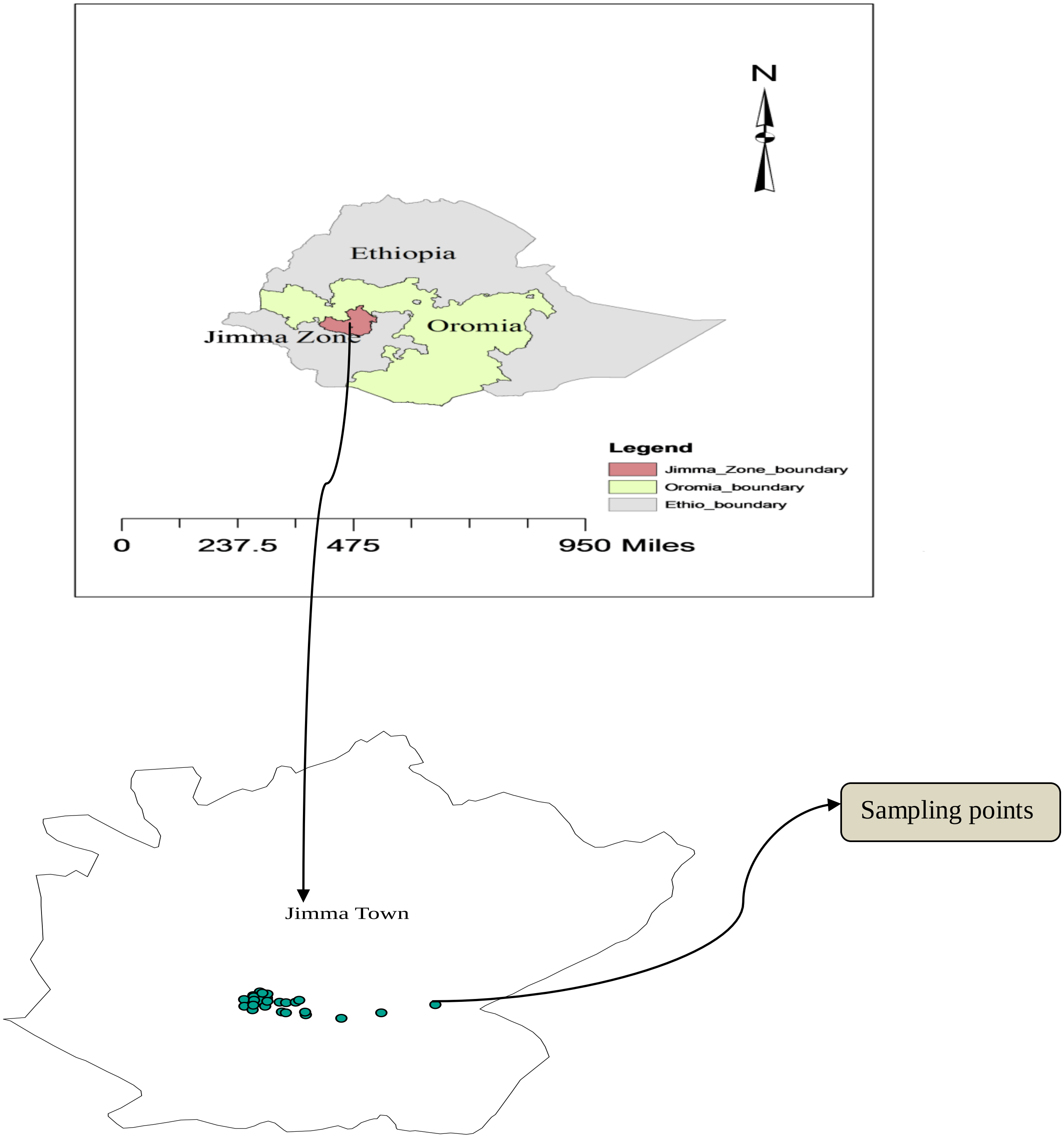

Figure3.1 Map of study area.

3.2.Study design

A cross-sectional study design was conducted to assess the noise pollution level and the corresponding safety measures at Jimma road project.

3.3.Study variables

- ✓ Noise pollution and safety measures level
- ✓ Type of machineries
- ✓ Age
- ✓ Sex
- ✓ PPE
- ✓ Safety measures
- ✓ Noise exposure time

3.4. Social survey

Social survey was also conducted in the case study road construction project as part of the overall assessment of questionnaires. Questionnaire was designed to cover age, job identification, staff noise senility rate and condition, non-staff perception and business of non-staff within the vicinity of the project location. A total of 187 questionnaires were distributed and all were completed and returned, which form the basic data analysis and discussion in this study. The construction workers who exposed to the machineries noise were assessed for health risks and the safety measures they applied.

3.5. Source population:

All workers found in JRCP (including full and half time office and fieldworkers).

3.5.1. Study population:

The technical workers who work on the field and exposed to noise from machineries (both half and full time workers).

3.5.2. Sampling population:

Full time workers who work on the field and get an exposure of noise for eight hours per day (n=187).

3.6. Sampling method and procedure.

Non-probabilistic purposive sampling method was used to select the study participants to get information about the noise pollution level and safety measures in place to protect the health of workers. The noise levels of all the fourteen machineries were measured.

3.7. Data collection methods and tools.

Noise measurements were conducted at construction site using a Sound Level Meter (Model: 407730) 'Mediator 2238', which is a Digital Sound Level Meter (SLM) meter from FLIR System, Inc., USA. Primary data were gained from noise level measurements of the construction machineries by using the sound level meter and 187 construction workers were interviewed to obtain data for social survey.

3.8. Noise Measurements.

This SLM conforms a polarized ½" condenser microphone type model 407730 was used to the SLM. Sound level calibrator type 407744 was used to calibrate the SLM at 80 and 110 dB A and it istype 2, general-purpose SLM.Noise was measured using Slow time weighing and A-frequency weighing.

A total of 14 construction sites machineries the city of Jimma were selected for monitoring noise. Noise measurements were carried out two times at each site and at a distance of 1m, 3m, and 5 m from the construction equipment. The construction sites were selected based on project type, project size and construction stage. The construction projects included Soil compacting, Loading gravel on dam trucker, Scraping top soil, mixing cement, Paving asphalt, Cutting Asphalt edge and others. Different construction stages include excavation and foundation, construction activity and types of equipment include excavators, roller, asphalt cutter, concrete pumps, water pumps, generators, concrete mixers.

A time-varying noise, measured in dB A can be described in terms of its cumulative distribution. Different sound level values were determined in this study. It is obtained by averaging the mean energy of noise levels over the measurement period.

A time-varying noise, measured in dB A can be described in terms of its cumulative distribution. Different sound level values were determined in this study. Sound measurement was done at 1m, 3m, and 5m distance from the machine. The maximum and minimum sound levels were recorded. The sound measurement done before and after the machine started working to control the sound interference from the environment. Sound meter measures the sound pressure level in dB (A) i.e. decibels in A weighted scale. The sound level meter used, can measure the sound frequency from 300 Hz to 8 kHz and from 40 dB to 130 dB in A weighted scale Accuracy / Resolution ± 2dB @1kHz (under reference conditions)/0.1dB .Social survey data were collected by principal investigator and environmental health professional using checklist, questionnaires.

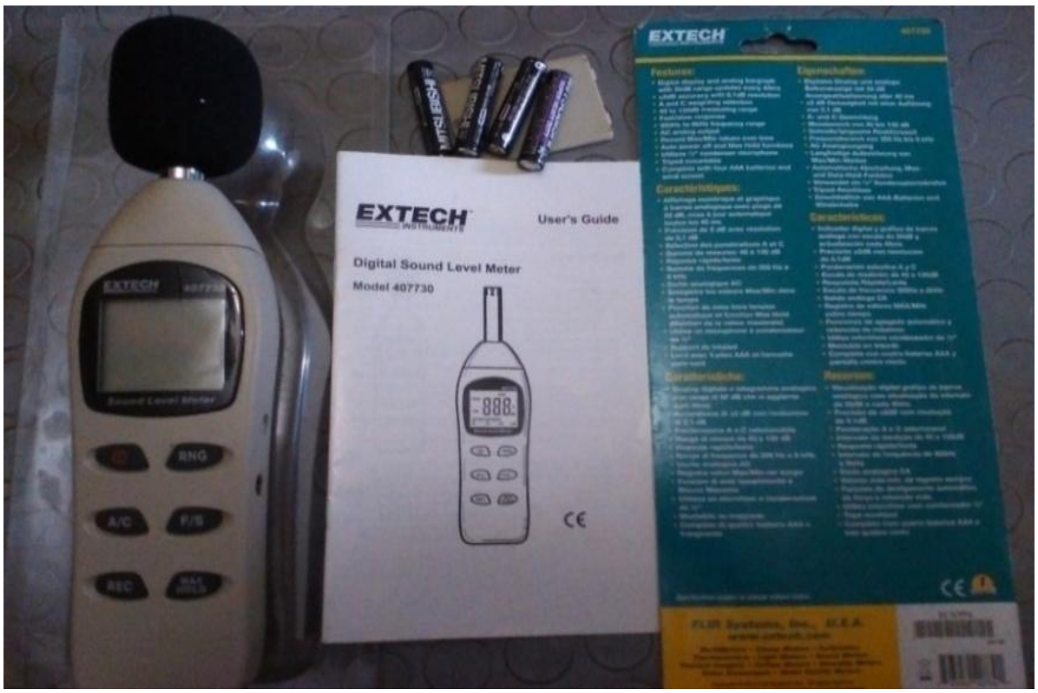

Figure 3.2 Extech407730 Digital Sound Level Meter.

All the data measured are compared with the OSHA and EASH standard guidelines. The sound level meter was handled at proper orientation to receive the maximum and minimum sound intensity at the height (elevation) of from ground 1.2m to1.5m.

Questionnaire was adopted to conduct a detailed noise survey around the sampling site to know the perception of the exposed individuals (i.e. construction workers) regarding the effect of noise in their daily life. In this form there are questions regarding noise problem and ways to solve it. By answering this questionnaire, it helps to get some information about the noise rate in particular area. The questionnaire contains yes/no response type, multiple choice for the purpose to response easily and open-ended for the purpose to get further information.

The questionnaire, which is consisted of four sections: section one; socio-demographic characteristics of the study groups, section two as well as section three contain awareness of noise pollution and about personal protective equipment measuring questions.

The first of the two sections of data collection instrument used for this paper had a list containing the general information, namely; age, sex, grade, educational status and religious. Section two as well as section three contains (ANNEX II) .The respondents were then requested to list down the problems in order of significance for each of the questions and these parts were generalized in to three during analysis, because of the conceptual similarities of the questions.

Key informants interview were also the tool used to gather primary data. The purpose of key informant's interview was to learn about the view of different experts at office level and from the leaders of the topic of interest, to measure the change that comes within the noise exposure and to understand their noise pollution perceptions. Hence, key informant interviews were conducted with the road construction sanitation and beautification office and including environmentalist level experts found in the study area. In relation to the interviews, interview guides for key informants were prepared and used in line with the objectives of the study.

The English version of the questionnaire and the interview was translated to Amharic twice by two different individuals so as to validate its correct translation and piloted for ten respondents within the study population before the actual data collection. During the pretest, it was understood that most of the survey participants can't read and write and to enhance the quality of the data, the questionnaire was filled by their searcher and survey. Due to financial constraints, the researcher didn't pay incentives for facilitators participants. Nevertheless, the individuals who survey to contact the participants were paid.

3.9. Direct personal observations

The study employed quantitative research approach in order to investigate important aspects of noise pollution in road construction project. Therefore, the researcher used data collection instruments such as questionnaire, interview, sound level meter and direct personal observation (checklist). Direct personal observations involved visiting of all Jimma road-working sites, one fixed machinery plant and construction material storage. Interview was conducted form JRCP worker. The questionnaire was used to collect data from the road construction worker. Both instruments were constructed on the bases of extensive review of literature that was made so far.

3.10. Data processing and analysis

The data were processed manually by using tally sheet, scientific calculator, Minitab 16 and Microsoft Office Excel 2007 software. Then, it was analyzed and interpreted using descriptive statistics. The study was analyzed qualitatively to give clear understanding about the workers noise pollution problem. Therefore, similarly, quantitative data was analyzed and presented using descriptive statistics like in words, figures, graphs and tables, percentages to give clear understanding of the issues quantitatively. In addition, the sample points were mapped by using Arc GIS 10.

3.11. Data Quality assurance

To increase the accuracy of the data collection the data collectors were trained and supervised by the principal investigator to test the quality of data collection tool pre-test were taken on % 5 of the sample and some corrections were made based on the pre-test and SLM measurement considerations done including calibration**.** Duplicate noise measurements were made and the minimum, maximum value was considered at the height (elevation) of from ground 1.2 m to1.5 m.

3.12. Ethical consideration

In the process of the study, the following ethical issues were considered. In order to obtain an informed consent from the respondents, the purpose of the study was explained clearly. Each respondent gave informed verbal consent, after being told the purpose and procedures of the study and official permission and letter were obtained from JIT ethical review board before data collection. JRCP data collector and leaders were asked to give their informed consent orally before filling out the questionnaire or participating in any of the key informant interview discussions. Once they agreed to participate, respondents were assured that their responses would be kept confidential, consequently giving any kind of information carry no consequence because their personal details including names was not incorporated in the questioner. Information obtained from the respondents was promised to be kept confidential. Necessary efforts were made so that the languages in the data collection tools would consider the culture, religion and the comprehending level of the respondents.

3.13. Dissemination plan

The final results of the will be presented to JIT and Jimma university research and publication office. Publication in a reputable journal is also considered.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Result of site measurement

The site measurement has been done in accordance, the sound level meter or SLM had been used in acquisition of noise level at the study site. The data presented shows the noise level, its maximum, minimum and average (avg.) readings of the different machineries and their observed tasks in the road construction project during sound measurement.

Table 4.1. Types of machineries and their observed tasks in the road construction project during sound measurement. October 2016

S.NO	Type of machine	Task
1	Roller	Soil compacting
2	Water truck	Spraying water on soil (ground)
3	Dam truck	Damping gravel
4	Excavator	Loading gravel on dam trucker
5	Grader	Scraping top soil
6	Pickup	Transport material to sit
7	Asphalt distributer	Dispersing liquid hot range
8	Mobile concrete mixer	Mixing cement, gravel and sand with water
9	Front-end loader	Loading gravel from concerti mixer
10	Asphalt paver	Paving asphalt
11	Pneumatic	Compacting asphalt
12	Asphalt cutter	Cutting Asphalt edge
13	Water pump	Pumping water form river
14	Asphalt mixer plant (hot mixer)	Mixing of gravel and petroleum

The main focus of this study was to assess and evaluate the effect and magnitude of noise pollution during road construction in Jimma town. Other central issues were to examine the influence of noise exposure in the road construction project.

Construction noise makers, e.g., heavy earth moving equipment, asphalt cutting machine, mixer machine operation and vibrator machines are taken as examples for this study. The disturbance in terms of severity of noise caused during the construction process and their impact vary depending on the nature of the activities being performed, the equipment being used, and the physical nature of the surrounding environment i.e., urban area versus green field conditions [34].

Exposure to excessive noise more than recommended duration may result in loss of hearing, stress, high-blood pressure, loss of sleep, distraction affecting productivity, and a general reduction in the quality of life. The effects of noise are difficult to quantify because tolerance levels among different populace and types of noise vary considerably. There is a large amount of scientific literature written on the effects of noise on human beings. It may cause deafness, nervous breakdown, mental disorder, heart troubles, high blood pressure, dizziness and insomnia [19].

Exposure to noise pollution exceeding 85 decibels for more than eight hours daily for a long period of time can cause loss of hearing [WHO]. The hazards increase with the intensity of the noise and the period of exposure [34]. This excessive noise could carry several ill-effects. irritation, speech interference, sleep disturbance, mental stress, headache, and lack of concentration. Similarly, Singh [OSHA] noted that the workers exposed to high noise levels have a higher incidence of circulatory problems, cardiac diseases, hypertension, peptic ulcers, and neuron sensory and motor impairment [34]. However, the entire construction sites for worker the noise level permissible limits are 90 dB (A) [OSHA].

Construction site machineries and their observed tasks in the road construction project during sound level measurement were, soil compacting Spraying water on soil (ground), Damping gravel, Loading gravel on dam trucker, Scraping top soil...etc., (Table 4.1). Research involved in field measurement of the noise levels generated by road construction machinery at 1 m,3 m and 5 m. The average sound pressure level Decibel, dB(A) that produced by different machineries in the road construction project at three (i.e. 1m, 3m, 5m) different distance from the highest sound producing part of the machine. The noise that is generated from the existing system of operation at average of 1m is about 2.6% to 20.8% higher than the standards prescribed by the OSHA. Such a severe noise pollution has to be reduced and at average 5 m the noise level was measured sound level are safest area but asphalt cutter and hot mixer not included under OSHA standard. The sound level meter or SLM had been used in acquisition of noise level at the study site. The data presented shows the noise level, its maximum, minimum and average (avg.) readings of the different machineries.

Table 4.2. The maximum, minimum and average sound level of machineries in the road project of Jimma town, October 2016.

Type of machine	dB at 1m			dB at 3m			dB at 5m		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Roller	98.3	102.4	100.35	88.1	91.8	89.95	83.7	85.9	84.8
Water truck	96.2	97.8	97	92.4	94.8	93.6	84.6	86.2	85.4
Dam truck	93.1	95.7	94.4	83.2	85.9	84.55	77.4	79	78.2
Excavator	102	105.2	103.6	96.8	98.7	97.75	89.1	91	90.05
Grader	97.1	104.3	100.7	89	91.2	90.1	83	85	84
Pickup	96.2	88.5	92.35	83.2	81.3	82.25	77	78.9	77.95
Asphalt distributer	96.2	98.2	97.2	89.7	91.2	90.45	85.2	85.8	85.5
Concrete mixer	97.9	100.4	99.15	88.1	89.2	88.65	84.1	85.9	85
Front End Loader	99.2	101.9	100.55	89.2	92	90.6	83.1	88.2	85.65
Asphalt paver	106.5	104.4	105.45	101.9	103.8	102.85	83.1	85.7	84.4
Pneumatic	97.8	96.1	96.95	89.9	92.1	91	84.1	85.9	85
Asphalt cutter	107.2	110.3	108.75	104.8	106.9	105.85	99.8	103.1	101.45
Water pump	101.2	104	102.6	98	99.6	98.8	86.9	89.2	88.05
Asphalt mixer (hot mixer)	102	103.9	102.95	99.9	101.2	100.55	94.2	93.1	93.65

The sound level meter or SLM had been used in acquisition of noise level at the study site. The data presented shows the noise level, its average (avg.) readings of the different machineries. The following figure 4.1 shows the average sound level in Decibel, dB (A) that produced by different machineries in the road construction project at three (i.e. 1m, 3m, 5m) different distance from the highest sound producing part of the machine.

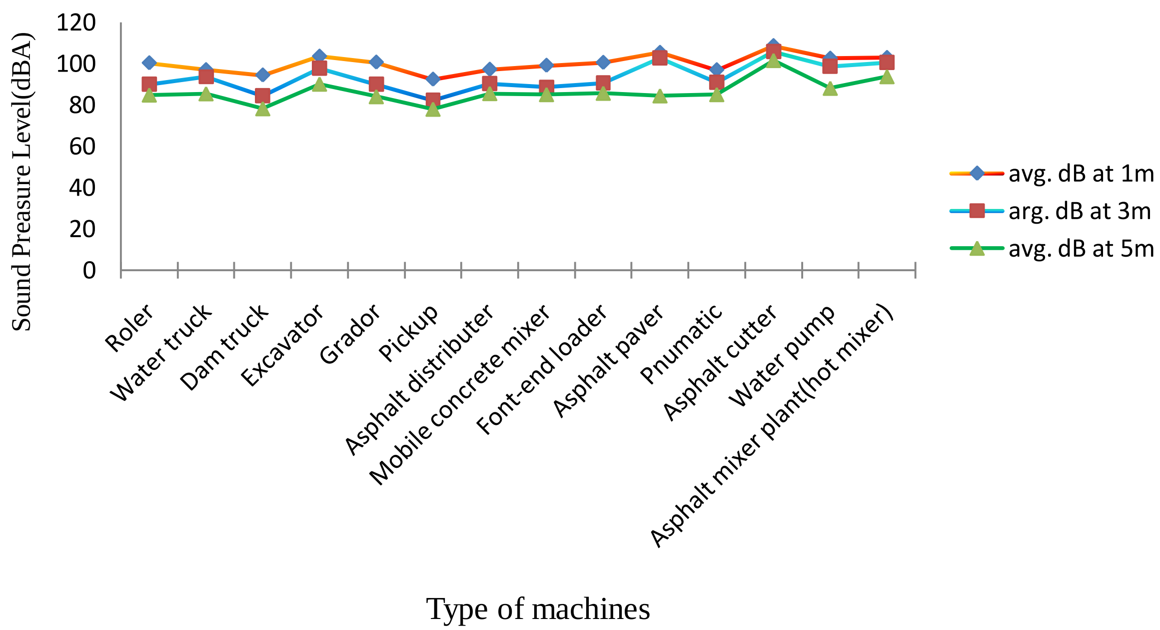

Figure 4.1. The average sound level values of machineries at three different measurement distances.

4.2. Questionnaire Response Analysis

From a total of 363 production workers in the road construction, 187 workers were included in the study. There was no non-response found during the data collection. Apart from the physical site data measurements, and surveys in the form of questionnaires are given to road construction workers data from survey are also significant to make sure the study achieves its objectives. Results from the questionnaires are supportive in the assessment of the effects of noise in the road construction workers and support in the search for source of noise. The following data shows the result collected from the questionnaire.

The first area of interest examined the issue of age bracket of the construction workers and the average working hours per day. Among many effects of noise pollution is that of accelerated decrease of hearing sensitivity with age or impairment of hearing acuity with age a process called presbycusis.

4.3. Socio demographic characteristics of the Workers

From the analysis of data from questionnaire the mean age of workers was less than 30 (45.5%) and about 163(87.2%) of the workers were males. The dominant religion in the study participants was Orthodox 102 (54.5 %) followed by Muslim 63 (33.7%). Most of educational level of the study participants were Technical/ college 75(40.1%) followed by complete diploma 61 (32.6%) (Table 4.3).51.3% of the respondents are single and 46.5% has less than three service year experiences and also54.5%are Orthodox and 33.7% are Muslim.

Table 4.3. Socio demo graphic characteristics of respondents of JRCW October 2016.

Characteristics	**Number (n=187)**	**Percent (%)**
Sex		
Male	163	87.2
Female	24	12.8
Age group		
<30	85	45.5
30- 39	64	34.2
40 – 49	26	13.9
> 50	12	6.4
Educational status		
Illiterate	6	3.2
Primary (1-8)	19	10.2
Secondary (9-10)	12	6.4
Technical/college	75	40.1
Diploma	61	32.6
Degree	11	5.9
Masters of science	3	1.6
Marital status		
Single	96	51.3
Married	69	37

Divorced	18	9.6
Widowed	4	2.1
Service year		
<3	87	46.5
3-6	52	27.8
>6	48	25.7
Religion		
Orthodox	102	54.5
Muslim	63	33.7
Protestant	22	11.8
Catholic	0	0
Other	0	0

According to OHSA for specific job there are different types of PPE, there for all worker must have good awareness of the function PPE, but the result show that 98% of the respondent's aware the function of PPE to control noise Pollution and 2% of them are not aware of PPE.

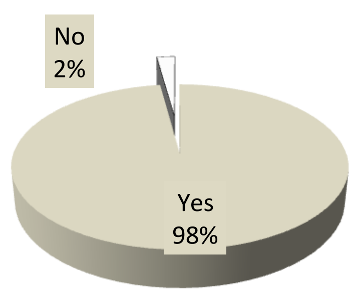

Figure 4.2. The respondent's awareness about the function of PPE.

The result in figure 4.3 indicates that the highest percentage for main source of noise pollution is Roller (36%) and Truck (4%) is the minimum. In addition, other noise sources from miscellaneous sources like cement concrete mixer, excavator, loud advertisement; loud music etc. accounts about 17%.

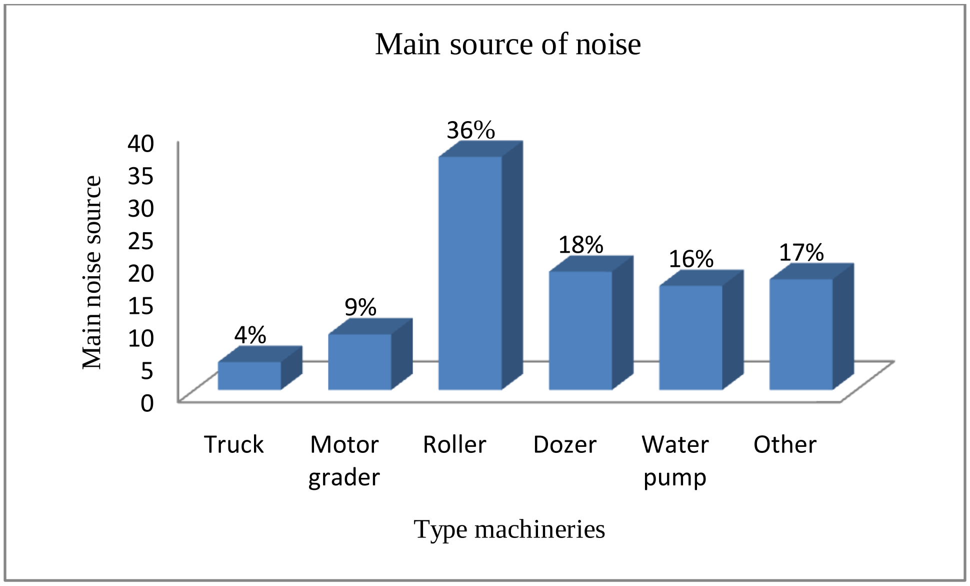

Figure 4.3. Main source of noise.

4.4. The health effect of noise on the construction workers

The health effect of noise according to WHO deafness, hearing loss, and headaches there for exposure of excessive noise at any place increasing the health effect human. A Jimma Road construction worker 90% has a chance of exposure to noisy sound and the rest 10% are not exposed to noisy sound.

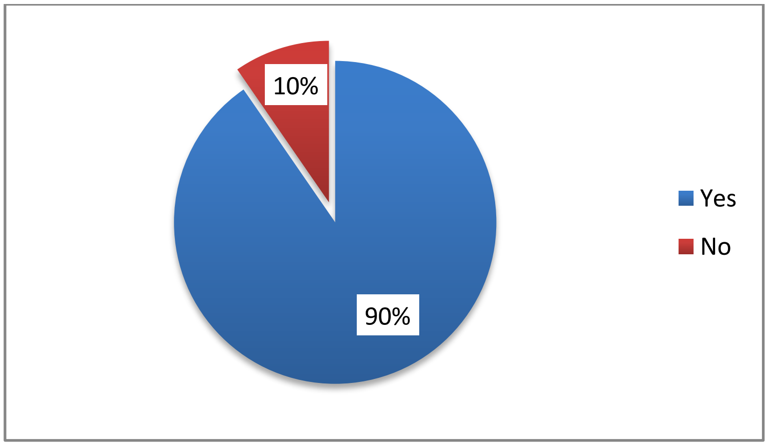

Figure 4.4. Noise exposure of workers in the road project.

The result that presented in figure 4.5 shows that 84.6% of the respondents have a headache, 13% hearing loss and 2.4% has other work related noise pollution effect on their health (vomiting, general pain, etc). The effect that caused by noise pollution on workers of JRCP are presented as follows.

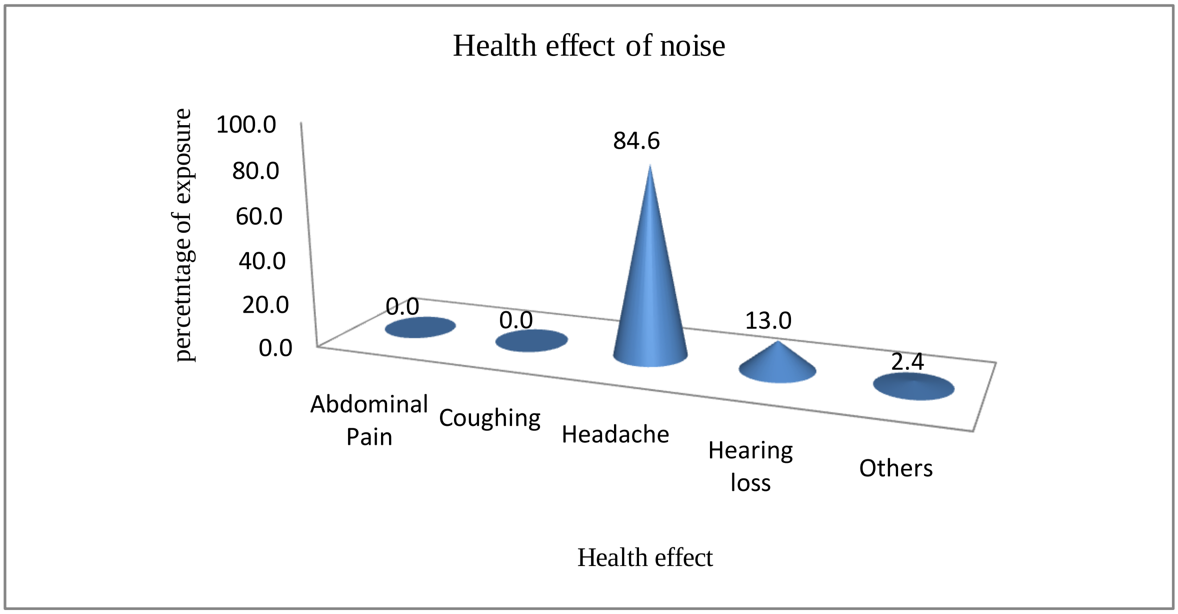

Figure 4.5. Effect of noise.

Figure 4.6 shows that 76% of the respondents agree that they stand for more than 4 hours during their work and the rest 24% are not standing during their work, but according to OSHA for specific job standing for more than 4 hour have heath risk.

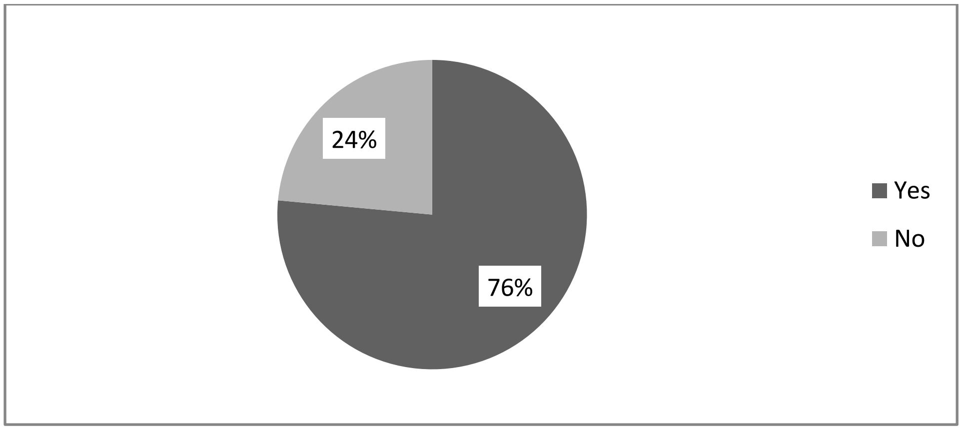

Figure 4.6. workers those stand for long time.

All worker must be use all types PPE for their job to decrease health problem (OSHA), Figure 4.7 shows that 56% of the respondents use at least one PPE effectively to control the health problem and 44%of the respondents are not use PPE (do not use hearing protecting device).

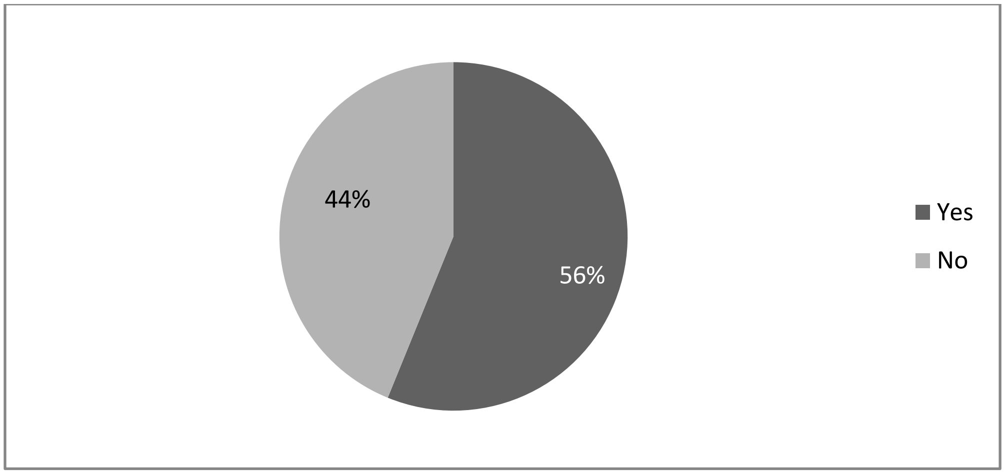

Figure 4.7. Utilization of personal protective equipment by workers.

The following figure 4.8 shows that 61% of the respondents use Gown, 33% use Safety-Shoe, 2% uses Gloves, 1% uses Ear-plugs and 3% uses others (eye glass, mouth mask) as PPE to control health problem.

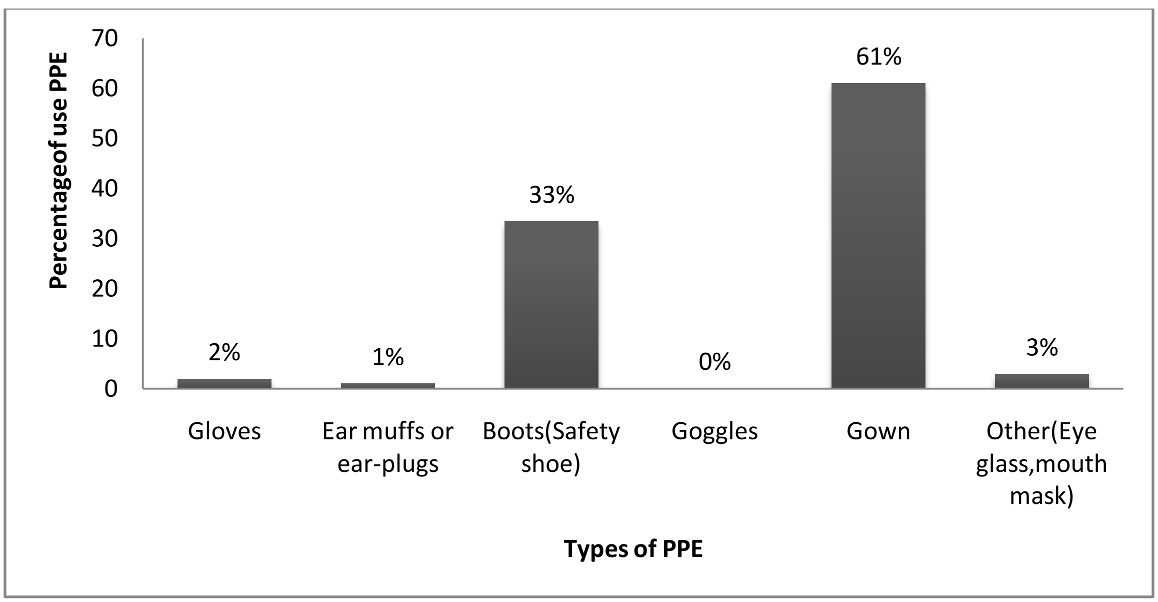

Figure 4.8. Personal protective equipment exercises by worker.

The workers were directly receiving the noise pollution from the road construction machineries. They were subjected to severe noise impact based on this study. The top construction noisemakers were Roller Compactor (ground), Excavator, Grader, Asphalt mixer plant (hot mixer), Asphalt paver and Font-end loader are some of the examples in this study. The measured noise level from the primary survey are compared with the standards set by OSHA is a standard for worker ear noise level 90 dB (A) and are presented in Figure 4.9.

This excessive noise could carry several ill effects. Irritation, speech interference, sleeps disturbance, mental stress, headache, and lack of concentration. Similarly, (OSHA) noted that the workers exposed to high noise levels have a higher incidence of circulatory problems, cardiac diseases, hypertension, peptic ulcers, and neuron sensory and motor impairment (34). However, the entire construction sites for worker the noise level permissible limits are 90 dB (A) (OSAH).

Construction site machineries and their observed tasks in the road construction project during sound level measurement were, soil compacting Spraying water on soil (ground), Damping gravel, Loading gravel on dam trucker, Scraping top soil...etc., (Table 4.1). Research involved in field measurement of the noise levels generated by road construction machinery at 1 m,3 m and 5 m. The average sound pressure level Decibel, dB (A) that produced by different machineries in the road construction project at three (i.e. 1m, 3m, 5m) different distance from the highest sound producing part of the machine. The noise that is generated from the existing system of operation at Avg of 1m is about 2.6% to 20.8% higher than the standards prescribed by the OSHA. Such a severe noise pollution has to be reduced and at average 5m the noise level was measured sound level are safest area but asphalt cutter and hot mixer not included under OSHA standard.
Figure 4.9 shows the simple comparison of measured machineries sound level with OSHA standards. The noise level is higher than the OSHA standards at one and three meter, but at five meter two machinery higher by 3.65dB (A) to 11.45dB (A).

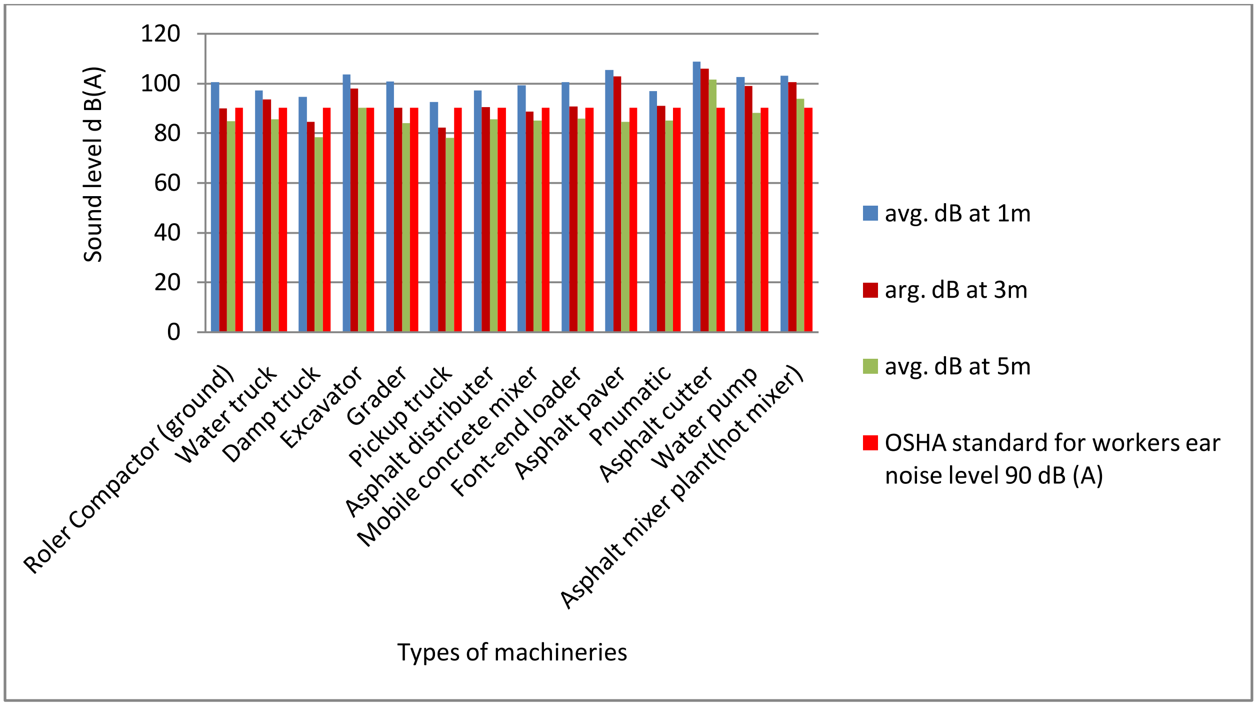

Figure 4.9. OSHA standards for workers ear noise level 90 dB (A) compared with JRCP vehicles.

The top construction noise makers were Roller Compactor (ground), Excavator, Grader, Asphalt mixer plant (hot mixer), Asphalt paver, asphalt mixer plant and Font-end loader are some of the examples in this study. The measured noise level from the primary survey are compared with the standards set by European Agency for Safety and Health (EASH) standards is a standard for worker ear noise level 94 dB (A)and are presented in Figure 4.10.

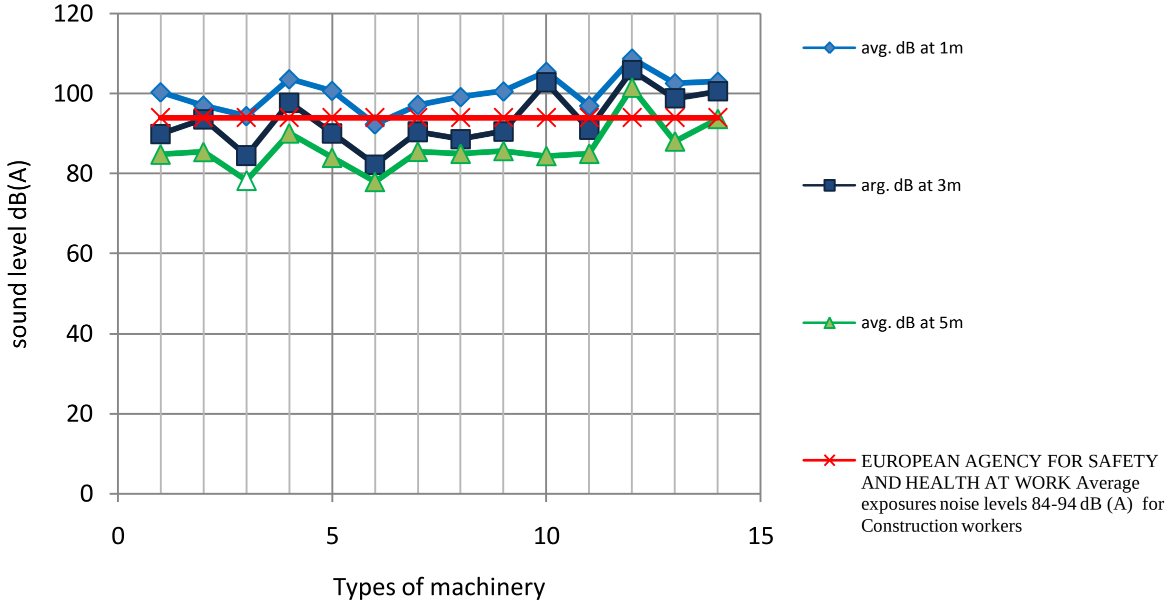

Figure 4.10. EASH standards for workers ear noise level 94 dB (A) compared with JRCP vehicles.

The exposure to noise during the construction of road worker 90% workers is exposed to noise. From the measurement of noise level meter in different machinery in JRCP shows that noise pollution does exist in the worker because of this 84.6% of the respondents has a headache, 13% hearing loss and 2.4% has other work related noise pollution effect on their health (vomiting, general pain, etc.).and76% of the respondents agree that they stand for long time during their work and the rest 24% are not standing during their work for long time.

The data of noise are done through various noise parameters, i.e. Min dB (A), Max dB (A) and Avg at different distance (1m,3m and 5m). Results of 14 specific sites of study area in respects to various construction machineries noise level.

The maximum average noise level observed at 1m 108.75 dB (A)road construction machinery like asphalt cutter and the minimum average noise level observed at 1m 90.35 dB (A) pickup truck, even the minimum value is greater than the standard set by OSHA guidelines for maximum noise levels.

4.5. The safe distance from noise source at workplace.

Generally, it was observed that the levels of Noise Pollution during road construction, in all selected machineries are much higher when compared with the standard limits OSHA. (Figure 4.9). The results were surprising in some locations the sound level is observed to be much greater than the permissible limit (OSHA), (EASH) throughout the day perceived noise exposure in the road construction project.

The noise that is generated from the existing system of operation at Avg of 1 m is about 2.6% to 20.8% higher than the standards prescribed by the OSHA. Such a severe noise pollution has to be reduced and at average 5m the noise level was measured sound level are safest area but asphalt cutter and hot mixer not included under OSHA standard. Figure 4.9 shows the simple comparison of measured machineries sound level with OSHA standards. The noise level is higher than the OSHA standards at one and three meter, but at five meter two machinery higher by 3.65dB (A) to 11.45dB (A).

The main finding of the present thesis indicate that irrelevant distance from noise source and difficulty of speech communication though road construction worker and also high level of headache that affects the process to achieve and provide knowledge for all actors in the road worker environment.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Road construction was divided into three stages, which were road construction, maintenance or rehabilitation and these stages were associated with the use of various heavy-equipment (machineries).

The human ear is not equally sensitive to sounds at different frequencies. In road construction project, workers have exposure to unwanted sound (noise). Especially, worker that don't use PPE are more exposed to problems related with high noise level.

This paper reviews research on issues relating to the effects of noise at Jimma road construction worker. Areas covered include source of noise and the effects of road construction worker and also surveys of treaty machinery noise levels. Research involved a field measurement of the noise levels generated by road construction machinery at 1m, 3m and 5m. Almost in all measurement points noise values exceeded the 90 dB (A), at 1m average, limit value according to OSHA standard noise control regulation. The noise that is generated from the existing system of operation at average of 1m is about 2.6% to 20.8% higher than the standards prescribed by the OSHA. 1% of respondent uses Ear-plugs (PPE), 84.6% has a headache and 13% has hearing loss. It is generally found that people feel much headache and hearing loss. This study suggests that noise induced hearing loss is a great challenge in environmental pollution. This road construction noise exposure and occupational noise exposure both interfere with their activities in their personal life as well as their healthy living. The findings of this study also indicated that except machine operators other workers should work their job as feasibly far as 5 m from the machinery. Indeed, some control measures and proper planning has to be implemented to overcome the adverse effects from noise pollution and for the well-being of the road construction worker.

5.2. Recommendations

Based on the results of this study the following recommendations are forwarded.

- Enough attention should be given to road construction machineries regarding to noise pollution.
- At all-time the best practicable means must be implemented to reduce noise. Site engineers must consider noise reduction in the sit layout, planning and execution phase.
- All workers should get training related with the effect of excessive noise and means of mitigation and also the importance of personal protective equipment and must use them on site.
- Where possible, any heavy machinery with an internal engine should not be left standing with its engine operating in a street adjacent to working area. Some control measures and proper planning has to be implemented to overcome the adverse effects from noise pollution and for the well-being of the road construction worker.
- Using sound proof materials at work place (i.e. fence using wood board walls which protect noise from machinery especially for water pump).
- A strict law concerning noise pollution in road construction should be implemented.
- Exposed workers suggested having an audiometric testing in order to identify deterioration in their hearing ability regularly.
- Develop rules and regulations that enforce road construction equipment noise level by their manufacture date and tones
- Should develop road construction noise prevention strategy.
- Should equipped with materials and competent professionals like doctor of occupational medicines, occupational therapists, occupational nurses, industrial hygienists and others to monitor, measure, record, report the impact of noise and also enforce rules and regulations designed by the ministry appropriately.
- It is better also if intersect orally collaborate with respective ministries to prevent noise induced hearing loss at work places and additionally share experience of developed countries to prevent and control noise induced hearing loss on construction site.

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ANNEX I

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMNTAL ENGINNERING

ENVIRONMENTAL ENGINEERING

1. Other information from the questionnaire about workers in the road construction. The information from the questionnaire about workers in the road construction project, October 2016.

Characteristics	Frequencies (n= 187)	Percent (%)
Eating at work place?		
Yes	155	82.9
No	32	17.1
Washing hand after eating?		
Yes	169	90.4
No	18	9.6
Injured the last one year?		
Yes	49	26.2
No	138	73.8
Feeling of thermal stress from auto machinery because of noise?		
Yes	147	78.6
No	40	21.4
Exposure to machinery Injury on your hear?		
Yes	87	46.5
No	100	53.5
Chance of exposed to noise hazards?		
Yes	169	90.4
No	18	9.6
Have you faced latex allergy?		
Yes	29	15.5
No	158	84.5

Disease you are liable to developed to explosive to biological hazards? Yes No	 5 182	 2.7 97.3
Accident at job? Yes No	 39 148	 20.9 79.1
Handling materials manually? Yes No	 122 65	 65.2 34.8
Your work needs repetitive motion? Yes No	 62 125	 33.2 66.8
Standing for long time? Yes No	 143 44	 76.4 23.6
Comfort with shift work? Yes No	 172 15	 92 8
Have you been insulted by workers? Yes No	 174 13	 93 7
Availability of PPE? Yes No	 134 53	 71.7 28.3

Calibration

To calibrate the meter, an external calibrator such as the Extech 407744 or the Extech 407766 is required in addition to a small screw-driver.

1. Turn the meter ON
2. Select the 80 to 110dB range
3. Select ‘A’ weighting and ‘SLOW’ response
4. Place the microphone into the calibrator. Set the calibrator to output a 1kHz sine wave @ 94dB
5. Adjust the calibration potentiometer for a display as close as possible to the calibrator’s output

Measurement Considerations

1. Wind blowing across the microphone increases the noise measurement. Use the supplied windscreen to cover the microphone when applicable.
2. Calibrate the instrument before each use if possible, especially if the meter has not been used for a long period of time.
3. Do not store or operate the instrument in areas of high temperature or humidity.
4. Keep meter and microphone dry.
5. Avoid severe vibration.
6. Remove the battery when the meter is to be stored for long periods of time.

Specifications SLM

Display…………………... LCD with bar graph

Microphone……………….10mm (0.5”) Electret condensor

Measurement……………...Bandwidth 300Hz to 8KHz

Measurement Range………40 to 130dB (A wtg), 45 to 130dB (C wtg)

Frequency weighting…… .‘A’ and ‘C’ (selectable)

Accuracy / Resolution……. ± 2dB @1kHz (under reference conditions) / 0.1dB

Response time……………. Fast: 125 milliseconds / Slow: 1 second

Calibration source…………. 1KHz sine wave @ 94 or 114dB

AC output…………………. 0.707Vrms full scale

Power……………………… 4 AAA Batteries

Battery life …………………30 hours (typical); low battery indicator alerts user

Automatic power off……….. After approx. 20 minutes

Operating temperature………. 0 to 50oC (32 to 122oF)

Operating humidity …………10 to 90% RH

Storage temperature………… -20 to 60oC (-4 to 140oF)

Dimensions/weight …………230 x 57 x 44mm (9 x 2.3 x 1.7”) / 172g (6oz)

Other information from the sound level meter at 1 m in the road construction project machineries, October 2016**.**

Type of machine	Min 1	Min 2	Avg min	Max 1	Max 2	Avg max	Avg, min & max
Roller	98.5	98.1	98.3	102.8	102	102.4	100.35
Water truck	96.6	95.8	96.2	97.6	98	97.8	97
Dam truck	92.4	93.8	93.1	96.1	95.3	95.7	94.4
Excavator	102.3	101.7	102	104.4	106	105.2	103.6
Grador	96.6	97.6	97.1	104.6	104	104.3	100.7
Pickup	95.9	96.5	96.2	88	89	88.5	92.35
Asphalt distributer	96.4	96	96.2	97.9	98.5	98.2	97.2
Mobile concrete mixer	97.8	98	97.9	100.7	100.1	100.4	99.15
Front ended loader	100	98.4	99.2	101.8	102	101.9	100.55
Asphalt paver	107.9	105.1	106.5	104.5	104.3	104.4	105.45
Pneumatic	97.3	98.3	97.8	95.8	96.4	96.1	96.95
Asphalt cutter	108	106.4	107.2	110.1	110.5	110.3	108.75
Water pump	100.4	102	101.2	104.1	103.9	104	102.6
Asphalt mixer plant (hot mixer)	102.2	101.8	102	103.8	104	103.9	102.95

Other information from the sound level meter at 3 m in the road construction project machineries, October 2016**.**

Type of machine	Min 1	Min 2	Avg min	Max 1	Max 2	Avg max	Avg, min & max
Roller	88.2	88	88.1	92.4	91.2	91.8	89.95
Water truck	92.1	92.7	92.4	95	94.6	94.8	93.6
Dam truck	82.4	84	83.2	86.1	85.7	85.9	84.55
Excavator	96.6	97	96.8	98.8	98.6	98.7	97.75
Grader	89.4	88.6	89	91.6	90.8	91.2	90.1
Pickup	83.4	83	83.2	81.7	80.9	81.3	82.25
Asphalt distributer	89.4	90	89.7	90.5	91.9	91.2	90.45
Mobile concrete mixer	88.5	87.7	88.1	89.8	88.6	89.2	88.65
Front ended loader	89.1	89.3	89.2	92.6	91.4	92	90.6
Asphalt paver	102.1	101.7	101.9	103.4	104.2	103.8	102.85
Pneumatic	90.4	89.4	89.9	91.1	93.1	92.1	91
Asphalt cutter	104.6	105	104.8	107.1	106.7	106.9	105.85
Water pump	98.3	97.7	98	100	99.2	99.6	98.8
Asphalt mixer plant (hot mixer)	99.8	100	99.9	101.6	100.8	101.2	100.55

Other information from the sound level meter at 5 m in the road construction project machineries, October 2016.

Type of machine	**min 1**	**min 2**	**avg min**	**max 1**	**max 2**	**avg max**	**avg min & max**
Roller	84	83.4	83.7	86	85.8	85.9	84.8
Water truck	85.2	84	84.6	85.9	86.5	86.2	85.4
Dam truck	77	77.8	77.4	78.8	79.2	79	78.2
Excavator	89.3	88.9	89.1	90.7	91.3	91	90.05
Grader	83.4	82.6	83	85.2	84.8	85	84
Pickup	76.7	77.3	77	78.8	79	78.9	77.95
Asphalt distributer	85.4	85	85.2	85.9	85.7	85.8	85.5
Mobile concrete mixer	83.6	84.6	84.1	85.8	86	85.9	85
Front ended loader	83.5	82.7	83.1	88	88.4	88.2	85.65
Asphalt paver	82.8	83.4	83.1	85.6	85.8	85.7	84.4
Pneumatic	84.6	83.6	84.1	86.2	85.6	85.9	85
Asphalt cutter	99.6	100	99.8	102.9	103.3	103.1	101.45
Water pump	87.3	86.5	86.9	89.5	88.9	89.2	88.05
Asphalt mixer plant (hot mixer)	94.1	94.3	94.2	92.9	93.3	93.1	93.65

Other information from the sound level meter measurement Noise pollution level working site October 201

S.No	Type of machineries	Average (L_{av}) dB (A)			Noise pollution level working site dB (A)			OHSA construction Noise pollution levels dB (A)	Standard deviation (±)
		1m	3m	5m	1m	3m	5m		
1	Roller	100.35	89.95	84.8	100.35	89.95	84.8	90	7.92
2	Water truck	97	93.6	85.4	97	93.6	85.4	90	5.96
3	Dam truck	94.4	84.55	78.2	94.4	84.55	78.2	90	8.16
4	Excavator	103.6	97.75	90.05	103.6	97.75	90.05	90	6.80
5	Grader	100.7	90.1	84	100.7	90.1	84	90	8.45
6	Pickup	92.35	82.25	77.95	92.35	82.25	77.95	90	7.39
7	Asphalt distributer	97.2	90.45	85.5	97.2	90.45	85.5	90	5.87
8	Mobile concrete mixer	99.15	88.65	85	99.15	88.65	85	90	7.35
9	Front End Loader	100.55	90.6	85.65	100.55	90.6	85.65	90	7.59
10	Asphalt paver	105.45	102.85	84.4	105.45	102.85	84.4	90	11.48
11	Pneumatic	96.95	91	85	96.95	91	85	90	5.98
12	Asphalt cutter	108.75	105.85	101.45	108.75	105.85	101.45	90	3.68
13	Water pump	102.6	98.8	88.05	102.6	98.8	88.05	90	7.55
14	Asphalt mixer plant (hot mixer)	102.95	100.55	93.65	102.95	100.55	93.65	90	4.83

ANNEX II

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMNTAL ENGINNERING

ENVIRONMENTAL ENGINEERING

2. Questionnaire developed to road construction workers safety and health risk in Jimma road project.

1. Demography and Social status.

1.1. Age.______________

1.2. Sex_______________

1.3. Service years a. <3 ____________________

b. 3-6 ___________________

c. > 6 _________________

1.4. Religion – Muslim _________________________

a) Christian orthodox______________

b) Protestant ______________________

c) Others (specify) ________________

1.5. Educational status - Doctors /PhD/___________

- MSc____________________

- BSc_____________________

- Diploma _________________

- Certificate _______________other-----------------

1.6. Marital status - Married__________________

- Unmarried_______________

- Divorced_________________

- Widowed _______________

2. Health related.

2.1. Do you have eating habit at work places?

a. Yes b. No

2.2. Do you wash your hands after you finished your work?

a. Yes b. No

2.3. What is the main sources of noise in your site?_________________

2.4. Which site you more risk of noise?

a. tuck operator b .motor grader c. roller

d. dozer operator e. water pump f. Other

3. Have you been injured by for the last one years?

a. Yes b. No

3.1. If yes for question 3 how many times________________

3.2. Is there any excess noise exposure?

a. Yes b. No

3.2.1. If yes what are the cause's ________________________

3.3. Do you feel thermal stress from auto machinery noise (wheel maintenance) during sterilization process?

a. Yes b. No

3.4. Do you have exposure to machinery injury on your hear?

a. Yes b. No

4. Do you have a chance of exposed to noise hazards?

a. Yes b. No

4.1. If yes for no 4 what happen to you?

a. Abdominal Pain b. Coughing c. Headaches

d. Hear loss e. Others

4.2. Have you faced latex allergy

a. Yes b. No

5. Do you have a chance of exposure to biological hazards?

a. Yes b. No

5.1. If yes for which of the following you are exposure?

a. Blood b. Body divides material

c. Respiratory secretions d. Contact with infected skin lesions

e. Urine and stool faces f. Air borne droplet

5.2. Which type of disease you are liable to developed to explosive to biological hazards

a. HIV c. TB e. meningitis

b. HCV d. HBV f. other

6. Have ever got any accident on your specific job?

a. Yes b. No

6.1 If yes what kinds of accident ______________________

7. Do you handle any working material manually during lifting or transferring?

a. Yes b. No

7.1. Does your work need repetitive motion?

a. Yes b. No

7.1.1. If yes for question 7.1. What was the possible cause?

____

7.1.2. If no, for no 7.1 what are the reasons________________________

7.2. Do you have work standing for more than 4 hours?

a. Yes b. No

7.2.1. If yes for no 7.2. How many long times?

a. 1 hr b 2-3 hr c. 3-4hr

d. > 4hr e. Others

8. Are you comfortable with your shift work?

a. Yes b. No If No what are the reasons?______________

8.1. Have you been insulted by workers?

a. Yes b. No

9. Is there any personal protective equipment for your specific job?

a. Yes b. No

9.1 Do you know the function of personal protective devices?

a. Yes b. No

9.2 Do you think personal protective equipment important for your work

a. Yes b. No.

9.3 Do you use personal protective devices?

a. Yes b. No.

9.3.1. If yes which type

a. gloves b. ear muffs or ear-plugs c. boots d. goggles

e. gown f. Other (specify)

10. Do you use hearing aid at work place?

a. Yes b. No

10.1. If yes for question number 10, when do you start?

a. before I start these job b. when I start these job

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ENGINEERING

2.1 checklists, this checklist applicable during physically observation of construction sit and also for administration staff at office level.

1. Are employees instructed in proper first aid and other emergency procedures?
2. Project office prepare for workers?
3. Are steps being taken to use engineering controls to reduce excessive noise levels?
4. Has there been a determination that noise levels in the facilities are within acceptable levels?
5. Does each industrial truck have a warning horn, whistle, gong or other device which can be clearly heard above the normal noise in the areas where operated?
6. Is protection against the effects of occupational noise exposure provided when sound levels exceed those of the Cal/OSHA noise standard?
7. Are employees exposed to continuous noise above 85 dB(A) given periodic audiometric testing to ensure that you have an effective hearing protection system?
8. Is approved hearing protective equipment (noise attenuating devices) available to every employee working in areas where continuous noise levels exceed 85 dB(A)?
9. Have work areas where noise levels make voice communication between employees difficult been identified and posted?
10. Is the training repeated annually for employees exposed to continuous noise above 85 dB (A)?
11. Is there an ongoing preventive health program to educate employees in safe levels of noise and exposure, effects of noise on their health, and use of personal protection?

12. Have you tried isolating noisy machinery from the rest of your operation?
13. Have engineering controls been used to reduce excessive noise levels?

2.2 Does the hearing protector provide adequate protection against the noise levels on the job?

- ✓ Does the ear-plug provide a tight seal within the ear canal?
- ✓ Does the ear-muff provide a tight seal against the side of the head?
- ✓ Does the headband collapse enough to snugly fit the head?
- ✓ Do the ear-plugs or muffs feel comfortable enough to be worn throughout the shift? (If too large or too heavy, they will cause discomfort)

ANNEX III

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SCHOOL OF CIVIL AND ENVIRONMNTAL ENGINNERINGENVIRONMENTAL ENGINEERING

1. Questionnaire data collection at different road construction site of Jimma road project.

Sample of some picture during Questionnaire data collection at different road construction work sit of Jimma road project.

2. Types of machineries and their observed tasks in the road construction project during sound measurement.




Sample of some picture during machineries noise level data collection at different road construction sit Jimma road project.