Supervisor

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DEDICATION

To:

My Father …

My Mother …

My brothers and my sisters

Also I dedicate this thesis to all those who are involved in the

path of knowledge.

Elshebli
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ABSTRACT

This study was conducted among the employees of the Khartoum North Power Station during the December 2002 up to May 2003. The main objective of this study is to investigate noise-induced hearing loss among the employees of the Khartoum North Power Station. The result showed that 31.1% of the employees had permanent threshold shift (PTS), (71.4%) of them had temporary threshold shift (TTS) and Tinnitus was recorded among 71.4% . All employees were not subjected to audiometry measurements. 66.0% of the employees did not wear suitable hearing protective devices. Sound level pressure in Turbine and Mechanical was above 85dBA. Not all employees were subjected to audiometric measurements, they did not wear suitable hearing protective devices and hearing conservation program was not implemented . The study recommended that hearing protectors must be made available to all employees in Turbine and Mechanical sections ((SPL more than TLV (85dBA)). Employees should be subjected to audiometric measurements, personal hearing protection devices (PHPD) should be provided and worn according to type of work and hearing conservation program should be implemented.
ملخص الدراسة

أجريت هذه الدراسة وسط العاملين بمحطة بحري الحرارية في الفترة من ديسمبر 2002 إلى مايو 2003. الهدف العام من الدراسة تقصى فقّد السمع الناتج من الضوضاء أظهرت الدراسة ان (31.1%) من العاملين مصابين بفقد سمع دائم و (71.4%) يعانون من فقد سمع مؤقت. (71.4%) يعانون من الطنين. أوصت الدراسة بضرورة توفير أدوات الوقاية لكل العاملين بقسمى التورباين و الورشة الميكانيكية (مستوى ضوضاء أكثر من 85 ديسيبل (TLV))، عدم خضوع كل العاملين لقياس السمع وان هناك نسبة من العاملين لا يرتدون معدات الوقاية المناسبة من الضوضاء ، عدم تطبيق برنامج حماية السمع. خرجت الدراسة بوصيات منها تقليل مستوى شدة الضوضاء في قسمي التورباين و الورشة الميكانيكية إلى 85 ديسبل فاقل و إخضاع جميع العاملين لقياس السمع وتوفير وبلس معدات الوقاية المناسبة من الضوضاء مع تنفيذ برنامج حماية السمع.
List of Tables: -

Table (1): Age distribution of noise exposed and non-exposed employees in Khartoum North Power Station------------------------37

Table (2): Readings sound pressure level value of selected non-exposed location in Khartoum North Power Station----------------38

Table (3): Octave – band sound pressure levels in test room-------------------39

Table (4): Octave- band analysis level in dBA (in regular points)
Turbine house – Phase one ground floor Khartoum North Power Station-------------------------------40

Table (5): Octave- band analysis level in dBA(in regular points)
Turbine House – Phase one – first floor – Khartoum North Power Station---------------------------------41

Table (6): Octave - band analysis level in dBA (in regular points)
Turbine House–phase two – ground floor
Khartoum North Power Station---------------------------------------------------------------42

Table (7): Octave- band analysis level in dBA(in regular points)
Turbine House – Phase two– first floor Khartoum North Power Station--------------------------------43

Table (8): Personal noise dosimeter readings (dBA (of selected employees in noise - exposed area - Khartoum North Power station-----44

Table (9): Time taken for Temporary Threshold Shift (TTS) recovery among noise – exposed and non – exposed employees in Khartoum North Power Station---------------------------------------------------48

Table (10): Relationship between Temporary Threshold Shift (TTS) feeling and Sections among employees in Khartoum North PowerStation------------------------------------------------------------49
Table (11): Relationship between Temporary Threshold Shift (TTS) Feeling and work duration among employees in Khartoum North Power Station

Table (12): Relationship between Tinnitus feeling and Sections among employees in Khartoum North Power Station N(%) - 2003

Table (13): Relationship between Tinnitus feeling and work duration among employees in Khartoum North Power Station

Table (14): Relationship between Personal Hearing Protection Devices (PHPD) usage and Tinnitus feeling among noise-exposed employees in Khartoum North Power Station

Table (15): Personal Hearing Protection Devices (PHPD) usage among noise-exposed and none-exposed employees in Khartoum North Power Station
List of Figures: -

Figure (1): Prevalence of Permanent Threshold Shift (PTS)
Among exposed employees in Khartoum North Power Station ---------------------------------------------------45

Figure (2): Prevalence of Permanent Threshold Shift (PTS)
among and non-exposed employees in Khartoum North Power Station -------------------------------46

Figure (3): Temporary Threshold Shift (TTS) among noise and non-exposed employees in Khartoum North Power Station ------------------------------------------47

Figure (4): Tinnitus among noise exposed and non-exposed employees in Khartoum North Power Station- N(%) – 2003 -----------------------------------------------50

Figure (5): Type of Personal Hearing Protection Devices (PHPD) used among noise – exposed and non – exposed employees in Khartoum North Power Station-----------------------------------56

Figure (6): Knowledge noise hazards among noise - exposed and non exposed employees in Khartoum North Power Station----------------------------------------------- 57
# CONTENTS

Dedication ........................................................................... i
Acknowledgement ................................................................... ii
Abstract (English) ............................................................... iii
Abstract (Arabic) ................................................................ iv
List of Tables ...................................................................... v
List of Figures .................................................................... vi
Contents ........................................................................ vii

Chapter One

1.1 Introduction ................................................................... 1
1.2 Justification ................................................................... 3
1.3 Objectives ..................................................................... 4

Chapter Two

2.1 Hearing mechanism ....................................................... 5
2.2 Properties of sound ....................................................... 6
2.3 Sound measuring instruments ....................................... 8
2.4 General classes of noise exposure .................................. 10
2.5 Quantifiable effects ....................................................... 12
  2.5.1 Noise-induce hearing loss ........................................ 12
  2.5.2.1 Noise-induce hearing loss risk factors ................... 14
  2.5.2.2 Noise-induce hearing loss diagnosis ....................... 15
2.6 Non-quantifiable effects ............................................... 18
  2.6.1 Tinnitus ................................................................. 18
  2.6.2 Elevation of blood pressure ..................................... 19
2.7 Control ......................................................................... 19

Chapter Three

3.1 Materials & Methods .................................................... 26

Chapter Four

4.1 Results .......................................................................... 33

Chapter Five

5.1 Discussion ..................................................................... 58

Chapter Six

6.1 Conclusion ..................................................................... 63
6.2 Recommendation ..................................................64
Chapter Seven

7.1 References ..........................................................65
Chapter Eight

8.1 Appendices ..........................................................70
CHAPTER ONE
CHAPTER ONE

1.1 INTRODUCTION

In many countries, worldwide working people are significantly exposed to a number of occupational hazards that may result in deterioration of their health, safety and well being.

Noise constitutes one of health problems of our highly mechanized era, being widely spread and underestimated as an industrial hazard. Broadly, noise is defined as “unwanted sound” (Waldron, 1989) that referred to variety of reasons: causing hearing loss such as temporary or permanent, interfering with communication, causing loss of sleep, adverse effects on human physiology and just plain annoyance. The US Department of Labour estimated that 19.3% of workers in manufacturing and utilities sectors are exposed to daily average noise levels of 90dBA and above, 34.4% are exposed to levels above 85dBA, and 53.2% to levels above 80 dBA. These estimates should be fairly typical of the percentage of workers exposed to hazardous level noise in other nations (Stellman, 1998).

Noise acts upon the body causing other stresses not only affecting just hearing but also other body functions (Osibogun, 2000) Industrial workers are constrained to work in areas where the noise level is 85 dBA or higher which is considered to be damaging to their hearing (Ambosankaran; et al, 1981 ). Rajott (1997) stated that
continual exposure to high noise level causes damage and destroys hearing cells within the ear making noise-induced hearing loss, and an irreversible impairment. One in ten persons is affected by hearing loss, it is considered as one of the top ten occupational hazards (Stellman, 1998). The major factors that determine the degree of hearing loss are the sound intensity and its duration whose product is the “noise dose”. Also Nedic; et al 2001) reported that the degree of negative effect of noise depends on its intensity, spectrum of frequencies, nature, duration of exposition and individual susceptibility.

Therefore, it is important to monitor the noise level in such areas, and to measure the hearing level for those exposed to noise with a view to adopt suitable control measures in order to preserve their hearing (Ambasankaran; et al, 1981).
1.2 JUSTIFICATION:

The witnessed increasing mechanization in all industries and most trades aggravated the noise problem. Noise level in work place, particularly those maintained in mechanized industries, are likely to be more intense and sustained than any noise levels experienced out the work place (Plog; et al, 1996).

There are approximately 5.2 million individuals exposed to noise levels above 85 dBA in manufacturing and working utilities, which represents about 35% of the total number of workers in US manufacturing industries (Plog; et al, 1996).

Noise is often accepted as a “necessary evil” because the progress of noise-induced hearing loss is insidious in that it creeps up gradually over the months and years, largely unnoticed until it reaches handicapping proportions. Another important reason why the hazards of noise are not always recognized is that there is a stigma attached to the resulting hearing impairment (Stellman, 1998).

During the last decades Sudan has witnessed progressing increase in an industrial development that is accompanied by many occupational problems and hazards specially in the absence of safety precautions and control measures in the work environment
1.3. OBJECTIVES

The objectives of this study are as follows:

3.1 General Objective: -

To investigate noise – induced hearing loss among Khartoum North Power Station employees.

3.2 Specific Objectives: -

- To identify and measure noise levels in the work place.

- To conduct audiometric measurements among Khartoum North Power Station employees.

- To assess the determinant factors behind noise-induced hearing loss in terms of:
  - Personal hearing protection devices.
  - Duration of expos
CHAPTER TWO
CHAPTER TWO

2. LITERATURE REVIEW

2.1 Hearing Mechanism:

The hearing mechanism comprises the following three parts (Appendix 1):

1-The outer ear comprises the visible part known as the auditory canal “meatus”, its function is to direct sound pressure pulses onto the eardrum “tympanic membrane” causing it to vibrate.

2-The middle ear contains the ossicles. These are three tiny articulated bones known as the hammer “malleus”, the anvil “incus” and the stirrup “stapes”, which transmit vibration from the eardrum to the oval window “Fenestra ovalis”, a membrane separating the middle ear from the fluid filling the inner ear.

3-The inner ear contains the semicircular canals which constitutes the organ of balance, and the cochlea which is the hearing organ of the body (Daniel, 1998).

The organ of corti a gelatinous mass, is one of the best protected parts of the body, encased as it is within the cochlea which in turn is deeply embedded in the temporal bone, perhaps the hardest of the 206 bones (Daniel, 1998).

The hair cells are connected to the nerve endings of the auditory “Vill the cranial” nerve, and lie along the basilar
membrane, which responds to, and transmits vibrations from the perilymph in the scala tympani, to the endolymph, thus exciting the nerve endings via the movement of the stereocillia. There are two separate rows of hair cells; the outer row is three or four cells deep, where as the inner row is a single line of cells. An enclosed channel between the two rows of hair cells “the tunnel of corti”, is filled with corti lymph, whose chemical composition is more like perilymph than endolymph (Waldron, 1989).

Organ of Corti serves two functions; converting mechanical energy to electrical, dispatching to the brain a coded version of the original sound with information about frequency, intensity and timbre. The hair cells of the organ of Corti sent their electrochemical signals into the central nervous system where the signals are picked up by thousands of auditory nerve fibers and transmitted to the brain (Daniel, 1998).

2.2 Properties of Sound:

2.2.1 Frequency: The numbers of complete vibration. The frequency of sound is measured in units of hertz (Hz).

2.2.2 Velocity: The velocity of sound depends upon the elasticity and density of the medium through which it is transmitted, the base formula relating to these parameters is:

\[ \lambda = CT = C/F \]

Where:
\[ T = \frac{I}{F} \]
\[ \lambda = \text{Wave length} \]
\[ C = \text{velocity} \]
\[ F = \text{frequency (Hz)} \]

**2.2.3 Sound Intensity:**

The sound intensity (I) is measured in watts per square meter (w/m²). The lowest intensity of sound that is detectable by the human ear is \( 10^{-12} \text{ w/m}^2 \) and which is considered as “threshold hearing” (*Waldron, 1989*). The sound level meter directly indicates sound pressure level referenced to a sound pressure of \( 20 \mu \text{P}_a \), the approximate threshold of hearing. The equation for sound pressure level is:

\[ L_p = 10 \log \frac{p^2}{p_0^2} = 20 \log \frac{p}{p_0} \]

Where:

- \( P \) = measured root-mean-square (rms) sound pressure.
- \( P_0 \) = reference rms sound pressure (\( 20 \mu \text{P}_a \)) (*Plog;etal,1996*).

The pure tone simplest type of sound is a sound of a single frequency. Most of an industrial noise comprises many different frequencies from a variety of sources (*Waldron, 1989*).

**2.3 Sound – Measuring Instruments:**

A wide assortment of equipment is available for noise measurements, including sound survey meters, sound level meters, octave-band analyzers, narrow band analyzers, noise dosimeters, tape and graphic level recorders, impact sound
level meters and equipment, for calibrating these instruments. For most noise problems encountered in industry, the sound level meter and octave-band analyzers provide ample information (Plog; et al, 1996).

2.3.1 Sound Level Meter:-

Standard sound level meter measures the sound pressure level. The meter has built into it electrical characteristics or weighting which simulate the way that the ear actually hears sound (Salvato, 1982). The basic instrument used to measure sound pressure variations in air is the sound level meter. This instrument contains a microphone, an amplifier with a calibrated attenuates, a set of frequency-response networks (weighting networks), and indicating meter (Plog; et al, 1996).

2.3.2 Octave-band Analyzer: -

This has filters which usually divide noise into eight possible frequency categorizes called an octave–bands. The bands are identified by their center or mid-frequencies: 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. The audible frequency range 20 to 20,000 Hz is then covered with 10 active bands (Salvato, 1982). For many industrial noisy situations, it is necessary to use some type of analyzers to determine where the noise energy lies in the frequency spectrum. In order to, properly, represent the total noise of a
noise source, it is usually necessary to break the total noise down into its various frequency components – low frequency, middle frequency or high frequency. This is necessary for two reasons: people react differently to low – frequency and high – frequency noises; and the engineering solutions of reducing or controlling noise are different for low – frequency and high – frequency (low – frequency noise is more difficult to control, in general) (Plog; et al, 1996)

2.3.3 Noise Dosimeter:

In many work environments, it may not be adequate to measure noise exposure at a fixed location for the duration of a work shift. Some workers move about to several locations in the course of their duties or perform a variety of operations during the day and are therefore subjected to different noise levels. The practical way to measure the noise exposure in these circumstances is with dosimeter that can be worn by the worker. The noise dosimeter records the noise energy to which the worker is exposed during the work shift (Plog; et al, 1996)

2.4 General Classes of Noise Exposure:

There are three general classes into which occupational noise exposure can be grouped: intermittent noise, continuous noise, and impulsive noise:
2.4.1 Intermittent Noise:-
Exposure to intermittent noise can be defined as exposure to a given normal working day (Plog; et al, 1996).

2.4.2 Impulsive Noise: -
This type of noise occurs as a result of gunfire, of various hammering, stamping, pressing, chipping and riveting operations. It is characterized by sudden short duration noises, which may be repeated at various Frequencies (Burns,1973). Sophisticated instrumentation is necessary to determine the peak levels for this type of noise. Employees should not be exposed to impulsive or impact noise that exceeds a peak sound pressure level of 140 dBA (Plog; et al, 1996).

2.4.3 Continuous Noise: -
Continuous noise is normally defined as broadband noise of approximately constant level and spectrum to which the employee is exposed to for a period of 8 hours per day, 40 hours per week. A large number of industrial operations fit into this class of noise exposure. The OSHA noise standard, 29 CFR 1990-95 (a) and (b) defines the permissible exposure level (PEL) as that noise dose that would result from a continuous 8 hour exposure to a sound level of 90 dBA. This dose is 100 percent. Doses for other exposures that are either continuous
or fluctuating in level are computed relative to the PEL based on a 5-dBA trading relationship between noise level and exposure time (Appendix 2). Every 5-dBA increase in noise level cuts the allowable exposure time in half. This is known as a 5-dBA exchange rate (Plog; et al, 1996). Continuous exposure to high-level noise is more harmful than intermittent or occasional exposure (Impulsive exposure) (Salvato, 1982).

2.5 Quantifiable effects:

2.5.1 Noise-induce hearing loss (NIHL):
The reference threshold level for auditory is a sound pressure of 0.00002 Pa, the medium threshold of normal young (aged 18 – 30 years) adults (David and Ian, 1994). The risk is defined by Malchaire and Piette(1997) as the probability for a worker with a given exposure history to noise to develop a hearing deficit above a given threshold. As stated by Lusk (1997) over 30 million workers are exposed to hazardous noise on the work site. Conditional exposure to high noise levels damages and destroys hearing cells within the ear, making noise-induced hearing loss, as stated by (Stellman, 1998). The degree of hearing impairment depends on the level of the noise, duration of the exposure and susceptibility of the individual worker. The sight of damage caused by continuous pure tone or narrow band noise appears to depend upon the frequency of the noise (Waldron, 1989). Periodic medical examinations have found that a number of industrial workers exposed to noise levels of
around 90 dBA have early signs of occupationally impaired hearing. The workers do not notice it in their daily activities but it will develop further into occupational deafness that could not be cured; not even hearing aids would help then (Ralph, 1993). Noise-induced hearing impairment is very common but it is often underrated because there are no visible effects, no pain (Stellman, 1998). The effects of noise are pervasive, and pathology can be found in the neural, sensory supporting and vascular cells of the cochlea after certain noise exposure. One of the most exciting recent findings that undoubtedly will affect people with NIHL is that it is possible for sensory cells to regenerate (Henderson and Hamernik, 1995). There is only, gradual, progressive loss of communication with family and friends, and loss of sensitivity to sounds in the environment. Hearing loss due to noise is often temporary at first, during the course of a noisy day, the ear becomes fatigued and the worker will experience a reduction in hearing known as temporary threshold shift (TTS). Between the end of one work shift and the beginning of the next the ear usually recovers from much of TTS (Stellman, 1998). The time taken for recovery depends upon the period of exposure and the sound level, but it can be as much as 48h, or more in extreme cases (Waldron, 1989). But often, some of the loss remains, after days, months and years of the exposure. The TTS leads to permanent effects and new amounts of TTS being to built onto known permanent
losses (Stellman, 1998). The most rapid increase of permanent threshold shift (PTS) occurs during the first 10 years of continuous exposure. Person’s attitude towards the noise in his working environment governs hearing impairment suffered, and probably accounts for individual differences in susceptibility to NIHL (Waldron, 1989). In most cases, however, deterioration of hearing occurs during the initial 5-10 years of employment in a noise – risk environment (Plog; et-al, 1996). The left ear was more severely affected. Significant associations were found between hearing loss and years worked and age. (Regan; et al, 1990). The hearing threshold levels for the noise - exposed group (noise level > 90 dBA) increases with the duration of noise exposure. Avery high prevalence rate of noise- induced hearing loss (79.8%) was recorded for noise – exposed group. The lowest prevalence rate (2.9%) was recorded for the administrative staff (Osibogun; et al, 2000).

2.5.2 Occupational Deafness: -
Occupational deafness is the term used to describe hearing loss, which results from exposure to noise at work. Because it would be impossible to quantify added effects due to non-occupational noise or other unrelated causes (waldron, 1989).

2.5.2.1 Noise-induced hearing loss risk factors:
If the ear is subjected to high levels of noise for a sufficient period of time, some loss of hearing will occur. There are many factors that affect the degree and extent of hearing loss. These
include the following (Plog; et al, 1996):
- The intensity of the noise (sound pressure level).
- The type of noise (frequency spectrum).
- The total work duration (years of employment).
- Individual susceptibility.
- The age of the worker.
- Coexisting hearing loss and ear disease.
- The character of the surroundings in which the noise is produced.
- The distance from the source.
- The position of the ear with respect to sound waves.

2.5.2.2 Noise-induced hearing loss diagnosis:

To diagnose NIHL it is important to elicit a detailed and accurate history of exposure to noise: although the notch at 4kHz is a well-established clinical sign and may be valuable in confirming the diagnosis, (McBride and Williams, 2002). Quantitative assessment of the hearing status of an individual can not therefore by itself establish what hearing loss is due to noise or indeed due any other factor. However, quantitative assessment is still essential. It enables a base line measurement to be made on which to judge future deterioration. It is therefore not possible to make a definite diagnosis of noise-induced hearing loss in an individual by
quantitative methods. The identification of the classical audiometric notch may, however, be pathognomonic of noise exposure. The frequency at which the notch occurs might either be some physical characteristic of the ear, or function of the spectral distribution of the noise. The notch usually occurs at 4kHz, may lie between 2 and 6 kHz, but rarely occurs outside this range (David and Ian, 1994). For audiometric test for industrial screening, it aims to identify NIHL, therefore the frequencies of interest are 4 – 6kHz (Waldron, 1989). The audiometer used generates pure tones at 0.5, 1, 2, 3, 4, 6 and 8kHz, which are presented in sequence to the subject through earphones. Each ear is tested separately, starting with the left one, the intensity being increased in 5dB steps until the subject responds, there it is decreased until the tone is inaudible. This is repeated several times for each frequency, until the threshold of audibility is established. The results are recorded either manually or automatically on a graph (audiogram).

David and Ian (1994) suggested the following guidelines for audiometric use:

*Audiometric testing is important to assess the hearing status of an individual.

*In some cases it may be possible to monitor hearing loss during employment by using serial audiometry, but only in populations who are potentially exposed to high noise levels.
Audiometry should be available to all workers who are likely to be exposed above the current action level and who must wear hearing protection.

1. Audiometry should be provided at recruitment, and repeated after 1 year. Further examination should be performed at intervals according to the risk of further hearing loss, but will not be at frequencies greater than 3 – 5 years.

2. It is possible to use audiometric data to analyze the hearing status of a group of employees.

Pre-placement hearing – threshold tests should be taken by all job applicants, not just those who are to work in noisy areas. This establishes a base line hearing threshold for each employee for future comparison. Periodic follow-up hearing tests should be administered to persons stationed in areas where noise exposures exceed permissible level (Plog, et al, 1996). There are certain drugs, which are toxic to the ear and can increase the damaging effect of noise, examples include certain antibiotics and cancer chemotherapy drugs. Those in charge of hearing conversation programme should be aware that workers exposed to these chemicals or using these drugs may be more susceptible to hearing loss, especially when exposed to noise in addition (Stellman, 1998).

2.6 Non-quantifiable Effects:

2.6.1 Tinnitus

According to Kanopka (2001) almost 10 – 15% of the
population suffer from chronic tinnitus. Tinnitus is subjective sensation of noise in the ear or head and can be a high-pitched ringing, hissing or whistling, or low rushing or buzzing. Low-pitched tinnitus is not normally associated with NIHL, short periods of high pitched tinnitus are often experienced before PTS [permanent threshold shift] is established and can therefore be taken as a warning sign of impending hearing damage (Waldron, 1989).

Tinnitus may range from mild in some cases to severe in others. Sometimes individual report that they are more bothered by their tinnitus than they are by their hearing impairment. People with tinnitus are likely to notice it most in quiet condition, such as when they are trying to go sleep at night, or when they are sitting in a soundproof room. It is often a precursor to noise-induced hearing loss and therefore an important signal (Stellman, 1998).

2.6.2 Elevation of the Blood Pressure: -

The occurrence of elevated blood pressure showed a highly significant correlation with severity of hearing loss (Ylikoski, 1995). Noise exposure has been associated with increased catecholamine production and blood pressure elevation in laboratory studies and in human volunteers (Sokas; et al, 1995). Recurrent daily exposure to high noise at work has an acute effect on resting heart rate (Kristal-Boneh; et al, 1995).
2.7 Control:

The deterioration of health and safety in the workplace may perhaps exist due to the inadequate resource facilities, economic constraints and lack of opportunity to conduct research and studies on the assessment of exposure – diseases associations (Ahasan and Partmnen, 2001). One of the most challenging aspects of noise control is identification of the actual source, in a typical industrial setting. There are usually multiple machines operating simultaneously, which make it difficult to identify the root cause of noise. One of the most effective methods for locating the source of the noise is to measure its frequency spectrum. Once the cause or source of noise is identified it is known how it radiates to employees work areas, the next step is to decide what the available noise control option may be (Stellman, 1998).

2.7.1 Administration Noise Control:

Include replacement of old equipment with quieter new models, adherence to equipment maintenance programs related to noise control, and changes in employees work schedules to reduce noise doses by limiting exposure time when practically and technically advisable. Planning and designing to achieve non-hazardous noise levels when new production facilities are brought on –line is an administrative control which can also eliminate the need for hearing conservation programme (HCP) (Stellman, 1998). Others may include as stated by Waldron (1989) reduce exposure time: if the sound level is above 90 dBA the leq (8h) can be kept below
90 dBA by reducing exposure time, this can be achieved by job rotation, reducing exposure time should be combined with other methods of controlling noise.

2.7.2 Engineering Noise Control:

The most effective means of noise control is to prevent the source of noise from entering into the plant environment in the first place by establishing an effective “Buy Quiet” programme to furnish the work place with equipment engineering for low noise output (Stellman, 1998).

Waldron (1989) suggested the engineering noise control methods in the following order:

1. Control at source:- treatment could include any, or all the following remedies, some of which involve minimal effort or cost:
   - Planned maintenance.
   - Modify speed.
   - Reduce impact noise.
   - Stiffen panels.
   - Replace equipment.
   - Insert an attenuates / silencers.

2. Increase the distance between source and receiver: One of the engineering controls is to increase distance; sound inversely proportional to the square of distance from the sound source “inverse square law”. In decibel terms, this means that doubling the distance from the source, reduce
the sound level by 6dB.

3. Acoustic barrier: To block or shield the receiver “the worker at risk of the noise hazard” from direct sound path. The effectiveness of barrier is a function of its location relative to the noise source or receivers and of its overall dimensions, to maximize the potential noise reduction, the barrier should be located as closely as practical to either the source or receiver (Stellman, 1998).

2.7.3 Personal Hearing Protection:

Hearing protectors must be made available to all workers exposed at or above a TLV (TWA) of 85 dBA. With the help of a person who is trained in fitting hearing protections, employees should decide which size and type protector is most suitable for their working environment. The protector selected should be comfortable to wear and offer sufficient attenuation to prevent hearing loss. Employees must be shown how to use and care for their protectors, and must be supervised on the job to ensure that they continue to wear them correctly. Hearing protectors must provide adequate attenuation in each employee's work environment (Plog, et al, 1996).

There are two types of personal hearing protection devices: Passive hearing protection devices such as ear muffs, canal caps, and ear plugs which reduce noise mechanically; active noise reduction devices, which electronically cancel
sound waves at the ear, the devices must be comfortable to the workers (Lusk, 1997).

Advantages and disadvantages of muffs and plugs are listed below:
- Ears muffs are more visible than plugs, making it easier to check if they are being worn.
- Because of their size muffs are not so easily lost.
- People with ear infections may be able to wear muffs, whereas they should not wear plugs without consulting a doctor.
- Dirt and toxic matter may be transferred to sensitive skin in the ear canal if plugs are inserted with dirty hands, or if they have been placed on a contaminated surface.
- Plugs are more conformable than muffs in hot environments (Waldron, 1989).

When selecting a hearing-protective device, one should consider how often a worker is exposed to excessive noise (Plog et al, 1996). Attenuating the noise reaching the eardrum by 30 to 33 dB, fitting the same workers with earmuffs for a period of 7 working days, resulted in a significant improvement in both psychological and physiological stress reactions. Besides decreasing noise intensity, no other changes were made either to ongoing work activities or to the other characteristics of the ambient noise (Melamed and Bruhis, 1996).

Understanding factors influencing the use of hearing protection
devices will provide direction for programs to increase their use and decrease risk of noise-induced hearing loss (McCullagh; et al, 2002).

2.8 Hearing Conservation Programs (HCP):

Noise levels in Danish work places at which hearing impairment will occur in more than 10% of the workers are still frequent. Annually 300 cases are compensated for noise-induced hearing loss at a national level. This may indicate that the current national hearing protection strategy, which relies on noise reduction only; is insufficient. The refore a national hearing conservation program should be implemented (Kolstad; Rasmussen, 2001). Aneffective hearing conservation program prevents hearing impairment as a result of noise exposure on the job. All employees whose noise exposures equal or exceeds an 8-hour TWA (Total - weighted average) of 85 dBA must be included in (HCP). Basic components of hearing conservation programs (HCP):

1. Monitoring.
2. Audiometric testing.
3. Audiograms (baseline and annual audiograms).
4. Audiogram evaluation.
5. Hearing protectors.
6. Training.
7. Record keeping (Plog; et-al, 1996).

According to Lusk (1997) HCP to be legalized for workers in industrial settings where noise exposure equal or exceeds 85dBA.
CHAPTER
THREE
3. MATERIALS AND METHODS

3.1 Study Area: -

Khartoum North Power Station is located in Bahri industrial area. Bahri Algazia Station, in southern side Alshefa Street and in Western side bound it from the eastern side by a road and in north side by the Balsm Street; It has an area of 24,000 m².

Khartoum North Power Station consists of many departments and sections as follows:

- Power house control.
- Electricity work shop.
- Machinery work shop.
- Boiler maintenance.
- Turbine maintenance.
- Administration sections.
- Instruments and control.
- Water treatment control building.
- Fire control.
- Oil unloading.
- Chemical laboratory.
The departments and sections are illustrated in the map (Appendix 3). The majority of employees are working in turbine area.

3.2 Study Population and Sampling: -

The sample contained a total population of employees in all sections. Those were 72 employees in power house section, 21 in unloading section, 17 in boiler section, 15 in turbine section, 16 employees in instrument and control section, 14 in electricity work shop, 8 in external maintenance, 27 in administration department and 19 employees in water treatment control building.

3.3 Data Collection: -

Different methods in this research were used in order to achieve the objectives. These methods include the following:

3.3.1 Environmental Measurements: -

Noise level was measured in various areas, creating, using a noise map for the determination of risky areas. In this case a sound level meter was used in order to get the readings at regular points in a coordinated network using a Bruel and Kjaer type 2203 (integrating) sound level meter, to construct a sound level contour (Appendix7). The work area was divided into a grid, which was evenly spaced at an approximated distance of 3.05m. A weighted sound level measurement was recorded at each point following the procedure adopted by Stellman (1998).
A sound level meter was used and set for A-scale slow response for the regularly occurring maximum noise level was recorded at the center of each work area (Waldron, 1989). Sound pressure level is measured at the same locations and if all sources were running concurrently the following method of calculation is used:

\[ L_p = 10 \log \left( \frac{P_{\text{total}}}{P_0} \right)^2 \]

\[ \left( \frac{P_{\text{total}}}{P_0} \right)^2 = 10^{\frac{Lp}{10}} + 10^{\frac{Lp_2}{10}} + 10^{\frac{Lp_3}{10}} + \ldots 10^{\frac{Lp_N}{10}} \]

\( P_0 \) = Measured root-mean-square (rms) sound pressure.
\( P_0 \) = reference (rms) sound pressure (20P\(_\mu\))

When the maximum sound level in a work area did not exceed 80dBA, it will be assumed that all employees in that area were working in an environment with an acceptable noise level. In certain areas, when noise level falls between 80-92dBA, more information were required (Plog; et al, 1996).

Employees in Khartoum North Power Station were divided into groups, based on the noise level observed at their work sites. Those exposed to noise level ≥ 85 – 90 dBA are considered as exposed group, while those exposed to ≤ 85 dBA as non-exposed group (Osibogun; et al, 2000).

When the noise level measured was greater than 85dBA, frequency characteristics of sound were analyzed.
with an octave band filter using Bruel and Kjaer meter type 1613,

3.3.2 Exposure Evaluation of Study Population: -

Evaluation exposure of each worker was determined by using noise dosimeter Bruel and Kjaer type 4428. The dosimeter, a microphone was clipped to the helmet for monitoring the sound energy received by the ear. The instrument worn was kept for a representative period of 5 minutes or 15 minutes during which it was set to signal (A) weighted and integrated as reported by (Waldron, 1989). Eight-hour time-weighted averages sound levels (TWA) in decibels were computed from QH0013 conversion table (Appendix 4).

3.4 Audiometric Measurements: -

Octave-band sound pressure levels for quiet room was measured according to Occupational Safety and Health Administration (OCHA) noise standard, 29 CFR 1910. 95 (h) (Appendix 5).

Before audiometry test is conducted an initial screening was made to exclude subjects with pathological middle ear as well as those currently working in sections classified as non-noise but who had been exposed to excessive noise in the past (Osibogun et al., 2000). Subjects were asked about hearing difficulty, tinnitus, otological anamnesis and past experience of noise exposure at work (Miyakita, 2001). The frequencies of interest were 4-6KHz, the audiometer used
was class 1 type B, Siemens which generated pure tones at 0.5, 1, 2, 3, 4, 6 and 8KHz. Each ear was tested separately, starting with the left ear, the intensity being increased in 5 dB steps until the subject responded. This was repeated several times for each frequency, until the threshold of audibility was established (Waldron, 1989). The results were recorded on a graph (audiogram). Cases of NIHL were identified by the presence of notch in either ear (McBride and Williams, 2001). If the average monaural hearing level at 500, 1000 and 2000 HZ is 25 dB or less, no impairment is considered concerning the ability to hear speech under everyday conditions (Plog; et al, 1996). Impairment is described as an average hearing loss, even for frequencies 500, 1000, 2000 and 4000 Hz in excess 25 dB (WHO, 1993). Some deterioration in the ability to hear is the result of aging alone. Where this is known, usually ½ dB deducted from the average hearing level at the three speeches frequencies for every year of the persons age beyond 40 (Lewis and Lester, 1979). Measurement of PTS, the subject had not been exposed to levels of noise likely to induce TTS, the test conducted after weekend (Waldron, 1989). Hearing measurements were carried out at the beginning of the shift due to occupational noise exposure (Plog; et-al, 1996) Hearing levels of persons not exposed to noise were measured for the purpose of comparison. Efforts were made
to include persons in age groups similar to those obtained in the occupationally exposed ones (Ambasankaran, et al., 1981).

3.5 Structured Interview: -

Structured questionnaire (Appendix 6) was designed and used to interview employees. The questionnaire consisted of:

- Basic information as regards to gender, age… etc.
- Tinnitus as regards to how and when they feel.
- Temporary hearing loss.
- Hearing as regards to investigation before and during implementation.
- Personal hearing protection as regards to type, problem of usage personal hearing protection devices.
- Awareness about noise hazard.

Interview with the Khartoum North Power Station (KNPS) Manager: -

The following issues were discussed with KNPS Manager:

- General information about KNPS as regards to date of working, type of machine, sections and departments, employees… etc.
- Employees medical examination.
Provision of a personal hearing protection.

Noise control i.e. administrative, engineering.

3.6 Data analysis: -

Data was analyzed using computer package SPSS. Chi – square and p-value were obtained to find out the significance between different variables.
CHAPTER
FOUR
4. RESULTS

4.1 General Characteristic of Study Population: -

The age distribution of noise—exposed and non-exposed employees in Khartoum North Power Station-2003 is shown in Table (1). Seventy four percent of the exposed population are in the age group between 30-40 years old (74%), while 70% of the non-exposed are in the same age group, less than 1% are in the age group more than 60 years old in an exposed and non groups.

4.2 Environmental Measurements: -

The values of sound pressure levels in selected sections are shown in Table (2). The highest recorded sound pressure level (70dBA) was in Boiler workshop and the lowest recorded sound pressure level (47dBA) was in electrical workshop.

The results of the octave-band sound pressure levels in test room are summarized in Table (3).

Tables (4), (5), (6) and (7) are illustrating the octave-band analysis levels in dBA in Turbine house. Range of dBA varied between 90 -103.5 dBA.

The personal noise dosimeter readings in dBA were between 95.9 dBA and 101.0 dBA in Turbine house, 95.5 dBA in Machinery workshop and 85.3 dBA in oil unloading area section (Table 8).
4.3 Audiometric Measurements: -

Figure (1) illustrates the prevalence of permanent threshold Shift (PTS) among exposed employees. The highest percentage (46.7%) of permanent threshold Shift (PTS) occurred among the employees in Boiler section followed by oil unloading (40.0%) and the lowest percentage (11.1%) was recorded in Electricity work shop.

The prevalence of permanent threshold shift (PTS) among non-exposed employees was highly prevalent (45.5%) in Water Treatment Control Building section and (40.0%) in External Maintenance section (Fig 2).

Temporary threshold shift (TTS) among exposed and non-exposed is shown in Fig (2). It was prevalent 50.7% among exposed employees and 21.7% among non-exposed employees.

About 22% of the exposed employees, who complained of TTS recover after 48 hours, however, non-of the unexposed employees needed the same period to recover from (Table9).

The relationship between TTS feeling in various sections of the Power Station is shown in Table(10). There is a statistically significant difference (P=0.001) between the sections regarding TTS.

A high percentage (56.6%) of the exposed employees working for a duration 1-9 years had temporary threshold shift
(TTS) and (43.4%) of those exposed for 10 years or more had (TTS) (Table 11).

4.4 Tinnitus: -

Figure (4) illustrates the resulting tinnitus among noise-exposed and non-exposed employees. (68.0%) of the exposed employees suffered from tinnitus while 40.0% of the non-exposed employees also complained of tinnitus.

There is strong relationship between tinnitus feeling and section. The work place i.e. There is a highly statistically significant difference (P=0.001) regarding the tinnitus feeling among employees worked in sections (Table 12). The highest percentage (100.0%) recorded among those who worked in external maintenance section, followed by boiler section (85.7%). The lowest percentage (21.0%) was recorded among employees in chemical laboratory.

About 57.8% of the exposed employees working for a duration of 1-9 years had tinnitus in comparison 42.2% of the exposed employees working for 10 years or more. This has been shown in (Table 13). 87.3% of the exposed employees who use PHPD had tinnitus. However, it was not recorded among 12.7% of those who didn’t use PHPD (Table 14).
4.5 Personal Hearing Protection Devices (PHPD) usage: -

In 88.7% of the exposed employees used the personal hearing protection devices (PHPD) and 11.3% of them did not use (PHPD). 48.3% of the non-exposed employees used personal hearing protection devices (PHPD) while 51.7% did not use them (Table15).

The result in Figure (5) revealed that the types of personal hearing protection devices (PHPD) used by employees. (66.2%) of the exposed employees used earmuffs and (18.0%) of them used earplugs.

Figure (6) illustrates employee’s knowledge about the hazard of noise. 24.7% of the exposed employees don’t know about noise hazards.
Table (1): age distribution of noise –exposed and non-exposed employees in Khartoum North Power Station-2003

<table>
<thead>
<tr>
<th>Age distribution</th>
<th>Exposed</th>
<th>Non-exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>20 --- 24</td>
<td>2</td>
<td>1.3</td>
</tr>
<tr>
<td>25 --- 29</td>
<td>21</td>
<td>14.0</td>
</tr>
<tr>
<td>30 --- 34</td>
<td>45</td>
<td>30.0</td>
</tr>
<tr>
<td>35 --- 39</td>
<td>39</td>
<td>26.0</td>
</tr>
<tr>
<td>40 --- 44</td>
<td>27</td>
<td>18.0</td>
</tr>
<tr>
<td>45 --- 49</td>
<td>8</td>
<td>5.3</td>
</tr>
<tr>
<td>50 --- 54</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>55 --- 59</td>
<td>2</td>
<td>1.3</td>
</tr>
<tr>
<td>60 +</td>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table (2): Sound pressure level values in selected locations in Khartoum North Power Station – 2003

<table>
<thead>
<tr>
<th>Location</th>
<th>Sound pressure level (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration room (1)</td>
<td>64</td>
</tr>
<tr>
<td>Administration room (2)</td>
<td>52.5</td>
</tr>
<tr>
<td>Administration room (3)</td>
<td>55</td>
</tr>
<tr>
<td>Administration room (4)</td>
<td>47</td>
</tr>
<tr>
<td>Electrical work shop</td>
<td>68</td>
</tr>
<tr>
<td>Water treatment plant control building</td>
<td>50</td>
</tr>
<tr>
<td>Turbine work shop</td>
<td>69</td>
</tr>
<tr>
<td>Control house</td>
<td>49</td>
</tr>
<tr>
<td>Instruments work shop</td>
<td>56</td>
</tr>
<tr>
<td>External maintenance</td>
<td>51.5</td>
</tr>
<tr>
<td>Chemistry laboratory</td>
<td>54</td>
</tr>
<tr>
<td>Boiler work shop</td>
<td>70</td>
</tr>
</tbody>
</table>
Table (3): Octave – band sound pressure levels in test room

<table>
<thead>
<tr>
<th>Octave – band frequency (Hz)</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound pressure level (dBA)</td>
<td>35</td>
<td>35</td>
<td>34.5</td>
<td>34.7</td>
<td>34.5</td>
</tr>
<tr>
<td>Center Frequency of octave Band Hz</td>
<td>4.4</td>
<td>5.5</td>
<td>6.6</td>
<td>7.7</td>
<td>8.8</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>4.4</td>
<td>44</td>
<td>54</td>
<td>64</td>
<td>74</td>
<td>84</td>
</tr>
<tr>
<td>5.5</td>
<td>55</td>
<td>65</td>
<td>75</td>
<td>85</td>
<td>95</td>
</tr>
<tr>
<td>6.6</td>
<td>66</td>
<td>76</td>
<td>86</td>
<td>96</td>
<td>106</td>
</tr>
<tr>
<td>7.7</td>
<td>77</td>
<td>87</td>
<td>97</td>
<td>107</td>
<td>117</td>
</tr>
<tr>
<td>8.8</td>
<td>88</td>
<td>98</td>
<td>108</td>
<td>118</td>
<td>128</td>
</tr>
<tr>
<td>9.9</td>
<td>99</td>
<td>109</td>
<td>119</td>
<td>129</td>
<td>139</td>
</tr>
<tr>
<td>10.0</td>
<td>100</td>
<td>110</td>
<td>120</td>
<td>130</td>
<td>140</td>
</tr>
</tbody>
</table>

Table (4) Octave Band analysis Level in dBA (in regular points) - Turbine House - Phase 1, 2, 3, 4, 5

Note: The image contains a table with center frequencies of octave bands and corresponding levels in dBA. The table includes frequency bands from 4.4 Hz to 14.8 Hz and their respective levels.

<table>
<thead>
<tr>
<th>Regular point in turbine house</th>
<th>Center frequency of octave Band Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>A₁</td>
<td>94.0</td>
</tr>
<tr>
<td>A₂</td>
<td>96.0</td>
</tr>
<tr>
<td>A₃</td>
<td>95.0</td>
</tr>
<tr>
<td>A₄</td>
<td>97.0</td>
</tr>
<tr>
<td>A₅</td>
<td>98.0</td>
</tr>
<tr>
<td>A₆</td>
<td>97.5</td>
</tr>
</tbody>
</table>
Table (6) Octave-band analysis level in dBA (in regular points) – Turbine House – Phase two – ground floor – Khartoum North Power Station – 2003

<table>
<thead>
<tr>
<th>Regular point in turbine house</th>
<th>Center frequency of octave Band Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>A1</td>
<td>95.0</td>
</tr>
<tr>
<td>A2</td>
<td>94.7</td>
</tr>
<tr>
<td>A3</td>
<td>94.4</td>
</tr>
<tr>
<td>A4</td>
<td>99.9</td>
</tr>
<tr>
<td>A5</td>
<td>100.0</td>
</tr>
<tr>
<td>A6</td>
<td>98.9</td>
</tr>
<tr>
<td>A7</td>
<td>99.1</td>
</tr>
<tr>
<td>A8</td>
<td>95.0</td>
</tr>
<tr>
<td>A9</td>
<td>90.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regular point in turbine house</th>
<th>Center frequency of octave Band Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>A₁</td>
<td>94.0</td>
</tr>
<tr>
<td>A₂</td>
<td>94.0</td>
</tr>
<tr>
<td>A₃</td>
<td>94.0</td>
</tr>
<tr>
<td>A₄</td>
<td>92.5</td>
</tr>
<tr>
<td>A₅</td>
<td>95.0</td>
</tr>
<tr>
<td>A₆</td>
<td>93.0</td>
</tr>
</tbody>
</table>
Table (8): Personal noise dosimeter readings (dBA) of selected employees in noise-exposed area - Khartoum North Power station – 2003

<table>
<thead>
<tr>
<th>Location identification</th>
<th>Selected employees</th>
<th>Decibel (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine house</td>
<td>1</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>95.9</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>98.2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>97.5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>100.5</td>
</tr>
<tr>
<td>Machinery Workshop</td>
<td>1</td>
<td>95.5</td>
</tr>
<tr>
<td>Oil unloading area</td>
<td>1</td>
<td>85.3</td>
</tr>
</tbody>
</table>
Figur (1). Prevelance of permanent Threshold shift (PTS) among exposed employees in Khartoum North Power Station

- Power use control: 27.1%
- Instrument & control: 18.2%
- Boiler: 46.7%
- Electricity workshop: 11.1%
- Turbine: 33.3%
- Mechanical workshop: 22.2%
- Oil unloading: 40.0%
Figure (2). Prevalence of permanent threshold shift (PTS), among non-exposed employees in Khartoum North Power Station.
Figure (3). Temporary threshold shift (TTS) among noise exposed and non-exposed employees, in Khartoum North Power Station.
Table (9): Time taken for temporary threshold shift (TTS) recovery among noise–exposed and non–exposed employees -Khartoum North Power Station in N (%) – 2003

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Immediately</th>
<th>After 24 hours</th>
<th>After 48 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expose n(%)</td>
<td>76</td>
<td>36(47.4)</td>
<td>5(6.6)</td>
<td>17(22.4)</td>
</tr>
<tr>
<td>Non- exposed n(%)</td>
<td>13</td>
<td>8(61.5)</td>
<td>5(38.5)</td>
<td>0(00.0)</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>44(49.4)</td>
<td>28(31.5)</td>
<td>17(19.1)</td>
</tr>
</tbody>
</table>
Table (10) Relationship between temporary threshold shift (TTS) feeling and Sections among employees- Khartoum North Power Station in N (%) – 2003

<table>
<thead>
<tr>
<th>Sections</th>
<th>No of employees</th>
<th>TTS N(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power house control n(%)</td>
<td>72</td>
<td>36(50.0)</td>
</tr>
<tr>
<td>Instruments &amp;Control n(%)</td>
<td>6</td>
<td>2(33.3)</td>
</tr>
<tr>
<td>Boiler n(%)</td>
<td>14</td>
<td>8(57.1)</td>
</tr>
<tr>
<td>Electricity work shop n(%)</td>
<td>12</td>
<td>3(25.0)</td>
</tr>
<tr>
<td>Turbine n(%)</td>
<td>8</td>
<td>5(62.5)</td>
</tr>
<tr>
<td>Mechanical work shop n(%)</td>
<td>15</td>
<td>9(60.0)</td>
</tr>
<tr>
<td>Oil unloading n(%)</td>
<td>23</td>
<td>13(56.5)</td>
</tr>
<tr>
<td>Administration n(%)</td>
<td>24</td>
<td>6(25.0)</td>
</tr>
<tr>
<td>Water treatment control building n(%)</td>
<td>16</td>
<td>4(25.0)</td>
</tr>
<tr>
<td>Eternal maintenance n(%)</td>
<td>6</td>
<td>3(50.0)</td>
</tr>
<tr>
<td>Fir control n(%)</td>
<td>9</td>
<td>0(0.0)</td>
</tr>
<tr>
<td>Chemical laboratory n(%)</td>
<td>5</td>
<td>0(0.0)</td>
</tr>
<tr>
<td><strong>Total n(%)</strong></td>
<td><strong>210</strong></td>
<td><strong>89(42.4)</strong></td>
</tr>
</tbody>
</table>

Chi-square = 30.768  
P = 0.001
Figure (4). Tinnitus among noise exposed and non-exposed employees, in Khartoum North Power Station.
Table (11): Relationship between Temporary Threshold Shift (TTS) feeling and period of work among Khartoum North Power Station employee’s

<table>
<thead>
<tr>
<th>Duration in years</th>
<th>N</th>
<th>TTS N(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-9</td>
<td>76</td>
<td>43(56.6)</td>
</tr>
<tr>
<td>10+</td>
<td>74</td>
<td>33(43.4)</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>76(50.7)</td>
</tr>
</tbody>
</table>

Chi-square = 0.00  P = 1.00
Table (12): Relationship between Tinnitus feeling and sections among employees Khartoum North Power Station in N (%) - 2003

<table>
<thead>
<tr>
<th>Sections</th>
<th>Tinnitus</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes n(%)</td>
<td>No n(%)</td>
<td>Total n(%)</td>
<td></td>
</tr>
<tr>
<td>Power house control</td>
<td>51(70.8)</td>
<td>21(29.2)</td>
<td>72(34.3)</td>
<td></td>
</tr>
<tr>
<td>Instruments &amp; Control</td>
<td>3(50.0)</td>
<td>3(50.0)</td>
<td>6(2.9)</td>
<td></td>
</tr>
<tr>
<td>Boiler n(%)</td>
<td>12(85.7)</td>
<td>2(14.3)</td>
<td>14(6.7)</td>
<td></td>
</tr>
<tr>
<td>Electricity n(%)</td>
<td>6(50.0)</td>
<td>6(50.0)</td>
<td>12(5.7)</td>
<td></td>
</tr>
<tr>
<td>Turbine n(%)</td>
<td>5(62.5)</td>
<td>3(37.5)</td>
<td>8(3.8)</td>
<td></td>
</tr>
<tr>
<td>Mechanical n(%)</td>
<td>8(53.3)</td>
<td>7(46.7)</td>
<td>15(7.1)</td>
<td></td>
</tr>
<tr>
<td>Oil unloading n(%)</td>
<td>17(73.9)</td>
<td>6(26.1)</td>
<td>23(11.0)</td>
<td></td>
</tr>
<tr>
<td>Administration n(%)</td>
<td>8(33.3)</td>
<td>16(66.7)</td>
<td>24(11.4)</td>
<td></td>
</tr>
<tr>
<td>Water treatment control building n(%)</td>
<td>6(37.5)</td>
<td>10(62.5)</td>
<td>16(7.6)</td>
<td></td>
</tr>
<tr>
<td>Eternal maintenance n(%)</td>
<td>6(100.0)</td>
<td>0(0.0)</td>
<td>6(2.9)</td>
<td></td>
</tr>
<tr>
<td>Fir control n(%)</td>
<td>3(33.3)</td>
<td>6(66.7)</td>
<td>9(4.3)</td>
<td></td>
</tr>
<tr>
<td>Chemical laboratory n(%)</td>
<td>1(21.0)</td>
<td>4(80.0)</td>
<td>5(2.4)</td>
<td></td>
</tr>
<tr>
<td>Total n(%)</td>
<td>126(60.0)</td>
<td>84(40.0)</td>
<td>210(100.0)</td>
<td></td>
</tr>
</tbody>
</table>

Chi-square = 30.768  
P = 0.001
Table (13): Relationship between Tinnitus feeling and work duration among exposed employees Khartoum North Power Station in N (%) – 2003

<table>
<thead>
<tr>
<th>Duration in years</th>
<th>No of employees</th>
<th>Tinnitus N(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-9</td>
<td>85</td>
<td>59 (69.4)</td>
</tr>
<tr>
<td>10+</td>
<td>65</td>
<td>43 (66.2)</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>102 (68.0)</td>
</tr>
</tbody>
</table>

Chi-square = 0.180  P = 0.672
Table (14): Tinnitus feeling and personal hearing protection devices (PHPD) usage among exposed employees - Khartoum North Power Station in N (%) – 2003

<table>
<thead>
<tr>
<th>PHPD</th>
<th>No of employees</th>
<th>Tinnitus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes n(%)</td>
<td>133</td>
<td>89(66.9)</td>
</tr>
<tr>
<td>No(%)</td>
<td>17</td>
<td>13(76.5)</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>102(68.0)</td>
</tr>
</tbody>
</table>
Table (15): Personal hearing protection devices (PHPD) usage among noise – exposed and none – exposed employees Khartoum North Power Station in N (%) – 2003

<table>
<thead>
<tr>
<th>Group</th>
<th>No of employees</th>
<th>Usage of PHPD n(%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Exposed n(%)</td>
<td>150</td>
<td>133(88.7)</td>
<td>17(11.3)</td>
<td></td>
</tr>
<tr>
<td>Non – exposed n(%)</td>
<td>60</td>
<td>29(48.3)</td>
<td>31(51.7)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>162</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>
Figure(5). Types of personal hearing protection devices (PHPD) usage among noise-exposed employees, in Khartoum North Power Station.
Figure(6). Knowledge about noise hazards among noise exposed and non-exposed employees, in Khartoum North Power Station.
CHAPTER
FIVE
5. DISCUSSION

The percentage of permanent threshold shift (PTS), temporary threshold shift (TTS) and tinnitus among exposed group were more than percentage among non-exposed group. These conditions occurred as a result of high noise levels recorded in different sections. These results are in accordance with the previously mentioned evidence by Stellman (1998). The amount of hearing impairment depends on the level of noise. Employees exposed to noise level of around 90 dBA have early signs of occupationally impairment Ralph (1993). Highest percentage among exposed group had temporary threshold shift (TTS) where as low percentage (TTS) was recorded among non-exposed group. According to Stellman (1998) employees with Temporary Threshold shift (TTS) will gradually suffer from permanent threshold shift (PTS) during the course of work. As it was indicated in results of employees who suffered from temporary threshold shift (TTS) remained for 48 hours after exposure to noise risk this may be due to high levels of noise involved (Waldron1989). The time taken for temporary threshold shift (TTS) recovery depends upon the period of exposure and the sound level, but it can be as much as 48 hours or more in extreme cases. The delayed recovery from temporary threshold shift (TTS) may leads to induction of permanent threshold shift (PTS) (Stellman1998),
as to the detection employees who had a permanent threshold shift (PTS) among exposed group while in non-exposed group the percentage of those workers who had permanent threshold shift (PTS) is 29.7%. Although the percentage of permanent threshold shift (PTS) among exposed group is seem to be small, it is excepted to increase since there are employees among exposed group have a temporary threshold shift (TTS).

A significant association was found between noise – induced hearing loss and different levels of noise existed in different sections (P. value = 0.001). The highest percentage of Temporary Threshold shift (TTS) was recorded at mechanical workshop section, while the lowest was recorded at both fire control and laboratory sections. Noise levels in the former was said to be 78 dB and in the later 54 dBA according. This condition (i.e. temporary threshold shift (TTS) depend on the level of noise involved. Type of noise in Khartoum North Power Station (KNPS) is continuous (Plog et a 1996). The continuous exposure to high level noise is more harmful than intermittent or impulsive exposure. The octave –band in Turbine section ranged from 90 to 103.5dBA. According to Waldron (1989) the degree of hearing impairment depends on the level susceptibility of the individual worker. The size of damage caused by continuous pure tone or narrow band noise appears to depend upon the frequency of the noise.

Although Stellman (1998) recommended that
audiometry measurement should be applied for all employees who are likely to be exposed to noise levels above 85dBA, all employees (100.0%) were not subjected to audiometry measurement.

According to Melamed and Bruhis (1996) workers with hearing protection devices, resulted in a significant improvement regarding physiological stress reactions, and as a result of this condition, the risk of hearing impairment may prevail among employees although no significant association was found between these two conditions. This may be attributed to the good job rotation and to the barriers and shielding in the work place or for individual susceptibility. This could be appeared in case of tinnitus.

Results revealed that, no significant association between temporary threshold shift (TTS) and work duration among exposed employees. The findings in this study disagree with the reported evidence by Plog; et al (1996). They reported that there are many factors that affect the degree and extent of hearing loss, one of them is the total work duration the same case was hold to the Tinnitus. The use of personal hearing protective devices (PHPD) was predominant among exposed group. They used earmuffs as a personal protective measure while 18.0% of them preferred to use earplugs. The use of earplugs should be enforced because it is more suitable and comfortable for employees than earmuffs.
especially in hot environment Waldron (1989).

**Interview results: Presentation and Discussion:**

The results obtained from the interviewed Khartoum North Power Station Manager showed that employees were not involved in deciding on what types and sizes of personal hearing protection devices (PHPD) are needed. These findings contradicted with the previously reported results (Plog; et al 1996). It was suggested that employees should decide which size and type of protective devices are most suitable for their working environment and they must be supervised on Job. According to Khartoum North Power Station Manager close supervision and monitoring of work environment concerning wearing of personal protective devices is almost lacking although many regulations regarding personal protective measures existed but they were not enforced. Understanding factors influencing the use of hearing protection devices will provide direction for programs to increase their use and decrease risk of noise-induced hearing loss (McCullagh et al 2002). Also Plog; et al.,(1996) reported that when selecting a hearing – protective device, one should consider how often a worker is exposed to excessive noise. Persons attitude towards the noise in his working environment governs hearing impairment suffered (Waldron 1989).

The results obtained from Khartoum North Power Station Manager showed that there was no hearing conservation
program (HCP) illustrating noise levels different section of the Power Station. An effective hearing conservation program (HCP) prevents hearing impairment as result of noise exposure on the job. It should be applied when appropriate (Kolstad and Rasmussen 2002). Lusk (1997) reported that hearing conservation program (HCP) must be provided or legally to be in sections where noise level reach 85 dBA.
CHAPTER SIX
6.1 CONCLUSION

- Sound level pressure in Turbine house, Machinery workshop and unloading sections in Khartoum North Power Station above TLV (85dBA) recommended standard.

- Prevalence of noise-induced hearing loss among employees was high.

- All employees were not subjected to audiometry measurements.

- Employees did not wear suitable hearing protective devices during the work course and were not under supervision regarding wearing of protective devices.

- Hearing conservation programme (HCP) was not present.
6.2 RECOMMENDATION

- Hearing protectors must be made available to all employees in Turbine and Mechanical sections ((SPL more than TLV (85dBA))
- All employees should be subjected to audiometric measurements:
  1. Basic line audiometric measurements.
- Hearing conservation programme (HCP) should be implemented.
- Personal hearing protection devices should be provided and worn according to noise levels and type of work.
- Supervision should be made to ensure that the regulations were applied in term of personal protection devices.
CHAPTER SEVEN
REFERENCES


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- Razadan, U; Sidhu, T, S. Need for research on health hazards due to noise pollution in metropolitan. Journal of Indian Medical Association 2000,98: 453- 6, 460.


CHAPTER EIGHT
8.1. APPENDICES


<table>
<thead>
<tr>
<th>Duration (Hours)</th>
<th>Sound Level Slow Response</th>
</tr>
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<tbody>
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<td>32.0</td>
<td>80</td>
</tr>
<tr>
<td>27.9</td>
<td>81</td>
</tr>
<tr>
<td>24.3</td>
<td>82</td>
</tr>
<tr>
<td>21.1</td>
<td>83</td>
</tr>
<tr>
<td>18.4</td>
<td>84</td>
</tr>
<tr>
<td>16.0</td>
<td>85</td>
</tr>
<tr>
<td>13.9</td>
<td>86</td>
</tr>
<tr>
<td>12.1</td>
<td>87</td>
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<tr>
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<td>88</td>
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<tr>
<td>9.2</td>
<td>89</td>
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<td>8.0</td>
<td>90</td>
</tr>
<tr>
<td>7.0</td>
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</tr>
<tr>
<td>6.2</td>
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<td>93</td>
</tr>
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<td>4.6</td>
<td>94</td>
</tr>
<tr>
<td>4.0</td>
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<td>97</td>
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</tr>
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<td>101</td>
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<td>1.5</td>
<td>102</td>
</tr>
<tr>
<td>1.4</td>
<td>103</td>
</tr>
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<td>104</td>
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<tr>
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Appendix (3): Khartoum North Power Station Plan.
Appendix (4): Conversion Table.

<table>
<thead>
<tr>
<th></th>
<th>5min</th>
<th>15min</th>
<th>1h</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dB(A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>70</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>60</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Octave – band frequency (Hz)</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound pressure level (dB)</td>
<td>40</td>
<td>40</td>
<td>47</td>
<td>57</td>
<td>62</td>
</tr>
</tbody>
</table>

(Barbara; et al, 1996)
Questionnaire about noise - induced loss

(1) Name of employee:__________
(2) Age:__________
(3) Location of work:__________
(4) Work duration:__________
(5) Previous work:__________
(6) Duration of previous work:__________
(7) work system:__________
(8) Do you hear Tinnitus?  Yes  No
(8-1) if “yes” when ?
   During work  after work  weekend
(9) Do you feel Temporary Threshold shift (TTS)? Yes  No
(9-1) If “yes” when?
   During work  after work  other  Specify
(9-2) When the recovery takes pace?
   After work directly  after 24 hours  after 8 hours
(10) Do you make initial test of hearing before attaching the work? Yes  No
(11) Do you make periodic test of hearing? Yes  No
(12) Do you wear personal protection devices of noise? Yes  No
(12-1) If “yes” what type?______________________________
(12-2) Are you using them regularly? Yes  No
(12-3) If “No” why?______________________________
(13) Do you know the noise hazards? No  Yes
(13-1) If “yes” what are they?______________________________
Appendix (7): Sound level map contour of Khartoum North Power Station