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Excessive Sound Noise Risk Assessment in Textile Mills of an Ethiopian-Kombolcha Textile Industry Share Company

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A B S T R A C T

In countries like Ethiopia, the textile industries are facing a big problem of sound noise pollution. In these countries, the industrial hearing conservation program is not yet clearly developed. Thus, characterizing excessive noise pollutions in textile industries have been the aim of this research project and Kombolcha Textile Mill (KTM) is chosen as the case study. The study is concerned with noise exposure and its characteristics at the different section of the textile mill. Before the actual excessive noise level measurements are collected in the textile mill, the main areas where measurements are done have to be identified. This is done by prior physical observation and A-Weighted time-averaged sound pressure levels (L_Aeq) survey. More than one hundred walkthrough measurement points are done inside the textile mill. These data are analyzed using MATLAB software packages. Based on our analysis, the spinning and the weaving sections of the mills with its unit processes are identified as potential noise pollution in the factory. On these sections, the measurements are done for 4–5 h/d. The instrument used for measurements is a precision integrated portable professional sound level meter. The findings reveal that the KTM employees work in hazardous environments above 90 dB, which is the recommended safe limit of noise in the working environment for 8 h used in international standard. As a result, engineering and administration programs which include different methods of how to control the problem has been recommended for conserving hearing at the KTM.

Keywords: Textile mill, Sound noise pollution, Sound pressure levels, MATLAB software, Sound level meter.

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1. Introduction

Ethiopia has an ambitious program to increase its technological and manufacturing competitiveness in the global marketplace during the next few years. Government leaders have emphasized that achieving success both internationally and domestically will depend in large measure on the effectiveness of domestic and foreign direct investments in large scale farming, industrial, and manufacturing sectors. It is fact that in the current Ethiopia, farming is dominant, backed by the export of commodities, but besides to old manufacturing and industrial sectors, the new textile plant investments are emerging in the country. The textile

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tradition in Ethiopia goes back a long way, but the industry has only started to develop in the last decade. Recently, the textile sector is considered by the government as the main priority sector of the country's industrial development strategy as part of the nation's growth and transformation plan. As a result, the investment flows in the textile industries are very good. For example, the investment projects in textile industries are coming from India, Turkey, China, Bangladesh, and South Korea that are still rising. Over 65 textile investment projects from international investors have been licensed in Ethiopia with retails such as H&M and Primark. These textile industries with modern automated machines have considerably decreased the physical burden of the industrial work on workers in addition to increasing the productivity of the Ethiopian textile enterprises. However, the current industrial environment is quite different than the past. Market driven forces and globalization have made the industrial environment quite competitive [1]. For example, owing to the improvements in technology through greater energy efficiency, higher labor productivity, continuous production methods and mechanization have advanced textile processing plants. In parallel to this improvement, emissions of excessive sound noise and ambient sound at work in the textile industry have shown a noticeable increase [1]. Previous studies documented that the machines and devices used in textile industries are highly diverse in its nature and most of them emit excessive sound noise due to frequent operation of noise generating components [1, 2]. Jayawardana et al. [2] claimed that the operational speed of industrial machines is highly increased and heralded high efficiency as well as productivity. Nevertheless, corresponding to technological and economic progress, ever increasing occupational noise problem, reached to an alarming level with adverse health effects to its workers [2]. As a result, high levels of industrial noise are becoming a global occupational health hazard, with considerable economic, social, and physiological impacts, including noise that induced the hearing loss [1, 2]. Aside from damaging to hearing, there is confirmation that excessive industrial noise exposure also affects workers in the different ways including reduced performance (e.g. reducing ability to concentration), disturbance of sleep, annoyance, excitement of the central and vegetative nervous system (e.g. increasing blood pressure, higher heart frequency, and effect on metabolism) [3]. To protect workers from hearing loss due to excessive noise exposure and other related health effects, a number studies have been carried out till date concerning its nature, etiology, and time course [4]. While a large proportion of textile industries over the world are located in developing contents like Africa, most of these studies have been conducted in developed countries. In the last few decades, excessive industrial noise assessment has been a topic of research debate among developing country scientists. For example, few studies have been carried out to assess the occupational environment in textile industries in African countries like Nigeria, Tanzania, and Sudan [5-7]. As a result, these African countries have taken positive steps against excessive textile industrial noise. Excessive industrial noise pollution has been accepted as a major threat to industrial workers in these countries. Research-based scientific discussion and legislations have been made in an attempt to recognize and combat the problem of industrial noise pollution. In contrast, there is still ignorance amongst researchers and majority of people working in industries in Ethiopia about its nature and ill effects of exposure to high value of industrial noise. In the literature, there are no studies concerning noise level assessment in the Ethiopian textile industries. Therefore, this study is aimed at evaluating the equivalent and peak noise level inside a spinning and weaving mills of a modern Ethiopian textile plant, the Kombolcha Textile Share Company (KTSC).

2. Noise in Textile Industries

As it is commonly defined, the noise is an unwanted and excessive sound that interferes with the function in a given occupational environment. It is a disturbing sound, regardless of its intensity or duration. Often the unwanted and excessive noise levels have been taken granted in many textile plants. In textile industries, the increased mechanization results in increased noise levels. The high level sound because of the clatter of gears, high speed whine of twisting and spinning mills can generally be assumed to generate a great deal of noise [4]. Noise levels of 70 to 110 dB are commonly recorded in textile plants workrooms. Most importantly, the speeds of recent textile machines are highly increased and heralded the high productivity as well as efficiency [2, 4, 8, 9]. As might be expected, this progress towards greater speeds has resulted in excessive noise levels, often exceeding 110 dBA in spinning and weaving mills [4]. An investigation conducted by Ahmedabad textile industry's research association indicated that the noise level in spinning department is between 80 dBA and 90 dBA, of which the lowest is in blow room and the highest is in ring frame [3]. A report on noise pollution in textile industries in India has also confirmed the presence of high noise levels of the range of 90 to 106 dBA in various sections like ring frame, carding, loom shed, etc. [4]. These studies associated the variations in the noise levels with the design type, erection and number of used looms, condition of machines, fabric structure, building type, and building size [3]. Evidences documented that the high levels of noise emissions in textile industries are related to high production speeds, and these high levels cannot be adequately compensated by the noise reduction techniques that are currently are used. The textile industry must tolerate the amount of the costs resulting from the exposure to dangerously high noise levels of its employees. However, very little progress has been made in reducing excessive noise in textile industries.

As can be presented above, a lot of studies have been carried out to evaluate textile plants noise in textile mills and the results show that the high percentage of industrial workers were exposed to more than 85 dBA noise levels [4, 6, 10, 11, 12, 13]. For example, a study conducted in Tanzania revealed that about 30% of the FTM employees are working in hazardous environments above 90 dB, which is the recommended safe limit of noise in the working environment for 8 h used in Tanzania [5]. Thus, textile mills are among the many industrial occupational settings that pose the risk of noise induced hearing loss. Bedi [4] reported that in addition to causing damage to hearing, occupational noise exposure has been found to be related to a range of indicators physical health including cardiac problems and sickness related self-reported fatigue. A significant body of finding also showed that the increased noise levels reduce productivity, increase accident incidence and severity rates, and increase absenteeism [12-14].These hidden costs have also a significant impact on the profitability of the textile industries.

3. Directives for Noise Control

The general effect of noise on the hearing of workers has been a topic of debate among scientists for years. Regulations limiting noise exposure of industrial workers have been instituted in many places. For instance, the maximum permissible occupational noise limit in the range of 85-90 dBAL_eq for 8 h/d (40 h/wk) has been established by the International Standards Organization (ISO), EEC, and other developed countries. In many European countries, the occupational noise exposure regulation states that industrial employers must limit noise exposure of their employees to 90 dBAL_eqfor 8 hr period; other countries such as Japan, Sweden, Germany, and Norway allow 85 dBAL_eq. These limits are allowed for halving rates of 3 dBA and working schedules of 8 h/d. OSHA (USA) allows 85 dBA for 8 h/d with halving rate of 5 dBA. This level is supposed to inhibit hearing impairment of industrial workers. The International Labour organization agrees with this indication. As discussed earlier, excessive noise exposure is a global occupational health hazard, with considerable social and physiological impacts, including noise induced hearing loss (9). As a result, in recent few decades, many countries have been carried out various studies to assess the occupational environment in textile plants [4, 12, 13, 14, 15, 16]. Nevertheless, in Ethiopia, no systematic study has been conducted so far [8]. In view of the negative effect of noise on textile factory workers, this study is aimed at evaluating the equivalent and peak noise level inside a textile plant area of an Ethiopian textile share company.

4. Description of Study Area

4.2. KTSC-Textile Mill

The study reported here has been carried out at one textile plant, i.e. the Kombolcha Textile Share Company (KTSC), located in the north eastern part of Ethiopia. KTSC was established in 1984 at Kombolcha town in the South Wollo administration zone of the Amhara regional state, 380 km north of Addis Ababa, the capital city of Ethiopia. With this investment, the company has renovated its old production line by the new state of the art technology and started production in the 2011 budget year. KTSC is an integrated Textile mill producing 100% cotton fabric with grey, bleached, dyed and printed cotton fabrics, and yarns with different counts. The company has about 1400 employees working at existing time. At KTSC, the production is run intermittently for 24 h/d. Like many textile mills, machines at KTSC are grouped together in accordance with function or process and arranged in separate flow patterns. In all workrooms, the open aisles are left to facilitate transportation of materials and products. Thus, the functional layout of the factory facilitates an excellent opportunity for good machine utilization. Within the KTSC textile mill, the production flow is divided into spinning, weaving, processing, and garment. Spinning mill at KTSC has 13200 spindles at ring frame and its attainable capacity is processing 7000 tons of cotton to yield 6000 tons of yarn, for weaving consumption and market, per work year in 3 shifts. The spinning section includes also the pre-spinning machineries such as Carding, Drawing, opened the post spinning machineries such as the winding auto Conner, reeling, and twisting machines. Weaving unit has total of 223 looms fully automated type. This includes Versamat, Picanol, Sulzer, and Dornier. It has annual designed capacity of 22 million square meters of fabrics working in 3 shifts. The processing and garment unit consists of continuous processing machineries which can wash, dry, dye, and/or print.

5. Materials and Methods

Noise level measurements were conducted at KTSC-textile mill. Proper care was taken against reflected sound waves from the operators' body when the sound level meter was used. The noise level was recorded at a regular interval of ten (10) minutes for twelve times at nine different unit processes (i.e. six unit processes at spinning mill and three unit processes at weaving mill; see section below). The measurements were done for 4–5 h/d. The instrument used for measurements was a precision integrated portable professional sound level meter (vellman, Belgium, model DM202; (Figure 1)).

Figure 1. DM202 integrating portable and professional sound level meter by velleman.

Noise measurements were made in areas normally occupied by factory workers. The sound levels were measured in all locations. The measurements were performed in compliance with international regulations (such as, in compliance with EN ISO 9612 (12) and UN 9432 (13)). A-weighted time-average sound pressure levels (L_{Aeq}) and C-weighted peak sound pressure levels (L_{Aeq}) were measured. Here, the exposure limit values and exposure action values in respect to the daily noise exposure levels and the peak sound pressure are fixed based international directive (i.e. directive 2003/10/EC of the European parliament) as follows:

- Lower Exposure Action Values (LEAV) - $L_{EX,8h} = 80\ dBA$; $p_{peak} = 135\ dBC$;
- Upper Exposure Action Values(UEAV) - $L_{EX,8h} = 85\ dBA$; $p_{peak} = 137\ dBC$;
- Exposure Limit Values(ELV) - $L_{EX,8h} = 87\ dBA$; $p_{peak} = 140\ dBC$.

Where $L_{EX,8h}$ values (occupational noise) are reported to 8 working hours.

$L_{EX,8h}$value is given by the following equation:

$$L_{EX,8h} = L_{Aeq,T_e} + 10\log(T_e/T_0),$$

where T_e is the effective duration, in hours, of the working day and T_0 is the reference duration equal to 8 h. In this case, T_e is assumed to be 7.5 h.

6. Analysis and Results

Before the noise level measurements are collected in the factory, the main areas where the measurements are done have to be identified. This was done by prior physical observation and A-Weighted time-averaged sound pressure levels (L_Aeq) survey, considering the department and unit processes where excessive levels of noise are generated. The A-Weighted time-averaged sound pressure levels (L_Aeq) for walkthrough locations are shown in Figure 2 for the 105 measuring points within textile mill.

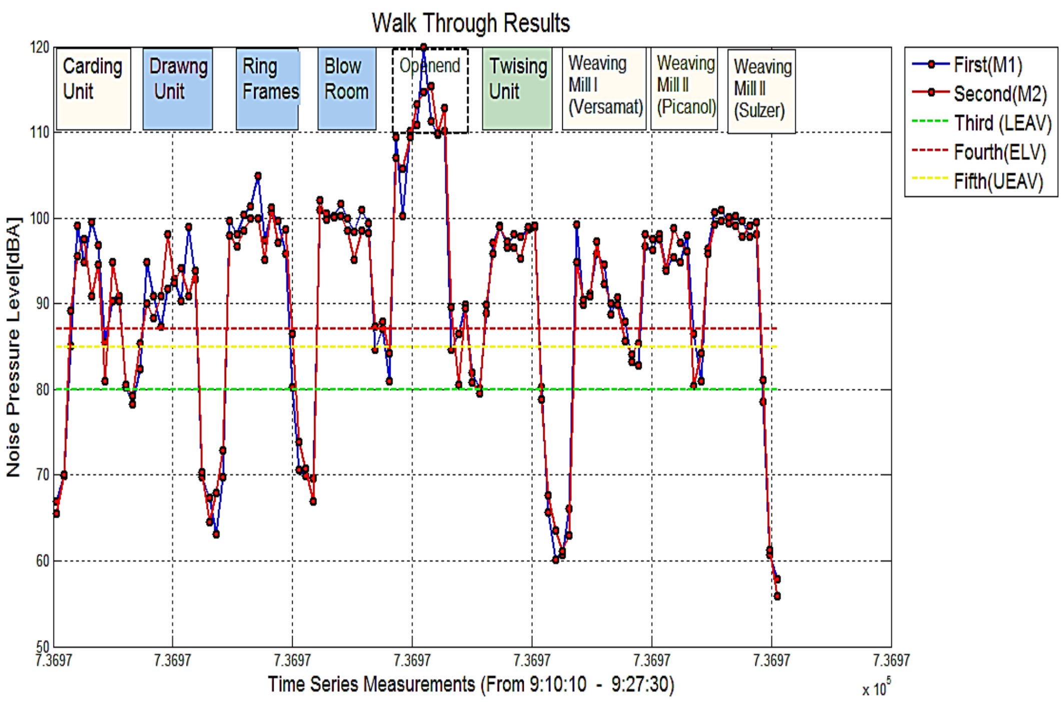

Figure 2. Noise pressure levels (L_Aeq) for walkthrough sound level measurements at the 105 measuring points.

The walkthrough dosimetry with location log was useful for identifying high risk areas. Thus, based on the analysis presented in Figure 2, the spinning and the weaving mills with its unit processes were selected as follows:

Spinning mill: In this department, six unit processes were selected which seemed to have excessive noise levels as compared to other places. The unit processes were selected that included carding, drawing, ring frames, blow room, and opened (the post spinning machineries such as the winding auto conner and twisting machines).

Weaving mill: The weaving mill has total of 223 looms fully automated type. This includes Versamat, Picanol, Sulzer & Dornier. From this mile, all the three places were selected.

Before each series of measurements in all selected places, an instrument calibration was performed by applying a sound calibrator as instructed in the manual. During each series of measurements, the instrument was held at arm’s length in order to minimize reflection from the operator. The sound level meter microphone was positioned at a height of 1.5 m from the ground in the vicinity of operator’s working place without directly attaching to the operator. It is observed that all active workers in all selected places did not use hearing protection during the time of the noise measurements. The overall noise level measurement results in dB recorded at KTSC-textile mill is presented in Table 1 and Table 2.

Table 1. The overall noise level measurement result in dBA recorded from each unit processes.

Type of Mills	Unit Process in Work Area	Series of Measurements (M1 – M8) in each Unit Process											
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Spinning mill	Carding	89.8	89.4	90.9	95.6	94.2	99.0	96.9	96.1	90.9	92.4	88.7	91.9
	Drawing	89.2	90.6	94.8	95.2	96.8	90.9	85.7	95.1	91.8	89.4	90.2	90.1
	Ring frames	97.9	96.7	100.1	98.1	96.6	99.5	101	100.9	98.9	100.3	96.7	98.5
	Blow room	100.5	101.1	100.3	100	99.8	95.7	99.9	100.2	99.4	100.7	98.9	99.2
	Openend	109.4	105.9	105.5	109.1	110	120	111.9	110.7	111.3	109.8	115.3	110.5
	Twisting	89.6	97.1	99.4	96.6	96.5	98.1	98.4	99.2	91.5	89.5	90.9	94.8
Weaving mill	Versamat	90.9	89	98.9	90.9	96.9	95.9	89	90.5	91.1	89.6	93.2	92.1
	Picanol	97.2	96.5	97.8	95.5	93.9	97.2	96.9	97.1	96.5	98.9	92.8	92.2
	Sulzer &Dornier	96.9	100.2	100.9	99.8	100.2	99.4	98.6	100	98.4	99.1	95.6	99.7

Table 2. Noise pressure levels (LAeq) for spinning and weaving mills at the 12 measuring points (data are reported as means ± standard deviations).

Type of mills	Unit process in Work Area	Sample size	Mean value	Standard deviation
Spinning mill	Carding	12	92.98333	3.31795
	Drawing	12	91.65	3.21375
	Ring frames	12	98.76667	1.61602
	Blow room	12	99.64167	1.39118
	Openend	12	110.78333	3.87341
	Twisting	12	95.13333	3.76209
Weaving mill	Versamat	12	92.3333	3.2500
	Picanol	12	96.0417	2.0531
	Sulzer & Dornier	12	99.0667	1.5144

7. Findings and Conclusions

A-Weighted time-averaged sound pressure levels (LAeq) for spinning and weaving mills of each unit processes are shown in Figure 3 for the 12 measuring points.

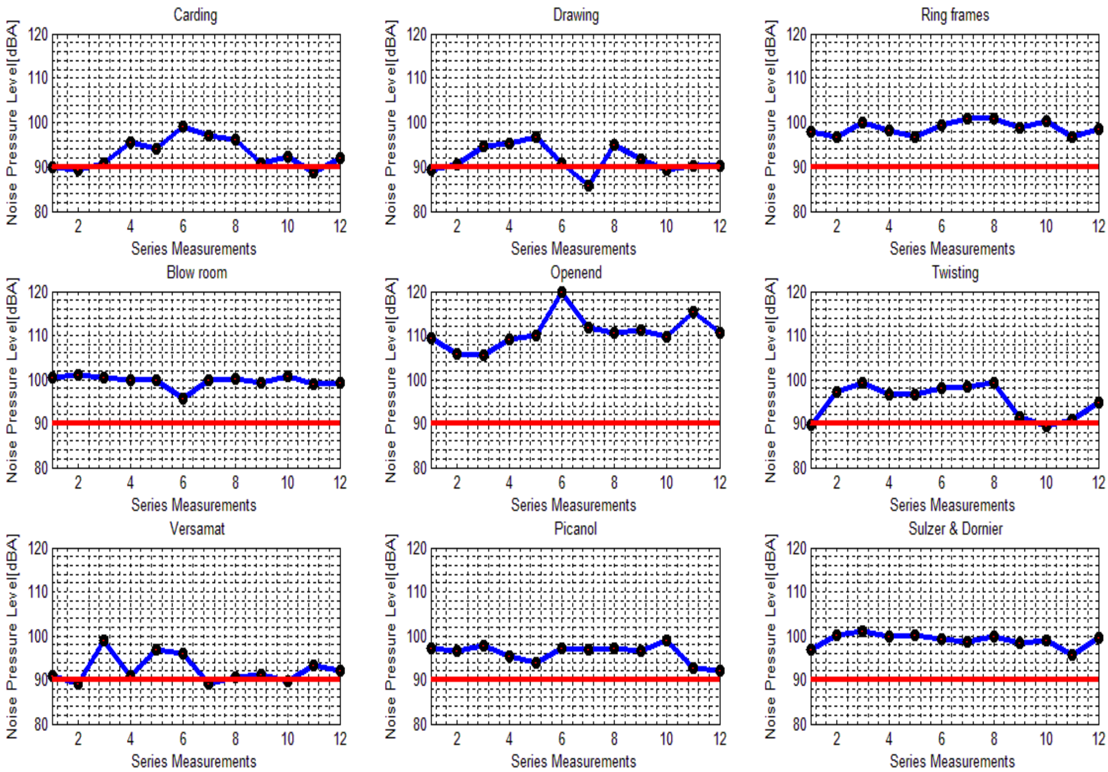

Figure 3. MATLAB-based analyzed data related to the two main sections of the KTM presented together.

Results of the noise measurement presented in Figure 3 show that overall noise levels dBA Leq at KTM included in this study ranged between 88.7 and 99 dBA in the carding section; between 85.7 and 96.8 dBA in the drawing process unit; between 96.6 and 101 dBA in the ring frames; between 95.7 and 101.1 dBA in the blow rooms; between 105.9 and 120 dBA in the openend process units; and between 89.5 and 99.4 dBA in the twisting rooms of the spinning mill. Similarly, noise levels dBA Leq at weaving mill ranged between 92.3333 ±3.25 and 99.0667±1.5144. Workers in spinning and weaving mills at KTM were exposed to average levels of noise above 85 dBA; the threshold limit value had been set and allowed by the International Standards Organization (ISO), EEC, and other developed countries. That means, daily period of noise exposure was 8 hours for all of the workers in KTM factory. The daily noise exposure of workers in areas like weaving and spinning mills in KTM factory exceeded the maximum exposure limit of 90 dBA, specified by occupational health developing countries. As can be seen in the MATLAB based data analysis related to the two mills that are reported together in Figure 3, the findings have depicted that employees in KTM investigated in this study are at high risk of developing excessive noise induced hearing loss and associated diseases due to excessive exposure to industrial noise. A significant part of the study is that the results of this study shows that noise control measures were not put in place or where they were provided they were not adequate in the spinning and weaving mills of KTM. We recommende that engineering controlling means should institute to decrease the number of sources of noise production and to reduce the level of noise produced. To prevent these noise induced harms, as an additional mechanism, workers at KTM should be encouraged to use earmuffs and plugs. Despite all, there is a pressing need to develop a hearing conservation program at KTM such as recurrent noise assessment, increasing workers' awareness about the effects of noise exposure, and use of hearing protection devices.

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