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Technical note

INDUSTRIAL NOISE LEVEL STUDY IN A WHEAT PROCESSING FACTORY IN ILORIN, NIGERIA

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An industrial process such as wheat processing generates significant noise which can cause adverse effects on workers and the general public. This study assessed the noise level at a wheat processing mill in Ilorin, Nigeria. A portable digital sound level meter HD600 manufactured by Extech Inc., USA was used to determine the noise level around various machines, sections and offices in the factory at pre-determined distances. Subjective assessment was also mode using a World Health Organization (WHO) standard questionnaire to obtain information regarding noise ratings, effect of noise on personnel and noise preventive measures. The result of the study shows that the highest noise of *99.4* dBA was recorded at a pressure blower when compared to other machines. WHO Class-4 hearing protector is recommended for workers on the shop floor and room acoustics should be upgraded to absorb some sounds transmitted to offices.

Key words: wheat processing, noise level, digital sound meter, questionnaire, hearing protector.

1. Introduction

Discrimination and differentiation between sound and noise also depends upon the habit and interest of the person or species receiving it, the ambient conditions and impact of the sound generated during that particular duration of time. At present, noise pollution is considered as one of the key problems of urban communities that has numerous hazardous effects on the urban environment and may result in a great deal of costs on the society [1]. Industrial machinery and processes are noise generating media in which their sources include: rotors, stators, fans, vibrating panels, turbulent fluid flow, impact processes, electrical machines, internal combustion engines etc [2]. It was described that the increasing number of vehicles, musical instruments, small scale industries and urbanization also contribute to noise level. Human activities are the main sources of noise pollution [3]. Hence, the term noise refers to a sound without agreeable musical quality, or an unwanted or undesired sound. Noise is no less a pollutant than the toxic chemicals in the environment. As a result of increasing mechanization, the use of increasingly voluminous and complicated machinery, equipment and the stepping up of the pace of production, noise is becoming an increasingly widespread and serious source of discomfort and danger [4]. In an occupational setting, failure or inability to understand the spoken word can compromise worker safety, especially the safety of those in hazardous occupations. Hearing loss may also impair and constrain activities of daily life and personal enjoyment.

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Noise exposure in industry has been a considerable concern with respect to functional impairment arising from noise induced hearing loss (NIHL) and other physiological and psychological effects on exposed workers [5].

The wheat processing factory plays a vital role and contributes largely to the economy of our nation. It can be perceived that man consumes more of fast foods than traditional foods simply because of technological advancement in processing the raw materials. Wheat milling is the science of analyzing, blending, grinding, sifting, and blending a variety of wheat. The miller analyzes the wheat and blends it to meet the requirements of the end users. The wheat grain moves from the bottom of the silo/bin through conveyors to the top floor of the mill where the cleaning process begins. The milling steps involve equipment that separates grains from seeds and other grains, removes foreign materials that might have originated during the farmer's harvest such as metal, sticks, stones and straw; and scours the kernels of wheat. The grain passes through a magnet that removes ferrous metal particles. It will pass through other metal detectors after milling to ensure that no metal pieces are in the finished product. Magnets are also positioned throughout the milling process and at the last step prior to load-out. Air currents act as a vacuum to remove dust and lighter impurities from the product. By gravity, the heavy material will be separated from the light to remove stones that may be the same size as the desired grain. The scourer removes outer husks, dirt in the kernel crease and any smaller impurities with an intense scouring action. Currents of air pull all the loosened materials away. The wheat is then conditioned by adding the precise amount of moisture to toughen the bran and mellow the inner endosperm, the process is termed tempering. This makes the parts of the kernel separate more easily and cleanly. The length of soaking time ranges from 6-24 hours. The time and temperature depend on the type of wheat and its moisture level. The wheat kernels are now ready to be milled into flour. The modern milling process is a gradual reduction of the wheat kernels through a process of grinding and sifting. The millers' skill is analyzing the wheat and blending it to meet the requirements of the end use. Wheat kernels are measured and fed from the tempering bins to the roller mills. The rolls are paired and rotate inward against each other, moving at different speeds to separate the bran, endosperm (starch) and germ [6].

2. Materials and methods

2.1. Study area

The present study was conducted at wheat processing factory in Ilorin located in North-Central of Nigeria. The factory with over 100 employees has production facilities and produces mainly flour, semovita and bran for human and animal consumption.

Noise level measurements

The noise levels were measured between November to January 2014 during working hours. Noise measurement was done in area around machines, in various sections and in offices of the wheat processing factory. The machines that were considered are: rollers, air-lock, magnetic drum, sieve, high pressure blower, turbo sifters, combined-cleaner, and scourer. The sections were flour bagging and stitching section, bran bagging and stitching section, bakery section, and quality control laboratory, while the offices were the maintenance, control room, and production's head office. A portable digital sound level meter HD600 manufactured by Extech Inc., USA, set to the A-weighting scale was used to measure the noise levels. The equipment meets Type 2 requirements of ANSI S1.4 and IEC 61672-1, has dimensions 278 x 76 x 50mm which can be powered by one 9V battery or by an AC power adaptor, and measures and displays the sound pressure level (SPL) from 30dB(A) to 130 dB(A) with ±1.4 dB(A) accuracy in 3 measurement ranges and 0 to 40^{o}C and 10% to 90% relative humidity operating conditions. The equipment was placed at least 1.5 m and 1.0 m above the ground and from the source of noise respectively. The meter was directed toward the nearby noisy source and was calibrated before the start of the study. At the end of the experiment, data were downloaded to a personal computer with the help of utility software packed with the equipment; equivalent sound pressure level and noise spectrum at each reading were obtained. The following measurements all expressed in dB were recorded:

1. Maximum sound pressure level (peak noise) – the noise with the maximum intensity (Lmax).
2. Minimum sound pressure level (baseline noise) – the noise with the minimum intensity (Lmin).
3. A-weighted equivalent continuous level (L_{Aeq}) is given as

$$L_{eq} = 10 \log \sum_{i=t}^{i=n} \left(10^{L_i/10} \right) (t_i) \tag{2.1}$$

where
n the total number of samples taken
L_i = the noise level in dB (A) of the i^{th} sample
T_i = fraction of total sample time.

4. Average Noise level (L_{avg})

$$\overline{L_P} = 20 \log \frac{1}{N} \sum_{j=1}^{N} 10^{L_j/20} . \tag{2.2}$$

On the other hand, subjective assessment was mode during the rest period and it was assessed with personal interviews with each worker separately using a World Health Organization (WHO) standard questionnaire to obtain the workers' response to noise level in all sections of the factory. The questionnaire was filled by each worker under close supervision to avoid any influence on one's results by other subject. Information like demographic information, nature of work, noise annoyance and effects, hearing ability, use of protective devices (e.g. earplugs and earmuffs) were among the questions included in the questionnaire.

3. Results and discussion

3.1. Noise levels

Noise levels were measured from different production sections with different types of machines and in non-production sections. Average, equivalent, minimum and maximum noise levels at different sections in the wheat processing factory are shown in Tab.1. The maximum noise level was measured at the flour bagging and stitching section which was *100.9 dB* (A). This value is above the maximum permitted noise level of *85 dB* (A) described by the National Environmental Standards and Regulations Enforcement agency NESREA (2009) [7]. The flour bagging and stitching section houses automated packing and stitching machines with personnel working in the section. It was also found that workers working within the floors where there are air locks, magnetic drums, high pressure blowers, scourers, sieves, turbo sifters, rollers and combined-cleaner are exposed to noise levels well above the threshold of *85 dB*(A). The minimum noise level was *56 dB* (A), measured in the uppermost floor. In addition, the results further demonstrated that workers in the maintenance office, quality control laboratory, production's office, bakery section, bran bagging and stitching section, and control room are less exposed to noise where the average noise values in these sections were below *80 dB*(A). The graphs of noise level around the machines, in various sections and offices are presented in the appendix.

Table 4.0: Noise levels around machines in various sections and offices.

Machines/sections/offices	L_{max} dB (A)	L_{min} dB (A)	L_{Aeq} dB (A)	L_{avg} dB(A)	% > 85dB
Magnetic drum	*89.6*	*84.9*	*88.45*	*88.41*	*99.4*
Air-lock	*96.8*	*63*	*94.60*	*94.53*	*96.1*
Rollers	*92.9*	*83.9*	*89.13*	*89.07*	*86.4*
High pressure blower	*99.4*	*56*	*93.42*	*92.59*	*75.4*
Sieve	*85.6*	*58.7*	*78.21*	*75.93*	*3.6*
Combined-cleaner	*90.5*	*56.4*	*84.81*	*82.70*	*44.0*
Scourer	*91.9*	*83.7*	*87.73*	*87.50*	*90.7*
Turbo sifter	*85*	*79.2*	*82.38*	*82.34*	*0*
Flour bagging and stitching section	*100.9*	*72*	*85.49*	*82.18*	*10.3*
Bran bagging and stitching section	*81.7*	*73*	*78.74*	*78.47*	*0*
Quality control laboratory	*73.6*	*58.7*	*64.72*	*63.73*	*0*
Bakery section	*74.5*	*61.4*	*66.49*	*65.87*	*0*
Maintenance office	*82.5*	*66.9*	*71.54*	*70.42*	*0*
Production's head office	*70.9*	*59.9*	*61.95*	*61.66*	*0*
Control room	*80*	*66.1*	*70.65*	*69.61*	*0*

3.2. Workers response to noise pollution

Table 2 shows the socio-demographic characteristics and frequency distribution of workers at the wheat processing factory. The assessments showed that about *61.9* % of workers were of age range 18-35 years whereas about *23.8* % were above 35 years, while *14.3* % did not specify. Of the workers, *43* % were in production section, *9.5* % were in maintenance, bagging and stitching section, quality control laboratory, and gave no response, while *19* % were in the bakery section.

Table 2: Socio-demographic characteristics of workers at the wheat processing factory.

Section	Task at section	No.	Percentage	Age group(years)	No.	Percentage
Production	Milling of the raw materials	9	*43*	18-35	13	*61.9*
Maintenance	Maintenance of the machinery	2	*9.5*	35 and above	5	*23.8*
Bagging and Stitching section	Packaging of the products	2	*9.5*	Unspecified	3	*14.3*
Quality Control	Analysis and test of the products at various points	2	*9.5*			
Bakery	Baking of the products	4	*19*			
Unspecified		2	*9.5*			
Total		21	*100*		21	*100*

Source: WHO (2004) [8]

Table 3 shows comments among workers at the wheat processing factory on impacts of noise and use of hearing protectors. The results show that *71.4* % of respondents experience speech interference about one meter away while *28.6* % did not experience it. *47.6* % noticed a reduction in hearing over the course of

the day while *52.4* % did not. The workers experience ringing in the ears, i.e., tinnitus (*38.1* %), the same sound having a different tone in each ear, i.e., diplacusis (*61.9* %), blurred hearing (*38.1* %), nervous and annoyance (*14.3* %), long term hearing problem (*14.3* %) and heaviness in ear at the end of work shift (*14.3* %). The hearing capacity of workers over phone was also surveyed where *61.9* % reported that voice is being raised when talking on phones both at work place and home. Also, *85.7* % of the workers responded that audiometric test have not been carried out. However, it was reported that some equipment has manufacturer noise information that indicates noise levels equal or greater than *80* dB(A) L_{Aeq} (*47.6* %), *130* dB(A) peak noise level (*19* %), *88* dB(A) sound power level (*52.4* %). Also *61.9* % expressed that noise in some parts of the workplace sound as loud as or louder than *85* dB(A). On the other hand, it was found that personal hearing protectors such as earplugs or muffs or canal caps were provided and *76.2* % use them while at work. Some of workers (*23.8* %) did not use them mainly because of dislike and may cause lack of concentration during work. Therefore, these assessments showed that most workers are aware of health effects that can be caused by noise and the importance of using personal hearing protectors.

Table 3. Effects of noise and use of hearing protectors.

Characteristics	Respondents	Percentage %
Is a raised voice needed to communicate with someone?		
Yes	15	*71.4*
No	6	*28.6*
No Response	-	-
Do people working in the area notice a reduction in hearing over the course of the day?		
Yes	10	*47.6*
No	11	*52.4*
No Response	-	-
Do employees experience ringing in ears (tinnitus)		
Yes	8	*38.1*
No	13	*61.9*
No Response	-	-
Do employees experience the same sound having a different tone in each ear (Diplacusis)?		
Yes	13	*61.9*
No	7	*33.3*
No Response	1	*4.8*
Do employees experience blurred hearing?	-	-
Yes	8	*38.1*
No	13	*61.9*
No Response	-	-
Are any long term employees having hearing problems?		
Yes	3	*14.3*
No	18	*85.7*
No Response	-	-
Are personal hearing protectors provided?		
Yes	21	*100*
No	-	-
No Response	-	-
Are you using personal hearing protectors?		
Yes	16	*76.2*
No	5	*23.8*

No Response	-	-
Does any equipment have manufacturer's noise information (including labels) that indicates noise levels equal or greater than 80dB(A) L_{Aeq}		
Yes	10	*47.6*
No	11	*52.4*
No Response	-	-
Does any equipment have manufacturer's noise information (including labels) that indicates noise levels equal or greater than 130 dB(A) peak noise level?		
Yes	4	*19*
No	17	*81*
No Response	-	-
Does any equipment have manufacturer's noise information (including labels) that indicates noise levels equal or greater than 88 dB(A) sound power level?		
Yes	11	*52.4*
No	10	*47.6*
No Response	-	-
Have you done an audiometric test before?		
Yes	3	*14.3*
No	18	*85.7*
No Response	-	-
If yes, has the result indicated that past or present employees have hearing loss?		
Yes	3	*14.3*
No	18	*85.7*
No Response	-	-
Does the noise in any part of the workplace sound as loud as or louder than 85dB?		
Yes	13	*61.9*
No	4	*19.05*
No Response	4	*19.05*
Do you feel your voice is being raised when talking on phones when you are both at workplace and home?		
Yes	13	*61.9*
No	8	*38.1*
No Response	-	-
Do you feel nervous and annoyed without any reasons at times?		
Yes	3	*14.3*
No	18	*85.7*
No Response	-	-
Do you feel heaviness and ringing in your ear at the end of work shift?		
Yes	3	*14.3*
No	18	*85.7*
No Response	-	-

Source: Code of practice (2002) [9]

3.3. Comparison with other studies

The results from the present study at the wheat processing factory on noise levels and workers response to impacts of noise in the workplace are comparable to those reported in other studies (Boateng and Amedofu [10], Prasanna Kumar *et al*. [11], Mohammadi *et al*. [12], Mndeme and Mkoma [13], Mijinyawan *et al*. [14]). Previous studies carried out by researchers in other factories confirmed that there is an increase in noise levels in the workplaces of various factories.

Boateng and Amedofu [10] conducted a survey on noise levels in saw mills, corn mills and printing houses so as to determine the impacts of noise levels on hearing capabilities of workers in such working settings. The results showed that noise level in corn mills exceed the limiting value of *85* dBA as recommended by NESREA [7]. It was also found that *23*%, *20*% and *7.9*% of workers in corn mills, saw mills and the printing industry have evidence of noise induced hearing loss which were well correlated with noise exposure level and duration of exposure. Prasanna Kumar *et al*. [11] conducted studies in three oil mills in north-eastern region of India. The result showed that the workers engaged in the workrooms of the oil mills are exposed to high noise, which will have a detrimental effect on their health. The poor maintenance of the drive system was found to be the main reason for high noise level. Another study by Mohammadi *et al*. [12] was conducted in a textile factory in Iran to determine the risk assessment of workers exposed to noise pollution and reported that hearing loss is not the only problem caused by occupational noise besides that other physiological and even psychological effects of noise must be considered which can affect workers performance. Tanga, Tanzania, Mndeme and Mkoma [13] assessed the work zone noise level at a cement factory. It was showed that the measured noise levels were found to be higher than WHO acceptable limit in some production sections. Workers exposed to noise above *85* dBA will eventually develop hearing loss and workers are aware of this hazard. Mijinyawan *et al*. [14] studied the assessment of noise levels generated in some feed mills in Ibadan, Nigeria. The result indicated that the noise levels and exposure periods in many of the mills were above the code specification indicative of threat to employees' health.

4. Conclusion

This study revealed that the noise levels in some points in the wheat processing factory are well above the standard limit of exposure of *85* dB. Workers exposed to noise above *85* dB will eventually develop hearing loss and workers are aware of this hazard.

Noise should be seen as a nuisance that constitutes health hazard to the recipients and on this basis, some control measures that include the following should be adopted:

The wall acoustic of the factory should be upgraded to absorb sound emanating from the machines. The speed of rotating and moving parts in machines and mechanical systems should be reduced. Absorbing materials should be introduced. Workers should be subjected to hearing tests and other tests periodically. Noise suppressing features should be working and maintained properly and as a last resort, Class-4 hearing protectors should be worn by workers in noisy sections such as the flour bagging and stitching section, air-lock, rollers, etc.

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APPENDIX

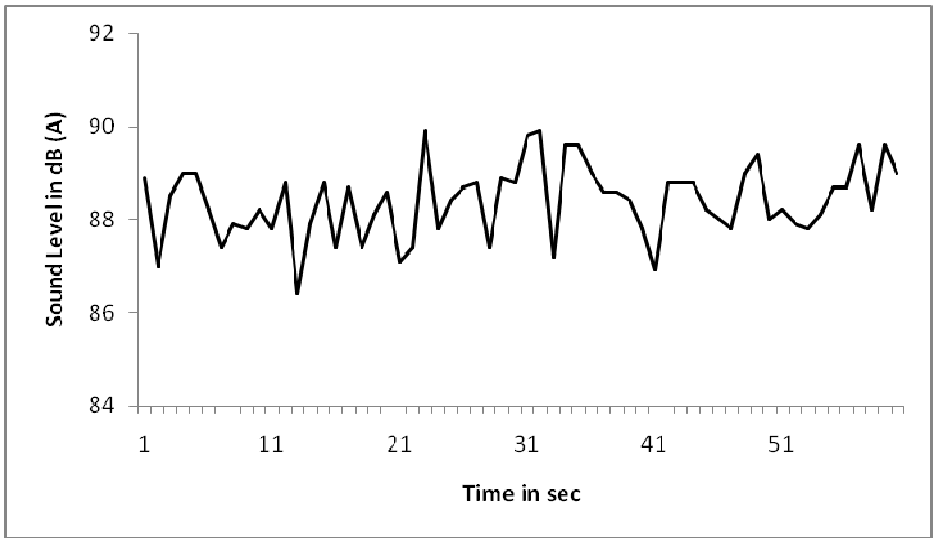

Fig.4.0. Sound level readings around the magnetic drum.

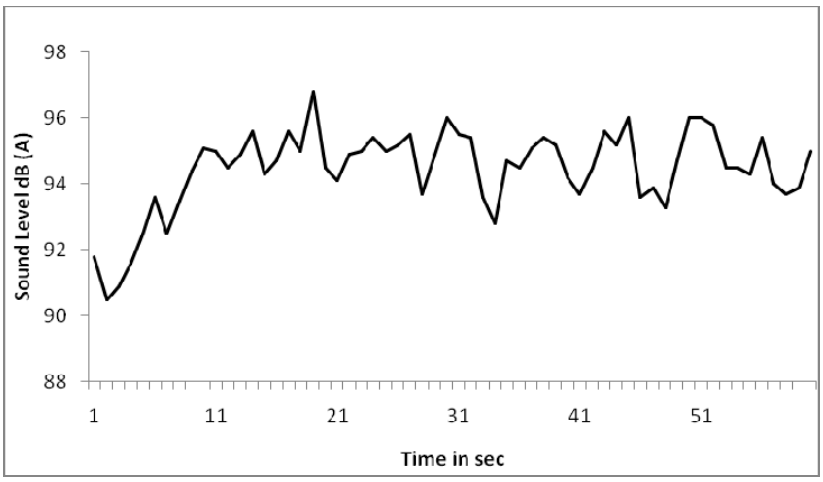

Fig.4.1. Sound level around the airlock.

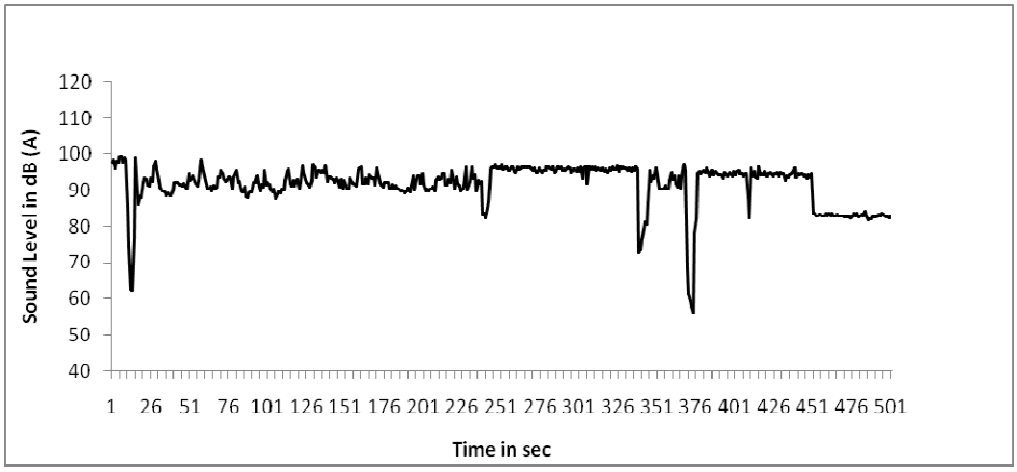

Fig.4.2. Noise level around the high pressure blower.

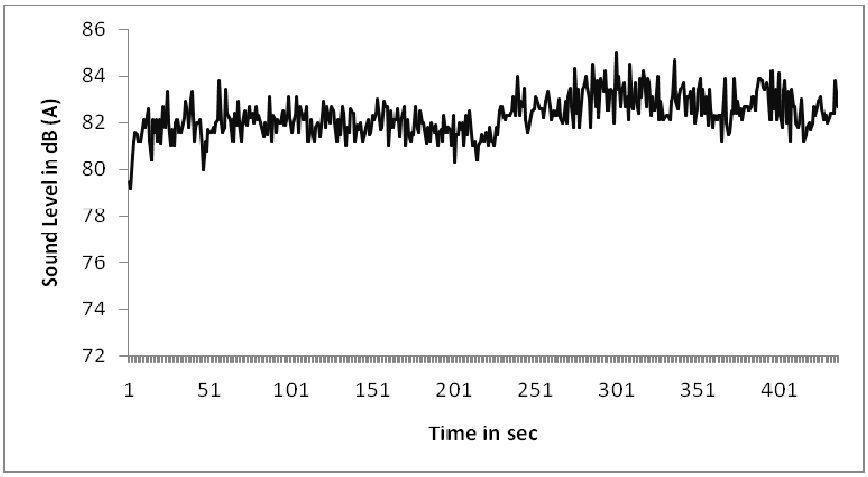

Fig.4.3. Sound level around the turbosifter.

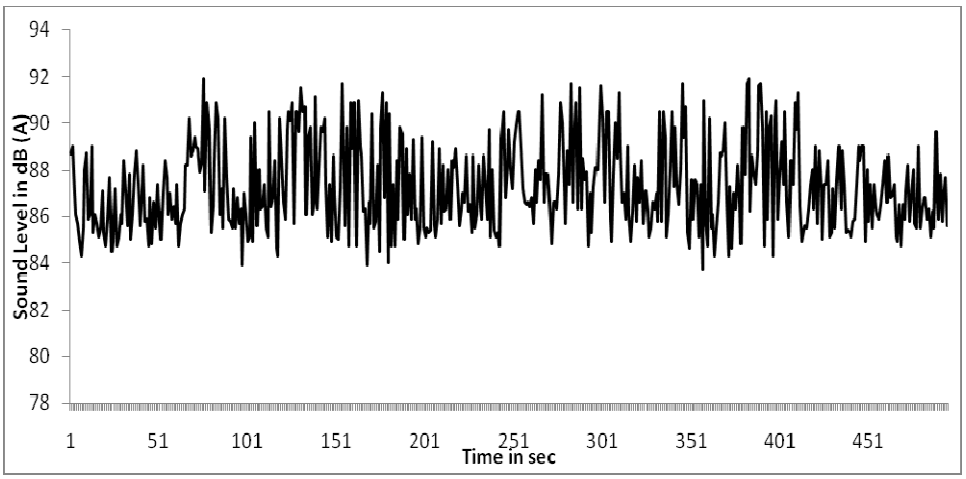

Fig.4.4. Sound level around the scourer.

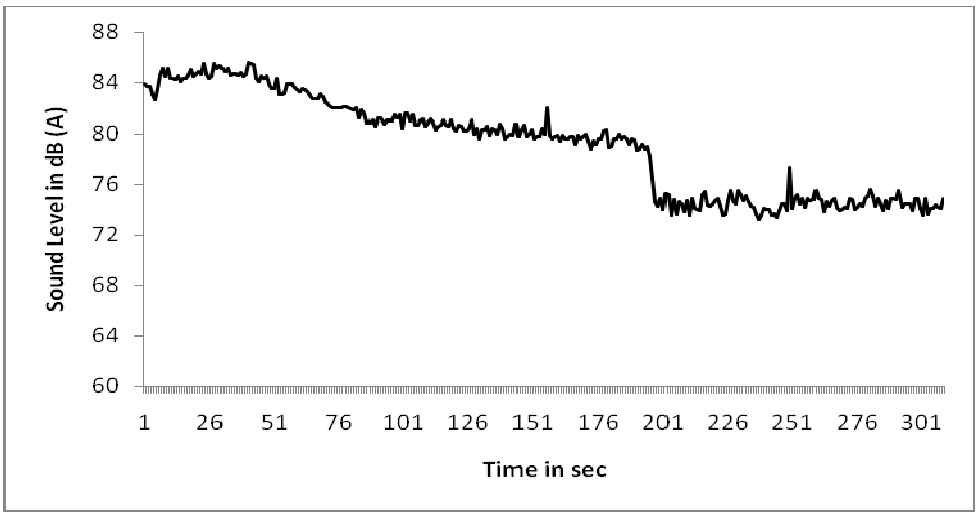

Fig 4.5 Sound level around the sieve.

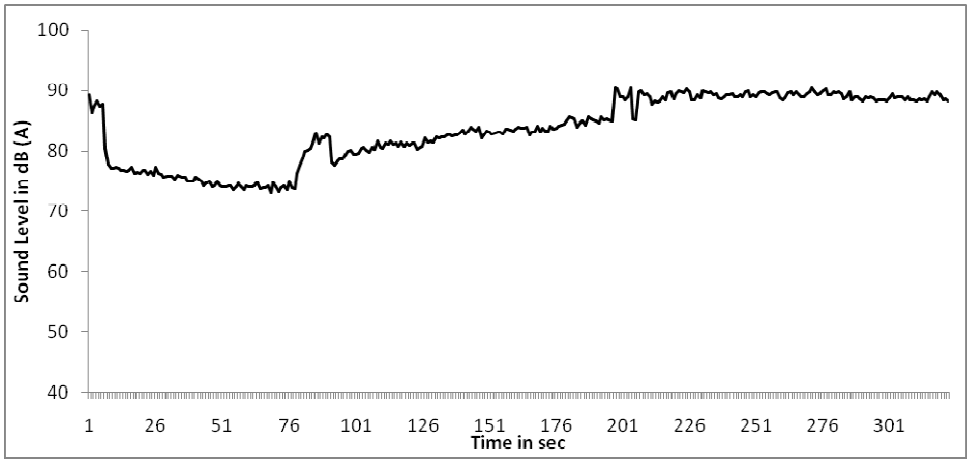

Fig 4.6 Sound level around the combi-cleaner.

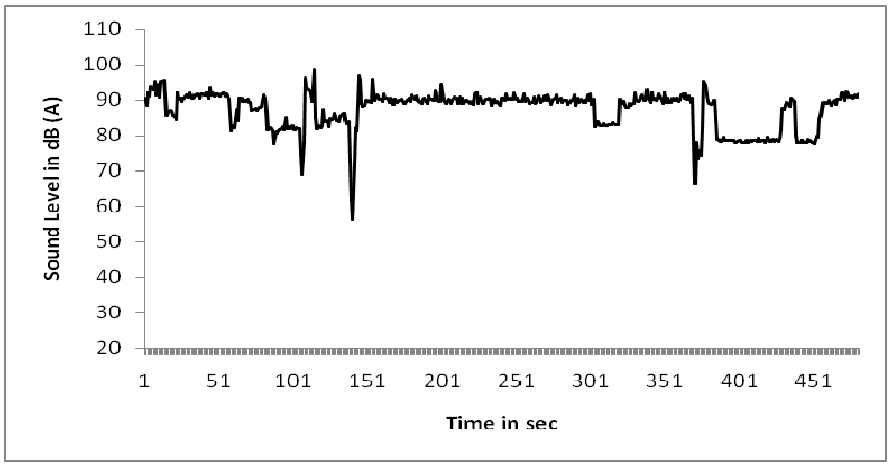

Fig 4.7 Sound level around the roller mill.

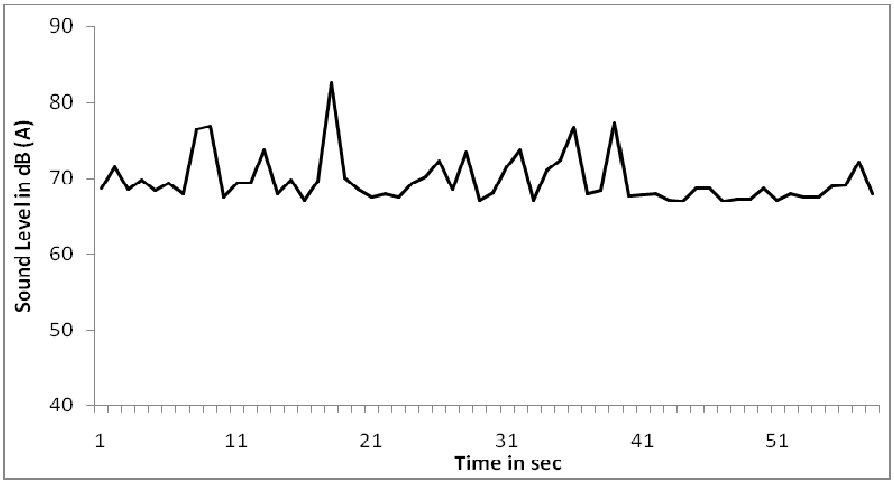

Fig 4.8 Sound level in the maintenance section.

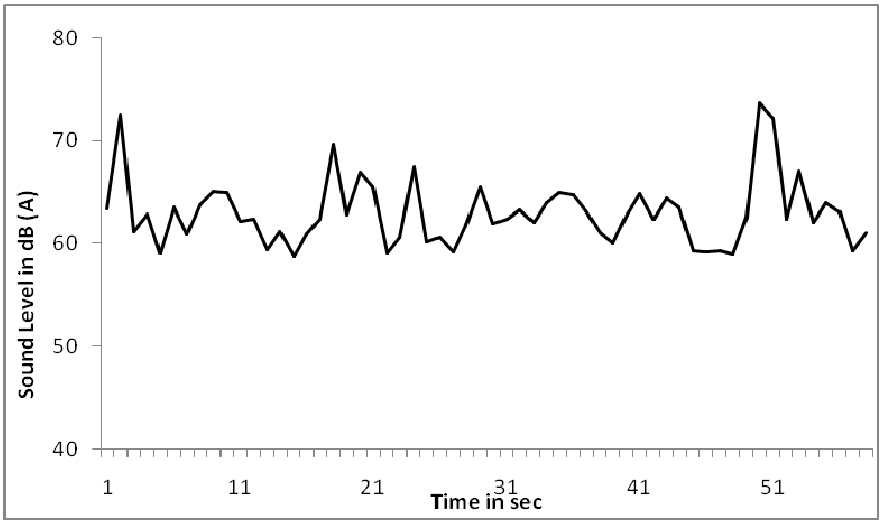

Fig 4.9 Sound level in Quality Control Laboratory.

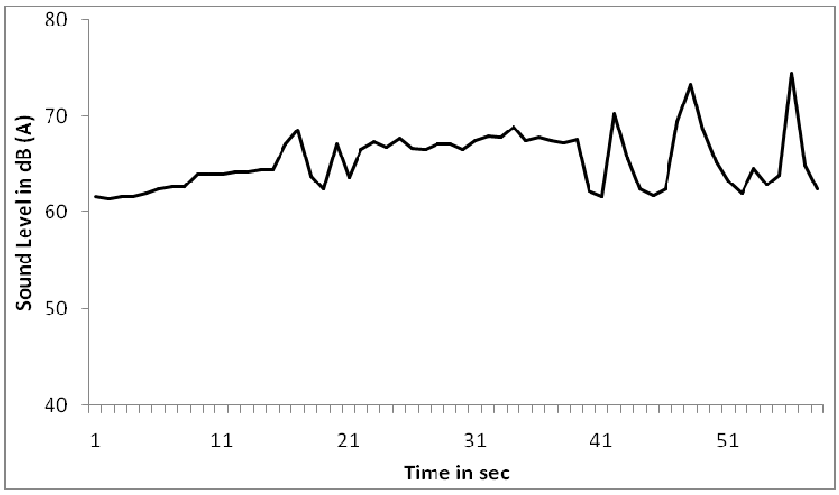

Fig 4.10 Sound level in the Bakery section.

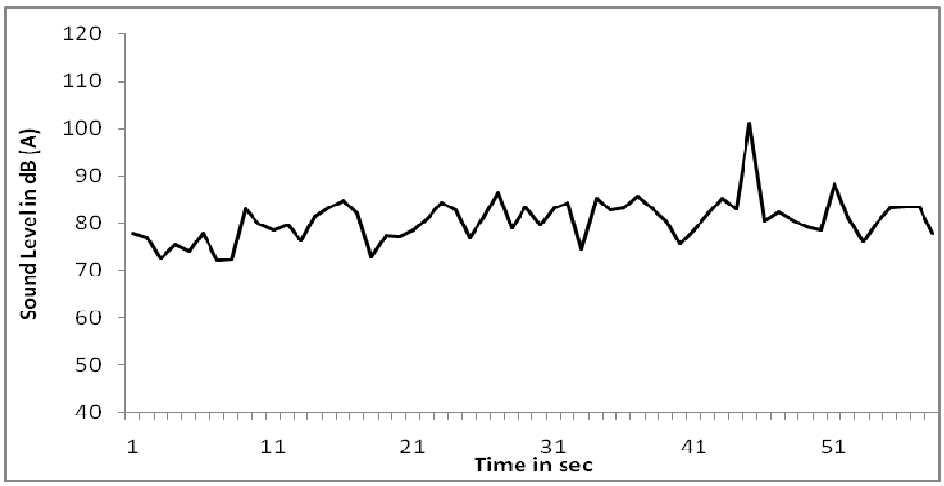

Fig 4.11 Sound level in the Flour Bagging and Stitching section.

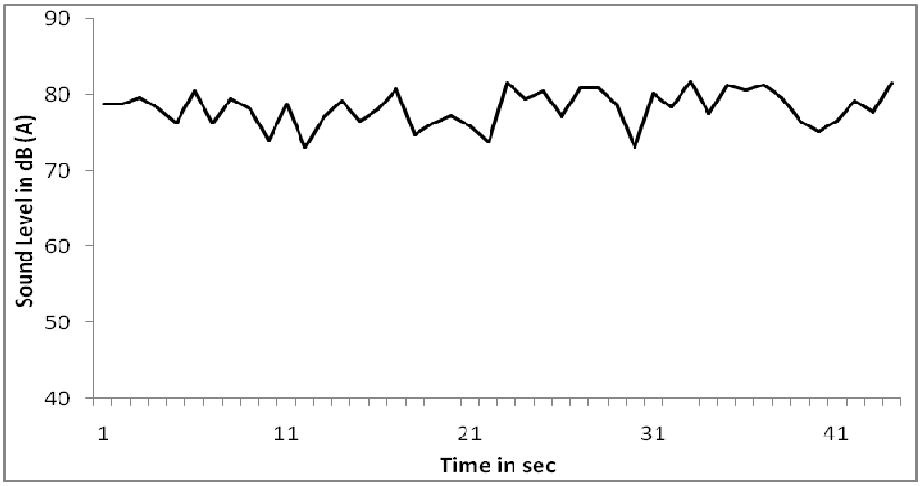

Fig 4.12 Sound level in the Bran Bagging and Stitching section.

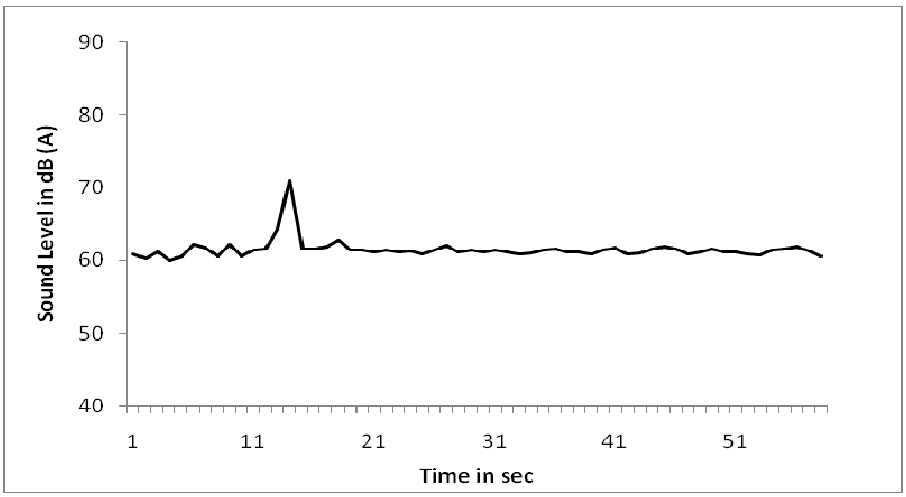

Fig 4.13 Sound level in the Production sectional head's office.

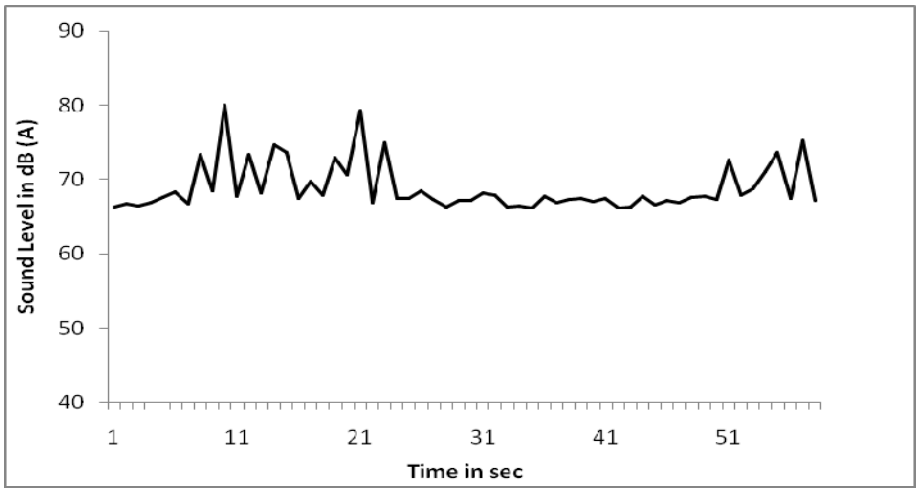

Fig 4.14 Sound level in the Control Room.

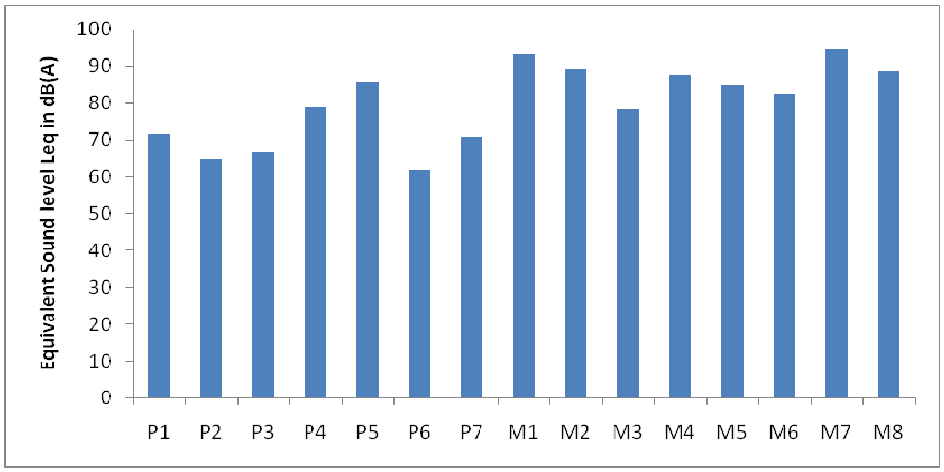

Fig 4.15 Equivalent Noise level at various points of measurement.