



An Assessment of Occupational Noise Levels in a Plastic Manufacturing Industry in Zimbabwe

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Authors' contributions

This work was carried out in collaboration between both authors. Authors JT and DVP designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author JT managed the literature searches and author VPD managed the analyses of the data. Both authors read and approved the final manuscript.

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ABSTRACT

The aim of the study was to assess occupational noise levels in a plastic manufacturing industry in Zimbabwe between April 2014 and July 2014. The research followed an experimental design set up. Three sites were selected (1, 2 and 3) and each site had three sampling points randomly selected where the measurements were done. One out of two workers per site (three sites in total) was chosen and occupational noise levels were measured using a sound level meter which was calibrated. Measurements were done at hourly intervals for 8 hours. These were done for five days a week during the three weeks per month for a total period of three months. In order to determine the Time Weighted Average (TWA), a formula was used for the calculations. Results showed that the average noise levels ranged from 89–96 dBA among the study sites. Results from ANOVA showed that there was no significant difference in the TWAs among the sites ($F=1.67$; $df=2$ and 126 ; $P=.19$), among the workers ($F=.17$; $df=2$ and 126 ; $P=.54$) and the interaction of site and worker ($F=1.67$; $df=4$ and 126 ; $P=.16$). The one sample t-test for comparison of the 8hr TWA noise levels with the national and International standards showed that the mean TWA was significantly higher than the Zimbabwean standard by a mean difference of 3 dBA ($t=15.79$; $df=134$; $P<.0001$). The mean TWA was also significantly higher than the International standard by 8 dBA ($t=41.53$; $df=134$;

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$P < .0001$). The present findings suggest that the noise levels in the plastic manufacturing industry under study were high in all the three sites. Workers are exposed to noise levels which are above the international legislated occupational level.

Keywords: Occupational noise; Time Weighted Average (TWA); plastic industry; noise level.

1. INTRODUCTION

Noise is present in every human activity and can be classified as either occupational noise (noise in workplace) or environmental noise, which includes noise in all other settings, whether at the community, residential and domestic level (for example traffic, playgrounds, sports, music) [1,2]. Exposure to excessive occupational noise is common in a great variety of many industrial processes [3,4]. In the US alone approximately 11 million people are exposed to hazardous noise levels at the work place and in Sweden it is 9% of the total workforce who are exposed to this potentially hazardous noise level [3,4,5]. Continuous exposure to noise levels in the range 85-90 dB(A) over a long period of time for example in a lifetime can lead to a progressive loss of hearing which is commonly referred to as Noise Induced Hearing Loss (NIHL) [2,3,6,7,8]. Over the past decade, over 275 million people globally with the majority (80%) from low to middle income countries had moderate to profound hearing impairment [3]. To date few studies have been carried out to investigate occupational hazards such as noise levels in the workplace in Zimbabwe. Summary statistics on noise exposure are not available for most countries and of the 17 studies carried out; 12 countries were reported to have high occupational noise exposure levels [4].

In occupational safety and health (O.S.H), the most widely used expressions when assessing the impact of occupational noise exposure levels on employee's health and well being is the noise dose level per worker and the total weighted averages (TWAs) [5]. The noise dose level per worker denotes the amount of noise that reaches the workers ear per unit time measured using a sound level meter (SLM) whilst the TWAs indicate the workers exposure to occupational noise normalized to an eight hour work shift taking into account the average noise dose levels and the time spent in each area [9]. Occupational or workplace noise exposure is within the top five

pervasive global occupational health and safety hazards and has considerable adverse effects both at individual and organizational level [6,7,10,11,12,13]. Workplace noise exposure also works synergistically with other hazards (such as dangerous substances and extreme working temperature), and can have an additive effects on workers' health and well being, productivity levels and safety performance [8,14]. Monitoring of occupational noise exposure levels in the developing countries has been poorly practiced [10]. Most of the organizations in the developing nations rely on reactive approaches after incidents or recorded illnesses [15,16]. The reason behind this is that most developing countries fail to appreciate the negative impact of occupational noise exposure on employees' productivity levels and safety performance [15,16]. In Zimbabwe, most noise monitoring exercises by the regulatory authorities (NSSA) cover mainly major manufacturing industries such as mining and aircraft yet occupational noise exposure can be an issue in a great variety of industrial processes [17].

The plastic industry, though it has the potential to generate elevated noise levels that may endanger workers' hearing has been overlooked in terms of occupational noise exposure assessments. Few studies to date have been carried out in this area. Noise in the plastic industry, is more pronounced in the plastic recycling processes originating from the simultaneous running of diverse machinery such as drop hammers, pneumatic chippers and grinders. One major problem that has hindered the success of the noise control measures in this industry is that the occupational noise exposure baseline data is not known. Prior to this present study, no known attempts if any have been made to quantify the noise exposure levels in the plastic industry. This study hence seeks to assess the occupational noise exposure levels in plastic recycling facilities and to gather baseline information for further studies.

2. METHODOLOGY

Three sites from a plastic recycling industry were selected. These sites were labeled 1, 2 and 3 which also represented the liquid injection moulding (LIM), Blow and PET factories respectively. Three sampling points were then randomly selected at each site and at these sites, noise level measurements were done. Each site had two workers, the machine operator and the assistant. Out of the two workers per site, only one worker was randomly chosen and the probability of being chosen or not was half. Three workers were then selected for the noise level exposure measurement. The personal or occupational noise dose levels were measured using the Quest noise sound level meter “model SOUNDPRO SP-DL-1/3”. When sound levels fluctuate in time, which is often the case with occupational noise, the equivalent sound level is determined over a specific time of period. The A weighted sound level is averaged over a period of time (T) and is designated by $L_{Aeq,T}$. A common exposure period, T, in occupational studies and regulations is 8 hr, and the parameter is designated by the symbol, $L_{Aeq,8h}$. The sound level meter was calibrated to the recommended 93.8 dB (A) using the 4230 Bruel and Kjaer and the Quest technologies Calibrator for reproducibility of results and accuracy [18]. The noise sound levels were measured at one hour interval per each worker throughout the eight hours work shift from 0830-1530hrs. The measurements were done for a period of three weeks per month for five days a week and this was carried out for three months. The noise sound levels were then averaged in order to obtain the average noise level at one machine and over a day. Time Weighted Averages were calculated using the formula according [18]:

$$TWA = (t_1c_1 + t_2c_2 + \dots + t_n c_n) / (t_1 + t_2 + \dots + t_n)$$

Where

c_i = concentration during the i^{th} interval and
 t_i = duration of the i^{th} interval

Data were analyzed using an Analysis of Variance (ANOVA) to test for mean 8hr TWAs levels of noise among the three sites, workers and between the sites and the workers. One sample t-test was used to test the mean 8hr TWAs noise levels for the sites against Zimbabwean standards and International standards. All tests were carried out at 95% level

of significance within the statistical package SPSS version 21.

3. RESULTS AND DISCUSSION

The noise levels ranged from 89 – 96 dBA among the study sites (Table 1). These noise levels were higher than the ones obtained in a study in Taiwan in a chemical manufacturing industry, where average noise levels ranged from 70 - 85 dBA, however their study sites included the administrative offices and these had the least noise levels [8]. In Ghana a study was carried out to assess noise level in four manufacturing industries and the plastic manufacturing industry recorded a minimum of 90.2 dB and a maximum of 97.2dB. The noise level was measured at the compressor and the workers were exposed for an average of 8 hours per day [10]. The results are in agreement with the ones obtained in this study and this could be attributed to the fact that Ghana and Zimbabwe are both developing countries with little advancement in technology. Contrary to these results, a study in New Zealand revealed most noise lies in the range 85 - 90 dBA. Some industries produce noise exposures of up to 100 dBA and these account for very few of occupations exposed in excess of these levels [19].

Results from ANOVA showed that there was no significant difference in the TWAs among the sites ($F=1.67$; $df=2$ and 126 ; $P=.19$), among the workers ($F=.17$; $df=2$ and 126 ; $P=.54$) and the interaction of site and worker ($F=1.67$; $df=4$ and 126 ; $P=.16$). This finding indicates that the three recycling facilities produce almost the same noise levels. This can be attributed to the fact that there are two machines (the chipper and the pelletizer) in each recycling facility which are placed parallel to each other. As they work simultaneously, the worker is continuously exposed to the two noise emission sources. However, since the noise levels are above the permissible exposure limits, the associated workers in the plastic recycling facilities are at risk of developing noise exposure related disabilities such as, tinnitus temporary threshold shift (TTS), standard threshold shift (STS) and finally occupational noise induced hearing loss (ONIHL). This is supported by [16] who articulated that noise levels ≥ 72 dB is of great concern to the safety and health of the employees. The actual ear damage due to occupational noise exposure starts at 75 dB, therefore, there is need to monitor and control noise levels at this range.

The one sample t-test for comparison of the 8hr TWA noise levels with the national and International standards showed that the mean TWA was significantly higher than the Zimbabwean standard by a mean difference of 3 dBA ($t=15,79$; $df=134$; $P<.0001$). The mean TWA was also significantly higher than the International standard by 8 dBA ($t=41.53$; $df=134$; $P<.0001$). Noise levels were all above the international standards of 85 dBA according to the American Conference on Governmental Industrial Hygienists (ACGIH) and very few measurements were within the allowed exposure limits of 90 dBA according to the national regulatory limits [7,20,21,22] (Fig. 1).

These results are similar to a study carried out in two plants in Saudi Arabia. Noise levels ranged between 72.0 and 102 dBA and exceeded the 85 dBA regulatory standard adopted in Saudi Arabia in four fifths of the departments in the two factories [3]. In Iran a study in tile and ceramic industry reported that most workers were exposed to noise levels higher than 85 dBA [7]. This also applies to Korea where more than 90% of all workplaces exceeded the noise exposure limit in 2010 [2]. Similarly in Serbia 40% of the machines in printing companies produced noise levels above the limiting threshold level of 85 dBA [5].

Table 1. 8hr TWAs noise levels for the different sites and workers

Site	Worker	Mean (dBA)	+SD
1	A	94	2.02
	B	93	1.49
	C	93	1.96
2	A	93	2.24
	B	93	1.83
	C	92	3.17
3	A	92	2.26
	B	94	2.42
	C	93	2.29

*Assumptions have been met i.e. normality and equality of variances (Refer to Fig. 2a and 2b)

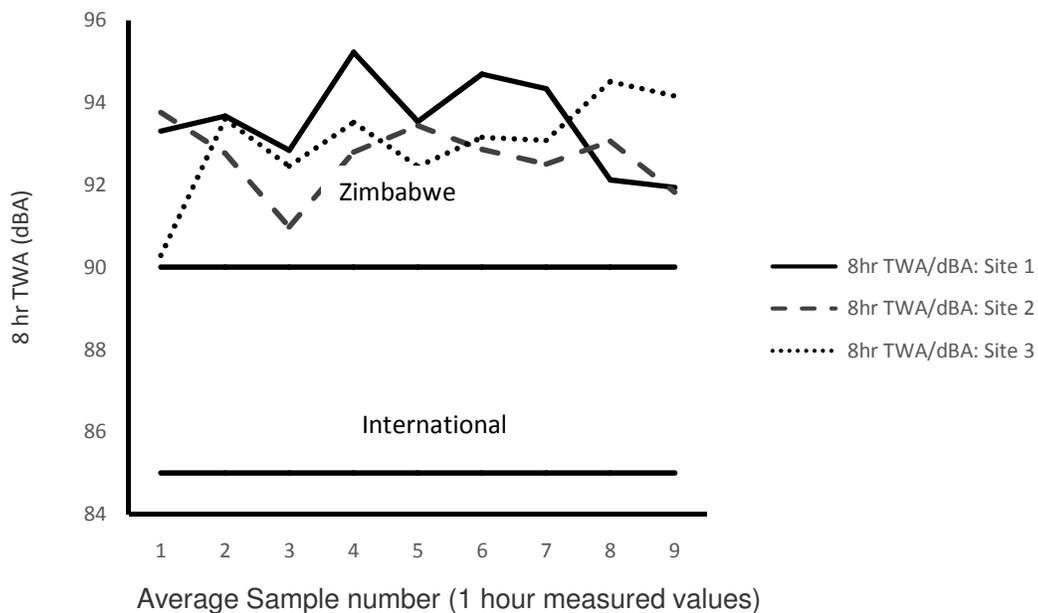


Fig. 1. Comparison of the noise levels with the national and international standards

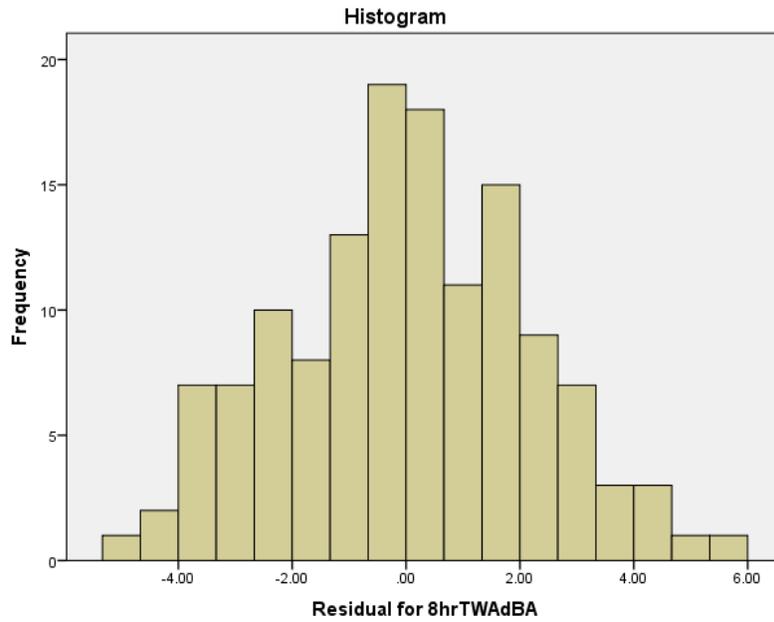


Fig. 2a. Histogram for residuals

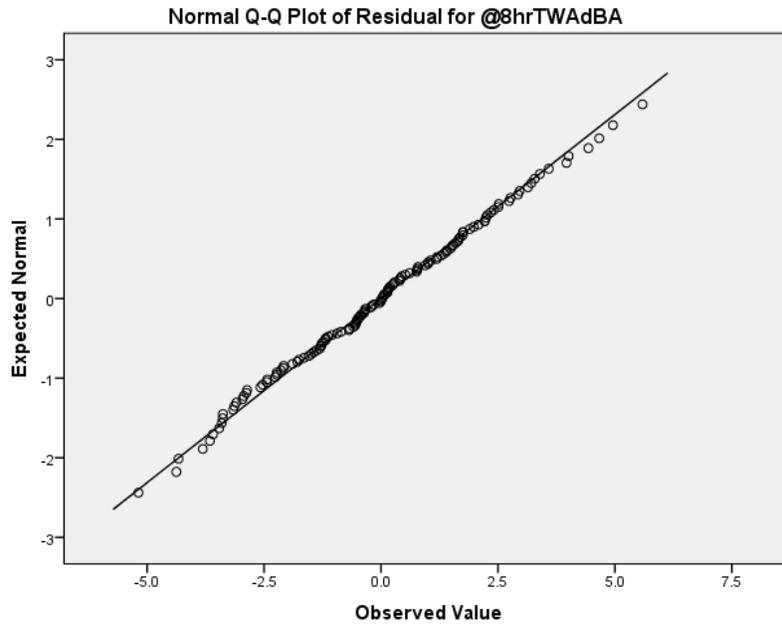


Fig. 2b. Normal Q-Q plot for the residuals

A similar study conducted in South African mining industry showed that 70% of the workers were exposed to noise exposures exceeding the legislated Occupational Exposure Level (OEL) of 85 dBA. The highest overexposure levels

occurred in the underground gold mining with an average of 90.4 dBA in an 8-hour working shift [9]. Considering that a mining industry produces the most noise due to the heavy machinery as compared to the plastic manufacturing industry

several factors may be attributed to the unexpected high noise levels. The high noise levels might have also been influenced by the lack of maintenance on the machines. A study in metal fabrication facilities in Australia revealed that machine maintenance and occupational noise exposure levels are correlated [23]. The conclusion was that lack of maintenance on machines such as loose bolts and lubrication may significantly increase the amount of sound pressure levels that may in turn affect the personal noise dose levels of the associated workers [23]. Literature also points out to the importance of maintenance of machines and engineering controls so as to reduce noise levels produced [3,4,9,10,24].

4. CONCLUSION

The present findings suggest that the noise levels in the plastic manufacturing industry under study were high in all the three sites. Workers are exposed to noise levels which are above the international legislated occupational level and 10% of the measurements were within the regulated national permissible exposure limit.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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