

Evaluation of noise pollution and the efficiency of workers' personal protective equipment in a plastic manufacturing factory in Birjand city

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Abstract

Background: Disturbing noise in a workplace is one of the main harmful occupational factors which has irreparable consequences for the health of workers. Technical evaluation of this problem opens the way to take precautionary measures in order to protect the health of workers, who constitute the main capital of each country. This study was conducted to evaluate noise pollution and the efficiency of personal protective equipment in the workers of a plastic manufacturing factory in Birjand city.

Methods: In this descriptive cross-sectional study, noise measurements were performed through stationing method using the sound-sensor analyzer, TES 1358A model, in 27 stations, and indicators of exposure level for workers and interference level in conversation were calculated using relevant relations. Also, the efficiency of workers' protective earmuffs was investigated by octave-band method. Finally, the data were analyzed in SPSS software using t-test. The significant level was set at $P \leq 0.05$.

Results: In the production hall, the mean and the standard deviation of the noise intensity level was 83.9 ± 3.03 dB and it was 88 ± 3.06 dB in the mill, showing that 47.6% of the stations in the production hall and 83.3% of the stations in the mill had a noise intensity level higher than the limit. The mean and the standard deviation of the workers' exposure level was 85.7 ± 2.8 dB, which in 71.43% of cases, it was more than the limit. The efficiency of the workers' protective earmuffs was acceptable at frequencies of 1000, 2000, 4000 and 8000 Hz with a significant decrease in the noise intensity level at these frequencies ($P=0.001$). However, their efficiency was not acceptable at 250 and 500 Hz. The interference level in conversation was 61.3 dB in the production line and 85.5 dB in the mill.

Conclusions: In some sections of the production hall and the milling hall of the studied factory, the noise intensity level and the 8-hour exposure level of the workers are higher than occupational limits, which indicates that noise pollution is one of the problems of the factory that needs to be addressed via controlling methods. Also, the examination of the efficiency of the workers' protective earmuffs indicates that these earmuffs are not efficient at frequencies of 250 and 500 Hz, and based on the results of the factory's noise measurement, the workers should be provided with appropriate protective earmuffs.

Keywords: Noise pollution; Plastic containers; Protective earmuffs

1. Introduction

In the modern era, the advancement of technology in all industrial fields has led to the rapid expansion and application of various equipment and machinery. This growth has caused increased vulnerability of the people in their occupational and everyday life to sounds with varying degrees of intensity, which threatens – in its extremity known as noise pollution – the health and the well-being of

the individuals (1, 2). The occurrence of different physical complications such as hearing impairment, cardiovascular complications, and psychological complications are among the major complications caused by the exposure to excessive noise, which has been mentioned in many studies. Hearing loss due to noise is the main complication of exposure to noise, which should be taken into consideration. Exposure to high-intensity noise causes

temporary hearing loss which is of sensory-neurotic type and usually disappears after 24 hours; however, the continuation of the exposure may lead to the individual's permanent hearing loss.

Hearing loss in the form of the permanent change in the threshold of sensory perception due to continuous exposure to the beyond-limit noise is first observed typically at the frequency of 4000 Hz in the audiogram, and gradually, if the exposure is not stopped, it not only increases at this frequency but also involves other frequencies too. Long exposure to noise can often affect the spiral organ of in the inner ear, causing permanent loss of hearing. The hairy cells in the spiral organ are sensitive to the various amplitudes of ambient sound, and their cellular bodies become swollen when exposed to high sound waves and eventually degraded. Combinations of mechanical, metabolic and vascular factors are involved in degenerative changes that reduce hearing due to noise. These changes are initially reversible and will be improved in the passage of time by the interruption of the exposure; but continued exposure to high-frequency and high- amplitudes sounds leads to the loss of sensory hairs; and changes at this stage are irreversible (3-12). Prevention of hearing impairment is beneficial to the employer as much as it is useful to the worker, as employers benefit from the reduction of medical costs as well as from avoiding compensating the worker. In our country, which is considered a developing country, noise is regarded as one of the main problems in the workplaces. According to the studies carried out in this regard, hearing loss is greater among the workers in developing countries. Also, according to the statistics, about 16% of hearing losses are occupational, indicating the necessity of paying attention to the issue of noise in workplaces. (8, 13, 14).

In addition to the harmful effects on hearing, noise pollution in the workplace causes reduced concentration, increased number of mistakes, and decreased speed of work, especially in complex occupations that are important in terms of safety. In fact, noise control is one of the ways that reduces accidents and increases productivity (15). Prevention of adverse complications of noise in work environments requires the technical examination of noise in different industrial environments and the provision of appropriate controlling solutions. Taking this into consideration and with respect to the fact that in the process of manufacturing plastic containers, the activity of different

devices produces noise pollution that could potentially threaten the health of workers, this study aims to evaluate noise pollution and the efficiency of personal protective equipment of the workers in a plastic manufacturing.

2. Methods

This study was a cross-sectional descriptive study in which the plan of the production hall and the milling hall were prepared. According to the area of the halls, gridding was carried out in the dimensions of 1 × 1 m. There were 30 stations in the production hall and 20 stations in the milling hall. Given the fact that a major part of the halls was occupied by the devices, the measurement of noise in the production hall was performed at 21 stations and the measurement of noise in the milling hall was performed at 6 stations by using a regular network method in the network A at SLOW speed at the height of the workers' hearing area at a temperature of 33 °C in the production hall and 28° C in the milling hall with the sound-sensor analyzer TES 1358A model. The indexes of the workers' exposure level was calculated using the equation

$$L_{eq} = 10 \log \left[\frac{1}{T} \sum_{i=1}^n t_i \times 10^{\frac{L_{A_i}}{10}} \right]$$

and the level of interference in the conversation was calculated using the equation

$$SPL = \frac{SPL500 + SPL1000 + SPL2000 + SPL4000}{4}$$

In addition, the efficiency of the protective earmuffs of the workers was calculated by the octave-band calculations (16). Finally, the data were entered into the software SPSS and analyzed by t-test at a significant level of $p \leq 0.05$.

3. Results

In table 1, the mean and the of sound intensity level at 27 stations in the factory halls are presented together with the number of stations with excessive noise in Iran.

In Table 2, the results of the worker's exposure level at their workplaces are presented and compared with its allowed limit in Iran. In Table 3, the results of the performance of protective earmuffs of the workers in different frequencies are presented with respect to the maximum level of sound intensity of their work environment.

The performance of workers' protective earmuffs were acceptable at frequencies of 1000, 2000, 4000 and 8000 Hz; and there was a significant decrease in sound intensity level at these frequencies (P=0.001). However, their performance was not acceptable at 250 and 500 Hz (P>0.05). According to the workers, none of them use earmuffs on a regular basis. The level of interference in conversation (SIL1) was

obtained 61.3 dB in the production line and 85.5 dB in the mill.

Table 4 presents the mean of the sound intensity level measured at different frequencies, the SIL index, and the maximum distance (in meters) for the comprehension of speech.

Table 1: Minimum, maximum, mean, and standard deviation of noise pressure level in the factory halls compared to occupational limit

Factory halls	number of measurement stations	SPLmin (dB)	SPLmax (dB)	Mean and standard deviation of sound pressure level (dB)	standard stations with more than 85 dB	Stations with 85 dB and less
Production Line	21	78.3	88.1	83.9±3.03	10 (47.6%)	11 (52.4%)
Mill	6	83.6	92.8	88±3.06	5 (83.3%)	1 (16.7%)

Table 2: Minimum, maximum, mean and standard deviation of 8 hour exposure of the workers compared with its allowed limit in Iran

the number of studied workers	Leqmin (dB)	Leqmax (dB)	Mean and standard deviation of exposure level dB	Cases with more than 85 dB	Cases with the level of 85 dB and more
7	80.71	89.10	85.74±2.77	5 (71.43%)	2 (28.57%)

Table 3: Efficiency of workers' protective handsets in reducing the level of sound intensity by frequency

Frequency Hz	intensity level			performance of Protective earmuff				Paired t test		
	Maximum level of sound intensity dB	Noise allowed limit dB	Reduction required dB	Minimum decrease of sound intensity level dB	Maximum decrease of sound intensity level dB	Mean reduction of sound intensity level dB	Standard deviation	P-value	df	T
	125	90.2	96	-	-5.60	9.30	-0.84	5.84	0.764	4
250	93.3	92	1.3	-8.80	4.50	-4.64	5.31	0.123	4	-1.95
500	93.3	88	5.3	-3.10	9.00	0.64	5.05	0.791	4	0.28
1000	91.9	86	5.9	10.0	18.90	13.70	3.69	0.001*	4	8.29
2000	88.7	85	3.7	16.8	22.50	19.92	2.26	0.000*	4	19.69
4000	87.9	85	2.9	12.90	24.00	17.60	4.12	0.001*	4	9.54
8000	83.1	86	-	11.10	22.20	16.08	4.30	0.001*	4	8.34

Significant at the level of P ≤ 0.05

Table 4: Mean sound intensity level at different frequencies, SIL index, and maximum distance for speech comprehension

Sound intensity level	Variable				SIL index dB	maximum distance for speech comprehension
	Frequency Hz					
	500	1000	2000	4000		
Production Line	64.8	59.1	60.9	60.4	61.3	0.7
Mills	90.15	88.85	86.03	85.10	87.53	0.07

4. Discussion

As the results of Table 1 show, in some parts of the studied factory halls, the sound intensity level and the 8-hour exposure level of the workers are higher than its limit in Iran, which is expected to result in various harms to the health of workers. So far, similar studies have been performed in industries such as steel, tile, petrochemicals and fire-proof materials, mentioning the existence of the harmful factor of noise in this group of industries. Based on the results of this study, it can be said that the plastic containers production industry is among those industries in which the harmful factor of sound is relevant, requiring consideration from the perspective of control measures (8, 12, 15, 17).

This study which was conducted at the factory's halls shows that at the present time practically no technical and administrative action is taken to reduce the sound level in the halls; and the type of protective earmuffs which are designed to protect the hearing of the workers is merely earmuffs which are of high efficiency in reducing the level of sound intensity at high frequencies; in the lower frequencies, however, airplugs are more effective (17).

The results of the examination of the performance of the workers' protective earmuffs in this study, which are listed in Table 3, show that these earmuffs do not have the desired performance at frequencies of 250 and 500 Hz, which suggests a lack of due attention when selecting protective earmuffs for workers, which has also been reported in the study by Hojjati et al. (18). At the time of the provision of protective earmuffs for workers, it is necessary to first analyze the sound at different frequencies in the working environment and, in the light of the results of the sound analysis, appropriate protective earmuffs – that can provide the workers with hearing protection at frequencies with the intensity of higher than limit – be prepared. However, besides this issue, one should also pay attention to other features of the earmuff such as the fitness of the earmuff to the individual, proper care, proper size, and the compatibility with other equipment of personal protection (19).

In addition to technical specifications, the amount of the use of protective earmuffs by workers has an important part concerning their efficiency. According to the workers in this study, none of them used the earmuff regularly. In the study by Peyvandi et al., the amount of the workers' use of protective earmuffs has been reported to be low (20%). The

low utilization of the earmuffs by the workers is due to their lack of awareness of the benefits of using the earmuff, which could be improved by the implementation of educational programs. Based on the results of previous studies, the upgrading of the employers' level of awareness is also effective in increasing the use of personal protective equipment by workers (21, 22).

According to the results of the index of interference level in conversation in table 4 and the NR batch curves, the maximum distance (in meters) for speech comprehension is 0.7 meter and it is 0.07 m for the mill hall. In other words, in the production line hall, the worker should not be at a distance more than 0.7 meters, which in fact is a very short distance. As for the mill hall, this distance is 7 cm, which, given the fact that the distance is too short, workers, in order to communicate with each other, will have to talk by calling out and shouting to each other (16). This suggests that the existing sound level in these halls, especially in the mill hall, has created the conditions for interference in the workers' conversations, as a result of which the incidence of possible accidents would be predictable. From the perspective of safety, it can be said that, paying attention to sound control in this industry is of importance, as it has been emphasized in previous studies in other industries. (12, 15, 20).

5. Conclusion

According to the results of this study, the necessity of applying a program against noise in the studied factory is obvious. Technical measures should be taken in terms of the reduction of sound intensity level of the devices, the reduction of the distribution of noise in the environment, the annual inspections of workers, and, if needed, the change of job in workers with high hearing loss. Furthermore, attention should be paid when selecting protective earmuffs for the workers.

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